

#### 19A

#### Event Trees for Core Damage Sequences Initiated During Power Operation

Appendix 19A presents the event 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
BDA	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	O SGTR Induced Steam Generator Tube Rupture	
ISL-CCW RCPTB	ISLOCA Due to RCP Thermal Barrier Tube Break	19A-5
ISL-CVCS HPTR	ISLOCA Due to Tube Rupture in CVCS High Pressure Cooler	19A-6
ISL-CVCS INJ	ISLOCA Due to Rupture of High Pressure CVCS Pipe Outside Containment	19A-7
ISL-CVCS REDS	ISLOCA Due to Spurious Opening of Reducing Station	19A-8
ISL-SIS LHSI	ISLOCA Due to Break in LHSI Cold Leg Injection Valves with LHSI Rupture in Respective SAB	19A-9
ISL-SIS MHSI	ISLOCA Due to Break in MHSI Cold Leg Injection Valves with MHSI Rupture in Respective SAB	19A-10
ISL-SIS RHR	ISLOCA Due to Failure of Suction Line MOVs and Subsequent RHR Line Rupture in Respective SAB	19A-11
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 BDA: Loss of Divisional Emergency AC Power Sheet 1 of 3

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
BDA	Consequence* - loss of divisional emergency AC (switchgear BDA)	_	IE BDA (consequence)	Loss of divisional emergency AC (switchgear BDA)
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 (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
OP FCD	Operator initiates fast cooldown within 40 min (Condition 1)	Action within 40 min	OPE-FCD-40M (basic event)	Operator fails to initiate fast cooldown for SLOCA
MFW	Main feedwater available	1 of 4 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 STs and to remove steam via 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 – normal 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 BDA: Loss of Divisional Emergency AC Power Sheet 2 of 3

E E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
EFW	EFW available for:		EFW	Failure of secondary heat removal and
	Secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal (MSRVs or MSSVs)	(FT top gate)	secondary cooldown
	Partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)		
	Fast cooldown (Condition 3)	1 of 4 EFW trains available for fast cooldown (MSRVs only)		
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed-and- bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed-and- bleed for transient
	SLOCA (i.e., RCP seal LOCA), within 40 min (Condition 3)	Initiation of feed-and-bleed within 40 min	OPE-FB-40M (basic event)	Operator fails to initiate feed-and- bleed for SLOCA
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT tope gate)	Failure of 4 out of 4 MHSI trains



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

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)
	Long Term Cooling of IRWST via LHSI or SAHR (Condition 2)	1 of 4 LHSI trains (with Htx) available (SI signal required) OR 1 of 1 SAHR pump available in recirculation mode		

\*This event tree structure is used for several initiating events in addition to BDA which includes FIRE-BATT, FIRE-CSR, FIRE-SAB14-ELEC, FIRE-SAB23-ELEC and FIRE-SAB-MECH.



## Table 19A-2—Event Tree Headings for ATWS: Failure to ScramSheet 1 of 2

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
ATWS	Consequence* - anticipated transient without scram	-	ATWS (consequence)	ATWS – Anticipated Transient Without Scram
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)	1 of 2 EBS trains available – manual actuation in ATWS	EBS ATWS 2/2 (FT top gate)	Failure of boration via EBS – ATWS 1 (1 of 2 EBS trains required)
	Stuck-open PSV (Condition 2)	2 of 2 EBS trains – manual actuation in ATWS	EBS ATWS ½ (FT top gate)	Failure of boration via EBS – ATWS 1 (1 of 2 EBS trains required)
EFW	EFW available for:	EFW ATWS		Failure of secondary heat removal and
	Secondary hear removal (Condition 7)	EFW to 2 of 4 steam generators available for secondary heat removal with relief by MSRTs	(FT top gate)	secondary cooldown (3 of 4 steam generators) – ATWS
	Partial cooldown (Condition 8)	EFW to 2 of 4 steam generators available for partial cooldown with relief by MSRTs		
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
MHSI	MHSI available (Condition 2)	2 of 4 MHSI pumps available	MHSI ¾ (FT top gate)	Failure of 3 of 4 MHSI trains



#### Table 19A-2—Event Tree Headings for ATWS: Failure to Scram Sheet 2 of 2

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 2)	1 of 4 LHSI trains (with Htx) available (SI signal required) OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)

\*This event tree structure is used for several initiating events including GT, LBOP, LOC, LOMFW, LOOP, FIRE-FB, FIRE-MCR, FIRE-SWGR, FIRE-TB, FIRE XF YARD and FLD-TB.



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

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
GT	Consequence* - general transient (including turbine trip and reactor trip)	-	IE GT (consequence)	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 1out of 2 twice for reactor trip breakers or 2 out 4 contactors	RT1 (FT top gate)	Failure of reactor trip 1 (turbine trip type events)
MFW	Main feedwater available	1 of 4 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 STs and to remove steam via 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 – normal cooldown	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 (MSRVs or MSSVs)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed-and-bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed-and-bleed for transient



## Table 19A-3—Event Tree Headings for Initiating Event GT: General TransientSheet 2 of 2

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT Top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)

\*This event tree structure is used for several initiating events in addition to GT which includes FIRE-FB and FIRE-XF YARD.

#### 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	
IE IND SGTR	Induced steam generator tube rupture	_	IE IND SGTR (initiator)	Initiator - induced SGTR	
TUBES	Induced SGTR – 1 tube broken (Condition 1)	_	1 TUBE (basic event)	1 ruptured SG tube	
	Induced SGTR – 2-9 tubes broken (Condition 2)	-	2-9 TUBES (basic event)	2-9 ruptured SG tubes	
	Induced SGTR – more than 10 tubes broken (Condition 3)	_	10 TUBES (basic event)	10 or more ruptured SG tubes	
EFW	EFW available for partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown	
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains	
OP RHR	Operator aligns and initiate RHR within T>12 hr (Condition 2)	Action after 12 hr	OPE-RHR-L12H (basic event)	Operator fails to initiate RHR (longer than 12 hours)	
	Operator aligns and initiates RHR within 3 hr (Condition 4)	Action within 3 hr	OPE-RHR-3H (basic event)	Operator fails to initiate RHR within 3 hours	
	Operator mitigates multiple (>10 tubes) induced SGTR (Condition 5)		OPE-RHR/ SG10TR (basic event)	Likelihood to survive multiple (10+) ruptured tubes	
RHR	RHR available (Condition 3)	2 out of 4 LHSI pumps available for RHR	RHR 3/4 (FT top gate)	Failure of 3 out 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	
IE ISL-CCW- RCPTB	ISLOCA due to break in RCP thermal barrier tube, allowing overpressure of CCW piping	_	IE ISL-CCW- RCPTB (initiator)	Initiator - ISLOCA due to break in RCP thermal barrier tube, allowing overpressure of CCW piping	
EFW	EFW available for partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown	
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains	
OP RHR	Operator aligns and initiates RHR within 4 hr (Condition 1)	Action within 4 hr	OPE-RHR-4H (basic event)	Operator fails to initiate RHR within 4 hours	
RHR	RHR available (Condition 3)	2 out of 4 LHSI pumps available for RHR	RHR 3/4 (FT top gate)	Failure of 3 out 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
IE ISL-CVCS HPTR	ISLOCA due to rupture of tube in CVCS high pressure cooler (0.4" tube)	_	IE ISL-CVCS HPTR (initiator)	Initiator - ISLOCA due to rupture of tube in CVCS high pressure cooler (0.4" tube)
EFW	EFW available for partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
OP RHR	Operator aligns and initiates RHR within 4 hr (Condition 1)	Action within 4 hr	OPE-RHR-4H (basic event)	Operator fails to initiate RHR within 4 hours
RHR	RHR available (Condition 3)	2 out of 4 LHSI pumps available for RHR	RHR 3/4 (FT top gate)	Failure of 3 out 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

