Westinghouse

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, D.C. 20555

Direct tel: 412-374-6306
Direct fax: 412-374-5005
e-mail: sterdia@westinghouse.com

Your ref: Project Number 740
Our ref: DCP/NRC2029

October 26, 2007

Subject: AP1000 COL Standard Technical Report Submittal of APP-GW-GLR-101 (TR 101) Revision 1

In support of Combined License application pre-application activities, Westinghouse is submitting Revision 1 of AP1000 Standard Combined License Technical Report Number 101. This report completes and documents, on a generic basis, activities required for partial closure of COL Information Item 19.59.10-2 in the AP1000 Design Control Document. The purpose of this revision to TR 101 is to make a correction to the High Winds analysis, to provide clarification of the Section 5.1 discussion on Aviation Accidents, and to incorporate changes in response to Requests for Additional Information (RAIs) received from the NRC. This report is submitted as part of the NuStart Bellefonte COL Project (NRC Project Number 740). The information included in this report is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification.

The purpose for submittal of this report was explained in a March 8, 2006 letter from NuStart to the U.S. Nuclear Regulatory Commission.

Pursuant to 10 CFR 50.30(b), APP-GW-GLR-101, Revision 1, "AP1000 Probabilistic Risk Assessment Site-Specific Considerations," Technical Report Number 101, is submitted as Enclosure 1 under the attached Oath of Affirmation. Revision 0 of Technical Report 101 was submitted under Westinghouse letter DCP/NRC1885, dated May 11, 2007.

It is expected that when the NRC review of Technical Report Number 101 is complete, COL Information Item 19.59.10-2 will be considered partially complete for COL applicants referencing the AP1000 Design Certification.

Questions or requests for additional information related to content and preparation of this report should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Westinghouse requests the NRC to provide a schedule for review of the technical report within two weeks of its submittal.

D063
D079
NRO

Very truly yours,

A. Sterdis, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Attachment

1. "Oath of Affirmation," dated October 26, 2007

/Enclosure

1. APP-GW-GLR-101, Revision 1, "AP1000 Probabilistic Risk Assessment Site-Specific Considerations," Technical Report Number 101

cc:	D. Jaffe	-	U.S. NRC	1E	1A
	E. McKenna	-	U.S. NRC	1E	1A
	G. Curtis	-	TVA	1E	1A
	P. Hastings	-	Duke Power	1E	1A
	C. Ionescu	-	Progress Energy	1E	1A
	A. Monroe	-	SCANA	1E	1A
	M. Moran	-	Florida Power & Light	1E	1A
	C. Pierce	-	Southern Company	1E	1A
	E. Schmiech	-	Westinghouse	1E	1A
	G. Zinke	-	NuStart/Entergy	1E	1A
	R. Anderson	-	Westinghouse	1E	1A

ATTACHMENT 1

"Oath of Affirmation"

ATTACHMENT 1

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:)

NuStart Bellefonte COL Project)

NRC Project Number 740)

APPLICATION FOR REVIEW OF
"AP1000 GENERAL COMBINED LICENSE INFORMATION"
FOR COL APPLICATION PRE-APPLICATION REVIEW

W. E. Cummins, being duly sworn, states that he is Vice President, Regulatory Affairs and Standardization, for Westinghouse Electric Company; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission this document; that all statements made and matters set forth therein are true and correct to the best of his knowledge, information and belief.

W E Cummins

W. E. Cummins
Vice President
Regulatory Affairs and Standardization

Subscribed and sworn to
before me this 26th day
of October 2007.

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Patricia S. Aston, Notary Public
Murrysville Boro, Westmoreland County
My Commission Expires July 11, 2011
Member, Pennsylvania Association of Notaries

Patricia S Aston
Notary

ENCLOSURE 1

APP-GW-GLR-101, Revision 1

"AP1000 Probabilistic Risk Assessment Site-Specific Considerations"

Technical Report 101

AP1000 DOCUMENT COVER SHEET

TDC: ________ Permanent File: ________ APY ________

RFS#: ________ RFS ITEM #: ________

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PATENT REVIEW ~~Mike Corletti~~ Douglas Ekeroth	SIGNATURE/DATE [signature] 10/23/07

☐ WESTINGHOUSE PROPRIETARY CLASS 2

ORIGINATOR R. G. Anderson	SIGNATURE/DATE RG Anderson 10/23/2007	
REVIEWERS	SIGNATURE/DATE	
VERIFIER D. T. McLaughlin	SIGNATURE/DATE [signature] 10/23/07	VERIFICATION METHOD Independent 3-Pass Review
AP1000 RESPONSIBLE MANAGER A. Sterdis	SIGNATURE* [signature] /for [illegible]	APPROVAL DATE 10/24/2007

* Approval of the responsible manager signifies that document is complete, all required reviews are complete, electronic file is attached and document is released for use.

APP-GW-GLR-101
Revision 1

October 2007

AP1000 Standard Combined License Technical Report

AP1000 Probabilistic Risk Assessment Site–Specific Considerations

Westinghouse Electric Company LLC
P.O. Box 355
Pittsburgh, PA 15230-0355

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1.0 INTRODUCTION

This technical report addresses AP1000 Design Control Document (DCD) (Reference 1) Combined Operating License (COL) Information Item 19.59.10-2 on page 19.59-37.

DCD Paragraph 19.59.10.5 Combined License Information Item 19.59.10-2 states:

> "The Combined License applicant referencing the AP1000 certified design will review differences between the as-built plant and the design used as the basis for the AP1000 PRA and Table 19.59-18. If the effects of the differences are shown, by a screening analysis, to potentially result in a significant increase in core damage frequency or large release frequency, the PRA will be updated to reflect these differences. Based on site-specific information, the COL should also reevaluate the qualitative screening of external events (PRA Section 58.1). If any site-specific susceptibilities are found, the PRA should be updated to include the applicable external event."

The purpose of this report is to identify the potential external events that may impact the AP1000 risk on a site-specific basis. The Combined License information requested in COL Item 19.59.10-2 has been partially addressed in this report. Additional work is required by the Combined Operating License Applicant to address the aspects of the Combined License information requested in this subsection as delineated in the following paragraph:

The Combined Operating License Applicant will confirm that the High Winds, Floods, and Other External Events analysis documented in this report is applicable to the COL site. Further evaluation will be required if any site-specific susceptibilities are found.

The first part of the COL Item 19.59.10-2, regarding difference between the as-built plant and the design used as the basis for the AP1000 PRA has been addressed by Technical Report TR-06 (Reference 2).

This report also discusses impact of site selection on PRA Level 3 requirements. There is no specific COL item associated with this Level 3 PRA scope. However, as the Level 3 PRA is not required for COL application, this report suggests removing the Level 3 PRA information from the AP1000 DCD. This change to the AP1000 DCD is editorial in nature and does not impact the Level 3 analysis documented in the AP1000 Probabilistic Risk Assessment report (Reference 3).

This Revision 1 is focused on three areas. The first is a correction to the High Winds analysis, in which a more limiting initiating event frequency for the Tornado events is used. While this change does impact the total High Winds core damage frequency, the conclusions drawn in Revision 0 are still applicable. The High Winds analysis was also revised in accordance with RAI-TR-101-SPLA-5 to consider that Category 3 Hurricanes may have 3-second gust wind speeds that exceed the AP1000 operating basis wind speed.

The second area is a clarification of the Section 5.1 discussion on Aviation Accidents. This change does not impact results or conclusions, only clarifying the intent of the discussion.

The third change is actually a series of changes made in response to Requests for Additional information provided by the Nuclear Regulatory Commission (NRC) for Revision 0. These changes are summarized as follows:

1. Revise the Core Damage Frequency (CDF) screening criterion to use 1.0E-08 events/yr (the 1.0E-08 events/yr criterion is applied throughout in this revision). This change is due to RAI-TR101-SPLA-04 Revision 0.

2. Consideration that Category 3 hurricanes may, during 3-second gusts, exceed the operating basis wind speed. The High Winds Case 2 sensitivity study was revised with this new scenario. This change is due to RAI-TR101-SPLA-05 Revision 0.

3. Add clarifying statements to the Section 4.0 External Floods discussion. This change is due to RAI-TR101-SPLA-06 Revision 0.

4. A discussion of external fires was added to Section 2.0. This change is due to RAI-TR101-SPLA-03 Revision 0.

Minor editorial changes have been made throughout the text to improve readability.

2.0 EXTERNAL EVENTS METHODOLOGY

To support resolution of AP1000 COL Item 19.59.10-2, Westinghouse gathered site-specific, external event information from the NUSTART utilities interested in the AP1000 design. The process began when Westinghouse developed a list of PRA external events and provided this list to the utilities currently considering the AP1000 design.

External events considered in the AP1000 PRA are those events whose cause is external to all systems associated with normal and emergency operations situations. Some external events may not pose a significant threat of a severe accident. Some external events are considered at the design stage and have a sufficiently low contribution to core damage frequency or plant risk.

Based upon the guidelines provided in Reference 4 and Reference 5, the following is a list of external events that are considered for evaluation. Note that sabotage events are not included in the scope of this evaluation.

- High winds and tornadoes;
  - Tornados are based on the Enhanced Fujita Scale (see Table 2.0-1)
  - Hurricanes are based on the Saffir-Simpson Scale (see Table 2.0-2)
- External floods;
- Transportation and nearby facility accidents
  - Aviation (accidental commercial/general/military)
  - Marine (ship/barge)
  - Pipeline (gas/oil)
  - Railroad
  - Truck

Each utility then evaluated each external event for applicability to their proposed sites. Events that were not applicable to any of the surveyed sites were screened from the evaluation. For events determined by the utility to be applicable to their proposed sites, the utility provided to Westinghouse an external event initiating event frequency. Westinghouse gathered initiating event frequencies from the utilities and compiled them. For a given initiating event, the initiating event frequencies are ordered in decreasing value. The highest initiating event frequency was selected to "bound" each event. Westinghouse then selected the largest initiating event frequency for each initiating event category and evaluated the frequency versus modified criteria in NUREG-1407.

The criteria developed in this report are that external events with an initiating event frequency less than 1.0E-07 events/yr can be screened from the evaluation. For external event frequencies greater than 1.0E-07 events/yr, a quantitative evaluation will be performed. If that evaluation can show that the resulting CDF would be less than 1.0E-08 events/yr, then that external event can also be screened from the evaluation. Events that can not be screened from the evaluation would have to be considered for further detailed analysis.

Per Chapter 58 of the NRC approved AP1000 PRA and DCD Chapter 19, external fires are not required to be evaluated in the AP1000 PRA. External fires are those occurring outside the plant site boundary. Potential effects on the plant could be loss of offsite power and forced isolation of the plant ventilation and possible control room evacuation. Usually, external fires are unable to spread onsite because of site clearing during the construction phase. NUREG-1407 notes that because the loss-of-offsite power is addressed in the Individual Plant Examination (IPE), it does not need to be reevaluated for Individual Plant Examination of External Events (IPEEE). As it relates to the AP1000 design, loss-of-offsite power was evaluated in the AP1000 internal events PRA. Loss-of-offsite power contributes less than 1% to the AP1000 plant core damage frequency. External fires do not need to be evaluated further as their contribution to core damage frequency is expected to be less than 1% of the total AP1000 plant CDF.

Table 2.0-1: Description of Enhanced Fujita Scale (Tornados)[1]			
Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
EF0	Gale tornado	65-85 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
EF1	Moderate tornado	86-110 mph	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
EF2	Significant tornado	111-135 mph	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	Severe tornado	136 - 165 mph	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
EF4	Devastating tornado	166-200 mph	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
EF5	Incredible tornado	>200 mph	Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

1. Enhanced Fujita Scale extracted from Reference 6.

Table 2.0-2: Description of Saffir-Simpson Scale (Hurricanes)[1]		
Category Number	Wind Speed	Category Description
1	74-95 mph	Storm surge generally 4-5 ft above normal. No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Some damage to poorly constructed signs. Also, some coastal road flooding and minor pier damage.
2	96-110 mph	Storm surge generally 6-8 feet above normal. Some roofing material, door, and window damage of buildings. Considerable damage to shrubbery and trees with some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers. Coastal and low-lying escape routes flood 2-4 hours before arrival of the hurricane center. Small craft in unprotected anchorages break moorings.
3	111-130 mph	Storm surge generally 9-12 ft above normal. Some structural damage to small residences and utility buildings with a minor amount of curtain wall failures. Damage to shrubbery and trees with foliage blown off trees and large trees blown down. Mobile homes and poorly constructed signs are destroyed. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Flooding near the coast destroys smaller structures with larger structures damaged by battering from floating debris. Terrain continuously lower than 5 ft above mean sea level may be flooded inland 8 miles (13 km) or more. Evacuation of low-lying residences with several blocks of the shoreline may be required.
4	131-155 mph	Storm surge generally 13-18 ft above normal. More extensive curtain wall failures with some complete roof structure failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Low-lying escape routes may be cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of structures near the shore. Terrain lower than 10 ft above sea level may be flooded requiring massive evacuation of residential areas as far inland as 6 miles (10 km).
5	>155 mph	Storm surge generally greater than 18 ft above normal. Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of all structures located less than 15 ft above sea level and within 500 yards of the shoreline. Massive evacuation of residential areas on low ground within 5-10 miles (8-16 km) of the shoreline may be required.

1. Saffir-Simpson Scale extracted from Reference 7.

3.0 HIGH WINDS EVALUATION

The overall methodology recommended by NUREG-1407 (Reference 5) for analyzing plant risk due to high winds and tornados is a progressive screening approach. This approach is modified to consider determining the acceptability of hazard frequency and risk. High winds (including tornadoes) can affect plant structures in at least two ways: (1) If wind forces exceed the load capacity of a building or other external facility, the walls or framing might collapse or the structure might overturn from the excessive loading; and (2) If the wind is strong enough, as in a tornado or hurricane, it may be capable of lifting materials and thrusting them as missiles against the plant structures that house safety related equipment. Critical components or other contents of plant structures not designed to resist missile penetration might be damaged and lose their function.

The NUREG-1407 criterion for High Winds and Tornados states that "these events pose no significant threat of a severe accident because the current design criteria for wind are dominated by tornadoes having an annual frequency of exceedance of about 10^{-7}". This is interpreted to mean that events with an annual frequency of exceedance less than 1.0E-07 events/yr may be removed from further consideration and events with an annual frequency of exceedance greater than 1.0E-07 events/yr must be further evaluated. However, the NUREG-1407 criterion was developed for currently operating plants. This 1.0E-07 events/yr value is sufficiently low to capture important contributors to AP1000 risk, and is consistent with the acceptance criteria outlined in Section 2.0 of this report.

High Winds and Tornados tend to behave as a Loss of Offsite Power (LOSP), since the site switchyard is unprotected and not designed against high winds velocities. For wind velocities greater than the design basis, additional Structures, Systems and Components (SSC) may also be damaged. Therefore, two analyses will be performed, one considering only a LOSP, and another considering a LOSP with failure of the standby non-safety systems. This analysis considers not only excessive wind forces, but also missile generation. A Conditional Core Damage Probability will be calculated for each of those two scenarios. Risk due to the event can be estimated using the following equation:

$$CDF = IEF * CCDP \qquad \text{(Equation 1)}$$

Where CDF is annual Core Damage Frequency, IEF is the Initiating Event Frequency and CCDP is the Conditional Core Damage Probability. If this evaluation indicates an acceptably small contribution to risk (e.g. CDF less than 1.0E-08 events/yr), then the progressive screening is complete and no detailed PRA will be necessary.

