Appendix C

National Pollutant Discharge Elimination System Permit

LaSalle County Station Environmental Report

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ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 • (217) 782-2829
PAT QUINN, GOVERNOR LISA BONNETT, DIRECTOR

217/782-0610

July 5, 2013

Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, Illinois 60555

Re: Exelon Generation Company, LLC
LaSalle County Generating Station
NPDES Permit No. IL0048151
Final Permit

Gentlemen:

Attached is the final NPDES Permit for your discharge. The Permit as issued covers discharge limitations, monitoring, and reporting requirements. Failure to meet any portion of the Permit could result in civil and/or criminal penalties. The Illinois Environmental Protection Agency is ready and willing to assist you in interpreting any of the conditions of the Permit as they relate specifically to your discharge.

The Agency received your letter dated June 20, 2013 regarding the draft NPDES permit. Based on the information provided, the Agency has the following response.

1. Special Condition 3D was revised as requested.
2. Special Condition 16, the first paragraph was revised as requested
3. Special Condition 16, the third paragraph was not revised as requested. The change was unnecessary based on the current language.

The Agency has begun a program allowing the submittal of electronic Discharge Monitoring Reports (eDMRs) instead of paper Discharge Monitoring Reports (DMRs). If you are interested in eDMRs, more information can be found on the Agency website, http://epa.state.il.us/water/edmr/index.html. If your facility is not registered in the eDMR program, a supply of preprinted paper DMR Forms for your facility will be sent to you prior to the initiation of DMR reporting under the reissued permit. Additional information and instructions will accompany the preprinted DMRs upon their arrival.

The attached Permit is effective as of the date indicated on the first page of the Permit. Until the effective date of any re-issued Permit, the limitations and conditions of the previously-issued Permit remain in full effect. You have the right to appeal any condition of the Permit to the Illinois Pollution Control Board within a 35 day period following the issuance date.

4302 N. Main St., Rockford, IL 61103 (815)987-7760
595 S. State, Elgin, IL 60123 (847)608-3131
2125 S. First St., Champaign, IL 61820 (217)278-5800
2009 Mall St., Collinsville, IL 62234 (618)346-5120
9511 Harrison St., Des Plaines, IL 60016 (847)294-4000
5407 N. University St., Arbor 113, Peoria, IL 61614 (309)693-5462
2309 W. Main St, Suite 116, Marion, IL 62959 (618)993-7200
100 W. Randolph, Suite 11-300, Chicago, IL 60601 (312)814-6026

PLEASE PRINT ON RECYCLED PAPER

Should you have questions concerning the Permit, please contact Leslie Lowry at 217/782-0610.

Sincerely,

Alan Keller

Alan Keller, P.E.
Manager, Permit Section
Division of Water Pollution Control

SAK:DEL:LRL:12030801.daa

Attachment: Final Permit

cc: Records Unit
Compliance Assurance Section
Rockford Region
Billing
USEPA

NPDES Permit No. IL0048151

Illinois Environmental Protection Agency

Division of Water Pollution Control

1021 North Grand Avenue East

Springfield, Illinois 62794-9276

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Reissued (NPDES) Permit

Expiration Date: July 31, 2018

Issue Date: July 5, 2013
Effective Date: August 1, 2013

Name and Address of Permittee:

Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, Illinois 60555

Facility Name and Address:

Exelon Generation Company, LLC
LaSalle County Generating Station
2601 N. 21st Street
Marseilles, Illinois 61341
(LaSalle County)

Discharge Number and Name:		Receiving Waters:
001	Cooling Pond Blowdown	Illinois River
A01	Demineralizer Regenerant Wastes	
B01	Sewage Treatment Plant Effluent	
C01	Wastewater Treatment System Effluent	
D01	Cooling Water Intake Screen Backwash	
E01	Unit 1 and 2 Radwaste Treatment System Effluent	
F01	Auxiliary Reactor Equipment Cooling and Flushing Water	
G01	North Site Stormwater Runoff	
H01	South Site Stormwater Runoff	
I01	Reverse Osmosis System Reject Water and Greensand Filter Backwash	
002	Illinois River Make-Up Water Intake Screen Backwash	Illinois River

In compliance with the provisions of the Illinois Environmental Protection Act, Title 35 of Ill. Adm. Code, Subtitle C and/or Subtitle D, Chapter 1, and the Clean Water Act (CWA), the above-named permittee is hereby authorized to discharge at the above location to the above-named receiving stream in accordance with the standard conditions and attachments herein.

Permittee is not authorized to discharge after the above expiration date. In order to receive authorization to discharge beyond the expiration date, the permittee shall submit the proper application as required by the Illinois Environmental Protection Agency (IEPA) not later than 180 days prior to the expiration date.

Alan Keller

Alan Keller, P.E.
Manager, Permit Section
Division of Water Pollution Control

SAK:LRL:12030801.daa

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NPDES Permit No. IL0048151

Effluent Limitations and Monitoring

1. From the effective date of this permit until the expiration date, the effluent of the following discharges shall be monitored and limited at all times as follows:

PARAMETER	LOAD LIMITS lbs/day DAF (DMF) 30 DAY AVERAGE	DAILY MAXIMUM	CONCENTRATION LIMITS mg/l 30 DAY AVERAGE	DAILY MAXIMUM	SAMPLE FREQUENCY	SAMPLE TYPE

Outfall 001 – Cooling Pond Blowdown*
(Average Flow = 34.9 MGD)

This discharge consists of:

1. Main Condenser Cooling Water
2. Clean Condensate System Flushing and Maintenance (Alternate Route)
3. House Service Water
4. Demineralizer Regenerant Wastes (Outfall A01)
5. Sewage Treatment Plant Effluent (Outfall B01)
6. Wastewater Treatment System Effluent (Outfall C01)
7. Cooling Pond Intake Screen Backwash (Outfall D01)
8. Unit 1 and 2 Radwaste Treatment System Effluent (Outfall E01)
9. Auxiliary Reactor Equipment Cooling and Flushing Water (Outfall F01)
10. North Site Stormwater Runoff (Outfall G01)**
11. South Site Stormwater Runoff (Outfall H01)**
12. Reverse Osmosis System Reject Water and Greensand Filter Backwash (Outfall I01)
13. Water Softener Regenerant Waste
14. North Inlet Canal Stormwater Runoff**
15. South Inlet Canal Stormwater Runoff**
16. IDNR Fish Hatchery Effluents

PARAMETER	30 DAY AVERAGE (lbs/day)	DAILY MAXIMUM (lbs/day)	30 DAY AVERAGE (mg/l)	DAILY MAXIMUM (mg/l)	SAMPLE FREQUENCY	SAMPLE TYPE
Flow (MGD)	See Special Condition 1.				Daily	Continuous
pH	See Special Condition 2.				2/Month	Grab
Temperature	See Special Condition 3.				Daily	Continuous
Total Residual Chlorine / Total Residual Oxidant	See Special Condition 4 and 16.			0.05	2/Month	Grab
Zinc (Total)			Monitor Only		1/Quarter	Grab

* - See Special Condition 13.

** - See Special Condition 8.

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Effluent Limitations and Monitoring

1. From the effective date of this permit until the expiration date, the effluent of the following discharges shall be monitored and limited at all times as follows:

PARAMETER	LOAD LIMITS lbs/day DAF (DMF) 30 DAY AVERAGE	DAILY MAXIMUM	CONCENTRATION LIMITS mg/l 30 DAY AVERAGE	DAILY MAXIMUM	SAMPLE FREQUENCY	SAMPLE TYPE

Outfall A01 – Demineralizer Regenerant Wastes*
(Intermittent Discharge)

This discharge consists of:

1. Make-Up Demineralizer Regenerant Wastes
2. Off-Specification Demineralized Water
3. Make-Up Demineralizer Maintenance Wastewater
4. Unit Waterbox Vacuum Pump Condensate
5. Radwaste Treatment Acid/Caustic System Drains

PARAMETER	30 DAY AVERAGE (lbs/day)	DAILY MAXIMUM (lbs/day)	30 DAY AVERAGE (mg/l)	DAILY MAXIMUM (mg/l)	SAMPLE FREQUENCY	SAMPLE TYPE
Flow (MGD)	See Special Condition 1.				1/Week	24 Hour Total
Total Suspended Solids			15	30	1/Week	Grab

* - Also discharge to the Wastewater Treatment System (Outfall C01) as an alternate route.

Outfall B01 – Sewage Treatment Plant Effluent
(DAF = 0.06 MGD)

This discharge consists of:

1. Sanitary Wastewater
2. Eyewash Station Wastewater

PARAMETER	30 DAY AVERAGE (lbs/day)	DAILY MAXIMUM (lbs/day)	30 DAY AVERAGE (mg/l)	DAILY MAXIMUM (mg/l)	SAMPLE FREQUENCY	SAMPLE TYPE
Flow (MGD)	See Special Condition 1.				Daily	Continuous
pH	See Special Condition 2.				2/Month	Grab
$CBOD_5$	13	42	25	50	2/Month	24 Hour Composite
Total Suspended Solids	15	50	30	60	2/Month	24 Hour Composite

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1. From the effective date of this permit until the expiration date, the effluent of the following discharges shall be monitored and limited at all times as follows:

PARAMETER	LOAD LIMITS lbs/day DAF (DMF) 30 DAY AVERAGE	DAILY MAXIMUM	CONCENTRATION LIMITS mg/l 30 DAY AVERAGE	DAILY MAXIMUM	SAMPLE FREQUENCY	SAMPLE TYPE

Outfall C01 – Wastewater Treatment System Effluent
(DAF = 0.044 MGD)

This discharge consists of:

1. Turbine Building Fire and Miscellaneous Non-Radioactive Wastewater Sump
2. Greensand Filter Backwash (Alternative Route)
3. Diesel Fuel Storage and Service Water Building Sump
4. Auxiliary Boiler Blowdown
5. Water Softener Regenerant Waste
6. Demineralizer Regenerant Wastes (Outfall A01 Alternate Route)
7. Heat Bay Building Roof Area
8. Fire Protection System Flushing and Maintenance*
9. Service Water System Flushing and Maintenance*
10. Domestic Water System Flushing and Maintenance*
11. Clean Condensate System Flushing and Maintenance**
12. Laboratory Liquid Wastes
13. Station Heat System Condensate
14. Diesel Generator Cooling Water
15. Standby Liquid Control Test Skid Flush Water
16. Groundwater

PARAMETER	30 DAY AVERAGE (lbs/day)	DAILY MAXIMUM (lbs/day)	30 DAY AVERAGE (mg/l)	DAILY MAXIMUM (mg/l)	SAMPLE FREQUENCY	SAMPLE TYPE
Flow (MGD)	See Special Condition 1.				Daily	Continuous
pH	See Special Condition 2.				1/Week	Grab
Total Suspended Solids	5	17	15	30	1/Month	24 Hour Composite
Oil & Grease	2.5	3.34	15	20	1/Month	Grab

* - Also discharges to the North Site Stormwater Runoff (Outfall G01) and/or South Site Stormwater Runoff (Outfall H01) as an alternate route.
** - Also discharges to the Cooling Pond Blowdown (Outfall 001) via the service water system and resulting main condenser cooling water as an alternate route.

Outfall D01 – Cooling Water Intake Screen Backwash*
(Intermittent Discharge)

* - This discharge is limited to cooling water intake screen backwash free from other wastewater discharges. Adequate maintenance of the trash basket is required to prevent the discharge of floating debris collected on intake screens back to the cooling pond.

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Effluent Limitations and Monitoring

1. From the effective date of this permit until the expiration date, the effluent of the following discharges shall be monitored and limited at all times as follows:

	LOAD LIMITS lbs/day DAF (DMF)		CONCENTRATION LIMITS mg/l			
PARAMETER	30 DAY AVERAGE	DAILY MAXIMUM	30 DAY AVERAGE	DAILY MAXIMUM	SAMPLE FREQUENCY	SAMPLE TYPE

Outfall E01 – Unit 1 and 2 Radwaste Treatment System Effluent
(Intermittent Discharge)

This discharge consists of:

1. Equipment Drains in the Turbine, Auxiliary, and Reactor Buildings
2. Floor Drains in the Turbine, Auxiliary, and Reactor Buildings
3. Condensate Polisher Waste from the Turbine Building
4. Decontamination and Laundry Waste

PARAMETER	30 DAY AVERAGE	DAILY MAXIMUM	30 DAY AVERAGE	DAILY MAXIMUM	SAMPLE FREQUENCY	SAMPLE TYPE
Flow (MGD)	See Special Condition 1.				1/Week	Estimate
Total Suspended Solids			15	30	1/Week	Grab
Oil & Grease			15	20	1/Week	Grab

Outfall F01 – Auxiliary Reactor Equipment Cooling and Flushing Water*
(Intermittent Discharge)

* - This discharge is limited to auxiliary reactor equipment cooling and flushing water free from other wastewater discharges.

Outfall G01 – North Site Stormwater Runoff*
(Intermittent Discharge)

This discharge consists of:

1. Fire Protection System Flushing and Maintenance (Alternate Route)
2. Service Water System Flushing and Maintenance (Alternate Route)
3. Domestic Water System Flushing and Maintenance (Alternate Route)
4. Clean Condensate System Flushing and Maintenance (Alternate Route)
5. North Site Uncontaminated Stormwater Runoff

* - See Special Condition 8.

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Effluent Limitations and Monitoring

1. From the effective date of this permit until the expiration date, the effluent of the following discharges shall be monitored and limited at all times as follows:

	LOAD LIMITS lbs/day DAF (DMF)		CONCENTRATION LIMITS mg/l			
PARAMETER	30 DAY AVERAGE	DAILY MAXIMUM	30 DAY AVERAGE	DAILY MAXIMUM	SAMPLE FREQUENCY	SAMPLE TYPE

Outfall H01 – South Site Stormwater Runoff*
(Intermittent Discharge)

This discharge consists of:

1. Fire Protection System Flushing and Maintenance (Alternate Route)
2. Service Water System Flushing and Maintenance (Alternate Route)
3. Domestic Water System Flushing and Maintenance (Alternate Route)
4. Clean Condensate System Flushing and Maintenance (Alternate Route)
5. South Site Uncontaminated Stormwater Runoff

* - See Special Condition 8.

Outfall I01 – Reverse Osmosis System Reject Water and Greensand Filter Backwash
(Average Flow = 0.003 MGD)

PARAMETER	30 DAY AVERAGE	DAILY MAXIMUM	30 DAY AVERAGE	DAILY MAXIMUM	SAMPLE FREQUENCY	SAMPLE TYPE
Flow (MGD)	See Special Condition 1.				1/Week	24 Hour Total
Total Suspended Solids			15	30	1/Month	Grab

Outfall 002 – Illinois River Makeup Water Intake Screen Backwash*
(Intermittent Discharge)

This discharge consists of:

1. River Intake Screen Backwash
2. Trench Wash Water
3. Process Sampling Discharge
4. Lake Make-Up Pump Gland Leakoff, Coolers, Reliefs, and Min Flow
5. Lake Make-Up Pump Strainer Backwash
6. Air Compressor Receiver and Prefilter Drainage
7. Dewatering Pump Discharge
8. Fire Protection Water
9. River Screen House Switchyard Stormwater Runoff**
10. River Screen House Floor Drains and Roof Drains

* - Adequate maintenance of the intake screen system is required to prevent the discharge of floating debris collected on intake screens back to the Illinois River.
** - See Special Condition 8.

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Special Conditions

SPECIAL CONDITION 1. Flow shall be measured in units of Million Gallons per Day (MGD) and reported as a monthly average and a daily maximum on the Discharge Monitoring Report.

SPECIAL CONDITION 2. The pH shall be in the range 6.0 to 9.0. The monthly minimum and monthly maximum values shall be reported on the DMR form.

SPECIAL CONDITION 3. This facility meets the criteria for establishment of a formal mixing zone for thermal discharges pursuant to 35 IAC 302.102. The following mixing zone defines the area and volume of the receiving water body in which mixing is allowed to occur. Water quality standards for temperature listed in table below must be met at every point outside of the mixing zone.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
°F	60	60	60	90	90	90	90	90	90	90	90	60
°C	16	16	16	32	32	32	32	32	32	32	32	16

A. The temperature at the edge of the mixing zone should be calculated using the mass balance equation below:

$T_{EDGE} = [0.25 \times (Q_{US} \times T_{US}) + Q_E \times T_E] / (0.25 \times Q_{US} + Q_E)$

Where:

T_{EDGE} = Temperature at the edge of the mixing zone.
Q_{US} = Upstream Flow
T_{US} = Upstream Temperature
Q_E = Effluent Flow
T_E = Temperature of the effluent.

B. There shall be no abnormal temperature changes that may adversely affect aquatic life unless caused by natural conditions. The normal daily and seasonal temperature fluctuations which existed before the addition of heat due to other than natural causes shall be maintained.

C. The maximum temperature rise above natural temperatures shall not exceed 2.8° C (5° F).

D. The water temperature at the edge of the mixing zone defined above shall not exceed the maximum limits in the foregoing table during more than one percent of the hours in the 12 month period ending with any month. Moreover, at no time shall the water temperature at the edge of the mixing zone exceed the maximum limits in the foregoing table by more than 1.7° C (3° F).

E. The monthly maximum value shall be reported on the DMR form.

SPECIAL CONDITION 4. All samples for Total Residual Chlorine / Total Residual Oxidant shall be analyzed by an applicable method contained in 40 CFR 136, equivalent in accuracy to low-level amperometric titration. Any analytical variability of the method used shall be considered when determining the accuracy and precision of the results obtained.

SPECIAL CONDITION 5. There shall be no discharge of complexed metal bearing wastestreams and associated rinses from chemical metal cleaning unless this permit has been modified to include the new discharge.

SPECIAL CONDITION 6. The Permittee shall record monitoring results on Discharge Monitoring Report (DMR) Forms using one such form for each outfall each month.

In the event that an outfall does not discharge during a monthly reporting period, the DMR Form shall be submitted with no discharge indicated.

The Permittee may choose to submit electronic DMRs (eDMRs) instead of mailing paper DMRs to the IEPA. More information, including registration information for the eDMR program, can be obtained on the IEPA website, http://www.epa.state.il.us/water/edmr/index.html.

The completed Discharge Monitoring Report forms shall be submitted to IEPA no later than the 28th day of the following month, unless otherwise specified by the permitting authority.

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Permittees not using eDMRs shall mail Discharge Monitoring Reports with an original signature to the IEPA at the following address:

Illinois Environmental Protection Agency
Division of Water Pollution Control
1021 North Grand Avenue East
Post Office Box 19276
Springfield, Illinois 62794-9276

Attention: Compliance Assurance Section, Mail Code # 19

SPECIAL CONDITION 7. The upset defense provisions as defined in 40 CFR 122.41(n) are hereby incorporated by reference.

SPECIAL CONDITION 8.

STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

A. A storm water pollution prevention plan shall be maintained by the permittee for the storm water associated with industrial activity at this facility. The plan shall identify potential sources of pollution which may be expected to affect the quality of storm water discharges associated with the industrial activity at the facility. In addition, the plan shall describe and ensure the implementation of practices which are to be used to reduce the pollutants in storm water discharges associated with industrial activity at the facility and to assure compliance with the terms and conditions of this permit. The permittee shall modify the plan if substantive changes are made or occur affecting compliance with this condition.

1. Waters not classified as impaired pursuant to Section 303(d) of the Clean Water Act.

   Unless otherwise specified by federal regulation, the storm water pollution prevention plan shall be designed for a storm event equal to or greater than a 25-year 24-hour rainfall event.

2. Waters classified as impaired pursuant to Section 303(d) of the Clean Water Act.

   For any site which discharges directly to an impaired water identified in the Agency's 303(d) listing, and if any parameter in the subject discharge has been identified as the cause of impairment, the storm water pollution prevention plan shall be designed for a storm event equal to or greater than a 25-year 24-hour rainfall event. If required by federal regulations, the storm water pollution prevention plan shall adhere to a more restrictive design criteria.

B. The operator or owner of the facility shall make a copy of the plan available to the Agency at any reasonable time upon request.

Facilities which discharge to a municipal separate storm sewer system shall also make a copy available to the operator of the municipal system at any reasonable time upon request.

C. The permittee may be notified by the Agency at any time that the plan does not meet the requirements of this condition. After such notification, the permittee shall make changes to the plan and shall submit a written certification that the requested changes have been made. Unless otherwise provided, the permittee shall have 30 days after such notification to make the changes.

D. The discharger shall amend the plan whenever there is a change in construction, operation, or maintenance which may affect the discharge of significant quantities of pollutants to the waters of the State or if a facility inspection required by paragraph H of this condition indicates that an amendment is needed. The plan should also be amended if the discharger is in violation of any conditions of this permit, or has not achieved the general objective of controlling pollutants in storm water discharges. Amendments to the plan shall be made within 30 days of any proposed construction or operational changes at the facility, and shall be provided to the Agency for review upon request.

E. The plan shall provide a description of potential sources which may be expected to add significant quantities of pollutants to storm water discharges, or which may result in non-storm water discharges from storm water outfalls at the facility. The plan shall include, at a minimum, the following items:

1. A topographic map extending one-quarter mile beyond the property boundaries of the facility, showing: the facility, surface water bodies, wells (including injection wells), seepage pits, infiltration ponds, and the discharge points where the facility's storm water discharges to a municipal storm drain system or other water body. The requirements of this paragraph may be included on the site map if appropriate. Any map or portion of map may be withheld for security reasons.

2. A site map showing:

   i. The storm water conveyance and discharge structures;

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ii. An outline of the storm water drainage areas for each storm water discharge point;

iii. Paved areas and buildings;

iv. Areas used for outdoor manufacturing, storage, or disposal of significant materials, including activities that generate significant quantities of dust or particulates.

v. Location of existing storm water structural control measures (dikes, coverings, detention facilities, etc.);

vi. Surface water locations and/or municipal storm drain locations

vii. Areas of existing and potential soil erosion;

viii. Vehicle service areas;

ix. Material loading, unloading, and access areas.

x. Areas under items iv and ix above may be withheld from the site for security reasons.

3. A narrative description of the following:

   i. The nature of the industrial activities conducted at the site, including a description of significant materials that are treated, stored or disposed of in a manner to allow exposure to storm water;

   ii. Materials, equipment, and vehicle management practices employed to minimize contact of significant materials with storm water discharges;

   iii. Existing structural and non-structural control measures to reduce pollutants in storm water discharges;

   iv. Industrial storm water discharge treatment facilities;

   v. Methods of onsite storage and disposal of significant materials.

4. A list of the types of pollutants that have a reasonable potential to be present in storm water discharges in significant quantities. Also provide a list of any pollutant that is listed as impaired in the most recent 303(d) report.

5. An estimate of the size of the facility in acres or square feet, and the percent of the facility that has impervious areas such as pavement or buildings.

6. A summary of existing sampling data describing pollutants in storm water discharges.

F. The plan shall describe the storm water management controls which will be implemented by the facility. The appropriate controls shall reflect identified existing and potential sources of pollutants at the facility. The description of the storm water management controls shall include:

1. Storm Water Pollution Prevention Personnel - Identification by job titles of the individuals who are responsible for developing, implementing, and revising the plan.

2. Preventive Maintenance - Procedures for inspection and maintenance of storm water conveyance system devices such as oil/water separators, catch basins, etc., and inspection and testing of plant equipment and systems that could fail and result in discharges of pollutants to storm water.

3. Good Housekeeping - Good housekeeping requires the maintenance of clean, orderly facility areas that discharge storm water. Material handling areas shall be inspected and cleaned to reduce the potential for pollutants to enter the storm water conveyance system.

4. Spill Prevention and Response - Identification of areas where significant materials can spill into or otherwise enter the storm water conveyance systems and their accompanying drainage points. Specific material handling procedures, storage requirements, spill cleanup equipment and procedures should be identified, as appropriate. Internal notification procedures for spills of significant materials should be established.

5. Storm Water Management Practices - Storm water management practices are practices other than those which control the source of pollutants. They include measures such as installing oil and grit separators, diverting storm water into retention

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basins, etc. Based on assessment of the potential of various sources to contribute pollutants, measures to remove pollutants from storm water discharge shall be implemented. In developing the plan, the following management practices shall be considered:

i. Containment - Storage within berms or other secondary containment devices to prevent leaks and spills from entering storm water runoff. To the maximum extent practicable storm water discharged from any area where material handling equipment or activities, raw material, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water should not enter vegetated areas or surface waters or infiltrate into the soil unless adequate treatment is provided.

ii. Oil & Grease Separation - Oil/water separators, booms, skimmers or other methods to minimize oil contaminated storm water discharges.

iii. Debris & Sediment Control - Screens, booms, sediment ponds or other methods to reduce debris and sediment in storm water discharges.

iv. Waste Chemical Disposal - Waste chemicals such as antifreeze, degreasers and used oils shall be recycled or disposed of in an approved manner and in a way which prevents them from entering storm water discharges.

v. Storm Water Diversion - Storm water diversion away from materials manufacturing, storage and other areas of potential storm water contamination. Minimize the quantity of storm water entering areas where material handling equipment of activities, raw material, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water using green infrastructure techniques where practicable in the areas outside the exposure area, and otherwise divert storm water away from exposure area.

vi. Covered Storage or Manufacturing Areas - Covered fueling operations, materials manufacturing and storage areas to prevent contact with storm water.

vii. Storm Water Reduction - Install vegetation on roofs of buildings within adjacent to the exposure area to detain and evapotranspirate runoff where precipitation falling on the roof is not exposed to contaminants, to minimize storm water runoff; capture storm water in devices that minimize the amount of storm water runoff and use this water as appropriate based on quality.

6. Sediment and Erosion Prevention - The plan shall identify areas which due to topography, activities, or other factors, have a high potential for significant soil erosion. The plan shall describe measures to limit erosion.

7. Employee Training - Employee training programs shall inform personnel at all levels of responsibility of the components and goals of the storm water pollution control plan. Training should address topics such as spill response, good housekeeping and material management practices. The plan shall identify periodic dates for such training.

8. Inspection Procedures - Qualified plant personnel shall be identified to inspect designated equipment and plant areas. A tracking or follow-up procedure shall be used to ensure appropriate response has been taken in response to an inspection. Inspections and maintenance activities shall be documented and recorded.

G. Non-Storm Water Discharge - The plan shall include a certification that the discharge has been tested or evaluated for the presence of non-storm water discharge. The certification shall include a description of any test for the presence of non-storm water discharges, the methods used, the dates of the testing, and any onsite drainage points that were observed during the testing. Any facility that is unable to provide this certification must describe the procedure of any test conducted for the presence of non-storm water discharges, the test results, potential sources of non-storm water discharges to the storm sewer, and why adequate tests for such storm sewers were not feasible.

H. Quarterly Visual Observation of Discharges - The requirements and procedures for quarterly visual observations are applicable to all outfalls covered by this condition.

1. You must perform and document a quarterly visual observation of a storm water discharge associated with industrial activity from each outfall. The visual observation must be made during daylight hours. If no storm event resulted in runoff during daylight hours from the facility during a monitoring quarter, you are excused from the visual observations requirement for that quarter, provided you document in your records that no runoff occurred. You must sign and certify the document.

2. Your visual observation must be made on samples collected as soon as practical, but not to exceed 1 hour or when the runoff or snow melt begins discharging from your facility. All samples must be collected from a storm event discharge that is greater than 0.1 inch in magnitude and that occurs at least 72 hours from the previously measureable (greater than 0.1 inch rainfall) storm event. The observation must document: color, odor, clarity, floating solids, settled solids, suspended solids, foam, oil

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sheen, and other obvious indicators of storm water pollution. If visual observations indicate any unnatural color, odor, turbidity, floatable material, oil sheen or other indicators of storm water pollution, the permittee shall obtain a sample and monitor for the parameter or the list of pollutants in Part E.4.

3. You must maintain your visual observation reports onsite with the SWPPP. The report must include the observation date and time, inspection personnel, nature of the discharge (i.e., runoff or snow melt), visual quality of the storm water discharge (including observations of color, odor, floating solids, settled solids, suspended solids, foam, oil sheen, and other obvious indicators of storm water pollution), and probable sources of any observed storm water contamination.

4. You may exercise a waiver of the visual observation requirement at a facility that is inactive or unstaffed, as long as there are no industrial materials or activities exposed to storm water. If you exercise this waiver, you must maintain a certification with your SWPPP stating that the site is inactive and unstaffed, and that there are no industrial materials or activities exposed to storm water.

5. Representative Outfalls - If your facility has two or more outfalls that you believe discharge substantially identical effluents, based on similarities of the industrial activities, significant materials, size of drainage areas, and storm water management practices occurring within the drainage areas of the outfalls, you may conduct visual observations of the discharge at just one of the outfalls and report that the results also apply to the substantially identical outfall(s).

6. The visual observation documentation shall be made available to the Agency and general public upon written request.

I. The permittee shall conduct an annual facility inspection to verify that all elements of the plan, including the site map, potential pollutant sources, and structural and non-structural controls to reduce pollutants in industrial storm water discharges are accurate. Observations that require a response and the appropriate response to the observation shall be retained as part of the plan. Records documenting significant observations made during the site inspection shall be submitted to the Agency in accordance with the reporting requirements of this permit.

J. This plan should briefly describe the appropriate elements of other program requirements, including Spill Prevention Control and Countermeasures (SPCC) plans required under Section 311 of the CWA and the regulations promulgated there under, and Best Management Programs under 40 CFR 125.100.

K. The plan is considered a report that shall be available to the public at any reasonable time upon request.

L. The plan shall include the signature and title of the person responsible for preparation of the plan and include the date of initial preparation and each amendment thereto.

M. Facilities which discharge storm water associated with industrial activity to municipal separate storm sewers may also be subject to additional requirement imposed by the operator of the municipal system

Construction Authorization

Authorization is hereby granted to construct treatment works and related equipment that may be required by the Storm Water Pollution Prevention Plan developed pursuant to this permit.

This Authorization is issued subject to the following condition(s).

N. If any statement or representation is found to be incorrect, this authorization may be revoked and the permittee there upon waives all rights there under.

O. The issuance of this authorization (a) does not release the permittee from any liability for damage to persons or property caused by or resulting from the installation, maintenance or operation of the proposed facilities; (b) does not take into consideration the structural stability of any units or part of this project; and (c) does not release the permittee from compliance with other applicable statutes of the State of Illinois, or other applicable local law, regulations or ordinances.

P. Plans and specifications of all treatment equipment being included as part of the stormwater management practice shall be included in the SWPPP.

Q. Construction activities which result from treatment equipment installation, including clearing, grading and excavation activities which result in the disturbance of one acre or more of land area, are not covered by this authorization. The permittee shall contact the IEPA regarding the required permit(s).

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REPORTING

R. The facility shall submit an electronic copy of the annual inspection report to the Illinois Environmental Protection Agency. The report shall include results of the annual facility inspection which is required by Part I of this condition. The report shall also include documentation of any event (spill, treatment unit malfunction, etc.) which would require an inspection, results of the inspection, and any subsequent corrective maintenance activity. The report shall be completed and signed by the authorized facility employee(s) who conducted the inspection(s). The annual inspection report is considered a public document that shall be available at any reasonable time upon request.

S. The first report shall contain information gathered during the one year time period beginning with the effective date of coverage under this permit and shall be submitted no later than 60 days after this one year period has expired. Each subsequent report shall contain the previous year's information and shall be submitted no later than one year after the previous year's report was due.

T. If the facility performs inspections more frequently than required by this permit, the results shall be included as additional information in the annual report.

U. The permittee shall retain the annual inspection report on file at least 3 years. This period may be extended by request of the Illinois Environmental Protection Agency at any time.

Annual inspection reports shall be mailed to the following address:

Illinois Environmental Protection Agency
Bureau of Water
Compliance Assurance Section
Annual Inspection Report
1021 North Grand Avenue East
Post Office Box 19276
Springfield, Illinois 62794-9276

V. The permittee shall notify any regulated small municipal separate storm sewer owner (MS4 Community) that they maintain coverage under an individual NPDES permit. The permittee shall submit any SWPPP or any annual inspection to the MS4 community upon request by the MS4 community.

SPECIAL CONDITION 9. This permit authorizes the use of water treatment additives that were requested as part of this renewal. The use of any new additives, or change in those previously approved by the Agency, or if the permittee increases the feed rate or quantity of the additives used beyond what has been approved by the Agency, the permittee shall request a modification of this permit in accordance with the Standard Conditions - Attachment H.

The permittee shall submit to the Agency on a yearly basis a report summarizing their efforts with water treatment suppliers to find a suitable alternative to phosphorus based additives.

SPECIAL CONDITION 10. This permit may be modified to include different final effluent limitations or requirements which are consistent with applicable laws, regulations, or judicial orders. The Agency will public notice the permit modification.

SPECIAL CONDITION 11. The effluent, alone or in combination with other sources, shall not cause a violation of any applicable water quality standard outlined in 35 Ill. Adm. Code 302.

SPECIAL CONDITION 12. The use or operation of this facility shall be by or under the supervision of a Certified Class K operator.

SPECIAL CONDITION 13. There shall be no discharge of polychlorinated biphenyl compounds (PCBs).

SPECIAL CONDITION 14. Samples taken in compliance with the effluent monitoring requirements shall be taken at a point representative of the discharge, but prior to entry into the receiving stream.

SPECIAL CONDITION 15. The facility utilizes a closed-cycle recirculating cooling system, a 2058 acre cooling pond, for cooling of plant condensers and is determined to be the equivalent of Best Technology Available (BTA) for cooling water intake structures to prevent/minimize impingement mortality in accordance with the Best Professional Judgment (BPJ) provisions of 40 CFR 125.3 because it allows the facility to only withdraw the amount of water necessary to maintain the cooling pond level rather than the entire volume used for cooling of the plant condensers.

In order for the Agency to evaluate the potential impacts of cooling water intake structure operations pursuant to 40 CFR 125.90(b), the permittee shall prepare and submit information to the Agency outlining current intake structure conditions at this facility, including a detailed description of the current intake structure operation and design, description of any operational or structural modifications from

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original design parameters, source waterbody flow information as necessary.

The information shall also include a summary of historical 316(b) related intake impingement and/or entrainment studies, if any, as well as current impingement mortality and/or entrainment characterization data; and shall be submitted to the Agency within six (6) months of the permit's effective date.

Upon the receipt and review of this information, the permit may be modified to require the submittal of additional information based on a Best Professional Judgment review by the Agency. This permit may also be revised or modified in accordance with any laws, regulations, or judicial orders pursuant to Section 316(b) of the Clean Water Act.

SPECIAL CONDITION 16. For a period of 18 months following the effective date of this permit during times when the condenser cooling water is chlorinated intermittently, Total Residual Chlorine may be discharged from each generating unit's main condensers for no more than 2 hours per day. During such authorized discharge time period, the maximum discharge limit is 0.2 mg/l, measured as an instantaneous maximum.

A Total Residual Chlorine limit of 0.05 mg/l (Daily Maximum) for outfall 001 shall become effective 18 months from the effective date of this Permit.

The Permittee shall construct a dechlorination system or some alternative means of compliance in accordance with the following schedule:

1. Status Report	4 months from the effective date
2. Commence Construction	10 months from the effective date
3. Status Report	14 months from the effective date
4. Complete Construction	16 months from the effective date
5. Obtain Operation Level	18 months from the effective date

Compliance dates set out in this Permit may be superseded or supplemented by compliance dates in judicial orders, or Pollution Control Board orders. This Permit may be modified, with Public Notice, to include such revised compliance dates.

The Permittee shall operate the dechlorination system or an alternative means of compliance in a manner to ensure continuous compliance with the Total Residual Chlorine limit, not to the extent that will result in violations of other permitted effluent characteristic, or water quality standards.

REPORTING

The Permittee shall submit a report no later than fourteen (14) days following the completion dates indicated above for each numbered item in the compliance schedule, indicating, a) the date the item was completed, or b) that the item was not completed, the reason for non-completion, and the anticipated completion date.

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Attachment H

Standard Conditions

Definitions

Act means the Illinois Environmental Protection Act, 415 ILCS 5 as Amended.

Agency means the Illinois Environmental Protection Agency.

Board means the Illinois Pollution Control Board.

Clean Water Act (formerly referred to as the Federal Water Pollution Control Act) means Pub. L 92-500, as amended. 33 U.S.C. 1251 et seq.

NPDES (National Pollutant Discharge Elimination System) means the national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 402, 318 and 405 of the Clean Water Act.

USEPA means the United States Environmental Protection Agency.

Daily Discharge means the discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurements, the "daily discharge" is calculated as the average measurement of the pollutant over the day.

Maximum Daily Discharge Limitation (daily maximum) means the highest allowable daily discharge.

Average Monthly Discharge Limitation (30 day average) means the highest allowable average of daily discharges over a calendar month, calculated as the sum of all daily discharges measured during a calendar month divided by the number of daily discharges measured during that month.

Average Weekly Discharge Limitation (7 day average) means the highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges measured during that week.

Best Management Practices (BMPs) means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Aliquot means a sample of specified volume used to make up a total composite sample.

Grab Sample means an individual sample of at least 100 milliliters collected at a randomly-selected time over a period not exceeding 15 minutes.

24-Hour Composite Sample means a combination of at least 8 sample aliquots of at least 100 milliliters, collected at periodic intervals during the operating hours of a facility over a 24-hour period.

8-Hour Composite Sample means a combination of at least 3 sample aliquots of at least 100 milliliters, collected at periodic intervals during the operating hours of a facility over an 8-hour period.

Flow Proportional Composite Sample means a combination of sample aliquots of at least 100 milliliters collected at periodic intervals such that either the time interval between each aliquot or the volume of each aliquot is proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot.

(1) **Duty to comply.** The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action, permit termination, revocation and reissuance, modification, or for denial of a permit renewal application. The permittee shall comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish these standards or prohibitions, even if the permit has not yet been modified to incorporate the requirements.

(2) **Duty to reapply.** If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and obtain a new permit. If the permittee submits a proper application as required by the Agency no later than 180 days prior to the expiration date, this permit shall continue in full force and effect until the final Agency decision on the application has been made.

(3) **Need to halt or reduce activity not a defense.** It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

(4) **Duty to mitigate.** The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

(5) **Proper operation and maintenance.** The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up, or auxiliary facilities, or similar systems only when necessary to achieve compliance with the conditions of the permit.

(6) **Permit actions.** This permit may be modified, revoked and reissued, or terminated for cause by the Agency pursuant to 40 CFR 122.62 and 40 CFR 122.63. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

(7) **Property rights.** This permit does not convey any property rights of any sort, or any exclusive privilege.

(8) **Duty to provide information.** The permittee shall furnish to the Agency within a reasonable time, any information which the Agency may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with the permit. The permittee shall also furnish to the Agency upon request, copies of records required to be kept by this permit.

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(9) **Inspection and entry**. The permittee shall allow an authorized representative of the Agency or USEPA (including an authorized contractor acting as a representative of the Agency or USEPA), upon the presentation of credentials and other documents as may be required by law, to:
   (a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;
   (b) Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
   (c) Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and
   (d) Sample or monitor at reasonable times, for the purpose of assuring permit compliance, or as otherwise authorized by the Act, any substances or parameters at any location.