E	vent Tree Top Event	Success Criteria	Failure Event	Event Description
IE ISL-CVCS INJ	ISLOCA due to rupture of high pressure CVCS pipe outside containment		IE ISL-CVCS INJ (initiator)	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
IE ISL-CVCS REDS	ISLOCA due to spurious opening of reducing station	_	IE ISL-CVCS REDS (initiator)	Initiator - ISLOCA due to spurious opening of reducing station
EFW	EFW available for partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
OP RHR	Operator aligns and initiates RHR within 4 hr (Condition 1)	Action within 4 hr	OPE-RHR-4H (basic event)	Operator fails to initiate RHR within 4 hours
RHR	RHR available (Condition 3)	2 out of 4 LHSI pumps available for RHR	RHR 3/4 (FT top gate)	Failure of 3 out 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

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

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

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
IE ISL-SIS RHR	ISLOCA due to failure of suction line MOVs and subsequent RHR line rupture in respective SAB	_	IE ISL-SIS RHR (initiator)	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 Sheet 1 of 2

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
LBOP	Consequence* - loss of balance of plant – closed cooling water or auxiliary cooling water	-	IE LBOP (consequence)	Loss of balance of plant – closed 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 1out of 2 twice for reactor trip breakers or 2 out 4 contactors	RT2 (FT top gate)	Failure of reactor trip 1 (loss-of-feedwater type events)
EFW	EFW available for secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal (MSRVs or MSSVs)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and-bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed-and-bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed-and-bleed for transient
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and-bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and-bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)



#### Table 19A-12—Event Tree Headings for Initiating Event LBOP: Loss of Balance of Plant Closed Loop Cooling Water or Auxiliary Cooling Water 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 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)

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

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
IE LLOCA	Large loss-of-coolant accident (> 6 in break)	_	IE LLOCA (initiator)	Initiator - large LOCA (>6 in diameter)
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and-bleed cooling (Condition 2)	1 of 4 LHSI pump available (SI signal required)	LHSI ING 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 2)	1 of 4 LHSI trains (with Htx) available (SI signal required) OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)

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

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
IE LOC	Loss of main condenser (including MSIV closure)	_	IE LOC (initiator)	Initiator - loss of main condenser
RT	Reactor Trip (Condition 1 signals – high RCS pressure or high steam line pressure)	2 out of 4 RPS input signals and 1out of 2 twice for reactor trip breakers or 2 out 4 contactors	RT1 (FT top gate)	Failure of reactor trip 1 (turbine trip 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 – normal cooldown	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 (MSRVs or MSSVs)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and-bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB- L90M(basic event)	Operator fails to initiate feed-and- bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed-and- bleed for transient
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators



## Table 19A-14—Event Tree Headings for Initiating Event LOC: Loss of Main CondenserSheet 2 of 2

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and-bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)



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

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
LOCCW	Consequence <sup>*</sup> - loss of component cooling water or emergency service water	_	IE 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	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
OP FCD	Operator initiates fast cooldown within 40 min (Condition 1)	Action within 40 min	OPE-FCD-40M (basic event)	Operator fails to initiate fast cooldown for SLOCA
MFW	Main feedwater available	1 of 4 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 STs and to remove steam via 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 – normal 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	EFW available for:		EFW	Failure of secondary heat removal
	Secondary heat removal (Condition 1)1 of 4 EFW trains available for secondary heat removal (MSRVs or MSSVs)(FT -	(FT top gate)	and secondary cooldown	
	Partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)		
	Fast cooldown (Condition 3)	1 of 4 EFW trains available for fast cooldown (MSRVs only)		
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed-and- bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed-and- bleed for transient
	SLOCA (i.e., RCP seal LOCA), within 40 min (Condition 3)	Initiation of feed-and-bleed within 40 min	OPE-FB-40M (basic event)	Operator fails to initiate feed-and- bleed for SLOCA
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI 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 feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)
	Long Term Cooling of IRWST via LHSI or SAHR (Condition 2)	1 of 4 LHSI trains (with Htx) available (SI signal required) OR 1 of 1 SAHR pump available in recirculation mode		

\*This event tree structure is used for several initiating events in addition to LOCCW which includes FIRE-ESW, FLD-ANN, FLD-EFW, FLD-ESW, FLD-SAB14 FB, FLD-SAB23 and FLD-SIS.

## 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
IE LOMFW	Total loss of main feedwater	_	IE LOMFW (initiator)	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 4 contactors	RT2 (FT top gate)	Failure of reactor trip 1 (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 – normal cooldown	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 (MSRVs or MSSVs)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed- and-bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed- and-bleed for transient
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators



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

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)



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

Event Tree Top Event		Success Criteria	Failure Event	Event Description
IE LOOP	Loss of offsite power	_	IE LOOP (initiator)	Initiator - loss of offsite power
EDG	EDG buses available	1 of 4 EDGs available	EDG (FT top gate)	Failure of all EDGs
RT	Reactor Trip (Condition 1 signals – high RCS pressure or high steam line pressure)	2 out of 4 RPS input signals and lout of 2 twice for reactor trip breakers or 2 out 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 – RCP seal LOCA (Condition 1)	Recovery within 1 hr	REC OSP 1HR (basic event)	Failure to recover offsite power within 1 hr
	2 hr (Condition 2)	Recovery within 2 hr	REC OSP 2HR (basic event)	Failure to recover offsite power within 2 hr
SBO	Station blackout diesel- generator buses available	Train 1 or Train 2 SBO diesel supplied BBH buses available	SBO (FT top gate)	Failure of the station blackout diesel generator buses