The analysis for High Winds and Tornados begins with an examination of the Design Basis for the plant, which is documented in Section 2.0 of the AP1000 DCD (Reference 1). It is anticipated that a high wind or tornado event would result in a loss of offsite power, as the switchyard is likely to become unavailable during the event.

The AP1000 design basis wind speed for tornados is 300 mph as discussed in Chapter 2 of the AP1000 DCD. This value is assumed to be the maximum wind speed that will not challenge the safety related structures. The AP1000 operating basis wind speed is 145 mph as discussed in Chapter 2 of the AP1000 DCD. This value is assumed to be the maximum wind speed that will not challenge the non-safety related structures.

The structures protecting safety related features of the AP1000 are designed for extreme winds and missiles associated with these winds. As long as the external event winds are less than these design basis winds (300 mph, per Chapter 2 of the DCD), the safety features of the AP1000 will be unaffected. If the winds exceed the design values, then the integrity of the safety related structures may be compromised.

The structures protecting non-safety related features of the AP1000 are designed according to uniform building code and have some level of protection against seismic and high wind events. As long as the external event winds are less than the operating basis winds (145 mph, per Chapter 2 of the DCD), the non-safety features of the AP1000 will be unaffected. If the winds exceed the operating basis values, then the integrity of the non-safety related structures may be compromised.

In summary of the design against high winds, the plant is designed against 300 miles per hour (mph) winds. The operating basis of the plant is winds up to 145 mph. This means that the safety structures are protected against winds up to 300 mph and non-safety system structures are protected against winds up to 145 mph. Per the Enhanced Fujita Scale for Tornados (Table 2.0-1), no tornados are expected to exceed 300 mph; however, EF3, EF4, and EF5 tornados do exceed the operating basis of the AP1000. Per the Saffir-Simpson Scale for Hurricanes (Table 2.0-2), no hurricanes are expected to reach 300 mph winds; however, Category 3, Category 4 and Category 5 Hurricane winds may exceed the operating basis of the AP1000.

Three studies are performed to evaluate the high wind events. The Case 1 study is a Loss of Offsite Power (LOSP) induced by each of the events, with no other equipment unavailable. A Conditional Core Damage Probability (CCDP) is developed for this scenario, which may be multiplied by the high wind event frequency. The CCDP was calculated as 9.81E-09. All tornados and hurricanes are considered in this Case 1 as they may challenge the AP1000 switchyard. Extratropical cyclones are normal storms and thunderstorms with winds expected to fall below the operating basis for the AP1000. They are also included in the Case 1 analysis.

As stated above, the EF3, EF4, and EF5 Tornados and Category 3, Category 4 and Category 5 Hurricanes may challenge the non-safety related structures in the AP1000. Therefore, these events will be evaluated with the loss of additional SSCs. The Case 2 study is created by modifying the Case 1 analysis for the EF3, EF4, and EF5 tornados, and Category 3, Category 4 and Category 5 hurricanes to have a LOSP with additional failures of non-safety systems. A CCDP was developed for this scenario, which may be multiplied by the high wind event frequency. The CCDP was calculated as 5.85E-08.

The final Case 3 is a conservative study where all high wind events are evaluated as a LOSP with failure of the non-safety systems. The CCDP developed for Case 2 is applied to all events. This case is created to represent the risk to the plant if the non-safety structures were not designed to any code. Admittedly, this is a very conservative sensitivity study as all of the AP1000 structures are designed to some code and will resist high winds to some degree.

In this high winds analysis, events are considered of low risk importance if their initiating event frequency is less than 1.0E-07 or if their estimated CDF is less than 1.0E-08 events/yr.

The results of the CDF calculation are shown in Table 3.0-1. Equation 1 was used to determine the resultant CDF.

Table 3.0-1: High Winds and Tornados Results					
Category	Event	Limiting Initiating Event Freq. (events/yr)	CDF (events/yr)		
			LOSP (Case 1) (events/yr)	LOSP with non-safety systems unavailable for select events (Case 2) (events/yr)	LOSP with non-safety systems unavailable for all events (Case 3) (events/yr)
High Winds	EF0 Tornado	1.00E-03	9.81E-12	9.81E-12[1]	5.85E-11
	EF1 Tornado	1.00E-03	9.81E-12	9.81E-12[1]	5.85E-11
	EF2 Tornado	1.00E-03	9.81E-12	9.81E-12[1]	5.85E-11
	EF3 Tornado	1.00E-03	9.81E-12	5.85E-11	5.85E-11
	EF4 Tornado	1.00E-03	9.81E-12	5.85E-11	5.85E-11
	EF5 Tornado	1.00E-03	9.81E-12	5.85E-11	5.85E-11
	Cat. 1 Hurricane	1.00E-01	9.81E-10	9.81E-10[1]	5.85E-09
	Cat. 2 Hurricane	5.00E-02	4.91E-10	4.91E-10[1]	2.93E-09
	Cat. 3 Hurricane	3.00E-02	2.94E-10	1.76E-09	1.76E-09
	Cat. 4 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Cat. 5 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Extratropical Cyclones	3.00E-02	2.94E-10	2.94E-10[1]	1.76E-09
Totals			2.32E-09	4.90E-09	1.38E-08

[1]CDF values from Case 1 were used to illustrate the winds from these events will not challenge additional plant SSCs.

In the above table, none of the limiting initiating event frequencies were sufficiently low to be removed from further consideration. Therefore, the CDF calculation was performed. In each case, the resultant CDF is less than 1.0E-08 events/yr. The Category 4 and Category 5 Hurricane frequency is considered to be extremely conservative at 1.00E-02 events/yr. Yet, even with that initiating event frequency, and the worst case sensitivity study (Case 3), the resultant CDF is still less than the CDF criterion of 1.0E-08 events/yr. Furthermore, the sum of the estimated CDF for Case 1 and Case 2 falls below the CDF criterion of 1.0E-08 events/yr. Case 2 is considered to be the representative model for High Winds, with Case 1 and Case 3 being treated as sensitivity studies on the baseline. Case 3 is conservative in that it assumes total failure of the standby non-safety systems (CVS, RNS, SFW, automatic DAS, and Diesel Generators) for all high wind events. As AP1000 non-safety structures have been designed to a building code that offers an added level of protection, the above failures are considered extreme and conservative. Therefore, while the total Case 3 CDF does fall above the 1.0E-08 events/year CDF screening criteria, the results are considered very conservative for the above reasons. Consequently, no further detailed PRA is necessary for the AP1000 High Winds and Tornados analysis.

It is recognized that by failing all non-safety systems for Case 3, the total CDF increases by an approximate factor of 3 compared to the Case 2. In Case 3, the larger frequencies for the lower intensity events are driving the CDF. In Case 3, there is an assumption that no non-safety structure will survive any high wind event. But, in fact, the AP1000 non-safety structures have been designed to a building code that offers an added level of protection. It is concluded that the added level of protection for the non-safety structures is important in preventing core damage.

4.0 EXTERNAL FLOODING EVALUATION

An external flooding analysis was performed to account for any significant contribution to core damage frequency resulting from plant damage caused by storms, dam failure, and flash floods.

The analysis for External Floods begins with an examination of the Design Basis for the plant, which is documented in Section 2.0 of the AP1000 DCD (Reference 1). The AP1000 is protected against floods up to the 100' level. The 100' level corresponds to the plant ground level. From this point, the ground is graded away from the structures. Thus, water will naturally flow away from the structures. Additionally, all seismic Category I SSCs are designed to withstand the effects of flooding. The seismic Category I SSCs below grade (below ground level) are protected against flooding by a water barrier consisting of waterstops and a waterproofing system. None of the non-safety SSCs were found to be important based on flooding considerations (Reference 1).

Only one site indicated susceptibility to external floods, due to hurricane surge water. That site is located at an elevation of 45 feet above sea level. Therefore, the AP1000 100' level, for this site, corresponds to 45' above sea level. Per DCD Chapter 3.4.1.1, the ground will be graded away from the structures beginning at the 100' level and sloping downward away from the structures. The Saffir-Simpson hurricane scale notes that Category 5 hurricanes have the ability to generate storm surges in excess of 18 feet. Hurricane Camille (1969) generated a storm surge of 25 feet along the Mississippi Gulf Coast (Reference 7).

Based on the description of a Category 5 hurricane in the Saffir-Simpson hurricane scale, a hurricane storm surge in excess of 18 feet may be classified as an extremely rare event. The American Society of Mechanical Engineers (ASME) has recently approved changes to the ASME PRA Standard to assign a value to an "extremely rare event". That value is defined as 1E-06 / year for currently operating plants. Recognizing that the AP1000 design provides additional levels of safety, TR-101 suggests a value of 1E-07 /year to define an extremely rare event for the AP1000 design.

As a sensitivity study, the 1.0E-07 events/yr initiating event frequency is taken as the frequency of an event that may challenge the non-safety structures in the plant. This sensitivity study also considers failure of the switchyard due to flooding. A LOSP with failure of the non-safety systems CCDP was developed. Equation 1 was used to determine the resultant CDF.

As expected, the risk due to a flooding event is very low for the AP1000. The resultant CDF of 5.85E-15 events/yr is an insignificant contribution to total plant CDF.

For other sites, the AP1000 is designed to site characteristics described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 1.0E-06 per year. As explained above, this criterion should be extended to an annual frequency of occurrence less than 1.0E-07 per year. As none of the surveyed sites indicated susceptibility to floods due to dam failure and/or flash floods, those events should be considered on a site-by-site basis.

5.0 TRANSPORTATION AND NEARBY FACILITIES ACCIDENTS

These events consist of accidents related to transportation near the nuclear power plant and accidents at industrial and military facilities in the vicinity. The following modes of transportation are considered:

- Aviation (commercial/general/military)
- Marine (ship/barge)
- Pipeline (gas/oil)
- Railroad
- Truck

5.1 Aviation Accidents

Two of the surveyed sites reported that Aviation Accidents are a concern. The limiting event frequency is 1.21E-06 events/yr; however, most of that frequency is for small aircraft, with commercial aircraft contribution of 9.40E-09 events/yr.

A conservative analysis has been performed to evaluate the risk due to small aircraft accidents on-site. This analysis assumed a Loss of Offsite Power event, and conservatively failed a set of standby non-safety systems. This is acceptable as it is unlikely that a small aircraft accident would challenge any of the passive safety systems inside containment. This leaves only the non-safety systems outside of containment as vulnerable. However, this evaluation is conservative as it is unlikely that a small aircraft would have the capacity to fail such a large area of the AP1000.

Equation 1 is used to determine the resultant CDF. A CDF of 7.08E-14 events/yr is calculated and is an insignificant contribution to total plant CDF of approximately 5.08E-07 events/yr (Reference 1). Therefore, sites that can demonstrate an aviation event frequency less than or equal to 1.21E-06 events/yr for small aircraft accidents are bounded by this evaluation.

Larger commercial aircraft may have the capacity to challenge SSCs within the AP1000 containment. However, the containment structure and safety systems are designed to withstand various earthquake levels, such that many of the safety system SSCs will still be available following the accident. Therefore the 1.0E-07 events/yr criterion for event frequency is still applicable for larger commercial aircraft. Sites that can demonstrate a commercial aircraft aviation event frequency less than the 1.0E-07 events/yr criterion are also bounded by this analysis. For this current evaluation, the highest initiating event frequency reported for large commercial aircraft is 9.40E-09 events/yr. This value falls below the 1.0E-07 events/yr screening criteria. Therefore, no further evaluation is necessary.

5.2 Marine Accidents

Only sites with large waterways with ship and/or barge traffic that go through or near the site need to consider Marine Accidents. One of the surveyed sites reported that Marine Accidents are a concern.

Marine accidents involving ship or barge accidents pose a hazard to a nuclear power plant due to two possibilities:

1. Release of hazardous material towards the plant
2. Explosion with resulting damage to the plant.

The potential exists for a Marine Accident that leads to a release of toxic materials into the atmosphere. This type of event may compromise the safety of the plant operators, resulting in reduced operator reliability. However, the toxic release will not directly lead to any failure of plant equipment. To evaluate the risk impact of this scenario, a CCDP is developed that models a reactor trip followed by the guaranteed failure of all PRA credited operator actions. The resulting CCDP is 6.26E-08. The initiating event frequency is 1.0E-06 events/yr, which was selected as the bounding value of the surveyed sites based on supplied information.

Equation 1 is used to determine the resultant CDF. The resultant CDF is 6.26E-14 events/yr. The results indicate a very low estimated CDF contribution due to toxic releases from a Marine Accident.

The above analysis is conservative. The AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event.

There is also a potential for marine explosion accidents. The AP1000 is not designed with a Service Water intake structure; thus, Loss of Service Water events as a consequence of marine explosions are not a nuclear safety concern for the AP1000 design. Regulatory Guide 1.91 (Reference 8) provides the acceptance criterion of an overpressure event in excess of 1 psi at a frequency less than 1E-06 /yr.

Additional evaluations were performed in NUREG/CR-5042 (Reference 9), which documents a study performed for the Waterford site. Waterford lies in a heavily trafficked (>100,000 vessels per year) area of the Mississippi River. The Waterford reactor building is located approximately 2,200 feet from the main shipping channel in the Mississippi River.

The Waterford site is of no special relation to the AP1000 design; however, several insights may be gained from the NUREG/CR-5042 evaluation. The NUREG/CR-5042 evaluation considered detonation of a 300,000 barrel barge filled with gasoline. The detonation of this fuel loading produced an acceptable overpressure for the safety-related buildings. This evaluation provides justification that the Regulatory Guide 1.91 acceptance criterion is conservative, at least for the safety-related buildings. Marine explosion accidents do not need to be considered further for the AP1000 PRA as long as the Regulatory Guide 1.91 criterion is met.

5.3 Pipeline Accidents

Pipeline accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. One of the surveyed sites noted a potential pipeline accident applicable to the site. For the site, there is a 30" Gas line approximately 5800 feet away. An evaluation was performed.

Considerations for the evaluation are:

- Gas pipe rupture frequency,
- Gas cloud formation probability,
- Gas cloud transportation and non-dispersion probability,
- Gas cloud ignition probability on-site.

Consider Figure 5.3-1 to further evaluate the probability of this accident. When considering the pipe rupture frequency, the probability of forming a dense gas cloud, and the probability of the wind speed and direction to be in the ranges necessary to transport the gas cloud 5800 feet to the site, without dispersing the gas, including ignition of the gas cloud on-site in a location that may challenge the plant, this event probability becomes very low.

Site habitability is also a concern for toxic materials. However, the AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event.

The expected frequency value is expected to be below the initiating event criterion of 1.0E-07 events/yr. This is based on the expected low frequency of a pipe rupture combined with the low probability of forming and igniting a gas cloud. Therefore, no further quantitative evaluation is necessary.