(10) **Monitoring and records.**
   (a) Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.
   (b) The permittee shall retain records of all monitoring information, including all calibration and maintenance records, and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of this permit, measurement, report or application. Records related to the permittee's sewage sludge use and disposal activities shall be retained for a period of at least five years (or longer as required by 40 CFR Part 503). This period may be extended by request of the Agency or USEPA at any time.
   (c) Records of monitoring information shall include:
      (1) The date, exact place, and time of sampling or measurements;
      (2) The individual(s) who performed the sampling or measurements;
      (3) The date(s) analyses were performed;
      (4) The individual(s) who performed the analyses;
      (5) The analytical techniques or methods used; and
      (6) The results of such analyses.
   (d) Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit. Where no test procedure under 40 CFR Part 136 has been approved, the permittee must submit to the Agency a test method for approval. The permittee shall calibrate and perform maintenance procedures on all monitoring and analytical instrumentation at intervals to ensure accuracy of measurements.

(11) **Signatory requirement**. All applications, reports or information submitted to the Agency shall be signed and certified.
   (a) **Application.** All permit applications shall be signed as follows:
      (1) For a corporation: by a principal executive officer of at least the level of vice president or a person or position having overall responsibility for environmental matters for the corporation:
      (2) For a partnership or sole proprietorship: by a general partner or the proprietor, respectively; or
      (3) For a municipality, State, Federal, or other public agency: by either a principal executive officer or ranking elected official.
   (b) **Reports.** All reports required by permits, or other information requested by the Agency shall be signed by a person described in paragraph (a) or by a duly authorized representative of that person. A person is a duly authorized representative only if:
      (1) The authorization is made in writing by a person described in paragraph (a); and
      (2) The authorization specifies either an individual or a position responsible for the overall operation of the facility, from which the discharge originates, such as a plant manager, superintendent or person of equivalent responsibility; and
      (3) The written authorization is submitted to the Agency.
   (c) **Changes of Authorization.** If an authorization under (b) is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of (b) must be submitted to the Agency prior to or together with any reports, information, or applications to be signed by an authorized representative.
   (d) **Certification.** Any person signing a document under paragraph (a) or (b) of this section shall make the following certification:

   I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

(12) **Reporting requirements.**
   (a) **Planned changes.** The permittee shall give notice to the Agency as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required when:
      (1) The alteration or addition to a permitted facility may meet one of the criteria for determining whether a facility is a new source pursuant to 40 CFR 122.29 (b); or
      (2) The alteration or addition could significantly change the nature or increase the quantity of pollutants discharged. This notification applies to pollutants which are subject neither to effluent limitations in the permit, nor to notification requirements pursuant to 40 CFR 122.42 (a)(1).
      (3) The alteration or addition results in a significant change in the permittee's sludge use or disposal practices, and such alteration, addition, or change may justify the application of permit conditions that are different from or absent in the existing permit, including notification of additional use or disposal sites not reported during the permit application process or not reported pursuant to an approved land application plan.
   (b) **Anticipated noncompliance.** The permittee shall give advance notice to the Agency of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.
   (c) **Transfers**. This permit is not transferable to any person except after notice to the Agency.
   (d) **Compliance schedules.** Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each schedule date.
   (e) **Monitoring reports.** Monitoring results shall be reported at the intervals specified elsewhere in this permit.
      (1) Monitoring results must be reported on a Discharge Monitoring Report (DMR).

(2) If the permittee monitors any pollutant more frequently than required by the permit, using test procedures approved under 40 CFR 136 or as specified in the permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR.

(3) Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean unless otherwise specified by the Agency in the permit.

(f) **Twenty-four hour reporting.** The permittee shall report any noncompliance which may endanger health or the environment. Any information shall be provided orally within 24-hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within 5 days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and time; and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance. The following shall be included as information which must be reported within 24-hours:

(1) Any unanticipated bypass which exceeds any effluent limitation in the permit.

(2) Any upset which exceeds any effluent limitation in the permit.

(3) Violation of a maximum daily discharge limitation for any of the pollutants listed by the Agency in the permit or any pollutant which may endanger health or the environment.

The Agency may waive the written report on a case-by-case basis if the oral report has been received within 24-hours.

(g) **Other noncompliance.** The permittee shall report all instances of noncompliance not reported under paragraphs (12) (d), (e), or (f), at the time monitoring reports are submitted. The reports shall contain the information listed in paragraph (12) (f).

(h) **Other information.** Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application, or in any report to the Agency, it shall promptly submit such facts or information.

(13) **Bypass.**

(a) Definitions.

(1) Bypass means the intentional diversion of waste streams from any portion of a treatment facility.

(2) Severe property damage means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

(b) Bypass not exceeding limitations. The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions of paragraphs (13)(c) and (13)(d).

(c) Notice.

(1) Anticipated bypass. If the permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible at least ten days before the date of the bypass.

(2) Unanticipated bypass. The permittee shall submit notice of an unanticipated bypass as required in paragraph (12)(f) (24-hour notice).

(d) Prohibition of bypass.

(1) Bypass is prohibited, and the Agency may take enforcement action against a permittee for bypass, unless:

(i) Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

(ii) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

(iii) The permittee submitted notices as required under paragraph (13)(c).

(2) The Agency may approve an anticipated bypass, after considering its adverse effects, if the Agency determines that it will meet the three conditions listed above in paragraph (13)(d)(1).

(14) **Upset.**

(a) Definition. Upset means an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

(b) Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with such technology based permit effluent limitations if the requirements of paragraph (14)(c) are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

(c) Conditions necessary for a demonstration of upset. A permittee who wishes to establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

(1) An upset occurred and that the permittee can identify the cause(s) of the upset;

(2) The permitted facility was at the time being properly operated; and

(3) The permittee submitted notice of the upset as required in paragraph (12)(f)(2) (24-hour notice).

(4) The permittee complied with any remedial measures required under paragraph (4).

(d) Burden of proof. In any enforcement proceeding the permittee seeking to establish the occurrence of an upset has the burden of proof.

(15) **Transfer of permits.** Permits may be transferred by modification or automatic transfer as described below:

(a) Transfers by modification. Except as provided in paragraph (b), a permit may be transferred by the permittee to a new owner or operator only if the permit has been modified or revoked and reissued pursuant to 40 CFR 122.62 (b) (2), or a minor modification made pursuant to 40 CFR 122.63 (d), to identify the new permittee and incorporate such other requirements as may be necessary under the Clean Water Act.

(b) Automatic transfers. As an alternative to transfers under paragraph (a), any NPDES permit may be automatically transferred to a new permittee if:

(1) The current permittee notifies the Agency at least 30 days in advance of the proposed transfer date;

(2) The notice includes a written agreement between the existing and new permittees containing a specified date for transfer of permit responsibility, coverage and liability between the existing and new permittees; and

(3) The Agency does not notify the existing permittee and the proposed new permittee of its intent to modify or revoke and reissue the permit. If this notice is not received, the transfer is effective on the date specified in the agreement.

(16) All manufacturing, commercial, mining, and silvicultural dischargers must notify the Agency as soon as they know or have reason to believe:

(a) That any activity has occurred or will occur which would result in the discharge of any toxic pollutant identified under Section 307 of the Clean Water Act which is not limited in the permit, if that discharge will exceed the highest of the following notification levels:

(1) One hundred micrograms per liter (100 ug/l);

(2) Two hundred micrograms per liter (200 ug/l) for acrolein and acrylonitrile; five hundred micrograms per liter (500 ug/l) for 2,4-dinitrophenol and for 2-methyl-4,6 dinitrophenol; and one milligram per liter (1 mg/l) for antimony.

(3) Five (5) times the maximum concentration value reported for that pollutant in the NPDES permit application; or

(4) The level established by the Agency in this permit.

(b) That they have begun or expect to begin to use or manufacture as an intermediate or final product or byproduct any toxic pollutant which was not reported in the NPDES permit application.

(17) All Publicly Owned Treatment Works (POTWs) must provide adequate notice to the Agency of the following:

(a) Any new introduction of pollutants into that POTW from an indirect discharge which would be subject to Sections 301 or 306 of the Clean Water Act if it were directly discharging those pollutants; and

(b) Any substantial change in the volume or character of pollutants being introduced into that POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.

(c) For purposes of this paragraph, adequate notice shall include information on (i) the quality and quantity of effluent introduced into the POTW, and (ii) any anticipated impact of the change on the quantity or quality of effluent to be discharged from the POTW.

(18) If the permit is issued to a publicly owned or publicly regulated treatment works, the permittee shall require any industrial user of such treatment works to comply with federal requirements concerning:

(a) User charges pursuant to Section 204 (b) of the Clean Water Act, and applicable regulations appearing in 40 CFR 35;

(b) Toxic pollutant effluent standards and pretreatment standards pursuant to Section 307 of the Clean Water Act; and

(c) Inspection, monitoring and entry pursuant to Section 308 of the Clean Water Act.

(19) If an applicable standard or limitation is promulgated under Section 301(b)(2)(C) and (D), 304(b)(2), or 307(a)(2) and that effluent standard or limitation is more stringent than any effluent limitation in the permit, or controls a pollutant not limited in the permit, the permit shall be promptly modified or revoked, and reissued to conform to that effluent standard or limitation.

(20) Any authorization to construct issued to the permittee pursuant to 35 Ill. Adm. Code 309.154 is hereby incorporated by reference as a condition of this permit.

(21) The permittee shall not make any false statement, representation or certification in any application, record, report, plan or other document submitted to the Agency or the USEPA, or required to be maintained under this permit.

(22) The Clean Water Act provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Clean Water Act is subject to a civil penalty not to exceed $25,000 per day of such violation. Any person who willfully or negligently violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318 or 405 of the Clean Water Act is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than one year, or both.
Additional penalties for violating these sections of the Clean Water Act are identified in 40 CFR 122.41 (a)(2) and (3).

(23) The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than 2 years, or both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment is a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or both.

(24) The Clean Water Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or non-compliance shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

(25) Collected screening, slurries, sludges, and other solids shall be disposed of in such a manner as to prevent entry of those wastes (or runoff from the wastes) into waters of the State. The proper authorization for such disposal shall be obtained from the Agency and is incorporated as part hereof by reference.

(26) In case of conflict between these standard conditions and any other condition(s) included in this permit, the other condition(s) shall govern.

(27) The permittee shall comply with, in addition to the requirements of the permit, all applicable provisions of 35 Ill. Adm. Code, Subtitle C, Subtitle D, Subtitle E, and all applicable orders of the Board or any court with jurisdiction.

(28) The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit is held invalid, the remaining provisions of this permit shall continue in full force and effect.

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Appendix D

Special Status Species Correspondence

LaSalle County Station Environmental Report

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Exelon Generation

Michael P. Gallagher
Vice President, License Renewal
Exelon Nuclear

200 Exelon Way
[illegible] Square, PA [illegible]

[illegible] Office
[illegible]
[illegible]

[illegible]

March 7, 2014

Mr. Richard Nelson
U.S. Fish and Wildlife Service
Rock Island Field Office
1511 47th Avenue
Moline, Il 61265

SUBJECT: Exelon Generation Company, LLC – LaSalle County Station Units 1 and 2 License Renewal Project. Request for Information on Listed Species and Sensitive Habitats – LaSalle County

Dear Mr. Nelson:

Exelon Generation Company, LLC (Exelon) plans to apply to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating licenses for LaSalle County Station (LaSalle) Units 1 and 2 no later than January 2015. The existing operating license for Unit 1 will expire on April 17, 2022, and the existing operating license for Unit 2 will expire on December 16, 2023. Renewed licenses would allow LaSalle Units 1 and 2 to operate until 2042 and 2043, respectively.

As part of the license renewal process, the NRC requires (10 CFR 51.53(c)(3)(ii)(E)) that the LaSalle license renewal application include an environmental report assessing the impacts from license renewal activities on species listed or proposed for listing as threatened or endangered in accordance with the Endangered Species Act (ESA) (16 USC 1531, et seq.) and on important plant and animal habitats, including critical habitats as defined by the ESA and essential fish habitat as identified under the Magnuson-Stevens Fishery Conservation and Management Act (16 USC 1801. et seq.). Because no species with essential fish habitat is found in Illinois, this letter seeks input from the U.S. Fish and Wildlife Service (USFWS) regarding effects on species and habitats protected under the ESA only that are in the vicinity of LaSalle, including along the right-of-way (ROW) for the cooling water makeup and blowdown pipelines between the LaSalle cooling pond and the Illinois River.

In June 2013, the NRC revised its regulations at 10 CFR Part 51 such that no transmission line ROW associated with LaSalle requires assessment for environmental impacts from license renewal activities.

Project Features

LaSalle is located in northeastern Illinois, about 75 miles southwest of Chicago, in LaSalle County. The property is approximately 6 miles southwest of Seneca and 7 miles south-southeast of Marseilles, as shown in the attached Figure 1. The area surrounding LaSalle is relatively flat, and is rural and agricultural. Numerous wind turbines operate in the immediate vicinity.

LaSalle occupies approximately 3,875 acres, of which approximately 2,058 acres comprise the cooling pond. The generating facilities at LaSalle are on the southwest portion of the site and include the reactor building and related structures, a switchyard, administration buildings, warehouses, and other structures. The ROW for the cooling water makeup and blowdown pipelines runs for a distance of 3.5 miles north from the cooling pond to the Marseilles Pool portion of the Illinois River. An intake pumphouse and a discharge structure are on the south bank of the Marseilles Pool, approximately 1,000 feet apart.

The ROW for the makeup and blowdown pipelines crosses the eastern portion of the Marseilles State Fish and Wildlife Area, a 2,550-ac area managed by the Illinois Department of Natural Resources (DNR) for hunting and wildlife habitat. Marseilles State Fish and Wildlife Area (including the portion of the pipelines ROW that crosses it) also is used by the Illinois National Guard for training when hunting seasons are closed.

The cooling pond, which provides the LaSalle condenser with a continuous supply of cooling water, was created by constructing dikes that rise above the surrounding land. The cooling pond has an elevation of 700 feet above mean sea level at normal pool capacity. Illinois DNR leases the cooling pond, except the ultimate heat sink portion (83 acres), from Exelon and manages it for public fishing. The cooling pond serves as the water supply for an Illinois DNR fish hatchery located on land adjacent to the pond and also leased to Illinois DNR by Exelon Generation.

Cooling water blowdown from the cooling pond as well as monitored plant effluents are released to the Illinois River via the blowdown pipeline, a plunge pool, and an open, rip-rap-lined channel located downstream of the river intake pumphouse. This discharge is subject to limitations established by National Pollutant Discharge Elimination System (NPDES) Permit IL0048151.

Threatened and Endangered Species in the Project Vicinity

Bald eagles were observed in the LaSalle vicinity during the 1970s, but Exelon is not aware of bald eagle sightings in recent years. Although the USFWS removed the bald eagle from the federal list of threatened and endangered species in 2007, it is still federally protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Exelon is not aware of any other federally listed aquatic or terrestrial species being observed on the LaSalle site. The only state-listed species that Exelon is aware of being observed or recorded at LaSalle is the peregrine falcon. A pair nested on the roof of the LaSalle auxiliary building several years ago, but no nesting has been observed in recent years. Exelon personnel occasionally observe peregrine falcons flying in the vicinity of LaSalle.

The LaSalle license renewal project information was submitted to the Illinois DNR through the EcoCAT system. Attached for your review are the EcoCAT Natural Resource Review results from a query of the Illinois Natural Heritage database for LaSalle. The attached query response for LaSalle indicates that the Marseilles Illinois Natural Area Inventory (INAI), the LaSalle Lake INAI, and the Marseilles Hill Prairie INAI sites are in the vicinity of LaSalle. No protected species were identified.

Activities during the License Renewal Terms

Renewal of LaSalle operating licenses will not require new construction, land-disturbing activities, changes to plant operations, or modifications of the intake or discharge pipelines. Operation and maintenance activities during the terms of the renewed licenses are expected to occur mostly in previously disturbed areas. In addition, Exelon adheres to regulatory requirements regarding sensitive areas that could contain threatened or endangered species and works closely with USFWS and Illinois DNR to protect these resources. Therefore, Exelon expects that continued operation and maintenance of LaSalle over the license renewal periods (i.e., an additional 20 years for each unit), including maintenance of the ROW for the cooling water makeup and blowdown pipelines, would not adversely affect any ecologically significant habitats or any species that is federally-listed or proposed for listing as threatened or endangered.

Nevertheless, Exelon is requesting your help to identify potential impacts or other issues we may have overlooked that need to be addressed in the LaSalle license renewal environmental report. We are also interested in learning of any information that is not included here and that your staff believes could help expedite the NRC's review of the LaSalle license renewal application. Hence, in closing, we would appreciate receiving a response from you detailing such issues and information for the LaSalle site and cooling water pipeline ROW. We would also welcome your confirmation of our conclusion that LaSalle license renewal activities would not adversely affect ecologically significant habitats or any species that is federally-listed or proposed for listing as threatened and endangered.

Because Exelon will incorporate a copy of your response, as well as this letter, into the LaSalle license renewal environmental report that will be submitted to the NRC as part of the LaSalle license renewal application, your response will be most helpful if it is received by April 30, 2014.

Please refer any questions regarding this submittal to Nancy Ranek, our License Renewal Environmental Lead, at (610) 765-5369. Thank you in advance for your assistance.

Sincerely,

Michael P. Gallagher

Michael P. Gallagher

Enclosures:

Figure 1: Project Location Map
EcoCAT Natural Resources Review results for LaSalle Station

Nelson - 4

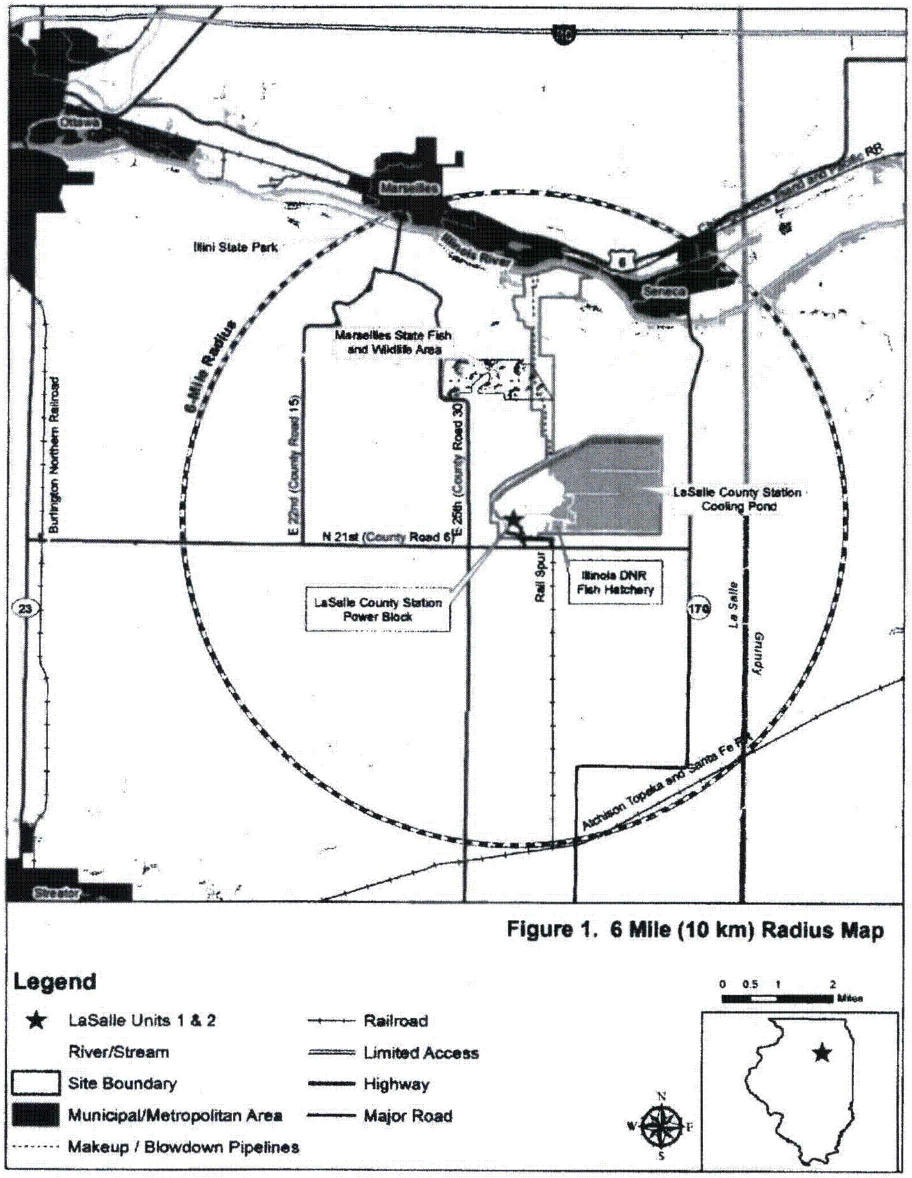

Figure 1. 6 Mile (10 km) Radius Map

Nelson - 5

EcoCAT

Applicant:	Exelon Generation Company LLC	*IDNR Project Number:*	1404780
Contact:	Nancy L. Ranek	*Date:*	09/24/2013
Address:	200 Exelon Way Kennett Square, PA 19348		

Project: Renewal of Facility Operating Licenses by the U.S Nuclear Regulatory Commission
Address: (NRC) for LaSalle Generating Station, Units 1 and 2
2601 North 21st Road, Marseilles

Description: Exelon Generation Company LLC seeks renewal of the NRC operating licenses for LaSalle Generating Station, Units 1 and 2, in order to provide an option for power generation capability beyond the term of the current operating licenses, as such needs may be determined by State, utility, and where authorized, Federal (other than the NRC) decision makers. License renewal will authorize no new construction or operational changes at the Station.

Natural Resource Review Results

This project was submitted for information only. It is not a consultation under Part 1075.

The Illinois Natural Heritage Database shows the following protected resources may be in the vicinity of the project location:

Illinois River - Marseilles INAI Site
Lasalle Lake INAI Site
Marseilles Hill Prairie INAI Site

Location

The applicant is responsible for the accuracy of the location submitted for the project.

County: LaSalle

Township, Range, Section:
32N, 5E, 4
32N, 5E, 5
32N, 5E, 8
32N, 5E, 9
32N, 5E, 10
32N, 5E, 11
32N, 5E, 14
32N, 5E, 15
32N, 5E, 16
32N, 5E, 17
33N, 5E, 21
33N, 5E, 22
33N, 5E, 28
33N, 5E, 29
33N, 5E, 32
33N, 5E, 33

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IDNR Project Number: 1404780

IL Department of Natural Resources
Contact
Impact Assessment Section
217-785-5500
Division of Ecosystems & Environment

Disclaimer

The Illinois Natural Heritage Database cannot provide a conclusive statement on the presence, absence, or condition of natural resources in Illinois. This review reflects the information existing in the Database at the time of this inquiry, and should not be regarded as a final statement on the site being considered, nor should it be a substitute for detailed site surveys or field surveys required for environmental assessments. If additional protected resources are encountered during the project's implementation, compliance with applicable statutes and regulations is required.

Terms of Use

By using this website, you acknowledge that you have read and agree to these terms. These terms may be revised by IDNR as necessary. If you continue to use the EcoCAT application after we post changes to these terms, it will mean that you accept such changes. If at any time you do not accept the Terms of Use, you may not continue to use the website.

1. The IDNR EcoCAT website was developed so that units of local government, state agencies and the public could request information or begin natural resource consultations on-line for the Illinois Endangered Species Protection Act, Illinois Natural Areas Preservation Act, and Illinois Interagency Wetland Policy Act. EcoCAT uses databases, Geographic Information System mapping, and a set of programmed decision rules to determine if proposed actions are in the vicinity of protected natural resources. By indicating your agreement to the Terms of Use for this application, you warrant that you will not use this web site for any other purpose.

2. Unauthorized attempts to upload, download, or change information on this website are strictly prohibited and may be punishable under the Computer Fraud and Abuse Act of 1986 and/or the National Information Infrastructure Protection Act.

3. IDNR reserves the right to enhance, modify, alter, or suspend the website at any time without notice, or to terminate or restrict access.

Security

EcoCAT operates on a state of Illinois computer system. We may use software to monitor traffic and to identify unauthorized attempts to upload, download, or change information, to cause harm or otherwise to damage this site. Unauthorized attempts to upload, download, or change information on this server is strictly prohibited by law.

Unauthorized use, tampering with or modification of this system, including supporting hardware or software, may subject the violator to criminal and civil penalties. In the event of unauthorized intrusion, all relevant information regarding possible violation of law may be provided to law enforcement officials.

Privacy

EcoCAT generates a public record subject to disclosure under the Freedom of Information Act. Otherwise, IDNR uses the information submitted to EcoCAT solely for internal tracking purposes.

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Ranek, Nancy L.:(GenCo-Nuc)

Subject: FW: Request for Information on Listed Species and Sensitive Habitats -- LaSalle County

From: Duyvejonck, Jon [mailto:jon_duyvejonck@fws.gov]
Sent: Monday, August 11, 2014 9:59 AM
To: Ranek, Nancy L.:(GenCo-Nuc)
Cc: Fulvio, Albert A:(GenCo-Nuc); Hufnagel Jr, John G:(GenCo-Nuc)
Subject: Re: Request for Information on Listed Species and Sensitive Habitats -- LaSalle County

Nancy,
I have reviewed the information you provided regarding federally listed species and the potential effect of license renewal at the LaSalle Generating Station. I concur with your conclusion that the license renewal will not affect any federally listed species. Thank you.

Jon Duyvejonck
US Fish and Wildlife Service
1511 - 47th ave
Moline, IL 61265
tel. 309/757-5800, ex 207

****

On Wed, Aug 6, 2014 at 9:05 AM, Ranek, Nancy L.:(GenCo-Nuc) <Nancy.Ranek@exeloncorp.com> wrote:

Hi Jon –
Exelon Generation has reviewed information about the Northern Long eared bat, as you suggested in your email message (below) dated July 2, 2014.

I am attaching a biological evaluation covering all species potentially present at the LaSalle County Station (LSCS) that are federally listed or proposed for federal listing as threatened or endangered.
Hopefully, this document will provide the information you need about all species, including the Northern Long-eared Bat, to be able to concur with the conclusion in Exelon Generation's letter to USFWS dated March 7, 2014 concerning impacts from renewal by the NRC of the LSCS Operating License.

Thank you for your assistance in this matter.

Sincerely,
Nancy

Nancy L. Ranek
License Renewal Environmental Lead
Exelon Generation, LLC
200 Exelon Way, KSA/2-E
Kennett Square, PA 19348
Phone: 610-765-5369

1

Fax: 610-765-5658
Email: nancy.ranek@exeloncorp.com

****

From: Duyvejonck, Jon [mailto:jon_duyvejonck@fws.gov]

Sent: Wednesday, July 02, 2014 9:34 AM
To: Ranek, Nancy L.:(GenCo-Nuc)
Subject: Re: Request for Information on Listed Species and Sensitive Habitats -- LaSalle County

Nancy,

I reviewed your letter concerning the re-licensing of the LaSalle Nuclear Plant. There has been one recent addition to the federally listed species known to occur in the plant vicinity. That is the Northern Long eared bat. It is not officially listed yet, only proposed. However, it should be considered as listed in your review. That way ,if and when it is listed, you will not have to re-do any consultation. You may wish to visit our web site: http://www.fws.gov/midwest/endangered/section7/index.html to learn more about the Northern Long eared bat. Its habitat is similar enough to the Indiana bat that you can more or less do an assessment for both at the same time.

After all that, we can concur with your letter of March 7, 2014 that the relicensing of the operating permit for the La Salle Plant will not adversely affect any federally listed species. Any further questions, please contact me.

Jon Duyvejonck
US Fish and Wildlife Service
1511 - 47th ave
Moline, IL 61265
tel. 309/757-5800, ex 207

2

Exelon Generation

Michael P. Gallagher

March 7, 2014

Mr. Todd Rettig
Division Manager
Office of Realty and Environmental Planning
Illinois Department of Natural Resources
1 Natural Resources Way, 2" Floor
Springfield, Illinois 62702-1271

SUBJECT: Exelon Generation Company, LLC – LaSalle County Station Units 1 and 2 License Renewal Project. Request for Information on Listed Species and Sensitive Habitats – LaSalle County

Dear Mr. Rettig:

Exelon Generation Company, LLC (Exelon) plans to apply to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating licenses for LaSalle County Station (LaSalle) Units 1 and 2 no later than January 2015. The existing operating license for Unit 1 will expire on April 17, 2022, and the existing operating license for Unit 2 will expire on December 16, 2023. Renewed licenses would allow LaSalle Units 1 and 2 to operate until 2042 and 2043, respectively.

As part of the license renewal process, the NRC requires (10 CFR 51.53(c)(3)(ii)(E)) that the LaSalle license renewal application include an environmental report assessing the impacts from license renewal activities on species listed or proposed for listing as threatened or endangered in accordance with the Endangered Species Act (ESA) (16 USC 1531, et seq.) and on important plant and animal habitats, including critical habitats as defined by the ESA and essential fish habitat as identified under the Magnuson-Stevens Fishery Conservation and Management Act (16 USC 1801. et seq.). Because no species with essential fish habitat is found in Illinois, this letter seeks input from the Illinois Department of Natural Resources (DNR) regarding effects on species and habitats protected under the ESA only that are in the vicinity of LaSalle, including along the right-of-way (ROW) for the cooling water makeup and blowdown pipelines between the LaSalle cooling pond and the Illinois River.

In June 2013, the NRC revised its regulations at 10 CFR Part 51 such that no transmission line ROW associated with LaSalle requires assessment for environmental impacts from license renewal activities.

Project Features

LaSalle is located in northeastern Illinois, about 75 miles southwest of Chicago, in LaSalle County. The property is approximately 6 miles southwest of Seneca and 7 miles south-southeast of Marseilles, as shown in the attached Figure 1. The area surrounding LaSalle is relatively flat, and is rural and agricultural. Numerous wind turbines operate in the immediate vicinity.

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LaSalle occupies approximately 3,875 acres, of which approximately 2,058 acres comprise the cooling pond. The generating facilities at LaSalle are on the southwest portion of the site and include the reactor building and related structures, a switchyard, administration buildings, warehouses, and other structures. The ROW for the cooling water makeup and blowdown pipelines runs for a distance of 3.5 miles north from the cooling pond to the Marseilles Pool portion of the Illinois River. An intake pumphouse and a discharge structure are on the south bank of the Marseilles Pool, approximately 1,000 feet apart.

The ROW for the makeup and blowdown pipelines crosses the eastern portion of the Marseilles State Fish and Wildlife Area, a 2,550-ac area managed by the Illinois DNR for hunting and wildlife habitat. Marseilles State Fish and Wildlife Area (including the portion of the pipelines ROW that crosses it) also is used by the Illinois National Guard for training when hunting seasons are closed.

The cooling pond, which provides the LaSalle condenser with a continuous supply of cooling water, was created by constructing dikes that rise above the surrounding land. The cooling pond has an elevation of 700 feet above mean sea level at normal pool capacity. Illinois DNR leases the cooling pond, except the ultimate heat sink portion (83 acres), from Exelon and manages it for public fishing. The cooling pond serves as the water supply for an Illinois DNR fish hatchery located on land adjacent to the pond and also leased to Illinois DNR by Exelon Generation.

Cooling water blowdown from the cooling pond as well as monitored plant effluents are released to the Illinois River via the blowdown pipeline, a plunge pool, and an open, rip-rap-lined channel located downstream of the river intake pumphouse. This discharge is subject to limitations established by National Pollutant Discharge Elimination System (NPDES) Permit IL0048151.

Threatened and Endangered Species in the Project Vicinity

Bald eagles were observed in the LaSalle vicinity during the 1970s, but Exelon is not aware of bald eagle sightings in recent years. Although the USFWS removed the bald eagle from the federal list of threatened and endangered species in 2007, it is still federally protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Exelon is not aware of any other federally listed aquatic or terrestrial species being observed on the LaSalle site. The only state-listed species that Exelon is aware of being observed or recorded at LaSalle is the peregrine falcon. A pair nested on the roof of the LaSalle auxiliary building several years ago, but no nesting has been observed in recent years. Exelon personnel occasionally observe peregrine falcons flying in the vicinity of LaSalle.

The LaSalle license renewal project information was submitted to the Illinois DNR through the EcoCAT system. Attached for your review are the EcoCAT Natural Resource Review results from a query of the Illinois Natural Heritage database for LaSalle. The attached query response for LaSalle indicates that the Marseilles Illinois Natural Area Inventory (INAI), the LaSalle Lake INAI, and the Marseilles Hill Prairie INAI sites are in the vicinity of LaSalle. No protected species were identified.

Activities during the License Renewal Terms

Renewal of LaSalle operating licenses will not require new construction, land-disturbing activities, changes to plant operations, or modifications of the intake or discharge pipelines.

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Operation and maintenance activities during the terms of the renewed licenses are expected to occur mostly in previously disturbed areas. In addition, Exelon adheres to regulatory requirements regarding sensitive areas that could contain threatened or endangered species and works closely with USFWS and Illinois DNR to protect these resources. Therefore, Exelon expects that continued operation and maintenance of LaSalle over the license renewal periods (i.e., an additional 20 years for each unit), including maintenance of the ROW for the cooling water makeup and blowdown pipelines, would not adversely affect any ecologically significant habitats or any species that is federally-listed or proposed for listing as threatened or endangered.

Nevertheless, Exelon is requesting your help to identify potential impacts or other issues we may have overlooked that need to be addressed in the LaSalle license renewal environmental report. We are also interested in learning of any information that is not included here and that your staff believes could help expedite the NRC's review of the LaSalle license renewal application. Hence, in closing, we would appreciate receiving a response from you detailing such issues and information for the LaSalle site and cooling water pipeline ROW. We would also welcome your confirmation of our conclusion that LaSalle license renewal activities would not adversely affect ecologically significant habitats or any species that is federally-listed or proposed for listing as threatened and endangered.

Because Exelon will incorporate a copy of your response, as well as this letter, into the LaSalle license renewal environmental report that will be submitted to the NRC as part of the LaSalle license renewal application, your response will be most helpful if it is received by April 30, 2014.

Please refer any questions regarding this submittal to Nancy Ranek, our License Renewal Environmental Lead, at (610) 765-5369. Thank you in advance for your assistance.

Sincerely,

Michael P. Gallagher

Michael P. Gallagher

Enclosures:

Figure 1: Project Location Map
EcoCAT Natural Resources Review results for LaSalle Station

Rettig - 4

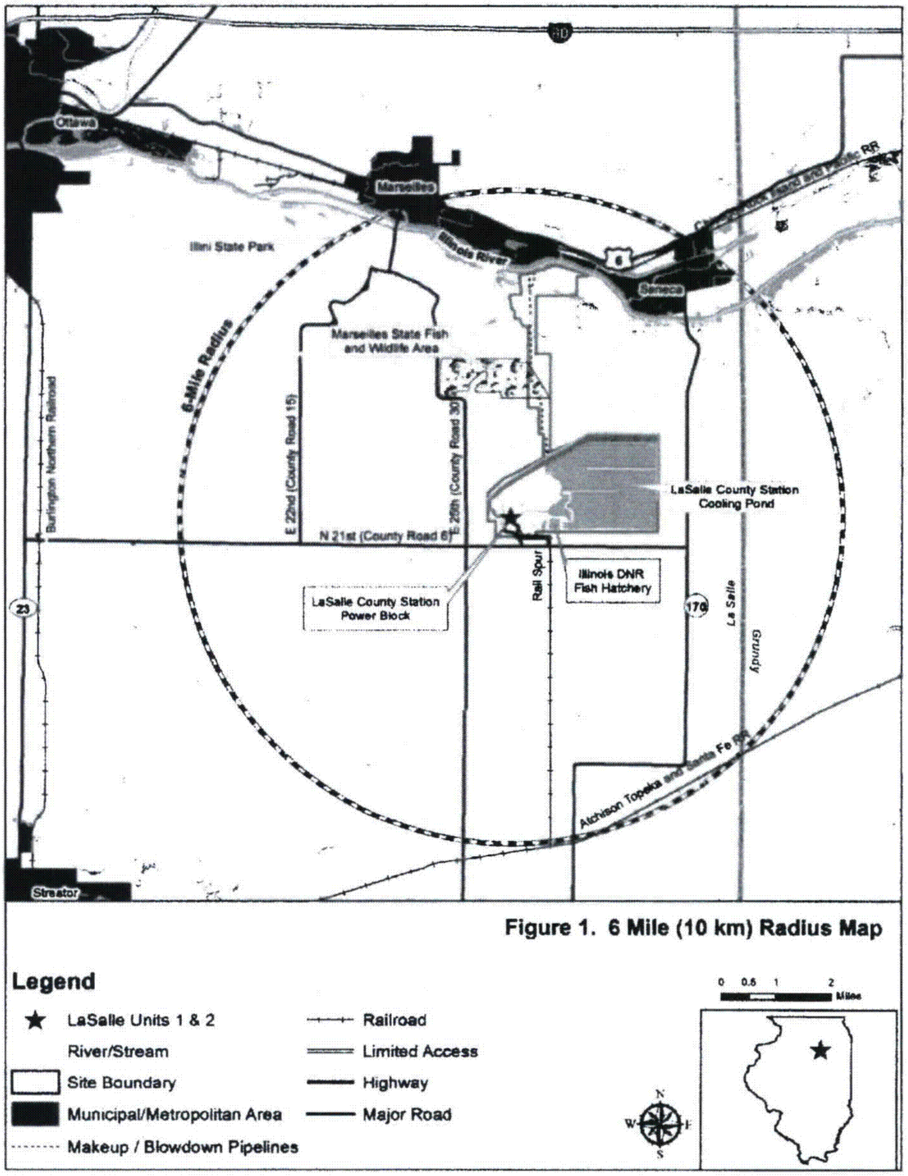

Figure 1. 6 Mile (10 km) Radius Map

Rettig - 5

Applicant:	Exelon Generation Company LLC	*IDNR Project Number:*	1404780
Contact:	Nancy L. Ranek	*Date:*	09/24/2013
Address:	200 Exelon Way Kennett Square, PA 19348		

Project: Renewal of Facility Operating Licenses by the U.S. Nuclear Regulatory Commission
Address: (NRC) for LaSalle Generating Station, Units 1 and 2
2601 North 21st Road, Marseilles

Description: Exelon Generation Company LLC seeks renewal of the NRC operating licenses for LaSalle Generating Station, Units 1 and 2, in order to provide an option for power generation capability beyond the term of the current operating licenses, as such needs may be determined by State, utility, and where authorized, Federal (other than the NRC) decision makers. License renewal will authorize no new construction or operational changes at the Station.

Natural Resource Review Results

This project was submitted for information only. It is not a consultation under Part 1075.

The Illinois Natural Heritage Database shows the following protected resources may be in the vicinity of the project location:

Illinois River - Marseilles INAI Site
Lasalle Lake INAI Site
Marseilles Hill Prairie INAI Site

Location

The applicant is responsible for the accuracy of the location submitted for the project.