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

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
OP FCD	Operator initiates fast cooldown within 40 min (Condition 1)	Action within 40 min	OPE-FCD-40M (basic event)	Operator fails to initiate fast cooldown for SLOCA
EFW	EFW available for:		EFW	Failure of secondary heat
	Secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal (MSRVs or MSSVs)	(FT top gate)	removal and secondary cooldown
	Partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)		
	Fast cooldown (Condition 3)	1 of 4 EFW trains available for fast cooldown (MSRVs only)		
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed- and-bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed- and-bleed for transient
	SLOCA (i.e., RCP seal LOCA), within 40 min (Condition 3)	Initiation of feed-and-bleed within 40 min	OPE-FB-40M (basic event)	Operator fails 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

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)
	Long Term Cooling of IRWST via LHSI or SAHR (Condition 2)	1 of 4 LHSI trains (with Htx) available (SI signal required) OR 1 of 1 SAHR pump available in recirculation mode		

### 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
IE MLOCA	Medium loss-of-coolant accident (3 to 6 in break)	_	IE MLOCA (initiator)	Initiator - medium break LOCA (3 to 6 in break)
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
OP FCD	Operator initiates fast cooldown within 30 min (Condition 2)	Action within 40 min	OPE-FCD-30M (basic event)	Operator fails to initiate fast cooldown for MLOCA
MSR	Main steam relief for:	Steam relief from 4 of 4 steam generators with at least one MRST train	MSR MLOCA	Failure of steam relief from 1 of 4 steam generators
	Partial cooldown (Condition 2)		(FT top gate)	
	Fast cooldown (Condition 3)			
OP FB	Operator initiates feed-and- bleed cooling within 30 min (Condition 4)	Initiation of feed-and-bleed within 30 min	OPE-FB-30M (basic event)	Operator fails to initiate feed- and-bleed for MLOCA
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)



Table 19A-18—Event Tree Headings for Initiating Event MLOCA: M	Adium Loss-of-Coolant-Accident
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 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)
	Long Term Cooling of IRWST via LHSI or SAHR (Condition 2)	1 of 4 LHSI trains (with Htx) available (SI signal required) OR 1 of 1 SAHR pump available in recirculation mode		

## Table 19A-19—Event Tree Headings for Initiating Event MSSV: Spurious Opening of Main Steam Safety Valve Sheet 1 of 3

Event Tree Top Event		Success Criteria	Failure Event	Event Description
MSSV	Consequence <sup>*</sup> - spurious opening of MSSV	_	IE MSSV (consequence)	Spurious opening of MSSV
MSIV ISO	MSIV isolation of affected steam generators	3 of 4 steam generators isolated		
	Two steam generators blowing down (Condition 4)	2 steam generators isolated	MSIV ISO SLBI 1 (FT top gate)	Failure to isolate impacted SG (SLBI – 2 SG blowing down)
	Three (or more) steam generators blowing down (Condition 5)	1 steam generator isolated	MSIV ISO SLBI 2 (FT top gate)	Failure to isolate impacted SG (SLBI – 3 or more SG blowing down)
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)	Boration with EBS – SLB (1 of 2 EBS trains required)
EFW	EFW available for:			
	Secondary heat removal, three steam generators available (Condition 5)	1 of 3 EFW trains available for secondary heat removal (MSRVs only)	EFW 3/3 (FT top gate)	Failure of 3 out of 3 EFW trains (with MSRVs)
	Secondary heat removal, two steam generators available (Condition 6)	1 of 2 EFW trains available for manual cooldown (MSRVs only)	EFW 2/2 (FT top gate)	Failure of 2 out of 2 EFW trains (with MSRVs)
EFW INV	EFW maintains adequate inventory.	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory



Table 19A-19—Event Tree Headings for Initiating Event MSSV	: Spurious Opening of Main Steam Safety Valve
Sheet 2 of 3	

	Event Tree Top Event	Success Criteria	Failure Event	Event Description
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed- and-bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed- and-bleed for transient
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)
OP RHR	Operator aligns and initiates RHR within T>12 hr (Condition 2)	Action after 12 hr	OPE-RHR-L12H (basic event)	Operator fails to initiate RHR (longer than 12 hours)

### Table 19A-19—Event Tree Headings for Initiating Event MSSV: Spurious Opening of Main Steam Safety Valve Sheet 3 of 3

Ev	ent Tree Top Event	Success Criteria	Failure Event	Event Description
RHR	RHR available	1 out of 4 LHSI pumps available	RHR 4/4	Failure of 4 out of 4 LHSI
	(Condition 1)	for RHR	(FT top gate)	trains for RHR

\*This event tree structure is used for several initiating events in addition to MSSV which includes FIRE-MS-VR.

## Table 19A-20—Event Tree Headings for Initiating Event SGTR: Steam Generator Tube RuptureSheet 1 of 3

Event Tree Top Event		Success Criteria	Failure Event	Event Description
IE SGTR	Steam generator tube rupture	-	IE SGTR (initiator)	Initiator - steam generator tube rupture
SG ISO	Operator isolates affected steam generators	Automatic isolation or operator isolation	SG ISO (FT top gate)	Failure to isolate SG after SGTR
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
SSS	Startup and shutdown system available for secondary heat removal (Condition 1)	SSS flow to 1 of 4 steam generators for secondary heat removal – normal cooldown	SSS (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 4 steam generators
	Partial cooldown (Condition 2)	SSS flow to 1 of 3 steam generators for secondary heat removal – partial cooldown	SSS SGTR (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 3 steam generators (SGTR)
	Partial cooldown, MHSI failed (Condition 3)	SSS flow to 1 of 3 steam generators with steam relief from all MSRTs – partial cooldown	SSS MHSI F (FT top gate)	Failure of startup and shutdown system to deliver flow to 1 of 3 steam generators (SGTR MHSI=F)



Table 19A-20—Event Tree Headings for Initiating Event SGTR:	Steam Generator Tube Rupture
Sheet 2 of 3	

Event Tree Top Event		Success Criteria	Failure Event	Event Description
EFW	EFW available for:			
	Secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal (MSRVs or MSSVs)	EFW (FT top gate)	Failure of secondary heat removal and secondary cooldown
	Partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)		
	Partial cooldown (Condition 10)	1 of 3 EFW trains available for partial cooldown (all MSRVs available)	EFW SGTR (FT top gate)	Failure of 3 out of 3 EFW trains, all MSRTs required (SGTR with MHSI failed)
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed- and-bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed- and-bleed for transient
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains



Table 19A-20—Event Tree Headings for Initiatin	g Event SGTR:	<b>Steam Generator</b>	Tube Rupture
Sheet	3 of 3		

Event Tree Top Event		Success Criteria	Failure Event	Event Description	
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)	
OP RHR	Operator aligns and initiates RHR within T>12 hr (Condition 2)	Action after 12 hr	OPE-RHR-L12H (basic event)	Operator fails to initiate RHR (longer than 12 hours)	
	Operator aligns and initiates RHR given EFW failure (Condition 3)	Action after EFW failure	OPE-RHR-EFW (basic event)	Operator fails to initiate RHR given EFW failure	
RHR	RHR available (Condition 1)	1 out of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains for RHR	

