7.1 Design Basis Accidents

This section evaluates the radiological consequences of design basis accidents at STP 3 & 4.

7.1.1 Selection of Accidents

Consistent with the ABWR Design Control Document (DCD), Revision 4 (Reference 7.1-1), the following design basis accidents are evaluated as those having potential for radioactivity releases to the environment:

- Failure of small lines carrying primary coolant outside containment
- Main steam line break
- Loss of coolant accident (LOCA)
- Cleanup water line break outside containment
- Fuel handling accident

The radiological consequences of these accidents are assessed to demonstrate that STP 3 & 4 could be sited at the STP site without undue risk to the health and safety of the public.

The above accidents are identified in NUREG-1555, Section 7.1, Appendix A, for consideration in an environmental report. The following additional accidents identified in NUREG-1555, Section 7.1, Appendix A, are not evaluated for the reasons provided below:

- Radiological consequences of main steam line failures outside containment of a PWR - Not applicable to the ABWR
- Feedwater system pipe breaks inside and outside containment (PWR) - Not applicable to the ABWR
- Reactor coolant pump rotor seizure - As indicated in the ABWR DCD, because this accident does not result in any fuel failures, it has no radiological consequences (Reference 7.1-1, Subsection 15.3.3.5)
- Reactor coolant pump shaft break - As indicated in the ABWR DCD, because this accident does not result in any fuel failures, it has no radiological consequences (Reference 7.1-1, Subsection 15.3.4.5)
- Radiological consequences of control rod drop accident (BWR) - As indicated in the ABWR DCD, there is no basis for this accident to occur (Reference 7.1-1, Subsection 15.4.10.3)
- Radiological consequences of steam generator tube failure (PWR) - Not applicable to the ABWR

7.1.2 Evaluation Methodology

The ABWR DCD presents the radiological consequences of the accidents identified in Subsection 7.1.1. The basic scenario for each accident is that some quantity of activity is released at the accident location inside a building and this activity is eventually released to the environment. The transport of activity within the plant is independent of the site and is specific to the ABWR design. Details about the methodologies and assumptions pertaining to each of the accidents, such as activity release pathways and credited mitigation features, are provided in the reference ABWR DCD (Reference 7.1-1, Chapter 15).

The dose to an individual located at the exclusion area boundary (EAB) or in the low population zone (LPZ) is calculated based on the amount of activity released to the environment, the atmospheric dispersion of the activity during the transport from the release point to the off-site location, the breathing rate of the individual at the off-site location, and activity-to-dose conversion factors. The only site-specific parameter is atmospheric dispersion. Site-specific doses are obtained by adjusting the reference ABWR DCD doses to reflect site-specific atmospheric dispersion factors (χ/Q values).

NUREG-1555 provides two options for calculating χ/Q values: either 50th percentile χ/Q values based on onsite meteorological data or 10% of the levels given in Regulatory Guide 1.3 (Reference 7.1-2) to represent more realistic dispersion conditions than assumed in the safety evaluation. The option to use 50th percentile site-specific χ/Q values was selected. Short-term accident χ/Q values are calculated using the methodology of Regulatory Guide 1.145, Revision 1 (Reference 7.1-3) with site-specific meteorological data. As indicated in Section 2.7, the Regulatory Guide 1.145 methodology is implemented in the NRC-sponsored PAVAN computer program. This program computes χ/Q values at the EAB and the LPZ for each combination of wind speed and atmospheric stability for each of the 16 downwind direction sectors. Releases are assumed to be at ground level, and the shortest distances between the power block and the off-site locations are selected to conservatively maximize the χ/Q values.

Consistent with the reference ABWR DCD, the accident doses are presented for the whole body and the thyroid. Furthermore, the whole body and thyroid doses are converted into total effective dose equivalent (TEDE) to demonstrate compliance with 10 CFR 50.34. The conversion to TEDE is performed by multiplying the thyroid dose by a weighting factor of 0.03 and adding the result to the whole body dose, in accordance with ICRP 30 (Reference 7.1-4).