County: LaSalle

Township, Range, Section:
32N, 5E, 4
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32N, 5E, 8
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32N, 5E, 14
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33N, 5E, 29
33N, 5E, 32
33N, 5E, 33

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IDNR Project Number: 1404780

IL Department of Natural Resources
Contact
Impact Assessment Section
217-785-5500
Division of Ecosystems & Environment

Disclaimer

The Illinois Natural Heritage Database cannot provide a conclusive statement on the presence, absence, or condition of natural resources in Illinois. This review reflects the information existing in the Database at the time of this inquiry, and should not be regarded as a final statement on the site being considered, nor should it be a substitute for detailed site surveys or field surveys required for environmental assessments. If additional protected resources are encountered during the project's implementation, compliance with applicable statutes and regulations is required.

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1. The IDNR EcoCAT website was developed so that units of local government, state agencies and the public could request information or begin natural resource consultations on-line for the Illinois Endangered Species Protection Act, Illinois Natural Areas Preservation Act, and Illinois Interagency Wetland Policy Act. EcoCAT uses databases, Geographic Information System mapping, and a set of programmed decision rules to determine if proposed actions are in the vicinity of protected natural resources. By indicating your agreement to the Terms of Use for this application, you warrant that you will not use this web site for any other purpose.

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Unauthorized use, tampering with or modification of this system, including supporting hardware or software, may subject the violator to criminal and civil penalties. In the event of unauthorized intrusion, all relevant information regarding possible violation of law may be provided to law enforcement officials.

Privacy

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Illinois Department of
Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
http://dnr.state.il.us

Pat Quinn, Governor
Marc Miller, Director

May 22, 2014

MPG 6.3.14

Mr. Michael P. Gallagher
Vice President, License Renewal
Exelon Nuclear
200 Exelon Way
Kennett Square, PA 19348

Re: Renewal of Facility Operating Licenses by the U.S. Nuclear Regulatory Commission (NRC) for LaSalle Generating Station, Units 1 and 2 - Correspondence dated March 7, 2014
County: LaSalle

Dear Mr. Gallagher:

This letter is in reference to your request for information on listed threatened and endangered species relative to your license renewal correspondence dated March 7, 2014.

The Department has records of several state-listed species that were observed just downstream of your discharge point on the Illinois River. These include the state-endangered Blacknose Shiner (*Notropis heterolepis)* and Greater Redhorse (*Moxostoma valenciennesi*), and the state-threatened River Redhorse (*Moxostoma carinatum*) and Banded Killifish (*Fundulus diaphanous*). These species were all observed within the Illinois River – Marseilles INAI site, which extends approximately seven miles upstream and downstream of your discharge structure and intake pumphouse.

Since you have indicated there will be no new construction, land-disturbing activities, changes to plant operations, or modifications of the intake or discharge piplelines, no further comment by the Department is necessary at this time.

Thank you for the opportunity to provide this clarification. Please contact me if you need additional information.

Cordially,

Sheldon R. Fairfield

Sheldon R. Fairfield
Impact Assessment Section
Division of Ecosystems & Environment
Phone: (217) 782-0031
Sheldon.Fairfield@illinois.gov

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Appendix E

Cultural Resources Correspondence

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Exelon Generation.

Michael P. Gallagher
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[illegible]
[illegible]
[illegible] Office
[illegible] Fax
[illegible]
[illegible]

March 7, 2014

Ms. Anne E. Haaker
Deputy State Historic Preservation Officer
Preservation Services Division
Illinois Historic Preservation Agency
1 Old State Capitol Plaza
Springfield, Illinois 62701-1507

Subject: Exelon Generation Company, LLC – LaSalle County Station Units 1 and 2 License Renewal Application. Request for Information on Historic and Archaeological Resources

Dear Ms. Haaker:

Exelon Generation Company, LLC (Exelon) plans to apply to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating licenses for LaSalle County Station (LaSalle) Units 1 and 2, no later than January 2015. The existing operating license for Unit 1 expires on April 17, 2022, and the existing operating license for Unit 2 expires on December 16, 2023. Renewed licenses would allow LaSalle Units 1 and 2 to operate until 2042 and 2043, respectively.

As part of the license renewal process, the NRC requires that the LaSalle license renewal application include an environmental report assessing the impacts from license renewal activities on historic and cultural resources on or near the LaSalle site. Pursuant to the National Environmental Policy Act (NEPA), this letter seeks input from the Illinois SHPO regarding such effects in the vicinity of LaSalle, including along the right-of-way (ROW) for the cooling water makeup and blowdown pipelines between the LaSalle cooling pond and the Illinois River. Later, the NRC may also request an informal consultation with your office in accordance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 USC 470), and the federal Advisory Council on Historic Preservation regulations (36 CFR 800).

In June 2013, the NRC revised its regulations at 10 CFR Part 51 such that no transmission line ROW associated with LaSalle requires assessment for environmental impacts from license renewal activities.

Project Features

LaSalle is located in northeastern Illinois, approximately 75 miles southwest of Chicago, in LaSalle County. The property is approximately 6 miles southwest of Seneca and 7 miles south-southeast of Marseilles, as shown in the attached Figure 1. The area surrounding LaSalle is relatively flat, and is rural and agricultural. Numerous wind turbines operate in the immediate vicinity.

LaSalle occupies approximately 3,875 acres, of which approximately 2,058 acres comprise the cooling pond. The generating facilities at LaSalle are on the southwest portion of the site and include the reactor building and related structures, a switchyard, administration buildings, warehouses, and other structures. The ROW for the cooling water makeup and blowdown pipelines runs for a distance of 3.5 miles north from the cooling pond to the Marseilles Pool portion of the Illinois River. An intake pumphouse and a discharge structure are on the south bank of the Marseilles Pool, approximately 1,000 feet apart.

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The cooling pond, which provides the LaSalle condenser with a continuous supply of cooling water, was created by constructing dikes that rise above the surrounding land. The cooling pond has an elevation of 700 feet above mean sea level at normal pool capacity. Illinois DNR leases the cooling pond, except the ultimate heat sink portion (83 acres), from Exelon and manages it for public fishing. The cooling pond serves as the water supply for an Illinois DNR fish hatchery located on land adjacent to the pond and also leased to Illinois DNR by Exelon Generation.

Identification of Historic and Archaeological Resources

The land occupied by LaSalle was previously used primarily for agriculture. Settlement was slow to begin along the southern side of the Illinois River Valley, and the oldest historic sites are on or near the prairie forest ecotone and near either upland closed depressions, or valley springs. Historic farmsteads in the area replicate a trend noted throughout the Prairie Peninsula—early settlers tended to settle along the ecotone to obtain wood for fuel and building materials, to use the prairie as open range for cattle, and to plow the more easily tillable forest soils after the advent of the steel-tipped plow. In comparison, while historic sites are predominantly in the level uplands, prehistoric sites are found in near-riverine settings.

The National Register Information System (NRIS) on-line database was accessed during 2012 to identify historic properties listed on the NRHP within a 6-mile radius of LaSalle. Seven listed properties were identified and are summarized in Table 1.

Table 1. Sites listed on National Register of Historic Places within 6 miles of LaSalle

Site Name/Number	Address	City, County
Sacred Heart Church (NR165052)	221 W. Emmet St.	Kinsman, Grundy
Hay Barn (NR165106)	2319 N. 14th Rd.	Streator, LaSalle
Ransom Water Tower (NR200859)	Plumb St.	Marseilles, LaSalle
Marseilles Hydro Plant (NR200999)	Commercial St.	Marseilles, LaSalle
Armour's Warehouse (NR201063)	William & Bridge Sts.	Seneca, LaSalle
Rock Island & Pacific Railroad Depot (NR201098)	151 Washington St.	Marseilles, LaSalle
Illinois & Michigan Canal (NR200462)	U.S. 6 in Channahon State Park	Lockport to LaSalle-Peru; Will, Grundy, LaSalle

In 1972, prior to construction at LaSalle, the Illinois Archaeological Survey (IAS) completed a Phase I Archaeological Survey of the LaSalle site (originally proposed as the Collins Generating Station) and concluded that the facility would have no significant impact on archaeological resources. Locations LS00207, LS00208, and LS00209 were three of five isolated finds identified in the 1972 survey. At the time of the Phase I survey, IAS did not recognize isolated finds as sites, and the isolated finds were not recorded or assigned IAS accession numbers. Because isolated finds LS00207, LS00208, and LS00209, by definition, were not eligible for inclusion on the NRHP, they were not evaluated. The NRC's Final Environmental Statement relating to the operation of LaSalle, which was published in November 1978 (NUREG-0486), stated that "[t]here are no historical and cultural sites recorded in the National Registry of National Landmarks, as supplemented 8 June 1976, or the National Register of Historic Places, as supplemented 3 January 1978, located on the LaSalle County Station site."

The results of an Illinois State Archaeological Site Files review conducted in 2012 indicated that 146 previously-recorded archaeological sites are located within 6 miles of LaSalle. Six sites are on the LaSalle property; three of the six are the previously discussed isolated finds identified in the 1972 survey. The remaining three sites (LS00252, LS00514, LS00533) were identified in reports of archaeological surveys conducted during 1974-1975 for LaSalle's transmission and pipeline corridors or during 1983 and 1993-1994 for the Marseilles Training Area. No additional archaeological resources have been recorded on the LaSalle property since 1995. Table 2 provides an overview of the known archaeological resources on the LaSalle property.

Table 2. Archaeological Sites located within the LaSalle Property

Site Number/Name	Site Type	NRHP Eligibility
LS00207/ Collins Station Site #1	Unknown Prehistoric	Isolated, Not Eligible
LS00208/ Collins Station Site #2	Unknown Prehistoric	Isolated, Not Eligible
LS00209/ Collins Station Site #3	Unknown Prehistoric	Isolated, Not Eligible
LS00252	Unknown Prehistoric	Not Eligible
LS00514/ Boog Powell	Unknown Prehistoric	Not Eligible
LS00533	Unknown Prehistoric	Not Eligible

Activities during the License Renewal Term

Renewal of LaSalle operating licenses will not require new construction, land-disturbing activities, changes to plant operations, or modifications of the intake or discharge pipelines. Operation and maintenance activities during the terms of the renewed licenses are expected to occur mostly in previously disturbed areas. Therefore, Exelon expects that continued operation and maintenance of LaSalle over the license renewal periods (i.e., an additional 20 years for each unit), including maintenance of the ROW for the cooling water makeup and blowdown pipelines, would not adversely affect any archaeological or historically significant resources. Even so, Exelon has implemented specific procedures to protect cultural resources in undisturbed areas from activities related to operation and maintenance on the LaSalle site, including along the ROW for the makeup and blowdown pipelines. Potential effects on cultural resources from future activities would be identified in advance and avoided, if a practical alternative to the proposed activity can be identified. If avoidance is not practical, then the Illinois SHPO would be consulted regarding mitigation.

As stated earlier, this letter seeks input from the Illinois SHPO regarding the effects that license renewal activities may have on historic and archaeologically significant resources in the vicinity of LaSalle. After your review of the information provided in this letter, Exelon would appreciate your sending a letter detailing any concerns you may have about historic and archaeological resources within 2 miles of LaSalle or the ROW for the makeup and blowdown pipelines, or confirming that the operation of LaSalle over the license renewal terms would have no effect on known historic or archaeological resources.

Because Exelon will incorporate a copy of your response, as well as this letter, into the LaSalle license renewal environmental report that will be submitted to the NRC as part of the LaSalle license renewal application, your response would be most helpful if it is received by April 30, 2014.

Please refer any questions regarding this submittal to Nancy Ranek, our License Renewal Environmental Lead at (610) 765-5369. Thank you in advance for your assistance.

Sincerely,

Michael P. Gallagher

Michael P. Gallagher

Enclosures:

Figure 1: Project Location Map

Haaker - 5

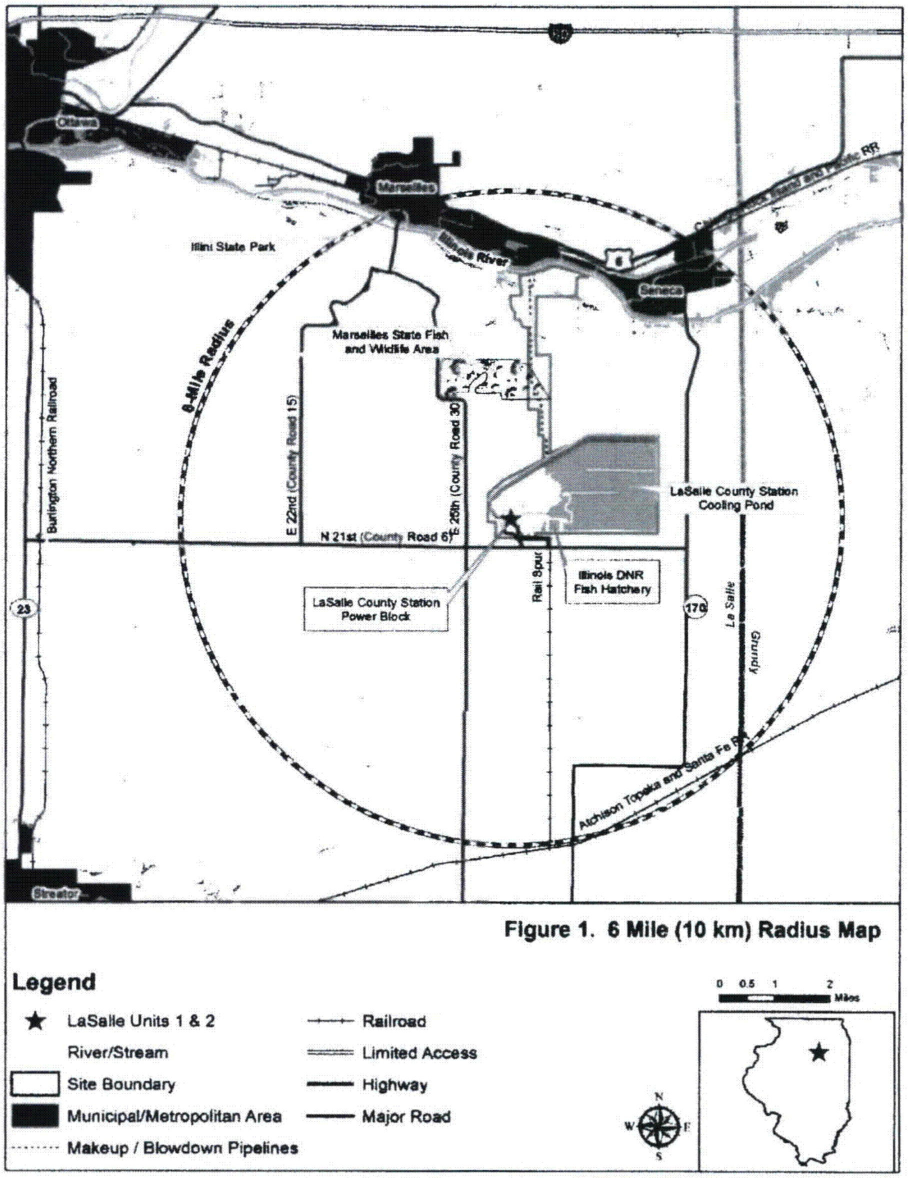

Figure 1. 6 Mile (10 km) Radius Map

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Illinois Historic Preservation Agency

1 Old State Capitol Plaza, Springfield, IL 62701-1512

FAX (217) 524-7525
www.illinoishistory.gov

received 3/31/2014

LaSalle County
Marseilles
Renewal of Operating Licenses for LaSalle County Station Units 1 and 2
2601 N. 21st Rd.
IHPA Log #016031314

March 27, 2014

Nancy Ranek
Exelon Generation Company, LLC
200 Exelon Way
Kennett Square, PA 19348

Dear Ms. Ranek:

We have reviewed the documentation submitted for the referenced project in accordance with 36 CFR Part 800.4. Based upon the information provided, no historic properties are affected. We, therefore, have no objection to the undertaking proceeding as planned.

Please retain this letter in your files as evidence of compliance with section 106 of the National Historic Preservation Act of 1966, as amended. This clearance remains in effect for two years from date of issuance. It does not pertain to any discovery during construction, nor is it a clearance for purposes of the Illinois Human Skeletal Remains Protection Act (20 ILCS 3440).

If you have any further questions, please contact me at 217/785-5027.

Sincerely,

Anne E. Haaker

Anne E. Haaker
Deputy State Historic
Preservation Officer

For TTY communication, dial 888-440-9009. It is not a voice or fax line.

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Appendix F

Severe Accident Mitigation Alternatives Analysis

LaSalle County Station Environmental Report

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Acronyms

ADS	Automatic Depressurization System
ATD	Atmospheric Transport and Dispersion
ATWS	Anticipated Transient Without Scram
BOC	Break Outside Containment
BOP	Balance of Plant
BWR	Boiling Water Reactor
CCF	Common Cause Failure
CDF	Core Damage Frequency
CET	Containment Event Tree
CRD	Control Rod Drive
CSCS	Core Standby Cooling System
CST	Condensate Storage Tank
DFP	Diesel Fire Pump
DG	Diesel Generator
DGCW	Diesel Generator Cooling Water
DW	Drywell
EALs	Emergency Action Levels
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EGC	Exelon Generation Company
EOPs	Emergency Operating Procedures
EPZ	Emergency Planning Zone
ESW	Emergency Service Water
ETE	Evacuation Time Estimate
F&Os	Facts and Observations
FASA	Focused Area Self-Assessment
FP	Fire Protection
FPS	Fire Protection System
F-V	Fussell - Vesely
FW	Feedwater
GE	General Emergency
HCTL	Heat Capacity Temperature Limit

Acronyms

HEAF	High Energy Arcing Fault
HEP	Human Error Probability
HFE	Human Failure Event
HPCS	High Pressure Core Spray
HRA	Human Reliability Analysis
HVAC	Heating Ventilating Air Conditioning
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination – External Events
ISLOCA	Interfacing Systems Loss of Coolant Accident
JHEP	Joint Human Error Probability
LERF	Large Early Release Frequency
LOCA	Loss of Coolant Accident
LOIA	Loss of Instrument Air
LOOP	Loss of Offsite Power
LP	Low Pressure
LPCI	Low Pressure Coolant Injection
LPCS	Low Pressure Core Spray
LSCS	LaSalle County Station
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequences Code System, Version 2
MACR	Maximum Averted Cost-Risk
MCC	Motor Control Center
MSIV	Main Steam Isolation Valve
NDE	Nondestructive Evaluation
NPSH	Net Positive Suction Head
NRC	U.S. Nuclear Regulatory Commission
OECR	Off-site economic cost risk
OSP	Off Site Power
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
PSF	Performance Shaping Factor
RAW	Risk Achievement Worth

Acronyms	
RCIC	Reactor Core Isolation Cooling
RDR	Real Discount Rate
RHR	Residual Heat Removal
RHRSW	Residual Heat Removal Service Water
RMIEP	Risk Methods Integration & Evaluation Program
RPS	Reactor Protection System
RPV	Reactor Pressure Vessel
RRW	Risk Reduction Worth
RWCU	Reactor Water Cleanup
SACs	Station Air Compressions
SAG	Severe Accident Guidelines
SAMA	Severe Accident Mitigation Alternative
SAT	System Auxiliary Transformer
SBLC	Standby Liquid Control
SBO	Station Blackout
SORV	Stuck Open Relief Valve
SP	Suppression Pool
SPC	Suppression Pool Cooling
SRV	Safety Relief Valve
SSES	Susquehanna Steam Electric Station
SW or WS	Service Water
T&RM	Training and Reference Material (Exelon Generation Company guidance document one tier lower than a procedure)
TDRFP	Turbine Driven Reactor Feedwater Pump
URE	Updating Requirement Evaluation

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SEVERE ACCIDENT MITIGATION ALTERNATIVES

The severe accident mitigation alternatives (SAMA) analysis summarized in Section 4.15 of this Environmental Report is presented below.

F.1 METHODOLOGY

The methodology selected for this analysis is contained in NEI 05-01, Rev. A, Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document (NEI 2005), which has been reviewed and endorsed by the U.S. Nuclear Regulatory Commission (NRC). It involves identifying SAMA candidates that have the potential to reduce plant risk (frequency and/or consequences of a severe accident) and evaluating whether or not the implementation of those candidates is potentially beneficial on a cost-risk reduction basis. The metrics chosen to represent plant risk include the core damage frequency (CDF), the dose-risk, and the offsite economic cost-risk. Those metrics provide a measure of both the likelihood and consequences of a core damage event.

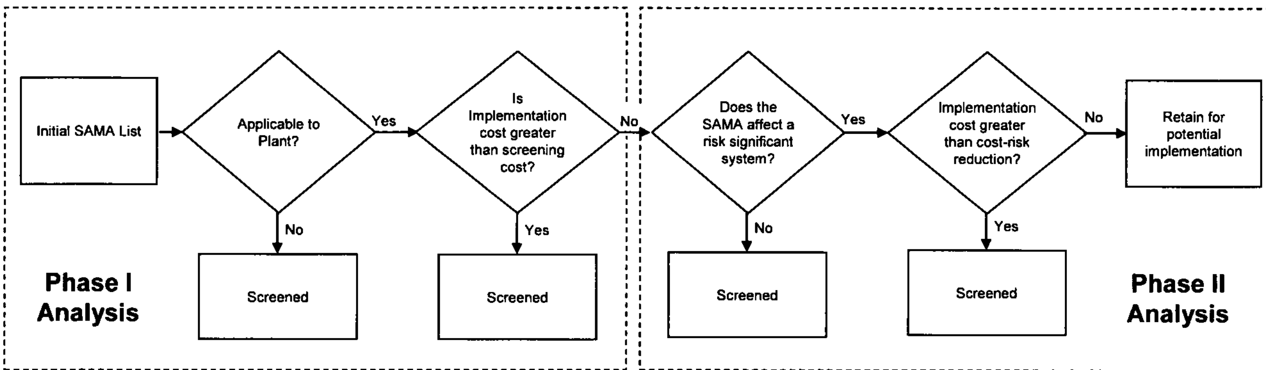
The SAMA process consists of the following principal steps:

- LaSalle County Station (LSCS) Probabilistic Risk Assessment (PRA) Model – Use the LSCS Internal Events PRA model as the basis for the analysis (Section F.2). Incorporate External Events contributions as described in Section F.4.6.2.
- Level 3 PRA Analysis – Use the LSCS Level 1 and 2 Internal Events PRA output and site-specific meteorology, demographic, land use, and emergency response data as inputs to a Level 3 PRA performed using the MELCOR Accident Consequences Code System Version 2 (MACCS2) (Section F.3). Incorporate External Events contributions as described in Section F.4.6.2.
- Baseline Risk Monetization – Use NRC regulatory analysis techniques (NRC 1997) to calculate the monetary value of the LSCS severe accident risk. That value represents the maximum averted cost-risk (MACR) (Section F.4).
- Phase 1 SAMA Analysis – Identify potential SAMA candidates based on the LSCS Probabilistic Risk Assessment (PRA), Individual Plant Examination (IPE), Individual Plant Examination – External Events (IPEEE), and other relevant industry and NRC documentation. Screen out SAMA candidates that are not applicable to the LSCS plant design or are of low benefit in boiling water reactors (BWRs) such as LSCS; candidates that have already been implemented at LSCS or whose benefits have been achieved at LSCS using other means; and candidates whose estimated cost exceeds the maximum possible averted cost-risk (Section F.5).
- Phase 2 SAMA Analysis – Calculate the risk reduction attributable to each of the remaining SAMA candidates and compare it to the estimated cost of implementation to identify the net cost-benefit. PRA insights are also used to screen SAMA candidates in this phase (Section

F.6). For example, SAMAs that only impact interfacing system loss of coolant accidents (ISLOCAs) may be screened if the SAMA's cost of implementation exceeds the cost-risk associated with ISLOCA scenarios.

- Sensitivity Analysis – Evaluate how changes in the SAMA analysis assumptions might affect the cost-benefit evaluation (Section F.7).
- Conclusions – Summarize results and identify conclusions (Section F.8).

The steps outlined above are described in more detail in the subsections of this appendix. The graphic below provides a high level overview of the SAMA analysis screening process.



SAMA SCREENING PROCESS

F.2 LSCS PRA MODEL

The purpose of this section is to summarize the key aspects of the LSCS PRA model, including its development, quantitative results, and insights from the LSCS PRA 2013 update. The LSCS PRA model (LS213A), which was used to support the SAMA analysis, quantifies the core damage frequency (CDF) and a full range of Level 2 release categories. The PRA is a Unit 2 model, but because the units are nearly identical, it is considered to be applicable to Unit 1 unless otherwise noted.

The Level 1 PRA quantifies the frequency of severe accidents that may compromise mitigative and preventive engineering safety features and, ultimately, cause damage to the nuclear reactor core. The primary result of a Level 1 PRA is quantification of the CDF based on initiating events analysis, scenario development, system analyses, and human-factor evaluations.

The LSCS Level 1 PRA addresses internal events, including flooding, and loss of off-site power. External events such as fires, seismic, tornadoes and external flooding, which were analyzed separately in response to NRC Generic Letter 88-20, Supplement 4 (NRC 1991) are also addressed separately from the internal events risk in the SAMA analysis (refer to sections F.4.6.2 and F.5.1.6).

The mitigating systems referred to in the Level 1 logic model are those which shut down the reactor, provide core cooling to prevent overheating (or, ultimately, fuel melting), or provide containment heat removal. Any support systems that are necessary for the front-line systems to be successful are also included within the Level 1 scope.

The B.5.b and FLEX equipment[1] are not incorporated into the PRA.

The Level 1 logic model is developed to display and provide a calculational vehicle for the critical safety functions to mitigate these initiating events and to estimate the overall core damage frequency. The basic concept of a Level 1 PRA is simple. However, the large number of initiating events, systems, components, and human interactions associated with nuclear plant operation and maintenance, make the performance of the Level 1 PRA analysis complex.

The LSCS PRA model is updated periodically in accordance with internal Exelon Generation Company (EGC) procedures to reflect plant modifications, procedure changes, and the plant-specific failure data and maintenance unavailability for major plant components

F.2.1 PRA UPDATE FREEZE DATE

The freeze date for data and plant modifications to be considered for the Level 1 portion of the LS213A model (the 2011 LSCS PRA update, LS211A) is December 31, 2010.

The Emergency Operating Procedures (EOPs) and Severe Accident Guidelines (SAGs) used in this analysis are those in place as of the freeze date.

No significant plant modifications affecting the risk profile were performed since the PRA model freeze date. EOP and SAG changes made since the freeze date were reviewed and incorporated, as necessary, into the LS213A model. The freeze date for the LS213A model was December 31, 2013.

[1] The Diverse and Flexible Coping Strategies (FLEX) are measures intended to reduce the risk associated with beyond design basis external events. The B.5.b program includes the implementation of procedures and equipment designed to reduce plant risk associated with core damage and release caused by a large fire or explosion.

F.2.2 PRA HISTORY

Since the original LSCS Individual Plant Examination (IPE) submittal to the NRC (CeCo 1994), eight LSCS PRA revisions have been performed up to and including this analysis:

1. 1994 IPE
2. 1996 Model
3. 1999 Model Upgrade[2]
4. 2000 Model Upgrade
5. 2001A Model
6. 2003A Model
7. 2006 (A, B, and C) Model
8. 2011A Model
9. 2013A Upgrade

Two of the upgrades (items 3 and 4) shown above were done in stages. The 1999 upgrade included two revisions (0 and 1), while the 2000 upgrade included three revisions (A, B, and C). Table F.2-1 provides a summary of the quantitative results for each of these models.

F.2.2.1 1994 IPE

Sandia National Laboratories, under contract to the NRC, completed a Level 1 and Level 2 PRA for LSCS Unit 2 in 1992. This PRA was documented in the multi-volume *Analysis of the LaSalle Unit 2 Nuclear Power Plant: Risk Methods Integration and Evaluation Program (RMIEP)* (NRC 1992a). A summary of the Sandia PRA was submitted to the NRC in April 1994 as LSCS's response to NRC Generic Letter 88-20, *Individual Plant Examination for Severe Accident Vulnerabilities (IPE)* (NRC 1989).

F.2.2.2 1996 MODEL

The "Updated IPE" (1996) was aimed at resolving NRC questions regarding the 1994 IPE. Major revisions included converting the model to a CAFTA linked fault tree, and incorporating plant procedure changes and modifications.

2 An upgrade is a model update that involves significant changes to modeling methodology and / or level of detail.

F.2.2.3 1999 MODEL

The purpose of the 1999 LSCS PRA upgrade was to support plant applications. The 1999 model upgrade was documented in two revisions. Revision 0 was issued before System Manager reviews had been completed. Those reviews identified corrections for several logic errors and other potential enhancements that were incorporated into Revision 1. Since the Revision 0 model was not used for any plant applications, the Revision 1 model is referred to as the 1999 model. Major differences between the 1996 model and the 1999 (Revision 1) model are summarized below:

- The 1999 model provides more credit for offsite AC power recovery;
- The 1999 model credits use of the turbine driven reactor feedwater pump (TDRFP) for turbine trip (TT) initiating events, including anticipated transient without scram (ATWS) events.
- The main condenser was credited in the 1999 model. This non-safety-related system is the normal means of achieving hot and cold shutdown following a SCRAM, but it was not included in the IPE model because it was not necessary to meet the intent of Generic Letter 88-20. Modeling this non-safety-related decay heat removal system is important for plant applications because, without it, the PRA model would overestimate the importance of safety-related decay heat removal systems (e.g., suppression pool cooling) and support systems (e.g., core standby cooling system (CSCS));
- Reactor Core Isolation Cooling (RCIC) dependency was corrected for AC power. The 1996 model had a dependency on AC for room cooling, whereas the 1999 model best estimate is that the RCIC system can operate for the four-hour station blackout (SBO) coping time without the need for room cooling. This is important for SBO scenarios where RCIC is a turbine (steam) driven source;
- Containment modeling in the 1999 model was changed to not always assume core damage upon containment failure; the model allowed for potential success paths (which also reduces dependency on Station Air needed for venting);
- The turbine trip initiating event was a much larger contributor due to the contribution of TT-ATWS. The increase in CDF is due to single operator error for "Operator fails to bypass main steam isolation valves (MSIVs) given FW success;"
- The Service Water (SW) system model was more realistic, including success criteria that are seasonally-dependent; and,
- Credit alignment of diesel fire pump (DFP) for injection post-containment challenge

F.2.2.4 2000A MODEL

The fault trees, event trees, and database of the 1999 model were upgraded to the 2000A model to reflect the current plant configuration and expand the scope of the model to include selected internal floods. This upgrading process involved the following significant changes:

- Increased 125 VDC battery life from four to seven hours to extend RCIC operability during station blackout;
- Included dependency for room cooling for high pressure core spray (HPCS), RCIC, Residual Heat Removal (RHR), and low pressure core spray (LPCS) for a 24 hour mission time;
- Incorporated realistic assessment of equipment reliability under degraded conditions post venting (the original RMIEP evaluation was conservative);
- Included a seismic PRA model (removed when the 2006A model was developed);
- Updated common cause failure (CCF) probabilities to be consistent with latest NUREG-5497 (INEL 1998) data;
- Revised the CCF probabilities of all Plant Service Water (WS) and CSCS suction strainers;
- Expanded the treatment of HRA dependencies to include additional combinations of human error probabilities (HEPs);
- Incorporated internal floods identified in RMIEP (i.e., Reactor Building floods);
- Expanded the internal flood evaluation to include potential Turbine Building flood sources;
- Incorporated unit electrical cross ties to ensure that the plant capability to respond to accidents is accurately portrayed; and,
- Included recovery of Station Air for containment venting during long term loss of decay heat removal sequences.

F.2.2.5 2000B MODEL

The 2000B model included minor enhancements. The 2000B model was an interim model and was not used to support any regulatory applications.

The 2000A and 2000B models used the same model structure and basic event databases. When the "NOT" logic was introduced in the 2000A model, the flags were not applied for the success paths in the PRAQUANT input file for the ONE4ALL model. This was corrected during the development of the 2000B model. Appropriately applying the flag settings to the success paths in the 2000B model eliminated four (4) flag basic events that had existed in the 2000A ONE4ALL logic model.

Another change in generating the 2000B model was modifying the mutually exclusive file. The overall impact on the model was insignificant.

F.2.2.6 2000C MODEL

The 2000C model incorporated changes to the 2000B model based on a revised Turbine Building flood model and an updated LSCS HRA. The 2000C CDF increased approximately 40% over the 2000B model.

F.2.2.7   2001A MODEL

The 2001A model incorporated the following changes:

- Changed the Turbine Building flood initiating event frequencies to reflect changes to the pipe inspection program;
- Revised the ATWS multipliers to agree with the findings in NUREG/CR-5500, Volume 3 (INEEL 1999);
- Changed Plant Service Water (WS) success criteria to reflect the latest operating data; and,
- Reduced the success criteria for RHR heat removal from two trains to one train provided early success of Standby Liquid Control (SBLC) injection.

F.2.2.8   2003A MODEL

The 2003A model was the result of a regularly scheduled update per the Risk Management Program. Major changes incorporated into the model included:

- Revised component failure data including extensive use of plant-specific component failure data gathered from the LSCS Maintenance Rule program;
- Revised initiating events data utilizing the latest LSCS operating experience;
- Added alternate configuration logic for all systems with alternate/standby trains;
- Added logic for newly installed redundant 125 VDC backup battery chargers on both Divisions of Unit 2;
- Added new logic for the trailer mounted Station Air compressor to the model;
- Revised Station Air success criteria (changed from one out of three compressors to any one of four compressors including the trailer mounted compressor);

F.2.2.9   2006 (A, B, AND C) MODEL

The major changes incorporated as part of the 2006A model were:

- Seismic-induced accident sequences were removed from the model (because they are outside the scope of the at-power internal events PRA)
- Modular Accident Analysis Program (MAAP) 4.0.5 code parameter file is updated to reflect:
    - the 5% LSCS Power Uprate.
    - the latest LGA[3] limit curves, e.g., heat capacity temperature limit (HCTL), PSP, PCPL, and
    - the initial pool temperature and service water temperatures are the values based on recent operating experience.

---

[3] LGAs are the LaSalle specific emergency operating procedures (EOPs).

- The EOPs for LSCS (LGAs) do not direct the operators to prevent the actuation of the automatic depressurization system (ADS) (referred to as "ADS inhibit") unless a failure to scram occurs (or power is unknown). The PRA model was modified to reflect the LGAs which differ from the generic BWROG EPGs.
- The results of the LSCS 2006 HRA FASA (Focused Area Self-Assessment) were incorporated into the 2006A model and documentation.
- An update of the TB flooding accident sequences was performed. This was subsequently revised again for the 2006B model.
- Emergency diesel generator (EDG) recovery/repair based on NUREG/CR-6890 (INEEL 2005) evaluation of data used in the loss of offsite power (LOOP)/SBO analysis was added to the LOOP/dual unit loss of offsite power (DLOOP) event sequence evaluations.
- LOOP frequency and LOOP duration based on INEEL evaluation of data in NUREG/CR-6890 (INEEL 2005) was used to characterize LSCS LOOP frequency and duration by cause category.
- Timing to core damage and time for crew response was modified to be consistent with the latest MAAP 4.0.5 calculations.
- The suppression pool cooling evaluation included both an early and late initiation to account for the time phase impacts on RCIC.
- The impact of venting and the control of the vent on the ECCS suction and RB environment were modified from the 2003A model to better represent:
  - the procedural guidance to control the vent pressure
  - the MAAP 4.0.5 assessment of net positive suction head (NPSH)
  - the MAAP 4.0.5 assessment of secondary containment environmental conditions
- The room cooling of the Residual Heat Removal Service Water/Diesel Generator Cooling Water (RHRSW/DGCW) vaults was reassessed using the latest EGC calculations. Room cooling is now required for success of these CSCS systems.
- The event trees were revised to make the vent and post containment pressure challenge RPV injection nodes more transparent.
- Performed a Bayesian update on the initiating event frequencies utilizing most recent LSCS operating experience.
- Allocated LOCA frequencies on a location and size specific basis. The LOCA locations were subdivided for more accurate assessments of their consequences.
- Initiating event fault trees were developed for the support system induced initiators of loss of TBCCW, RBCCW, and SW.
- Revised component failure data including extensive use of plant-specific component failure data gathered from the LSCS Maintenance Rule program.
- Individual component random failure probabilities Bayesian updated (as applicable) based upon the most recent plant specific data and the most current generic sources.
- CCF calculations revised to incorporate the updated individual random basic event probabilities and the most up to date Multiple Greek Letter (MGL) parameters from NUREG/CR-5497 (INEL 1998) and NUREG/CR-5485 (INEEL 1998).

- Updated maintenance unavailability data based on the most recent LSCS operating experience.
- Coincident maintenance basic events were added.
- Extensively re-assessed the HRA based on operating crew interviews using the latest training, EOPs and support procedures.
- Responded to LSCS BWROG Peer Review comments using the NEI PRA Peer Review Process.
- Performed a self-assessment against the ASME PRA Standard and resolved “gaps” to achieve Capability Category II.
- Added recirculation pump seal leakage scenarios.
- Included additional pre-initiating events in the model.
- Added alternate configuration logic for systems with alternate/standby trains.
- The conditional probability of a DLOOP given a transient or LOCA signal event was incorporated into the PRA modeling.
- RHR repair based on operating experience data was included in the evaluation.
- RCIC/LPCS room cooling was evaluated on a realistic basis and found to not be required for the accident with no gland seal failure (i.e., plant configuration with large open ventilation path exists).
- The LSCS physical location on the power grid is such that grid stability has not been shown to be a significant contributor to the LOOP and DLOOP events.

The 2006B PRA update was a follow-on to the 2006A periodic update completed in January 2007. The 2006B update addressed the following items:

- Complete revision of the internal flooding analysis
- Additional dependent HEP combinations identified and added to quantification recovery file
- The %TSW, %RBCCW, and %TBCCW initiator fault trees were quantified using the latest database and the revised frequencies were inserted into the model.

The 2006C PRA update was a follow-on to the 2006B update. During review and use of the 2006B model in the summer of 2007 to answer a site risk question, a gate error was identified in a sub-tree of the RHR suppression pool cooling logic. One of the responses to this identified error was to perform an independent review of model changes made for the 2006A and B updates. That review resulted in a number of comments. The comments ranged from non-issues (i.e., modeling correct as-is), to potential enhancements, to suggested fixes. Many of the suggested fixes and enhancements were completed, along with the suppression pool cooling (SPC) logic gate correction, for the 2006C update. The remaining comments were added to the

Updating Requirement Evaluation (URE) database for future consideration. The changes made for the 2006C update are summarized as follows:

- Revised the RHR suppression cooling fault tree gates RHR-SPC-L and RHR-SPC to address the gate error.
- Performed other fault tree logic updates on several systems to enhance the model and address self-identified issues.
- Revised the probabilities of miscellaneous CCF basic events in the database for consistency with similar events.
- Revised an initiating event frequency for a specific medium, below core LOCA.
- Input additional flood scenario links in the system fault trees that were identified in the internal flooding analysis but were not represented in the fault tree.
- Added "coincident maintenance" event links in system fault trees to reflect all the cases identified in the PRA Component Data Notebook.