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

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
IE SLBI	Steam-line break inside containment	_	IE SLBI (initiator)	Initiator – steam-line break inside containment
MSIV ISO	MSIV isolation of affected steam generators	3 of 4 steam generators isolated		
	Two steam generators blowing down (Condition 4)	2 steam generators isolated	MSIV ISO SLBI 1 (FT top gate)	Failure to isolate impacted SG (SLBI – 2 SG blowing down)
	Three (or more) steam generators blowing down (Condition 5)	1 steam generator isolated	MSIV ISO SLBI 2 (FT top gate)	Failure to isolate impacted SG (SLBI – 3 or more SG blowing down)
FW ISO	MFW and isolated to affected steam generator(s):			
	One steam generator blowing down (Condition 1)	Feedwater lines to 1 of 1 affected steam generator isolated	FW ISO TR4 (FT top gate)	Failure to isolate FW to steam generator 4
	Two or more steam generators blowing down (Condition 2)	Feedwater lines to 2 or more affected steam generators isolated	FW ISO (FT top gate)	Failure to isolate FW to impacted SG (2 or more SGs blowing down)
	Four steam generators blowing down – EFW isolated (Condition 3)	Feedwater lines to all steam generators isolated and operator isolates EFW	FW ISO 3 (FT top gate)	Failure to isolate FW and EFW (4 SGs blowing down)
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)	Boration with EBS – SLB (1 of 2 EBS trains required)



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

E	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 (MSRVs only)	EFW 3/3 (FT top gate)	Failure of 3 out of 3 EFW trains (with MSRVs)
	Secondary heat removal, two steam generators available (Condition 6)	1 of 2 EFW trains available for manual cooldown (MSRVs only)	EFW 2/2 (FT top gate)	Failure of 2 out of 2 EFW trains (with MSRVs)
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed- and-bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed- and-bleed for transient
	SLB, within 4 hr (Condition 10)	Initiation of feed-and-bleed within 4 hr	OPD-FB/FW ISO-4H (basic event)	Dependency (LOW) between operator action to isolate FW/ EFW and initiation of F&B
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)



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

E	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 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)
OP RHR	Operator aligns and initiates RHR within T>12 hr (Condition 2)	Action after 12 hr	OPE-RHR-L12H (basic event)	Operator fails to initiate RHR (longer than 12 hours)
	Operator aligns and initiates RHR given FW isolation failure (Condition 9)		OPD-RHR/FW ISO (basic event)	Dependency (LOW) between operator actions for isolating FW and initiating RHR
RHR	RHR available (Condition 1)	1 out of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains for RHR

## Table 19A-22—Event Tree Headings for Initiating Event SLBO: Steam-Line Break Outside Containment Sheet 1 of 3

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
IE SLBO	Steam-line break downstream of MSIV	_	IE SLBO (initiator)	Initiator – steam-line break downstream of MSIV
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 (FT top gate)	Failure of 1 out of 4 MSIV trains to isolate
	Two steam generators blowing down (Condition 2)	2 steam generators isolated	MSIV ISO SLBO 2/4 (FT top gate)	Failure of 2 out of 4 MSIV trains to isolate
	Three steam generators blowing down (Condition 3)	1 steam generator isolated	MSIV ISO SLBO 3/4 (FT top gate)	Failure of 3 out 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)	Boration with EBS – SLB (1 of 2 EBS trains required)
EFW	EFW available for:			
	Secondary heat removal (Condition 1)	1 of 4 EFW trains available for secondary heat removal (MSRVs or MSSVs)	EFW (FT top gate	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 (MSRVs only)	EFW 3/3 (FT top gate)	Failure of 3 out of 3 EFW trains (with MSRVs)
	Secondary heat removal, two steam generators available (Condition 6)	1 of 2 EFW trains available for manual cooldown (MSRVs only)	EFW 2/2 (FT top gate)	Failure of 2 out of 2 EFW trains (with MSRVs)



Table 19A-22—Event Tree Headings for Initiating Event SLBO: S	Steam-Line Break Outside Containment
Sheet 2 of 3	

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory
OP FB	Operator initiates feed-and- bleed cooling for:			
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB-L90M (basic event)	Operator fails to initiate feed- and-bleed for transient with low decay heat
	Transient, within 90 min (Condition 2)	Initiation of feed-and-bleed within 90 min	OPE-FB-90M (basic event)	Operator fails to initiate feed- and-bleed for transient
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 MHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 LHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)



### Table 19A-22—Event Tree Headings for Initiating Event SLBO: Steam-Line Break Outside Containment Sheet 3 of 3

Eve	ent Tree Top Event	Success Criteria	Failure Event	Event Description
OP RHR	Operator aligns and initiates RHR within T>12 hr (Condition 2)	Action after 12 hr	OPE-RHR-L12H (basic event)	Operator fails to initiate RHR (longer than 12 hours)
RHR	RHR available (Condition 1)	1 out of 4 LHSI pumps available for RHR	RHR 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains for RHR

## Table 19A-23—Event Tree Headings for Initiating Event SLOCA: Small Loss-of-Coolant Accident Sheet 1 of 2 Sheet 2

Event Tree Top Event		Success Criteria	Failure Event	<b>Event Description</b>	
SLOCA	Consequence* - small loss-of- coolant accident (0.6 to 3 in break)	_	IE SLOCA (consequence)	Small break LOCA (0.6 to 3 in break)	
MHSI	Medium-head safety injection available (Condition 1)	1 of 4 MHSI pumps supply flow	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains	
OP FCD	Operator initiates fast cooldown within 40 min (Condition 1)	Action within 40 min	OPE-FCD- 40M (basic event)	Operator fails to initiate fast cooldown for SLOCA	
EFW	EFW available for:		EFW	Failure of secondary heat	
	Partial cooldown (Condition 2)	1 of 4 EFW trains available for partial cooldown (MSRVs only)	(FT top gate)	removal and secondary cooldown	
	Fast cooldown (Condition 3)	1 of 4 EFW trains available for fast cooldown (MSRVs only)			
EFW INV	EFW maintains adequate inventory	All 4 EFW tanks cross tied (or refilled)	EFW INV (FT top gate)	Failure to provide adequate EFW Inventory	
OP FB	Operator initiates feed-and- bleed cooling for:				
	Transient, after Longer Time (low DH) (Condition 1)	Initiation of feed-and-bleed after 90 min	OPE-FB- L90M (basic event)	Operator fails to initiate feed- and-bleed for transient with low decay heat	
	SLOCA, within 40 min (Condition 3)	Initiation of feed-and-bleed within 40 min	OPE-FB-40M (basic event)	Operator fails to initiate feed- and-bleed for SLOCA	



