3.4 Water Level (Flood) Design

The information in this section of the reference ABWR DCD, including all subsections and tables and figures, is incorporated by reference with the following supplements and departures.

STP DEP T1 5.0-1 (Table 3.4-1)

STD DEP T1 2.3-1

STD DEP T1 2.15-1

STP DEP 1.2-2

STD DEP 3.8-1

3.4.1.1.1 Flood Protection from External Sources

STP DEP T1 5.0-1

Waterproofing of foundations and walls of Seismic Category I structures below ~~grade~~ flood level *~~arise~~ is accomplished principally by the use of water stops at expansion and construction joints. In addition to water stops, waterproofing of the plant structures and penetrations that house safety-related systems and components is provided up to 8 cm above the ~~plant ground~~* flood *level to protect the external surfaces from exposure to water.*

3.4.1.1.2 Compartment Flooding from Postulated Component Failures

STDP DEP T1 2.3-1

The MSL tunnel area is instrumented with ~~radiation and~~ air temperature monitors that are used to automatically isolate the MSIVs upon detection of high abnormal limits.

3.4.1.1.2.3 Evaluation of Radwaste Building Flooding Events

STD DEP T1 2.15-1

STD DEP 3.8-1

The Radwaste Building is a reinforced concrete structure consisting of a ~~Seismic Category I~~ substructure ~~13.5~~ 13.7*m below grade at the basemat top and a super-structure ~~15.7~~* 13.7*m above grade. This building does not contain safety-related equipment and is not contiguous with other plant structures except through the radwaste piping and tunnel. In case of a flood, the building substructure serves as a large sump which can collect and hold any leakage within the building. Also, the medium and large radwaste tanks are housed in sealed compartments which are designed to contain any spillage or leakage from tanks that may rupture. The piping that transfer the liquid waste from the other buildings to the Radwaste Building traverse through a tunnel. ~~which runs near (but does not penetrate) the Radwaste Building.~~* The top of the radwaste tunnel is at grade (Figure 1.2-23e). *~~at an elevation of 1,500mm, 3m~~*

~~*above the basemat slab 1,036cm (Table 3.4-1).*~~ *Seals are provided for all penetrations from the tunnel to prevent building to building flooding.*

The structural design of this building is such that no internal flooding is expected or will occur under the worst case conditions from ~~*those tanks that are isolated by the Seismic Category I compartments*~~medium and large radwaste tanks.

3.4.1.1.2.5 Evaluation of Turbine Building Flood Events

STP DEP 1.2-2

Circulating Water System and Turbine Building Water System (TSW) *are the only systems large enough to fill the* ~~*condenser pit*~~Turbine Building*; therefore, only these two systems can flood into adjacent buildings.*

A failure ~~*in either*~~ *of* ~~*these systems*~~Circulating Water System *will result in the total flooding of the Turbine Building* ~~*up to*~~ below *grade.* Another failure in TSW system will result in the total flooding of Turbine Building still within the TSW System equipment room. These are accomplished by leak detectors in a condenser pit and TSW System equipment room, and automatic means to shutdown those systems. *Water is prevented from crossing to other buildings by two means* in the case of the leak detection failure. *The first is a normally closed alarmed door in the connecting passage between the Turbine Building and Service Building. The second is that the radwaste tunnel will be sealed at both ends to prevent water from either entering the tunnel or leaving the tunnel. A large hydrostatic head is prevented by a large non-water-tight truck door at grade to provide a release point for any* flooding *water*.

Because of the large size of the circulating water system and the TSW system, ~~*a*~~ *leak*s *will fill the condenser pit* and the TSW System equipment room *quickly. Monitors were added in the condenser pit* and the TSW System equipment room *of the Turbine Building to provide leak detection and an automatic means to shutdown the Circulating Water System* and TSW System *in the event of flooding in the Turbine Building (Subsections 10.4.5.2.3 and 10.4.5.6).*

3.4.2 Analytical and Test Procedures

STP DEP T1 5.0-1

Since the design basis *flood elevation is* ~~*30.5 cm below*~~ at El. 40.0 ft (see Subsection 2.4S.2.2), 182.9 cm above *the finished plant grade,* ~~*there is no dynamic force due to flood. The*~~ the *lateral hydrostatic* and hydrodynamic *pressure on the structures due to the design flood water level, as well as ground and soil pressures, are calculated.*

As discussed in Section 2.4S.4.2.2.4.3, the hydrodynamic force due to the wind-generated wave action on building walls has been calculated as shown in Figure 3.4-1.

