

19A EVENT TREES FOR CORE DAMAGE SEQUENCES INITIATED DURING POWER OPERATION

Appendix 19A presents the events trees that delineate the core-damage sequences for internal events initiated during power operation. The event trees and summary of top events are provided in the following figures and tables, respectively:

Event Tree	Event Tree Description	Table and Figure Number
31BDA	Loss of Divisional Emergency AC Power	19A-1
ATWS	Failure to Scram Following Loss of Main Feedwater	19A-2
GT	General transient	19A-3
IND SGTR	Induced Steam Generator Tube Rupture	19A-4
ISL-CCW RCPTB	ISLOCA Due to RCP Thermal Barrier Tube Break	19A-5
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LBOP	Loss of Balance of Plant Closed Loop Cooling Water or Auxiliary Cooling Water	19A-12
LLOCA	Large Loss-of-Coolant Accident	19A-13
LOC	Loss of Main Condenser	19A-14
LOCCW	Loss of Component Cooling Water or Emergency Service Water	19A-15
LOMFW	Loss of Main Feedwater	19A-16
LOOP	Loss of Offsite Power	19A-17
MLOCA	Medium Loss-of-Coolant Accident	19A-18
MSSV	Spurious Opening of Main Steam Safety Valve	19A-19
SGTR	Steam Generator Tube Rupture	19A-20
SLBI	Steam-Line Break Inside Containment	19A-21
SLBO	Steam-Line Break Outside Containment	19A-22
SLOCA	Small Loss-of-Coolant Accident	19A-23

In each case, the summary tables provide the following information:

- The definition of the top event. Note that some of the top events are configured differently for particular branch points. These configurations reflect conditions (e.g., different success criteria or timing) presented by the initiating event or by other failures in the sequence. The event trees denote these conditional states by an integer at relevant branch points. These conditional states are identified in the table as well.
- The success criteria for the top event.
- The corresponding failure event that is developed for purposes of evaluating the core-damage sequence.
- The description for the failure event.

**Table 19A-1—Event-Tree Headings for Initiating Event 31BDA: Loss of Divisional Emergency AC Power
Sheet 1 of 3**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
31BDA	Loss of divisional emergency AC (switchgear 31BDA)	—	IE 31BDA (initiator)	Loss of divisional emergency AC (switchgear 31BDA)
RCP LOCA	RCP seal LOCA does not occur	Seal injection with CVCS or seal cooling with CCWS or standstill seal actuation or seals withstand challenge	RCP LOCA (FT top gate)	RCP seal LOCA
MHSI	Medium-head safety injection available	1 of 4 MHSI pumps supply flow	MHSI 4/4	Failure of 4 out of 4 MHSI trains
OP FCD	Operators initiate fast cooldown within 40 min (Condition 1)	Action within 40 min	OPE-FCD-40M (basic event)	Operators fail to initiate fast cooldown for SLOCA
MFW	Main feedwater available	1 of 3 MFW pumps available to deliver flow to 1 of 4 steam generators (main condenser required with turbine bypass)	MFW (FT top gate)	Failure of the MFWS to deliver flow to 1 of 4 SGs or failure of main condenser with turbine bypass
SSS	Startup and shutdown system available for Secondary heat removal (Condition 1) Partial cooldown (Condition 2) Fast cooldown (Condition 3)	SSS flow to 1 of 4 steam generators for secondary heat removal SSS flow to 1 of 4 steam generators for partial cooldown SSS flow to 1 of 4 steam generators for fast cooldown	SSS (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 4 steam generators

**Table 19A-1—Event-Tree Headings for Initiating Event 31BDA: Loss of Divisional Emergency AC Power
Sheet 2 of 3**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
EFW	EFW available for: Secondary heat removal (Condition 1) Partial cooldown (Condition 2) Fast cooldown (Condition 3)	1 of 4 EFW trains available for secondary heat removal 1 of 4 EFW trains available for partial cooldown 1 of 4 EFW trains available for fast cooldown	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP FB	Operators initiate feed-and-bleed cooling for: Transient, within 90 min (Condition 1) SLOCA (i.e., RCP seal LOCA), within 40 min (Condition 2)	Initiation of feed-and-bleed within 90 min Initiation of feed-and-bleed within 40 min	OPE-FB-90M (basic event) OPE-FB-40M (basic event)	Operators fail to initiate feed-and-bleed within 90 min for transient Operators fail to initiate feed-and-bleed for SLOCA
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADVs and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and safeties) on a steam generator
MHSI 01	MHSI available for feed-and-bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains

**Table 19A-1—Event-Tree Headings for Initiating Event 31BDA: Loss of Divisional Emergency AC Power
Sheet 3 of 3**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LHSI	LHSI available for injection and containment heat removal, for: Feed-and-bleed cooling (Condition 1) SLOCA (RCP seal LOCA) (Condition 2)	1 of 4 LHSI pumps available 1 of 4 LHSI pumps available (SI signal required)	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode) Failure of 4 of 4 LHSI trains (injection/CHR mode, SI signal needed)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

**Table 19A-2—Event-Tree Headings for ATWS: Failure to Scram Following Loss of Main Feedwater
Sheet 1 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ATWS	Failure to scram following transient	—	ATWS (consequence)	ATWS
PSR	Pressurizer relief with RCP shutdown	Main feedwater available AND 3 of 3 PSR valves open (1 of 3 if RCPs trip)	PSR (FT top gate)	Failure of pressurizer relief or corresponding RCP shutdown during ATWS event
PSV	Pressurizer safety valves reclose	3 of 3 PSR valves reclose	PSV (FT top gate)	Failure of pressurizer relief valves to reclose after opening
EBS	Boration via extra borating system (EBS) for: Intact RCS, PSVs reclose (Condition 1) Stuck-open PSV (Condition 2)	1 of 2 EBS trains available—manual actuation in ATWS 2 of 2 EBS trains available—manual actuation in ATWS	EBS ATWS 2/2 (FT top gate) EBS ATWS ½ (FT top gate)	Failure of boration via EBS—ATWS1 (1 of 2 EBS trains required) Failure of boration via EBS—ATWS2 (2 of 2 EBS trains required)
EFW	EFW available for: Secondary heat removal (Condition 7) Partial cooldown (Condition 8)	EFW to 2 of 4 steam generators available for secondary heat removal with relief by MSRTs EFW to 2 of 4 steam generators available for partial cooldown with relief by MSRTs	EFW ATWS (FT top gate)	Failure of secondary heat removal and secondary cooldown (3 of 4 steam generators)—ATWS

**Table 19A-2—Event-Tree Headings for ATWS: Failure to Scram Following Loss of Main Feedwater
Sheet 2 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
MHSI	MHSI available (Condition 2)	2 of 4 MHSI pumps available	MHSI 3/4 (FT top gate)	Failure of 3 of 4 MHSI trains
LHSI	LHSI available for injection and containment heat removal, safety injection signal required (Condition 2)	1 of 4 LHSI pumps available (SI signal required)	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode, SI signal needed)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

Table 19A-3—Event-Tree Headings for Initiating Event GT: General Transient
Sheet 1 of 2

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
GT	General transient (including turbine trip and reactor trip)	—	IE GT (initiator)	General transient (including turbine trip and reactor trip)
RT	Reactor trip (Condition 1 signals – high RCS pressure or high steam line pressure)	2 out of 4 RPS input signals and 1 out of 2 twice for reactor trip breakers or 2 out of 4 contactors	RT1 (FT top gate)	Failure of reactor trip 1 (turbine-trip type events)
MFW	Main feedwater available	1 of 3 MFW pumps available to deliver flow to 1 of 4 steam generators (main condenser required with turbine bypass)	MFW (FT top gate)	Failure of the MFWS to deliver flow to 1 of 4 SGs or failure of main condenser with turbine bypass
SSS	Startup and shutdown system available for secondary heat removal (Condition 1)	SSS flow to 1 of 4 steam generators for secondary heat removal	SSS (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 4 steam generators
EFW	EFW available for secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP FB	Operators initiate feed and bleed cooling for transient, within 90 min (Condition 1)	Initiation of feed and bleed within 90 min	OPE-FB-90M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator

**Table 19A-3—Event-Tree Headings for Initiating Event GT: General Transient
Sheet 2 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains
LHSI	LHSI available for injection and containment heat removal, for feed and bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRs to provide cooling to the IRWST

Table 19A-4—Event-Tree Headings for Initiating Event IND SGTR: Induced Steam Generator Tube Rupture

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
IND SGTR	Induced steam generator tube rupture	—	IE IND SGTR (initiator)	Induced SGTR
EFW	EFW available for PCD (Condition 4)	1 of 3 EFW trains available for secondary heat removal	EFW SGTR (FT top gate)	Failure of 3 of 3 EFW trains (with MSRTs)
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP RHR	Operators initiate secondary cooldown and align RHR in 4 hr (Condition 1)	Initiation of secondary cooldown within 4 hr	OPE-RHR-4H (basic event)	Operators fail to initiate RHR within 4 hr
RHR	RHR	1 of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains for RHR