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

E	Event Tree Top Event	Success Criteria	Failure Event	Event Description
PBL	Primary bleed available	3 of 3 PSVs or 1 of 2 PDVs and steam generator relief (4 SGs)	PBL (FT top gate)	Failure of a PSV and both PDVs or steam generator relief valves (MSRTs and safeties) on the steam generators
MHSI FB	MHSI available for feed-and- bleed cooling	1 of 4 LHSI pumps available	MHSI 4/4 (FT top gate)	Failure of 4 out of 4 MHSI trains
LHSI	LHSI available for feed-and- bleed cooling (Condition 1)	1 of 4 MHSI pumps available	LHSI INJ 4/4 (FT top gate)	Failure of 4 out of 4 LHSI trains (injection mode only)
ACC	Accumulator injection available (Condition 1)	1 of 4 Accumulators available	ACC 4/4 (FT top gate)	Failure of 4 out of 4 Accumulator trains
	Accumulator injection available (Condition 2)	2 of 4 Accumulators available	ACC 3/4 (FT top gate)	Failure of 3 out of 4 Accumulator trains
LTC	Long Term Cooling of IRWST via LHSI or SAHR (Condition 1)	1 of 4 LHSI trains (with Htx) available OR 1 of 1 SAHR pump available in recirculation mode	LTC (FT top gate)	Failure of IWRST Long Term Cooling (LHSI & SAHR)
	Long Term Cooling of IRWST via LHSI or SAHR (Condition 2)	1 of 4 LHSI trains (with Htx) available (SI signal required) OR 1 of 1 SAHR pump available in recirculation mode		

\*This event tree structure is used for several initiating events in addition to SLOCA which includes FIRE-PZR.

## Table 19A-24—Event Tree Headings for Initiating Event FLD-ANN: Flooding in Annulus (FWDS Pipe Break)Sheet 1 of 2

E	vent Tree Top Event	Success Criteria	Failure Event	Event Description
FLD-ANN	Flooding in annulus (FWDS pipe break)	_	IE FLD-ANN (initiator)	Initiator – flood in the reactor building annulus
AFS ISO	Annulus FWDS motor-operated valves closed	FWDS isolation motor-operated valves closed	FWDS ISOL (FT top gate)	Failure of the FWDS isolation MOVs on the 8 in line in the annulus
AFS BRK	Break size of FWDS pipe:	-		
	1 in (Condition 1)		BREAK 1IN (basic event)	FWDS pipe break with 1 in flow
	Between 1 and 2 in (Condition 2)		BREAK LESS 2IN (basic event)	FWDS pipe break with less than 2 in flow
	Greater than 2 in (Condition 3)		BREAK MORE 2IN (basic event)	FWDS pipe break with more than 2 in flow
AFS ISO	Annulus FWDS ring header isolation valves	FWDS ring header isolation valves closed	FWDS HEADER ISO (FT top gate)	Failure of FWDS rind header isolation
OP AFS-S1	Operator isolates annulus FWDS break before water level reaches ground level within:	Action within allotted time		
	10 hr for 1 in break (Condition 1)		OPE-AFS-10H (basic event)	Operator fails to isolate FWDS pipe break (flow from 1 in line)
	2 hr for less than 2 in break (Condition 2)		OPE-AFS-2H (basic event)	Operator fails to isolate small (< 2 in) FWDS pipe break
	40 min for 2 in break (Condition 3)		OPE-AFS-40M (basic event)	Operator fails to isolate large (> 2 in) FWDS pipe break



Table 19A-24—Event Tree Headings for Initiating Event FLD-ANN:	Flooding in Annulus (FWDS Pipe Break)
Sheet 2 of 2	

Ev	vent Tree Top Event	Success Criteria	Failure Event	Event Description
OP AFS-S2	Operator isolates annulus FWDS break before water level reaches penetration level within:	Action within allotted time		
	32 hr for 1 in break (Conditions 1 & 2)		OPD-AFS-S2-32H (basic event)	Operator fails to isolate break before penetration level in 32 hr
			OPD-AFS-S2-32H=S (basic event)	Operator isolates break before penetration level in 32 hr
	8 hr for less than 2 in break (Conditions 3 & 4)		OPD-AFS-S2-8H (basic event)	Operator fails to isolate break before penetration level in 8 hr
			OPD-AFS-S2-8H=S (basic event)	Operator isolates break before penetration level in 8 hr
	120 min for 2 in break (Conditions 5 & 6)		OPD-AFS-S2-120M (basic event)	Operator fails to isolate break before penetration level in 120 min
			OPD-AFS-S2-120M=S (basic event)	Operator isolates break before penetration level in 120 min



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



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Figure 19A-2—Anticipated Failure without Scram



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Figure 19A-3—General Transient aliable aliable fead SAHR) aliable alia



REV 005 EPR6510 T2



Figure 19A-4—Induced Steam Generator Tube Rupture



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ISLOCA - CCWS RCP Thermal Barrier Tube Break EFW System Available Operator Initiates Secondary Cooldown and Aligns RHR MHSI Available RHR Available IE ISL-CCW RCPTB EFW OP RHR RHR MHSI Code No. Conseq. S 3 F,IS RHR 2 F,IS OP RHR 1 3 F,IS MHSI 1 EFW 2 F,IS 5

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

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ISLOCA - Tube Rupture High Pressure Letdown Cooler EFW System Available Operator Initiates Secondary Cooldown and Aligns RHR MHSI Available **RHR** Available IE ISL-CVCS HPTR RHR EFW MHSI **OP RHR** No. Conseq. Code S 3 F,IS RHR 2 F,IS OP RHR 1 з F,IS MHSI 1 EFW 2 F,IS

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

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	_				
ISLOCA - High Pressure CVCS Pipe Rupture Outside Containment					
	IE ISL-C	VCS INJ	Ne	Conner	Cada
			No.	Conseq.	Code
			1	F,IS	

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

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

REV 005 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			
IE ISL-SIS LHSI	No	Conseq	Code
	1	E IS	
	1	F,IS	

REV 005 EPR6540 T2 Figure 19A-10—ISLOCA Due to Break in MHSI Cold Leg Injection Valves with MHSI Rupture in Respective SAB

ISLCCA - Break in MHSI Cold Leg Injection Check Valves with MHSI Line Break in Respective SAB			
IE ISL-SIS MHSI	No	Conseg	Code
	-1	F,IS	

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•			
Suction Line Isolation MOVs and Subsequent RHR Line Break in Respective SAB			
IE ISL-SIS RHR	No	Conseg	Code
	- 1	F,IS	