Consistent with Standard Review Plan Section 3.4.2 requirements, and the discussion provided in Section 2.4S.4.2.2.4.3, the following criteria will be applied for the design of the safety-related structures:

(a) Flotation stability evaluations shall be based on the buoyancy calculations using the conservatively established design basis flood level of 40'-0" MSL.

(b) The lateral loads on the structural walls and overturning moment on the structure will include the effect of the wave-generated hydrodynamic forces. As such, external walls of the structures shall be capable of resisting the following loads:

- Hydrostatic force considering a conservatively established design basis flood level of 40'-0" MSL.
- Hydrodynamic drag force of 44 psf due to flood water flow, applicable to above grade portion.
- Wind generated wave forces as shown in Figure 3.4-1, applicable to above grade portion.
- Impact due to a 500 lbs floating debris traveling at 4.72 ft/sec.

(c) Watertight seals protecting the exterior penetrations and seismic gaps against flooding shall be designed to take into account the increase in hydrostatic head due to the design basis flood elevation of 40'-0" MSL.

3.4.3 COL License Information

3.4.3.1 Flood Elevation

The following site specific supplement addresses COL License Information Item 3.5.

The site specific design basis flood elevation is defined as 182.9 cm above grade. The design basis flood is described in Subsection 2.4S.2.

As described in Table 3.4-1 note 3 and 5, all penetrations and doors that penetrate the exterior walls of Seismic Category I Buildings that are located below the design basis flood level are watertight. Therefore all safety-related equipment in these buildings are protected from postulated external floods and satisfy the requirements of GDC 2.

Watertight doors or barriers are provided on the Reactor Building and Control Building to protect the buildings from the external design basis flood. These watertight doors or barriers are considered Seismic Category I components. In order to ensure that the watertight doors and barriers can withstand the ABWR Standard Plant loading requirements, the watertight doors and barriers of the Reactor Building and Control Building will be designed for the more severe of the standard plant and site-specific loading. Watertight doors shall be designed to meet the Incorporated Barrier requirements of Regulatory Guide 1.102.

The watertight doors or barriers for the Reactor Building consist of the six exterior doors and the exterior Large Equipment Access indicated in Tier 1 Figures 2.15.10h and 2.15.10j. The watertight doors for the Control Building consist of the access doors between the Control Building and the Service Building shown in Tier 1 Figures 2.15.12d, e, and f, the exterior equipment access door shown in Tier 1 Figure 2.15.12g, and an access door between the Control Building and the Service Building shown in Tier 1 Figure 2.15.12g. Each door will be given a unique component ID in the construction drawings.

The locations for watertight doors in the Reactor Building and Control Building include:

Exterior Watertight Door or Barriers

Structure	Door or Barrier Description	Elevation
Reactor Building	Clean Access Area Corridor Entrance	B1F (4800 mm)
	Diesel Generator A Access	1F (12300 mm)
	Diesel Generator B Access	1F (12300 mm)
	Diesel Generator C Access	1F (12300 mm)
	East Equipment Hatch Access	1F (12300 mm)
	West Equipment Hatch Access	1F (12300 mm)
	Large Equipment Access	1F (12300 mm)
Control Building	HX Area Access at Service Building	B3F (-2150 mm)
	Electrical Area Access at Service Building	B2F (3500 mm)
	Control Building Access at Service Building	B1F (7900 mm)
	Entrance to Reactor Building Controlled Access	1F (12300 mm)
	Equipment Access	1F (12300 mm)