**Table 19A-5—Event-Tree Headings for Initiating Event ISL-CCW RCPTB:
ISLOCA Due to RCP Thermal Barrier Tube Break**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ISL-CCW-RCPTB	ISLOCA due to break in RCP thermal barrier tube, allowing overpressure of CCW piping	—	IE IND SGTR (initiator)	ISLOCA due to break in RCP thermal barrier tube, allowing overpressure of CCW piping
OP RHR	Operators initiate secondary cooldown and align RHR in 4 hr (Condition 1)	Initiation of secondary cooldown within 4 hr	OPE-RHR-4H (basic event)	Operators fail to initiate RHR within 4 hr
RHR	RHR	1 of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains for RHR

**Table 19A-6—Event-Tree Headings for Initiating Event ISL-CVCS HPTR:
ISLOCA Due to Tube Rupture in CVCS High Pressure Cooler**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ISL-CVCS HPTR	ISLOCA due to rupture of tube in CVCS high pressure cooler (0.4” tube)	—	IE ISL-CVCS HPTR (initiator)	ISLOCA due to rupture of tube in CVCS high pressure cooler
OP RHR	Operators initiate secondary cooldown and align RHR; medium dependence conditional on failure to isolate the ISLOCA (Condition 2)	Initiation of secondary cooldown with medium dependence	OPD-RHR4H/ISLOCA (basic event)	Operators fail to initiate RHR within 4 hr; medium dependence conditional on failure to isolate ISLOCA
RHR	RHR	1 of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains for RHR

**Table 19A-7—Event-Tree Headings for Initiating Event ISL-CVCS INJ:
ISLOCA Due to Rupture of High Pressure CVCS Pipe Outside Containment**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ISL-CVCS INJ	ISLOCA due to rupture of high pressure CVCS pipe outside containment	—	IE ISL-CVCS INJ (initiator)	ISLOCA due to rupture of high pressure CVCS pipe outside containment

**Table 19A-8—Event-Tree Headings for Initiating Event ISL-CVCS REDS:
ISLOCA Due to Spurious Opening of Reducing Station**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ISL-CVCS REDS	ISLOCA due to spurious opening of reducing station	—	IE ISL-CVCS HPTR (initiator)	ISLOCA due to rupture of tubein CVCS high pressure cooler
OP RHR	Operators initiate secondary cooldown and align RHR; medium dependence conditional on failure to isolate the ISLOCA (Condition 2)	Initiation of secondary cooldown with medium dependence	OPE/D-RHR4H/ISLOCA (basic event)	Operators fail to initiate RHR within 4 hr; medium dependence conditional on failure to isolate ISLOCA
RHR	RHR	1 of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains for RHR

**Table 19A-9—Event-Tree Headings for Initiating Event ISL-SIS LHSI:
ISLOCA Due to Break in LHSI Cold Leg Injection Valves with LHSI Rupture in Respective SAB**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ISL-SIS LHSI	ISLOCA due to break in LHSI cold leg injection valves with LHSI break in respective SAB	—	IE ISL-SIS LHSI-CL8 (initiator)	ISLOCA due to break in LHSI cold leg injection valves with LHSI break in respective SAB

**Table 19A-10—Event-Tree Headings for Initiating Event ISL-SIS MHSI:
ISLOCA Due to Break in MHSI Cold Leg Injection Valves with MHSI Rupture in Respective SAB**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ISL-SIS MHSI	ISLOCA due to break in MHSI cold leg injection valves with MHSI break in respective SAB	—	IE ISL-SIS MHSI-CL6 (initiator)	ISLOCA due to break in MHSI cold leg injection valves with MHSI break in respective SAB

**Table 19A-11—Event-Tree Headings for Initiating Event ISL-SIS RHR:
ISLOCA Due to Failure of Suction Line MOVs and Subsequent RHR Line Rupture in Respective SAB**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ISL-SIS RHR	ISLOCA due to failure of suction line MOVs and subsequent RHR line rupture in respective SAB	—	IE ISL-SIS RHR-CL1 (initiator)	ISLOCA due to failure of suction line MOVs and subsequent RHR line rupture in respective SAB

**Table 19A-12—Event-Tree Headings for Initiating Event LBOP:
Loss of Balance of Plant Closed Loop Cooling Water or Auxiliary Cooling Water**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LBOP	Loss of balance of plant closed loop cooling water or auxiliary cooling water	—	IE LBOP (initiator)	Loss of balance of plant closed loop cooling water or auxiliary cooling water
RT	Reactor trip (Condition 2 signals – low DNBR or low steam generator level)	2 out of 4 RPS input signals and 1 out of 2 twice for reactor trip breakers or 2 out of 4 contactors	RT2 (FT top gate)	Failure of reactor trip 2 (loss-of-feedwater type events)
EFW	EFW available for secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP FB	Operators initiate feed and bleed cooling for transient, within 90 min (Condition 1)	Initiation of feed and bleed within 90 min	OPE-FB-90M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTs and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains
LHSI	LHSI available for injection and containment heat removal, for feed and bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRs to provide cooling to the IRWST

Table 19A-13—Event-Tree Headings for Initiating Event LLOCA: Large Loss-of-Coolant Accident

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LLOCA	Large LOCA	—	IE LLOCA (initiator)	Large LOCA (> 6” in diameter)
MHSI	MHSI available	1 of 4 MHSI trains available for injection [Train 4 failed by initiator]	MHSI 4/4 (FT top gate)	Failure of 4 of 4 MHSI trains [Train 4 failed by initiator]
ACC	Accumulator injection available with Success of MHSI (Condition 2)	1 of 3 accumulators	ACC 3/3	Failure of 3 of 3 accumulator trains (train 4 unavailable due to initiator)
	Failure of MHSI (Condition 4)	2 of 3 accumulators	ACC 2/3	Failure of 2 of 3 accumulator trains (train 4 unavailable due to initiator)
LHSI	LHSI available for injection and containment heat removal, with actuation via safety injection signal required (Condition 2)	1 of 4 LHSI pumps available [Train 4 failed by initiator]	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode); SI signal needed [Train 4 failed by initiator]

Table 19A-14—Event-Tree Headings for Initiating Event LOC: Loss of Main Condenser
Sheet 1 of 2

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LOC	Loss of main condenser (including MSIV closure)	—	IE LOC (initiator)	Loss of main condenser
RT	Reactor trip (Condition 2 signals – low DNBR or low steam generator level)	2 out of 4 RPS input signals and 1 out of 2 twice for reactor trip breakers or 2 out of 4 contactors	RT2 (FT top gate)	Failure of reactor trip 2 (loss-of-feedwater type events)
SSS	Startup and shutdown system available for secondary heat removal (Condition 1)	SSS flow to 1 of 4 steam generators for secondary heat removal	SSS (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 4 steam generators
EFW	EFW available for secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP FB	Operators initiate feed and bleed cooling for transient, within 90 min (Condition 1)	initiation of feed and bleed within 90 min	OPE-FB-90M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains

**Table 19A-14—Event-Tree Headings for Initiating Event LOC: Loss of Main Condenser
Sheet 2 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LHSI	LHSI available for injection and containment heat removal, for feed and bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

Table 19A-15—Event-Tree Headings for Initiating Event LOCCW: Loss of CCWS or ESWS
Sheet 1 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LOCCW	Consequence*—loss of component cooling water or emergency service water	—	LOCCW (consequence)	Loss of component cooling water or emergency service water
RCP LOCA	RCP seal LOCA does not occur	Seal injection with CVCS or seal cooling with CCWS or standstill seal actuation or seals withstand challenge	RCP LOCA (FT top gate)	RCP seal LOCA
MHSI	MHSI available	1 of 4 MHSI trains available for injection	MHSI 4/4 (FT top gate)	Failure of 4 of 4 MHSI trains
OP FCD	Operators initiate fast cooldown (Condition 1)	Initiation within 40 min	OPE-FCD-40M (basic event)	Operators fail to initiate fast cooldown for SLOCA
MFW	Main feedwater available	1 of 3 MFW pumps available to deliver flow to 1 of 4 steam generators (main condenser required with turbine bypass)	MFW (FT top gate)	Failure of the MFWS to deliver flow to 1 of 4 SGs or failure of main condenser with turbine bypass
SSS	Startup and shutdown system available for: Secondary heat removal (Condition 1) Partial cooldown (Condition 2) Fast cooldown (Condition 3)	SSS flow to 1 of 4 steam generators for secondary heat removal SSS flow to 1 of 4 steam generators for partial cooldown SSS flow to 1 of 4 steam generators for fast cooldown	SSS (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 4 steam generators