7.1.3 Source Terms

The design basis accident source terms in the reference ABWR DCD are presented as time-dependent isotopic activity releases to the environment in the unit of megabecquerel (MBq) in Tables 7.1-1 to 7.1-6.

7.1.4 Radiological Consequences

As indicated in NUREG-1555, environmental report design basis accident doses are evaluated based on more realistic meteorological conditions than those used in the safety analysis report. For each of the accidents identified in Subsection 7.1.1, the site-specific dose for a given time interval is calculated by multiplying the ABWR DCD dose by the ratio of the site χ/Q value provided in Section 2.7 to the DCD χ/Q value. The time-dependent DCD and site χ/Q values

and their ratios are shown in Table 7.1-7. Since all site χ/Q values are bounded by DCD χ/Q values, site-specific doses for all accidents would also be bounded by DCD doses. However, site-specific doses are presented for completeness. All accident doses are presented in Tables 7.1-8 to 7.1-13.

The 10 CFR 50.34 dose limit is 25 rem TEDE at the EAB and the LPZ, as specified in 50.34(a)(1)(ii). The ABWR is certified to the 10 CFR 100.11 dose limits of 25 rem to the whole body and 300 rem to the thyroid. The limit of 10 CFR 50.34(a)(1)(ii) applies to extremely low probability accidents that could result in the release of significant quantities of radioactive fission products. Similarly, the limits of 10 CFR 100.11 apply to a major accident with the release of appreciable quantities of fission products. For accidents with smaller releases, more restrictive dose limits are specified in Subsections 15.6.2, 15.6.4, and 15.7.4 of NUREG-0800. Where applied, the more restrictive dose limits are either 10% or 25% of the 10 CFR 100.11 limits. Although conformance to these more restrictive dose limits is not required for an environmental report, they are shown in Tables 7.1-8 to 7.1 13 for comparison purposes.

The doses shown in Tables 7.1-8 to 7.1-13 are summarized in Tables 7.1-14 and 7.1-15. Tables 7.1-14 and 7.1-15 also show the equivalent TEDE doses. The summary tables demonstrate that, in addition to meeting the limits of 10 CFR 100.11 and NUREG-0800 as indicated above, all accident doses also meet the 25 rem TEDE acceptance criteria of 10 CFR 50.34(a)(1)(ii). Because the dose criterion of 10 CFR 50.34 is intended to provide assurance of low risk to the public under postulated accidents, any health effects resulting from the design basis accidents are considered to be negligible.

7.1.5 References

7.1-1 ABWR Design Control Document, Tier 2, GE Nuclear Energy, Revision 4.

7.1-2 “Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors,” Regulatory Guide 1.3, Revision 2, June 1974.

7.1-3 “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants,” Regulatory Guide 1.145, Revision 1, November 1982.

7.1-4 “Limits for Intakes of Radionuclides by Workers,” Part 1, ICRP Publication 30, International Commission on Radiological Protection, Pergamon Press, 1979.

Table 7.1-1 Activity Releases for Failure of Small Lines Carrying Primary Coolant Outside Containment

Isotope	Activity Release (MBq)	
	0-2 Hours	0-8 Hours
I-131	6.81E+04	1.41E+05
I-132	5.96E+05	1.19E+06
I-133	4.59E+05	9.44E+05
I-134	9.92E+05	1.90E+06
I-135	6.59E+05	1.34E+06
Total	**2.77E+06**	**5.51E+06**

Source: ABWR DCD (Reference 7.1-1, Table 15.6-2)

Table 7.1-2 Table 7.1-2 Activity Releases for Main Steam Line Break

Isotope	Activity Release (MBq)	
	Preexisting Iodine Spike	Equilibrium Iodine Activity
I-131	1.46E+06	7.29E+04
I-132	1.42E+07	7.10E+05
I-133	9.99E+06	5.00E+05
I-134	2.79E+07	1.40E+06
I-135	1.46E+07	7.29E+05
Kr-83m	2.44E+03	4.07E+02
Kr-85m	4.29E+03	7.18E+02
Kr-85	1.36E+01	2.26E+00
Kr-87	1.47E+04	2.44E+03
Kr-88	1.48E+04	2.46E+03
Kr-89	5.92E+04	9.88E+03
Kr-90	1.55E+04	2.55E+03
Xe-131m	1.06E+01	1.76E+00
Xe-133m	2.04E+02	3.39E+01
Xe-133	5.70E+03	9.47E+02
Xe-135m	1.74E+04	2.89E+03
Xe-135	1.62E+04	2.70E+03
Xe-137	7.40E+04	1.23E+04
Xe-138	5.66E+04	9.44E+03
Xe-139	2.59E+04	4.33E+03
Total Iodine	6.81E+07	3.41E+06
Total Noble Gases	3.07E+05	5.11E+04