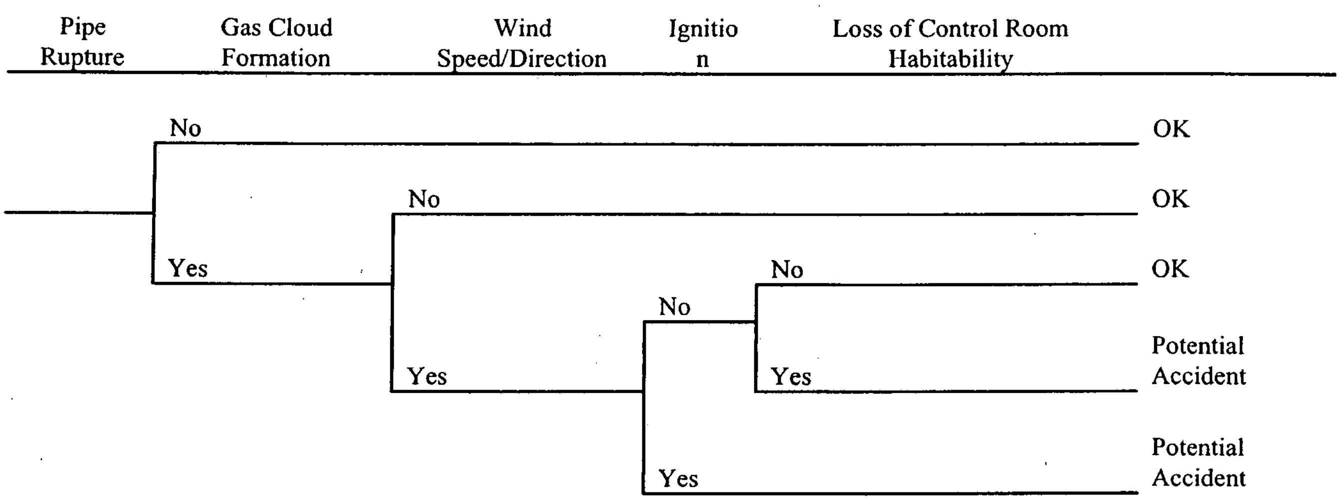


Figure 5.3-1: Pipeline Accident Model

5.4 Railroad and Truck Accidents

Railroad and Truck accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. Toxic material releases were evaluated in the Marine Accident evaluation as to not be important to AP1000 plant risk. Significant damage to the AP1000 plant was evaluated in the Aviation Accident evaluation. Neither truck nor railroad accidents are expected to result in the amount of damage that may be seen from an Aviation Accident. This is especially true considering the increased security barriers established at U.S. nuclear power plants. None of the surveyed sites noted railroad accidents as applicable to the site. Therefore, no further analysis is necessary.

For other sites, the AP1000 is designed to site characteristics described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 1.0E-06 per year. As explained in Section 2.0, this criterion should be extended to an annual frequency of occurrence less than 1.0E-07 per year.

6.0 SITE-SPECIFIC LEVEL 3 PRA

A probabilistic risk assessment was performed in support of the AP1000 Design Certification application. The purpose of the PRA was to improve plant design using risk insights. Included in the PRA was an assessment of offsite dose risk (commonly referred to as a Level 3 PRA) for a reference site. There was no explicit regulatory requirement for a Level 3 PRA; however, the Level 3 PRA was suggested for Design Certification in the EPRI ALWR Utility Requirements Document (Reference 10). The purpose of the Level 3 PRA was to estimate the potential ground-level exposure, expressed as both effective dose equivalent (EDE), whole-body dose and acute red bone marrow dose, resulting from the possible accidental release of radioactive fission products.

The results of the AP1000 Level 3 PRA were used to support the DCD Appendix 1B Severe Accident Mitigation Design Alternatives (SAMDA) for the Westinghouse AP1000 design. This evaluation is performed to evaluate whether or not the safety benefit of the SAMDA outweighs the costs of incorporating the SAMDA in the plant, and is conducted in accordance with applicable regulatory requirements as identified below.

The National Environmental Policy Act (NEPA), Section 102.(C)(iii) requires, in part, that:

> ... all agencies of the Federal Government shall ... (C) include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on ... (iii) alternatives to the proposed action.

The 10 CFR 52.47(a)(ii) requires an applicant for design certification to demonstrate:

> ... compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f) ...

A relevant requirement of 10 CFR 50.34(f) contained in subparagraph (1)(i) requires the performance of:

> ... a plant/site specific probabilistic risk assessment, the aim of which is to seek such improvements in the reliability of core and containment heat removal systems as are significant and practical and do not impact excessively on the plant ...

In SECY-91-229, the U.S. Nuclear Regulatory Commission (NRC) staff recommends that SAMDAs be addressed for certified designs in a single rulemaking process that would address both the 10 CFR 50.34 (f) and NEPA considerations in the 10 CFR Part 52 design certification rulemaking. SECY-91-229 further recommends that applicants for design certification assess SAMDAs and the applicable decision rationale as to why they will or will not benefit the safety of their designs. The Commission approved the staff recommendations in a memorandum dated October 25, 1991 (Reference 11).

Similar to the analysis performed in support of the AP1000 Design Certification, there is no explicit regulatory requirement for a Level 3 PRA to support COL Applications. Furthermore, there is no regulatory requirement for a SAMDA analysis to support COL Applications, although similar work will be performed to support the site Environmental Report.

The Level 3 PRA performed to support the AP1000 Design Certification provided valuable insights to confirm public safety will be maintained for a reference AP1000. Those same levels of safety are expected to hold true for a specific site COL application. This conclusion is especially true considering the "standard design" approach taken by Westinghouse and the potential COL applicants in which the Certified Design will be maintained from site-to-site in order to guarantee the already proven low risk levels. Based on this conclusion, this Technical Report recommends that the Level 3 results summary data be removed from AP1000 DCD Chapter 19 (See Section 11.0). This change also impacts the DCD Appendix 1B SAMDA assessment. Therefore, AP1000 DCD Appendix 1B is revised accordingly (see Section 12.0). The above revisions are editorial in nature. The changes to DCD Appendix 1B are simply made to indicate that the Level 3 PRA inputs to the SAMDA analysis were extracted from the AP1000 PRA report (Reference 3), rather than from AP1000 DCD Chapter 19.

7.0 REGULATORY IMPACT

AP1000 is expected to achieve a higher standard of severe accident safety performance than current operating plants, because both prevention and mitigation of severe accidents have been addressed during the design stage, taking advantage of PRA insights, PRA success criteria analysis, severe accident research, and severe accident analysis. Since PRA considerations have been integrated into the AP1000 design process from the beginning, many of the traditional PRA insights relating to current operating plants are not at issue for the AP1000. The Level 1, and Level 2 PRA results show that addressing PRA issues in the design process leads to a low level of risk. The PRA results indicate that the AP1000 design meets the higher expectations and goals for new generation passive pressurized water reactors (PWRs).

The AP1000 design is shown to be highly robust against the external events discussed in this Technical Report. The design is resilient against high winds, external floods and other external events that challenge various equipment in the plant.

The following conclusions and insights are derived from the AP1000 external events assessment for events at power:

1. High Winds and Tornados were quantitatively evaluated to be of low risk to the AP1000 design for each of the participating sites. A bounding assessment is provided to show that the expected CDF due to any one of these events does not exceeds 1.0E-08 events/yr. The same is true for the aggregate results. Sensitivity studies were performed to ensure low risk for more limiting scenarios. No further analysis is suggested.
2. The AP1000 is designed to flooding levels described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 1.0E-06 per year. This criterion should be extended to an annual frequency of occurrence less than 1.0E-07 per year. No further analysis is suggested.
3. Transportation and Nearby Facilities Accidents are qualitatively evaluated to be of low risk importance and do not warrant further evaluation.

The changes to the DCD presented in this report do not represent an adverse change to the design or the PRA. The DCD changes do not require a license amendment per the criteria of VIII.B.5.b of Appendix D to 10 CFR Part 52.

The closure of the COL Information Item 19.59.10-2 will not alter barriers or alarms that control access to protected areas of the plant. The closure of the COL Information Item will not alter requirements for security personnel. Therefore, the closure of the COL Information item does not have an adverse impact on the security assessment of the AP1000.

8.0 REFERENCES

1. APP-GW-GL-700, "AP1000 Design Control Document", Revision 15.

2. APP-GW-GLR-021, "AP1000 As-Built COL Information Items", Revision 0, June 2006.

3. APP-GW-GL-022, "AP1000 Probabilistic Risk Assessment", Revision 5.

4. "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - 10 CFR 50.54(f)", Generic Letter 88-20, Supplement 4, June 28, 1991.

5. U.S. Nuclear Regulatory Commission, NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities", June 1991.

6. National Weather Service, "The Enhanced Fujita Scale", February 02, 2007, Available: http://www.spc.noaa.gov/efscale/.

7. National Weather Service, "The Saffir-Simpson Hurricane Scale", June 22, 2006, Available: http://www.nhc.noaa.gov/aboutsshs.shtml.

8. U.S. Nuclear Regulatory Commission Regulatory Guide 1.91, "Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants", Revision 1, February 1978.

9. U.S. Nuclear Regulatory Commission, NUREG/CR-5042, "Evaluation of External Hazards to Nuclear Power Plants in the United States", December 1987.

10. "Advanced Light Water Reactor Utility Requirements Document," Volume III, APPENDIX A to Chapter 1, PRA Key Assumptions and Groundrules", EPRI, Rev. 5 & 6, December 1993.

11. U.S. Nuclear Regulatory Commission, "SECY-91-229 - Severe Accident Mitigation Design Alternatives for Certified Standard Designs", USNRC Memorandum from Samuel J. Chilk to James M. Taylor, dated October 25, 1991.

9.0 DCD SECTION 19.58 MARKUP

The following DCD markup identifies how COL application Final Safety Analysis Reports should be prepared to incorporate the subject change. This section represents the original DCD Section 19.58 markup, as identified in APP-GW-GLR-101, Revision 0. No changes have been made to this text in this revision.

Revise Section 19.58:

19.58 Winds, Floods, and Other External Events

~~This section intentionally blank.~~

19.58.1 Introduction

External events considered in the AP1000 PRA are those events whose cause is external to all systems associated with normal and emergency operations situations. Some external events may not pose a significant threat of a severe accident. Some external events are considered at the design stage and have a sufficiently low contribution to core damage frequency or plant risk.

Based upon the guidelines provided in References 19.58-1 and 19.58-2, the following is a list of five external events that are included for AP1000 analysis:

- High winds and tornadoes
- External floods
- Transportation and nearby facility accidents
- Seismic events
- Internal fires

The first three external events are addressed in this Section. Seismic events and internal fires are addressed in the AP1000 PRA.

Chapter 2 of the *AP1000 Design Control Document* (DCD) defines the site characteristics for which the AP1000 is designed. A site is acceptable if the site characteristics fall within the AP1000 site interface parameters.

19.58.2 External Events Analysis

19.58.2.1 Severe Winds and Tornadoes

The overall methodology recommended by NUREG-1407 for analyzing plant risk due to high winds and tornados is a progressive screening approach. This approach is modified to consider determining the acceptability of hazard frequency and risk. High winds (including tornadoes) can affect plant structures in at least two ways: (1) If wind forces exceed the load capacity of a building or other external facility, the walls or framing might collapse or the structure might overturn from the excessive loading; and (2) If the wind is strong enough, as in a tornado or hurricane, it may be capable of lifting materials and thrusting them as missiles against the plant structures that house safety related equipment. Critical components or other contents of plant structures not designed to resist missile penetration might be damaged and lose their function.

The NUREG-1407 criterion for High Winds and Tornados states that "these events pose no significant threat of a severe accident because the current design criteria for wind are dominated by tornadoes having an annual frequency of exceedance of about 10^{-7}". This is interpreted to mean that events with an annual frequency of exceedance less than 10^{-7} may be removed from further consideration and events with an annual frequency of exceedance greater than 10^{-7} must be further evaluated. However, the NUREG-1407 criterion was developed for currently operating plants.

High Winds and Tornados tend to behave as a Loss of Offsite Power (LOSP), since the site switchyard is unprotected and not designed against high winds velocities. For wind velocities greater than the design basis, additional Structures, Systems and Components (SSC) may also fail. Therefore, two analyses are performed, one considering only a LOSP, and another considering a LOSP with failure of the standby non-safety systems. This analysis considers not only excessive wind forces, but also missile generation. A Conditional Core Damage Probability will be calculated for each of those scenarios. Risk due to the event can be estimated using the following equation:

$$CDF = IEF * CCDP \qquad \text{(Equation 19.58.2.1-1)}$$

Where CDF is annual Core Damage Frequency, IEF is the Initiating Event Frequency and CCDP is the Conditional Core Damage Probability. If this evaluation indicates an acceptably small contribution to risk (e.g. CDF less than 1.0E-08 events/yr), then the progressive screening is complete and no detailed PRA will be necessary.

The analysis for High Winds and Tornados begins with an examination of the Design Basis for the plant, which is documented in Section 2.0 of the AP1000 DCD. The analysis for winds and tornadoes is site-specific. It is anticipated that a high wind or tornado event would result in a loss of offsite power, as the switchyard is likely to become unavailable during the event.

The AP1000 design basis wind speed for tornados is 300 mph as discussed in Chapter 2 of the AP1000 DCD. This value is assumed to be the maximum wind speed that will not challenge the safety related structures. The AP1000 operating basis wind speed is 145 mph as discussed in Chapter 2 of the AP1000 DCD. This value is assumed to be the maximum wind speed that will not challenge the non-safety related structures.

The structures protecting safety related features of the AP1000 are designed for extreme winds and missiles associated with these winds. As long as the external event winds are less than these design basis winds, the safety features of the

AP1000 will be unaffected. If the winds exceed the design values, then the integrity of the safety related structures may be compromised.

The structures protecting non-safety related features of the AP1000 are designed according to uniform building code and have some level of protection against seismic and high wind events. As long as the external event winds are less than the operating basis winds (145 mph, per Chapter 2 of the DCD), the non-safety features of the AP1000 will be unaffected. If the winds exceed the operating basis values, then the integrity of the non-safety related structures may be compromised.

In summary of the design against high winds, the plant is designed against 300 miles per hour (mph) winds. The operating basis of the plant is winds up to 145 mph. This means that the safety structures are protected against winds up to 300 mph and non-safety system structures are protected against winds up to 145 mph. Per the Enhanced Fujita Scale for Tornados (Table 19.58.2.1-1), no tornados are expected to exceed 300 mph; however, EF3, EF4, and EF5 tornados do exceed the operating basis of the AP1000. Per the Saffir-Simpson Scale for Hurricanes (Table 19.58.2.1-2), no hurricanes are expected to reach 300 mph winds; however, Category 3, Category 4 and Category 5 Hurricane winds do exceed the operating basis of the AP1000.

Three studies are performed to evaluate the high wind events. The Case 1 study is a Loss of Offsite Power (LOSP) induced by each of the events, with no other equipment unavailable. A Conditional Core Damage Probability (CCDP) is developed for this scenario, which may be multiplied by the high wind event frequency. All tornados and hurricanes are considered in this Case 1 as they may challenge the AP1000 switchyard. Extratropical cyclones are normal storms and thunderstorms with winds expected to fall below the operating basis for the AP1000. They are also included in the Case 1 analysis.