Table 19A-15—Event-Tree Headings for Initiating Event LOCCW: Loss of CCWS or ESWS
Sheet 2 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
EFW	<p>EFW available for Secondary heat removal (Condition 1)</p> <p>Partial cooldown (Condition 2)</p> <p>Fast cooldown (Condition 3)</p>	<p>1 of 4 EFW trains available for secondary heat removal</p> <p>1 of 4 EFW trains available for partial cooldown</p> <p>1 of 4 EFW trains available for fast cooldown</p>	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP FB	<p>Operators initiate feed and bleed cooling for:</p> <p>Transient, within 90 min (Condition 1)</p> <p>SLOCA (RCP seal LOCA), within 40 min (Condition 2)</p>	<p>Initiation of feed and bleed within 90 min</p> <p>Initiation of feed and bleed within 40 min</p>	<p>OPE-FB-90M (basic event)</p> <p>OPE-FB-40M (basic event)</p>	<p>Operators fail to initiate feed and bleed within 90 min for transient</p> <p>Operators fail to initiate feed and bleed for SLOCA</p>
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains

Table 19A-15—Event-Tree Headings for Initiating Event LOCCW: Loss of CCWS or ESWS
Sheet 3 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LHSI	LHSI available for injection and containment heat removal, for: Feed-and-bleed cooling (Condition 1) SLOCA (RCP seal LOCA) (Condition 2) Only injection required, FCD (Condition 3)	1 of 4 LHSI pumps available 1 of 4 LHSI pumps available (SI signal required) 1 of 4 LHSI pumps available (injection only, SI signal required)	LHSI CHR 4/4 (FT top gate) LHSI CHR 4/4 (FT top gate) LHSI INJ 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode) Failure of 4 of 4 LHSI trains (injection/CHR mode, SI signal needed) Failure of 4 of 4 LHSI trains (injection mode only)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

*This event-tree structure is used for several initiating events involving losses of the CCWS or ESWS, including events LOCCW1, LOCCW12, LOCCW14-CH1, LOCCW14-CH12, LOCCW1L, LOCCW-ALL and LOCCW-CH1L.

**Table 19A-16—Event-Tree Headings for Initiating Event LOMFW: Loss of Main Feedwater
Sheet 1 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LOMFW	Total loss of main feedwater	—	IE LOMFW (initiator)	Total loss of main feedwater
RT	Reactor trip (Condition 2 signals – low DNBR or low steam generator level)	2 out of 4 RPS input signals and 1 out of 2 twice for reactor trip breakers or 2 out of 4 contactors	RT2 (FT top gate)	Failure of reactor trip 2 (loss-of-feedwater type events)
SSS	Startup and shutdown system available for secondary heat removal (Condition 1)	SSS flow to 1 of 4 steam generators for secondary heat removal	SSS (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 4 steam generators
EFW	EFW available for secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP FB	Operators initiate feed and bleed cooling for transient, within 90 min (Condition 1)	initiation of feed and bleed within 90 min	OPE-FB-90M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains

**Table 19A-16—Event-Tree Headings for Initiating Event LOMFW: Loss of Main Feedwater
Sheet 2 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LHSI	LHSI available for injection and containment heat removal, for feed and bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

Table 19A-17—Event-Tree Headings for Initiating Event LOOP: Loss of Offsite Power
Sheet 1 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LOOP	Loss of offsite power	—	IE LOOP (initiator)	Loss of offsite power
EDG	EDG buses available	1 of 4 EDGs available	EDG (FT top gate)	Failure of EDG buses
RT	Reactor trip (Condition 1 signals – high RCS pressure or high steam line pressure)	2 out of 4 RPS input signals and 1 out of 2 twice for reactor trip breakers or 2 out of 4 contactors	RT1 (FT top gate)	Failure of reactor trip 1 (turbine trip-type events)
I&C	Power supply for I&C available for 2-hr duration of LOOP	1 of 4 I&C buses available	I&C (FT top gate)	Failure of I&C buses during a LOOP
MSR	Main steam relief (Condition 1)	Steam relief from 4 of 4 steam generators secondary heat removal mode	MSR (FT top gate)	Failure of steam relief from 1 of 4 steam generators
RCP LOCA	RCP seal LOCA does not occur	Seal injection with CVCS or seal cooling with CCWS or standstill seal actuation or seals withstand challenge	RCP LOCA (FT top gate)	RCP seal LOCA
REC LOOP	Recovery of offsite power within: 1 hr (Condition 1) [RCP seal LOCA] 2 hr (Condition 2)	Recovery within 1 hr Recovery within 2 hr	REC OSP 1HR REC OSP 2 HR (basic events)	Failure to recover offsite power within 1 hr Failure to recover offsite power within 2 hr
SBO	Station blackout diesel-generator buses available	Div 1 or Div 4 BDC bus supplied from either its emergency power bus BDA or its SBO diesel supplied bus BBH	SBO (FT top gate)	Failure of power at 31BDC and 34BDC from both normal, emergency and station blackout diesel generator buses

Table 19A-17—Event-Tree Headings for Initiating Event LOOP: Loss of Offsite Power
Sheet 2 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
MHSI	MHSI available	1 of 4 MHSI trains available for injection	MHSI 4/4 (FT top gate)	Failure of 4 of 4 MHSI trains
OP FCD	Operators initiate fast cooldown within 40 minutes No station blackout (Condition 1) Station blackout (Condition 3)	Initiation of fast cooldown within 40 min	OPE-FCD-40M (basic event) OPE-FCD40MSBO (basic event)	Operators fail to initiate fast cooldown within 40 min
EFW	EFW available for: Secondary heat removal (Condition 1) Partial cooldown (Condition 2) Fast cooldown (Condition 3)	1 of 4 EFW trains available for secondary heat removal 1 of 4 EFW trains available for partial cooldown 1 of 4 EFW trains available for fast cooldown	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP FB	Operators initiate feed and bleed cooling for Transient, within 90 min (Condition 1) SLOCA (RCP seal LOCA), within 40 min (Condition 2)	Initiation of feed and bleed within 90 min Initiation of feed and bleed within 40 min	OPE-FB-90M (basic event) OPE-FB-40M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient Operators fail to initiate feed and bleed for SLOCA

Table 19A-17—Event-Tree Headings for Initiating Event LOOP: Loss of Offsite Power
Sheet 3 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains
LHSI	LHSI available for injection and containment heat removal, for: Feed-and-bleed cooling (Condition 1) SLOCA (RCP seal LOCA) (Condition 2) Only injection required, FCD (Condition 3)	1 of 4 LHSI pumps available 1 of 4 LHSI pumps available (SI signal required) 1 of 4 LHSI pumps available (injection only, SI signal required)	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode) Failure of 4 of 4 LHSI trains (injection/CHR mode, SI signal needed) Failure of 4 of 4 LHSI trains (injection mode only)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRs to provide cooling to the IRWST

Table 19A-18—Event-Tree Headings for Initiating Event MLOCA: Medium Loss-of-Coolant-Accident
Sheet 1 of 2

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
MLOCA	Medium LOCA (3 to 6" break)	—	IE MLOCA (initiator)	Medium LOCA (3 to 6" break)
MHSI	MHSI available	1 of 4 MHSI trains available for injection [Train 4 failed by initiator]	MHSI 4/4 (FT top gate)	Failure of 4 of 4 MHSI trains [Train 4 failed by initiator]
OP FCD	Operators initiate fast cooldown within 30 min (Condition 2)	Initiation of fast cooldown within 30 min	OPE-FCD-30M (basic event)	Operators fail to initiate fast cooldown within 30 min for a medium LOCA
MSR	Main steam relief Partial Cooldown (Condition 2) Fast Cooldown (Condition 3)	Steam relief from 4 of 4 steam generators	MSR (FT top gate)	Failure of 1 of 4 steam generator steam relief
OP FB	Operators initiate feed and bleed cooling within 30 min (Condition 3)	Initiation of feed and bleed within 30 min	OPE-FB-30M (basic event)	Operators fail to initiate feed and bleed within 30 min for medium LOCA
PBL	Primary bleed available for medium LOCA (Condition 2)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief from 1 of 4 steam generators	PBL MLOCA (FT top gate)	Failure of a PSV and both SADVs or all steam generator relief valves (MSRTS and MSSVs)
ACC	Accumulator injection available with: Success of MHSI and MSR (Condition 2) Failure of MHSI or MSR (Condition 3)	1 of 3 accumulators available	ACC 3/3	Failure of 3 of 3 accumulator trains (train 4 unavailable due to initiator)

**Table 19A-18—Event-Tree Headings for Initiating Event MLOCA: Medium Loss-of-Coolant-Accident
Sheet 2 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
LHSI	LHSI available for injection and containment heat removal, for: SI signal not required (Condition 1)	1 of 3 LHSI pumps [Train 4 failed by initiator]	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode) [Train 4 failed by initiator]
	SI signal required (Condition 2)	1 of 3 LHSI pumps available (SI signal required) [Train 4 failed by initiator]		Failure of 4 of 4 LHSI trains (injection/CHR mode, SI signal needed) [Train 4 failed by initiator]
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

Table 19A-19—Event-Tree Headings for Initiating Event MSSV: Spurious Opening of Main Steam Safety Valve
Sheet 1 of 2