F.2.2.10 2011A MODEL

The 2011A model (LS211A) was the result of a regularly scheduled update. Major changes incorporated into the model included:

- Revised component failure data including extensive use of plant-specific component failure data gathered from the LSCS Maintenance Rule program and Mitigating Systems Performance Index (MSPI).
- Bayesian updates of generic priors from NUREG/CR-6928 for both initiating events (transients) and component failures using the latest LSCS specific data.
- Refined the modeling of room cooling for the Core Standby Cooling System.
- Added the Reactor Building Ventilation (VR) check damper closure as a potential flood mitigation strategy.
- Incorporation of support system initiating event fault trees into the single top logic.
- Deletion of loss of bus 241Y and 242Y as initiating events and addition of loss of bus 241X, 242X, and 251 as initiating events.
- Converted the Human Reliability Analysis (HRA) calculations to the EPRI HRA Calculator® software platform. Minor changes in human error probabilities (HEP) were observed with this change in methodology. The HRA Calculator® was also used to facilitate the HEP dependence analysis.
- Updated maintenance unavailability data based on the most recent LSCS operating experience.
- Revised common cause failure (CCF) calculations to incorporate the updated individual random basic event probabilities and 2009 CCF parameters from INEEL (NUREG/CR-6268).
- Added a detailed pre-initiator HEP evaluation and added pre-initiators as necessary to the model.

- Deleted most of the coincident maintenance terms that had previously been added because they no longer meet the definition of the coincident maintenance as defined in the ASME/ANS PRA standard as "planned and repetitive."
- Mitigated ATWS scenarios (i.e., ATWS scenarios with successful reactivity control) with failure of containment heat removal were classified as Class IV. This was inconsistent with other EGC BWR PRAs where they were classified these as Class II (or Class I as appropriate). To address this issue, the ATWS event trees were re-evaluated and the end states were changed to Class II where appropriate. Note that the classification as Class IV was conservative with respect to the Level 2 PRA and reclassification resulted in a decrease in the large early release frequency (LERF).
- The power supplies for the station air compressors (SACs) were modified to reflect plant modifications.
- The RHR water hammer scenarios were re-evaluated as part of the 2011A model update.
- Another change was made related to the water hammer scenarios. The probability of a water hammer event causing a rupture was changed from 1E-2 to 1E-3. This probability is more consistent with industry experience and other EGC BWR PRA models.
- A change was made to the small LOCA water event tree to reflect that, for some small LOCAs, RCIC may be a viable long term injection source.
- The diesel generator recovery factors DGRECOV-4HR and DGRECOV-7HR were changed to 1.0 due to peer review comments and consistency efforts.
- The offsite power recovery factors were corrected in the model to match the values documented in LS-PSA-001 Appendix E and as given in NUREG/CR-6890.
- Multiple system fault trees and basic events were updated to address Peer Review comments and self-identified issues.
- Addressed many 2008 Peer Review findings and suggestions as tracked in the URE database. Several of these issues related to documentation. Additionally, addressed several other UREs.

F.2.2.11 2013A UPGRADE

In order to support the SAMA analysis, the LSCS LERF model was replaced by a full Level 2 model. The Level 1 logic from the 2011A model was not changed beyond what was required to integrate it with the Level 2 model.

The expansion of the LERF model to a full Level 2 model involved a reassessment of the timing and release categorization of each containment event tree (CET) endstate. To perform this reassessment, MAAP calculations for each accident class were performed and used to assess the CET endstates. Each CET node was evaluated and updated to reflect the current state of knowledge regarding Level 2 accident phenomenology. The endstate timing was also updated to reflect the current emergency plan and evacuation time estimates.

F.2.3 2013A LEVEL 1 MODEL OVERVIEW

The CDF for the 2013A model is calculated using the single top model in CAFTA at a truncation of 1E-12/yr. The 2013A Level 1 CDF is 2.58E-06/yr.

Additional details related to the 2013A Level 1 model are provided in the following subsections:

- F.2.3.1: CDF contribution by initiating event
- F.2.3.2: Contribution by accident class
- F.2.3.3: System importance measures
- F.2.3.4: Summary of the impact of asymmetries on risk

F.2.3.1 CDF CONTRIBUTION BY INITIATING EVENT

Table F.2-2 summarizes the CDF contributors by initiating event.

The turbine trip initiating event is important to note because it also represents the ATWS frequency (i.e., all ATWS events are modeled as a turbine trip). The DLOOP and LOOP are significant because they represent a major loss of mitigating events that places a high importance on the emergency diesel generators. Loss of instrument air is significant in that it causes a plant scram, main steam isolation valve (MSIV) closure, loss of containment venting capability, and loss of many balance-of-plant systems. The loss of condenser vacuum initiator causes a plant scram and loss of the power conversion system.

F.2.3.2 CDF CONTRIBUTION BY ACCIDENT CLASS

Table F.2-3 gives the definitions of the LSCS functional accident sequences. These core damage accident class definitions are consistent with the NEI guidance in NEI 91-04 (NEI 1994). Table F.2-3 also includes the 2013A model quantification of the functional classes.

The overall CDF and the distribution of the CDF among the contributing functional accident sequence classes are consistent with the significant plant mitigating system capability at LSCS.

The top 10 accident sequences are described below:

<u>Sequence #1: GTR-023 = 3.28E-7/yr (Class IIA)</u>

GTR-023 is a transient initiated loss of containment heat removal sequence.

In this sequence, SPC is not initiated (either due to operator error or hardware failure), feedwater is failed (either due to the initiator directly, operator error or hardware failure) and

HPCS is being used for core cooling. As the containment continues to heat up, the operators successfully emergency depressurize the RPV per the LGAs upon reaching the Heat Capacity Temperature Limit (HCTL). HPCS continues to be used for injection. The containment emergency vent is not initiated (due to the initiator induced failure, operator error, or hardware failure). The containment ultimately fails due to overpressurization and fails all core cooling options due to environmental impacts, resulting in a Class IIA core damage accident class.

<u>Sequence #2: DLOP-041 = 2.76E-7/yr (Class IBE)</u>

Sequence #2 is a collection of cutsets formed by different DLOOP events with the following characteristics:

- Dual unit loss of offsite power initiator or transient/LOCA induced DLOOP event
- Successful scram
- SPC is unavailable (e.g., no AC power available from EDGs)
- HPCS and RCIC fail to operate
- Low pressure coolant injection (LPCI) and LPCS are unavailable
- Offsite and onsite AC power are not recovered within 30 minutes.

These cutsets result in early core damage events with no AC power available (Class IBE).

<u>Sequence #3: ATW1-037 = 2.63E-7/yr (Class IV)</u>

This sequence is a transient initiated failure to scram (ATWS) scenario. Operators successfully lower RPV level and put HPCS in pull-to-lock per the LGAs. The main condenser is not available (e.g., operators do not bypass the MSIV low level interlock in time to prevent MSIV closure; or due to the initiator itself such as loss of service water; etc.). Motor-driven FW is used initially to provide core cooling but is not viable long-term due to inadequate hotwell inventory. However, SBLC injection fails (either due to hardware failure or operator error), resulting in a Class IV core damage accident.

<u>Sequence #4: TBRBFL-017 = 1.87E-7/yr (Class IBL)</u>

The TBRBFL-017 sequence includes the collection of all unisolated internal flooding initiating events that involve flooding of the turbine building, CSCS building, and reactor building.

The flood propagation pathway between the turbine building and reactor building is via the reactor building ventilation check dampers in the reactor building raceway at elevation 694'-6" when they are not isolated by Operations using plant procedures. The flood propagation pathway between the turbine building and the CSCS building is via the Auxiliary Building (AB) stairwell and through the door to the Division 2 CSCS room (this door is not designed to withstand floods propagating from the stairwell side of the door); and via the Division 3 switchgear room (also connected to the AB stairwell by a door not watertight for floods in the stairwell) and through another non-watertight door into the Division 3 CSCS room. The Division 1 CSCS room in each unit is protected as the doors to these rooms are watertight in both directions of water flow; however, the availability of Division 1 CSCS is irrelevant once the flood inundates the reactor building ECCS corner rooms because the primary inventory makeup system and heat removal systems are not available.

The flood progression through the Division 3 CSCS switchgear rooms is assumed to result in a DLOOP due to flood impacts on the system auxiliary transformer (SAT) breaker cubicles feeding the Division 3 switchgear. Reactor scram is successful; however, RCIC and HPCS fail to provide initial core cooling. The ADS system with LPCS or LPCI injection is used for initial core cooling. In these sequences, Operations fail to align fire protection for long term RPV alternate injection resulting in a Class IBL core damage accident.

All of the significant contributors, however, are associated with fire protection system breaks within the reactor building that lead to ECCS failure.

<u>Sequence #5: GTR-013 = 1.58E-7/yr (Class IIA)</u>

GTR-013 is a transient initiated loss of containment heat removal sequence.

In this sequence, SPC is not initiated (either due to operator error or hardware failure), feedwater is successful, but the main condenser is not available (either due to the initiator directly, operator error or hardware failure). As the containment continues to heat up, the operators successfully emergency depressurize the RPV per the LGAs upon reaching the Heat Capacity Temperature Limit (HCTL). FW continues to be used for injection. The containment emergency vent is not initiated (either due to the initiator directly, operator error or hardware failure). The containment ultimately fails due to overpressurization and fails all core cooling options due to environmental impacts, resulting in a Class IIA core damage accident.

<u>Sequence #6: DLOP-014 = 1.35E-7/yr (Class IIA)</u>

Sequence #6 is a collection of cutsets formed by different DLOOP events with the following characteristics:

- Dual unit loss of offsite power initiator or transient/LOCA induced DLOOP event
- Successful scram
- SPC is unavailable (e.g., no AC power available from EDGs)
- HPCS is successful and the RPV is successfully depressurized
- Containment heat removal is unavailable and ultimately fails all injection
- Offsite and onsite AC power are not recovered within 30 minutes.

These cutsets result in core damage events with no containment heat removal (Class IIA).

<u>Sequence #7: ATW1-031 = 9.78E-8/yr (Class IC)</u>

This sequence is a transient-initiated failure to scram (ATWS) scenario. Operators successfully lower RPV level and put HPCS in pull-to-lock per the LGAs. The main condenser is not available (e.g., operators do not bypass the MSIV low level interlock in time to prevent MSIV closure; or due to the initiator itself such as loss of service water; etc.). Motor-driven FW is used initially to provide core cooling but is not viable long-term due to inadequate hotwell inventory. Operators successfully inhibit ADS and successfully control RPV level during the SBLC injection process. However, following hotwell depletion, RPV emergency depressurization is not performed in a timely manner (either due to operator error or hardware failure) to allow low pressure injection to provide adequate core cooling. This scenario leads to a Class IC core damage accident.

<u>Sequence #8: GTR-011 = 8.72E-8/yr (Class IIV)</u>

In this sequence, SPC is not initiated (either due to operator error or hardware failure), feedwater is successful, but the main condenser is unavailable (either due to the initiator directly, operator error or hardware failure). As the containment continues to heat up, the operators successfully emergency depressurize the RPV per the LGAs upon reaching the Heat Capacity Temperature Limit (HCTL). FW continues to be used for injection. The containment emergency vent is initiated; however, containment venting results in failure of all injection sources post venting, resulting in a Class IIV core damage accident.

<u>Sequence #9: ATW1-032 = 7.71E-8/yr (Class IV)</u>

This sequence is a transient initiated failure to scram (ATWS) scenario. Operators successfully lower RPV level and put HPCS in pull-to-lock per the LGAs. The main condenser is not available (e.g., operators do not bypass the MSIV low level interlock in time to prevent MSIV closure; or due to the initiator itself such as loss of service water; etc.). Motor-driven FW is used initially to provide core cooling but is not viable long-term due to inadequate hotwell inventory. In these scenarios the operators either fail to inhibit ADS or control RPV level late in the sequence. This scenario leads to a Class IV core damage accident.

Sequence #10: ILOC-009 = 7.59E-8/yr (Class V)

This sequence is an unisolated break outside of containment. After a successful scram, operators fail to isolate the rupture, resulting in a Class V core damage accident.

F.2.3.3 SYSTEM IMPORTANCE MEASURES

The LSCS PRA utilizes three industry standard risk importance measures to put the importance of components, trains, functions, initiating events (IE), HEPs, etc. into perspective:

- Fussell-Vesely (F-V) is the fractional contribution of the specific element in question (component, train, system, function, IE, or HEP) to the total risk. The F-V importance calculation is generally in the form of a fractional number that may be directly translated into a percentage contribution to risk. For example, 0.0230 or 2.3E-02 may be directly translated into a 2.3% contribution to risk.
- Risk Achievement Worth (RAW) is the factor by which the risk would increase if the specific element in question (component, train, system, function, IE, or HEP) is assumed to fail. For example, if a component, train, system, function or HEP has a RAW of 2.0, the calculated risk would double if the event were assumed to have a failure probability of 1.0.
- Risk Reduction Worth (RRW) is the factor by which the risk would decrease if the component, train, system, function, IE, or HEP is assumed to be perfectly reliable (i.e., if its probability of failure were zero).

Risk importance measures reflect the degree of contribution that a system or train's failure has to the current assessment of risk (Fussell-Vesely) or how greatly risk would be increased by the guaranteed failure of a train or system (RAW). These importance measures can be different for the different trains of a system or different among seemingly similar systems. Such asymmetries reflect the fact that system and train importance determinations for the LSCS risk profile are affected by a number of factors. The three principal factors are:

- Plant design features that create higher importance for certain systems and trains
- Masking of system or train importance by other failures
- Modeling asymmetries (including pumps assumed normally operating)

Figure F.2-1 shows the relative importance of system, train, or component importance to LSCS Unit 2 CDF using the Fussell-Vesely importance measure.

Figure F.2-2 shows the relative importance of system, train, or component importance to LSCS Unit 2 CDF using the RAW importance measure.

F.2.3.4 SUMMARY OF THE IMPACT OF ASYMMETRIES ON RISK

The principal plant design feature asymmetries impacting the LSCS risk profile are:

- AC and DC Divisions 1, 2, and 3 support substantially different equipment;
- AC Division 1 does not have a dedicated diesel generator (DG) and may require operator action to share the DG between both units;
- DC Divisions 1 and 2 have the safety relief valves (SRVs) plus support instrumentation and control of their associated AC divisions;
- C RHR is not a heat removal train, whereas A and B RHR are capable of suppression pool cooling and shutdown cooling;
- LPCS, A RHR, and RCIC are on Division 1;
- B and C RHR are on Division 2;
- The RCIC/LPCS room and the A RHR room share a common floor drain, without a check valve, which results in flood water propagating between both rooms;
- LPCS does not require room cooling for the 24 hour mission time, but RHR and HPCS do require room cooling; and
- Plant service water (WS (system designator), also referred to as SW in PRA document discussions) Unit 0 swing pump 0WS01P is powered from Unit 2 4.16 kVAC switchgear 241X.

F.2.4 2013A LEVEL 2 MODEL OVERVIEW

The core damage frequency (CDF) model provides a tool for estimating the likelihood or frequency of core damage. Because consequences of a core damage event can range from minimal (as in the case of the Three Mile Island event in 1979) to more severe (as in the case of the Fukushima event in 2011), additional information is needed to assess risk. Therefore, the Level 2 PRA model is designed to identify underlying causes of containment failure for severe accidents and the associated release pathways and their frequencies. Specifically, the Level 2 PRA determines the release frequency, severity, and timing of postulated releases based on the Level 1 PRA, accident progression analysis, and containment performance.

The Level 2 PRA includes two types of analyses: (1) a deterministic analysis of the physical processes for a spectrum of severe accident progressions, and (2) a probabilistic analysis component in which the likelihood of the various outcomes are assessed. The deterministic analysis examines the response of the containment to the physical processes associated with a severe accident. Containment response is modeled by: (1) using the MAAP4 code to simulate severe accidents that have been identified as dominant contributors to core damage in the Level 1 analysis, and (2) performing reference calculations for hydrodynamic and heat transfer phenomena that occur during the progression of a severe accident.

The Level 2 PRA is based on a containment event tree (CET) model. The CET represents an accident progression given initial plant damage states and is a logic model with functional nodes that represent sequential phenomenological events and the status of containment protection systems. The CET provides the framework for evaluating containment failure modes and conditions that would affect the magnitude of the release.

The LSCS CETs allow core damage scenarios defined in the Level 1 model to be further developed into consequence bins. Separating scenarios this way allows results of plant risk calculations to be presented in simple, meaningful terms. Consequence bins are based on the severity of the source term and the timing of the release relative to the time a general emergency is declared and then initiation of protective actions for the public. The characteristics of these bins are then used as input for the Level 3 model. The following subsections summarize the breakdown of the bins and the Level 2 results.

F.2.4.1 CONSEQUENCE BINS: SOURCE TERM SEVERITY

The radionuclide release categories are defined based on two parameters: timing and severity. Timing of the release for each sequence is based on MAAP calculations of the sequence chronology. The classification of release magnitude is also based on MAAP 4.0.5 calculations.

The inputs for determining the plant specific characteristics of the radionuclide release bins are the following:

- The Level 1 PRA
- The MAAP 4.0.5 plant specific calculations
- The LSCS Emergency Plan and Emergency Action Levels (EALs)
- The magnitude of releases that can contribute to public health effects
- The evacuation timing

The magnitude of the radionuclide releases for purposes of binning sequences is characterized in terms of the radionuclide release fraction for CsI, which is a dominant contributor to both prompt and latent health effects. The CsI release fraction also correlates well with other contributors to offsite effects. For consequence calculations, additional radionuclides are included as inputs to the release.

The bins used to define the release magnitude spectrum are as follows:

Characterization	Designator	CsI Release Fraction
High	H	> 10%
Medium	M	> 1% and ≤ 10%
Low	L	> .1% and ≤ 1%
Low-Low	LL	≤ .1%

The resulting definitions of the radionuclide release end states are summarized in Table F.2-4.

Using the MAAP results and the Level 2 containment event trees, the radionuclide release categories can be assigned to each CET sequence end state. When MAAP is not well suited to modeling the accident phenomena associated with a scenario, the scenario is modeled using conservative estimates (e.g., steam explosion) and insights from other Level 2 PRA models from plants of a similar type.

F.2.4.2 CONSEQUENCE BINS: TIMING OF RELEASE

Each sequence that leads to a radioactive release from containment is classified as "early", "intermediate", or "late". This designation is intended to reflect mitigation of consequences by evacuating people from the area, as appropriate. The "early" classification is used for scenarios in which a radioactive release occurs before the evacuation of the 10 mile Emergency Planning Zone (EPZ) is assumed to be complete. Based on the Evacuation Time Estimate (ETE) study (ARCADIS 2012), the worst case conditions (weather, etc.) correlate to a 10 mile EPZ evacuation time of 5 hours from the point when a general emergency (GE) is declared. The "Early" scenarios, therefore, are those scenarios in which a radioactive release occurs within 5 hours of the time that a GE is declared. Releases occurring between 5 and 24 hours from the declaration of a GE are categorized as "intermediate". Releases occurring at times greater than 24 hours after the declaration of a GE are considered "late". Release timing is summarized in Table F.2-4, which is reproduced from the LSCS Level 2 model documentation.

F.2.4.3 LEVEL 2 PRA RADIONUCLIDE RELEASE CATEGORIES

Classifications of radionuclide releases need to be adequate to distinguish the severe accident scenarios that can result in potentially high public consequences versus those that have public consequences below measurable values. Therefore, the LSCS PRA model has been expanded to be a full Level 2 model with a spectrum of radionuclide release categories. This knowledge of consequences, coupled with the quantification of the accident sequence frequencies, allows for the characterization of the public risk and the identification of potentially cost-beneficial plant or procedure modifications.

As mentioned previously, the source terms associated with each of these release severity categories are quantified through the use of LSCS-specific calculations. A review of existing consequence analyses performed in previous and current PRAs was also performed to confirm the reasonableness of the radionuclide release values.

The frequency of radionuclide release is characterized by the quantification of the Level 1 and Level 2 PRA models. The Level 2 radioactive release frequency event tree end states are delineated by the magnitude and timing bins of the calculated radionuclide release, as described above. Therefore, the CET end states are characterized using a two-term matrix (severity, time) as shown in Table F.2-5.

Tables F.2-4 and F.2-5 provide the nomenclature used in the definition of radionuclide release categories. Table F.2-6 provides a quantitative summary of the radioactive release frequency event tree results. For each of the release categories from Table F.2-5, the corresponding frequency is provided. Table F.2-6 provides quantitative information that is useful in the interpretation of the current containment capability given the spectrum of core damage sequences calculated in the Level 1 PRA.

The quantification provides a method with which to measure the best estimate of containment performance given that severe accidents could progress to beyond core damage. The quantification may include some conservatism to account for the limitations of current models and experiments to predict certain severe accident-related phenomena (e.g., ATWS is always assumed to result in a large containment failure).

A fraction (approximately 29 percent) of the core damage accidents transferred from Level 1 PRA are effectively mitigated, such that releases are essentially contained within an intact containment (i.e., INTACT release bin). In addition, only about 5.5 percent of the postulated accidents lead to "large" releases occurring before protective action can be taken (i.e., approximately 5.5 percent of the accidents result in LERF).

Figure F.2-3 is a histogram that compares the total core damage frequency (i.e., the results of the Level 1 PRA) with the frequencies for each of the release categories from Level 2. A substantial fraction of the core damage frequency (approximately 50 percent) lead to "small" (low or low-low) or negligible (i.e., INTACT) categories from Level 2.

F.2.5 PRA QUALITY

The 2013A update to the LS PRA model is the most recent evaluation of the risk profile at LSCS for internal event challenges (LS213A). This PRA model is documented as an application-specific model developed for the use in the SAMA risk-informed application. The current PRA model of record is the 2011A PRA. The CDF portions of the 2011A and 2013A PRA models are identical. The 2011A model is a LERF-only model while the 2013A PRA model is expanded to include a full Level 2 model. The LERF results for the 2011A and 2013A PRA models are similar; and the 2013A model provides a detailed risk categorization of release bins and timing for all release categories, in addition to the large early release category.

The LS PRA modeling is highly detailed, including a wide variety of initiating events, modeled systems, operator actions, and common cause events. The PRA model quantification process used for the LS PRA is based on the event tree / fault tree methodology, which is a well-established methodology in the industry.

EGC employs a multi-faceted approach to establishing and maintaining the technical adequacy and plant fidelity of the PRA models for all operating EGC nuclear generation sites. This approach includes both a proceduralized PRA maintenance and update process, and the use of self-assessments and independent peer reviews. The following information describes this approach as it applies to the LSCS PRA.

F.2.5.1 PRA MAINTENANCE AND UPDATE

The EGC risk management process ensures that the applicable PRA model remains an accurate reflection of the as-built and as-operated plants. This process is defined in the EGC Risk Management program, which consists of a governing procedure (ER-AA-600, "Risk Management") and subordinate implementation guidelines. The overall EGC Risk Management program defines the process for implementing regularly scheduled and interim PRA model updates, for tracking issues identified as potentially affecting the PRA models (e.g., due to changes in the plant, errors or limitations identified in the model, industry operating experience), and for controlling the model and associated computer files. To ensure that the current PRA model remains an accurate reflection of the as-built, as-operated plants, the following activities are routinely performed:

- Design changes and procedure changes are reviewed for their impact on the PRA model.
- New engineering calculations and revisions to existing calculations are reviewed for their impact on the PRA model.
- Maintenance unavailabilities are captured, and their impact on CDF is trended.
- Plant-specific initiating event frequencies, failure rates, and maintenance unavailabilities are updated approximately every four years.

In addition to these activities, EGC risk management procedures provide the guidance for particular risk management and PRA quality and maintenance activities. This guidance includes:

- Documentation of the PRA model, PRA products, and bases documents.
- The approach for controlling electronic storage of Risk Management (RM) products, including PRA update information, PRA models, and PRA applications.
- Guidelines for updating the full-power, internal events PRA models for EGC nuclear generation sites.
- Guidance for use of quantitative and qualitative risk models in support of the On-Line Work Control Process Program for risk evaluations for maintenance tasks (corrective maintenance, preventive maintenance, minor maintenance, surveillance tests and modifications) on systems, structures, and components (SSCs) within the scope of the Maintenance Rule (10 CFR 50.65(a)(4)).

In accordance with this guidance, regularly scheduled PRA model updates nominally occur on an approximately four-year cycle; shorter intervals may be required if plant changes, procedure enhancements, or model changes result in significant risk metric changes. In addition, EGC now maintains a continuous updated model to ensure the risk assessment of the as-built, as-operated plant does not deviate significantly from the model of record.

F.2.5.2 APPLICABILITY OF PEER REVIEW FINDINGS AND OBSERVATIONS

Several assessments of technical capability have been made, and more are planned for the LSCS PRA model. The completed assessments are summarized in the paragraphs below.

- An independent PRA peer review was conducted under the auspices of the BWR Owners' Group in July 2000, following the Industry PRA Peer Review process (BWROG 1997). This peer review included an assessment of the PRA model maintenance and update process. All findings from this peer review were addressed and closed out.
- During 2005 and 2006, the LSCS PRA model results were evaluated in the BWR Owners' Group PRA cross-comparisons study performed in support of implementation of the

mitigating systems performance indicator (MSPI) process. No significant issues resulted from this comparison.

- A self-assessment analysis was performed using Agenda B of the ASME PRA Standard (ASME 2005) and Regulatory Guide 1.200, Rev. 1 (NRC2007a) as part of the periodic update of the LSCS PRA. This was updated and finalized to represent the current status near the completion of the update in 2007.
- A PRA Peer Review of the LSCS PRA was performed during the spring of 2008 (in accordance with the NEI Peer Review process). The results of the PRA Peer Review indicated that a small number of the supporting requirements (SRs) were "Not Met" or met only at the Capability Category I. However, many of these SRs related principally to documentation and the treatment of modeling uncertainty. The results of the LSCS PRA Peer Review support the quality of the LSCS PRA and its use for the SAMA analysis.

A PRA update was conducted in 2011 and addressed the majority of 2008 peer review findings and ASME/ANS PRA Standard supporting requirements assigned a Capability Category II or lower. Table F.2-7 provides a summary of the open findings and supporting requirements assigned a capability category II or lower and a discussion of the potential impact on the SAMA analysis. "Open" items, or those that have not been "closed out", are issues that are still being tracked and have not yet had their dispositions finalized through the ER-AA-600-1015 process. As documented in Table F.2-7, the impact of resolving the "open" items would have a negligible impact on the SAMA analysis.

F.2.5.3 CONSISTENCY WITH APPLICABLE PRA STANDARDS

As indicated above, a formal peer review was performed in the spring of 2008 and the final peer review report issued in July 2008. This peer review was performed against Addendum B of the PRA Standard (ASME 2005), the criteria in RG-1.200, Rev. 1 (NRC 2007a), including the NRC positions stated in Appendix A of RG-1.200, Rev. 1 and further issue clarifications (NRC 2007b). The remaining open supporting requirements (SRs) identified from the peer review as not meeting Capability Category II and associated findings are summarized in Table F.2-7 along with an assessment of the impact on the base PRA.

F.2.5.4 PRA QUALITY SUMMARY

The LSCS PRA maintenance and update processes and technical capability evaluations described above provide a robust basis for concluding that the PRA is suitable for use in this risk-informed application.

F.3 LEVEL 3 RISK ANALYSIS

The Level PRA 3 combines the Level 2 PRA results with site-specific parameters (e.g., population distribution, meteorological data, land use data, and economic data) to estimate offsite public dose and offsite economic consequences of the postulated releases to the environment. This section addresses the key input parameters and analysis of the Level 3 portion of the risk assessment. In addition, Section F.7.3 summarizes a series of sensitivity evaluations to potentially critical input parameters.

F.3.1 ANALYSIS

The MACCS2 code (NRC 1998), version 1.13.1, was used to perform the Level 3 probabilistic risk assessment (PRA) for LSCS. The MACCS2 code was developed to support probabilistic risk assessments (NRC 1998) and is the standard code used to calculate off-site population dose and economic costs in support of a SAMA analysis, as recognized in NEI 05-01 (NEI 2005). The atmospheric transport and dispersion (ATD) straight-line Gaussian plume segment model incorporated in MACCS2 has been compared against more sophisticated, variable trajectory ATD models, such as the three-dimensional ADAPT/LODI code, and shown to be acceptable for the purposes of typical MACCS2 code applications (NRC 2004b).

For the LSCS MACCS2 analysis, the input parameter values used in NUREG-1150 (NRC 1990a), as detailed in NUREG/CR-4551 (NRC 1990b) and reflected in the MACCS2 "Sample Problem A," (NRC 1998) formed the initial bases in addition to those utilized in the LSCS Unit 2 Risk Methods Integration and Evaluation Program (RMIEP) as documented in the NUREG/CR-5305 volumes (NRC 1992c). NUREG-1150 is a seminal work in PRA performed by the NRC and the national laboratories that includes a Level 3 PRA for five different reactor sites. It was subjected to extensive peer review and has been accepted by the NRC as a standard reference for MACCS2 inputs for SAMA analyses. The RMIEP study is a LSCS-specific risk analysis study that includes a Level 3 (MACCS2) analysis. Where applicable, the initial values from these sources were replaced with updated site-specific values applicable to LSCS and the surrounding region. Site-specific data included, for example, population distribution, certain economic parameters such as property value of farm and non-farm land, and meteorological data. Standardized economic parameters from the NUREG-1150 study for the costs of evacuation, relocation and decontamination were escalated from the time of their formulation (1986) to reflect more recent (July 2013) costs. Plant-specific release data included release frequencies and the time-dependent distribution of nuclide releases from eight (8) accident sequences at LSCS. The behavior of the population during a release (as modeled through evacuation parameters) was based on plant and site-specific set points (i.e., declaration of a General Emergency) and evacuation time estimates (ARCADIS 2012). These data were used in combination with site-specific meteorology to calculate risk impacts (exposure and economic) to the surrounding population within a 50 mile radius of LSCS.

F.3.2 POPULATION

The population surrounding the LSCS site is estimated for the year 2043, the last year of projected operation for Unit 2 given a 20 year license extension (Unit 1 license expires in 2042). Estimating the population of the SAMA analysis region entailed three major steps: (1) determining the year 2000 permanent population within a 50-mile radius of LaSalle; (2) accounting for the transient population within the SAMA analysis region; and (3) projecting that permanent and transient population out to the year 2043 based on available population projection data.

The population distribution projection was based on year 2000 census data available via SECPOP2000 (NRC 2003). A comparison to 2010 census data has been performed. The baseline resident year 2000 population from SECPOP2000 was determined for each of 160 grid elements of a polar coordinate grid consisting of sixteen directions (i.e., N, NNE, NE,...NNW) for each of ten concentric distance rings with outer radii at 1, 2, 3, 4, 5, 10, 20, 30, 40 and 50 miles surrounding the site. Transient population data from the LSCS Evacuation Time Estimate (ETE) study (ARCADIS 2012) for the approximate 10-mile radial area around the site were added to the SECPOP permanent population, consistent with the guidance of NEI 05-01 (NEI 2005), on a grid element basis. In addition to the ETE category of transient population (which includes employees), seasonal residents and special facilities[4] populations derived from the LaSalle ETE study (ARCADIS 2012) were also included in the initial year 2000 population estimate.

To estimate growth rates, Illinois county population projection data for the year 2030 were used. Table F.3-1 presents the county growth rates for the years 2000 to 2030. Individual growth rates were calculated for each grid element based on the county growth rate and the proportion of land in each grid element associated with the applicable counties. The combined resident

[4] In this analysis, special facilities include medical, nursing care, and correctional facilities as well as schools and day cares. These facilities require special considerations for evacuation of the population.

and transient data (including seasonal residents and special facilities) were projected from year 2000 to 2030, and then from 2030 to 2043 (using the year 2000 to 2030 growth rate times a 0.433 factor, i.e., 13/30) to calculate the 2043 population distribution.

Table F.3-2 presents the year 2000, projected year 2010, and year 2010 census population for the counties surrounding LSCS and demonstrates that use of the Census 2000 data in combination with projected county growth rates rather than Census 2010 data in the analysis is reasonable and slightly conservative (i.e., the projected data shows a slightly higher total population relative to that estimated using the Census 2010 data). Table F.3-3 presents the year 2000 transient (including employees) and special facility population within 10 miles of the LSCS. Table F.3-4 presents the year 2000 residential population within 50 miles of the LSCS site. Table F.3-5 presents the year 2010 projected population including transient, seasonal resident, and special facilities and provides a basis for comparing other 2010 population estimates developed to support the LSCS license extension.

The total year 2043 population for the 160 grid elements in the region is estimated at 3,107,897. The distribution of the population is given for the 10-mile radius and the 50-mile radius from LSCS in Tables F.3-6 and F.3-7, respectively.

F.3.3 ECONOMY

MACCS2 requires certain agricultural and land-based economic data (fraction of land devoted to farming, annual farm sales, fraction of farm sales resulting from dairy production, and property value of farm and non-farm land) for each of the 160 grid elements. This data can be generated by SECPOP2000 (NRC 2003), but due to known issues associated with the economic parameter processing portion of the SECPOP2000, SECPOP2000 was not utilized to develop the county-specific economic values for the LSCS analysis. The issue in question only impacts economic data and does not affect population output of the SECPOP2000 code. Instead, the economic values were developed manually following the SECPOP calculation approach documented in NUREG/CR-6525 (NRC 2003) using data from the 2007 National Census of Agriculture (USDA 2009) and 2007 data (for consistency with the census of agricultural data) from the Bureau of Economic Analysis (BEA 2013) for each of the 21 counties surrounding the plant, to a distance of 50 miles. Economic values were updated to July 2013 using the consumer price index (CPI) from the Bureau of Labor Statistics (BLS 2013). The values used for each of the 160 grid elements were the data from each of the surrounding counties multiplied by the fraction of that county's area that lies within that sector. Region-wide wealth data (i.e., farm wealth and non-farm wealth) were based on county-weighted averages for the region within 50-miles of the site using the same economic data sources. Spatial elements within the same county have the same index value. Spatial elements involving multiple counties have unique index values. The portion of each county within 50-miles of the site was accounted for in the calculation. The fraction of each spatial element that is land (as opposed to water) was visually estimated using maps and images of the regions surrounding LSCS and was also taken into consideration. Region index values were assigned based on application of the county-level data to a 50-mile radius grid surrounding each site. Data from the 2007 Census of Agriculture (USDA 2009) was used to determine the farmland fraction for each of the counties surrounding LSCS. County-specific land use and related economic parameter values are summarized in Table F.3-8.

In addition, generic standardized economic data values that are applied to the region as a whole were adjusted from the NUREG-1150 based data to account for cost escalation since 1986, the year those input values were first specified. A factor of 2.13, representing cost escalation from 1986 (CPI index of 109.6) to July 2013 (CPI index of 233.6) was applied to parameter values describing cost of evacuating and relocating people and decontamination activities. The use of appropriately escalated standardized economic parameter values from NUREG-1150 is consistent with NEI 05-01 guidance and previous NRC-approved SAMA analyses for other nuclear power plants seeking renewed operating licenses.

MACCS2 standardized economic parameter values utilized in the LSCS analysis are summarized in Table F.3-9.

F.3.4 FOOD, AGRICULTURE, AND WATERSHED

Food ingestion is modeled using the new MACCS2 ingestion pathway model COMIDA2, consistent with MACCS2 User's Guide (NRC 1998). The COMIDA2 model utilizes national based food production parameters derived from the annual food consumption of an average individual such that site specific food production values are not utilized. Annual dose limits trigger crop or milk disposal, as appropriate. Values are chosen consistent with the most recent guidance of FDA 63 FR-43402 (FDA 1998). These parameters and their values used in the LSCS analysis are presented in Table F.3-10. The fraction of population dose due to food ingestion is typically small compared to other population dose sources. For LSCS, MACCS2 results indicate that approximately 2.7% of the total population dose is due to food ingestion for the base case.

Spatial elements are designated as river systems or lake systems. Per NUREG/CR-4551 (NRC 1990b) the designation of lake is only used for very large bodies of water, such as Lake Michigan, which may serve as drinking water sources. Lake Michigan is outside the 50-mile radius region. The other lakes around the LSCS site are smaller and are expected to behave like river systems.

F.3.5 NUCLIDE RELEASE

The core inventory at the time of the accident is based on a plant-specific calculation (Exelon 2011). The core inventory represents bounding isotopic values for 100 effective full power days (EFPD) or 711 EFPD (end-of-cycle) for LSCS operating at 3489 MWt. The current licensed core power level is 3546 MWt based upon a recent power uprate associated with measurement uncertainty recapture (MUR). The MACCS2 model includes a reactor power scaling factor of 1.0163 (i.e., 3546 MWt/3489 MWt) to address the MUR power uprate to 3546 MWt. Table F.3-11 summarizes the estimated LSCS core inventory used in the MACCS2 analysis.

Wake effect data are based on LSCS Reactor Building dimensions. The top of the Reactor Building structure is 184 ft. (56.1 m) above grade. The average outer width of the combined Reactor Building structure is 217 ft. (66.1 m). Plume standard deviations sigma-y and sigma-z are based on MACCS2 User's Guide formulas (NRC 1998).

LSCS nuclide radioisotope groups, as represented using the MAAP computer code version 4.0.5, are related to the MACCS2 radioisotope groups as shown in Table F.3-12. MAAP 4.0.5 is a computer code used to predict source terms resulting from severe accidents. Thirteen (13) different source-term categories were developed in the LSCS Level 2 PRA, shown in Table F.3-13. These release categories represent a radionuclide release severity and timing classification as shown in Table F.3-14. A separate release category for a break outside containment (BOC) is included with the categories. The thirteen (13) release categories were grouped into eight (8) release bins as shown in Table F.3-15. The frequency of each release bin is shown in Table F.3-16.

For each of the eight (8) release bins, a representative MAAP case was chosen based on a review of the Level 2 model cutsets and the dominant types of scenarios that contribute to the release category. MAAP cases were not required for the High/Late, Moderate/Late, Low/Late, or any of the Low-Low release categories due to negligible frequency in the Level 2 analysis (LS213A). Brief descriptions of each release category, dominant Level 2 sequences, frequency of the release category, and the representative MAAP case are provided in Table F.3-17. It should be noted that the release category reference MAAP cases in the Level 2 analysis are used along with the Level 2 release category rules to assign an appropriate end state to the Level 2 sequence. A summary of the representative MAAP cases (i.e., key case timings) is shown in Table F.3-18.