Source: ABWR DCD (Reference 7.1-1, Table 15.6-6)

Table 7.1-3 Activity Releases from Reactor Building for Loss-of-Coolant Accident

Isotope	Activity Release (MBq)				
	0-2 Hours	0-8 Hours	0-24 Hours	0-96 Hours	0-720 Hours
I-131	9.6E+06	1.3E+07	3.6E+07	1.9E+08	6.7E+08
I-132	1.3E+07	1.4E+07	1.5E+07	1.5E+07	1.5E+07
I-133	2.0E+07	2.6E+07	5.6E+07	1.2E+08	1.3E+08
I-134	1.9E+07	1.9E+07	1.9E+07	1.9E+07	1.9E+07
I-135	1.9E+07	2.3E+07	3.1E+07	3.5E+07	3.5E+07
Kr-83m	1.2E+07	2.8E+07	3.3E+07	3.3E+07	3.3E+07
Kr-85	1.5E+06	1.2E+07	8.1E+07	6.7E+08	5.6E+09
Kr-85m	3.1E+07	1.3E+08	2.7E+08	2.9E+08	2.9E+08
Kr-87	4.4E+07	7.8E+07	8.1E+07	8.1E+07	8.1E+07
Kr-88	7.8E+07	2.5E+08	3.6E+08	3.7E+08	3.7E+08
Kr-89	6.7E+06	6.7E+06	6.7E+06	6.7E+06	6.7E+06
Xe-131m	7.8E+05	5.9E+06	4.1E+07	3.0E+08	1.4E+09
Xe-133	2.8E+08	2.1E+09	1.4E+10	8.9E+10	2.5E+11
Xe-133m	1.1E+07	8.5E+07	5.2E+08	2.6E+09	4.1E+09
Xe-135	3.4E+07	1.9E+08	6.7E+08	1.0E+09	1.0E+09
Xe-135m	1.8E+07	1.8E+07	1.8E+07	1.8E+07	1.8E+07
Xe-137	1.9E+07	1.9E+07	1.9E+07	1.9E+07	1.9E+07
Xe-138	7.4E+07	7.4E+07	7.4E+07	7.4E+07	7.4E+07
Total Iodine	8.1E+07	9.5E+07	1.6E+08	3.8E+08	8.6E+08
Total Noble Gases	6.1E+08	3.0E+09	1.6E+10	9.4E+10	2.6E+11

Source: ABWR DCD (Reference 7.1-1, Tables 15.6-10 and 15.6-12)