As stated above, the EF3, EF4, and EF5 Tornados and Category 4 and Category 5 Hurricanes may challenge the non-safety related structures in the AP1000. Therefore, these events will be evaluated with the loss of additional SSCs. The Case 2 study is created by modifying the Case 1 analysis for the EF3, EF4, and EF5 tornados, and Category 3, Category 4 and Category 5 hurricanes to have a LOSP with additional failures of non-safety systems unavailable. A CCDP is developed for this scenario, which may be multiplied by the high wind event frequency.

The final Case 3 is a conservative study where all high wind events are evaluated as a LOSP with failure of the non-safety systems. This case is created to represent the worst case scenario unavailable. In this analysis, events are considered of low risk importance if their initiating event frequency is less than 10^{-7} events/yr or if their estimated CDF is less than 1.0E-08 events/yr.

The results of the CDF calculation are shown in Table 19.58.2.1-3. Equation 19.58.2.1-1 was used to determine the resultant CDF.

In Table 19.58.2.1-3, none of the limiting initiating event frequencies were sufficiently low to be removed from further consideration. Therefore, the CDF calculation was performed. In each case, the resultant CDF is less than 1.0E-08 events/yr. The Category 4 and Category 5 Hurricane frequency is considered to be extremely conservative at 1.00E-02 events/yr. Yet, even with that initiating event frequency, and the worst case sensitivity study (Case 3), the resultant CDF is still less than the CDF criterion of 1.0E-08 events/yr. Furthermore, the sum of the estimated CDF for Case 1 and Case 2 falls below the CDF criterion of 1.0E-08 events/yr. Case 2 is considered to be the representative model for High Winds, with Case 1 and Case 3 being treated as sensitivity studies on the baseline. Therefore, while the total Case 3 CDF does fall above the 1.0E-08 events/year CDF screening criteria, the results are considered very conservative. Consequently, no further detailed PRA is necessary for the AP1000 High Winds and Tornados analysis.

19.58.2.2 External Floods

An external flooding analysis was performed to account for any significant contribution to core damage frequency resulting from plant damage caused by storms, dam failure, and flash floods.

The analysis for External Floods begins with an examination of the Design Basis for the plant, which is documented in Section 2.0 of the AP1000 DCD (Reference 1). The AP1000 is protected against floods up to the 100' level. The 100' level corresponds to the plant ground level. From this point, the ground is graded away from the structures. Thus, water will naturally flow away from the structures. Additionally, all seismic Category I SSCs are designed to withstand the effects of flooding. The seismic Category I SSCs below grade (below ground level) are protected against flooding by a water barrier consisting of waterstops and a waterproofing system. None of the non-safety SSCs were found to be important based on flooding considerations .

Only one site indicated susceptibility to external floods, due to hurricane surge water. That site is located at an elevation of 45 feet above sea level. Therefore, the AP1000 100' level, for this site, corresponds to 45' above sea level. Per DCD Chapter 3.4.1.1, the ground will be graded away from the structures beginning at the 100' level and sloping downward away from the structures. The Saffir-Simpson hurricane scale notes that Category 5 hurricanes have the ability to generate storm surges in excess of 18 feet. Hurricane Camille (1969) generated a storm surge of 25 feet along the Mississippi Gulf Coast.

Based on the description of a Category 5 hurricane in the Saffir-Simpson hurricane scale, a hurricane storm surge in excess of 18 feet may be classified as an extremely rare event. The ASME has recently approved changes to the ASME PRA Standard to assign a value to an "extremely rare event". That value is defined as 1E-06 / year for currently operating plants. Recognizing that the AP1000 design provides additional levels of safety, TR-101 suggests a value of 1E-07 /year to define an extremely rare event for the AP1000 design.

As a sensitivity study, the 1.0E-07 events/yr initiating event frequency is taken as the frequency of an event that may challenge the non-safety structures in the plant. This sensitivity study also considers failure of the switchyard due to flooding. A LOSP with failure of the non-safety systems CCDP was developed. Equation 19.58.2.1-1 was used to determine the resultant CDF.

As expected, the risk due to a flooding event is very low for the AP1000. The resultant CDF of 5.85E-15 events/yr is an insignificant contribution to total plant CDF.

For other sites, the AP1000 is designed to site characteristics described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 1.0E-06 per year. As explained in Section 2.0, this criterion should be extended to an annual frequency of occurrence less than 1.0E-07 per year. As none of the surveyed sites indicated susceptibility to floods due to dam failure and/or flash floods, those events should be considered on a site-by-site basis.

19.58.2.3 Transportation and Nearby Facility Accidents

These events consist of accidents related to transportation near the nuclear power plant and accidents at industrial and military facilities in the vicinity. The following modes of transportation are considered:

- Aviation (commercial/general/military)
- Marine (ship/barge)
- Pipeline (gas/oil)
- Railroad
- Truck

19.58.2.3.1 Aviation Accidents

If a limiting event frequency is 1.21E-06 events/yr, and most of that frequency is for small aircraft, with commercial aircraft contribution 9.40E-09 events/yr then the following discussion is applicable.

A conservative analysis was performed to evaluate the risk due to small aircraft accidents on-site. This analysis assumes a Loss of Offsite Power and conservatively failed a set of standby non-safety systems. This is acceptable as it is unlikely that a small aircraft accident would challenge the passive safety systems inside containment. This leaves only the non-safety systems outside of containment as vulnerable. However, this evaluation is conservative as it is unlikely that a small aircraft would have the capacity to fail such a large area of the AP1000.

Equation 19.58.2.1-1 is used to determine the resultant CDF. A CDF of 7.08E-14 events/yr is calculated and is an insignificant contribution to total plant CDF of approximately 5.08E-07 events/yr. Therefore, sites that can demonstrate an aviation event frequency less than or equal to 1.21E-06 events/yr for small aircraft accidents are bounded by this evaluation.

Larger commercial aircraft may have the capacity to challenge SSCs within the AP1000 containment. However, the containment structure and safety systems are designed to withstand various earthquake levels, such that many of the safety system SSCs will still be available following the accident. Therefore the 1.0E-07 events/yr criterion for event frequency is still applicable for larger commercial aircraft. Sites that can demonstrate a commercial aircraft aviation event frequency less than the 1.0E-07 events/yr criterion are also bounded by this analysis. For this current evaluation, the highest initiating event frequency reported for large commercial aircraft is 9.40E-09 events/yr. This value falls below the 1.0E-07 events/yr screening criteria. Therefore, no further evaluation is necessary.

19.58.2.3.2 Marine Accidents

Only sites with large waterways with ship and/or barge traffic that go through or near the site should consider Marine Accidents. Marine accidents involving ship or barge accidents pose a potential hazard to a nuclear power plant due to two possibilities:

1. Release of hazardous material towards the plant
2. Explosion with resulting damage to the plant.

The potential exists for a Marine Accident that leads to a release of toxic materials into the atmosphere. This type of event may compromise the safety of the plant operators, resulting in reduced operator reliability. However, the toxic release does not directly lead to any failure of plant equipment. To evaluate the risk impact of this scenario, a CCDP is developed that models a reactor trip followed by the guaranteed failure of all PRA credited operator actions. The resulting CCDP is 6.26E-08. The bounding initiating event frequency is 1.0E-06 events/yr.

Equation 19.58.2.1-1 is used to determine the resultant CDF. The resultant CDF is 6.26E-14 events/yr. The results indicate a very low estimated CDF contribution due to toxic releases from a Marine Accident.

The above analysis is conservative. The AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event.

There is also a potential for marine explosion accidents. The AP1000 is not designed with a Service Water intake structure; thus, Loss of Service Water events as a consequence of marine explosions are not a nuclear safety concern for the AP1000 design. As long as the Regulatory Guide 1.91 (Reference 19.58-5) acceptance criterion is met, marine explosion accidents do not need to be considered further for the AP1000 PRA.

19.58.2.3.3 Pipeline Accidents

Pipeline accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. For a site with a 30" Gas line approximately 5800 feet away, a semi-quantitative evaluation was performed.

Considerations for the evaluation are:

- Gas pipe rupture frequency,
- Gas cloud formation probability,
- Gas cloud transportation and non-dispersion probability,
- Gas cloud ignition probability on-site.

Consider Figure 19.58.2.3.3-1 to further evaluate the probability of this accident. When then considering the probability of forming a dense gas cloud, and the probability of the wind speed and direction to be in the ranges necessary to transport the gas cloud 5800 feet to the site, without dispersing the gas, including ignition of the gas cloud on-site in a location that may challenge the plant, this probability becomes very low.

Site habitability is also a concern for toxic materials. However, the AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event. The expected frequency value is expected to be below the initiating event criterion of 10-7 events/yr. Therefore, no further quantitative evaluation is necessary.

19.58.2.3.4 Railroad and Truck Accidents

Railroad accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. Toxic material releases were evaluated in the Marine Accident evaluation as to not be important to AP1000 plant risk. Significant damage to the AP1000 plant was evaluated in the Aviation Accident evaluation. No railroad accidents are expected to result in the amount of damage that may be seen from an Aviation Accident. This is especially true considering the increased security barriers established at U.S. nuclear power plants.

The AP1000 is designed to site characteristics described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 10^{-6} per year. As explained in Section 2.0, this criterion should be extended to an annual frequency of occurrence less than 10^{-7} per year.

19.58.3 Conclusion

The risk due to external hazards is low for the AP1000 design. The AP1000 design is shown to be highly robust against the external events discussed in this section. The design is resilient against high winds, external floods and other external events that challenge various equipment in the plant.

The following conclusions and insights are derived from the AP1000 external events assessment for events at power:

1. High Winds and Tornados were quantitative evaluated to be of low risk to the AP1000 design for each of the participating sites. A bounding assessment is provided to show that the expected CDF due to any one of these events exceeds 1.0E-08 events/yr. The same is true for the aggregate results. Sensitivity studies were performed to determine that there is low risk for more limiting scenarios. No further analysis is suggested.
2. The AP1000 is designed to flooding levels described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 10-6 per year. As explained in Section 4.1, this criterion can be extended to an annual frequency of occurrence less than 10-7 per year. No further analysis is suggested.
3. Transportation and Nearby Facilities Accidents are qualitatively evaluated to be of low risk importance and do not warrant further evaluation.

19.58.4 References

19.58-1 U.S. Nuclear Regulatory Commission "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - 10 CFR 50.54(f)," Generic Letter 88-20, Supplement 4, June 28, 1991.

19.58-2 U.S. Nuclear Regulatory Commission NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," June 1991.

19.58-3 National Weather Service, "The Enhanced Fujita Scale", February 02, 2007, Available: http://www.spc.noaa.gov/efscale/.

19.58-4 National Weather Service, "The Saffir-Simpson Hurricane Scale", June 22, 2006, Available: http://www.nhc.noaa.gov/aboutsshs.shtml.

19.58-5 U.S. Nuclear Regulatory Commission Regulatory Guide 1.91, "Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants", Revision 1, February 1978.

Table 19.58.2.1-1: Description of the Enhanced Fujita Scale (Tornados)[1]			
Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
EF0	Gale tornado	65-85 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
EF1	Moderate tornado	86-110 mph	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
EF2	Significant tornado	111-135 mph	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	Severe tornado	136 - 165 mph	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
EF4	Devastating tornado	166-200 mph	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
EF5	Incredible tornado	>200 mph	Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

1. Enhanced Fujita Scale extracted from Reference 19.58-3.

Table 19.58.2.1-2: Description of Saffir-Simpson Scale (Hurricanes)[1]		
Category Number	Wind Speed	Category Description
1	74-95 mph	Storm surge generally 4-5 ft above normal. No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Some damage to poorly constructed signs. Also, some coastal road flooding and minor pier damage.
2	96-110 mph	Storm surge generally 6-8 feet above normal. Some roofing material, door, and window damage of buildings. Considerable damage to shrubbery and trees with some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers. Coastal and low-lying escape routes flood 2-4 hours before arrival of the hurricane center. Small craft in unprotected anchorages break moorings.
3	111-130 mph	Storm surge generally 9-12 ft above normal. Some structural damage to small residences and utility buildings with a minor amount of curtain wall failures. Damage to shrubbery and trees with foliage blown off trees and large trees blown down. Mobile homes and poorly constructed signs are destroyed. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Flooding near the coast destroys smaller structures with larger structures damaged by battering from floating debris. Terrain continuously lower than 5 ft above mean sea level may be flooded inland 8 miles (13 km) or more. Evacuation of low-lying residences with several blocks of the shoreline may be required.
4	131-155 mph	Storm surge generally 13-18 ft above normal. More extensive curtain wall failures with some complete roof structure failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Low-lying escape routes may be cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of structures near the shore. Terrain lower than 10 ft above sea level may be flooded requiring massive evacuation of residential areas as far inland as 6 miles (10 km).
5	≥155 mph	Storm surge generally greater than 18 ft above normal. Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of all structures located less than 15 ft above sea level and within 500 yards of the shoreline. Massive evacuation of residential areas on low ground within 5-10 miles (8-16 km) of the shoreline may be required.

1. Saffir-Simpson Scale extracted from Reference 19.58-4.

Table 19.58.2.1-3: High Winds and Tornados Results					
Category	Event	Limiting Initiating Event Freq. (events/yr)	CDF (events/yr)		
			LOSP (Case 1) (events/yr)	LOSP with non-safety systems unavailable for select events (Case 2) (events/yr)	LOSP with non-safety systems unavailable for all events (Case 3) (events/yr)
High Winds	EF0 Tornado	8.00E-05	7.85E-13	7.85E-13[1]	4.68E-12
	EF1 Tornado	8.00E-05	7.85E-13	7.85E-13[1]	4.68E-12
	EF2 Tornado	1.60E-04	1.57E-12	1.57E-12[1]	9.36E-12
	EF3 Tornado	8.00E-05	7.85E-13	7.85E-13[1]	4.68E-12
	EF4 Tornado	8.00E-05	7.85E-13	7.85E-13[1]	4.68E-12
	EF5 Tornado	8.00E-05	7.85E-13	4.68E-12	4.68E-12
	Cat. 1 Hurricane	1.00E-01	9.81E-10	9.81E-10[1]	5.85E-09
	Cat. 2 Hurricane	5.00E-02	2.94E-10	2.94E-10[1]	2.93E-09
	Cat. 3 Hurricane	3.00E-02	2.94E-10	2.94E-10[1]	1.76E-09
	Cat. 4 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Cat. 5 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Extratropical Cyclones	3.00E-02	2.94E-10	2.94E-10[1]	1.76E-09
Totals			2.07E-09	3.05E-09	1.35E-08

[1]CDF values from Case 1 were used to illustrate the winds from these events will not challenge additional plant SSCs.