Consistent with the NEI 05-01 guidance (NEI 2005), a plume release height of 28 m (92 ft.) above grade is used to represent a release from the mid-height of the containment. Buoyant plume rise is modeled assuming a thermal plume heat content of 10 MW for all releases except intact containment (where zero heat content is assumed). A value of 10 MW bounds typical values in NUREG/CR-4551 (NRC 1990b). Assumptions associated with release height and plume heat content are considered in the sensitivity analyses, presented in Section F.7.3.

Representative MAAP cases were run until plateaus of the CsI and CsOH release fractions were achieved. Experience has shown that CsI is a primary contributor to early dose, and CsOH is a primary contributor to late dose and cleanup costs.

Multiple release duration periods (i.e., plume segments) were defined and represent the time distribution of each category's releases. A summary of the release magnitude and timing for those cases is provided in Table F.3-19.

A dry deposition velocity of 0.01 m/sec is used for the MACCS2 analysis, consistent with the NRC's recommendation as documented in the MACCS2 Sample Problem A (NRC 1998). The dry deposition velocity is evaluated in the sensitivity analysis, presented in Section F.7.3.

F.3.6 EVACUATION AND SHIELDING AND PROTECTION

Reactor trip for each sequence is taken as time zero relative to the core containment response times. A General Emergency (GE) is declared when plant conditions degrade to the point where it is judged that there is a credible risk to the public. For the LSCS analysis, the time of the GE declaration is estimated based on the LSCS emergency action levels (Exelon 2013). The declaration times are presented in Table F.3-19. For most release categories, the GE time is established as the time of core damage. However, a minimum GE time of 30 minutes is used for release categories with core damage projected to occur in less than 30 minutes.

Ninety five percent of the population within 10 miles of the plant (Emergency Planning Zone, EPZ) is assumed to evacuate and 5 percent is assumed not to evacuate, consistent with guidance in the MACCS2 User's Guide (NRC 1998). These values are conservative relative to the NUREG-1150 study (NRC 1990a), which assumed evacuation of 99.5 percent of the population within the EPZ.

The evacuees are assumed to begin evacuation 100 minutes after a general emergency has been declared at a base evacuation radial speed of 1.6 m/sec. A time of approximately 4.4 hours is used to model evacuation of the 10-mile EPZ, based on weighting the ETE times to account for the season (i.e., winter vs. summer), time of the week (i.e., midweek vs. weekend), time of day (i.e., daytime vs. nighttime), and weather conditions (i.e., fair vs. adverse). The ETE study does not present any specific event (e.g., festival) evacuation time estimates.

The time to begin evacuation and the base speed are derived from the site-specific evacuation study (ARCADIS 2012). The evacuation parameters were considered further in the sensitivity analyses presented in Section F.7.3.2.

The ETE study evacuation times range from 3 hours and 50 minutes (for winter, nighttime, and fair conditions) to 5.0 hrs. (for winter, midweek, daytime, and adverse conditions or winter, nighttime, and adverse conditions) for a 100% evacuation of the 10 mile EPZ. These ETE times include "shadow evacuation" of 20% of the residential population outside the 10 mile EPZ, to a distance of 15 miles.

Shielding and exposure factors were chosen consistent with those developed and used in the NUREG-1150 (NRC 1990a) studies and the Integrated Risk Assessment for LSCS Unit 2 as documented in NUREG/CR-5305 (NRC 1992).

F.3.7 METEOROLOGY

Annual hourly meteorology LSCS data sets from 2010 through 2012 were processed for use in the MACCS2 analysis. These data sets were obtained from onsite meteorological stations. No additional offsite meteorological data were used with the exception of mixing layer height.

The meteorological file used as input into the MACCS2 code consists of one (1) year of hourly recordings (8760) of accumulated precipitation. When precipitation occurs during a release, the depletion of the plume occurs more rapidly due to plume washout. The amount of plume washout is proportional to the intensity and duration of precipitation. The MACCS2 code does not differentiate between rain and snow precipitation.

Of the hourly data of interest (10-meter wind speed, 10-meter wind direction, multi-level temperatures used to calculate stability class, and precipitation), 2% or less of the data were missing for each of the three years of data. Traditionally, up to 10% of missing data is considered acceptable (NRC 2007c). MACCS2 requires complete sequential hourly data for the full year, therefore missing data must be estimated. The percentages of data hours that included estimated data for missing data for years 2010, 2011, and 2012 were 2.0%, 1.6%, and 1.1%, respectively. Data gaps were filled in the following manner (order of priority):

- Wind speed and wind direction were taken from the 33-ft (~10m) sensor of the primary site tower. If wind direction data from the 33-ft sensor was not available, wind direction data was taken from the 200-ft sensor or the 375-ft sensor. If wind speed data from the 33-ft sensor was 77.7 (flag for calm), then 0.5 mph was used as a surrogate.
- Gaps containing less than six consecutive hours of missing data were filled by interpolation.
- Gaps containing six or more consecutive hours of missing data were filled by substitution from previous or following data (same time of day). For wind speed, the power law (see next bullet) was used prior to this approach, if possible.
- If wind speed data had six or more consecutive hours of data missing, the power law was used to determine the beta factor for the two rows of data immediately before and after the missing data rows and then the beta factor was averaged and used to estimate the wind speed for the missing hours. (This was only required for 2012 meteorological data.)

The 10-meter wind speed and direction were combined with precipitation and atmospheric stability (derived from the vertical temperature gradient) to create the hourly data file for each year for use by MACCS2.

The 2012 data set was found to result (see Section F.7.3.1 for discussion of sensitivity analysis) in the largest economic cost risk and dose risk compared to the 2010 and 2011 data sets. Therefore, the 2012 hourly meteorology was selected as the base case.

The MACCS2 code requires morning and afternoon mixing layer heights to be defined in the meteorological file for the four (4) seasons of the year. For a given season, MACCS2 uses the larger of the two values. The start day of each weather sequence determines the season in which that sequence lies. These values ranged from 310 meters to 1550 meters, as documented in the Holzworth data (EPA 1972).

F.3.8 MACCS2 RESULTS

Table F.3-20 shows the mean off-site doses and economic impacts to the region within 50 miles of LSCS for each of eight (8) release categories calculated using MACCS2. The mean off-site dose impacts are multiplied by the annual frequency for each release category (see Table F.3-15) and then summed to obtain the dose-risk and offsite economic cost-risk (OECR) for each unit.

Table F.3-20 indicates that the total dose-risk is approximately 7.11 p-rem/yr. The total OECR is calculated to be about 53,400 \$/yr. The largest contributor to these results is the moderate/intermediate release category which accounts for approximately 50% of the dose risk and 61% of the cost risk.

F.4 BASELINE RISK MONETIZATION

This section explains how LSCS calculated the monetary value of the status quo (i.e., accident consequences assuming no mitigation due to SAMA implementation). LSCS also used this analysis to establish the maximum benefit that could be achieved if all on-line LSCS risk were eliminated, which is referred to as the Maximum Averted Cost-Risk (MACR). Per the site PRA model (designated LS213A), the Unit 2 internal events CDF of 2.58E-06 (at a truncation of 1E-12/yr) was used for the calculations in the following sections. External risk is addressed in Section F.4.6.2.

F.4.1 OFF-SITE EXPOSURE COST

The baseline annual off-site exposure risk was converted to dollars using the NRC's standard conversion factor of \$2,000 per person-rem, and discounted to present value using the following NRC standard formula (NRC 1997):

$$Wpha = C \times Zpha$$

Where:

W_{pha}	=	monetary value of public health accident risk after discounting
C	=	$[1-\exp(-rt_f)]/r$
t_f	=	years remaining until end of facility life = 20 years

r	=	real discount rate (RDR) (as fraction) = 0.03 per year
Z_{pha}	=	monetary value of public health (accident) risk per year before discounting ($ per year)

The Level 3 analysis showed an annual off-site population dose-risk of 7.11 person-rem per year. The calculated value for C using 20 years and a 3 percent discount rate is approximately 15.04. Therefore, calculating the discounted monetary equivalent of accident dose-risk involves multiplying the dose (person-rem per year) by $2,000 and by the C value (15.04). The calculated off-site exposure cost is $213,863.

F.4.2 OFF-SITE ECONOMIC COST RISK

The Level 3 analysis showed an annual off-site economic risk of $53,358. Calculated values for off-site economic costs caused by severe accidents must also be discounted to present value. This is performed in the same manner as for public health risks and uses the same C value. The resulting value is $802,484.

F.4.3 ON-SITE EXPOSURE COST RISK

Occupational health was evaluated using the NRC-recommended methodology that involves separately evaluating immediate and long-term doses (NRC 1997).

For immediate dose, the NRC recommends using the following equation:

Equation 1:

$$WIO = R\{(FDIO)S - (FDIO)A\}\{[1 - \exp(-rtf)]/r\}$$

Where:

W_{IO}	=	monetary value of accident risk avoided due to immediate doses, after discounting
R	=	monetary equivalent of unit dose ($2,000 per person-rem)
F	=	accident frequency (events per year) (2.58E-06 (internal events CDF)) at an average 1E-12/yr truncation
D_{IO}	=	immediate occupational dose [3,300 person-rem per accident (NRC estimate)]
S	=	subscript denoting status quo (current conditions)
A	=	subscript denoting after implementation of proposed action
r	=	real discount rate (0.03 per year)

t_f = years remaining until end of facility life (20 years).

Assuming FA is zero, the best estimate of the immediate dose cost is:

W_{IO} = R $(FD_{IO})_S$ {[1 – exp(-rt$_f$)]/r}
= 2,000∗2.58E-06 ∗3,300∗{[1 – exp(-0.03∗20)]/0.03}
= $256

For long-term dose, the NRC recommends using the following equation:

Equation 2:

WLTO = R{(FDLTO)S –(FDLTO)A} {[1 – exp(-rtf)]/r}{[1 – exp(-rm)]/rm}

Where:

W_{LTO} = monetary value of accident risk avoided long-term doses, after discounting, $

D_{LTO} = long-term dose [20,000 person-rem per accident (NRC estimate)]

m = years over which long-term doses accrue (as long as 10 years)

Using values defined for immediate dose and assuming FA is zero, the best estimate of the long-term dose is:

W_{LTO} = R $(FD_{LTO})_S$ {[1 – exp(-rt$_f$)]/r} {[1 – exp(-rm)]/rm}
= 2,000∗2.58E-06 ∗20,000∗{[1 – exp(-0.03∗20)]/0.03} {[1 –exp (-0.03∗10)]/0.03∗10}
= $1,341

The total occupational exposure is then calculated by combining Equations 1 and 2 above. The total accident related on-site (occupational) exposure risk (W_O) is:

WO = WIO + WLTO = ($256+$1,341) = $1,597

F.4.4 ON-SITE CLEANUP AND DECONTAMINATION COST

The total undiscounted cost of a single event in constant year dollars (C_{CD}) that NRC provides for cleanup and decontamination is $1.5 billion (NRC 1997). The net present value of a single event is calculated as follows. NRC uses the following equation to integrate the net present value over the average number of remaining service years:

$$PV_{CD} = [C_{CD}/mr][1\text{-}\exp(\text{-}rm)]$$

Where:

PV_{CD}	=	net present value of a single event
C_{CD}	=	total undiscounted cost for a single accident in constant dollar years
r	=	real discount rate (0.03)
m	=	years required to return site to a pre-accident state

The resulting net present value of a single event is $1.3E+09. The NRC uses the following equation to integrate the net present value over the average number of remaining service years:

$$U_{CD} = [PV_{CD}/r][1\text{-}\exp(\text{-}rt_f)]$$

Where:

PV_{CD}	=	net present value of a single event ($1.3E+09)
r	=	real discount rate (0.03)
t_f	=	20 years (license renewal period)

The resulting net present value of cleanup integrated over the license renewal term, $1.95E+10, must be multiplied by the internal events CDF (2.58E-06) to determine the expected value of cleanup and decontamination costs. The resulting monetary equivalent is $50,284.

F.4.5 REPLACEMENT POWER COST

Long-term replacement power costs were determined following the methodology documented in NUREG/BR-0184 (NRC 1997). The net present value of replacement power for a single event, PV_{RP}, was determined using the following equation:

$$PV_{RP} = [\$1.2\times10^8/r] * [1 - \exp(\text{-}rt_f)]^2$$

Where:

PV_{RP}	=	net present value of replacement power for a single event, ($)
r	=	0.03
t_f	=	20 years (license renewal period)

To attain a summation of the single-event costs over the entire license renewal period, the following equation is used:

$$U_{RP} = [PV_{RP} / r] * [1 - \exp(-rt_f)]^2$$

Where:

U_{RP} = net present value of replacement power over life of facility ($-year)

After applying a correction factor to account for LSCS's size relative to the "generic" reactor described in NUREG/BR-0184 (NRC 1997) (i.e., 1210 megawatt electric / 910 megawatt electric), the replacement power costs are determined to be 7.35E+09 ($-year). Multiplying 7.35E+09 ($-year) by the CDF (2.58E-06) results in a replacement power cost of $18,955.

F.4.6 MAXIMUM AVERTED COST-RISK

The LSCS MACR is the total averted cost-risk if all internal and external events risks associated with on-line operation were eliminated. This is calculated by summing the following components:

- Maximum Internal Events Averted Cost-Risk
- Maximum External Events Averted Cost-Risk

The MACR is used in the Phase I analysis as a means of screening SAMAs. The following subsections provide a description of how each of these components is calculated and used together to obtain the LSCS MACR.

F.4.6.1 INTERNAL EVENTS MAXIMUM AVERTED COST-RISK

The maximum internal events averted cost-risk is the sum of the contributors calculated in Sections F.4.1 through F.4.5:

Maximum Averted Internal Events Cost-Risk

Off-site exposure cost	$213,863
Off-site economic cost	$802,484
On-site exposure cost	$1,597
On-site cleanup cost	$50,284
Replacement power cost	$18,955
Total cost (per unit)	$1,087,183

This total represents the per unit monetary equivalent of the risk that could be eliminated if all risk associated with on-line internal event hazards (including internal floods) could be eliminated for LSCS. The internal events MACR is rounded to next highest thousand ($1,088,000) for SAMA calculations. It should be noted that the Phase II cost benefit calculations account for the difference between the rounded MACR and the actual MACR by adding the difference to the averted cost-risk calculated for each SAMA.

F.4.6.2 EXTERNAL EVENTS MAXIMUM AVERTED COST-RISK

The maximum averted cost-risk for external events must be quantified for the cost-benefit calculations; however, this cost-risk must be estimated based on information in the RMIEP (NRC 1992b, NRC 1993) and IPEEE analyses (CECo 1994) given that complete, current, external events models are not available for LSCS (with the exception of the interim fire model, which is discussed further in section F.5.1.6.1). An update of the fire model will be performed in the future and a seismic model update is in progress, but those models are not developed to the point where they can be used for quantitative or qualitative input to the SAMA analysis. As a result, an alternate method of accounting for the external events contributions must be established.

The method chosen to account for external events contributions in the SAMA analysis is to use a multiplier on the internal events results. In previous NRC-approved SAMA analyses, it has been assumed that the risk posed by external events and internal events is approximately equal. This assumption is not unreasonable unless available analyses indicate that there are external events contributors that present a disproportionate risk to the site. Based on the magnitude of the LSCS fire CDF relative to the internal events CDF, it was concluded that the development of an external events multiplier was warranted.

The external events multiplier is the ratio of the total CDF (including internal and external events) to only the internal events CDF. The lack of detailed analyses makes it difficult to establish a meaningful CDF for some event types; however, some assumptions can be made about the non-quantified initiator groups that can be used to develop a total external events CDF. Estimates for each of the non-screened external events hazards were developed for use in the calculation of the external events multiplier. Because the LSCS IPEEE essentially reproduces what was reported in the RMIEP analysis for external events, the RMIEP analysis was used as the source for most of the information used to establish CDFs for the non-screened external events contributors. The contributors included are seismic, fire, turbine generated missiles, accidental aircraft impact, high winds, transportation and nearby facility accidents, and external flooding. A description of the CDF used in the development of the external events multiplier is provided below.

Seismic CDF: The seismic model that was developed as part of the RMIEP analysis in 1993 estimated a seismic CDF of 6.0E-07/yr, which accounted for 20 different accident sequences over a range of six seismic intervals. The RMIEP model was not maintained with the internal events PRA and the development of the LSCS seismic PRA is not yet complete; therefore, the RMIEP analysis represent the latest official assessment of seismic risk for LSCS. While the LSCS seismic PRA has not been developed to a stage where CDF results are available to support the SAMA analysis, the seismic hazard curves are available. Because the RMIEP documentation provides sequence specific conditional core damage probabilities, it was possible to update the RMIEP seismic CDF using the current LSCS seismic hazard curves, as described in section F.5.1.6.2. While there are limitations associated with this process, it is considered to represent a reasonable approach to estimating how the RMEIP results would be impacted by current seismic hazard information. The "updated" RMIEP seismic CDF of 6.6E-07/yr is used to here to develop the external events multiplier.

Fire CDF: The latest available fire results are from the LSCS Revision 1 fire model (Exelon 2009). While this model was completed in 2009, it is considered to be an interim model because there are portions of the NUREG/CR-6850 methodology (EPRI 2005) that have not yet been implemented. For the purposes of establishing the LSCS SAMA external events multiplier, the Revision 1 fire model CDF of 9.41E-06/yr is used.

Turbine Generated Missiles: A bounding analysis was performed in RMIEP to assess the risk associated with turbine generated missiles. The mean CDF was estimated to be 9.50E-08/yr, which is used to establish LSCS SAMA external events multiplier.

Accidental Aircraft Impact: A bounding analysis was performed in RMIEP to assess the risk associated with accidental aircraft impact. A median CDF of 5.0E-07/yr is documented in the analysis, but a mean CDF is not explicitly provided. For the purposes of establishing the LSCS SAMA external events multiplier, the mean was assumed to be approximated by the median and a CDF of 5.0E-07/yr was used for this contributor.

High Wind Events: A bounding analysis was performed in RMIEP to assess the risk associated with high wind events. A median CDF of 3.0E-08/yr is documented in the analysis, but a mean CDF is not explicitly provided. For the purposes of establishing the LSCS SAMA external events multiplier, the mean was assumed to be approximated by the median and a CDF of 3.0E-08/yr was used for this contributor.

Transportation and Nearby Facility Accidents: A bounding analysis was performed in RMIEP to assess the risk associated with transportation and nearby facility accidents. The conclusion of the analysis was that these types of events are not significant contributors to plant risk and a CDF was not explicitly developed as part of the analysis. The implication is that while transportation and nearby facility accidents are relevant to the plant, they are negligible contributors to risk and do not need to be included in the external events CDF used to develop the external events multiplier. A more conservative approach is taken here, however, which is to assume the risk associated with transportation and nearby facility accidents is equal to that of the lowest quantified external event CDF (3.0E-08/yr for high wind events). For the purposes of establishing the LSCS SAMA external events multiplier, a CDF of 3.0E-08/yr was used for this contributor.

External Flooding: A bounding analysis was performed in RMIEP to assess the risk associated with external flooding events. The conclusion of the analysis was that these types of events are not significant contributors to plant risk and a CDF was not explicitly developed as part of the analysis. The implication is that while external flooding events are relevant to the plant, they are negligible contributors to risk and need not be included in the external events CDF used to develop the external events multiplier. A more conservative approach is taken here, however, which is to assume the risk associated with external flooding events is equal to that of the lowest quantified external event CDF (3.0E-08/yr for high wind events). For the purposes of establishing the LSCS SAMA external events multiplier, a CDF of 3.0E-08/yr was used for this contributor.

Using the CDF values described above, the external events (EE) contributions could be summarized as follows:

LSCS External Events CDF Summary (per year)

Fire	9.41E-06
Seismic	6.60E-07
Turbine Generated Missiles	9.50E-08
Accidental Aircraft Impact	5.00E-07
High Winds	3.00E-08
Transportation & Nearby Facility Accidents	3.00E-08
External Flooding	3.00E-08
Total EE CDF	**1.08E-05**

The External Events multiplier is the ratio of the total CDF (including internal and external events) to the internal events CDF. Using the total external events of 1.08E-05 from above and the Unit 2 internal events CDF of 2.58E-06, the External Events multiplier is:

EE Multiplier = (2.58E-06 + 1.08E-05) / 2.58E-06 = 5.2

F.4.6.3 LSCS MAXIMUM AVERTED COST-RISK

The total MACR can be obtained by multiplying the internal events cost-risk by the EE multiplier of 5.2:

Single Unit MACR = $1,088,000 * 5.2 = $5,657,600

Alternatively, as stated in Section F.4.6, the MACR can be represented by the internal and external events contributions:

Internal Events	=	$1,088,000
External Events	=	$4,569,600
Single Unit Maximum Averted Cost-Risk	=	$5,657,600

The MACR and implementation costs are considered on a per-unit scale for consistency (unless otherwise noted).

F.5 PHASE 1 SAMA ANALYSIS

The Phase 1 SAMA analysis, as discussed in Section F.1, includes the development of the initial SAMA list and a coarse screening process. This screening process eliminated those candidates that are not applicable to the plant's design or are too expensive to be cost-beneficial even if the risk of on-line operations were completely eliminated (i.e., the implementation costs exceed the MACR). The following subsections provide additional details of the Phase 1 process.

F.5.1 SAMA IDENTIFICATION

The initial list of SAMA candidates for LSCS was developed from a combination of resources. These include the following:

- LSCS PRA results and PRA Group Insights

- Industry Phase 2 SAMAs (based on a review of potentially cost-effective Phase 2 SAMAs from selected plants, as documented in section F.5.1.3)
- LSCS Individual Plant Examination IPE (ComEd 1994)
- LSCS IPEEE (ComEd 1997b)

These resources are judged to provide a list of potential plant changes that are most likely to reduce risk in a cost-effective manner for LSCS.

In addition to the "Industry Phase 2 SAMA" review identified above, an industry based SAMA list was used in a different way to aid in the development of the LSCS plant-specific SAMA list. While the industry Phase 2 SAMA review cited above was used to identify potential SAMAs from specific sites that might have been overlooked in the development of the LSCS SAMA list due to PRA modeling issues, a generic SAMA list was used to help identify the types of changes that could be used to address the areas of concern identified through the LSCS importance list review. For example, if Instrument Air (IA) availability was determined to be an important issue for LSCS, the industry list would be reviewed to determine if a plant enhancement had already been identified that would address LSCS's needs. If an appropriate SAMA was found to exist, it would be used in the LSCS list to address the IA issue; otherwise, a new SAMA would be developed that would meet the site's needs. This generic list was compiled as part of the development of multiple industry SAMA analyses and is available in NEI 05-01 (NEI 2005).

It should be noted that the process used to identify LSCS SAMA candidates focuses on plant-specific characteristics and is intended to address only those issues important to the site. An evaluation of the generic SAMAs in NEI 05-01, as they are written, provides little benefit because in most cases the systems are not exactly the same as those at LSCS. Without modifying the NEI 05-01 SAMAs to match the systems at LSCS, many would be screened as "not applicable". Further, the scopes of the generic SAMAs are not tailored to match the needs of a specific plant such, that the generic SAMAs may address only a fraction of the required functions. As a result, evaluation of the entire generic SAMA list would only be useful after each SAMA has been modified to address the plant specific risk profile. The processes used for LSCS were more efficient than evaluating the entire generic SAMA list as written.

F.5.1.1 LEVEL 1 LSCS IMPORTANCE LIST AND RISK CONTRIBUTOR REVIEW

The importance list review was performed to identify the failure scenarios most important to the LSCS risk profile and to develop methods to mitigate those scenarios. For each event on the importance list, the reasons for the event's importance are determined through sequence/cutset and systems analysis. Strategies to mitigate the relevant failures are developed based on accident sequence review, plant knowledge, and industry insights. For LSCS, importance lists were developed and reviewed for the internal events model. For the fire model, the top contributing fire zone results were reviewed to identify SAMAs.

The importance list itself was developed from the LSCS PRA cutsets and comprises the model's basic events sorted according to their risk reduction worth (RRW) values. The events with the largest RRW values in this list are those events that would provide the greatest reduction in the CDF if the failure probability were set to zero. Because a PRA's importance list can be extensive, it is desirable to limit the review to only those contributors that could yield potentially cost-beneficial results.

One method that can be used to limit the scope of the importance list review is to correlate the RRW value threshold to the lowest expected cost of implementation for a SAMA. Usually, operator action modifications in the form of procedure changes are among the least expensive enhancements that can be made at a site, so they have often been used as the representative "lowest cost SAMA". However, because the cost of performing a procedure change can vary by orders of magnitude depending on the scope of the change and the procedure that is being changed, this does not provide a clear basis for a review threshold. In addition, the use of this type of a threshold can lead to a review process that is beyond the scope of what is described in NEI 05-01 (NEI 2005).

The NEI 05-01 guidance describes the SAMA identification process in Section 5.1 as a process to "identify plant-specific SAMA candidates by reviewing dominant risk contributors (to both CDF and population dose) in the Level 1 and Level 2 Probabilistic Safety Assessment (PSA) models." Section 5.1 indicates that the definition of the dominant contributors is open to interpretation, but the guidance does not imply that the identification process should represent an exhaustive search for all plant enhancements that could be cost-beneficial. For example, some minor plant procedure changes could be very inexpensive, but the SAMA identification process should not be defined as one that requires a review all events that could yield averted cost-risks that are greater than the cost of such a procedure change.

Because there is not a universal definition for "dominant risk contributors", an attempt has been made in this analysis to characterize "dominant contributors" and to establish a review threshold that can reasonably be considered to address them.

The ASME/ANS PRA Standard (ASME 2009) includes a definition of "significant" contributors to risk, but it is described in quantitative terms related to the percentages of risk represented, and the guidance does not provide many qualitative insights about the nature of "significant contributors". In general, the term "dominant" suggests something that is ruling, governing, or in a commanding position, which does not appear to be consistent with a "risk significant" basic event or accident sequence. For example, a risk significant basic event is one with a Fussell-Vesely (FV) value of 0.005 or greater, which corresponds to an event that would reduce the CDF by 0.5% if it were made completely reliable. Events contributing only 0.5% to the CDF could not reasonably be described as "governing" or "ruling" the risk profile.

For the SAMA analysis, the threshold of a dominant basic event is considered to be a factor of 10 larger than for a risk significant event. Similarly, the threshold for a dominant individual accident sequence is considered to be an order of magnitude large than the value of 1% defined in the ASME/ANS PRA Standard for risk significant accident sequences. The definitions of the "dominant" basic events and accident sequences are assumed to be:

- Dominant Basic Events are those events with FV values greater than or equal to 0.05 (or Risk Reduction Worth values of about 1.05 or greater) for the relevant figure of merit (e.g., CDF).
- Dominant Individual Accident Sequences are those which contribute 10 percent or more to the relevant figure of merit (e.g., CDF).

A complicating factor is that the level of detail and maturity of the risk assessments for different hazard groups are not necessarily consistent. In order to address this issue, the review thresholds are applied to the individual contributors rather than to the overall CDF.

For the internal events analysis, there are about 50 events with RRW values greater than 1.05, and these are considered to represent the dominant basic events for LSCS. However, events with RRW values of 1.01 or greater were reviewed as part of the analysis and the results have been included to make the review more robust. Table F.5-1a documents the disposition of each basic event in the Level 1 internal events model with an RRW value of 1.01 or greater. When the impact on external events is considered, this corresponds to an event that would reduce the cost-risk by about $56,000 if it were made completely reliable. Viewed from another perspective, a RRW value of 1.01 corresponds to a CDF reduction of about 1% assuming the basic event failure probability were set to zero. For a nominal 2.58E-6 /yr CDF from internal events, this corresponds to a potential CDF reduction of about 3E-8 /yr. Such a change in CDF is well below the widely accepted threshold in Region III of Figure 4 in Regulatory Guide 1.174 (USNRC 2011) of what constitutes a "very small change" (less than 1E-6 /yr).

The review of the fire model was performed on a fire zone level due to the similarity in the impact of the fires and the potential means that might be available to mitigate them. The fire CDF, based on the current LSCS Fire PRA (Exelon 2009), is 9.41E-06. If fire zones are equated to accident sequences, it would be necessary to review all fire zones with CDFs of 9.41E-07 or greater. This approach would include two fire zones from each unit. However, because fire zones and accident sequences are not equivalent, the review threshold has been reduced by a factor of two in order to capture a larger portion of the LSCS fire contributors (i.e., all fire zones contributing 5% or more to the fire CDF). If it is assumed that the ratio of internal events cost-risk to internal events CDF is equal to the ratio of fire cost-risk to fire CDF, the fire zone review threshold would correspond to about $198,000. The next largest un-reviewed fire zone is Unit 1 Zone 2F-2 at 3.36E-07/yr, which corresponds to a potential averted cost-risk of about $142,000.

For LSCS, the seismic risk is concentrated in a relatively few number of sequences. Over 88% of the risk is associated with the three accident sequences that meet the definition of a dominant accident sequence. However, because the RMIEP documentation includes a description of the Small-LOCA-3 accident sequence (5.6% of the updated seismic CDF), this sequence was included in the SAMA identification process due to ease of review. The next largest un-reviewed seismic accident sequence is Small-LOCA-4 at 2.50E-8/yr, which corresponds to a potential averted cost-risk of about $11,000.

The remaining external events contributors, such as high winds, were treated with bounding analyses in the RMIEP evaluation and limited information was available related to specific risk contributors for these types of events. The RMIEP documentation was reviewed to identify any SAMAs could reduce the risk associated with these events, as documented in sections F.5.1.6.3 through F.5.1.6.7.

F.5.1.2 LEVEL 2 LSCS IMPORTANCE LIST REVIEW

The review of the Level 2 importance listings was performed in a manner similar to that which was performed for the Level 1 importance list. In this case, three separate Level 2 importance lists were developed. The reviews were performed on composite importance files for the following release categories:

- High (H/E-BOC, H/E, H/I)
- Medium Early (ME)
- Medium Intermediate (MI)

These groupings were developed to prevent high frequency-low consequence events (i.e., the L/E release category) from biasing the importance lists. The release categories included in the review account for over 97 percent of the dose-risk while accounting for only about 55 percent of the Level 2 frequency. Exclusion of the other results from the Level 2 review allows the contributors that are most important to dose-risk and cost-risk to rise to the top of the importance lists.

For the importance groups defined above, the number of "dominant" basic events (RRW > 1.05) ranges from about 45 to 60 events. While a review of this group of events is considered to meet the intent of NEI 05-01, the review was expanded to include all events with RRW values of 1.03 or greater. If a basic event had and RRW value of just under 1.03 on the Level 1 importance list and all three Level 2 importance lists, the potential averted cost-risk associated with the event would be about $165,000 when the external events multiplier is applied.

None of the external events models are linked to the Level 2 model; therefore, it was not possible to perform a Level 2 importance review for the external events hazards.

Tables F.5-2a, F.5-2b, and F.5-2c document the disposition of each basic event in the Level 2 RRW lists with RRW values greater than 1.03.

F.5.1.3 INDUSTRY SAMA REVIEW

The SAMA identification process for LSCS is primarily based on the PRA importance listings, the IPE, and the IPEEE. Use of these sources should identify the types of changes that would most likely be potentially cost-beneficial for LSCS; however, a review of those SAMAs determined to be cost-beneficial for similar plants could capture potentially important changes not identified for LSCS due to PRA modeling differences or because an alternate approach was developed to mitigate a similar risk. Therefore, in addition to the plant-specific review, selected industry SAMA submittals and the NRC's associated Generic Environmental Impact Statement (NUREG-1437) supplement documents were reviewed to identify any SAMA candidates that were determined to be potentially cost-beneficial. These SAMAs were further analyzed and included in the LSCS SAMA list if they were considered to address potential risks not identified by the LSCS importance list review.

The following six BWRs were used as the sources for the SAMAs:

- Susquehanna Steam Electric Station (PPL 2006, NRC 2009)
- Cooper Nuclear Station (NPPD 2008, NRC 2010a)
- Duane Arnold Energy Center (FPL 2008, NRC 2010b)
- Nine Mile Point, Unit 2 (CEG 2004, NRC 2006)
- Columbia Generating Station (ENW 2010, NRC 2012a)
- Grand Gulf Nuclear Station (Entergy 2011, NRC 2013a)

The cost-beneficial SAMAs from each of these sites are reviewed in the following subsections.

F.5.1.3.1 Susquehanna Steam Electric Station (SSES)

Susquehanna identified two SAMAs in the baseline analysis that were determined to be potentially cost-beneficial and three additional SAMAs were identified as potentially cost-beneficial in the 95th percentile PRA results sensitivity analysis.

Review of Susquehanna Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
2a	Improve Cross-Tie Capability Between 4kV AC Emergency Buses (A-D, B-C)	SSES did not credit cross-tie between EDG trains and relied on the swing EDG to mitigate EDG failures. For LSCS, the bus configuration is not the same. Division I and II inter-unit cross-ties are available as well as power alignments between the ESF and non-ESF 4kV buses in the same division, but a potential improvement would be to provide an inter-division cross-tie capability (e.g., 241Y to 242Y) (SAMA 24). Division III power failures are relatively small contributors to risk and providing the additional capability of a division III inter-unit cross-tie would not be cost beneficial.	Added to SAMA list (SAMA 24).

Review of Susquehanna Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
6	Procure Spare 480V AC Portable Station Generator	This SAMA is not applicable to a plant without an existing 480V AC generator, but a SAMA to improve the availability of 480V AC power was developed for LSCS based on the review of the PRA results (SAMA 8). Installation of a 480V AC generator will mitigate most of the risk associated with the unavailability of 480V AC power.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.
2b	Improve Cross-Tie Capability Between 4kV AC Emergency Buses (A-BC-D)	This SAMA is an enhancement over SSES SAMA 2a and allows cross-tie between any EDG division. For LSCS, the bus configuration is not the same. Inter-unit cross-ties are available as well as power alignments between the ESF and non-ESF 4kV buses in the same division, but a potential improvement would be to provide an inter-division cross-tie capability (e.g., 241Y to 242Y) (SAMA 24).	Added to SAMA list (SAMA 24).
3	Proceduralize Staggered RPV Depressurization When Fire Protection System Injection is the Only Available Makeup Source	This SAMA is specific to the SSES site and is based on the need to split flow from a single injection system between units. The same type of fire protection system flow limitations do not exist for LSCS and this SAMA is not applicable to the LSCS design.	Not required on SAMA list.
5	Auto Align 480V AC Portable Station Generator	This SAMA is not applicable to a plant without an existing 480V AC generator, but a SAMA to improve the availability of 480V AC power was developed for LSCS based on the review of the PRA results (SAMA 8). Installation of a 480V AC generator will mitigate most of the risk associated with the unavailability of 480V AC power.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.

F.5.1.3.2 Cooper Nuclear Station

Cooper identified eight SAMAs in the baseline analysis that were determined to be potentially cost-beneficial, and three additional SAMAs were identified as potentially cost-beneficial in the 95th percentile PRA results sensitivity analysis.

Review of Cooper Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
14	Portable generator for DC power to supply the individual panels.	This SAMA was designed to allow High Pressure Coolant Injection operation after battery depletion. A simialr SAMA was developed for LSCS to address RCIC and SRV operation (SAMA 14).	Already included.
25	Revise procedure to allow bypass of RCIC turbine exhaust pressure trip	Allows RCIC to operate when suppression pool pressures are high enough to trip the RCIC turbine on high turbine exhaust pressure. The LSCS backpressure trip is relatively high and is not limiting for the current configuration. The backpressure trip could be bypassed in conjunction with modification of procedures to manage HCTL issues, but this would be used in post battery depletion periods in SBO scenarios where it would be required to controling RCIC without DC power. A more reliable means of mitigating long term SBOs is considered to be fire protection injection via SAMAs 1 and 8 (which would also provide instrumentation power). This SAMA is addressed by other means for LSCS.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.
78	Improve training on alternate injection via FPS	The intent of this SAMA is to improve the reliability of the operator action to align alternate injection with the fire protection system, but the SAMA does not identify what problems exist with the current training program, what credible changes could be made to measurably improve reliability, or how any such changes would impact the HRA assessment. SAMA 18 was developed for LSCS based on an assessment of the PRA results and the existing fire protection injection capabilities.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.
30	Revise procedures to allow manual alignment of the fire water system to RHR heat exchangers	This SAMA was designed to mitigate loss of SW cooling to the RHR heat exchangers. Loss of cooling to the RHR heat exchangers can occur at LSCS, but the important contributors are related to loss of room cooling for the Core Standby Cooling System vaults. For LSCS, a lower cost alternative that addresses these failures is considered to be SAMA 16.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.

Review of Cooper Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
68	Proceduralize the ability to cross connect the circulating water pumps and the service water going to the TEC heat exchangers	This SAMA is designed to provide an alternate cooling medium to the closed loop cooling system that cools the turbine building loads for Cooper. For LSCS, the service water system ultimately provides cooling to the turbine building closed loop cooling system. Service water does have an existing cross-tie to the fire protection system, but its intent is for service water to serve as an alternate supply to the fire protection system and there are check valves installed to prevent flow from the fire protection system to the service water system. This SAMA is not applicable to LSCS because it is not possible to provide an alternate water supply to the turbine building closed loop cooling system with only a procedure change (hardware changes would also be necessary).	Not required on SAMA list.
33	Create ability for emergency connection of existing or new water sources to feedwater and condensate systems.	This SAMA appears to be aimed at providing a long term supply of water to FW/Condensate. LSCS currently has the capability to provide makeup to the CST via several methods (e.g., using the fire protection system), which ultimatley supports hotwell makeup for FW/Condensate. This SAMA is considered to already be implemented at LSCS.	Not required on SAMA list.
40	Operator procedure revisions to provide additional space cooling to the EDG room via the use of portable equipment	For LSCS, the primary causes of room cooling failures for the EDGs are related to the loss of the room cooling for the EDG cooling water pumps. A similar SAMA was developed for LSCS to address these failures (SAMA 16).	Already included.
45	Provide an alternate means of supplying the instrument air header	This SAMA is intended to improve the reliability of the Instrument Air system by providing an alternate supply to the system header. LSCS has a trailer mounted air compressor that can be used to supply the instrument air system and this SAMA is considered to already be implemented at LSCS.	Not required on SAMA list.
64	Proceduralize the use of a fire pumper truck to pressurize the fire water system	Fire water reliability can be enhanced by proceduralizing the use of a fire truck to pressurize the fire water header. LSCS already has a procedure for this capability and this SAMA is considered to already be implemented at LSCS.	Not required on SAMA list.

Review of Cooper Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
75	Generation Risk Assessment implementation into plant activities	The intent of this SAMA appears to be the incorporation of risk management tools into work planning practices. This is already performed at LSCS.	Not required on SAMA list.
79	Modify procedures to allow use of the RHRSW system without a SWBP	Not applicable to LSCS; the service water system already operates without booster pumps for system cooling.	Not required on SAMA list.

F.5.1.3.3 Duane Arnold Energy Center

Duane Arnold identified two SAMAs in the baseline analysis that were determined to be potentially cost-beneficial and one additional SAMA was identified as potentially cost-beneficial in the uncertainty analysis.