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
MSSV	Spurious opening of MSSV	—	IE MSSV (initiator)	Spurious opening of MSSV
MSIV ISO	MSIV isolation of affected steam generators	3 of 4 steam generators isolated	(FT top gates) MSIV ISO SLBI 1	Failure to isolate affected steam generators: 2 blowing down Failure to isolate affected steam generators: 3 or more blowing down
	Two steam generators blowing down (Condition 4)	2 steam generators isolated	MSIV ISO SLBI 2	
	Three steam generators blowing down (Condition 5)	1 steam generator isolated		
EBS	Boration via extra borating system (EBS) for steam line break (Condition 3)	1 of 2 EBS trains available—manual actuation	EBS SLB 2/2 (FT top gate)	Failure of boration via EBS (1 of 2 EBS trains required)
OP RHR	Operators initiate secondary cooldown and align RHR (Condition 1)	Initiation of secondary cooldown within 4 hours	OPE-RHR-4H (basic event)	Operators fail to initiate RHR within 4 hr
EFW	EFW available for: Secondary heat removal, three steam generators available (Condition 5)	1 of 3 EFW trains available for secondary heat removal	EFW SLB 3/3 (FT top gate)	Failure of secondary heat removal and secondary cooldown
	Secondary heat removal, two steam generators available (Condition 6)	1 of 2 EFW trains available for secondary heat removal	EFW SLB 2/2 (FT top gate)	
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
RHR	RHR available for secondary heat removal	1 of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains for RHR

Table 19A-19—Event-Tree Headings for Initiating Event MSSV: Spurious Opening of Main Steam Safety Valve
Sheet 2 of 2

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
OP FB	Operators initiate feed and bleed cooling within 90 min (Condition 1)	Initiation of feed and bleed within 90 min	OPE-FB-90M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains
LHSI	LHSI available for injection and containment heat removal, for feed and bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

**Table 19A-20—Event-Tree Headings for Initiating Event SGTR: Steam Generator Tube Rupture
Sheet 1 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
SGTR	Steam generator tube rupture	—	IE SGTR (initiator)	Steam generator tube rupture
SG ISO	Operators isolate affected steam generators	Automatic isolation or operator isolation	SG ISO (FT top gate)	Failure to isolate affected steam generator
SSS	Startup and shutdown system available for secondary heat removal (Condition 4)	SSS flow to 1 of 3 steam generators for secondary heat removal	SSS SGTR (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 3 steam generators
EFW	EFW available for partial cooldown, three steam generators available (Condition 4)	1 of 3 EFW trains available for partial cooldown	EFW SGTR	Failure of 1 of 3 EFW trains (with MSRTs)
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
OP RHR	Operators initiate secondary cooldown and align RHR (Condition 1)	initiation of secondary cooldown within 4 hours	OPE-RHR-4H (basic event)	Operators fail to initiate RHR within 4 hr
RHR	RHR available for secondary heat removal	1 of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains for RHR
OP FB	Operators initiate feed and bleed cooling within 90 min (Condition 1)	initiation of feed and bleed within 90 min	OPE-FB-90M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed

**Table 19A-20—Event-Tree Headings for Initiating Event SGTR: Steam Generator Tube Rupture
Sheet 2 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains
LHSI	LHSI available for injection and containment heat removal for feed and bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

Table 19A-21—Event-Tree Headings for Initiating Event SLBI: Steam-Line Break Inside Containment
Sheet 1 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
SLBI	Steam-line break inside containment	—	IE SLBI (initiator)	Initiator—large steam-line break inside containment
MSIV ISO	MSIV isolation of affected steam generators	3 of 4 steam generators isolated	(FT top gates) MSIV ISO SLBI 1	Failure to isolate affected steam generators: 2 blowing down Failure to isolate affected steam generators: 3 blowing down
	Two steam generators blowing down (Condition 4)	2 steam generators isolated		
	Three steam generators blowing down (Condition 5)	1 steam generator isolated	MSIV ISO SLBI 2	
FW ISO	MFW and SSS isolated to affected steam generator(s): One steam generator (Condition 1)	Feedwater lines to 1 of 1 affected steam generator isolated	FW ISO TR4 (FT top gate)	Failure to isolate feedwater to steam generator 4
	Two steam generators (Condition 2)	Feedwater lines to 2 of 2 affected steam generators isolated	FW ISO (FT top gate)	Failure to isolate feedwater to two affected steam generators
EBS	Boration via extra borating system (EBS) for steam line break (Condition 3)	1 of 2 EBS trains available—manual actuation	EBS SLB 2/2 (FT top gate)	Failure of boration via EBS (1 of 2 EBS trains required)
OP RHR	Operators initiate secondary cooldown and align RHR (Condition 1)	initiation of secondary cooldown within 4 hr	OPE-RHR-4H (basic event)	Operators fail to initiate RHR within 4 hr;

Table 19A-21—Event-Tree Headings for Initiating Event SLBI: Steam-Line Break Inside Containment
Sheet 2 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
EFW	EFW available for: Secondary heat removal, three steam generators available (Condition 5)	1 of 3 EFW trains available for secondary heat removal	EFW SLB 3/3 (FT top gate)	Failure of secondary heat removal and secondary cooldown
	Secondary heat removal, two steam generators available (Condition 6)	1 of 2 EFW trains available for secondary heat removal	EFW SLB 2/2 (FT top gate)	
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
RHR	RHR available for secondary heat removal	1 of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains for RHR
OP FB	Operators initiate feed and bleed cooling within 90 min (Condition 1)	initiation of feed and bleed within 90 min	OPE-FB-90M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains
LHSI	LHSI available for injection and containment heat removal, for feed and bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode)

**Table 19A-21—Event-Tree Headings for Initiating Event SLBI: Steam-Line Break Inside Containment
Sheet 3 of 3**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

**Table 19A-22—Event-Tree Headings for Initiating Event SLBO: Steam-Line Break Outside Containment
Sheet 1 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
SLBO	Steam-line break downstream of MSIV	—	IE SLBI (initiator)	Initiator—large steam-line break inside containment
MSIV ISO	MSIV isolation of affected steam generators, with:	4 of 4 steam generators isolated		
	One steam generator blowing down (Condition 1)	3 steam generators isolated	MSIV ISO SLBO 1/4	Failure of 1 of 4 MSIV train to isolate
	Two steam generators blowing down (Condition 2)	2 steam generator isolated	MSIV ISO SLBO 2/4	Failure of 2 of 4 MSIV trains to isolate
	Three steam generators blowing down (Condition 3)	1 steam generator isolated	MSIV ISO SLBO 3/4	Failure of 3 of 4 MSIV trains to isolate
EBS	Boration via extra borating system (EBS) for steam line break (Condition 3)	1 of 2 EBS trains available—manual actuation	EBS SLB 2/2 (FT top gate)	Failure of boration via EBS (1 of 2 EBS trains required)
OP RHR	Operators initiate secondary cooldown and align RHR (Condition 1)	Initiation of secondary cooldown within 4 hr	OPE-RHR-4H (basic event)	Operators fail to initiate RHR within 4 hr
EFW	EFW available for:			
	Secondary heat removal, four steam generators available (Condition 1)	1 of 4 EFW trains available for secondary heat removal	EFW	Failure of secondary heat removal and secondary cooldown
	Secondary heat removal, three steam generators available (Condition 5)	1 of 3 EFW trains available for secondary heat removal	EFW SLB 3/3 (FT top gate)	Failure of secondary heat removal and secondary cooldown, 3 steam generators available
Secondary heat removal, two steam generators available (Condition 6)	1 of 2 EFW trains available for secondary heat removal	EFW SLB 2/2 (FT top gate)	Failure of secondary heat removal and secondary cooldown, 2 steam generators available	

**Table 19A-22—Event-Tree Headings for Initiating Event SLBO: Steam-Line Break Outside Containment
Sheet 2 of 2**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary
RHR	RHR available for secondary heat removal	1 of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains for RHR
OP FB	Operators initiate feed and bleed cooling within 90 min (Condition 1)	initiation of feed and bleed within 90 min	OPE-FB-90M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
MHSI 01	MHSI available for feed and bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 FB (FT top gate)	Failure of 4 of 4 MHSI trains for feed and bleed
ACC	Accumulator injection available (Condition 1)	1 of 4 accumulators available	ACC 4/4 (FT top gate)	Failure of 4 of 4 accumulator trains
LHSI	LHSI available for injection and containment heat removal, for feed and bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode)
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRs to provide cooling to the IRWST

Table 19A-23—Event-Tree Headings for Initiating Event SLOCA: Small Loss-of-Coolant Accident
Sheet 1 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
SLOCA	Small loss-of-coolant accident	—	IE SLOCA (initiator)	Initiator—small LOCA (0.6 to 3” equivalent diameter)
MHSI	MHSI available for safety injection	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 of 4 MHSI trains for safety injection
OP FCD	Operators initiate fast cooldown within 40 min	Initiation of fast cooldown within 40 min	OPE-FCD-40M (basic event)	Operators fail to initiate fast cooldown within 40 min
SSS	Startup and shutdown system available for: Partial cooldown (Condition 2) Fast cooldown (Condition 3)	SSS flow to 1 of 4 steam generators for partial cooldown SSS flow to 1 of 4 steam generators for fast cooldown	SSS (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 4 steam generators
EFW	EFW available for Partial cooldown (Condition 2) Fast cooldown (Condition 3)	1 of 4 EFW trains available for partial cooldown 2 of 4 EFW trains available for fast cooldown	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW PBF	EFW maintains pressure boundary conditions	4 of 4 EFW storage pools maintain integrity OR operators maintain adequate inventory after leak	EFW PBF (FT top gate)	Failure of EFW due to loss of inventory upon failure of pressure boundary