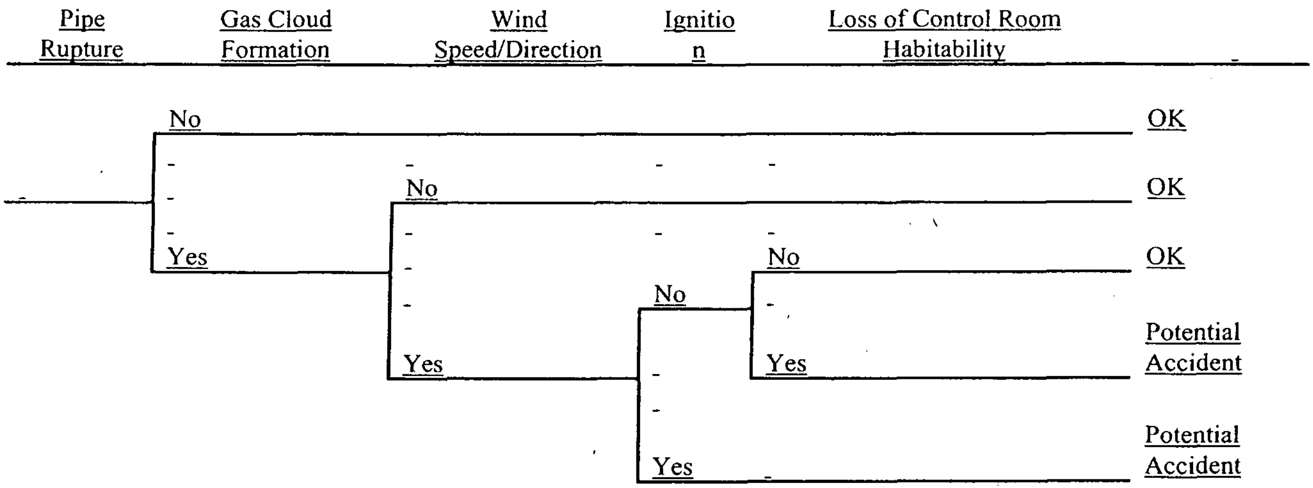


Figure 19.58.2.3.3-1: Pipeline Accident Model

9.1 DCD Section 19.58 INTERIM MARKUP

The following Section 19.58 DCD markup identifies changes made after APP-GW-GLR-101 Revision 0 that resulted in changes made to DCD Revision 16. These changes were made directly to the DCD Section 19.58 to support DCD Revision 16. These changes are repeated here to illustrate the differences between APP-GW-GLR-101, Revision 0 and DCD Revision 16.

19.58 Winds, Floods, and Other External Events

19.58.1 Introduction

External events considered in the AP1000 PRA are those events whose cause is external to all systems associated with normal and emergency operations situations. Some external events may not pose a significant threat of a severe accident. Some external events are considered at the design stage and have a sufficiently low contribution to core damage frequency or plant risk.

Based upon the guidelines provided in References 19.58-1 and 19.58-2, the following is a list of five external events that are included for AP1000 analysis:

- High winds and tornadoes
- External floods
- Transportation and nearby facility accidents
- Seismic events
- Internal fires

The first three external events are addressed in this Section. Seismic events and internal fires are addressed in the AP1000 PRA.

Chapter 2 ~~of the *AP1000 Design Control Document* (DCD)~~ defines the site characteristics for which the AP1000 is designed. A site is acceptable if the site characteristics fall within the AP1000 site interface parameters.

19.58.2 External Events Analysis

19.58.2.1 Severe Winds and Tornadoes

The overall methodology recommended by NUREG-1407 for analyzing plant risk due to high winds and tornados is a progressive screening approach. This approach is modified to consider determining the acceptability of hazard frequency and risk. High winds (including tornadoes) can affect plant structures in at least two ways: (1) If wind forces exceed the load capacity of a building or other external facility, the walls or framing might collapse or the structure might overturn from the excessive loading; and (2) If the wind is strong enough, as in a tornado or hurricane, it may be capable of lifting materials and thrusting them as missiles against the plant structures that house safety-related equipment. Critical components or other contents of plant structures not designed to resist missile penetration might be damaged and lose their function.

The NUREG-1407 criterion for h~~H~~igh w~~W~~inds and t~~T~~ornados states that "these events pose no significant threat of a severe accident because the current design criteria for wind are dominated by tornadoes having an annual frequency of exceedance of about 10^{-7}."~~.~~ This is interpreted to mean that events with an annual frequency of exceedance less than 10^{-7} may be removed from further consideration and events with an annual frequency of exceedance greater than 10^{-7} must be further evaluated. However, the NUREG-1407 criterion was developed for currently operating plants.

High w~~W~~inds and t~~T~~ornados tend to behave as a l~~L~~oss of o~~O~~ffsite p~~P~~ower (LOSP)~~,~~ since the site switchyard is unprotected and not designed against high winds velocities. For wind velocities greater than the design basis, additional s~~S~~tructures, s~~S~~ystems and c~~C~~omponents (SSC) may also fail. Therefore, two analyses are performed, one considering only a LOSP, and another considering a LOSP with failure of the standby non-safety systems. This analysis considers not only excessive wind forces, but also missile generation. A c~~C~~onditional c~~C~~ore d~~D~~amage p~~P~~robability will be calculated for each of those scenarios. Risk due to the event can be estimated using the following equation:

$$CDF = IEF * CCDP \qquad \text{(Equation 19.58.2.1-1)}$$

Where CDF is annual c~~C~~ore d~~D~~amage f~~F~~requency, IEF is the i~~I~~nitiating e~~E~~vent f~~F~~requency and CCDP is the c~~C~~onditional c~~C~~ore d~~D~~amage p~~P~~robability. If this evaluation indicates an acceptably small contribution to risk (e.g. less than 10% of the total plant CDF), then the progressive screening is complete and no detailed PRA will be necessary.

A sensitivity study is be performed for the above two cases with a loss of component cooling water service water considered also because those systems may not be available following above design basis winds.

~~The analysis for High Winds and Tornados begins with an examination of the Design Basis for the plant, which is documented in Section 2.0 of the AP1000 DCD.~~ The analysis for winds and tornadoes is site-specific. It is anticipated that a high wind or tornado event would result in a loss of offsite power, ~~as~~ because the switchyard is likely to become unavailable during the event.

The analysis for high winds and tornados begins with an examination of the design basis for the plant, which is documented in Chapter 2.

The AP1000 design basis wind speed for tornados is 300 mph as discussed in Chapter 2~~-of the AP1000 DCD~~. This value is assumed to be the maximum wind speed that will not challenge the safety related structures. The AP1000 operating basis wind speed is 145 mph as discussed in Chapter 2~~-of the AP1000 DCD~~. This value is assumed to be the maximum wind speed that will not challenge the non-safety-related structures.

The structures protecting safety-~~-~~related features of the AP1000 are designed for extreme winds and missiles associated with these winds. As long as the external event winds are less than these design basis winds, the safety features of the AP1000 will be unaffected. If the winds exceed the design values, then the integrity of the safety-~~-~~related structures may be compromised.

The structures protecting non-safety-~~-~~related features of the AP1000 are designed according to uniform building code and have some level of protection against seismic and high wind events. As long as the external event winds are less than the operating basis winds (145 mph, per Chapter 2 of the DCD), the non-safety features of the AP1000 will be unaffected. If the winds exceed the operating basis values, then the integrity of the non-safety-~~-~~related structures may be compromised.

In summary of the design against high winds, the plant is designed against 300 miles per hour (mph) winds. The operating basis of the plant is winds up to 145 mph. This means that the safety structures are protected against winds up to 300 mph and non-safety system (NSS) structures are protected against winds up to 145 mph. Per the Enhanced Fujita Scale for Tornados (Table 19.58~~.2.1~~-1), no tornados are expected to exceed 300 mph; however, EF3, EF4, and EF5 tornados do exceed the operating basis of the AP1000. Per the Saffir-Simpson Scale for Hurricanes (Table 19.58~~.2.1~~-2), no hurricanes are expected to reach 300 mph winds; however, Category 4 and Category 5 Hurricane winds do exceed the operating basis of the AP1000.

Three studies are performed to evaluate the high wind events. The Case 1 study is a ~~Loss of Offsite Power (~~LOSP~~)~~ induced by each of the events, with no other equipment unavailable. A c~~C~~onditional c~~C~~ore d~~D~~amage p~~P~~robability (CCDP) is developed for this scenario, which may be multiplied by the high wind event frequency. All tornados and hurricanes are considered in this Case 1 as they may challenge the AP1000 switchyard. Extratropical cyclones are normal storms and thunderstorms with winds expected to fall below the operating basis for the AP1000. They are also included in the Case 1 analysis.

As stated above, the EF3, EF4, and EF5 Tornados and Category 4 and Category 5 Hurricanes may challenge the non-safety related structures in the AP1000. Therefore, these events will be evaluated with the loss of additional SSCs. The Case 2 study is created by modifying the Case 1 analysis for the EF3, EF4, and EF5 tornados, and Category 4 and Category 5 hurricanes to have a LOSP with additional failures of non-safety systems unavailable. A CCDP is developed for this scenario, which may be multiplied by the high wind event frequency.

The final Case 3 is a conservative study where all high wind events are evaluated as a LOSP with failure of the non-safety systems. This case is created to represent the worst case scenario unavailable. In this analysis, events are considered of low risk importance if their initiating event frequency is less than 10^{-7} ~~events/yr~~ or if their estimated CDF is less than 10% of the total plant CDF. Therefore, the CDF screening values is 5.08E-08 events/yr.

The results of the CDF calculation are shown in Table 19.58~~.2.1~~-3. Equation

19.58~~.2.1~~-1 was used to determine the resultant CDF.

In that table- Table 19.58-3, none of the limiting initiating event frequencies were sufficiently low to be removed from further consideration. Therefore, the CDF calculation was performed. In each case, the resultant CDF is less than 10% of the total plant CDF, 5.08E-08 events/yr. The Category 4 and Category 5 h~~H~~urricane frequency is considered to be extremely conservative at 1.00E-02 events/yr. An e~~E~~vent with the conservative initiating event frequency, and the worst case sensitivity study (Case 3), the resultant CDF is still less than the CDF criterion of 5.08E-08 events/yr. Furthermore, the sum of the estimated CDF for each c~~C~~ase falls below the CDF criterion of 5.08E-08 events/yr. Therefore, no further detailed PRA is necessary for the AP1000 h~~H~~igh w~~W~~inds and t~~T~~ornados analysis.

19.58.2.2 External Floods

An external flooding analysis was performed to account for any significant contribution to core damage frequency resulting from plant damage caused by storms, dam failure, and flash floods is accounted for as follows:~~.~~

The analysis for e~~E~~xternal f~~F~~loods begins with an examination of the d~~D~~esign b~~B~~asis for the plant, which is documented in Section 2.0 of the AP1000 DCD. The AP1000 is designed against flood levels less than plant elevation 100 feet.

The basic steps involved in an external flooding analysis are similar to those followed for internal flooding in the individual plant examination. However, the focus of attention is on areas, which due to their location and grading, may be susceptible to external flood damage.~~,~~ This~~thus~~ requir~~es~~ing information on such items as dikes, surface grading, locations of structures, and locations of equipment within the structures. Information, such as meteorological data for the site, historical flood height, and frequency data, is also needed.

Category 5 h~~H~~urricanes, per the Saffir-Simpson scale, are capable of storm surges greater than 18 feet. However, the probability of generating a storm surge of 18 feet, combined with the frequency of a Category 5 hurricane results in a very small event frequency. Even conservatively assuming a storm surge of 18 feet, the frequency of an event capable of generating this storm surge is ~~very~~ small. Engineering judgment is used to establish that the frequency of this type of flood is significantly less than the 10^{-7} per year criterion for initiating event frequency.

As a sensitivity study, the 10^{-7} ~~events~~/yr initiating event frequency is taken as the frequency of an event that may challenge the non-safety structures in the plant. This sensitivity study also considers failure of the switchyard due to flooding. ~~A~~ LOSP with failure of the non-safety systems CCDP was developed. Equation ~~19.58.2.1~~-1 was used to determine the resultant CDF.

As expected, the risk due to a flooding event is very low for the AP1000. The resultant CDF of 5.85E-15 ~~events/~~per yr is an insignificant contribution to total plant CDF.

For other sites, the AP1000 is designed to site characteristics described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 10^{-6} ~~events/~~per yr. To consider the already low risk of the AP1000 design, this criterion should be extended to an annual frequency of occurrence less than 10^{-7} ~~events/~~per yr. ~~Susceptibility to floods due to dam failure and/or flash floods may need to be considered on a site-by-site basis.~~

19.58.2.3 Transportation and Nearby Facility Accidents

These events consist of accidents related to transportation near the nuclear power plant and accidents at industrial and military facilities in the vicinity. The following modes of transportation are considered:

- Aviation (commercial/general/military)
- Marine (ship/barge)
- Pipeline (gas/oil)
- Railroad
- Truck

19.58.2.3.1 Aviation Accidents

For~~If a~~ limiting event frequency of ~~is~~ 1.21E-06 ~~events~~/year~~, and~~ with most of that frequency ~~is~~ for small aircraft, and with commercial aircraft contribution 9.40E-09 events/yr, then the following discussion is applicable.

A conservative analysis was performed to evaluate the risk due to small aircraft accidents on-site. This analysis assumes a Loss of Offsite Power and conservatively failed a set of standby non-safety systems. This is acceptable ~~as~~ because it is unlikely that a small aircraft accident would challenge the passive safety systems inside containment. This leaves only the non-safety systems outside of containment as vulnerable. However, this evaluation is conservative because~~as~~ it is unlikely that a small aircraft would have the capacity to fail such a large area of the AP1000.

Equation 19.58~~.2.1~~-1 is used to determine the resultant CDF. A CDF of 7.08E-14 events/yr is calculated and is an insignificant contribution to total plant CDF of approximately 5.08E-07 events/yr. Therefore, sites that can demonstrate an aviation event frequency less than or equal to 1.21E-06 events/yr for small aircraft accidents are bounded by this evaluation.

Larger commercial aircraft may have the capacity to challenge SSCs within the AP1000 containment. However, the containment structure and safety systems are designed to withstand various earthquake levels, such that many of the safety system SSCs will still be available following the accident. To consider the already low risk of the AP1000 design, the 10^{-7} events/yr criterion for event frequency is applicable for larger commercial aircraft. Sites that can demonstrate a commercial aircraft aviation event frequency less than the 10^{-7} ~~events~~/yr criterion are also bounded by this analysis.

19.58.2.3.2 Marine Accidents

Only sites with large waterways with ship and/or barge traffic that go through or near the site should consider m~~M~~arine a~~A~~ccidents.

Marine accidents involving ship or barge accidents pose a potential hazard to a nuclear power plant due to two possibilities:

3. Release of hazardous material towards the plant
4. Explosion with resulting damage to the plant.

The potential exists for a m~~M~~arine a~~A~~ccident that leads to a release of toxic materials into the atmosphere. This type of event may compromise the safety of the plant operators, resulting in reduced operator reliability. However, the toxic release does not directly lead to any failure of plant equipment. To evaluate the risk impact of this scenario, a CCDP is developed that models a reactor trip followed by the guaranteed failure of all PRA credited operator actions. The resulting CCDP is 6.26E-08. The bounding initiating event frequency is 1.0E-06 events/yr.

Equation 19.58~~.2.1~~-1 is used to determine the resultant CDF. The resultant CDF is 6.26E-14 events/yr. The results indicate a ~~very~~ low estimated CDF contribution due to toxic releases from a m~~M~~arine a~~A~~ccident.

The above analysis is conservative. The AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event.