Table 7.1-4 Activity Releases from Condenser for Loss-of-Coolant Accident

Isotope	Activity Release (MBq)				
	0-2 Hours	0-8 Hours	0-24 Hours	0-96 Hours	0-720 Hours
I-131	1.2E+04	8.5E+05	1.2E+07	1.8E+08	2.0E+09
I-132	1.1E+04	2.4E+05	4.4E+05	4.4E+05	4.4E+05
I-133	2.4E+04	1.5E+06	1.5E+07	7.4E+07	8.9E+07
I-134	8.5E+03	4.8E+04	4.8E+04	4.8E+04	4.8E+04
I-135	2.1E+04	9.3E+05	5.2E+06	7.4E+06	7.4E+06
Kr-83m	7.8E+04	1.3E+06	1.9E+06	1.9E+06	1.9E+06
Kr-85	1.3E+04	9.3E+05	1.3E+07	2.3E+08	5.9E+09
Kr-85m	2.3E+05	8.5E+06	3.0E+07	3.6E+07	3.6E+07
Kr-87	2.4E+05	2.4E+06	2.8E+06	2.8E+06	2.8E+06
Kr-88	5.6E+05	1.4E+07	3.1E+07	3.2E+07	3.2E+07
Kr-89	4.1E+00	4.1E+00	4.1E+00	4.1E+00	4.1E+00
Xe-131m	6.7E+03	4.8E+05	6.7E+06	1.0E+08	1.3E+09
Xe-133	2.4E+06	1.6E+08	2.2E+09	3.0E+10	1.8E+11
Xe-133m	1.0E+05	6.7E+06	8.1E+07	8.1E+08	2.0E+09
Xe-135	2.7E+05	1.4E+07	9.6E+07	2.0E+08	2.0E+08
Xe-135m	1.0E+04	1.3E+04	1.3E+04	1.3E+04	1.3E+04
Xe-137	3.5E+01	3.5E+01	3.5E+01	3.5E+01	3.5E+01
Xe-138	3.2E+04	3.7E+04	3.7E+04	3.7E+04	3.7E+04
Total Iodine	7.7E+04	3.5E+06	3.3E+07	2.6E+08	2.1E+09
Total Noble Gases	3.9E+06	2.1E+08	2.5E+09	3.2E+10	1.9E+11

Source: ABWR DCD (Reference 7.1-1, Tables 15.6-10, and 15.6-12)

Table 7.1-5 Activity Releases for Cleanup Water Line Break Outside Containment

Isotope	Activity Release (MBq) 0-2 Hours
I-131	8.1E+04
I-132	1.9E+05
I-133	2.3E+05
I-134	3.2E+05
I-135	2.5E+05
Total	1.1E+06

Source: ABWR DCD (Reference 7.1-1, Table 15.6-17)

Table 7.1-6 Activity Releases for Fuel-Handling Accident

Isotope	Activity Release (MBq) 0-2 Hours
I-131	4.55E+06
I-132	5.62E+06
I-133	4.70E+06
I-134	2.28E-01
I-135	7.62E+05
Kr-83m	2.38E+05
Kr-85m	3.16E+06
Kr-85	1.77E+07
Kr-87	4.55E+02
Kr-88	8.99E+05
Kr-89	3.01E-06
Xe-131m	3.09E+06
Xe-133m	4.07E+07
Xe-133	1.04E+09
Xe-135m	8.18E+06
Xe-135	2.36E+08
Xe-137	7.66E-06
Xe-138	1.59E-05
Total Iodine	1.56E+07
Total Noble Gases	1.35E+09

Source: ABWR DCD (Reference 7.1-1, Table 15.7-10)

Table 7.1-7 Atmospheric Dispersion Factors

Location	Time (hr)	χ/Q (sec/m3)		Ratio (Site/DCD)
		Site	DCD	
EAB	0-2	4.20E-05	1.37E-03	3.07E-02
LPZ - LOCA	0-8	3.54E-06	1.56E-04	2.27E-02
	8-24	3.00E-06	9.61E-05	3.12E-02
	24-96	2.08E-06	3.36E-05	6.19E-02
	96-720	1.24E-06	7.42E-06	1.67E-01
LPZ - Non-LOCA	0 - 8	3.54E-06	1.37E-03	2.58E-3

Notes:

The site χ/Q values are from Section 2.7.

The DCD χ/Q values are from the ABWR DCD (Reference 7.1-1, Tables 15.6-3, 15.6-7, 15.6-13, 15.6-18, and 15.7-11).

The DCD does not show LPZ doses for accidents other than LOCA. Site LPZ doses for these non-LOCA accidents, all of which have their activity releases terminated within 8 hr, are estimated by multiplying the DCD EAB dose by the ratio of site LPZ χ/Q to DCD EAB χ/Q shown in the last row above.