Table 19A-23—Event-Tree Headings for Initiating Event SLOCA: Small Loss-of-Coolant Accident
Sheet 2 of 3

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
OP FB	Operators initiate feed and bleed cooling within 90 min with EFW success (Condition 1) 40 min with EFW failure (Condition 2)	initiation of feed and bleed within 90 min initiation of feed and bleed within 40 min	OPE-FB-90M (basic event) OPE-FB-40M (basic event)	Operators fail to initiate feed and bleed within 90 min for transient Operators fail to initiate feed and bleed within 40 min for SLOCA
PBL	Primary bleed available (Condition 1)	3 of 3 PSVs or 1 of 2 SADV and steam generator relief (4 SG)	PBL (FT top gate)	Failure of a PSV and both SADVs or steam generator relief valves (MSRTS and MSSVs) on a steam generator
ACC	Accumulator injection available One accumulator needed (Condition 1) Two accumulators needed (Condition 5)	1 of 4 accumulators available 2 of 4 accumulators available	ACC 4/4 (FT top gate) ACC 3/4 (FT top gate)	Failure of 4 of 4 accumulator trains Failure of 3 of 4 accumulator trains
LHSI	LHSI available for injection and containment heat removal, for: Feed-and-bleed cooling (Condition 1) SLOCA (Condition 2)	1 of 4 LHSI pumps available 1 of 4 LHSI pumps available (SI signal required)	LHSI CHR 4/4 (FT top gate)	Failure of 4 of 4 LHSI trains (injection/CHR mode) Failure of 4 of 4 LHSI trains (injection/CHR mode, SI signal needed)

**Table 19A-23—Event-Tree Headings for Initiating Event SLOCA: Small Loss-of-Coolant Accident
Sheet 3 of 3**

Event-Tree Top Event		Success Criteria	Failure Event	Event Description
SAHR	Severe accident heat removal through recirculation line	1 of 1 SAHR pump available in recirculation mode	SAHR IRWST (FT top gate)	Failure of SAHRS to provide cooling to the IRWST

Figure 19A-1—Loss of Divisional Emergency AC Power

Loss of Divisional Emergency AC (Switchgear 3) (BDA)	(No) RCP Seal LOCA	MHSI 1) 1/4 (1/3 for MLOCA, 1/2 for LLOCA) 2) 2/4	Operator Initiates FSCD 1) 40 min 2) 30 min 3) 40 min During SBO	Main Feedwater	Start-up and shutdown system available for 1) DHR, 2) PCD and 3) FCD 4) PCD 1/5	EFW System Available for 1, 5, 6, 7) SHR, 2, 4, 8) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates F&B 1) <1.5 hr 2) 40 min 3) 30 min	Primary Bleed Available 1) All 2) MLOCA	MHSI for Feed & Bleed 1) 1/4	Accumulator Injection 1) 1/4 2) 1/3 3) 1/4 4) 1/3 5) 2/3 6) 1/4 7) 2/3 8) 1/4 9) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Reactor Line	No.	Freq.	Conseq.	Code
														1		S	
														2		S	MFW
														3		S	MFW-SSS
														4		S	MFW-SSS-EFW PBF
														5		S	MFW-SSS-EFW PBF-LHSI
														6		F, PL	MFW-SSS-EFW PBF-LHSI-SAHR
														7		F, PL1	MFW-SSS-EFW PBF-MHSI 01
														8		F, TR1	MFW-SSS-EFW PBF-PBL
														9		F, TR	MFW-SSS-EFW PBF-OP FB
														10		S	MFW-SSS-EFW
														11		S	MFW-SSS-EFW-LHSI
														12		F, PL	MFW-SSS-EFW-LHSI-SAHR
														13		F, PL1	MFW-SSS-EFW-ACC
														14		F, PL1	MFW-SSS-EFW-MHSI 01
														15		F, TR1	MFW-SSS-EFW-PBL
														16		F, TR	MFW-SSS-EFW-OP FB
														17		S	RCP LOCA
														18		S	RCP LOCA-LHSI
														19		F, SS	RCP LOCA-LHSI-SAHR
														20		S	RCP LOCA-SSS
														21		S	RCP LOCA-SSS-LHSI
														22		F, SS	RCP LOCA-SSS-LHSI-SAHR
														23		S	RCP LOCA-SSS-EFW PBF
														24		S	RCP LOCA-SSS-EFW PBF-LHSI
														25		F, PL	RCP LOCA-SSS-EFW PBF-LHSI-SAHR
														26		F, SS1	RCP LOCA-SSS-EFW PBF-PBL
														27		F, SS2	RCP LOCA-SSS-EFW PBF-OP FB
														28		S	RCP LOCA-SSS-EFW
														29		S	RCP LOCA-SSS-EFW-LHSI
														30		F, PL	RCP LOCA-SSS-EFW-LHSI-SAHR
														31		F, PL1	RCP LOCA-SSS-EFW-ACC
														32		F, SS3	RCP LOCA-SSS-EFW-PBL
														33		F, SS	RCP LOCA-SSS-EFW-OP FB
														34		S	RCP LOCA-MHSI
														35		F, SS	RCP LOCA-MHSI-LHSI
														36		F, SS4	RCP LOCA-MHSI-ACC
														37		S	RCP LOCA-MHSI-SSS
														38		F, SS	RCP LOCA-MHSI-SSS-LHSI
														39		F, SS4	RCP LOCA-MHSI-SSS-ACC
														40		F, SS	RCP LOCA-MHSI-SSS-EFW PBF
														41		F, SS	RCP LOCA-MHSI-SSS-EFW
														42		F, SS5	RCP LOCA-MHSI-OP FCD

EPR6500 T2

Figure 19A-2—Failure to Scram Following Loss of Main Feedwater

ATWS Loss of Main Feedwater	PRZ-Relief With RCP Shutdowns	3/3 PZR Safety Valve Reclosure	Ejection with EBS 1) ATWS 1/2 2) ATWS 2/2 3) SLB 1/2	EFW System Available for 1.5, 6.7) SHR, 2.4, 8) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	MHSI 1) 1/4, 1/3 for W/DOCA, 1/2 for LLOCA 2) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Recirc Line	No.	Freq.	Conseq.	Code
ATWS	PSR	PSV	EBS	EFW	EFW PBF	MHSI	LHSI	SAHR				
									1		S	
									2		AF, ATR, F, TR	EFW PBF
				7					3		AF, ATR, F, TR	EFW
			1						4		AAT, AF, AT, F	EBS
									5		S	PSV
								2	6		S	PSV-LHSI
									7		AF, APL, F, PL	PSV-LHSI-SAHR
						2			8		AF, F, PL1, APL1	PSV-MHSI
									9		AF, F, PL1, APL1	PSV-EFW PBF
				8					10		AF, F, PL1, APL1	PSV-EFW
			2						11		AAT, AF, AT, F	PSV-EBS
									12		AF, ARV, F, RV	PSR

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Figure 19A-3—General Transient

General Transient (Includes Turbine Trip and Reactor Trip)	Reactor Trip	Main Feedwater	Startup and shutdown system available for 1) DHR, 2) PCD and 3) FCD 4) PCD 1/3	EFW System Available for 1) 3/3/3, 2) 4/5, 3) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates F&B 1) <1.5 hr 2) 40 min 3) 30 min	Primary Bleed Available 1) All 2) MLOCA	MHSI for Feed & Bleed 1) 1/4	Accumulator Injection 1) 1/4 2) 1/3 [TR4 U] 3) 3/3 [TR4 U] 4) 2/3 [TR4 U] 5) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Recirc Line	No.	Freq.	Conseq.	Code
GT	RT	MFW	SSS	EFW	EFW PBF	OP FB	PBL	MHSI 01	ACC	LHSI	SAHR				
												1		S	
												2		S	MFW
			1									3		S	MFW-SSS
												4		S	MFW-SSS-EFW PBF
											1	5		S	MFW-SSS-EFW PBF-LHSI
												6		F, PL	MFW-SSS-EFW PBF-LHSI-SAHR
												7		F, PL1	MFW-SSS-EFW PBF-MHSI 01
								1				8		F, TR1	MFW-SSS-EFW PBF-PBL
							1					9		F, TR	MFW-SSS-EFW PBF-OP FB
				1								10		S	MFW-SSS-EFW
											1	11		S	MFW-SSS-EFW-LHSI
												12		F, PL	MFW-SSS-EFW-LHSI-SAHR
											1	13		F, PL1	MFW-SSS-EFW-ACC
												14		F, PL1	MFW-SSS-EFW-MHSI 01
								1				15		F, TR1	MFW-SSS-EFW-PBL
							1					16		F, TR	MFW-SSS-EFW-OP FB
	1											17		ATWS	RT