There is also a potential for marine explosion accidents. The AP1000 is not designed with a s~~S~~ervice w~~W~~ater intake structure.~~;~~ Therefore~~thus~~, l~~L~~oss of s~~S~~ervice w~~W~~ater events as a consequence of marine explosions are not a nuclear safety concern for the AP1000 design. As long as the Regulatory Guide 1.91 ~~(Reference 19.58-5)~~ acceptance criterion is met, marine explosion accidents do not need to be considered further for the AP1000 PRA.

19.58.2.3.3 Pipeline Accidents

Pipeline accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. For a site with a 30-inch" ~~g~~Gas line approximately 5800 feet away, a semi-quantitative evaluation was performed.

Considerations for the evaluation are:

- Gas pipe rupture frequency,
- Gas cloud formation probability,
- Gas cloud transportation and non-dispersion probability,
- Gas cloud ignition probability on-site.

~~Consider~~ Figure 19.58~~.2.3.3~~-1 to further evaluate the probability of this accident. When then considering the probability of forming a dense gas cloud, and the probability of the wind speed and direction to be in the ranges necessary to transport the gas cloud 5800 feet to the site, without dispersing the gas, including ignition of the gas cloud on-site in a location that may challenge the plant, this probability becomes very low.

Site habitability is also a concern for toxic materials. However, the AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event. The expected frequency value is expected to be below the initiating event criterion of 10-7 events/yr. Therefore, no further quantitative evaluation is necessary.

19.58.2.3.4 Railroad and Truck Accidents

Railroad accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. Toxic material releases were evaluated in the m~~M~~arine a~~A~~ccident evaluation as to not be important to AP1000 plant risk. Significant damage to the AP1000 plant was evaluated in the a~~A~~viation a~~A~~ccident evaluation. No railroad accidents are expected to result in the amount of damage that may be seen from an a~~A~~viation a~~A~~ccident. This is especially true considering the increased security barriers established at U.S. nuclear power plants.

The AP1000 is designed to site characteristics described in Chapter 2~~-of the DCD~~. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 10^{-6} per year. As explained in Section 2.0, this criterion should be extended to an annual frequency of occurrence less than 10^{-7} per year.

19.58.3 Conclusion

The risk due to external hazards is low for the AP1000 design for the participating sites listed in Section 3.2. The AP1000 design is shown to be highly robust against the external events discussed in this section. The design is resilient against high winds, external floods and other external events that challenge various equipment in the plant.

The following conclusions and insights are derived from the AP1000 external events assessment for events at power:

1. High w~~W~~inds and t~~T~~ornados were quantitative evaluated to be of low risk to the AP1000 design for each of the participating sites. A bounding assessment is provided to show that the expected CDF due to any one of these events exceeds 10% of the total plant CDF (5.08E-08 events/year). The same is true for the aggregate results. Sensitivity studies were performed to determine that there is low risk for more limiting scenarios. No further analysis is suggested.
2. The AP1000 is designed to flooding levels described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 10^{-6} per year. As explained in Section 4.1, this criterion can be extended to an annual frequency of occurrence less than 10^{-7} per year. No further analysis is suggested.
3. Transportation and n~~N~~earby f~~F~~acilities a~~A~~ccidents are qualitatively evaluated to be of low risk importance and do not warrant further evaluation.

19.58.4 References

19.58-1 ~~U.S. Nuclear Regulatory Commission~~ "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - 10 CFR 50.54(f)," Generic Letter 88-20, Supplement 4, June 28, 1991.

19.58-2 ~~U.S. Nuclear Regulatory Commission~~ NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," June 1991.

19.58-3 National Weather Service, "The Enhanced Fujita Scale,"~~,~~ February 02, 2007, Available: http://www.spc.noaa.gov/efscale/.

19.58-4 National Weather Service, "The Saffir-Simpson Hurricane Scale,"~~,~~ June 22, 2006, Available: http://www.nhc.noaa.gov/aboutsshs.shtml.

19.58-5 -U.S. Nuclear Regulatory Commission Regulatory Guide 1.91, "Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants,"~~,~~ Revision 1, February 1978.

Table 19.58~~.2.1~~-1:

DESCRIPTION OF THE ENHANCED FUJITA SCALE (TORNADOS)~~[1]~~
(Reference 19.58-3)

Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
EF0	Gale tornado	65-85 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
EF1	Moderate tornado	86-110 mph	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
EF2	Significant tornado	111-135 mph	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	Severe tornado	136 - 165 mph	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
EF4	Devastating tornado	166-200 mph	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
EF5	Incredible tornado	>200 mph	Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

~~1. Enhanced Fujita Scale extracted from Reference 19.58-3.~~

Table 19.58.2.1-2: DESCRIPTION OF SAFFIR-SIMPSON SCALE (HURRICANES)[1] (Reference 19.58-4))		
Category Number	Wind Speed	Category Description
1	74-95 mph	Storm surge generally 4-5 ft above normal. No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Some damage to poorly constructed signs. Also, some coastal road flooding and minor pier damage.
2	96-110 mph	Storm surge generally 6-8 feet above normal. Some roofing material, door, and window damage of buildings. Considerable damage to shrubbery and trees with some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers. Coastal and low-lying escape routes flood 2-4 hours before arrival of the hurricane center. Small craft in unprotected anchorages break moorings.
3	111-130 mph	Storm surge generally 9-12 ft above normal. Some structural damage to small residences and utility buildings with a minor amount of curtain wall failures. Damage to shrubbery and trees with foliage blown off trees and large trees blown down. Mobile homes and poorly constructed signs are destroyed. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Flooding near the coast destroys smaller structures with larger structures damaged by battering from floating debris. Terrain continuously lower than 5 ft above mean sea level may be flooded inland 8 miles (13 km) or more. Evacuation of low-lying residences with several blocks of the shoreline may be required.
4	131-155 mph	Storm surge generally 13-18 ft above normal. More extensive curtain wall failures with some complete roof structure failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Low-lying escape routes may be cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of structures near the shore. Terrain lower than 10 ft above sea level may be flooded requiring massive evacuation of residential areas as far inland as 6 miles (10 km).
5	>155 mph	Storm surge generally greater than 18 ft above normal. Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of all structures located less than 15 ft above sea level and within 500 yards of the shoreline. Massive evacuation of residential areas on low ground within 5-10 miles (8-16 km) of the shoreline may be required.

~~1.Saffir-Simpson Scale extracted from Reference 19.58-4.~~

Table 19.58.2.1-3:

HIGH WINDS AND TORNADOS RESULTS

Category	Event	Limiting Initiating Event Freq. (~~events~~/yr)	CDF (~~events~~/yr) LOSP (Case 1) (~~events~~/yr)	LOSP with N~~n~~on-safety S~~s~~ystems U~~u~~navailable for S~~s~~elect E~~e~~vents (Case 2) (~~events~~/yr)	LOSP with N~~n~~on-safety S~~s~~ystems U~~u~~navailable for A~~a~~ll E~~e~~vents (Case 3) (~~events~~/yr)
High Winds	EF0 Tornado	8.00E-05	7.85E-13	7.85E-13(1)~~1~~	4.68E-12
	EF1 Tornado	8.00E-05	7.85E-13	7.85E-13(1)~~1~~	4.68E-12
	EF2 Tornado	1.60E-04	1.57E-12	1.57E-12(1)~~1~~	9.36E-12
	EF3 Tornado	8.00E-05	7.85E-13	7.85E-13(1)~~1~~	4.68E-12
	EF4 Tornado	8.00E-05	7.85E-13	7.85E-13(1)~~1~~	4.68E-12
	EF5 Tornado	8.00E-05	7.85E-13	4.68E-12	4.68E-12
	Cat. 1 Hurricane	1.00E-01	9.81E-10	9.81E-10(1)~~1~~	5.85E-09
	Cat. 2 Hurricane	5.00E-02	2.94E-10	2.94E-10(1)~~1~~	2.93E-09
	Cat. 3 Hurricane	3.00E-02	2.94E-10	2.94E-10(1)~~1~~	1.76E-09
	Cat. 4 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Cat. 5 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Extratropical Cyclones	3.00E-02	2.94E-10	2.94E-10(1)~~1~~	1.76E-09
Totals			2.07E-09	3.05E-09	1.35E-08

1. CDF values from Case 1 were used to illustrate the winds from these events will not challenge additional plant SSCs.

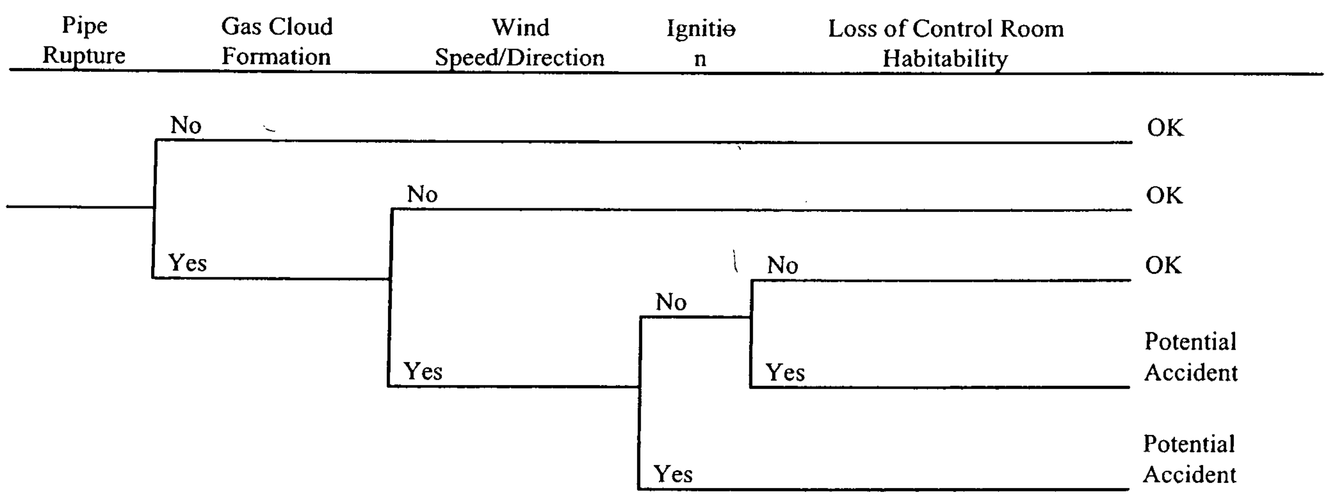


Figure 19.58~~.2.3.3-~~1~~:~~

Pipeline Accident Model

9.2 DCD Section 19.58 ADDITIONAL MARKUP

The following Section 19.58 DCD markup identifies changes made by APP-GW-GLR-101 Revision 1 that have not been formally included in the DCD. These changes are the result of the issues identified in Section 1.0 of this report.

Shading has been added to Table 3.0-1 to indicate the source of comments that resulted in changes to the table. The shading colors indicate the source of the comment as follows:

- Gray shading – Indicates that changes in Tornado frequencies resulting from correction discussed in section 1.
- Brown shading –Indicates that changes resulted from comments on document to review RAI comments.
- Green shading –Indicates change is made to resolve comments in RAI-TR101-SPLA-05.
- Blue shading – Column totals reflect changes from all sources above.

19.58 Winds, Floods, and Other External Events

19.58.1 Introduction

External events considered in the AP1000 PRA are those events whose cause is external to all systems associated with normal and emergency operations situations. Some external events may not pose a significant threat of a severe accident. Some external events are considered at the design stage and have a sufficiently low contribution to core damage frequency or plant risk.

Based upon the guidelines provided in References 19.58-1 and 19.58-2, the following is a list of five external events that are included for AP1000 analysis:

- High winds and tornadoes
- External floods
- Transportation and nearby facility accidents
- Seismic events
- Internal fires

The first three external events are addressed in this Section. Seismic events and internal fires are addressed in the AP1000 PRA.

Chapter 2 defines the site characteristics for which the AP1000 is designed. A site is acceptable if the site characteristics fall within the AP1000 site interface parameters.

19.58.2 External Events Analysis

19.58.2.1 Severe Winds and Tornadoes

The overall methodology recommended by NUREG-1407 for analyzing plant risk due to high winds and tornados is a progressive screening approach. This approach is modified to consider determining the acceptability of hazard frequency and risk. High winds (including tornadoes) can affect plant structures in at least two ways: (1) If wind forces exceed the load capacity of a building or other external facility, the walls or framing might collapse or the structure might overturn from the excessive loading; and (2) If the wind is strong enough, as in a tornado or hurricane, it may be capable of lifting materials and thrusting them as missiles against the plant structures that house safety-related equipment. Critical components or other contents of plant structures not designed to resist missile penetration might be damaged and lose their function.

The NUREG-1407 criterion for high winds and tornados states that "these events pose no significant threat of a severe accident because the current design criteria for wind are dominated by tornadoes having an annual frequency of exceedance of about 10^{-7}." This is interpreted to mean that events with an annual frequency of exceedance less than ~~10^{-7}~~1.0E-07 may be removed from further consideration and events with an annual frequency of exceedance greater than ~~10^{-7}~~1.0E-07 must be further evaluated. However, the NUREG-1407 criterion was developed for currently operating plants.

High winds and tornados tend to behave as a loss of offsite power (LOSP) since the site switchyard is unprotected and not designed against high winds velocities. For wind velocities greater than the design basis, additional structures, systems and components (SSC) may also fail. Therefore, two analyses are performed, one considering only a LOSP, and another considering a LOSP with failure of the standby nonsafety systems. This analysis considers not only excessive wind forces, but also missile generation. A conditional core damage probability will be calculated for each of those scenarios. Risk due to the event can be estimated using the following equation:

$$CDF = IEF * CCDP \qquad \text{(Equation 19.58.2.1-1)}$$

Where CDF is annual core damage frequency, IEF is the initiating event frequency and CCDP is the conditional core damage probability. If this evaluation indicates an acceptably small contribution to risk (e.g. less than 10% of the total plant CDF), then the progressive screening is complete and no detailed PRA will be necessary.

A sensitivity study is be performed for the above two cases with a loss of component cooling water service water considered also because those systems may not be available following above design basis winds.

The analysis for winds and tornadoes is site-specific. It is anticipated that a high wind or tornado event would result in a loss of offsite power, because the switchyard is likely to become unavailable during the event.

The analysis for high winds and tornados begins with an examination of the design basis for the plant, which is documented in Chapter 2.

The AP1000 design basis wind speed for tornados is 300 mph as discussed in Chapter 2. This value is assumed to be the maximum wind speed that will not challenge the safety related structures. The AP1000 operating basis wind speed is 145 mph as discussed in Chapter 2. This value is assumed to be the maximum wind speed that will not challenge the nonsafety-related structures.

The structures protecting safety-related features of the AP1000 are designed for extreme winds and missiles associated with these winds. As long as the external event winds are less than these design basis winds, the safety features of the AP1000 will be unaffected. If the winds exceed the design values, then the integrity of the safety-related structures may be compromised.

The structures protecting nonsafety-related features of the AP1000 are designed according to uniform building code and have some level of protection against seismic and high wind events. As long as the external event winds are less than the operating basis winds (145 mph, per Chapter 2 of the DCD), the non-safety features of the AP1000 will be unaffected. If the winds exceed the operating basis values, then the integrity of the nonsafety-related structures may be compromised.