Review of Duane Arnold Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
117	Increase boron concentration or enrichment in the standby liquid control system.	The LSCS design already uses an enriched boron solution that allows operation of a single standby liquid control pump to meet the requirements of 10CFR50.62. Further enriching the boron solution could potentially increase the time available to inject boron, but this would have a minimal impact on risk. Level control and boron injection are both required to limit the heat load to containment in ATWS events and the cues are essentially the same for both actions (very high dependence between actions). Providing margin for boron injection initiaton would not provide significant benefit if level control is delayed because the early heat load to the containment would be higher. Other SAMAs related to ATWS mitigation have been identified that are considered to be more effective means of reducing the risk of these scenarios (e.g. SAMAs 4 and 5) and further enriching boron is not suggested as a SAMA for LSCS.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.
156	Provide an alternate source of	This SAMA addresses clogging of flow to the RHRSW/ESW pump intake area. This was	Not required on SAMA list.

Review of Duane Arnold Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
	water for the RHRSW/ESW pit.	addressed at DAEC by assuming that a cross connect could be added to allow communication between the Circ Water and RHRSW/ESW pits. LSCS has a bypass line around the normal intake route to ensure that a continuous water supply is available to the water tunnel should the travelling screens become blocked. The bypass line is considered to meet the intent of this SAMA and this SAMA is considered to already be implemented for LSCS.	
166	Increase the reliability of the low pressure ECCS RPV low pressure permissive circuitry. Install manual bypass of low pressure permissive	The intent of this SAMA is to reduce the probability that low pressure injection will be failed by the low pressure permissive sensors or logic. The low pressure permissive is modeled for LSCS, but it is not a risk significant contributor and this type of enhancement would not be cost-beneficial for LSCS.	Not required on SAMA list.

F.5.1.3.4 Nine Mile Point, Unit 2

Review of Nine Mile Point, Unit 2 Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
U2-23a	Provide redundant ventilation for residual heat removal (RHR) pump rooms	A similar SAMA was developed based on the review of the LSCS PRA results (SAMA 16).	Already included.
U2-23b	Provide redundant ventilation for high pressure core spray (HPCS) pump room	For LSCS, the HPCS room cooling function is not risk significant, but SAMA 16 could also be used for alternate HPCS room cooling, if required.	Already included.
U2-23c	Provide redundant ventilation for reactor core isolation cooling (RCIC) pump room	For LSCS, RCIC does not require room cooling for the 24 hour mission time and this SAMA would not be a cost-beneficial change.	Not required on SAMA list.

Review of Nine Mile Point, Unit 2 Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
U2-213	Enhance loss of service water procedure	For NMP-2, the loss of service water is related to the loss of room cooling for the RHR, HPCS, and RCIC systems and actions to perform alternate room cooling alignments were expected to be integrated with the loss of service water procedure. LSCS SAMA 16 is considered to include the development of any procedure links required to use the equipment. The other issue for NMP-2 appears to be related to enhancing loss of SW procedure so that it addresses the dominate failures identified in the PRA. The LSCS service water system design is different than for NMP-2 and the loss of service water initiating event is below the SAMA review threshold. No additional SAMAs are considered to be required to address loss of service water at LSCS.	Already included.
U2-214	Enhance Station Blackout procedures	This SAMA was developed for NMP-2 to address plant specific procedure deficiencies for certain plant configurations, which at the time of the analysis, were addressed by compensatory measures. This is not expected to be applicable to the LSCS electric power configuration. In addition, LSCS constantly assesses and improves plant procedures as part of normal operations and the general intent of this SAMA is considered to be met for LSCS.	Not required on SAMA list.
U2-215	Use of a portable charger for the batteries	A similar SAMA was developed based on the review of the LSCS PRA results (SAMA 8).	Already included.
U2-216	Hard pipe diesel fire pump to the reactor pressure vessel	A similar SAMA was developed based on the review of the LSCS PRA results (SAMA 18). For LSCS, a hard pipe connection is suggested apart from a short, flexible connecting hose to help maintain a separation between the RCS inventory and the lake water in the fire protection system.	Already included.
U2-221a	Reduce unit cooler contribution to emergency diesel generator (EDG) unavailability by increasing the testing frequency	The DG cooling water pumps and fans have high availability and availability is managed through the work control and maintenance rule programs. No opportunities for improvement in availability were identified in either the test frequencies or maintenance practices.	Not required on SAMA list.

Review of Nine Mile Point, Unit 2 Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
U2-221b	Reduce unit cooler contribution to EDG unavailability by providing redundant means of cooling	The redundant means of cooling represented by this SAMA is to open the EDG control panel room doors. For LSCS, the primary causes of room cooling failures for the EDGs are related to the loss of the room cooling for the EDG cooling water pumps. A similar SAMA was developed for LSCS to address these failures (SAMA 16).	Already included.
U2-222	Improve procedure for loss of instrument air	For NMP-2, the suggested loss of IA procedure enhancements would help maintain feedwater by including steps to isolate the min flow lines back to the condenser. For LSCS, the loss of instrument air procedure already includes the steps to isolate the min flow lines.	Not required on SAMA list.
U2-223	Improve control building flooding scenarios	The NMP-2 SAMA does not provide specific procedure enhancements and includes only general suggestions to move a firewater header or to install doors that would prevent water accumulation. For LSCS, the significant flooding contributors are addressed in the importance list review and SAMAs were developed to address these events (e.g., SAMAs 9 and 11).	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.

F.5.1.3.5 Columbia Generating Station

Review of Columbia Generating Station Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
AC/DC-28	Reduce common cause failures (CCFs) between EDG-3 and EDG-1/2	The description of the Columbia SAMA is to reduce CCF by providing separate fuel supplies, separate maintenance crews, and diverse instrumentation. For LSCS, EDG CCF events are below the review threshold and the EDGs already have some elements of the Columbia SAMA, including separate instrumentation panels and EDG specific fuel tanks/fuel transfer systems. Because the EDGs are otherwise of the same design, efforts to further differentiate the EDGs would not provide a sufficient basis for excluding or reducing the CCF probabilities and no measurable benefit would be expected from this SAMA.	Not required on SAMA list.

Review of Columbia Generating Station Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
CC-03b	Raise RCIC backpressure trip set points	Allows RCIC to operate when suppression pool pressures are high enough to trip the RCIC turbine on high turbine exhaust pressure. The LSCS backpressure trip is relatively high and is not limiting for the current configuration. The backpressure trip could be bypassed in conjunction with modification of precedures to manage HCTL issues, but this would be used in post battery depletion periods in SBO scenarios where it would be required to controling RCIC without DC power. A more reliable means of mitigating long term SBOs is considered to be fire protection injection via SAMAs 1 and 8 (which would also provide instrumentation power). Thus, this SAMA is addressed by other means for LSCS.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.
FR-07a	Improve the fire resistance of critical cables for containment venting	The reliable hard pipe containment vent (SAMA 1) will allow LSCS to vent without support systems and is considered to address the intent of this SAMA.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.
FR-07b	Improve the fire resistance of critical cables for transformer E-TR-S	The equivalent transformer for LSCS may be the Unit SATs, which are failed in some essential switchgear room fires. In most cases, one or more diesel generators from the same unit would be available to provide power, which could be accomplished by allowing inter-division cross-tie. While it may be possible to protect the cables associated with the Unit SATs, a lower cost approach to providing power is considered to be through the implementation of inter-division 4kV AC cross-ties, which was identified in the internal events review.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.
FR-08	Improve the fire resistance of cables to RHR and standby SW	For LSCS, many of the dominant fires that impact RHR are those for which failure of the ignition source fails RHR. In such cases, there is no opportunity to protect the RHR system through the use of fire barriers or cable wrap. For the remaining cases, implementation of SAMA 1 will provide a viable containment heat removal path and the risk of those fires will be reduced such that further reductions are not expected to be cost-beneficial.	Not required on SAMA list.

Review of Columbia Generating Station Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
HV-02	Provide redundant train or means of ventilation	This SAMA is for alternate switchgear room cooling. For LSCS, switchgear room cooling is not required and this SAMA would not provide any benefit.	Not required on SAMA list.
SR-05R	Improve seismic ruggedness of MCC-7F and MCC-8F	The only seismically induced failure identified as significant for LSCS was failure of the CST (which has been addressed by other changes). Improving the seismic ruggedness of LSCS motor control centers (MCCs) would not provide any significant benefit.	Not required on SAMA list.
FL-05R	Clamp on flow instruments to certain drain lines in the control building of the radwaste building and alarm in the control room	The LSCS PRA results review included an assessment of the important flood scenarios and flood detection is available for these scenarios based on sump alarms and fire protection system actuation alarms. The addition of alarms on the building drains would not provide any significant new information or advantage in these cases. The next largest flood scenario has an RRW value of 1.003 and the response time is over 40 hours. The addition of flow instrumentation on building drains would have no measurable impact on plant risk and would not be cost-beneficial enhancement.	Not required on SAMA list.
FL-04R	Add one isolation valve in the SW, turbine SW, and fire protection lines in the control building area of the radwaste building	The LSCS PRA results review included an assessment of the important flood scenarios and remote flood isolation capability exists for these contributors, but procedures are not currently available to direct the use of these other isolation points. LSCS SAMA 9 was developed to address this issue and no additional SAMAs are required.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.

Review of Columbia Generating Station Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
FL-06R	Additional nondestructive evaluation (NDE) and inspections (in the control building)	For LSCS, the significant flooding events are related to fire protection system breaks in the reactor building rather than in the control building. Performing inspections of the fire protection piping in the reactor building is more difficult and costly than in the proposed SAMA because for LSCS, a large portion of the inspections would have to be performed in high radiation areas. The internal events review identified procedure enhancements that could address the fire protection flooding risk that are considered to be lower cost alternatives than an enhanced inspection program (SAMAs 9). In addition, a separate SAMA was developed to install fire protection pump kill switches in the MCR that would also reduce the risk of the fire protection system breaks (SAMA 11). For LSCS, these SAMAs are more appropriate and the Columbia SAMA is not considered to require further evaluation.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.
CC-24R	Backfeed the HPCS system with SM-8 to provide a third power source for HPCS	For LSCS, the HPCS system can be powered from the SAT or the dedicated EDG, but procedures are not available for inter-divisional cross-ties (e.g., bus 242Y to 243). Added to the LSCS SAMA list.	Added to SAMA list (SAMA 24).
CC-25R	Enhance alternate injection reliability by including RHR, SW and fire water cross-tie in the maintenance program	For LSCS, this is considered to be implemented. There are no proceduralized RHR cross-ties, but the valves that would be used to cross-tie pump suction paths are already in the maintenance rule program. For service water and fire water, there is a cross-tie between the systems and this function is included in the maintenance rule program. The fire protection system cross-tie to feedwater is also included in the maintenance rule program.	Not required on SAMA list.

Review of Columbia Generating Station Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
OT-07R	Increase operator training on systems and operator actions determined to be important from the Probabilistic Safety Assessment	Important HFEs are currently communicated to LSCS Operations and consideration is given to improving the response to those actions. Additionally, LSCS has an "Operator Response Time Program, which outlines a process to track and validate time limited actions in the design basis analyses and the PRA. These actions are validated with respect to the time required to implement them, but not necessarily given additional training and simulator practice. The quantitative benefits associated with improving training in HRA are subjective and reliability improvements are generally limited to cases where training can be provide for actions that are not currently practiced. The HFEs important to LSCS risk were reviewed to determine if there were any actions for which limited training was performed. Two HFE were identified where some risk reduction may be possible: 1) Controlling containment venting within the proceduralized pressure band, and 2) Initiating containment venting with the 2" vent/purge line to maintain pressure below the Hi DW pressure setpoint. Item 1 will be addressed by implementation of SAMA 1 and no additional SAMA is required. Some benefit could potentially be gained by including training specific to the water hammer scenario into Licensed Operator Cycle Training Plans to maintain operator proficiency in the relevant scenarios; however, recent operating experience indicates that use of the 2-inch vent purge line alone is not sufficient to prevent the high DW pressure signal and that additional steps will be required as part of the mitigation strategy. A SAMA has been added to address this training enhancement.	Added to SAMA list (SAMA 25).
FW-05R	Examine the potential for operators to control reactor feedwater (RFW) and avoid a reactor Trip	For LSCS, the transient initiating event frequencies are based on plant specific and industry data such that potential improvements to the operators' ability to control FW would not directly be reflected in the risk assessment and the benefit of such an improvement cannot be estimated reliably. No control issues have been identified for LSCS and this SAMA is not considered to be required.	Not required on SAMA list.

Review of Columbia Generating Station Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
OT-09R	For the non-Loss of Coolant Accident initiating events, credit the Z (power conversion system recovery) function	This appears to be a PRA model enhancement rather than a plant enhancement. The power conversion system is modeled and credited in the LSCS model. Not relevant.	Not required on SAMA list.
FR-11R	Install early fire detection in the following analysis units: RC-02, RC-03, RC-04, RC-05, RC-07, RC-08, RC-11, RC-13, RC-14, and RC-1A	For the LSCS fire contributors, other SAMAs have been identified that address the consequences of the fires and the risk is considered to be addressed by those SAMAs. Fire detection equipment is available in each of these areas. The reliability of early detection systems has not been established and these types of changes are not recommended as SAMAs.	Functional Equivalent Already Included on the SAMA list; Industry SAMA not added.

F.5.1.3.6 Grand Gulf

Review of Indian Point U2 Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
39	Change procedure to cross tie open cycle cooling system to enhance containment spray system.	It is not clear from the Grand Gulf SAMA analysis whether the intent of this SAMA is to cross-tie an open cycle system to RHR in order to supply the containment spray header, or to provide the RHR heat exchangers with an alternate cooling supply. For the LSCS RHR system, there are already proceduralized means of supplying the containment spray header from alternate sources (e.g., the fire protection system) and this function is already implemented. There are no existing connections between open cycle systems and the RHR SW side of the RHR heat exchanges that could be used to provide alternate cooling to the RHR system. A procedure change to allow this function is, therefore, not applicable to the LSCS design.	Not required on SAMA list.

Review of Indian Point U2 Potentially Cost-beneficial SAMAs

Industry Site SAMA ID	SAMA Description	Discussion for LSCS	Disposition for LSCS SAMA List
42	Enhance procedures to refill condensate storage tank from demineralized water or service water system	LSCS has the capability (with procedures) to provide makeup to the CST with fire water, but the capability is not currently credited in the PRA. Additional enhancements to provide other CST makeup capabilities would provide a negligible benefit for LSCS.	Not required on SAMA list.
59	Increase operator training for alternating operation of the low pressure emergency core cooling system pumps (low-pressure coolant injection and low pressure core spray) for loss of standby service water scenarios	For LSCS, the low pressure ECCS pumps are cooled by the Core Standby Cooling System and Equipment Cooling System. Rather than cycling large pumps in scenarios where the cooling system is lost, a more effective means of maintaining injection with the ECCS pumps is considered to be through the use of portable/temporary cooling alignment, which is addressed in the LSCS importance list review by SAMA 16.	Not required on SAMA list.
Un-numbered	Revise procedures to direct the operator monitoring a running diesel generator to ensure that the ventilation system is running or take action to open doors or use portable fans	The failure of diesel generator room cooling fans and dampers are not risk significant contributors for LSCS.	Not required on SAMA list.

F.5.1.3.7 Industry SAMA Identification Summary

The important issues for LSCS are generally considered to be addressed by the SAMAs developed through the PRA importance list review. The plant changes suggested as part of that review were developed to meet the specific needs of the plant, such that those SAMAs are more likely to provide effective means of risk reduction than SAMAs taken from other sites. However, effort was made to review other industry SAMA analyses to determine if other sites identified plant changes that could be potentially cost-beneficial for LSCS based on modeling differences or other factors. For LSCS, the industry review identified two (2) unique plant enhancements that have been included in the Phase 1 SAMA list for consideration:

- Provide Inter Division 4kV AC Cross-Tie Capability (SAMA 24)

- Periodic Training on Water Hammer Scenarios Resulting from a False LOCA Signal (SAMA 25)

F.5.1.4 LSCS IPE PLANT IMPROVEMENT REVIEW

The LSCS IPE/IPEEE submittal (CECo 1994), which is based on the RMIEP analysis, did not document a definitive list of proposed plant enhancements. Instead, there are references to lists of generic IPE insights and accident management insights from the Dresden and Quad Cities IPEs. The discussion indicates that over 218 IPE and Accident Management insights were developed that were potentially applicable to LSCS, and that they were evaluated by the review team and the BWR Owners' Group; however, these insights are not specifically provided. There is no indication that any of these generic insights had the potential to significantly impact plant risk and they are not pursued further as part of the SAMA analysis.

F.5.1.5 LSCS IPEEE PLANT IMPROVEMENT REVIEW

As described in Section F.5.1.4, the IPE/IPEEE document did not provide a definitive list of potential plant improvements for LSCS; however, the IPEEE Safety Evaluation Report does state that the RMIEP fire analysis identified two potential areas for plant improvement in addition to the Accident Management insights described in section F.5.1.4. While not listed in the IPE/IPEEE, these changes are considered to be potential plant improvements related to external events and they have been reviewed as part of the SAMA analysis.

The following table summarizes the status of the potential plant enhancements resulting from the IPEEE processes and the treatment of each in the SAMA analysis.

Status of IPEEE Plant Enhancements

Description of Potential Enhancement	Status of Implementation	Disposition
Put tops on the MCR electrical panels to reduce the potential for spread of fire to the overhead cables.	Not implemented.	Current industry guidance requires cabinets to be completely and robustly sealed in order for the configuration to preclude propagation and damage to overhead cables. In its original form, the proposed enhancement to install tops on the MCR cabinets, which also have ventilation on the sides, would not have a measurable impact on fire risk and would not be cost-beneficial for LSCS. In addition, the other SAMAs have been identified to address MCR fire risk, as described in section F.5.1.6.1.2. Screened from further review.

Status of IPEEE Plant Enhancements

Description of Potential Enhancement	Status of Implementation	Disposition
Institute a program to inspect the penetration seals at the top of the switchgear panels to minimize the potential that switchgear fires might damage the overhead cables.	Not implemented.	Current industry guidance requires cabinets to be completely and robustly sealed in order for the configuration to preclude propagation and damage to overhead and nearby "targets". The proposed inspection plan from RMEIP for these ventilated cabinets would not have a measurable impact on fire risk and would not be cost-beneficial for LSCS. In addition, the installation of the reliable hard pipe vent (SAMA 1) will mitigate about 70% of the fire risk in the switchgear rooms, as describe in section F.5.1.6.1.1. Screened from further review.

The plant changes identified in the IPEEE Safety Evaluation Report would not have a measurable impact on LSCS fire risk and are not considered further in this analysis.

F.5.1.6 EXTERNAL EVENTS IN THE LSCS SAMA ANALYSIS

The LSCS IPEEE (CECo 1994) was the result of a review of the NRC's "Risk Methods Integration and Evaluation Program" (RMIEP) (NRC 1992b, NRC 1993). Section 7.4 of the LSCS IPEEE summarizes the external events that were considered in the analysis, which were: Aircraft Impact, Avalanche, Biological Events, Coastal Erosion, Drought, External Flooding, Extreme Winds and Tornadoes, Fog, Forest Fire, Frost, Hail, High Tide, High Lake Level or High River Stage, High Summer Temperature, Hurricane, Ice Cover, Industrial or Military Facility Accident, Internal Flooding, Landslides, Lightning, Low Lake or River Water Level, Low Winter Temperatures, Meteorite, Pipeline Accident, Intense Precipitation, Release of Chemicals in Onsite Storage, River Diversion, Sandstorm, Seiche, Seismic Activity, Snow, Soil Shrink-Swell or Consolidation, Storm Surge, Transportation Accidents, Tsunami, Toxic Gas, Turbine Generated Missiles, Volcanic Activity, and Waves.

These potential contributors were evaluated using a multi stage approach, which consisted of initial screening, bounding analysis, and detailed analysis. The RMIEP analysis indicated that the screening criteria were designed to minimize the possibility of omitting risk significant contributors while reducing the amount of detailed analysis to manageable proportions. The high level set of screening criteria that were uses are as follows:

An external event was excluded if:

- It was an event for which the plant was designed,
- The event had a significantly lower mean frequency of occurrence than other events with similar uncertainties and could result in worse consequences than those events.
- The event could not occur close enough to the plant to affect it.
- The event was included in the definition of another event.

Aside from the events for which detailed analyses had already been determine to be required (seismic, fire, and internal flooding), the following events were identified for a more detailed assessment after the initial screening process was completed:

- Military and Industrial Facilities Accidents,
- Pipeline Accidents,
- Release of Chemicals in Onsite Storage,
- Aircraft Impact,
- External Flooding,
- Transportation Accidents,
- Turbine Missiles,
- Winds and Tornadoes.

The LSCS IPEEE indicates that additional information from the LSCS Final Safety Analysis Report was used to eliminate Military and Industrial Facilities Accidents, Pipeline Accidents, and Release of Chemicals in Onsite Storage.

A probabilistic analysis was performed for the remaining five event types in addition to the fire, seismic, and internal flooding events. Apart from internal flooding, which is integrated in the current LSCS PRA model, a review of the risks associated with these event types was performed in the following subsections as part of the SAMA identification process:

- Internal Fires (Section F.5.1.6.1)
- Seismic Events (Section F.5.1.6.2)
- Winds and Tornadoes (Section F.5.1.6.3)
- Turbine Missiles (Section F.5.1.6.4)
- Transportation and Nearby Facility Accidents (Section F.5.1.6.5)
- External Floods (Section F.5.1.6.6)
- Aircraft Impact (Section F.5.1.6.7)

The external event types that were not evaluated with a probabilistic assessment in the IPEEE for LSCS are considered to be negligible contributors to risk and they are excluded from further consideration in the SAMA identification process.

The types of information available for the initiators that were evaluated by LSCS varies based on the manner in which they were addressed in the IPEEE. For instance, core damage frequency information was developed as part of the fire risk analysis that includes component level failures, while the bounding analysis for winds and tornadoes is limited to information related to the frequency of building/structure failures.

Because of the differences in the methods used to evaluate the external events risks, each of the external event contributors must be considered in a manner suiting the type of analysis performed. A summary of the review process used to identify SAMAs is provided for each of the external event types listed above, followed by a description of the method used to quantitatively incorporate external events contributions into the SAMA analysis.

F.5.1.6.1 Internal Fires

As discussed above, the techniques used to model external events vary according to the type of initiator being analyzed. For LSCS, the Fire PRA (Exelon 2009) is available for use in the SAMA analysis. However, that model is considered to be an interim implementation of NUREG/CR-6850 because not all tasks identified in that document are completely addressed or implemented in model. That is, not all tasks identified in NUREG/CR-6850 were completely addressed or implemented in the latest update due to the limited scope of the current incremental update or due to the changing state-of-the-art of industry at the time of the LSCS Fire PRA development.

NUREG/CR-6850 task limitations and other precautions regarding the Fire PRA upgrade for LSCS are as follows:

1. Multiple Spurious Operation (MSO) Review (NUREG/CR-6850 Task 2) - MSOs are reviewed and considered; however, an expert panel is not used. At the time of the LSCS Fire PRA development, the BWR Owners' Group generic list of MSOs to be considered was reviewed for applicability to LSCS. This screening process is the first step in the overall MSO review process. In future updates, the MSO process should be completed and the results incorporated as necessary.
2. Instrumentation Review (NUREG/CR-6850 Task 2) - The new requirements of NUREG/CR-6850 regarding the explicit identification and modeling of instrumentation required to support PRA credited operator actions is not addressed. The industry

treatment for this task was still in development at the time the 2009 fire analysis was performed.

3. The Balance of Plant (BOP) (NUREG/CR-6850 Task 2) - The BOP is not fully treated. BOP support system failure is conservatively assumed. Additional modeling could be conducted to reduce the fire CDF due to this assumption as resources become available in future updates.
4. Large Early Release Frequency (LERF) (NUREG/CR-6850 Task 2) - LERF is not considered. LERF is expected to be addressed in future updates.
5. Limited Analysis Iterations (NUREG/CR-6850 Task 9-12) - The process of conducting a Fire PRA is iterative, and involves identifying conservative assumptions and high risk compartments and performing analyses to refine the assumptions and reduce those compartment risks. The ability to conduct iterations is limited based on resources. The scenarios developed for the LSCS Fire PRA may benefit from further refinement as necessary for application or for future updates.
6. Multi-Compartment Review (NUREG/CR-6850 Task 11) - This subtask reviews the fire analysis compartment boundaries to ensure they are sufficiently robust to prevent the spread of fire between Fire PRA analysis compartments or that such propagations are adequately addressed by the developed scenarios. The design and plant layout of LSCS make fire propagation to multiple compartments unlikely compared to the fire risk in individual compartments. RMIEP performed a multi-compartment analysis that can be used along with the results of the Fire PRA, as necessary.
7. Seismic Fire Interactions (NUREG/CR-6850 Task 13) - This task reviews previous assessments to identify any specific interaction between suppression system and credited components or adverse impact of fire protection system interactions that should be accounted for in the Fire PRA.
8. Uncertainty and Sensitivity Analysis (NUREG/CR-6850 Task 15) - This task explores the impacts of possible variation of input parameters used in the development of the model and the inputs to the analysis on the Fire PRA results. This task is not currently addressed because the industry treatment for this task was still in development at the time the 2009 fire analysis was performed.

Some limitations of these items are:

- Item 1(MSO), represents a source of additional fire CDF contribution (i.e., if the BWROG MSO list includes MSOs not addressed in this update).
- Item 2 (Instrumentation Review) represents a potential additional fire CDF contribution that cannot be estimated at this time since the methodology was not established.
- Items 3 (BOP) and 8 (Uncertainty) are potential sources of conservatism in the results.
- Item 4 (LERF) is a future scope issue not affecting the fire CDF model.
- Items 5 (Iterations) and 6 (Multi-compartment) represent modeling assumptions that should be reviewed with each Fire PRA application to determine their applicability and/or potential impact on the decision.
- Item 7 (Seismic) is a Fire PRA application completeness issue for which the methodology was not yet established.

The approach taken for the SAMA analysis is to use the fire model results to develop potential SAMAs and to use risk insights from both the fire and internal events PRA models to approximate potential averted cost-risk for the SAMAs, as necessary. Even if it was considered appropriate to use the fire model directly for SAMA quantification, the fire model is not integrated with the most recent Level 2 and 3 analyses that are available to support the SAMA analysis. This fact prevents the evaluation of accident consequences in a manner consistent with the process used for the internal events models. Finally, the fire model is based on a previous revision of the PRA (Revision LS206C) rather than the current revision (LS213A), which introduces additional area of inconsistency.

While the fire model results are not necessarily comparable to the current PRA results, the SAMA analysis directly uses the fire CDF to develop the external events multiplier, as described in Section F.4.6.2.

The dominant fire zones, as defined in the LSCS fire PRA, were those fire zones that contributed over 5% to the fire CDF (i.e., scenarios with CDFs greater than 4.70E-07/yr based on the Unit 2 Fire CDF of 9.41E-06/yr). This threshold correlates to about 3.5% of the total CDF of 1.34E-5 (refer to Section F.4.6.2), and the largest un-reviewed fire zone represents less than 2.5% of the overall CDF (Unit 1 Zone 2F-2 at 3.36E-07/yr), or about $142,000. The dominant fire zones were the same for Units 1 and Unit 2, although the order of the MCR and Auxiliary Equipment Room is reversed. The following tables summarize the fire zone results.

Dominant LSCS Unit 1 Fire Zone (Sorted by CDF)

Fire Zone	Description	CDF	Contribution to Fire CDF[5]
4F1	UNIT 1 - DIVISION 1 ESSENTIAL SWITCHGEAR ROOM	2.67E-06	30.0%
4E3-2	UNIT 1 - DIVISION 2 ESSENTIAL SWITCHGEAR ROOM	2.67E-06	30.0%
4C1	CONTROL ROOM	5.87E-07	6.6%
4E1-2	UNIT 1 - AUXILIARY ELECTRIC EQUIPMENT ROOM - MAIN AER ROOM	3.92E-07	4.4%

[5] The Unit 1 Fire CDF is 8.91E-06/yr.

Dominant LSCS Unit 2 Fire Zone (Sorted by CDF)

Fire Zone	Description	CDF	Contribution to Fire CDF[6]
4E4-2	UNIT 2 - DIVISION 2 ESSENTIAL SWITCHGEAR ROOM	2.86E-06	30.4%
4F2	UNIT 2 - DIVISION 1 ESSENTIAL SWITCHGEAR ROOM	2.73E-06	29.0%
4E2-2	UNIT 2 – AUXILIARY ELECTRIC EQUIPMENT ROOM - MAIN AER ROOM	7.69E-07	8.2%
4C1	CONTROL ROOM	5.92E-07	6.3%

The dominant fire zones identified above were reviewed to identify potential means of reducing the risk for those zones. The results of these reviews are documented in the following subsections.

F.5.1.6.1.1 Division 1 and 2 Essential Switchgear Rooms, Units 1 and 2 (Zones 4F1, 4E3-2, 4E4-2, 4F2)

The Division 1 and 2 Essential Switchgear Rooms are the dominate contributors to the LSCS Unit 1 and Unit 2 Fire PRA risk profile. Each switchgear room contributes ~30% to the overall fire CDF for Unit 1 and Unit 2. The Essential Switchgear Rooms are:

- Unit 1 Division 1 – Fire Zone 4F1 – CDF = 2.67E-6/yr (30% of Unit 1 fire CDF)
- Unit 1 Division 2 – Fire Zone 4E3-2 – CDF = 2.67E-6/yr (30% of Unit 1 fire CDF)
- Unit 2 Division 1 – Fire Zone 4F2 – CDF = 2.73E-6/yr (29% of Unit 2 fire CDF)
- Unit 2 Division 2 – Fire Zone 4E4-2 – CDF = 2.86E-6/yr (30% of Unit 2 fire CDF)

These fire zone risk profiles are dominated by High Energy Arching Fault (HEAF) fire scenarios at the 6.9kV and 4kV switchgears that are modeled as failing the switchgear as well as target cable trays above the switchgears. These scenarios are 2.50E-6/yr (28%) of the Unit 1 fire CDF and 2.31E-6/yr (25%) of the Unit 2 fire CDF.

[6] The Unit 2 Fire CDF is 9.41E-06/yr.

Other fire scenarios in the switchgear rooms are also key contributors to the Fire PRA. These fire scenarios include severe panel fires at the 6.9kV and 4kV switchgear and 480V substation fires, as well as, 480V substation HEAF fires.

The switchgear rooms do not have an automatic fire suppression system in the fire zone. Fire detectors are present in the fire zone and fire extinguishers are available throughout. However, no credit is applied for manual suppression.

The LSCS Fire PRA indicates that the panels in the switchgear rooms are considered closed and sealed. Ventilation does exist on the back of the panels, but it is considered negligible. Unless a cabinet is not ventilated and robustly sealed (in a way that warping of doors would be limited), NUREG/CR-6850 requires that the cabinet be treated as "open". For the LSCS Fire PRA, a factor of 0.1 was used to distinguish between severe fires that would propagate from these cabinets, and a factor of 0.9 was used to represent non-severe fires that would not propagate. This is an area that will be revisited when the fire analysis is updated.

The cutsets associated with this fire zone for Unit 2 indicate that adverse environmental conditions in the reactor building occur in about 70 percent of the cases. This is due to the fire induced failure of the containment vent. The reliable hard pipe containment vent (SAMA 1) addresses these scenarios by providing the capability to vent without support systems, and its assumed implementation will significantly reduce the contribution from this fire zone.

F.5.1.6.1.2 Main Control Room, Units 1 and 2 (Zone 4C1)

The Main Control Room (MCR) has a CDF of 5.87E-7/yr contributing 6.6% of the Unit 1 fire CDF and 5.92E-7/yr contributing 6.3% of the Unit 2 fire CDF. The MCR is shared between Unit 1 and Unit 2. The MCR is on the 768' elevation of the Auxiliary Building and contains cables and controls related to all critical equipment modeled in the Fire PRA.

The MCR is fire zone 4C1, which does not have an automatic fire suppression system, but which does have fire detectors and fire extinguishers available throughout and is continually manned. These features are considered in the MCR abandonment calculation.

The fire scenarios postulated for the MCR are considered in three separate analyses:

1. Main Control Board (MCB) Scenarios
2. MCR Electric Panel Scenarios

3. MCR Abandonment Scenarios

Two fire scenarios from 4C1, which are among the top fire scenarios, make up 3.86E-7/yr (66%) of the Unit 1 MCR fire CDF and 3.90E-7/yr (66%) of the Unit 2 MCR fire CDF. These fire scenarios are:

- Scenario 4C1(2)-D4: MCB fire in panel 1(2)H13-P601 that results in a general transient with the failure of ADS, RCIC, RHR A, and LPCS
- Scenario 4C1(2)-J4: MCB fire in panel 1(2)PM01J resulting in a loss of 4.16 kV switchgear 1(2)AP04E, non-essential power, and the shared diesel (DG0)

The MCR analysis was based on the previous update and did not take advantage of NUREG/CR-6850, Appendix L methodology for main control board fire scenario development. This is judged to result in conservative main control board fire scenarios; however, potential means of reducing the risk associated with these scenarios have still been developed.

For Scenario 4C1-D4, fire induced failures of RCIC and ADS emphasize the importance of high pressure injection. Over 80% of the risk associated with this scenario is associated with the failure of the operators to close the turbine driven feedwater pump discharge valves after they are tripped. The action itself is intended to prevent RPV overfill and/or hotwell depletion. The flow control for these pumps is currently provided by pump speed control such that when the pumps are tripped, the flowpath remains open. When reactor pressure is reduced, which would occur as part of a gradual cooldown in this scenario, flow from the condensate pumps or heater drain system can flow in an uncontrolled manner into the RPV resulting in RPV overfill and/or hotwell depletion. A large contributor to the internal events HEP, on which the Fire HEP is based, is from the time reliability curve. For these fire scenarios where ADS is failed, the RPV pressure would remain high for a longer time than what is assumed in the HRA and the HEP may be conservative. However, the frequency of these contributors could be reduced by changing the turbine driven reactor feedwater pump (TDRFP) feedwater system logic to automatically close the TDRFP discharge valves when the pumps trip or are not running to reduce the likelihood of uncontrolled injection. This was also identified as a potential enhancement in the internal events PRA review (SAMA 10).

For scenario 4C1-J4, the fire induced loss of division I emergency power and DG0 results significantly degrades plant capabilities. In over 80% of the cases, containment venting failure leads to a containment overpressure failure, which results in failure of the ECCS systems due to adverse environmental conditions in the reactor building. Containment venting failure is driven by the failure of support systems, which will be mitigated by the reliable hard pipe containment vent (SAMA 1) because venting can be performed without support systems.

F.5.1.6.1.3 Auxiliary Electric Equipment Room - Main AEER Room, Units 1 and 2 (Zone 4E1-2, 4E2-2)

The Auxiliary Electric Equipment Room (AEER) is the second largest contributor for Unit 2 behind the essential switchgear rooms. The AEER fire zones are:

- Unit 1 Main area of the AEER – Fire Zone 4E1-2 – CDF = 3.92E-7/yr (4.4% of Unit 1 fire CDF)
- Unit 2 Main area of the AEER - Fire Zone 4E2-2 – CDF = 7.69E-7/yr (8.2% of Unit 2 fire CDF)

The largest contributing fire scenario for the Unit 1 and Unit 2 fire scenario is a bounding cable fire caused by hot work. This scenario has a fire CDF of 1.88E-7/yr (2.1%) for Unit 1 and 2.56E-7/yr (2.7%) for Unit 2. Due to the large number of cables in the AEERs no attempt was made to refine these scenarios and determine where the "pinch point" in the fire zone is (i.e. the scenarios were left as bounding scenarios in which the initiating fire leads to the failure of all equipment in the zone).

Several individual panel fires are also key contributors to the overall AEER risk profile. These panels were identified as closed and sealed in walk downs and RMIEP. Ventilation does exist on several of the panels but is considered negligible. NUREG/CR-6850 requires that fire propagation be considered even for sealed panels. However, the panels in the AEERs are small and have lower voltage than switchgears and MCCs. Therefore, the panel fire scenarios in the AEERs did not consider propagation beyond the panel.

The AEERs do not have an automatic fire suppression system in the fire zone. Fire detectors are present in the fire zone and fire extinguishers are available throughout. However, no credit is applied for manual suppression.

Because the fires do not propagate in these scenarios and because automatic fire suppression systems cannot be credited to prevent damage in the cabinet where the fire originates, automatic fire suppression is not considered to be a potential SAMA.

The largest contributing scenarios for Unit 1 are M, B, and C (total of 80% of the fire zone frequency). Scenario M is the bounding transient scenario that fails both trains of RHR and containment venting (no heat removal), ADS, RCIC, SAT TR-142, and DG0. While severe, the reliable hard pipe containment vent will provide the capability to vent without support systems, and implementation of SAMA 1 will provide a viable heat removal path for these fires. For scenarios B and C, RCIC is failed with one division of RHR ("B" for scenario "B" and "A" for scenario C). The failures that are important to these scenarios are those related to HPCS and the remaining RHR train, including some cases in which the diesel generator supporting the non-failed RHR train fails. Providing the capability to cross-tie 4kV power between divisions on the same Unit would mitigate these scenarios (SAMA 22). SAMA 1 would also mitigate many of these cases by providing a heat removal mechanism.

The largest contributing scenarios for Unit 2 are M, E, and J (total of 80% of the fire zone frequency). Scenario M is the bounding transient scenario that fails both trains of RHR and containment venting (no heat removal), RCIC, SAT TR-242, and DG2A. Scenario E is similar, but RHR B is not failed by fire. Other single failures, which are diverse in nature, lead to loss of the RHR system. While severe, the reliable hard pipe containment vent will provide the capability to vent without support systems and implementation of SAMA 1 will provide a viable heat removal path for these fires. For scenario J, the DG2A and RHR B are the primary failures and in these cases, loss of DG0 results in the loss of heat removal and vent capability. Again, the reliable hard pipe containment vent will provide the capability to vent without support systems (SAMA 1). In addition, there are cases in which DG0 fails where RHR A could be used if power was aligned to bus 241Y from bus 243. Providing the capability to cross-tie 4kV power between divisions on the same Unit would mitigate these cases (SAMA 22).

F.5.1.6.1.4 Fire SAMA Identification Summary

Based on a review of the dominant LSCS fire zone results, no unique, fire-specific SAMAs have been identified.

F.5.1.6.2 Seismic Events

As described in the LSCS IPEEE, a simplified seismic PRA was performed as part of the RMIEP analysis. While efforts are in progress to update the LSCS seismic risk analysis, the RMIEP analysis represents the latest available seismic analysis for the site and it has been used to support the SAMA analysis. The LSCS IPEEE indicates that the event trees used for the analysis were taken directly from the RMIEP analysis with two simplifying modifications. The first was that the systems that were dependent on offsite power were removed from the trees since a loss of offsite power was assumed for seismic events. The second was that the suppression pool cooling and containment spray systems were removed from the Large and

Medium LOCA trees and the venting system was removed from all event trees since the RMIEP analysis did not evaluate Level 2 impacts. The differences between the two models are considered to have a negligible impact on the results and because only the RMIEP analysis provides detailed descriptions of the results, the RMIEP documentation was used to support the SAMA identification process. The details of the analysis are available in NUREG/CR-4832, Volume 8.