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

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Loss of Balance of Plant - Closed Loop Cooling Water or Aux Cooling Water	Reactor Trip	EFW System Available	EFW Maintains Adeqate Invertory	Operator Initiates F&B	Primary Bleed Available	MHSI Available for Feed & Bleed	LHSI Injection Available	Accumulator Injection Available	Long Term Cooling of IRWST (LHSI or SAHR)			
LBOP	RT	EFW	EFW INV	OP FB	PBL	MHSI FB	LHSI	ACC	LTC	No.	Conseq.	Code
										-1	S	
										2	s	EFW INV
									1	3	TR,F	EFW INV-LTC
										_4	S	EFW INV-MHSI FB
									1	5	TR,F	EFW INV-MHSI FB-LTC
							1			6	TR,F	EFW INV-MHSI FB-LHSI
										- 7	F,TR1	EFW INV-PBL
				1						8	F,TR	EFW INV-OP FB
		1								9	s	EFW
									1	10	TR,F	EFW-LTC
								1		11	F,TR1	EFW-ACC
										12	S	EFW-MHSI FB
									1	13	TR,F	EFW-MHSI FB-LTC
								2		- 14	TR1,F	EFW-MHSI FB-ACC
							1			15	TR,F	EFW-MHSI FB-LHSI
										16	F,TR1	EFW-PBL
				2						17	F,TR	EFW-OP FB
	2									18	ATWS	RT

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

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



REV 005 EPR6560 T2

Figure 19A-14—Loss of Main Condenser



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Available for Feed p and Shutdown א Available EFW Maintains Adeqate Inventory LHSI Injection Available Long Term Cooling of IRWST (LHSI or SAHR) Bleed Available Accumulator Injection Available Operator Initiates FCD EFW System Available Operator Initiates F&B oss of CCWS/ESWS No RCP Seal LOCA Main Feedwater Available MHSI Available Start-Up a System A Primary 1 MHSI A & Bleed OCCW RCP LOCA MHSI OP FCD MFW SSS EFW EFW INV OP FB PBL MHSI FB LHSI ACC LTC No. Consea Code S MFW 1-MFW-SSS S MFW-SSS-EFW INV S 1-TR,F MFW-SSS-EFW INV-LTC s MFW-SSS-EFW INV-MHSI FB 1-TR,F MFW-SSS-EFW INV-MHSI FB-LTC MFW-SSS-EFW INV-MHSI FB-LHSI 1 TR,F MFW-SSS-EFW INV-PBL F,TR1 1 F,TR MFW-SSS-EFW INV-OP FB 10 MFW-SSS-EFW 1 S TR,F 11 1-MFW-SSS-EFW-LTC 12 1 F,TR1 MFW-SSS-EFW-ACC MFW-SSS-EFW-MHSI FB 14 S 1-TR,F MFW-SSS-EFW-MHSI FB-LTC 15 TR1.F MFW-SSS-EFW-MHSI FB-ACC 2 16 1-17 TR,F MFW-SSS-EFW-MHSI FB-LHSI 18 F,TR1 MFW-SSS-EFW-PBL MFW-SSS-EFW-OP FB 2 19 F,TR 20 s RCP LOCA 2 -21 F,SS RCP LOCA-LTC \_\_\_\_\_22 1\_\_\_\_23 RCP LOCA-EFW INV S F,SS RCP LOCA-EFW INV-LTC 24 F,SS1 RCP LOCA-EFW INV-PBL 25 F,SS RCP LOCA-EFW INV-OP FB 1 26 RCP LOCA-EFW 2 S 1--27 F,SS RCP LOCA-EFW-LTC 1-F,SS1 RCP LOCA-EFW-ACC 28 F,SS1 RCP LOCA-EFW-PBL 29 3 -30 F,SS RCP LOCA-EFW-OP FB 1 31 RCP LOCA-MHSI 1--32 F,SSD RCP LOCA-MHSI-LTC 1 33 F.SS1D RCP LOCA-MHSI-ACC RCP LOCA-MHSI-LHSI F,SSD 1-34 35 RCP LOCA-MHSI-EFW INV 1-36 F,SSD RCP LOCA-MHSI-EFW INV-LTC 1-37 F,SSD RCP LOCA-MHSI-EFW INV-LHSI 38 F,SS1D RCP LOCA-MHSI-EFW INV-PBL RCP LOCA-MHSI-EFW INV-OP FB 1 39 F,SSD RCP LOCA-MHSI-EFW 40 1-41 F,SSD RCP LOCA-MHSI-EFW-LTC 2 F,SS1D RCP LOCA-MHSI-EFW-ACC 42 F,SSD RCP LOCA-MHSI-EFW-LHSI 43 1-44 F,SS1D RCP LOCA-MHSI-EFW-PBL 3 45 F,SSD RCP LOCA-MHSI-EFW-OP FB F,SSD RCP LOCA-MHSI-OP FCD

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

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Figure 19A-16—Loss of Main Feedwater



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Figure 19A-17—Loss of Offsite Power