~~Exterior openings of the Reactor Building and Control Building that could make safety-related SSCs vulnerable to tornado missiles are protected by separate barriers or doors designed to resist tornado missiles.~~

The watertight doors are seated such that the force of the water helps maintain the watertight seal. The watertight doors are designed to be leak tight. Watertight doors will be individually engineered assemblies designed by the supplier to satisfy the design basis performance requirements for external flooding. Watertight doors and water stops will allow only slight seepage during an external flooding event in accordance with criteria for Type 2 closures in U.S. Army Corps of Engineers (COE) EP 1165-2-314, "Flood-Proofing Regulations". This criterion will be met under hydrostatic loading of 12 inches of water above the design basis flood elevation per Table 3.4-1, plus ~~the height of wave run-up and~~ drag effects, as required. Water retaining capability of the doors shall be demonstrated by qualification tests for the water head levels. These tests will be completed prior to shipment of the doors. For this purpose a test fixture may be used, with gasket material and cross section, its retainers, and the anvil configuration being identical to that of the full size doors. The test fixture shall have the necessary valving, pressure gages, flow meters, and instruments for measuring gasket compression. To validate that the door satisfies a Type 2 closure per (COE) EP 1165-2-314, the leakage shall not exceed 0.10 gallon/hour/linear foot of gasket when subjected to 125% of the specified head pressure. The hydrostatic head shall be raised at a rate not more than 1 ft/min. If leaks occur during the rising of the hydrostatic head and the leakage rate begins to diminish as the hydrostatic head increases, the assembly shall be tested at the hydrostatic head where the more substantial leakage was observed.

The joint seals between the Reactor Building and the Control Building below the design basis flood level shall be made using a polyurethane foam impregnated with a waterproof sealing compound. The joint shall also include a redundant water stop at the interior side of the joint.

The seal material and joint seal assembly shall be tested to be watertight when subjected to the maximum anticipated hydrostatic head. The testing program will demonstrate the following:

- The seal material can withstand a movement of ±25% of the gap size or the expected long-term settlement, whichever is larger, in any resultant direction and still be watertight.
- The seal material can compress to 1/3 of its thickness without developing more than 25 psi pressure on the adjacent structures.
- The entire joint seal assembly, including the watertight joint seal and redundant water stop, prevents the total leakage during an SSE event from exceeding that which would cause internal flooding to exceed the height of the flooding protection curbs or raised equipment pads. The total permitted leakage of the joint seal assembly shall be determined for the entire duration of the SSE when subjected, simultaneously, to the maximum anticipated hydrostatic head pressure, the maximum differential displacements due to long term settlement or tilt, and the maximum differential displacements due to SSE.
- The seal material will function as a watertight barrier after being subjected to the maximum displacements due to a SSE and the redundant water stop on the interior side of the joint can withstand the SSE maximum displacements without degradation.

The foregoing requirements will demonstrate that the material is capable of being watertight after the effects of long term settlement or tilt, as well as during normal operating vibratory loading such as SRV actuation and not impact the adjacent structures. Although this will provide margin to accommodate differential displacements from the majority of the movements from short duration extreme environmental loading such as SSE, the seals need not be designed to be watertight during the maximum differential displacements from these extreme environmental loadings.

The joint seal and interior water stops used to protect the safety-related buildings against external water entry are classified as Seismic Category I with respect to their ability to remain in-place to stop significant water leakage into the safety-related buildings during and after a seismic event. An in-service inspection program will ensure that the joint seal materials do not significantly degrade.

The watertight doors or barriers that are utilized for protection against external flooding are normally closed and are used for egress, as required.

The watertight doors, frames, and all components are designed to the requirements of AISC N690 and SRP Section 3.8.4. The structural steel used for the watertight doors conforms to either ASTM A36, ASTM A992 or ASTM A500 Grade B. The faceplate conforms to ASTN A36 or ASTM A606, ~~t~~Type 4 and the rubber gasket conforms to ASTM ~~D2000, Grade BC~~D1056 Type 2 Class D. Fabrication of the doors shall meet the requirements of AISC N690. The welding shall meet the requirements of nondestructive testing, personnel qualifications and acceptance criteria contained in AWS D1.1.