Table 7.1-8 Doses for Failure of Small Lines Carrying Primary Coolant Outside Containment

Location	Time (hr)	DCD Dose (Sv)		χ/Q Ratio (Site/DCD)	Site Dose (rem)	
		Whole Body	Thyroid		Whole Body	Thyroid
EAB	0-2	9.4E-04	4.8E-02	3.07E-02	2.9E-03	1.5E-01
LPZ	0-8			2.58E-03	2.4E-04	1.2E-02
	8-24					
	24-96					
	96-720					
	Total				**2.4E-04**	**1.2E-02**
Regulatory Limit (NUREG-0800, Subsection 15.6.2)					2.5	30

Note:

DCD doses are from the ABWR DCD (Reference 7.1-1, Table 15.6-3).

The DCD does not provide LPZ doses. The site LPZ doses are obtained by multiplying the DCD EAB doses by the ratio of LPZ χ/Q to DCD EAB χ/Q.

Table 7.1-9 Doses for Main Steam Line Break, Preexisting Iodine Spike

Location	Time (hr)	DCD Dose (Sv)		χ/Q Ratio (Site/DCD)	Site Dose (rem)	
		Whole Body	Thyroid		Whole Body	Thyroid
EAB	0 - 2	1.3E-02	5.1E-01	3.07E-02	4.0E-02	1.6E+00
LPZ	0 - 8			2.58E-03	3.4E-03	1.3E-01
	8 - 24					
	24 - 96					
	96 - 720					
	Total				**3.4E-03**	**1.3E-01**
Regulatory Limit (10 CFR 100.11)					25	300

Note:

DCD doses are from the ABWR DCD (Reference 7.1-1, Table 15.6-7).

The ABWR DCD does not provide LPZ doses. The site LPZ doses are obtained by multiplying the DCD EAB doses by the ratio of LPZ χ/Q to DCD EAB χ/Q.

Table 7.1-10 Doses for Main Steam Line Break, Equilibrium Iodine Activity

Location	Time (hr)	DCD Dose (Sv)		χ/Q Ratio (Site/DCD)	Site Dose (rem)	
		Whole Body	Thyroid		Whole Body	Thyroid
EAB	0-2	6.2E-04	2.6E-02	3.07E-02	1.9E-03	8.0E-02
LPZ	0-8			2.58E-03	1.6E-04	6.7E-03
	8-24					
	24-96					
	96-720					
	Total				**1.6E-04**	**6.7E-03**
Regulatory Limit (NUREG-0800, Subsection 15.6.4)					2.5	30

Note:

DCD doses are from the ABWR DCD (Reference 7.1-1, Table 15.6-7).

The ABWR DCD does not provide LPZ doses. The site LPZ doses are obtained by multiplying the DCD EAB doses by the ratio of LPZ χ/Q to DCD EAB χ/Q.

Table 7.1-11 Table 7.1-11 Doses for Loss-of-Coolant Accident

Location	Time (hr)	DCD Dose (Sv)		χ/Q Ratio (Site/DCD)	Site Dose (rem)	
		Whole Body	Thyroid		Whole Body	Thyroid
EAB	0-2	4.1E-02	1.9E+00	3.07E-02	1.3E-01	5.8E+00
LPZ	0-8	1.0E-02	3.1E-01	2.27E-02	2.3E-02	7.0E-01
	8-24	8.0E-03	2.0E-01	3.12E-02	2.5E-02	6.2E-01
	24-96	1.1E-02	7.9E-01	6.19E-02	6.8E-02	4.9E+00
	96-720	9.0E-03	1.1E+00	1.67E-01	1.5E-01	1.8E+01
	Total	**3.8E-02**	**2.4E+00**		**2.7E-01**	**2.5E+01**
Regulatory Limit (10 CFR 100.11)					25	300

Note: DCD doses are from the ABWR DCD (Reference 7.1-1, Table 15.6-13)

Table 7.1-12 Table 7.1-12 Doses for Cleanup Water Line Break Outside Containment

Location	Time (hr)	DCD Dose (Sv)		χ/Q Ratio (Site/DCD)	Site Dose (rem)	
		Whole Body	Thyroid		Whole Body	Thyroid
EAB	0-2	1.7E-04	1.7E-04	3.07E-02	5.2E-04	5.2E-04
LPZ	0-8			2.58E-03	4.4E-05	4.4E-05
	8-24					
	24-96					
	96-720					
	Total				**4.4E-05**	**4.4E-05**
Regulatory Limit (10 CFR 100.11)					25	300

Notes:

DCD doses are from the ABWR DCD (Reference 7.1-1, Table 15.6-18).