In summary of the design against high winds, the plant is designed against 300 miles per hour (mph) winds. The operating basis of the plant is winds up to 145 mph. This means that the safety structures are protected against winds up to 300 mph and nonsafety system (NSS) structures are protected against winds up to 145 mph. Per the Enhanced Fujita Scale for Tornados (Table 19.58-1), no tornados are expected to exceed 300 mph; however, EF3, EF4, and EF5 tornados do exceed the operating basis of the AP1000. Per the Saffir-Simpson Scale for Hurricanes (Table 19.58-2), no hurricanes are expected to reach 300 mph winds; however, Category 3, Category 4 and Category 5 Hurricane winds do exceed the operating basis of the AP1000.

Three studies are performed to evaluate the high wind events. The Case 1 study is a LOSP induced by each of the events, with no other equipment unavailable. A conditional core damage probability (CCDP) is developed for this scenario, which may be multiplied by the high wind event frequency. All tornados and hurricanes are considered in this Case 1 as they may challenge the AP1000 switchyard. Extratropical cyclones are normal storms and thunderstorms with winds expected to fall below the operating basis for the AP1000. They are also included in the Case 1 analysis.

As stated above, the EF3, EF4, and EF5 Tornados and Category 3, Category 4 and Category 5 Hurricanes may challenge the non-safety related structures in the AP1000. Therefore, these events will be evaluated with the loss of additional SSCs. The Case 2 study is created by modifying the Case 1 analysis for the EF3, EF4, and EF5 tornados, and Category 3, Category 4 and Category 5 hurricanes to have a LOSP with additional failures of nonsafety systems unavailable. A CCDP is developed for this scenario, which may be multiplied by the high wind event frequency.

The final Case 3 is a conservative study where all high wind events are evaluated as a LOSP with failure of the nonsafety systems. This case is created to represent the worst case scenario unavailable. In this analysis, events are considered of low risk importance if their initiating event frequency is less than ~~10^{-7}~~1.0E-07 or if their estimated CDF is less than ~~10% of the total plant CDF. Therefore, the CDF screening values is 5.08~~1.0E-08 events/yr.

The results of the CDF calculation are shown in Table 19.58-3. Equation 19.58-1 was used to determine the resultant CDF.

In ~~that t~~Table 19.58-3, none of the limiting initiating event frequencies were sufficiently low to be removed from further consideration. Therefore, the CDF calculation was performed. In each case, the resultant CDF is less than ~~10% of the total plant CDF, 5.08~~1.0E-08 events/yr. The Category 4 and Category 5 hurricane frequency is considered to be extremely conservative at 1.00E-02 events/yr. An event with the conservative initiating event frequency, and the worst case sensitivity study (Case 3), the resultant CDF is still less than the CDF criterion of ~~5.08~~1.0E-08 events/yr. Case 2 is considered to be the representative model for High Winds, with Case 1 and Case 3 being treated as sensitivity studies on the baseline. . Case 3 is conservative in that it assumes total failure of the standby non-safety systems (CVS, RNS, SFW, automatic DAS, and Diesel Generators) for all high wind events. As AP1000 non-safety structures have been designed to a building code that offers an added level of protection, the above failures are considered extreme and conservative. Therefore, while the total Case 3 CDF does fall above the 1.0E-08 events/year CDF screening criteria, the results are considered very conservative for the above reasons. ~~Furthermore, the sum of the estimated CDF for each case falls below the CDF criterion of 5.08E-08 events/yr.~~ Therefore, no further detailed PRA is necessary for the AP1000 high winds and tornados analysis.

19.58.2.2 External Floods

An external flooding analysis was performed to account for any significant contribution to core damage frequency resulting from plant damage caused by storms, dam failure, and flash floods is accounted for as follows:

The analysis for external floods begins with an examination of the design basis for the plant, which is documented in ~~Section~~ Chapter 2 of the AP1000 DCD. The AP1000 is protected against floods up to the 100' level. The 100' level corresponds to the plant ground level. From this point, the ground is graded away from the structures. Thus, water will naturally flow away from the structures. Additionally, all seismic Category I SSCs are designed to withstand the effects of flooding. The seismic Category I SSCs below grade (below ground level) are protected against flooding by a water barrier consisting of waterstops and a waterproofing system. None of the non-safety SSCs were found to be important based on flooding considerations.~~The AP1000 is designed against flood levels less than plant elevation 100 feet.~~

The basic steps involved in an external flooding analysis are similar to those followed for internal flooding in the individual plant examination. However, the focus of attention is on areas, which due to their location and grading, may be susceptible to external flood damage. This requires information on such items as dikes, surface grading, locations of structures, and locations of equipment within the structures. Information, such as meteorological data for the site, historical flood height, and frequency data, is also needed.

Only one site indicated susceptibility to external floods, due to hurricane surge water. That site is located at an elevation of 45 feet above sea level. Therefore, the AP1000 100' level, for this site, corresponds to 45' above sea level. Per DCD Chapter 3.4.1.1, the ground will be graded away from the structures beginning at the 100' level and sloping downward away from the structures. The Saffir-Simpson hurricane scale notes that Category 5 hurricanes have the ability to generate storm surges in excess of 18 feet. Hurricane Camille (1969) generated a storm surge of 25 feet along the Mississippi Gulf Coast.

~~Category 5 hurricanes, per the Saffir-Simpson scale, are capable of storm surges greater than 18 feet. However, the probability of generating a storm surge of 18 feet, combined with the frequency of a Category 5 hurricane results in a very small event frequency. Even conservatively assuming a storm surge of 18 feet, the frequency of an event capable of generating this storm surge is small. Engineering judgment is used to establish that the frequency of this type of flood is significantly less than the 10^{-7} per year criterion for initiating event frequency.~~

Based on the description of a Category 5 hurricane in the Saffir-Simpson hurricane scale, a hurricane storm surge in excess of 18 feet may be classified as an extremely rare event. The ASME has recently approved changes to the ASME PRA Standard to assign a value to an "extremely rare event". That value is defined as 1E-06 / year for currently operating plants. Recognizing that the AP1000 design provides additional levels of safety, TR-101 suggests a value of 1E-07 /year to define an extremely rare event for the AP1000 design.

As a sensitivity study, the ~~10^{-7}~~1.0E-07 /yr initiating event frequency is taken as the frequency of an event that may challenge the nonsafety structures in the plant. This sensitivity study also considers failure of the switchyard due to flooding. LOSP with failure of the nonsafety systems CCDP was developed. Equation 1 was used to determine the resultant CDF.

As expected, the risk due to a flooding event is very low for the AP1000. The resultant CDF of 5.85E-15 per yr is an insignificant contribution to total plant CDF.

For other sites, the AP1000 is designed to site characteristics described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 1.0E-06~~10^{-6}~~ per yr. ~~To consider the already low risk of the AP1000 design, t~~This criterion should be extended to an annual frequency of occurrence less than ~~10^{-7}~~1.0E-07 per yr for the AP1000 design. As none of the surveyed sites indicated susceptibility to floods due to dam failure and/or flash floods, those events should be considered on a site-by-site basis.

19.58.2.3 Transportation and Nearby Facility Accidents

These events consist of accidents related to transportation near the nuclear power plant and accidents at industrial and military facilities in the vicinity. The following modes of transportation are considered:

- Aviation (commercial/general/military)
- Marine (ship/barge)
- Pipeline (gas/oil)
- Railroad
- Truck

19.58.2.3.1 Aviation Accidents

For limiting event frequency of 1.21E-06 /year with most of that frequency for small aircraft, and with commercial aircraft contribution 9.40E-09 events/yr, then the following discussion is applicable.

A conservative analysis was performed to evaluate the risk due to small aircraft accidents onsite. This analysis assumes a Loss of Offsite Power and conservatively failed a set of standby nonsafety systems. This is acceptable because it is unlikely that a small aircraft accident would challenge the passive safety systems inside containment. This leaves only the nonsafety systems outside of containment as vulnerable. However, this evaluation is conservative because it is unlikely that a small aircraft would have the capacity to fail such a large area of the AP1000.

Equation 19.58-1 is used to determine the resultant CDF. A CDF of 7.08E-14 events/yr is calculated and is an insignificant contribution to total plant CDF of approximately 5.08E-07 events/yr. Therefore, sites that can demonstrate an aviation event frequency less than or equal to 1.21E-06 events/yr for small aircraft accidents are bounded by this evaluation.

Larger commercial aircraft may have the capacity to challenge SSCs within the AP1000 containment. However, the containment structure and safety systems are designed to withstand various earthquake levels, such that many of the safety system SSCs will still be available following the accident. To consider the already low risk of the AP1000 design, the ~~10^{-7}~~1.0E-07 events/yr criterion for event frequency is applicable for larger commercial aircraft. Sites that can demonstrate a commercial aircraft aviation event frequency less than the ~~10^{-7}~~1.0E-07/yr criterion are also bounded by this analysis. For this current evaluation, the highest initiating event frequency reported for large commercial aircraft is 9.40E-09 events/yr. This value falls below the 1.0E-07 events/yr screening criteria.

Therefore, no further evaluation is necessary.

19.58.2.3.2 Marine Accidents

Only sites with large waterways with ship and/or barge traffic that go through or near the site should consider marine accidents.

Marine accidents involving ship or barge accidents pose a potential hazard to a nuclear power plant due to two possibilities:

5. Release of hazardous material towards the plant
6. Explosion with resulting damage to the plant.

The potential exists for a marine accident that leads to a release of toxic materials into the atmosphere. This type of event may compromise the safety of the plant operators, resulting in reduced operator reliability. However, the toxic release does not directly lead to any failure of plant equipment. To evaluate the risk impact of this scenario, a CCDP is developed that models a reactor trip followed by the guaranteed failure of all PRA credited operator actions. The resulting CCDP is 6.26E-08. The bounding initiating event frequency is 1.0E-06 events/yr.

Equation 19.58-1 is used to determine the resultant CDF. The resultant CDF is 6.26E-14 events/yr. The results indicate a low estimated CDF contribution due to toxic releases from a marine accident.

The above analysis is conservative. The AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event.

There is also a potential for marine explosion accidents. The AP1000 is not designed with a service water intake structure. Therefore, loss of service water events as a consequence of marine explosions are not a nuclear safety concern for the AP1000 design. As long as the Regulatory Guide 1.91 acceptance criterion is met, marine explosion accidents do not need to be considered further for the AP1000 PRA.

19.58.2.3.3 Pipeline Accidents

Pipeline accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. For a site with a 30-inch gas line approximately 5800 feet away, a semi-quantitative evaluation was performed.

Considerations for the evaluation are:

- Gas pipe rupture frequency,
- Gas cloud formation probability,
- Gas cloud transportation and non-dispersion probability,
- Gas cloud ignition probability on-site.

Figure 19.58-1 to further evaluate the probability of this accident. When then considering the probability of forming a dense gas cloud, and the probability of the wind speed and direction to be in the ranges necessary to transport the gas cloud 5800 feet to the site, without dispersing the gas, including ignition of the gas cloud onsite in a location that may challenge the plant, this probability becomes very low.

Site habitability is also a concern for toxic materials. However, the AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event. The expected frequency value is expected to be below the initiating event criterion of ~~10-7~~1.0E-07 events/yr. Therefore, no further quantitative evaluation is necessary.

19.58.2.3.4 Railroad and Truck Accidents

Railroad accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. Toxic material releases were evaluated in the marine accident evaluation as to not be important to AP1000 plant risk. Significant damage to the AP1000 plant was evaluated in the aviation accident evaluation. No railroad accidents are expected to result in the amount of damage that may be seen from an aviation accident. This is especially true considering the increased security barriers established at U.S. nuclear power plants.

The AP1000 is designed to site characteristics described in Chapter 2. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than ~~10^{-6}~~1.0E-06 per year. ~~As explained in Section 2.0, T~~this criterion should be extended to an annual frequency of occurrence less than ~~10^{-7}~~1.0E-07 per year for the AP1000 design.

19.58.3 Conclusion

The risk due to external hazards is low for the AP1000 design for the participating sites listed in Section 3.2. The AP1000 design is shown to be highly robust against the external events discussed in this section. The design is resilient against high winds, external floods and other external events that challenge various equipment in the plant.

The following conclusions and insights are derived from the AP1000 external events assessment for events at power:

1. High winds and tornados were quantitative evaluated to be of low risk to the AP1000 design for each of the participating sites. A bounding assessment is provided to show that the expected CDF due to any one of these events does not exceed~~s~~ ~~10% of the total plant CDF (5.08~~1.0E-08 events/year~~)~~. The same is true for the aggregate results. Sensitivity studies were performed to determine that there is low risk for more limiting scenarios. No further analysis is suggested.

2. The AP1000 is designed to flooding levels described in Chapter 2 of the DCD. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than ~~10^{-6}~~1.0E-06 per year. ~~As explained in Section 4.1,~~ T~~t~~his criterion can be extended to an annual frequency of occurrence less than ~~10^{-7}~~1.0E-07 per year for the AP1000 design. No further analysis is suggested.

3. Transportation and nearby facilities accidents are qualitatively evaluated to be of low risk importance and do not warrant further evaluation.

19.58.4 References

19.58-1 "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - 10 CFR 50.54(f)," Generic Letter 88-20, Supplement 4, June 28, 1991.

19.58-2 NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," June 1991.

19.58-3 National Weather Service, "The Enhanced Fujita Scale," February 02, 2007, Available: http://www.spc.noaa.gov/efscale/.

19.58-4 National Weather Service, "The Saffir-Simpson Hurricane Scale," June 22, 2006, Available: http://www.nhc.noaa.gov/aboutsshs.shtml.

19.58-5 U.S. Nuclear Regulatory Commission Regulatory Guide 1.91, "Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants," Revision 1, February 1978.

Table 19.58-1:

DESCRIPTION OF THE ENHANCED FUJITA SCALE (TORNADOS)
(Reference 19.58-3)

Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
EF0	Gale tornado	65-85 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
EF1	Moderate tornado	86-110 mph	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
EF2	Significant tornado	111-135 mph	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	Severe tornado	136 - 165 mph	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
EF4	Devastating tornado	166-200 mph	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
EF5	Incredible tornado	>200 mph	Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

Table 19.58-2:

DESCRIPTION OF SAFFIR-SIMPSON SCALE (HURRICANES)
(Reference 19.58-4))

Category Number	Wind Speed	Category Description
1	74-95 mph	Storm surge generally 4-5 ft above normal. No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Some damage to poorly constructed signs. Also, some coastal road flooding and minor pier damage.
2	96-110 mph	Storm surge generally 6-8 feet above normal. Some roofing material, door, and window damage of buildings. Considerable damage to shrubbery and trees with some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers. Coastal and low-lying escape routes flood 2-4 hours before arrival of the hurricane center. Small craft in unprotected anchorages break moorings.
3	111-130 mph	Storm surge generally 9-12 ft above normal. Some structural damage to small residences and utility buildings with a minor amount of curtain wall failures. Damage to shrubbery and trees with foliage blown off trees and large trees blown down. Mobile homes and poorly constructed signs are destroyed. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Flooding near the coast destroys smaller structures with larger structures damaged by battering from floating debris. Terrain continuously lower than 5 ft above mean sea level may be flooded inland 8 miles (13 km) or more. Evacuation of low-lying residences with several blocks of the shoreline may be required.
4	131-155 mph	Storm surge generally 13-18 ft above normal. More extensive curtain wall failures with some complete roof structure failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Low-lying escape routes may be cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of structures near the shore. Terrain lower than 10 ft above sea level may be flooded requiring massive evacuation of residential areas as far inland as 6 miles (10 km).
5	>155 mph	Storm surge generally greater than 18 ft above normal. Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of all structures located less than 15 ft above sea level and within 500 yards of the shoreline. Massive evacuation of residential areas on low ground within 5-10 miles (8-16 km) of the shoreline may be required.