EPR6510 T2

Figure 19A-4—Induced Steam Generator Tube Rupture

Induced Steam Generator Tube Rupture	EFW System Available (for 1, 5, 6, 7) SHR, 2, 4, 8) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates Secondary Cooldown and Aligns RHR (in 1) 4 (in 3) Medium Dep.	RHR 1) 1/4 (1/3 for (SL-CCW RCPTB))	No.	Freq.	Conseq.	Code
IND SGTR	EFW	EFW PBF	OP RHR	RHR				
					1		S	
					2		F, SG	RHR
			1		3		F, SG	OP RHR
					4		F, SG	EFW PBF
	4				5		F, SG	EFW

EPR6515 T2

Figure 19A-5—ISLOCA Due to RCP Thermal Barrier Tube Break

ISLOCA - CCWS RCP Thermal Barrier Tube Break	Operator Initiates Secondary Cooldown and Aligns RHR in 1, 4 hrs 3) Medium Dep.	RHR 1) 1/4 (1/3 for ISL-CCW RCPTB)				
ISL-CCW RCPTB	OP RHR	RHR	No.	Freq.	Conseq.	Code
			1		S	
			2		F, IS	RHR
1			3		F, IS	OP RHR

EPR6520 T2

Figure 19A-6—ISLOCA Due to Tube Rupture in CVCS High Pressure Cooler

ISLOCA - Tube Rupture High Pressure Letdown Cooler	Operator Initiates Secondary Shutdown and Aligns RHR (in 1) 4 ins 3) Medium Dep.	RHR 1) 1/4 (1/3 for ISL-CCW RCPTB)	No.	Freq.	Conseq.	Code
ISL-CVCS HPTR	OP RHR	RHR				
			1		S	
			2		F, IS	RHR
	2		3		F, IS	OP RHR

EPR6525 T2

Figure 19A-7—ISLOCA Due to Rupture of High Pressure CVCS Pipe Outside Containment

ISLOCA - High Pressure CVCS Pipe Rupture Outside Containment				
ISL-CVCS INJ	No.	Freq.	Conseq.	Code
	1		F, IS	

EPR6530 T2

Figure 19A-8—ISLOCA Due to Spurious Opening of Reducing Station

ISLOCA - Spurious Opening of Reducing Station	Operator Initiates Secondary Shutdown and Alarms: RHR in 1) 4 hrs 3) Medium Dep.	RHR 1) 1/4 (1/3 for ISL-CCW RCPTB)				
ISL-CVCS REDS	OP RHR	RHR	No.	Freq.	Conseq.	Code
			1		S	
			2		F, IS	RHR
		2	3		F, IS	OP RHR

EPR6535 T2

Figure 19A-9—ISLOCA Due to Break in LHSI Cold Leg Injection Valves with LHSI Rupture in Respective SAB

ISLOCA - Break in LHSI Cold Leg Injection Check Valves with LHSI Line Break in Respective SAB	No.	Freq.	Conseq.	Code
ISL-SIS LHSI	1		F, IS	

EPR6540 T2

Figure 19A-10—ISLOCA Due to Break in MHSI Cold Leg Injection Valves with MHSI Rupture in Respective SAB

ISLOCA - Break in MHSI Cold Leg Injection Check Valves with MHSI Line Break in Respective SAB	No.	Freq.	Conseq.	Code
ISL-SIS MHSI	1		F, IS	

EPR6545 T2

Figure 19A-11—ISLOCA Due to Failure of Suction Line MOVs and Subsequent RHR Line Rupture in Respective SAB

ISLOCA - Failure of Suction Line Isolation MOVs and Subsequent RHR Line Break in Respective SAB	No.	Freq.	Conseq.	Code
ISL-SIS RHR				
	1		F, IS	

EPR6550 T2

Figure 19A-12—Loss of Balance of Plant Closed Loop Cooling Water or Auxiliary Cooling Water

Loss of Balance of Plant Closed Loop Cooling Water or Aux Cooling Water	Reactor Trip	EFW System Available for 1, 5, 6, 7) SAHR, 2, 4, 8) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates F&B 1) <1.5 hr 2) 40 min 3) 30 min	Primary Bleed Available 1) All 2) MLOCA	MHSI for Feed & Bleed 1) 1/4	Accumulator Injection 1) 1/4, 2) 1/3 [TR4 U] 3) 3/3 [TR4 U] 4) 2/3 [TR4 U] 5) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Recirc Line	No.	Freq.	Conseq.	Code
LBOP	RT	EFW	EFW PBF	OP FB	PBL	MHSI 01	ACC	LHSI	SAHR				
										1		S	
										2		S	EFW PBF
										3		S	EFW PBF-LHSI
										4		F, PL	EFW PBF-LHSI-SAHR
										5		F, PL1	EFW PBF-MHSI 01
										6		F, TR1	EFW PBF-PBL
										7		F, TR	EFW PBF-OP FB
										8		S	EFW
										9		S	EFW-LHSI
										10		F, PL	EFW-LHSI-SAHR
										11		F, PL1	EFW-ACC
										12		F, PL1	EFW-MHSI 01
										13		F, TR1	EFW-PBL
										14		F, TR	EFW-OP FB
										15		ATWS	RT

EPR6555 T2

Figure 19A-13—Large Loss-of-Coolant Accident

Large LOCA (>6-inch Diameter)	MHSI 1) 1/4, (1/3 for M.LOCA, 1/2 for LLOCA) 2) 2/4	Accumulator Injection 1) 1/4 2) 1/3 [TR4-U] 3) 3/3 [TR4-U] 4) 2/3 [TR4-U] 5) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj. Only	No.	Freq.	Conseq.	Code
LLOCA	MHSI	ACC	LHSI				
				1		S	
			2	2		F, LL	LHSI
		2		3		F, LL1	ACC
	1			4		S	MHSI
			2	5		F, LL	MHSI-LHSI
		4		6		F, LL1	MHSI-ACC

EPR6560 T2

Figure 19A-14—Loss of Main Condenser

Loss of Main Condenser (Includes MSIV Closure etc.)	Reactor Trip	Start-up and shutdown system available for 1) DHR, 2) PCD and 3) FCD, 4) PCD, 1/3	EFW System Available (for 1,5,6,7) SHR, 2,4,8) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates F&B 1) <1.5 hr 2) 40 min 3) 30 min	Primary Bleed Available 1) All 2) MLOCA	MHSI for Feed & Bleed 1) 1/4	Accumulator Injection 1) 1/4 2) 1/3 [TR4 U] 3) 2/3 [TR4 U] 4) 2/3 [TR4 U] 5) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Resirc Line	No.	Freq.	Conseq.	Code
LOC	RT	SSS	EFW	EFW PBF	OP FB	PBL	MHSI 01	ACC	LHSI	SAHR				
											1		S	
		1									2		S	SSS
											3		S	SSS-EFW PBF
										1	4		S	SSS-EFW PBF-LHSI
											5		F, PL	SSS-EFW PBF-LHSI-SAHR
											6		F, PL1	SSS-EFW PBF-MHSI 01
										1	7		F, TR1	SSS-EFW PBF-PBL
					1						8		F, TR	SSS-EFW PBF-OP FB
			1								9		S	SSS-EFW
										1	10		S	SSS-EFW-LHSI
											11		F, PL	SSS-EFW-LHSI-SAHR
										1	12		F, PL1	SSS-EFW-ACC
											13		F, PL1	SSS-EFW-MHSI 01
										1	14		F, TR1	SSS-EFW-PBL
					1						15		F, TR	SSS-EFW-OP FB
	2										16		ATWS	RT

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Figure 19A-15—Loss of Component Cooling Water or Emergency Service Water