The watertight doors shall be designed for the following loads and load combinations:

$S = D + W + P_o$

~~$S = D + P$~~

$1.6S = D + \cancel{P +} E' + P_o$

$1.6S = D + W_t$ ~~(See definition below)~~ $+ P_o$

$1.6S = D + FL + P_o$

Where:

S = Normal allowable stresses as defined in AISC N690

D = Dead Loads

E' = Loads generated by SSE, per Sections 3H.1 and 3H.2.

~~P = Pressure Loads, which may be due to hydrostatic pressure,~~ ~~P_h~~~~, or differential pressure,~~ ~~P_d~~~~.~~

~~P_h~~ ~~= Loads due to hydrostatic pressure, determined based on the flood elevation per Table 3.4-1, plus the height of wave run-up and drag effects, as required.~~

~~P_d~~ ~~= Loads due to differential pressure~~

P_o = Loads due to normal operating differential pressure.

FL = Design basis extreme flood loads, including the hydrostatic load due to flood elevation at 40 ft MSL, the associated drag effects of 44 psf, impact due to floating debris per Section 3.4.2, and hydrodynamic load due to wind-generated wave action per Figure 3.4-1. Figure 3.4-1 shall only be used to calculate hydrodynamic load due to wind-generated wave action. The weight of the water (above ground) due to the flood loads shall be 63.85 pcf in order to include the effects of suspended sediments in the water.

W = Normal Wind Loads, per Sections 3H.1 and 3H.2.

W_t = Tornado Loads, per Sections 3H.1 and 3H.2, including wind velocity pressure W_w, differential pressure W_p, and tornado-generated missiles (if not protected) W_m

The value used for W_t shall be computed to satisfy the following possible combinations:

$$W_t = W_w$$

$$W_t = W_p$$

$$W_t = W_m$$

$$W_t = W_w + W_m$$

$$W_t = W_w + 0.5\ W_p$$

$$W_t = W_w + 0.5\ W_p + W_m$$

3.4.3.2 Ground Water Elevation

The following site specific supplement addresses COL License Information Item 3.6.

The site specific ground water elevation is defined in Subsection 2.4S.12. The ground water elevation is lower than 61.0cm below grade.

3.4.3.3 Flood Protection Requirements for Other Structures

The following site specific supplement addresses COL License Information Item 3.7.

The Ultimate Heat Sink and Reactor Service Water Piping Tunnel have the same flood protection features as other Seismic Category I structures within the scope of the certified design. These design features are addressed in Subsection 3.4.1.1. As described in that Subsection, they are protected from postulated flooding and satisfy the requirements of GDC 2 and the guidance of RG 1.102.

The Ultimate Heat Sink and Reactor Service Water Piping Tunnel are divisionally separated in accordance with Section 3.13 and 3.12. Penetrations that are located below design flood level are watertight thereby preventing an internal flood event from propagating from one division to another.

Watertight doors or barriers are provided on the site-specific Diesel Generator Fuel Oil Storage Vaults to protect the vaults from the external design basis flood. These watertight doors or barriers are considered site-specific Seismic Category I components. Each door will be given a unique component ID in the construction drawings.

The locations of watertight doors for the Diesel Generator Fuel Oil Storage Vaults include:

Exterior Watertight Door or Barrier ~~Component IDs~~

Structure	Door Description
Diesel Generator Fuel Oil Storage Vaults	Access to Vault A
	Access to Vault B
	Access to Vault C

The design requirements for Diesel Generator Fuel Oil Storage Vault watertight doors are similar to the requirements described in Section 3.4.3.1, except that only the site-specific loads are considered, as described in Section ~~3H.6.7.~~3H.6.4.

3.4.3.4 Penetration Seals

The following site specific supplement addresses COL License Information Item in Subsection 3.4.1.1.1.