Table 19.58-3:

HIGH WINDS AND TORNADOS RESULTS

Category	Event	Limiting Initiating Event Freq. (/yr)	CDF (/yr) LOSP (Case 1) (/yr)	CDF (/yr) LOSP with Nonsafety Systems Unavailable for Select Events (Case 2) (/yr)	CDF (/yr) LOSP with Nonsafety Systems Unavailable for All Events (Case 3) (/yr)
High Winds	EF0 Tornado	1.00E-03 ~~8.00E-05~~	9.81E-12 ~~7.85E-13~~	9.81E-12 ~~7.85E-13~~[1]	5.85E-11 ~~4.68E-12~~
	EF1 Tornado	1.00E-03 ~~8.00E-05~~	9.81E-12 ~~7.85E-13~~	9.81E-12 ~~7.85E-13~~[1]	5.85E-11 ~~4.68E-12~~
	EF2 Tornado	1.00E-03 ~~1.60E-04~~	9.81E-12 ~~1.57E-12~~	9.81E-12 ~~1.57E-12~~[1]	5.85E-11 ~~9.36E-12~~
	EF3 Tornado	1.00E-03 ~~8.00E-05~~	9.81E-12 ~~7.85E-13~~	5.85E-11 ~~7.85E-13[1]~~	5.85E-11 ~~4.68E-12~~
	EF4 Tornado	1.00E-03 ~~8.00E-05~~	9.81E-12 ~~7.85E-13~~	5.85E-11 ~~7.85E-13[1]~~	5.85E-11 ~~4.68E-12~~
	EF5 Tornado	1.00E-03 ~~8.00E-05~~	9.81E-12 ~~7.85E-13~~	5.85E-11 ~~4.68E-12~~	5.85E-11 ~~4.68E-12~~
	Cat. 1 Hurricane	1.00E-01	9.81E-10	9.81E-10[1]	5.85E-09
	Cat. 2 Hurricane	5.00E-02	4.91E-10 ~~2.94E-10~~	4.91E-10 ~~2.94E-10~~[1]	2.93E-09
	Cat. 3 Hurricane	3.00E-02	2.94E-10	1.76E-09 ~~2.94E-10[1]~~	1.76E-09
	Cat. 4 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Cat. 5 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Extratropical Cyclones	3.00E-02	2.94E-10	2.94E-10[1]	1.76E-09
Totals			2.32E-09 ~~2.07E-09~~	4.90E-09 ~~3.05E-09~~	1.38E-08 ~~1.35E-08~~

1. CDF values from Case 1 were used to illustrate the winds from these events will not challenge additional plant SSCs.

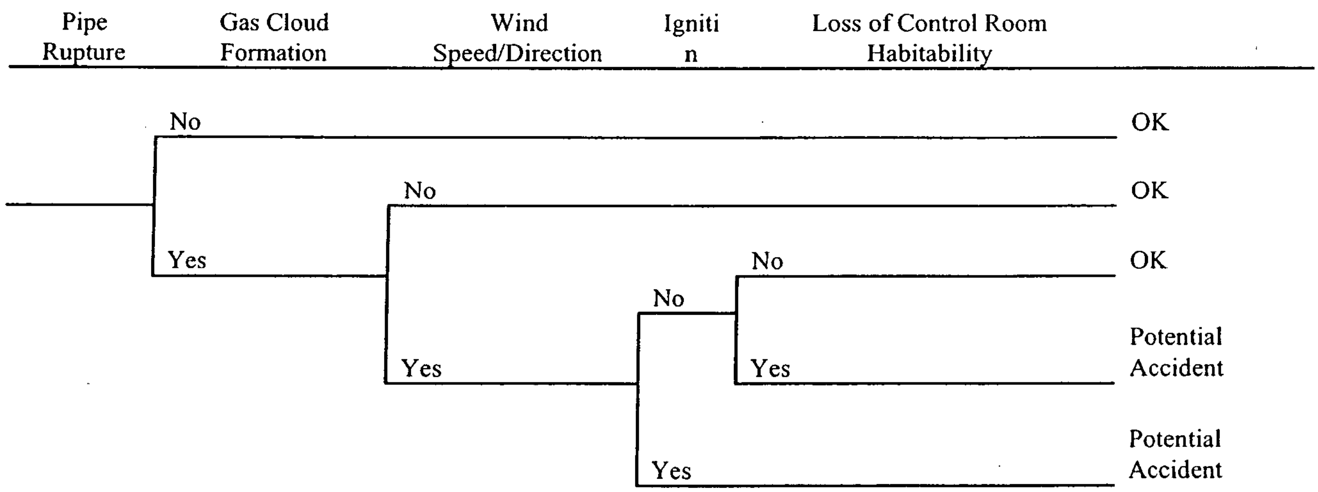


Figure 19.58-1

Pipeline Accident Model

10.0 DCD SECTION 19.1 MARKUP

The following DCD markup identifies how COL application Final Safety Analysis Reports should be prepared to incorporate the subject change.

Revise the final paragraph of Section 19.1.3:

External events analyses include:

- Internal fire assessment
- Internal flooding assessment
- Seismic margin assessment
- High winds assessment
- External flooding assessment
- Transportation and nearby facility accident assessment

11.0 DCD SECTION 19.59 MARKUP

The following DCD markup identifies how COL application Final Safety Analysis Reports can incorporate the subject change.

Delete the fourth paragraph of subsection 19.59.1:

~~The Level 3 analysis shows the potential offsite dose from a severe accident is very small and well within the established goals. The risk measured by the potential offsite dose does not increase significantly after the first 24 hours after a severe accident is assumed to cause a release to the environment.~~

Revise the subsection 19.59.7:

19.59.7 Plant Dose Risk From Release of Fission-Products

~~Chapter 49 discusses the Level 3 results for at-power and shutdown internal events. The dose risks are quantified by multiplying the fission-product release category frequency vector by the release category mean dose vectors. The goal is that a 24 hour, whole body, site boundary dose greater than 25 rem has a frequency (large release frequency) of less than 1E-06 per year. The AP1000 large release frequency is 1.95E-08 per year, which is a factor of 50 times less than the goal.~~

~~The total at-power risk from a postulated release of fission products (the 24-hour, site boundary effective dose equivalent (EDE) is 1.83E-04 rem per reactor-year. For shutdown, this risk was calculated to be 7.1E-05 rem per reactor-year for AP600. For AP1000, this shutdown risk could be estimated as 9.7E-05 rem per reactor-year (estimated the same way as shutdown LRF in Table 19.59-15). Table 19.59-16 and Figure 19.59-2 summarize the plant dose results.~~

~~Containment bypass failures account for 79 percent of the dose risk. These types of failures are usually assumed as a result of steam generator tube rupture. A less conservative analysis of the containment bypass failures may show a smaller frequency, and, as a result, a smaller dose risk.~~ This section intentionally left blank.

Delete the final sentence of subsection 19.59.8:

~~Figure 19.59-2 shows the 24-hour, whole body EDE site boundary dose cumulative distribution.~~

Revise the third paragraph of Section 19.59.10.5:

The Combined License information requested in this subsection has been *partially* addressed in *APP-GW-GLR-101, Revision ~~0~~1 (Reference 19.59-4)*, and the applicable changes are incorporated into the DCD. A*dditional work* is required by the Combined Operating License Applicant to address the aspects of the Combined License information requested in this subsection as delineated in the following paragraph:

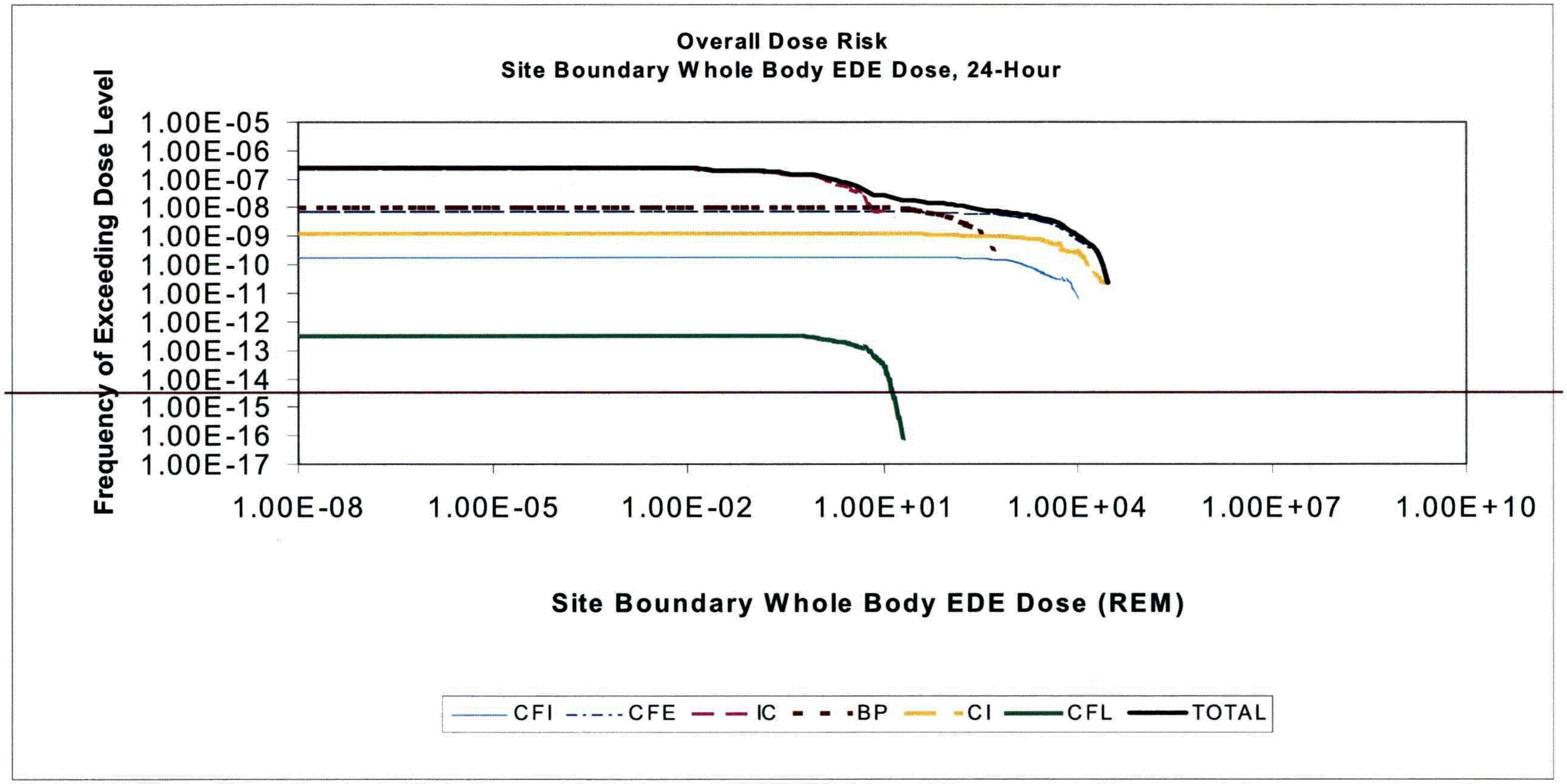
The Combined Operating License Applicant will confirm that the High Winds, Floods, and Other External Events analysis documented in Section 19.58 is applicable to the COL site. Further evaluation will be required if the COL site is shown to be outside of the bounds of the High Winds, Floods, and Other External Events analysis documented in Section 19.58~~The Combined~~

~~License applicant referencing the AP1000 certified design will review differences between the as-built plant and the design used as the basis for the AP1000 PRA and Table 19.59-18. If the effects of the differences are shown, by a screening analysis, to potentially result in a significant increase in core damage frequency or large release frequency, the PRA will be updated to reflect these differences. Based on site specific information, the COL should also reevaluate the qualitative screening of external events (PRA Section 58.1). If any site specific susceptibilities are found, the PRA should be updated to include the applicable external event.~~.

Delete Table 19.59-16:

~~Table 19.59-16~~ ~~**SITE BOUNDARY WHOLE BODY EDE DOSE RISK—24 HOURS**~~					
~~**Release Category**~~	~~**Release Frequency (/reactor year)**~~	~~**Mean Dose (sieverts)**~~	~~**Dose (REM)**~~	~~**Risk (REM/reactor year)**~~	~~**Percent Contribution to Total Risk**~~
~~CFI~~	~~1.89E-10~~	~~2.59E+01~~	~~2.59E+03~~	~~4.90E-07~~	~~0.3~~
~~CFE~~	~~7.47E-09~~	~~4.23E+01~~	~~4.23E+03~~	~~3.16E-05~~	~~17.3~~
~~IC~~	~~2.21E-07~~	~~1.82E-02~~	~~1.82E+00~~	~~4.02E-07~~	~~0.2~~
~~BP~~	~~1.05E-08~~	~~1.37E+02~~	~~1.37E+04~~	~~1.44E-04~~	~~78.6~~
~~CI~~	~~1.33E-09~~	~~5.10E+01~~	~~5.10E+03~~	~~6.78E-06~~	~~3.7~~
~~CFL~~	~~3.45E-13~~	~~3.84E-02~~	~~3.84E+00~~	~~1.32E-12~~	~~0.0~~
	~~2.4E-07~~		~~**Total Risk =**~~	~~1.83E-04~~	~~100.0~~

Delete Figure 19.59-2:



~~Figure 19.59-2~~

~~**24-Hour Site Boundary Dose Cumulative Frequency Distribution**~~

12.0 DCD APPENDIX 1.B MARKUP

The following DCD markup identifies how COL application Final Safety Analysis Reports can incorporate the subject change.

Revise the third paragraph of subsection 1B.1.4.1:

The dose risks are quantified by multiplying the calculated fission product release category frequency vector by the release category mean dose vectors. The frequencies for each of the six release categories are quantified in Chapter 45 of the AP1000 Probabilistic Risk Assessment (Reference 2), while the mean doses for each release category are identified in Chapter 49. Table 1B-1 presents the results of the dose risk calculations at the site boundary at 24 hours. The table presents the release category identifier, the release frequency (per reactor-year), the mean dose (in rem), and the resulting risk (in rem per reactor-year). In addition, each table presents the total dose risk and the percent that each release category contributes to the total risk. <u>The information from Table 1B-1 was extracted from Chapter 49 of the AP1000 Probabilistic Risk Assessment.</u>

Revise the second paragraph of subsection 1B.1.4.2

Level 3 analysis is performed only for internal events at power. The ensuing population dose was very low, and it was not pursued for other events. The population dose for internal events is given in Table 1B-3. <u>The information from Table 1B-3 was extracted from Chapter 49 of the AP1000 Probabilistic Risk Assessment.</u>