Consistent with the goal of NEI 05-01 (NEI 2005), the seismic SAMA identification effort was focused on the dominant contributors to risk. For LSCS, about 94% of the seismic risk is associated with the following four sequences:

- LOSP-Trans-3: 42.0%
- LOSP-Trans-4: 35.3%
- LOSP-Trans-1: 11.3%
- Small-LOCA-3: 5.2%

These sequences have been reviewed as part of the SAMA identification process, the results of which are provided below on a sequence by sequence basis.

In addition, the impact of the using the LSCS 2013 seismic hazard curves on the RMIEP analysis has been investigated. The complete LSCS seismic analysis is not available for use in the SAMA analysis, but the seismic hazard curves are available and it was considered beneficial to investigate how the use of the updated hazard curves would impact the RMIEP results. The seismic CDF results were updated by applying the 2013 seismic event frequencies to the conditional core damage probabilities for each of the ranges provided in table 11.2 of the RMIEP analysis.

LOSP-Trans-3

As described in the RMIEP report, this sequence involves successful operation of the Reactor Protection System (RPS) as well as the safety relief valves (SRVs), which implies a non-ATWS event in which overpressure protection is successful and there is not a stuck open relief valve. The high pressure injection systems, HPCS and RCIC, are failed due to a seismically induced failure of the CST. ADS functions to depressurize the RPV, but LPCI and LPCS are unavailable due to random electrical support failures (offsite power and combinations of EDG, bus, relay coil, and breaker failures).

While this sequence was considered to be a dominant contributor in the RMIEP analysis, plant changes have subsequently been implemented that reduce the contribution of these events. In the RMIEP analysis, HPCS was assumed to "burn up" in these scenarios because of the lack of a low suction pressure trip for the system. In a case where the CST volume is rapidly lost due to tank failure, it was assumed that no action was possible to trip the pump to protect it before failure. Since the time of the RMIEP analysis, the normal suction path for the HPCS system was changed from the CST to the suppression pool (the CST is now only available after installation of a spool piece), so loss of the CST would not cause the immediate failure of HPCS. Failure of AC power was the dominant contributor for the low pressure injection systems, but because HPCS is supported by a separate, dedicated power division (Division III), the HPCS system would be available in most of these scenarios and the CDF associated with this sequence would be significantly reduced relative to the RMIEP analysis.

The details associated with the failure of RCIC are not clearly documented for this sequence, but it appears that RCIC is also assumed to fail due to loss of the CST. RCIC is normally aligned to the CST, has a low suction pressure trip, and auto aligns to the suppression pool on low CST level and there is no indication that RCIC would not be available in these events (i.e., even if RCIC tripped on loss of the CST, it could be aligned to the suppression pool manually if the auto alignment function failed and then restarted). Based on information in the RCIC system notebook, the "sneak circuit" failure mode is not an issue. Even though review of the system design showed the "sneak circuit" failure was unlikely, the relay associated with this failure mode was replaced in 1996 to definitively eliminate this failure mode. While it appears that RCIC would be available in this sequence, it is assumed to be failed.

The changes implemented since performance of RMIEP have reduced the contribution of this sequence and it is not considered to be a dominant contributor to risk, but AC power failures may still be a factor. Providing long term RPV makeup capability in SBO scenarios with seismically qualified equipment could provide some benefit. This could be accomplished by providing a seismically qualified low pressure injection pump with a seismically qualified diesel generator for power. In order to respond to loss of injection cases, it would be necessary to provide the capability to align the system from the MCR. A hard piped connection between the RHRSW line in the Auxiliary Building to the seismically qualified, non-safety related pump would be installed in conjunction with a discharge line that would be routed to the Unit 1 and Unit 2 Feedwater systems piping headers. The seismically qualified, non-safety related diesel generator would be permanently installed outside of the reactor building with a remote start capability that would power the injection pump. Alignment to the existing safety related battery chargers will be performed manually and will be possible within 4 hours (SAMA 26).

LOSP-Trans-4

As described in the RMIEP report, this sequence involves successful operation of the Reactor Protection System (RPS) as well as the safety relief valves (SRVs), which implies a non-ATWS event in which overpressure protection is successful and there is not a stuck open relief valve. The high pressure injection systems, HPCS and RCIC, are failed due to the failure of the reactor level instrumentation or a seismically induced failure of the CST. Automatic depressurization fails due to the RPV level instrumentation failure and manual depressurization fails due to operator error, resulting in a high pressure core melt.

The RMIEP analysis includes a discussion of the re-evaluation of the water level reference leg failure probability, which was performed after the RMIEP analysis was complete. The updated value for the reference leg failure was 3 orders of magnitude lower than the value used in the RMIEP analysis and substitution of the new value into the analysis was described as decreasing the contribution of the LOSP-Trans-4 sequence by a factor of 10. When this insight is incorporated into the sequence, it is no longer a dominant contributor and becomes similar to LOSP-Trans-3. No additional SAMAs are considered to be required to address the risk associated with this sequence.

While the SAMA identification process accounts for the re-analysis of the reference leg failure probability, the seismic CDF used in the SAMA analysis has not been reduced to reflect this change.

LOSP-Trans-1

This sequence involves successful operation of the Reactor Protection System (RPS) as well as the safety relief valves (SRVs), which implies a non-ATWS event in which overpressure protection is successful and there is not a stuck open relief valve. The HPCS system fails due to random events, but RCIC is initially successful. Failure of the heat removal system (i.e., RHR in the suppression pool cooling, shutdown cooling, and containment spray modes) results in heatup of the suppression pool and forced RPV emergency depressurization (e.g., on violation of heat capacity temperature limit). The depressurization function is successful, but random failures of the low pressure injection systems lead to loss of RPV makeup and subsequent core damage.

For cases where RCIC is the only injection system available, it would be possible to prevent core damage by changing the EOPs to allow RPV pressure to be maintained in the range of 150 to 250 psig even when containment temperature and pressure limits are violated. This would ensure the RCIC steam head is not lost in long term loss of containment heat removal scenarios. Providing a 480V AC generator to supply a battery charger would maintain plant instrumentation and control power, which would improve the reliability of this strategy (SAMA 27).

Small-LOCA-3

Neither the RMIEP report nor the IPEEE provide a detailed description of this sequence, but the event tree provides the functional successes and failures of the scenario. This sequence involves successful operation of the Reactor Protection System (RPS) as well as the safety relief valves (SRVs), which implies a non-ATWS, small LOCA event in which overpressure protection is successful and there is not a stuck open relief valve. The event tree path defines that failure of HPCS and RCIC, but the causes of the failures are not provided. ADS functions to depressurize the RPV, but LPCI and LPCS are unavailable (causes not specified) and lack of RPV makeup leads to core damage.

If the HPCS and RCIC failures are due to either the RPV water level reference leg failure or the HPCS pump "burn up" case, the contributions from this scenario maybe overestimated, as described for sequences LOSP-Trans-3 and LOSP-Trans-4. Assuming that HPCS and RCIC are failed by other causes, a potential means of mitigating these scenarios would be to install a cross-tie between the RHRSW and LPCS systems for low pressure makeup (SAMA 15). It is assumed emergency AC power is available for these LOCA cases.

Impact of 2013 LSCS Hazard Curves

At the time the SAMA analysis was performed, the LSCS seismic model was only in the early stages of development and the complete model was not available for use in the SAMA analysis; however, the development of the 2013 LSCS seismic hazard curves was complete. While it was not possible to make use of the entire LSCS seismic model, it was possible to use the latest seismic hazard curves to gain an understanding of how the RMIEP results would be impacted by the latest available seismic event frequencies.

The 2013 versions of the LSCS seismic hazard use the NRC/DOE/EPRI CEUS-SSC sources model (NRC 2012b), a revised version of the EPRI 2004-2006 ground motion attenuation model, and updated local site amplification information received from the site. The following table provides the original RMIEP frequencies along with the 2013 LSCS hazard frequencies for the same seismic intervals:

Comparison of RMIEP and 2013 LSCS Seismic Hazard

Level (or Interval)	Lower bound (g PGA)	Upper bound (g PGA)	RMIEP Freq.	2013 LSCS Freq.
1	0.18	0.27	1.10E-04	8.32E-05
2	0.27	0.36	2.90E-05	3.03E-05
3	0.36	0.46	1.10E-05	1.55E-05
4	0.46	0.58	4.70E-06	8.47E-06
5	0.58	0.73	2.10E-06	4.61E-06
6	0.73		1.00E-06	4.63E-06

These curves were used in conjunction with the conditional accident sequence probabilities provided in Table 11.2 of the RMEIP analysis to re-quantify the accident sequence frequencies. Table F.5-3a and F.5-3b provide the estimated seismic accident sequence frequencies based on the RMIEP and 2013 LSCS seismic hazard curves, respectively. A spreadsheet was used to perform the calculations and because of rounding differences, the RMIEP results provided in table F.5-3a do not exactly match those documented in Table 11.1 of the RMEIP analysis. For the purposes of this comparison, the frequencies were calculated in a similar manner for consistency.

The results indicate a slight increase in the overall seismic CDF and a small shift of some of the risk from the Level 1 interval to the mid and upper seismic intervals (Levels 3 through 6). The Level 1 and 2 intervals still represent over 60% of the risk and the use of the 2013 LSCS seismic hazard information does not appear to represent a change that would alter the conclusions of sequence reviews performed above. The updated seismic CDF of 6.6E-07/year is, however, considered to be appropriate for use in the development of the LSCS external events multiplier (Section F.4.6.2).

F.5.1.6.2.1 Seismic SAMA Identification Summary

Based on a review of the LSCS seismic results, two (2) additional seismic-specific SAMAs have been identified for inclusion in the Phase 1 SAMA list:

- Seismically Qualified Low Pressure RPV Makeup Capability (SAMA 26)
- Preclude Emergency Depressurization When RCIC is the Only Injection System Available and Provide Long Term DC Power (SAMA 27)

F.5.1.6.3 Winds and Tornadoes

The approach taken to analyze the wind and tornado event risk in the RMIEP analysis was to perform a bounding analysis. Site specific tornado and high wind event frequencies were developed in conjunction with structure response assessments for Category I and non-Category I structures. Failures of Category I structures housing critical equipment were assumed to lead to core damage, which is consistent with the bounding analysis approach. Based on the design characteristics of the non-Category I structures, failures of the non-Category I structures were not assumed to lead to core damage.

The evaluation of extreme winds and tornadoes demonstrated that extreme winds were not significant contributors to LSCS risk and therefore could be eliminated from further analysis. The median frequency of plant core damage due to tornadoes was calculated to be 3.0E-08 per year and its 95th percent confidence bound was found to be 3.0E-07 per year. No plant enhancements were suggested to mitigate tornado events based on their low contribution to the LSCS core damage frequency and no vulnerabilities were identified related to these events.

For the SAMA analysis, high wind events are not dominant contributors to plant risk and no SAMAs are required; however, SAMAs that mitigate LOOP events that could be available in high wind events represent potential means of mitigating these types of scenarios. For example, SAMA 8 may provide a means of maintaining RPV makeup in the event that a high wind event fails offsite power and the EDG building.

In conclusion, no high wind or tornado related SAMAs are required for LSCS.

F.5.1.6.4 Turbine Missiles

The approach taken to analyze the risk associated with turbine generated missiles in the RMIEP analysis was to perform a bounding analysis. As indicated in the IPEEE, the 95th percent confidence bound on the CDF due to turbine generated missiles is on the order of 1E-07 per year and the mean value is documented in the RMIEP analysis as 9.5E-08/year.

The evaluation of turbine generated missiles demonstrated that these events were not significant contributors to LSCS risk and therefore could be eliminated from further analysis. No plant enhancements were suggested to mitigate turbine generated missile events based on their low contribution to the LSCS core damage frequency and no vulnerabilities were identified related to these types of events.

For the SAMA analysis, turbine generated missile events are not dominant contributors to plant risk and no SAMAs are required.

F.5.1.6.5 Transportation Accidents

The approach taken to analyze the risk associated with transportation accidents in the RMIEP analysis was to perform a bounding analysis. The types of events considered included:

- A chemical explosion due to a transportation accident that may cause damage to Category I structures and safety related equipment,
- A toxic chemical release from a transportation accident that may drift into the control room and cause incapacitation of the operators.

The analysis considered the frequency of occurrence of transportation accidents as well as the fragility of the plant structures against accident effects. It was determined that potential chemical explosions would not damage LSCS Category I structures and that these events do not contribute to plant risk. Chemical spills were also determined not to pose a significant risk to LSCS based on the types of chemicals that would potentially be transported near the plant, the distance of the plant from the local shipping lanes and highways, and the availability of specific chemical detectors in the main control room ventilation system. No plant enhancements were suggested to mitigate events related to transportation accidents based on their low contribution to the LSCS core damage frequency and no vulnerabilities were identified related to these types of events.

For the SAMA analysis, transportation accidents are not significant contributors to plant risk and no SAMAs are required. For the purposes of evaluating the external events multiplier, the same

CDF estimated for the risk associated with high winds (3.0E-08/year) is used to represent the risk from transportation accidents, which is considered to be conservative.

F.5.1.6.6 External Floods

The approach taken to analyze the risk associated with external flood events in the RMIEP analysis was to perform a bounding analysis. The analysis considered the following events:

- Probable maximum flood of the Illinois River,
- Probable maximum precipitation with antecedent standard project storm on the cooling lake and its drainage area,
- Probable maximum precipitation event at the plant site.

The LSCS plant grade is 710' mean sea level (MSL) and structure floor elevations are slightly higher at 710.5' MSL. The maximum probable flood event for the Illinois River, which is normally at levels below 500' MSL, was determined to be only 522' MSL when coincident wave effects were considered. Flooding of the Illinois River was determined not to affect plant safety.

Analysis of the probable maximum precipitation event on the cooling lake identified that overflow from the lake would flow away from the plant and into the creeks and gullies that empty into the Illinois River. In cases where the peripheral dikes of the cooling lake are breached, the impounded water would similarly drain to the same creeks and gullies and not impact the plant.

Local intense precipitation events at the site were also analyzed and it was determined that the resulting level of the flood water would be less than the 710.5' MSL elevation of the LSCS structure floors. The analysis included conservative assumptions related to the duration of the probable maximum precipitation event, the availability of drainage paths, and the permeation of water into the ground. It was also identified that the structure doors are leak-tight such that flood water elevations above 710.5' MSL would not necessarily result in the flooding of plant buildings. No plant enhancements were suggested to mitigate external flood events based on their low contribution to the LSCS core damage frequency and no vulnerabilities were identified related to these types of events.

For the SAMA analysis, external flooding events are not significant contributors to plant risk and no SAMAs are required. For the purposes of evaluating the external events multiplier, the same CDF estimated for the risk associated with high winds (3.0E-08/year) is used to represent the risk from external flooding events, which is considered to be conservative.

F.5.1.6.7 Aircraft Impact

The approach taken to analyze the risk associated with accidental aircraft impact in the RMIEP analysis was to perform a bounding analysis. As indicated in the IPEEE, the median CDF for these events was estimated to be 5.0E-07/year and the RMIEP analysis indicates that the 95th percent confidence bound on the CDF due to accidental aircraft impact is 1E-06/year. In this analysis, core damage was assumed to occur for any aircraft impact on a Category I structure that results in back face scabbing of the building wall, which is considered to be conservative.

The largest accidental aircraft risks were associated with twin engine plane crashes on the Reactor Building and Auxiliary Building. This is primarily because single engine planes were determined not to be capable of causing back scabbing on the walls of these buildings and the crash rate of commercial aircraft is relatively low compared to that of twin engine planes. The Unit 2 Diesel Generator Building was screened from the analysis due to its small size, because it is protected on two sides by other nearby buildings, and because the swing diesel generator would be available to provide power from the Unit 1 Diesel Generator Building if an aircraft impacted the Unit 2 Diesel Generator Building. These are relatively high level insights and do not provide any specific information about the potentially important equipment failures in these scenarios.

No plant enhancements were suggested in the IPEEE or RMIEP to mitigate accidental aircraft impact events based on their low contribution to the LSCS core damage frequency and no vulnerabilities were identified related to these types of events. It is recognized that the types of credible threats to nuclear facilities by aircraft have changed since the time the RMIEP analysis was performed. However, substantial efforts have been made within the industry to address this issue in conjunction (e.g., the development of extreme damage mitigation guidelines) with other forms of sabotage. Given that this topic is addressed by other industry initiatives, intentional aircraft impact events are considered to be out of the scope of the SAMA analysis, which is a mitigation alternatives analysis performed for purposes of compliance with NEPA and 10 C.F.R. Part 51. No additional SAMAs are considered to be required to address aircraft impact events.

F.5.2 PHASE 1 SCREENING PROCESS

The initial list of SAMA candidates is presented in Table F.5-4. The process used to develop the initial list is described in Section F.5.1.

The purpose of the Phase 1 analysis is to use high-level knowledge of the plant and SAMAs to preclude the need to perform detailed cost-benefit analyses on them. The following screening criteria were used:

- Applicability to the Plant: If a proposed SAMA does not apply to the LSCS design, it is not retained. Similarly, any SAMAs that have already been implemented by EGC or any modifications implemented by EGC that achieve the same results as a SAMA can be screened as they are not applicable to the current plant design. These criteria are not often explicitly used in the Phase I analysis because the SAMA identification methodology generally excludes such SAMAs; however, they are listed as a possible screening method given that there may be circumstances in which a SAMA would be included in the list even if it is not relevant to the site. An example may be the inclusion of a high profile SAMA that is well known in the industry, but not applicable to the specific site design. Such a SAMA may be included for documentation purposes. Another example may be an unimplemented SAMA from the IPE that has been superseded by another plant enhancement.
- Implementation Cost Greater than Screening Cost: If the estimated cost of implementation is greater than the MACR (refer to Section F.4.6), the SAMA cannot be cost-beneficial and is screened from further analysis.

Table F.5-4 provides a description of how each SAMA was dispositioned in Phase 1 (2 SAMAs were screened on excessive implementation cost). Those SAMAs that required a more detailed cost-benefit analysis are passed to the Phase 2 analysis and evaluated in Section F.6. Table F.6-1 contains the Phase 2 SAMAs.

F.6 PHASE 2 SAMA ANALYSIS

The SAMA candidates identified as part of the Phase 2 analysis are listed in Table F.6-1. The base PRA model was manipulated to simulate implementation of each of the proposed SAMAs and then quantified to determine the risk benefit. Truncation values and binning cutoffs are the same as used in the base PRA model, including Level 2 endstates.

In general, in order to maximize the potential risk benefit due to implementation of each of the SAMAs, the failure probabilities assigned to new basic events, such as human error probabilities (HEPs), were optimistically chosen so as not to inadvertently screen out any potential cost-beneficial SAMAs. Also, any new model logic that was added to the PRA model in order to simulate SAMA implementation was also simplified and optimistically configured to achieve the same effect.

Determining whether or not any given Phase 2 SAMA is potentially cost-beneficial involved calculating what is known as the averted cost-risk, which was obtained by a multi-step process that includes the use of the baseline MACR as well as the internal events PRA results and a multiplier to account for external events contributions.

- The averted cost-risk is the difference between the baseline MACR and the MACR for the configuration in which the SAMA has been implemented ($MACR_{SAMA}$). The $MACR_{SAMA}$ includes the internal events contribution and the external events contribution.
- The internal events portion of the $MACR_{SAMA}$ is calculated in the same manner as for the baseline MACR using the CDF, Level 2 PRA results, etc., as shown in Sections F.4.1 through F.4.6.1.
- The contribution from the external events to the $MACR_{SAMA}$ is accounted for by multiplying the internal events $MACR_{SAMA}$ by the External Events Multiplier (refer to section F.4.6.2).

For some SAMAs identified by the fire and seismic results review, the internal events PRA does not provide a means of modeling the impact of the SAMA. In these cases, the averted cost-risk is estimated using insights from the external events model/documentation and information from the internal events MACR calculation. The averted cost-risk is obtained by multiplying the internal events contribution to the MACR by the ratio of the CDF eliminated by the SAMA to the base internal events CDF.

- The assumption is that the fire and seismic CDFs are proportional to the internal events MACR. For example, if the SAMA is assumed to eliminate the entire CDF associated with Unit 2 fire zone 4E2-2, the averted cost risk would be (7.69E-07 / 2.58E-06 * $1,088,000 = $324,291)

Finally, a SAMA is determined to be potentially cost-beneficial if its net value is positive. The net value is determined by the following equation:

Net Value = averted cost-risk – cost of implementation

The implementation costs used in the Phase 1 and 2 analyses consist of industry estimates, LSCS specific estimates, or in some cases, combinations of these two sources. It should be noted that LSCS specific implementation costs <u>do</u> include contingency costs for unforeseen difficulties, but do <u>not</u> account for any replacement power costs that may be incurred due to consequential shutdown time unless specifically noted. The implementation costs were developed on a site basis to account for cost sharing between units, and then divided by a factor of 2 to obtain a single unit implementation cost (which is consistent with the single unit averted cost-risk calculation that is performed). Table F.5-4 provides implementation costs for each Phase 1 and Phase 2 SAMA.

The following sections describe the cost-benefit analysis that was used for each of the Phase 2 SAMA candidates.

It should be noted that apart from fire considerations, LSCS units 1 and 2 are essentially identical in design and operation. The differences associated with fire-related issues have been addressed by performing unit specific fire SAMA identification tasks and by using unit-specific risk insights for quantification, when relevant. SAMAs developed to prevent or mitigate fire damage or propagation in a specific fire scenario required a unit specific quantification using the method described above. Unit-specific fire SAMAs are applicable only to the unit for which they were derived. SAMAs identified to mitigate the impact of fire damage (e.g., SAMA 10 – CHANGE THE LOGIC TO CLOSE THE TURBINE DRIVEN FEEDWATER PUMP DISCHARGE VALVES WHEN THE PUMPS ARE NOT RUNNING) were all also applicable to the internal events model and the External Events Multiplier was used to account for any fire related benefits for those types of SAMAs.

For all non-fire based SAMAs, the Unit 2 PRA model was employed to evaluate the risk benefits and averted costs for each of the SAMAs, and was viewed as also being applicable to Unit 1. That is, if a particular SAMA proves potentially cost-beneficial for Unit 2, it will likewise be potentially cost-beneficial for Unit 1 given the essentially identical designs of Units 1 and 2.

F.6.1 SAMA 1: INSTALL RELIABLE HARD PIPE CONTAINMENT VENT

This is already a commitment for LSCS, but it has not yet been installed and is not modeled in the PRA. This SAMA will prevent vent path failure within the reactor building and will provide a means of safely operating the containment vent when normal support systems are unavailable (non-adverse environment for use of portable pneumatic supply or manual valve operation). This SAMA is used to track this enhancement and to facilitate the interpretation of the results (for example, by providing a description of the changes used to model SAMA 1 and to show how implementation impacts the results).

<u>Assumptions:</u>

This SAMA eliminates all support system dependencies.

The hard pipe vent eliminates vent path ruptures and leaks.

This SAMA reduces the complexity of venting and the failure probability of the operator action is reduced to 1.0E-04.

The action to control containment pressure during the venting process is still required to maintain adequate NPSH for the ECCS pump. No changes to this operator action's reliability are assumed due to implementation of this SAMA.

SAMA 1 is not designed to accommodate ATWS loads and no additional credit is taken for venting in ATWS scenarios.

The common cause failure probability of the valves in reliable hard pipe containment vent is negligible.

For the cases in which containment venting is part of a joint human error probability (JHEP), it will typically not be the chronologically first human failure event (HFE) in the action chain and the probability of the failure will be dominated by the dependence level rather than the independent failure probability of the HFE. As a result, no changes are made to the JHEPs that include the containment venting action.

The reliable hard pipe containment vent valves are designed to open against high differential pressures.

<u>PRA Model Changes to Model SAMA:</u>

The model was modified to incorporate this SAMA by eliminating the support system dependencies, improving the reliability of the venting action to reflect simplification of the controls, and eliminating the events related to vent path rupture and leakage.

<u>Model Change(s):</u>

The following modeling changes were made:

- Gate CV1: Deleted gate CV-122, deleted event 2CVPHRXENVIRMF--.
- Gate DWV: Deleted gate SA-TOTAL-LOSS
- Gate PCV: Deleted gate SA-TOTAL-LOSS
- Gate DWVX: Deleted gate DW-PATH-FAILS.
- Gate PCVX: Deleted gate CONT-PATH-FAILS, deleted event 2CVAV31343640DCC.
- Gate FC-VENTDW: Deleted gate FC-VNTEQFAIL.
- Gate CV-OPS-CONT: deleted event 2CVPH-CYCLES-F--.
- Events for adverse environment impacts from venting set to 0.0:
    - 2AD--VENT----F--(ADS FAILS DUE TO STEAM RELEASE)

- 2CR--VENT----F-- (COND PROB OF CRD FAILURE GIVEN STEAM RELEASE)
- 2HC--VENT----F-- (COND PROB OF HPCS FAILURE GIVEN STEAM RELEASE)
- 2SY--VENT----FCC (CCF OF HPCS & CRD & LPCI & LPCS GIVEN VENT TO RB)
- 2SY--VENT1---FCC (CCF OF HPCS & CRD & LPCI & LPCS GIVEN VENT TO STEAM TUNNEL)
- BFPOP-DFPENV-H-- (HEP: OP FAILS TO ALIGN DFP DUE TO ADVERSE ENV IN TB (VENT TO RB OR CNTNMT FAIL))
- BFPOP-DFPENV1H-- (HEP: OP FAILS TO ALIGN DFP DUE TO ADVERSE ENV IN TB (VENT TO STEAM TUNNEL))

- Gate HTR-DRN-OP-QUV: Deleted gate CTFAIL-HD.
- Gate DFP-MU-VT: Deleted gate DFP-ENVIRON.
- 2CVOPVENT----H-- (HEP: OPERATOR FAILS TO INITIATE PRIMARY CONTAINMENT VENTING): Basic event probability changed in the recovery file to 1.0E-04.
- 2HDOP-HTR-DRNH-- (HEP: OPERATOR FAILS TO ALIGN HEATER DRAIN DURING DBA LOCA): Basic event probability changed from 0.21 to 9.7E-02 to reflect the impact of being able to perform the action in nominal conditions rather than adverse conditions (reduced stress for execution).

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	1.87E-06	4.53	$30,472
Percent Change	27.5%	36.3%	42.9%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.30E-08	1.34E+00	1.34E+00	$7,222	$7,204
H/E	5.93E-08	5.82E-08	3.14E-01	3.08E-01	$2,763	$2,712
H/I	1.90E-08	3.74E-09	1.08E-01	2.12E-02	$954	$188
M/E	2.14E-07	1.99E-07	1.58E+00	1.47E+00	$9,395	$8,736
M/I	9.27E-07	3.23E-07	3.58E+00	1.25E+00	$32,723	$11,402
L/E	3.88E-07	3.87E-07	8.57E-02	8.55E-02	$124	$123
L/I	1.45E-07	8.70E-08	1.03E-01	6.17E-02	$177	$106
INTACT	7.45E-07	7.29E-07	1.62E-03	1.58E-03	$1	$1
Total	2.58E-06	1.87E-06	7.11E+00	4.53E+00	$53,358	$30,472

Applying the process described in Section F.4 yields an internal events cost-risk of $645,889. After accounting for "round up" of the base internal events cost-risk, this value is $646,706. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{\text{SAMA}} = \$646,706 * 5.2 = \$3,362,871$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 1 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$3,362,871	$2,294,729

Because implementation of this SAMA is planned for LSCS, a net value is not required for this SAMA. If the implementation cost of $12,940,000 is used, however, the net value would be -$10,645,271 ($2,294,729 - $12,940,000), implying that SAMA 1 is not cost-beneficial.

F.6.2 SAMA 2: AUTOMATE SUPPRESSION POOL COOLING

Suppression pool cooling initiation is a reliable action, but for non-LOCA events, automating SPC initiation on high suppression pool temperature could further improve the reliability of the containment heat removal function.

Many of the largest contributors to LSCS risk include the failure to align SPC for containment heat removal, either alone, or in combination with other mitigating actions, such as primary containment venting. These scenarios lead to failure of primary containment and a release of steam to the reactor building. The harsh reactor building environment resulting from the steam release often results in the failure of the injection systems located in the reactor building and prevents further operator actions in the building. Automating SPC initiation will reduce the frequency of these contributors.

<u>Assumptions:</u>

One of the conditions of this SAMA's design is that SPC auto start will not be allowed for LOCA events in order to prevent the alignment of an RHR train to SPC when the RHR trains may all be needed for RPV makeup. However, the contributions from the failure to align SPC in LOCA events is small relative to non-LOCA events and for simplicity, this SAMA is assumed to apply to all initiating events in which manual alignment of SPC is currently required.

If the automatic SPC initiation signal fails, no credit is taken for manual initiation.

PRA Model Changes to Model SAMA:

The fault tree was modified to incorporate the automation of SPC alignment by changing the independent basic event IDs for SPC initiation to alternate IDs. This accomplishes two functions:

- It allows the assignment of alternate failure probabilities that are representative of an automated function, and
- It will prevent the recovery logic from identifying SPC initiation failures as human actions and preclude the SPC initiation failures from dependent human error combinations.

Model Change(s):

The following modeling changes were made:

- 2RHOPSPCINIT-H-- (HEP: OPERATOR FAILS TO INITIATE SUPPRESSION POOL COOLING (NON-ATWS)): Basic event ID changed to SAMA2. Failure probability changed from 0.1 to 1.0E-6.
- 2RHOPSPCLATE-H-- (HEP: OPERATOR FAILS TO INITIATE SPC LATE GIVEN EARLY FAILURE (COND PROB)): Basic event ID changed to SAMA2-LATE. Failure probability changed from 0.1 to 1.0 (the late conditional failure is always combined with the early failure event and has been set to 1.0 to preserve a total initiation failure probability of 1.0E-06).
- 2RHOPSPC-ATWSH-- (HEP: OPERATOR FAILS TO INITIATE SUPPRESSION POOL COOLING (ATWS)): Basic event ID changed to SAMA2-ATWS. Failure probability changed from 0.1 to 1.0E-6

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.22E-06	5.71	$40,120
Percent Change	14.0%	19.7%	24.8%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	6.24E-08	3.14E-01	3.30E-01	$2,763	$2,908
H/I	1.90E-08	1.73E-08	1.08E-01	9.79E-02	$954	$868
M/E	2.14E-07	1.98E-07	1.58E+00	1.46E+00	$9,395	$8,692
M/I	9.27E-07	5.65E-07	3.58E+00	2.18E+00	$32,723	$19,945
L/E	3.88E-07	5.32E-07	8.57E-02	1.18E-01	$124	$170
L/I	1.45E-07	2.58E-07	1.03E-01	1.83E-01	$177	$315
INTACT	7.45E-07	5.04E-07	1.62E-03	1.09E-03	$1	$0
Total	2.58E-06	2.22E-06	7.11E+00	5.71E+00	$53,358	$40,120

Applying the process described in Section F.4 yields an internal events cost-risk of $836,093. After accounting for "round up" of the base internal events cost-risk, this value is $836,910. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$836,910 * 5.2 = \$4,351,932$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 2 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$4,351,932	$1,305,668

Based on a $400,000 cost of implementation for LSCS, the net value for this SAMA is $905,668 ($1,305,668 - $400,000), which indicates this SAMA is potentially cost-beneficial.

F.6.3 SAMA 3: PASSIVE VENT PATH

For loss of containment heat removal scenarios, the reliability of the containment venting function could be improved by installing a passive vent path. If the suppression chamber vent path were equipped with a rupture disk in parallel with the remotely operated vent path, a scrubbed release path would be available to prevent containment failure in the event that normal venting fails. The rupture disk failure pressure would have to be less than the ultimate containment strength to ensure it would rupture before the containment, but consideration could also be given to a lower pressure to ensure SRVs could remain operable to support low pressure injection in loss of containment heat removal cases. Effectiveness is contingent on the implementation of the hard pipe vent.

Assumptions:

SAMA 1 has been implemented (the model used to evaluation SAMA 1 is used as the starting point for the additional changes described here to model the passive vent).

A rupture disk helps ensure that a containment failure does not occur in undesirable areas of the drywell and wetwell, but because the rupture disk is designed to fail at a lower pressure than other parts of the containment, radioactive releases would be expected to occur earlier than they would with the current plant configuration. While release from the passive vent path is considered to be "scrubbed", which would result in a lower dose relative to an unscrubbed release, the earlier release time may result in the more of the population being impacted by the plume (before evacuation is complete).

The passive vent reliability (appropriate rupture disk failure) can be approximated by the failures of the valves in the existing vent path (with the support system dependencies removed).

PRA Model Changes to Model SAMA:

In order to approximate the impact of a passive vent, the basic event for the operator action for venting was replaced with a new placeholder event with a value of 1.0E-06 (prevents the creation of dependent operator actions including the vent action). The hardware failures associated with the vent path valves have been retained to approximate the potential failures of the rupture disk (with the support system dependencies removed).

Model Change(s):

The model changes described for SAMA 1 are also applicable here.

In addition, the following changes were made to the model:

- 2CVVT-VENT---M-- (VQ CONTAINMENT VENT / PURGE SYSTEM MUA): Event deleted.

- 2CVOPVENT----H-- (HEP: OPERATOR FAILS TO INITIATE PRIMARY CONTAINMENT VENTING): Basic event changed to "SAMA3" and assigned a failure probability of 1.0E-06.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	1.65E-06	3.47	$21,036
Percent Change	36.0%	51.2%	60.6%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.30E-08	1.34E+00	1.34E+00	$7,222	$7,204
H/E	5.93E-08	5.82E-08	3.14E-01	3.08E-01	$2,763	$2,712
H/I	1.90E-08	2.54E-09	1.08E-01	1.44E-02	$954	$128
M/E	2.14E-07	1.87E-07	1.58E+00	1.38E+00	$9,395	$8,209
M/I	9.27E-07	7.23E-08	3.58E+00	2.79E-01	$32,723	$2,552
L/E	3.88E-07	3.87E-07	8.57E-02	8.55E-02	$124	$123
L/I	1.45E-07	8.70E-08	1.03E-01	6.17E-02	$177	$106
INTACT	7.45E-07	7.73E-07	1.62E-03	1.68E-03	$1	$1
Total	2.58E-06	1.65E-06	7.11E+00	3.47E+00	$53,358	$21,036

Applying the process described in Section F.4 yields an internal events cost-risk of $466,051. After accounting for "round up" of the base internal events cost-risk, this value is $466,868. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$466,868 * 5.2 = \$2,427,714$$

SAMA 3 assumes implementation of SAMA 1 in order to provide a viable vent path for the passive vent. Because LSCS is committed to install the reliable hard pipe containment vent (for reasons unrelated to the SAMA analysis), the averted cost-risk of SAMA 3 is considered to be the difference between the SAMA 1 "revised cost-risk" value reported in Section F.6.1 ($3,362,871) and the cost-risk for the configuration of the plant with both SAMAs 1 and 3 implemented ($2,427,714). Therefore, the averted cost-risk for this SAMA is $935,157 ($3,362,871 - $2,427,714).

Based on a $1,000,000 cost of implementation for LSCS, the net value for this SAMA is -$64,843 ($935,157 - $1,000,000), which indicates this SAMA is not cost-beneficial.

F.6.4 SAMA 4: INSTALL A KEYLOCK MSIV LOW LEVEL ISOLATION BYPASS SWITCH

Operator errors are some of the largest contributors to ATWS scenarios, which are complicated by the short times available for response. One of the more time limited actions in these scenarios is the action to bypass the main steam isolation valve (MSIV) low level isolation signal, which is currently an action that requires the installation of jumpers. Providing a switch in the MCR that would bypass the isolation logic would simplify the bypass action and provide more time margin for the power/level control actions for these scenarios. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators are directed to immediately lower level to a control band above the MSIV closure setpoint and given the option to bypass the MSIV low level isolation logic before lowering level further.

Assumptions:

It is assumed that this SAMA reduces the failure probability of the independent operator action to bypass the MSIV low level isolation logic to 1.0E-05.

The action to bypass the MSIV low level isolation logic occurs early in the accident scenario. Because the timing for this action could arguably be the chronologically first action in most operator action combinations; a reduced HEP for this action would significantly reduce most of the associated JHEPs. For simplicity, the JHEPs that include this action are assumed to be eliminated.

PRA Model Changes to Model SAMA:

The independent HEP to bypass the MSIV low level isolation interlock was set to 1.0E-5 and the JHEPs that include this action have been eliminated.

Model Change(s):

The following modeling changes were made:

- 2MSOPMSIVINLKH-- (HEP: OPERATOR FAILS TO BYPASS LOW LEVEL MSIV INTERLOCK): Basic event ID changed to "SAMA4". Failure probability changed from 0.7 to 1.0E-5.
- 2MSOPMSIVINLKHSU (HEP: OP SUCCESSFULLY BYPASSES MSIV LOW LEVEL INTERLOCK): Probability changed from 0.3 to 9.9999E-01 in the fault tree.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.16E-06	6.23	$47,928
Percent Change	16.3%	12.4%	10.2%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	4.82E-08	3.14E-01	2.55E-01	$2,763	$2,246
H/I	1.90E-08	1.90E-08	1.08E-01	1.08E-01	$954	$954
M/E	2.14E-07	1.18E-07	1.58E+00	8.72E-01	$9,395	$5,180
M/I	9.27E-07	9.09E-07	3.58E+00	3.51E+00	$32,723	$32,088
L/E	3.88E-07	2.14E-07	8.57E-02	4.73E-02	$124	$68
L/I	1.45E-07	1.39E-07	1.03E-01	9.86E-02	$177	$170
INTACT	7.45E-07	6.30E-07	1.62E-03	1.37E-03	$1	$1
Total	2.58E-06	2.16E-06	7.11E+00	6.23E+00	$53,358	$47,928

Applying the process described in Section F.4 yields an internal events cost-risk of $967,518. After accounting for "round up" of the base internal events cost-risk, this value is $968,335. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$968,335 * 5.2 = \$5,035,342$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 4 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$5,035,342	$622,258

Based on a $635,242 cost of implementation for LSCS, the net value for this SAMA is -$12,984 ($622,258 - $635,242), which indicates this SAMA is not cost-beneficial.

F.6.5 SAMA 5: AUTOMATE STANDBY LIQUID CONTROL (SBLC) INITIATION

ATWS events rely on timely initiation of the SBLC system for mitigation. A potential means of improving the reliability of this function would be to automate system initiation, as is that case at Limerick Generation Station.

Assumptions:

It is assumed that this SAMA reduces the failure probability of the SBLC initiation to a negligible value.

No credit is taken for manual SBLC initiation in the event that automatic actuation fails.

It is assumed that if the SBLC system is available, than all support systems required for automatic initiation would also be available.