Loss of CCW/ESWS	(No) RCP Seal LOCA	MHSI 1) 1/4 (1/3 for MLOCA, 1/2 for LLOCA) 2) 2/4	Operator Initiates FSCD (1) 40 min 2) 30 min 3) 40 min During SBC	Main Feedwater	Start-up and shutdown system available for 1) DHR, 2) PCD and 3) FCD 4) PCD 1/3	EFW System Available for 1.5, 6.7) SHR, 2.4, 8) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates F&B (1) <1.5 hr 2) 40 min 3) 30 min	Primary Bleed Available (1) All 2) MLOCA	MHSI for Feed & Bleed (1) 1/4	Accumulator Injection 1) 1/4 2) 1/3 [TR4 U] 3) 3/3 2/4 [TR4 U] 4) 2/3 [TR4 U] 5) 2/4	LHSI (1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Recirc Line	No.	Freq.	Conseq.	Code
														1		S	
														2		S	MFW
														3		S	MFW-SSS
														4		S	MFW-SSS-EFW PBF
														5		F, PL	MFW-SSS-EFW PBF-LHSI
														6		F, PL1	MFW-SSS-EFW PBF-MHSI 01
														7		F, TR1	MFW-SSS-EFW PBF-PBL
														8		F, TR	MFW-SSS-EFW PBF-OP FB
														9		S	MFW-SSS-EFW
														10		F, PL	MFW-SSS-EFW-LHSI
														11		F, PL1	MFW-SSS-EFW-ACC
														12		F, PL1	MFW-SSS-EFW-MHSI 01
														13		F, TR1	MFW-SSS-EFW-PBL
														14		F, TR	MFW-SSS-EFW-OP FB
														15		S	RCP LOCA
														16		S	RCP LOCA-LHSI
														17		F, SS	RCP LOCA-LHSI-SAHR
														18		S	RCP LOCA-SSS
														19		S	RCP LOCA-SSS-LHSI
														20		F, SS	RCP LOCA-SSS-LHSI-SAHR
														21		S	RCP LOCA-SSS-EFW PBF
														22		F, PL	RCP LOCA-SSS-EFW PBF-LHSI
														23		F, SS1	RCP LOCA-SSS-EFW PBF-PBL
														24		F, SS2	RCP LOCA-SSS-EFW PBF-OP FB
														25		S	RCP LOCA-SSS-EFW
														26		F, PL	RCP LOCA-SSS-EFW-LHSI
														27		F, PL1	RCP LOCA-SSS-EFW-ACC
														28		F, SS3	RCP LOCA-SSS-EFW-PBL
														29		F, SS	RCP LOCA-SSS-EFW-OP FB
														30		S	RCP LOCA-MHSI
														31		F, SS	RCP LOCA-MHSI-SAHR
														32		F, SS	RCP LOCA-MHSI-LHSI
														33		F, SS4	RCP LOCA-MHSI-ACC
														34		S	RCP LOCA-MHSI-SSS
														35		F, SS	RCP LOCA-MHSI-SSS-SAHR
														36		F, SS	RCP LOCA-MHSI-SSS-LHSI
														37		F, SS4	RCP LOCA-MHSI-SSS-ACC
														38		F, SS	RCP LOCA-MHSI-SSS-EFW PBF
														39		F, SS	RCP LOCA-MHSI-SSS-EFW
														40		F, SS5	RCP LOCA-MHSI-OP FCD

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Figure 19A-16—Loss of Main Feedwater

Total Loss of Main Feedwater	Reactor Trip	Start-up and shutdown system available for 1) DHR, 2) PCD and 3) FCD 4) PCD 1/3	EFW System Available for 1) SHR, 2) 4, 5) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates F&B 1) <1.5 hr 2) 40 min 3) 30 min	Primary Bleed Available 1) All 2) MLOCA	MHSI for Feed & Bleed 1) 1/4	Accumulator Injection 1) 1/4 2) 1/3 [TR4 U] 3) 3/3 [TR4 U] 4) 2/3 [TR4 U] 5) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Recirc Line	No.	Freq.	Conseq.	Code
LOMFW	RT	SSS	EFW	EFW PBF	OP FB	PBL	MHSI 01	ACC	LHSI	SAHR				
		1									1		S	
		1									2		S	SSS
											3		S	SSS-EFW PBF
									1		4		S	SSS-EFW PBF-LHSI
											5		F, PL	SSS-EFW PBF-LHSI-SAHR
											6		F, PL1	SSS-EFW PBF-MHSI 01
						1					7		F, TR1	SSS-EFW PBF-PBL
					1						8		F, TR	SSS-EFW PBF-OP FB
			1								9		S	SSS-EFW
									1		10		S	SSS-EFW-LHSI
											11		F, PL	SSS-EFW-LHSI-SAHR
									1		12		F, PL1	SSS-EFW-ACC
											13		F, PL1	SSS-EFW-MHSI 01
						1					14		F, TR1	SSS-EFW-PBL
					1						15		F, TR	SSS-EFW-OP FB
	2										16		ATWS	RT

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Figure 19A-18—Medium Loss-of-Coolant Accident

Medium Break LOCA (3 to 6-inch Diameter)	MLOCA	MHSI	OP FCD	MSR	OP FB	PBL	ACC	LHSI	SAHR	No.	Freq.	Conseq.	Code
Operator Initiates FSCD (1) 40 min (2) 30 min (3) 40 min During SBO										1		S	
								2		2		S	LHSI
				2						3		F, ML	LHSI-SAHR
										4		S	MSR
								1		5		S	MSR-LHSI
										6		F, PL	MSR-LHSI-SAHR
							2			7		F, PL1	MSR-ACC
						2				8		F, ML1	MSR-PBL
					3					9		F, ML2	MSR-OP FB
	1									10		S	MHSI
										11		F, ML	MHSI-LHSI
							2			12		F, ML2	MHSI-ACC
				3						13		S	MHSI-MSR
										14		F, PL	MHSI-MSR-LHSI
							3			15		F, PL1	MHSI-MSR-ACC
						2				16		F, ML1	MHSI-MSR-PBL
					3					17		F, ML2	MHSI-MSR-OP FB
			2							18		F, ML2	MHSI-OP FCD

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Figure 19A-19—Spurious Opening of Main Steam Safety Valve

Spurious Opening of Steam Safety Valve														No.	Freq.	Conseq.	Code
MSSV	MSIV ISO	EBS	OP RHR	EFW	EFW PBF	RHR	OP FB	PBL	MHSI 01	ACC	LHSI	SAHR					
														1		S	
														2		S	EFW PBF
														3		S	EFW PBF-LHSI
														4		F, PL	EFW PBF-LHSI-SAHR
														5		F, PL1	EFW PBF-MHSI 01
														6		F, TR1	EFW PBF-PBL
														7		F, TR	EFW PBF-OP FB
														8		S	EFW
														9		S	EFW-LHSI
														10		F, PL	EFW-LHSI-SAHR
														11		F, PL1	EFW-ACC
														12		F, PL1	EFW-MHSI 01
														13		F, TR1	EFW-PBL
														14		F, TR	EFW-OP FB
														15		S	MSIV ISO(3)
														16		F, TR	MSIV ISO(3)-RHR
														17		S	MSIV ISO(3)-EFW
														18		S	MSIV ISO(3)-EFW-LHSI
														19		F, PL	MSIV ISO(3)-EFW-LHSI-SAHR
														20		F, PL1	MSIV ISO(3)-EFW-ACC
														21		F, PL1	MSIV ISO(3)-EFW-MHSI 01
														22		F, TR1	MSIV ISO(3)-EFW-PBL
														23		F, TR	MSIV ISO(3)-EFW-OP FB
														24		F, TR	MSIV ISO(3)-OP RHR
														25		S	MSIV ISO(4)
														26		S	MSIV ISO(4)-LHSI
														27		F, PL	MSIV ISO(4)-LHSI-SAHR
														28		F, PL1	MSIV ISO(4)-ACC
														29		F, PL1	MSIV ISO(4)-MHSI 01
														30		F, TR1	MSIV ISO(4)-PBL
														31		F, TR	MSIV ISO(4)-OP FB
														32		AT, F	MSIV ISO(4)-EBS

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Figure 19A-20—Steam Generator Tube Rupture

Steam Generator Tube Rupture	Operator Isolation of Impacted SG	Start-up and shutdown system available for 1) DHR, 2) PCD and 3) FCD 4) PCD 1/3	EFW System Available for 1,5,6,7) SHR, 2,4,8) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates Secondary Cooldown and Alarms RHR in 1) 4 hrs, 3) Medium Dep.	RHR 1) 1/4 (1/3 for ISL-CCW RCPTB)	Operator Initiates F&B 1) <1.5 hr 2) 40 min 3) 30 min	Primary Bleed Available 1) All 2) MLOCA	MHSI for Feed & Bleed 1) 1/4	Accumulator Injection 1) 1/4 2) 1/3 [TR4 U] 3) 3/3 [TR4 U] 4) 2/3 [TR4 U] 5) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Recirc Line	No.	Freq.	Conseq.	Code
		4											1		S	
													2		S	SSS
													3		S	SSS-EFW PBF
													4		S	SSS-EFW PBF-LHSI
													5		F, PL	SSS-EFW PBF-LHSI-SAHR
													6		F, PL1	SSS-EFW PBF-MHSI 01(3)
													7		F, SG1	SSS-EFW PBF-PBL
			4										8		F, SG	SSS-EFW PBF-OP FB
													9		S	SSS-EFW
													10		S	SSS-EFW-LHSI
													11		F, PL	SSS-EFW-LHSI-SAHR
													12		F, PL1	SSS-EFW-ACC
													13		F, PL1	SSS-EFW-MHSI 01
													14		F, SG1	SSS-EFW-PBL
													15		F, SG	SSS-EFW-OP FB
													16		S	SG ISO
													17		F, SG2	SG ISO-RHR
		4											18		F, SG2	SG ISO-OP RHR
													19		S	SG ISO-SSS
													20		F, SG2	SG ISO-SSS-RHR
													21		F, SG2	SG ISO-SSS-OP RHR
													22		S	SG ISO-SSS-EFW PBF
													23		S	SG ISO-SSS-EFW PBF-LHSI
													24		F, SG	SG ISO-SSS-EFW PBF-LHSI-SAHR
													25		F, SG	SG ISO-SSS-EFW PBF-MHSI 01
													26		F, SG	SG ISO-SSS-EFW PBF-PBL
													27		F, SG	SG ISO-SSS-EFW PBF-OP FB
			4										28		S	SG ISO-SSS-EFW
													29		S	SG ISO-SSS-EFW-LHSI
													30		F, SG	SG ISO-SSS-EFW-LHSI-SAHR
													31		F, SG	SG ISO-SSS-EFW-ACC
													32		F, SG	SG ISO-SSS-EFW-MHSI 01
													33		F, SG	SG ISO-SSS-EFW-PBL
													34		F, SG	SG ISO-SSS-EFW-OP FB