Loss Of Offsite Power	EDG Buses Available	Reactor Trip	Power Supply for I&C for 2 hr LOOP Duration	Main Steam Relief Available	No RCP Seal LOCA	Recovery of Offsite Power	Station Blackout Diesel Generator Buses Available	MHSI Available	Operator Initiates FCD	EFW System Available	EFW Maintains Adeqate Inventory	Operator Initiates F&B	Primary Bleed Available	MHSI Available for Feed & Bleed	LHSI Injection Available	Accumulator Injection Available	Long Term Cooling of IRWST (LHSI or SAHR)			
IE LOOP	EDG	RT	I&C	MSR	RCPLOCA	REC LOOP	SBO	MHSI	OP FCD	EFW	EFW INV	OP FB	PBL	MHSI FB	LHSI	ACC	LTC	No.	Conseq.	Code
						z -												1 2	s c	RECLOOP
																	h-	3 4	S LOOP,TP,F	REC LOOP-EFW INV REC LOOP-EFW INV-LTC
																		5	S LOOP TRE	REC LOOP-EFW INV-MHSI FB
															1-			7	LOOP, TP,F	REC LOOP-EFW INV-MHSI FB-LHSI
												1-						8	F,LOOP,TP1 F,LOOP,TP	REC LOOP-EFW INV-PBL REC LOOP-EFW INV-OP FB
										1							-	10	S LOOP TRE	REC LOOP-EFW
																1_	пн	12	F,LOOP,TP1	REC LOOP-EFW-LCC
																	1	13	S TP.F.LOOP	REC LOOP-EFW-MHSI FB REC LOOP-EFW-MHSI FB-LTC
															_	2		15	LOOP, TP1, F	REC LOOP-EFW-MHSI FB-ACC
																		17	F,LOOP,TP1	REC LOOP-EFW-MINSI FB-LINSI REC LOOP-EFW-PBL
												2						18	F,LOOP,TP S	REC LOOP-EFW-OP FB RCP LOCA
						1												20	s	RCP LOCA-REC LOOP
																	2	21 22	F,LOOP-SL,SP S	RCP LOCA-REC LOOP-LTC RCP LOCA-REC LOOP-EFW INV
																	1_	23	LOOP-SL,F,SP	RCP LOCA-REC LOOP-EFW INV-LTC
												1-						24 25	F,LOOP-SL,SP1 F,LOOP-SL,SP	RCP LOCA-REC LOOP-EFW INV-PBL RCP LOCA-REC LOOP-EFW INV-OP FB
										2 -							-	26	S LOOP-SLE SP	RCP LOCA-REC LOOP-EFW
																1_		28	F,LOOP-SL,SP1	RCP LOCA-REC LOOP-EFW-ACC
												3						29 30	F,LOOP-SL,SP1 F,LOOP-SL,SP	RCP LOCA-REC LOOP-EFW-PBL RCP LOCA-REC LOOP-EFW-OP FB
								1_				-						31	S	RCP LOCA-REC LOOP-MHSI
																17-		32	F,LOOP-SL,SPD,P	RCP LOCA-REC LOOP-MHSI-LITC RCP LOCA-REC LOOP-MHSI-ACC
															<u> </u>			34	FLOOP-SL SPD F	RCP LOCA-REC LOOP-MHSI-I HSI RCP LOCA-REC LOOP-MHSI-EFW INV
										3								36	F,LOOP-SL,SP1D	RCP LOCA-REC LOOP-MHSI-EFW
				1					1									38	F,LOOP-SL,SPD F,LOOP,TP	MSR
		2																39 40	F,LOOP,TP	I&C RT
																		41	s	EDG
						2												42 43	S F,SBO,TP	EDG-REC LOOP EDG-REC LOOP-EFW INV
										1							4-1	44 45	S F.SBO.TP	EDG-REC LOOP-EFW EDG-REC LOOP-EFW-LTC
																1		46	F,SBO,TP1	EDG-REC LOOP-EFW-ACC
																	T-	47 48	SBO,F,TP	EDG-REC LOOP-EFW-MHSI FB EDG-REC LOOP-EFW-MHSI FB-LTC
															L	2		49	F,SBO,TP1	EDG-REC LOOP-EFW-MHSI FB-ACC
																		51	F,SBO,TP1	EDG-REC LOOP-EFW-MHSI FB-LHSI EDG-REC LOOP-EFW-PBL
												2						52 53	F,SBO,TP F SBO TP	EDG-REC LOOP-EFW-OP FB EDG-REC LOOP-SBO
						-												54	S	EDG-RCP LOCA
						1											1-	56	SBO-SL,SP,F	EDG-RCP LOCA-REC LOOP
															-	2		57 58	F,SBO-SL,SP1 SBO-SL SP F	EDG-RCP LOCA-REC LOOP-ACC
																		59	F,SP1,SB0-SL	EDG-RCP LOCA-REC LOOP-PBL
												3						60 61	F,SBO-SL,SP F,SBO-SL,SP	EDG-RCP LOCA-REC LOOP-OP FB EDG-RCP LOCA-REC LOOP-SBO
				h														62	F,SBO,TP	EDG-MSR
																		64	ATWS	EDG-RT

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



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MHSI Available for Feed & Bleed EFW Maintains Adeqate Inventory Long Term Cooling of IRWST (LHSI or SAHR) LHSI Injection Available EFW System Available Primary Bleed Available Operator Initiates F&B Accumulator Injection Available Operator Initiates Secondary Cooldown and Aligns RHR Spurious Opening of Steam Safety Valve Boration with EBS Available of MSIV Isolation ( Impacted SG **RHR** Available MSSV MSIV ISO EFW INV OP FB EBS EFW PBL MHSI FB LHSI ACC LTC OP RHR RHR No Conseq. Code s EFW INV 2 s 1 F.TRD EFW INV-LTC 3 s EFW INV-MHSI FB 4 1-5 F,TRD EFW INV-MHSI FB-LTC 1 EFW INV-MHSI FB-LHSI F,TRD 6 F,TR1D EFW INV-PBL F,TRD EFW INV-OP FB 1 8 EFW 5 9 s 1-EFW-LTC 10 F,TRD 1 11 F,TR1D EFW-ACC EFW-MHSI FB 12 S 1 13 F.TRD EFW-MHSI FB-LTC F,TR1D EFW-MHSI FB-ACC 2 14 1 15 F,TRD EFW-MHSI FB-LHSI F,TR1D EFW-PBL 16 17 F,TRD EFW-OP FB 2 MSIV ISO(3) 4 18 s 1-19 F,TRD MSIV ISO(3)-RHR 2 20 F,TRD MSIV ISO(3)-OP RHR MSIV ISO(3)-EFW 21 s 6 1 22 F,TRD MSIV ISO(3)-EFW-LTC F,TR1D MSIV ISO(3)-EFW-ACC 23 1 24 F,TR1D MSIV ISO(3)-EFW-MHSI FB 25 MSIV ISO(3)-EFW-PBL F,TR1D 2 26 F,TRD MSIV ISO(3)-EFW-OP FB 27 s MSIV ISO(4) 5 1-28 F, TRD MSIV ISO(4)-LTC 1 MSIV ISO(4)-ACC 29 F,TR1D 30 F,TR1D MSIV ISO(4)-MHSI FB 31 F,TR1D MSIV ISO(4)-PBL 2 MSIV ISO(4)-OP FB 32 F,TRD 33 MSIV ISO(4)-EBS AT,F

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

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Figure 19A-20—Steam Generator Tube Rupture