The DCD does not provide LPZ doses. The site LPZ doses are obtained by multiplying the DCD EAB doses by the ratio of LPZ χ/Q to DCD EAB χ/Q.

Table 7.1-13 Table 7.1-13 Doses for Fuel Handling Accident

Location	Time (hr)	DCD Dose (Sv)		χ/Q Ratio (Site/DCD)	Site Dose (rem)	
		Whole Body	Thyroid		Whole Body	Thyroid
EAB	0-2	1.2E-02	7.5E-01	3.07E-02	3.7E-02	2.3E+00
LPZ	0-8			2.58E-03	3.1E-03	1.9E-01
	8 -24					
	24-96					
	96-720					
	Total				**3.1E-03**	**1.9E-01**
Regulatory Limit (NUREG-0800, Subsection 15.7.4)					6	75

Note:

DCD doses are from the ABWR DCD (Reference 7.1-1, Table 15.7-11).

The DCD does not provide LPZ doses. The site LPZ doses are obtained by multiplying the DCD EAB doses by the ratio of LPZ χ/Q to DCD EAB χ/Q.

Table 7.1-14 Table 7.1-14 Summary of Design Basis Accident EAB Doses

DCD Section	Accident	Site Dose (rem)			Dose Limit (rem)	
		Whole Body	Thyroid	TEDE	Whole Body	Thyroid
15.6.2	Failure of Small Lines Carrying Primary Coolant Outside Containment	2.9E-03	1.5E-01	7.3E-03	2.5	30
15.6.4	Main Steam Line Break	-	-	-	-	-
	Preexisting Iodine Spike	4.0E-02	1.6E+00	8.7E-02	25	300
	Equilibrium Iodine Activity	1.9E-03	8.0E-02	4.3E-03	2.5	30
15.6.5	Loss-of-Coolant Accident	1.3E-01	5.8E+00	3.0E-01	25	300
None	Cleanup Water Line Break Outside Containment	5.2E-04	5.2E-04	5.4E-04	25	300
15.7.4	Fuel-Handling Accident	3.7E-02	2.3E+00	1.1E-01	6	75

Notes:

The site doses and dose limits are taken from Tables 7.1-8 to 7.1-13.

The dose limits are from either NUREG-0800 or 10 CFR 100.11, as indicated in Tables 7.1-8 to 7.1-13.

Preexisting Iodine Spike and Equilibrium Iodine Activity are subsets of Main Steam Line Break.

All accidents meet the 10 CFR 50.34(a)(1)(ii) dose limit of 25 rem TEDE.

Table 7.1-15 Table 7.1-15 Summary of Design Basis Accident LPZ Doses

DCD Section	Accident	Site Dose (rem)			Dose Limit (rem)	
		Whole Body	Thyroid	TEDE	Whole Body	Thyroid
15.6.2	Failure of Small Lines Carrying Primary Coolant Outside Containment	2.4E-04	1.2E-02	6.1E-04	2.5	30
15.6.4	Main Steam Line Break	-	-	-	-	-
	Preexisting Iodine Spike	3.4E-03	1.3E-01	7.3E-03	25	300
	Equilibrium Iodine Activity	1.6E-04	6.7E-03	3.6E-04	2.5	30
15.6.5	Loss-of-Coolant Accident	2.7E-01	2.5E+01	1.0E+00	25	300
None	Cleanup Water Line Break Outside Containment	4.4E-05	4.4E-05	4.5E-05	25	300
15.7.4	Fuel Handling Accident	3.1E-03	1.9E-01	8.9E-03	6	75

Notes:

The site doses and dose limits are taken from Tables 7.1-8 to 7.1-13.

The dose limits are from either NUREG-0800 or 10 CFR 100.11, as indicated in Tables 7.1-8 to 7.1-13.

Preexisting Iodine Spike and Equilibrium Iodine Activity are subsets of Main Steam Line Break.

All accidents meet the 10 CFR 50.34(a)(1)(ii) dose limit of 25 rem TEDE.