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Figure 19A-21—Steam-Line Break Inside Containment

SLBI	MSIV ISO	FW ISO	EBS	OP RHR	EFW	EFW PBF	RHR	OP FB	PBL	MHSI 01	ACC	LHSI	SAHR	No.	Freq.	Conseq.	Code
														1		S	
												1		2		S	EFW PBF
														3		S	EFW PBF-LHSI
														4		F, PL	EFW PBF-LHSI-SAHR
									1					5		F, PL1	EFW PBF-MHSI 01
								1		1				6		F, SI1	EFW PBF-PBL
					5									7		F, SI	EFW PBF-OP FB
														8		S	EFW
												1		9		S	EFW-LHSI
														10		F, PL	EFW-LHSI-SAHR
												1		11		F, PL1	EFW-ACC
									1	1				12		F, PL1	EFW-MHSI 01
														13		F, SI1	EFW-PBL
		1							1					14		F, SI	EFW-OP FB
														15		S	FW ISO
					5									16		F, SI	FW ISO-EFW PBF
														17		F, SI	FW ISO-EFW
	4													18		S	MSIV ISO
					6									19		F, SI	MSIV ISO-RHR
														20		S	MSIV ISO-EFW
												1		21		S	MSIV ISO-EFW-LHSI
														22		F, PL	MSIV ISO-EFW-LHSI-SAHR
												1		23		F, PL1	MSIV ISO-EFW-ACC
														24		F, PL1	MSIV ISO-EFW-MHSI 01
									1	1				25		F, SI1	MSIV ISO-EFW-PBL
														26		F, SI	MSIV ISO-EFW-OP FB
		2			1									27		F, SI	MSIV ISO-OP RHR
														28		S	MSIV ISO-FW ISO
														29		F, SI	MSIV ISO-FW ISO-RHR
					6									30		F, SI	MSIV ISO-FW ISO-EFW
														31		F, SI	MSIV ISO-FW ISO-OP RHR
	5													32		S	MSIV ISO(3)
														33		S	MSIV ISO(3)-LHSI
												1		34		F, PL	MSIV ISO(3)-LHSI-SAHR
														35		F, PL1	MSIV ISO(3)-ACC
														36		F, PL1	MSIV ISO(3)-MHSI 01
									1	1				37		F, SI1	MSIV ISO(3)-PBL
														38		F, SI	MSIV ISO(3)-OP FB
														39		F, ATI	MSIV ISO(3)-EBS
		2												40		F, ATI	MSIV ISO(3)-FW ISO

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Figure 19A-22—Steam Line Break Outside Containment

Steam Break Downstream of MSIV													No.	Freq.	Conseq.	Code
SLBO	MSIV ISO	EBS	OP RHR	EFW	EFW PBF	RHR	OP FB	PBL	MHSI 01	ACC	LHSI	SAHR				
													1		S	
													2		S	EFW PBF
													3		S	EFW PBF-LHSI
													4		F, PL	EFW PBF-LHSI-SAHR
													5		F, PL1	EFW PBF-MHSI 01
													6		F, TR1	EFW PBF-PBL
													7		F, TR	EFW PBF-OP FB
													8		S	EFW
													9		S	EFW-LHSI
													10		F, PL	EFW-LHSI-SAHR
													11		F, PL1	EFW-ACC
													12		F, PL1	EFW-MHSI 01
													13		F, TR1	EFW-PBL
													14		F, TR	EFW-OP FB
	1												15		S	MSIV ISO
													16		S	MSIV ISO-EFW PBF
													17		S	MSIV ISO-EFW PBF-LHSI
													18		F, PL	MSIV ISO-EFW PBF-LHSI-SAHR
													19		F, PL1	MSIV ISO-EFW PBF-MHSI 01
													20		F, TR1	MSIV ISO-EFW PBF-PBL
													21		F, TR	MSIV ISO-EFW PBF-OP FB
													22		S	MSIV ISO-EFW
													23		S	MSIV ISO-EFW-LHSI
													24		F, PL	MSIV ISO-EFW-LHSI-SAHR
													25		F, PL1	MSIV ISO-EFW-ACC
													26		F, PL1	MSIV ISO-EFW-MHSI 01
													27		F, TR1	MSIV ISO-EFW-PBL
													28		F, TR	MSIV ISO-EFW-OP FB
	2												29		S	MSIV ISO(3)
													30		F, TR	MSIV ISO(3)-RHR
													31		S	MSIV ISO(3)-EFW
													32		S	MSIV ISO(3)-EFW-LHSI
													33		F, PL	MSIV ISO(3)-EFW-LHSI-SAHR
													34		F, PL1	MSIV ISO(3)-EFW-ACC
													35		F, PL1	MSIV ISO(3)-EFW-MHSI 01
													36		F, TR1	MSIV ISO(3)-EFW-PBL
													37		F, TR	MSIV ISO(3)-EFW-OP FB
													38		F, TR	MSIV ISO(3)-OP RHR
	3												39		S	MSIV ISO(4)
													40		S	MSIV ISO(4)-LHSI
													41		F, PL	MSIV ISO(4)-LHSI-SAHR
													42		F, PL1	MSIV ISO(4)-ACC
													43		F, PL1	MSIV ISO(4)-MHSI 01
													44		F, TR1	MSIV ISO(4)-PBL
													45		F, TR	MSIV ISO(4)-OP FB
													46		AT, F	MSIV ISO(4)-EBS

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Figure 19A-23—Small Loss-of-Coolant Accident

Small LOCA (0.6 to 3-inch Diameter)	MHSI 1/4 (1/3 for MLOCA, 1/2 for LLOCA) 2/2/4	Operator Initiates FSCD (1) 40 min 2) 30 min 3) 40 min During SBO	Start-up and shutdown system available for (1) DHR, 2) PCD and 3) FCD 4) PCD 1/3	EFW System Available for 1.5(6.7) SHR, 2.4(6) PCD and 3) FCD	EFW Maintains Pressure Boundary Conditions	Operator Initiates F&B 1) <1.5 hr 2) 40 min 3) 30 min	Primary Bleed Available 1) All 2) MLOCA	Accumulator Injection 1) 1/4 2) 1/3 (TR4 U) 3) 3/3 (TR4 U) 4) 2/3 (TR4 U) 5) 2/4	LHSI 1) 1/4 2) 1/4 w/SIAS 3) 1/4, Inj Only	Severe Accident Heat Removal Through Recirc Line	No.	Freq.	Conseq.	Code
SLOCA	MHSI	OP FCD	SSS	EFW	EFW PBF	OP FB	PBL	ACC	LHSI	SAHR				
									2		1		S	
											2		S	LHSI
			2										F, SL	LHSI-SAHR
									2		4		S	SSS
											5		S	SSS-LHSI
											6		F, SL	SSS-LHSI-SAHR
									1		7		S	SSS-EFW PBF
											8		S	SSS-EFW PBF-LHSI
											9		F, PL	SSS-EFW PBF-LHSI-SAHR
						1		1			10		F, SL1	SSS-EFW PBF-PBL
											11		F, SL	SSS-EFW PBF-OP FB
				2							12		S	SSS-EFW
											13		S	SSS-EFW-LHSI
											14		F, PL	SSS-EFW-LHSI-SAHR
								1			15		F, PL1	SSS-EFW-ACC
											16		F, SL1	SSS-EFW-PBL
	1					2					17		F, SL	SSS-EFW-OP FB
											18		S	MHSI
											19		F, SL	MHSI-LHSI
											20		F, SL	MHSI-ACC
			3								21		S	MHSI-SSS
											22		F, SL	MHSI-SSS-LHSI
											23		F, SL	MHSI-SSS-ACC
											24		S	MHSI-SSS-EFW PBF
											25		F, PL	MHSI-SSS-EFW PBF-LHSI
											26		F, PL1	MHSI-SSS-EFW PBF-ACC
											27		F, SL1	MHSI-SSS-EFW PBF-PBL
						1					28		F, SL	MHSI-SSS-EFW PBF-OP FB
				3							29		S	MHSI-SSS-EFW
											30		F, PL	MHSI-SSS-EFW-LHSI
											31		F, PL1	MHSI-SSS-EFW-ACC
											32		F, SL1	MHSI-SSS-EFW-PBL
											33		F, SL	MHSI-SSS-EFW-OP FB
		1				2					34		F, SL	MHSI-OP FCD

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