Penetrations located between Seismic Category I building and non-Seismic Category I building or to the outside below site- specific flood elevation are similar to a primary containment penetration. They consist of a steel sleeve embedded in the wall with a closure plate that acts as a seal and as a pipe anchor. The sleeve, closure plate and pipe are welded together to form a highly reliable seal.

Table 3.4-1 Structures, Penetrations, and Access Openings Designed for Flood Protection (Note 9)

Structure	Reactor Building	Service Building	Control Building	Radwaste Building	Turbine Building	Ultimate Heat Sink/RSW Pump House (Note 8)
Design Flood Level ~~(mm)~~	~~11,695~~ **12,192 mm (40.0 ft)**	~~11,695~~ **10058 mm (33 ft) (Note 7)**	~~11,695~~ **12,192 mm (40.0 ft)**	~~11,695~~ **10058 mm (33 ft) (Note 7)**	~~11,695~~ ***10058* mm (33 ft) (Note 7)**	**12,192 mm (40.0 ft)**
Design Ground Water Level ~~(mm)~~	~~11,390~~ **9,753mm (32 ft)**	~~11,390~~ **9,753 mm (32 ft)**	~~11,390~~ **9,753 mm (32 ft)**	~~11,390~~ **9,753 mm (32 ft)**	~~11,390~~ **9,753 mm (32 ft)**	**8,534 mm (28.0 ft)**
Reference Plant Grade ~~(mm)~~	~~12,000~~ **10,363 mm (34ft)**	~~12,000~~ **10,363 mm (34ft)**	~~12,000~~ **10,363 mm (34ft)**	~~12,000~~ **10,363 mm (34ft)**	~~12,000~~ **10,363 mm (34ft)**	**10,363 mm (34 ft)**
Top of Base Slab ~~(mm)~~	~~-8,200~~ **–9,837 mm (-32.27 ft)**	~~-2,150 & 3,500~~ **-3,787 mm (-12.42 ft)**	~~-8,200~~ **–9,837 mm (-32.27 ft)**	~~-1,500~~ **-3,353 mm (-11 ft)**	~~5,300~~ **-4,840 mm (-15.88 ft)**	**4,267 mm (UHS), -5,486 mm (RSW Pump House) (14 ft, UHS) (-18 ft, RSW Pump House)**
Actual Plant Grade ~~(mm)~~	~~12,000~~ **Varies between 9,753 mm (32 ft) and 10,973 mm (36 ft)**	~~12,000~~ **Varies between 9,753 mm (32 ft) and 10,973 mm (36 ft)**	~~12,000~~ **Varies between 9,753 mm (32 ft) and 10,973 mm (36 ft)**	~~12,000~~ **Varies between 9,753 mm (32 ft) and 10,973 mm (36 ft)**	~~12,000~~ **Varies between 9,753 mm (32 ft) and 10,973 mm (36 ft)**	**Varies between 9,753 mm (32 ft) and 10,973 mm (36 ft)**
~~*Building Height (mm)*~~	~~49,700~~	~~22,200~~	~~22,200~~	~~28,000~~	~~54,300~~	
Penetrations Below Design Flood Level (Notes 1 through 4)	Refer to Table 6.2-9	None	RCW, RSW and miscellaneous lines, and electrical penetrations	None, except radwaste piping	Radwaste piping	**RSW piping and electric cables**

Table 3.4-1 Structures, Penetrations, and Access Openings Designed for Flood Protection (Note 9) (Continued)