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

am Break Inside ntainment	IV Isolation of pacted SG	W and SSS Isolated Impacted SG	ration with EBS ailable	W System Available	W Maintains Adeqate entory	erator Initiates F&B	mary Bleed Available	ISI Available for Feed Bleed	SI Injection Available	cumulator Injection ailable	ng Term Cooling of WST (LHSI or SAHR)	erator Initiates condary Cooldown d Aligns RHR	IR Available			
ပ် ဆိ	<u>a</u> R	to M	A B	ш	ШĘ	õ	Pri	₹∾	5	Ac	ਹ ਦ	a s e	R			
IE SLBI	MSIV ISO	FW ISO	EBS	EFW	EFW INV	OP FB	PBL	MHSI FB	LHSI	ACC	LTC	OP RHR	RHR	No.	Conseq.	Code
														1	S	
											1			3	F.ATI	EFW INV-LTC
														4	S	EFW INV-MHSI FB
											1			5	ATI,F	EFW INV-MHSI FB-LTC
									1					6	F,ATI	EFW INV-MHSI FB-LHSI
														7	F,ATI1	EFW INV-PBL
				_		1								8	F,ATI	EFW INV-OP FB
				5							1			10	ΕΔΤΙ	EFW FEW_LTC
										1-				-11	F ATI1	EFW-ACC
														12	S	EFW-MHSI FB
											1			13	F,ATI	EFW-MHSI FB-LTC
										2				14	F,ATI1	EFW-MHSI FB-ACC
									1					15	F,ATI	EFW-MHSI FB-LHSI
														16	F,ATI	EFW-PBL
		-				2								17	F,AII	EFW-OP FB
														10	5 F ATI	EW ISO-EEW INV
				5										20	F.ATI	FW ISO-EFW
	4													21	S	MSIV ISO
													1	22	F,ATI	MSIV ISO-RHR
												2		23	F,ATI	MSIV ISO-OP RHR
				6										24	S	MSIV ISO-EFW
										_	1			-25	F,ATI	MSIV ISO-EFW-LTC
										1				20	Ε ΔΤΙ1	MSIV ISO-EFW-ACC MSIV ISO-EFW-MHSI FR
														-28	F ATI1	MSIV ISO-EFW-PBI
						2								29	F.ATI	MSIV ISO-EFW-OP FB
		2												30	S	MSIV ISO-FW ISO
													1—	31	F,ATI	MSIV ISO-FW ISO-RHR
												9		32	F,ATI	MSIV ISO-FW ISO-OP RHR
				6										33	F,ATI	MSIV ISO-FW ISO-EFW
	5										1			35	ΕΔΤΙ	
										1-				-36	F ATI1	MSIV ISO(3)-ACC
														37	F.ATI1	MSIV ISO(3)-MHSI FB
1														38	F,ATI1	MSIV ISO(3)-PBL
						2								39	F,ATI	MSIV ISO(3)-OP FB
			3											10	F,ATI	MSIV ISO(3) EBS
		3									-			41	S	MSIV ISO(3)-FW ISO
										L	1			42	F,AII E ATH	MSIV ISO(3)-FW ISO-LTC
														43	Ε ΔΤΙ1	MSIV ISO(3)-EW ISO-ACC MSIV ISO(3)-EW ISO-MHSI ER
														45	F ATI1	MSIV ISO(3)-FW ISO-PBI
						10								46	F.ATI	MSIV ISO(3)-FW ISO-OP FB
			3											47	F.ATI	MSIV ISO(3) FW ISO EBS

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Figure 19A-22—Steam Line Break Outside Containment

aam Break wnstream of MSIV	sIV Isolation of pacted SG	ration with EBS ailable	W System Available	W Maintains Adeqate rentory	erator Initiates F&B	mary Bleed Available	HSI Available for Feed Bleed	SI Injection Available	cumulator Injection ailable	ng Term Cooling of WST (LHSI or SAHR)	ierator Initiates condary Cooldown d Aligns RHR	HR Available			
Do Ste	<u>n</u>	A Bo	Ш	비	g	Pri	₹ <mark>%</mark>	Ξ	Ac	J R	an Se	Ł			
IE SLBO	MSIV ISC	EBS	EFW	EFW INV	OP FB	PBL	MHSI FB	LHSI	ACC	LTC	OP RHR	RHR	Na	C	Cada
													-1	S	Code
													2	S	EFW INV
										1—			-3	F.TR	EFW INV-LTC
													4	S	EFW INV-MHSI FB
										1—			5	F,TR	EFW INV-MHSI FB-LTC
								1—					6	F,TR	EFW INV-MHSI FB-LHSI
													7	F,TR1	EFW INV-PBL
					1								8	F,TR	EFW INV-OP FB
1			1-										9	S	EFW
										1			10	F,TR	EFW-LTC
									1—				11	F,TR1	EFW-ACC
													12	S	EFW-MHSI FB
										1			-13	F,TR	EFW-MHSI FB-LTC
									2				- 14	F,TR1	EFW-MHSI FB-ACC
								1—					15	F,TR	EFW-MHSI FB-LHSI
													- 16	F,TR1	EFW-PBL
					2								- 17	F,TR	EFW-OP FB
	1-												18	S	MSIV ISO
													- 19	S	MSIV ISO-EFW INV
										1			-20	F,TRD	MSIV ISO-EFW INV-LTC
													-21	F,TR1D	MSIV ISO-EFW INV-MHSI FB
													-22	F,TR1D	MSIV ISO-EFW INV-PBL
					1—								-23	F,TRD	MSIV ISO-EFW INV-OP FB
			5 –										-24	S	MSIV ISO-EFW
1										1—			-25	F,TRD	MSIV ISO-EFW-LTC
1									1				-26	F, IR1D	MSIV ISO-EFW-ACC
1							L						2/	F, IR1D	MSIV ISO-EFW-MHSI FB
1													-28	F, IR1D	MSIV ISO-EFW-PBL
1					2								- 29	F, IKU	MSIV ISO-EFW-OPFB
1	2											-	- 30	5	MSIV ISO(3)
1												1	31		
1			6								2		22	r, ind	
1			6							-			- 33	5	
1										1			25		MSIV ISO(3)-EFW-LIG
1									1				- 30		
1													27		
1					-								38		INISIV ISO(3)-EFW-PBL MSIV ISO(3)-EFW-OP EB
1	2				2								20	e	
	3									1			40	5 F TRD	
													41	E TR1D	MSIV ISO(4)-ACC
													42		
													42	E TRID	
					2								44	F TRD	MSIV ISO(4)-PBL
		3			2								45	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 Available	Operator Initiates FCD	EFW System Available	EFW Maintains Adeqate Inventory	Operator Initiates F&B	Primary Bleed Available	LHSI Injection Available	Accumulator Injection Available	Long Term Cooling of IRWST (LHSI or SAHR)			
SLOCA	MHSI	OP FCD	EFW	EFW INV	OP FB	PBL	LHSI	ACC	LTC	No.	Consea.	Code
										- 1	S	
									2	2	F,SL	LTC
										3	S	EFW INV
									1	4	F,SL	EFW INV-LTC
										5	F,SL1	EFW INV-PBL
					1					6	F,SL	EFW INV-OP FB
			2							7	S	EFW
									1	8	F,SL	EFW-LTC
								1		9	F,SL1	EFW-ACC
										10	F,SL1	EFW-PBL
					3					11	F,SL	EFW-OP FB
	1									12	S	MHSI
									1	13	F,SLD	MHSI-LTC
								1		14	F,SL1D	MHSI-ACC
							1			15	F,SLD	MHSI-LHSI
										16	S	MHSI-EFW INV
									1	17	F,SLD	MHSI-EFW INV-LTC
							1			18	F,SLD	MHSI-EFW INV-LHSI
										19	F,SL1D	MHSI-EFW INV-PBL
					1					20	F,SLD	MHSI-EFW INV-OP FB
			3			1				21	S	MHSI-EFW
			_						1	22	F,SLD	MHSI-EFW-LTC
								2		23	F,SL1D	MHSI EFW ACC
							1			24	F,SLD	MHSI-EFW-LHSI
										25	F,SL1D	MHSI-EFW-PBL
					3					26	F,SLD	MHSI-EFW-OP FB
		1								27	F,SLD	MHSI OP FCD

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Figure 19A-24—Flooding in Annulus (FWDS Pipe Break)



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