Structure	Reactor Building	Service Building	Control Building	Radwaste Building	Turbine Building	Ultimate Heat Sink/RSW Pump House (Note 8)
Access Openings Below Design Flood Level (Notes 5 and 6)	Access way**s to outside and** from S/B **and C/B (Fig. 1.2-4 through 1.2-8)** ~~@ 4,800 mm~~	Access way**s** from R/B, **C/B and T/B. (Fig. 1.2-17 through 1.2-20)** ~~@ 3,500 mm, (Fig. 1.2-18)~~ ~~Area access ways from C/B @ 2,150 mm, 3,500 mm, and 7,900 mm (Fig. 1.2-19)~~ ~~Area access way from T/B @ 3,500 mm (Fig. 1.2-24)~~	~~Hx area access from S/B @ 2,150 mm, (Fig. 1.2-15)~~ ~~Area access from S/B @ 3,500 (See Fig. 1.2-18~~ ~~Area access way from S/B @ 7,900 mm, (See Fig. 1.2-15)~~ **Access ways to outside, S/B, R/B, and RW/B (See Fig 1.2-17 through 1.2-20)**	None	Access ways from S/B ~~@ 5,300 mm,~~ **(Fig 1.2-18)**	**None**

Notes:

1 *Watertight penetrations will be provided for all Reactor, ~~and~~ Control, Turbine and Radwaste Building~~s~~ penetrations that are below ~~grade~~ design flood level.*

2 *The safety-related and non-safety-related tunnels prevent the lines running through them from being exposed to outside ground flooding.*

3 *Penetrations below design flood level will be sealed against any hydrostatic head resulting from the design basis flood, or from a moderate energy pipe failure in the tunnel or inside a connecting building.*

4 *Waterproof sealant applied to the building exterior walls below flood level will also be extended a minimum of 150 mm along the penetration surfaces.*

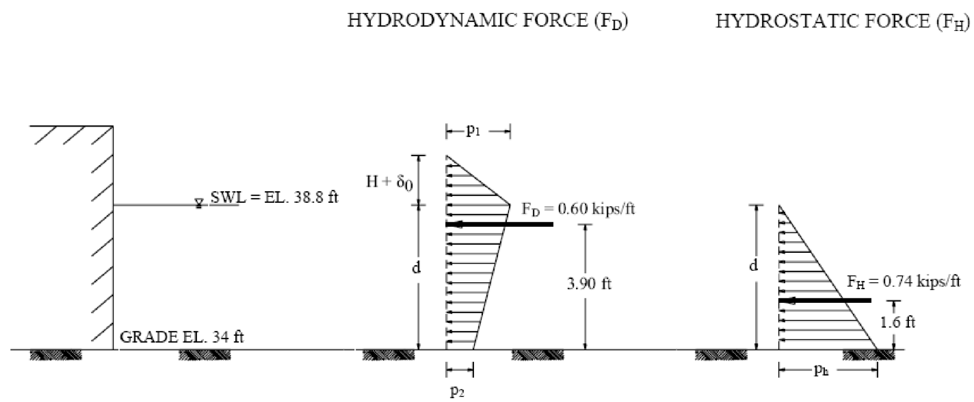
5 *Watertight doors (bulkhead type) are provided at all Reactor and Control Building access ways that are below ~~grade~~ design flood level.*

6 The figure shown best depicts the indicated access.

7 The Turbine Building and Service Building shall also meet the flood design requirements of ASCE 7-05. The Radwaste Building shall also meet the flood design requirements of ASCE 7-95.

8 UHS includes safety-related cooling towers and RSW Pump House, which are contiguous to the UHS.

9 All elevations in this table correspond to mean sea level (msl).



F_D = Resultant hydrodynamic force (in kips per linear foot) equivalent to the hydrodynamic wave pressure (p_1 and p_2) acting on the structure
F_H = Resultant hydrostatic force (in kips per linear foot) equivalent to the hydrostatic pressure (p_h) acting on the structure
H = Non-Breaking Wave Height(1%) = 2.1 ft
T = Non-Breaking Wave Period = 1.7 sec
d = depth of water at the structure = 4.8 ft
δ_0 = vertical shift of the wave crest and trough at the structure = 1.0 ft

p_1 = hydrodynamic wave pressure at the still water level = 132.8 lb/ft^2
p_2 = hydrodynamic wave pressure at the base of the structure = 32.5 lb/ft^2

p_h = hydrostatic pressure at the base of the structure = 306.5 lb/ft^2

Figure 3.4-1 Non-Breaking Wave Force on Vertical Wall