PRA Model Changes to Model SAMA:

The automatic SBLC initiation capability is modeled by manipulation of the basic events associated with SBLC initiation. The early SBLC initiation basic event ID (2SLOP-LVLCTRLH--) was changed to "SAMA5" and set to a probability of 1.0E-06. This reduces the independent failure contribution to a small value and prevents the inclusion of dependent operator action combinations with SBLC initiation failures, which is consistent with the automation of the action.

Model Change(s):

The following modeling changes were made:

- 2SLOP-IN-ERLYH-- (HEP: OPERATOR FAILS TO INITIATE SBLC EARLY): Basic event ID changed to "SAMA5". Failure probability changed from 0.1 to 1.0E-6.

- 2SLOP-IN-LATEH-- (HEP: OPERATOR FAILS TO INITIATE SBLC LATE (COND PROB)): Basic event ID changed to "SAMA5-L". Failure probability changed from 0.1 to 0.0 (a conditional late failure is not applicable to an automated action).

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.38E-06	6.59	$50,215
Percent Change	7.8%	7.3%	5.9%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	5.31E-08	3.14E-01	2.81E-01	$2,763	$2,474
H/I	1.90E-08	1.90E-08	1.08E-01	1.08E-01	$954	$954
M/E	2.14E-07	1.53E-07	1.58E+00	1.13E+00	$9,395	$6,717
M/I	9.27E-07	9.23E-07	3.58E+00	3.56E+00	$32,723	$32,582
L/E	3.88E-07	2.80E-07	8.57E-02	6.19E-02	$124	$89
L/I	1.45E-07	1.45E-07	1.03E-01	1.03E-01	$177	$177
INTACT	7.45E-07	7.20E-07	1.62E-03	1.56E-03	$1	$1
Total	2.58E-06	2.38E-06	7.11E+00	6.59E+00	$53,358	$50,215

Applying the process described in Section F.4 yields an internal events cost-risk of $1,018,781. After accounting for "round up" of the base internal events cost-risk, this value is $1,019,598. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,019,598 * 5.2 = \$5,301,910$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 5 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,301,910	$355,690

Based on a $400,000 cost of implementation for LSCS, the net value for this SAMA is -$44,310 ($355,690 - $400,000), which indicates this SAMA is not cost-beneficial.

F.6.6 SAMA 6: CREATE ECCS SUCTION STRAINER BACKFLUSH CAPABILITY WITH RHRSW

For some LOCA contributors, common cause plugging of the ECCS suction strainers fails makeup/heat removal. Connecting the RHRSW system to the RHR pump suction line upstream of the F004A/B valves could provide a means of backflushing the system in conjunction with steps to close the F004A/B valves during the backflush.

The backflush capability is used in LOCA scenarios, which require a rapid response for success. The backflush capability for this SAMA can be aligned from the main control room by opening the cross connect MOVs and closing the F004A/B valve(s) to ensure water is forced through the ECCS strainers.

Assumptions:

The backflush operation can be performed in time to mitigate even large LOCA events.

The backflush function is 100% reliable.

The backflush connection cannot be used as an injection source to the RPV due to losses through the RHR pumps.

PRA Model Changes to Model SAMA:

The contribution related to CCF strainer clogging was eliminated by setting the corresponding basic events in the cutset files to 0.0.

Model Change(s):

The following change was made to the cutset files:

- 2CNFLIORV----PCC (CCF (PLUGGING) OF ECCS SUCT STRAINERS (IORV / SORV)): Probability changed to 0.0.
- 2CNFLNMLLOCA-PCC (CCF (PLUGGING) OF ECCS SUCT STRAINERS (NON-LOCA / IORV / SORV)): Probability changed to 0.0.
- 2CNFLMLLOCA—PCC (CCF (PLUGGING) OF ECCS SUCT STRAINERS (LOCA)): Probability changed to 0.0.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.55E-06	7.01	$52,598
Percent Change	1.2%	1.4%	1.4%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	5.92E-08	3.14E-01	3.13E-01	$2,763	$2,759
H/I	1.90E-08	1.89E-08	1.08E-01	1.07E-01	$954	$949
M/E	2.14E-07	2.10E-07	1.58E+00	1.55E+00	$9,395	$9,219
M/I	9.27E-07	9.11E-07	3.58E+00	3.52E+00	$32,723	$32,158
L/E	3.88E-07	3.79E-07	8.57E-02	8.38E-02	$124	$121
L/I	1.45E-07	1.39E-07	1.03E-01	9.86E-02	$177	$170
INTACT	7.45E-07	7.50E-07	1.62E-03	1.63E-03	$1	$1
Total	2.58E-06	2.55E-06	7.11E+00	7.01E+00	$53,358	$52,598

Applying the process described in Section F.4 yields an internal events cost-risk of $1,071,921. After accounting for "round up" of the base internal events cost-risk, this value is $1,072,738. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,072,738 * 5.2 = \$5,578,238$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 6 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$5,578,238	$79,362

Based on a $2,900,000 cost of implementation for LSCS, the net value for this SAMA is -$2,820,638 ($79,362 - $2,900,000), which indicates this SAMA is not cost-beneficial.

F.6.7 SAMA 7: WATER HAMMER PREVENTION

For LSCS, a high drywell pressure signal (2 psig in the drywell) will result in the generation of a LOCA signal independent of RPV water level. In certain scenarios initiated by non-LOCA events, this can lead to conditions that will result in a water hammer event.

In non-LOCA transient scenarios, the heat load rejected to the containment is sufficient to prompt the initiation of suppression pool cooling (SPC), but even with SPC in operation, the drywell pressure will reach 2 psig and a LOCA signal will register. If a consequential loss of offsite power occurs with the LOCA signal, the RHR discharge line can drain to the suppression pool in the ~45 seconds between RHR pump load shed and the time it is reloaded on the diesel backed bus, which sets up a water hammer condition in the voided pipe.

A potential means of preventing this evolution would be to alter the LOCA signal logic to require both high drywell pressure AND low RPV water level for initiation (as is the case for Limerick Generating Station). This will prevent the generation of a LOCA signal in transient scenarios where an operating train of RHR in SPC mode would be vulnerable to a water hammer event. This could also have the added benefit of simplifying the operators' response to loss of offsite power events where the LOOP signal has caused the EDGs to start and load and an ECCS signal is subsequently received due to loss of containment cooling (high drywell pressure). In this LOOP-delayed LOCA scenario, the operators are required to take many actions to handle the automatic actuations that occur due to the LOCA signal. This scenario is not specifically modeled in the PRA.

Assumptions:

This SAMA will completely eliminate the water hammer events related to the scenarios in which SPC is placed into service after the initiating event and a consequential loss of offsite power occurs after the LOCA signal.

This SAMA does not address the water hammer scenarios in which SPC is in operation prior to a LOOP initiating event and a high drywell pressure/LOCA signal subsequently occurs because the model already assumes that the system start signal from the LOCA signal is blocked. Water hammer in these scenarios is caused by the failure to properly fill and vent the RHR system before SPC start is required to prevent reaching the heat capacity temperature limit.

No adverse impact on plant risk results from requiring both high drywell pressure and low RPV water level to generate a LOCA signal.

PRA Model Changes to Model SAMA:

The water hammer events were eliminated from the results through manipulation of the cutsets. The relevant water hammer scenarios are all characterized by two events that identify the RHR train that is placed in SPC mode in response to the high suppression pool temperature. Setting these events to 0.0 approximates the impact of eliminating the water hammer events associated with the LOCA signal actuated solely on high drywell pressure.

Model Change(s):

The following change was made to the cutset files:

- 2RHSYSTARTA----- (RH TRAIN A IS PLACED INTO OPERATION FOLLOWING A TRANSIENT): Probability changed to 0.0.
- 2RHSYSTARTB----- (RH TRAIN B IS PLACED INTO OPERATION FOLLOWING A TRANSIENT): Probability changed to 0.0.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.39E-06	7.08	$53,132
Percent Change	7.4%	0.4%	0.4%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	5.72E-08	3.14E-01	3.03E-01	$2,763	$2,666
H/I	1.90E-08	1.90E-08	1.08E-01	1.08E-01	$954	$954
M/E	2.14E-07	2.12E-07	1.58E+00	1.57E+00	$9,395	$9,307
M/I	9.27E-07	9.26E-07	3.58E+00	3.57E+00	$32,723	$32,688
L/E	3.88E-07	3.85E-07	8.57E-02	8.51E-02	$124	$123
L/I	1.45E-07	1.42E-07	1.03E-01	1.01E-01	$177	$173
INTACT	7.45E-07	5.70E-07	1.62E-03	1.24E-03	$1	$0
Total	2.58E-06	2.39E-06	7.11E+00	7.08E+00	$53,358	$53,132

Applying the process described in Section F.4 yields an internal events cost-risk of $1,077,666. After accounting for "round up" of the base internal events cost-risk, this value is $1,078,483. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,078,483 * 5.2 = \$5,608,112$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 7 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,608,112	$49,488

Based on a $962,403 cost of implementation for LSCS, the net value for this SAMA is -$912,915 ($49,488 - $962,403), which indicates this SAMA is not cost-beneficial.

F.6.8 SAMA 8: OBTAIN A 480V AC PORTABLE GENERATOR TO SUPPLY THE 125V DC BATTERY CHARGERS AND PROCEDURALIZE ITS USE

For long term SBO scenarios, the hardened containment vent that LSCS is committed to install will provide a reliable means of containment heat removal, but the PRA analysis assumes that the battery life is currently limited to about 7 hours. After battery depletion, the SRVs will close and the RPV will re-pressurize and prevent injection with a low pressure system, such as the fire protection system. Use of a portable generator to provide power to the 125V DC battery chargers would provide a means of maintaining the SRVs open, energize critical instrumentation, and ensure RPV pressure remains low enough for use of low pressure alternate makeup systems.

This SAMA will address many SBO contributors, but some of the largest SBO events are related to internal flooding events initiated in the fire protection system. The fire protection flooding events are addressed by SAMAs 9 and 11.

Assumptions:

Flow from the fire protection system, in its current configuration, is only adequate in cases where RCIC has initially successfully operated. This injection system is not available in fire protection flooding events.

The benefit provided by this SAMA in non-long term SBO scenarios is small compared to the benefit from long term SBO scenarios and can be neglected for this analysis.

While the portable generator could support RCIC for longer periods of time, it is assumed that the diesel fire pump is required to place the plant in a stable state.

It is assumed that procedures direct the alignment of the 480V AC generator in scenarios where battery depletion is projected to occur, that RPV makeup with the diesel fire pump is directed to be aligned before containment failure, and that level can be controlled from outside the turbine building by either throttling a valve or by cycling the diesel fire pump (injection system is not impacted by containment vent path failure).

PRA Model Changes to Model SAMA:

The 480V AC generator capability has been approximated by adding the diesel fire pump as a low pressure injection source for SBO scenarios in which ADS and RCIC are initially successful.

In addition, a lumped event was added to represent the 480V AC power source that feeds the division 1 battery chargers.

Model Change(s):

The following modeling changes were made:

- Gate FPS-VNT (FIRE PROTECTION SYSTEM FAILURE GIVEN VENT CHALLENGE) added to the following gates: DLOP-025P, DLOP-028P, DLOP-030P, LOOP-025P, LOOP-028P, LOOP-030P, TBFLD-008P, TBFLD-010P, TBFLD-013P, TBFLD-015P, and TBFLD-016P.
- Created event SAMA8 (FAILURE OF 480V AC GENERATOR POWER): New basic with a failure probability of 5.0E-02 to represent hardware and human error related failure contributors for the use of the 480V AC generator.
- Created gate SAMA8-GATE: New AND gate including existing gate 2AP19E-PWR and new event SAMA8.
- Under gate 2AP73E-CHR-AC (LOSS OF POWER FROM MCC BUS 235X-3 TO U2 DIV1 CHARGERS): Deleted gate 2AP19E-PWR and added gate SAMA8-GATE
- Created gate SAMA8-GATE-CHRGR: New AND gate including existing gate 241Y-235X-PATH and new event SAMA8.
- Under gate 2AP73E-CHRGR (LOSS OF POWER FROM MCC BUS 235X-3 TO U2 DIV1 CHARGERS): Deleted gate 241Y-235X-PATH and added gate SAMA8-GATE-CHRGR.
- Created gate SAMA8-GATE-GL: New AND gate including existing gate 2AP19E-PWR-FLD and new event SAMA8.
- Under gate 2AP73E-CHR-AC-FL (LOSS OF MCC BUS 235X-3 TO U2 DIV1 CHARGERS FOR EARLY TB-RB-FLD): Deleted gate 2AP19E-PWR-FLD and added gate SAMA8-GATE-GL.

The recovery tree was merged with the updated fault tree logic in order to ensure the recovery logic includes the changes from the SAMA modifications.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.47E-06	6.83	$51,022
Percent Change	4.3%	3.9%	4.4%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	5.88E-08	3.14E-01	3.11E-01	$2,763	$2,740
H/I	1.90E-08	4.74E-09	1.08E-01	2.68E-02	$954	$238
M/E	2.14E-07	2.13E-07	1.58E+00	1.57E+00	$9,395	$9,351
M/I	9.27E-07	8.84E-07	3.58E+00	3.41E+00	$32,723	$31,205
L/E	3.88E-07	3.88E-07	8.57E-02	8.57E-02	$124	$124
L/I	1.45E-07	1.16E-07	1.03E-01	8.22E-02	$177	$142
INTACT	7.45E-07	7.20E-07	1.62E-03	1.56E-03	$1	$1
Total	2.58E-06	2.47E-06	7.11E+00	6.83E+00	$53,358	$51,022

Applying the process described in Section F.4 yields an internal events cost-risk of $1,040,608. After accounting for "round up" of the base internal events cost-risk, this value is $1,041,425. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,041,425 * 5.2 = \$5,415,410$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 8 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$5,415,410	$242,190

Based on a $400,000 cost of implementation for LSCS, the net value for this SAMA is -$157,810 ($242,190 - $400,000), which indicates this SAMA is not cost-beneficial.

F.6.9 SAMA 9: DEVELOP FLOOD ZONE SPECIFIC PROCEDURES

Many plants have analyzed internal flooding scenarios and have developed procedures that include guidance to identify flood sources and locations by using existing instrumentation related to pressures, flows, and sump alarms. Based on the flood source/location, the procedures direct specific actions to both terminate the flooding event and to mitigate the impacts of the flooding event (e.g., provide alternate cooling for systems that may have lost their normal cooling source).

For LSCS, the reliability of the internal flood mitigation actions could be improved by developing these types of location and system specific flood response procedures. For example, for fire protection floods in the reactor building, developing procedures that direct the isolation of the FP070 and FP080 valves could significantly reduce the time required to terminate reactor building floods from the fire protection system. Increasing the time margin for the operators to respond to the floods would improve the likelihood of preventing damage to critical ECCS equipment.

Assumptions:

The procedures will completely eliminate the risk of flooding events.

PRA Model Changes to Model SAMA:

To approximate the impact of this SAMA, the initiating event frequencies for flooding events were set to 0.0 in the cutsets.

Model Change(s):

The following initiating events were set to 0.0 in the cutsets:

- %FSAB1, %FSAB2, %FSDG1, %FSDG2, %FSRB1 0.0, %FSRB10, %FSRB11, %FSRB12, %FSRB2, %FSRB3, %FSRB4, %FSRB5, %FSRB6, %FSRB7 , %FSRB8, %FSRB9, %FSTB1, %FSTB10, %FSTB11, %FSTB2, %FSTB3, %FSTB4, %FSTB5, %FSTB6, %FSTB7

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.35E-06	6.88	$51,580
Percent Change	8.9%	3.2%	3.3%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	5.92E-08	3.14E-01	3.13E-01	$2,763	$2,759
H/I	1.90E-08	1.71E-08	1.08E-01	9.68E-02	$954	$858
M/E	2.14E-07	2.12E-07	1.58E+00	1.57E+00	$9,395	$9,307
M/I	9.27E-07	8.84E-07	3.58E+00	3.41E+00	$32,723	$31,205
L/E	3.88E-07	3.87E-07	8.57E-02	8.55E-02	$124	$123
L/I	1.45E-07	8.60E-08	1.03E-01	6.10E-02	$177	$105
INTACT	7.45E-07	6.20E-07	1.62E-03	1.35E-03	$1	$1
Total	2.58E-06	2.35E-06	7.11E+00	6.88E+00	$53,358	$51,580

Applying the process described in Section F.4 yields an internal events cost-risk of $1,047,209. After accounting for "round up" of the base internal events cost-risk, this value is $1,048,026. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,048,026 * 5.2 = \$5,449,735$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 9 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,449,735	$207,865

Based on a $115,000 cost of implementation for LSCS, the net value for this SAMA is $92,865 ($207,865 - $115,000), which indicates this SAMA is potentially cost-beneficial.

F.6.10 SAMA 10: CHANGE THE LOGIC TO CLOSE THE TURBINE DRIVEN FEEDWATER PUMP DISCHARGE VALVES WHEN THE PUMPS ARE NOT RUNNING

In cases where the turbine driven FW pumps are tripped or are malfunctioning, it is currently necessary to manually isolate the pump discharge valves to prevent hotwell depletion and/or

RPV overfill when RPV pressure is reduced. Failure to control the valves can make the hotwell unavailable as a suction source for other injection systems or flood the steam lines, which may lead to the unavailability of RCIC. Changing the system logic to automatically close the valves when the pumps trip or are not running would reduce the likelihood of uncontrolled injection (no RPV overfill from the Condensate/CB pumps when pressure is reduced).

Assumptions:

This SAMA completely eliminates the contributions from failing to isolate the turbine driven pump discharge valves after pump trip/failure.

No credit is taken for manual isolation of the valves in the event that auto isolation fails.

PRA Model Changes to Model SAMA:

The human failure event associated with closing the turbine driven feedwater pump discharge valves was changed to a new event with a failure probability of 1.0E-04. This reduces the independent contribution of the isolation failure and precludes the generation of dependent human error combination including the operator action to isolate the valves.

Model Change(s):

The following changes were made to the main fault tree and recovery tree:

- 2FWOPMOV10AB-H-- (HEP (REC): OPERATOR FAILS TO CLOSE THE TDRFP DISCHARGE MOVS 2FW010A & B): Basic event ID changed to "SAMA10" and assigned a probability of 1.0E-04.
- 2FWOP10ABQUV-H-- (HEP: OP FAILS TO CLOSE TDRFP MOVs 10A & B (COND PROB - QUV)): Basic event ID changed to "SAMA-10L" and assigned a probability of 0.0 (not relevant for automated function).

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.35E-06	5.65	$41,251
Percent Change	8.9%	20.5%	22.7%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	5.40E-08	3.14E-01	2.86E-01	$2,763	$2,516
H/I	1.90E-08	1.75E-08	1.08E-01	9.91E-02	$954	$879
M/E	2.14E-07	1.63E-07	1.58E+00	1.20E+00	$9,395	$7,156
M/I	9.27E-07	6.57E-07	3.58E+00	2.54E+00	$32,723	$23,192
L/E	3.88E-07	3.59E-07	8.57E-02	7.93E-02	$124	$115
L/I	1.45E-07	1.40E-07	1.03E-01	9.93E-02	$177	$171
INTACT	7.45E-07	8.80E-07	1.62E-03	1.91E-03	$1	$1
Total	2.58E-06	2.35E-06	7.11E+00	5.65E+00	$53,358	$41,251

Applying the process described in Section F.4 yields an internal events cost-risk of $854,868. After accounting for "round up" of the base internal events cost-risk, this value is $855,685. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$855{,}685 * 5.2 = \$4{,}449{,}562$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 10 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$4,449,562	$1,208,038

Based on a $260,219 cost of implementation for LSCS, the net value for this SAMA is $947,819 ($1,208,038 - $260,219), which indicates this SAMA is potentially cost-beneficial.

F.6.11 SAMA 11: PROVIDE THE CAPABILITY TO TRIP THE FPS PUMPS FROM THE MCR

The reliability of the internal flood mitigation actions could be improved by providing the capability to trip the fire protection system pumps from the MCR. Currently, is it is necessary to for an operator to travel to the Lake Screen House to locally trip the fire protection pumps to eliminate that system's flow. Increasing the time margin for the operators to respond to the floods would improve the likelihood of preventing damage to critical ECCS equipment. It is assumed that this change would be accompanied by a procedure update that would include directions to remotely isolate valves for service water isolation (e.g., 0FP070 and 0FP080) to ensure that the time benefits associated with the MCR pump control switches are fully realized.

Assumptions:

The HEP associated with the action to trip the FPS pumps is dominated by the time reliability curve contribution to the cognitive component of the HEP. Installation of pump controls in the MCR and directing isolation of service water using controls in the MCR is assumed to reduce the manipulation time to 2 minutes; 1 minute total to trip the two pumps and 1 minute total to isolate service water from the fire protection system header. This would reduce the manipulation time from 16 minutes to about 2 minutes, which results in a diagnosis time of 19 minutes. The time reliability curve contribution for this diagnosis time is 3.2E-02. The execution contributions and cause based decision tree contributions would increase the total HEP, but for this analysis, the total HEP for this action is assumed to be 3.2E-02.

PRA Model Changes to Model SAMA:

The human failure event associated with tripping the fire protection pumps and isolating the service water system from the fire protection header is not used in any dependent operator action combinations, so this SAMA was modeled by changing the basic event probability for the operator action in the cutsets.

Model Change(s):

The following changes were made to the cutsets:

- 2FPOPMANTRIP1H-- (HEP: OPERATOR FAILS TO TRIP FPS FOR FPS BREAK (SHORT TIME FRAME)): Basic probability changed to 3.2E-02.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.54E-06	7.09	$53,219
Percent Change	1.6%	0.3%	0.3%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	5.92E-08	3.14E-01	3.13E-01	$2,763	$2,759
H/I	1.90E-08	1.87E-08	1.08E-01	1.06E-01	$954	$939
M/E	2.14E-07	2.14E-07	1.58E+00	1.58E+00	$9,395	$9,395
M/I	9.27E-07	9.24E-07	3.58E+00	3.57E+00	$32,723	$32,617
L/E	3.88E-07	3.88E-07	8.57E-02	8.57E-02	$124	$124
L/I	1.45E-07	1.34E-07	1.03E-01	9.50E-02	$177	$163
INTACT	7.45E-07	7.20E-07	1.62E-03	1.56E-03	$1	$1
Total	2.58E-06	2.54E-06	7.11E+00	7.09E+00	$53,358	$53,219

Applying the process described in Section F.4 yields an internal events cost-risk of $1,083,394. After accounting for "round up" of the base internal events cost-risk, this value is $1,084,211. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1{,}084{,}211 * 5.2 = \$5{,}637{,}897$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 11 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,637,897	$19,703

Based on a $217,415 cost of implementation for LSCS, the net value for this SAMA is -$197,712 ($19,703 - $217,415), which indicates this SAMA is not cost-beneficial.

F.6.12 SAMA 12: CROSSITIE THE HPCS AND FW INJECTION LINES FOR ATWS MITIGATION

The use of HPCS is not allowed for ATWS due to reactivity issues, but installing a cross-tie between the HPCS and FW injection lines would provide another means of supplying high pressure injection to the RPV in ATWS scenarios.

This SAMA makes use of an existing injection system (HPCS) to provide an additional means of high pressure injection in ATWS scenarios. The other potential benefit would be to use the cross-tie to bypass HPCS injection valve failures, which are not significant contributors to risk. In order to provide a simplified, bounding assessment of benefit this SAMA, it was assumed that this SAMA eliminates the contribution of all ATWS events. This was accomplished by setting the accident class IV flag (RCVCL-4A) to 0.0 in the cutsets.

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.09E-06	5.63	$44,593
Percent Change	19.0%	20.8%	16.4%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	4.09E-08	3.14E-01	2.16E-01	$2,763	$1,906
H/I	1.90E-08	1.90E-08	1.08E-01	1.08E-01	$954	$954
M/E	2.14E-07	3.60E-08	1.58E+00	2.66E-01	$9,395	$1,580
M/I	9.27E-07	9.27E-07	3.58E+00	3.58E+00	$32,723	$32,723
L/E	3.88E-07	9.50E-08	8.57E-02	2.10E-02	$124	$30
L/I	1.45E-07	1.45E-07	1.03E-01	1.03E-01	$177	$177
INTACT	7.45E-07	7.40E-07	1.62E-03	1.61E-03	$1	$1
Total	2.58E-06	2.09E-06	7.11E+00	5.63E+00	$53,358	$44,593

Applying the process described in Section F.4 yields an internal events cost-risk of $897,389. After accounting for "round up" of the base internal events cost-risk, this value is $898,206. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$898,206 * 5.2 = \$4,670,671$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 12 Bounding Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$4,670,671	$986,929

Based on a $4,401,674 cost of implementation for LSCS, the net value for this SAMA is -$3,414,745 ($986,929 - $4,401,674), which indicates this SAMA is not cost-beneficial.

F.6.13 SAMA 14: PROVIDE A PORTABLE DC SOURCE TO SUPPORT RCIC AND SRV OPERATION

For scenarios with 125V DC bus faults, providing a means for a portable generator with DC output to supply 125V ESF DC distribution panel 1(2)11Y would support RCIC operation and long term SRV operation with Fire Protection System injection.

Assumptions:

DC bus failure initiating events will likely require rapid response to address loss of makeup. It is assumed that the required electric cables for the generator are pre-staged such that the generator can be wheeled into position, started and connected via simple actions.

Flow from the fire protection system, in its current configuration, is only adequate in cases where RCIC can be re-started after DC power alignment.

Fire protection system injection is not available in fire protection flooding events.

While the portable generator could support RCIC for longer periods of time, it is assumed that the diesel fire pump is required to place the plant in a stable state.

The procedures directing the alignment of the generator also direct subsequent alignment of the fire protection system such that it is available for RPV makeup when RPV depressurization is eventually required due to lack of suppression pool cooling.

The diesel fire pump is directed to be aligned before containment failure, and that level can be controlled from outside the turbine building by either throttling a valve or by cycling the diesel fire pump (injection system is not impacted by containment vent path failure).

PRA Model Changes to Model SAMA:

The DC generator capability has been approximated by adding the diesel fire pump as a low pressure injection source for SBO scenarios in which ADS and RCIC are initially successful. In addition, a lumped event was added to represent the 480V AC power source that feeds the division 1 battery chargers.

Model Change(s):

The following modeling changes were made:

- Gate FPS-VNT (FIRE PROTECTION SYSTEM FAILURE GIVEN VENT CHALLENGE) added to the following gates: DLOP-025P, DLOP-028P, DLOP-030P, LOOP-025P, LOOP-028P, LOOP-030P, TBFLD-008P, TBFLD-010P, TBFLD-013P, TBFLD-015P, and TBFLD-016P.
- Created event SAMA14 (FAILURE OF DC GENERATOR POWER): New basic with a failure probability of 5.0E-02 to represent hardware and human error related failure contributors for the use of the DC generator.
- Created gate SAMA14-AC: New AND gate including existing gate 2DC08E-PWR-AC and new event SAMA14.
- Under gate 2DC11E-PWR-AC (FAULTS AFFECTING POWER FROM DC BUS 2DC11E): Deleted gate 2DC08E-PWR-AC and added gate SAMA14-AC
- Created gate SAMA14-G: New AND gate including existing gate 2DC08E-PWR and new event SAMA14.
- Under gate 2DC11E-PWR (FAULTS AFFECTING POWER FROM DC BUS 2DC11E): Deleted gate 2DC08E-PWR and added gate SAMA14-G.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.35E-06	6.64	$49,422
Percent Change	8.9%	6.6%	7.4%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,222
H/E	5.93E-08	5.15E-08	3.14E-01	2.72E-01	$2,763	$2,400
H/I	1.90E-08	4.40E-09	1.08E-01	2.49E-02	$954	$221
M/E	2.14E-07	2.12E-07	1.58E+00	1.57E+00	$9,395	$9,307
M/I	9.27E-07	8.51E-07	3.58E+00	3.28E+00	$32,723	$30,040
L/E	3.88E-07	3.34E-07	8.57E-02	7.38E-02	$124	$107
L/I	1.45E-07	1.03E-07	1.03E-01	7.30E-02	$177	$126
INTACT	7.45E-07	7.10E-07	1.62E-03	1.54E-03	$1	$1
Total	2.58E-06	2.35E-06	7.11E+00	6.64E+00	$53,358	$49,422

Applying the process described in Section F.4 yields an internal events cost-risk of $1,007,535. After accounting for "round up" of the base internal events cost-risk, this value is $1,008,352. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,008,352 * 5.2 = \$5,243,430$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 14 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$5,243,430	$414,170

Based on a $489,277 cost of implementation for LSCS, the net value for this SAMA is -$75,107 ($414,170 - $489,277), which indicates this SAMA is not cost-beneficial.

F.6.14 SAMA 15: TIE RHRSW TO THE LPCS SYSTEM FOR ISLOCA MITIGATION

Interfacing systems LOCA (ISLOCA) events are dominated by isolation failures in which there are no long term RPV makeup sources. Providing a hard pipe connection with manual valves between the RHRSW system and the LPCS system would provide a source of makeup to the RPV for cases in which RPV depressurization is available.

Because manual valves are used for this cross-tie to reduce costs, this SAMA provides the capability to mitigate most ISLOCA events because in a high percentage of cases, an injection source is available for RCS makeup until the water source is depleted. By the time the water source is depleted, the local actions to align RHRSW to LPCS can be completed.

Assumptions:

The action to align the cross-tie occurs in the reactor building, but for core damage prevention, it can be performed before the deposition of any RPV inventory in to the reactor building makes the environment inhospitable.

The hardware associated with the use of the RHRSW-LPCS x-tie is not impacted by the reactor building environment.

The breaks outside containment (BOC) and ISLOCA rupture events are large enough to depressurize the RPV to allow low pressure injection without ADS. The ISLOCA leak events require ADS.

For the credited BOC and ISLOCA events, HPCS and/or LPCI provide initial makeup using available inventory sources. These systems are not included in the baseline logic and in most cases would be available for initial injection. This is not necessarily true for other LOCA contributors and no credit is taken for medium or larger LOCAs.

Post core damage alignment of the RHRSW-LPCS cross-tie can be performed to help prevent RPV meltthrough, drywell failure, debris cooling and to perform containment flooding.

Not credited for ATWS due to alignment time limitations.

The hardware modification was designed to use flow from at least two RHRSW pumps, but one pump is required for success in the SAMA model (to maximize benefit).

The HFE for aligning the cross-tie was treated as an independent event.

PRA Model Changes to Model SAMA:

The inclusion of the RHRSW-LPCS cross-tie required changes to both the main fault tree and the recovery fault tree. The cross-tie was assumed to require the LPCS injection path (existing logic from the LPCS system) and the availability of the RHRSW pumps (existing logic from the RHRSW system). ISLOCAs in the LPCS line were included as failure for the cross tie, as was an event representing the failure to align the cross-tie. The cross-tie logic was added at the sequence level for BOC and ISLOCA sequences where credit was not previously taken for any low pressure injection systems. The logic was also added to the existing fault tree structure in scenarios where venting or containment failure resulted in the loss of injection systems.

Model Change(s):

The following change was made to the main fault tree:

- Created new basic event SAMA15 (FAILURE TO ALIGN RHRSW-LPCS X-TIE): Probability set to 1.0E-03.
- Created new gate SAMA15-G1: OR gate including the following inputs:
  - Existing gate LPCS-PMP-ISOL
  - Existing gate RHRA-SW-FAILURE
  - Existing event %ISLOCA-LPCS
  - Existing event %R
  - Existing gate LLOCA
  - Existing gate IE-MLOCA
  - SCRAM-FAILS
  - New event SAMA15
- Created new OR gate SAMA15-G2 with the following inputs:
  - Existing gate ADS
  - New gate SAMA15-G1.
- Added gate SAMA15-G1 to the following gates:
  - BOC-003P

  - ILOC-006P
  - ILOC-009P
  - CTFAIL-MU-LPI
  - VENT-MU-LPI
  - LPCI-LPCS
- Added gate SAMA15-G2 to:
  - Gate ILOC-002P
  - Gate ILOC-008P
- Under existing gate BOC-002P:
  - Deleted gate HP-CS-LPI-BOC
  - Added new OR gate BOC-002-SAMA15
- Created new gate OR BOC-002-SAMA15 to preclude credit for SAMA 15 in this BOC sequence where early injection fails. Includes the following inputs:
  - New AND gate BOC-002-SAMA15-G2
  - Existing event 2SY--VENT1---FCC
- Created new AND gate BOC-002-SAMA15-G2 with the following inputs:
  - Existing gate LPCI
  - Existing gate LPCS
  - Existing gate HPCS
- Created new OR gate SAMA15-G1-L2 with the following inputs (to allow post core damage credit for LOCA and ATWS cases):
  - Existing gate LPCS-PMP-ISOL
  - Existing gate RHRA-SW-FAILURE
  - Existing event %ISLOCA-LPCS
  - New event SAMA15
- Added new OR gate SAMA15-G1-L2 to:
  - RX2HRDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
  - RX10RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
  - RX12RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
  - RX13RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
  - FC-HRDFLR-EXTSRC (HARDWARE FAILURE OF EXTERNAL SOURCES)
  - FC-HRDFLR-EXTSRC-SBO (HARDWARE FAILURE OF EXTERNAL SOURCES)

The recovery tree was merged with the updated fault tree logic in order to ensure the recovery logic includes the changes from the SAMA modifications.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	1.62E-06	3.06	$22,870
Percent Change	37.2%	57.0%	57.1%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq_{BASE}$	$Freq_{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.49E-09	1.34E+00	1.37E-01	$7,222	$737
H/E	5.93E-08	4.92E-08	3.14E-01	2.60E-01	$2,763	$2,293
H/I	1.90E-08	1.73E-08	1.08E-01	9.79E-02	$954	$868
M/E	2.14E-07	1.34E-07	1.58E+00	9.90E-01	$9,395	$5,883
M/I	9.27E-07	3.63E-07	3.58E+00	1.40E+00	$32,723	$12,814
L/E	3.88E-07	3.71E-07	8.57E-02	8.20E-02	$124	$118
L/I	1.45E-07	1.28E-07	1.03E-01	9.08E-02	$177	$156
INTACT	7.45E-07	5.49E-07	1.62E-03	1.19E-03	$1	$0
Total	2.58E-06	1.62E-06	7.11E+00	3.06E+00	$53,358	$22,870

Applying the process described in Section F.4 yields an internal events cost-risk of $480,477. After accounting for "round up" of the base internal events cost-risk, this value is $481,294. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$481,294 * 5.2 = \$2,502,729$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 15 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$2,502,729	$3,154,871

Based on a $1,370,000 cost of implementation for LSCS, the net value for this SAMA is $1,784,871 ($3,154,871 - $1,370,000), which indicates this SAMA is potentially cost-beneficial.

F.6.15 SAMA 16: PROVIDE PORTABLE FANS FOR ALTERNATE ROOM COOLING IN THE CORE STANDBY COOLING SYSTEM VAULTS

Pump cubicle cooling fan or damper failures can result in the failure of the pumps in the Core Standby Cooling System vaults after heat up. Providing portable fans (and potentially temporary ductwork) could prevent failure by providing a temporary, alternate source of cubicle cooling. Room heat up calculations would be required as part of this effort to demonstrate that the portable fans could provide adequate cooling.

Assumptions:

The model includes an action to manually initiate CSCS cooling if automatic initiation fails. No credit is taken to align alternate room cooling if the action to manually initiate the existing HVAC system fails after auto initiation failure.

This SAMA is assumed to completely eliminate room cooling hardware failures.

PRA Model Changes to Model SAMA:

The alternate CSCS room cooling capability has been approximated by deleting the gates associated with room cooling failures (excluding the automatic initiation failures, which are already addressed in the model).

Model Change(s):

The following modeling changes were made to the main and recovery fault trees:

- Gate CSCS-RM-1X (UNIT 1 CSCS DIV 1 PUMP ROOM COOLING FAILS): Deleted.
- Gate CSCS-RM-1 (UNIT 2 CSCS DIV 1 ROOM COOLING FAILS): Deleted.
- Gate CSCS-RM-2X (UNIT 1 CSCS DIV. 2 ROOM COOLING FAILS): Deleted.
- Gate CSCS-RM-2 (UNIT 2 CSCS DIV 2 ROOM COOLING FAILS): Deleted.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.23E-06	6.24	$45,595
Percent Change	13.6%	12.2%	14.5%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	5.92E-08	3.14E-01	3.13E-01	$2,763	$2,759
H/I	1.90E-08	1.40E-08	1.08E-01	7.92E-02	$954	$703
M/E	2.14E-07	2.10E-07	1.58E+00	1.55E+00	$9,395	$9,219
M/I	9.27E-07	7.20E-07	3.58E+00	2.78E+00	$32,723	$25,416
L/E	3.88E-07	3.77E-07	8.57E-02	8.33E-02	$124	$120
L/I	1.45E-07	1.27E-07	1.03E-01	9.00E-02	$177	$155
INTACT	7.45E-07	6.40E-07	1.62E-03	1.39E-03	$1	$1
Total	2.58E-06	2.23E-06	7.11E+00	6.24E+00	$53,358	$45,595

Applying the process described in Section F.4 yields an internal events cost-risk of $934,652. After accounting for "round up" of the base internal events cost-risk, this value is $935,469. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$935{,}469 * 5.2 = \$4{,}864{,}439$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 16 Averted Cost-Risk			
Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$4,864,439	$793,161

Based on a $475,000 cost of implementation for LSCS, the net value for this SAMA is $318,161 ($793,161 - $475,000), which indicates this SAMA is potentially cost-beneficial.

F.6.16 SAMA 18 IMPROVE THE CONNECTION BETWEEN THE FIRE PROTECTION AND FEEDWATER SYSTEMS

For SBO cases with failure of RCIC, aligning the fire protection system to the feedwater system using fire hoses cannot prevent core damage, primarily due to a lengthy alignment time. This time could be reduced by providing a hard pipe connection between the two systems. If a permanent connection between the systems is undesirable, a short, flexible connecting hose could potentially be maintained out of the flowpath provided that rapid alignment could be demonstrated.

Assumptions:

The improved hard pipe connection reduces alignment time such that fire water can be aligned in time to mitigate loss of all injection scenarios.

Even with the RPV depressurized and a hard pipe connection to the RPV, elevation differences may present pressure challenges that would limit injection flow such that it would be inadequate in cases where all injection fails at the time of the initiating event. However, it is assumed that this SAMA will allow fire protection to be used to prevent core damage even when injection from other sources is lost at the time of the initiating event.

No credit is taken for the fire water makeup alignment for scenarios involving loss of inventory from the RPV via LOCAs, IORV events, or leakage after water hammer events. The exception is for ISLOCAs that have been isolated and for the un-isolated ISLOCA leaks (but not ruptures) where the makeup requirements are low.

The short time frame associated with aligning fire protection for injection in cases where other injection systems have failed is likely a non-negligible contributor, but the action to align fire water in these scenarios is assumed to be 100% reliable.

The existing logic for aligning the fire protection system for injection post venting or containment failure includes alignment errors. One event represents the failure to align injection under nominal conditions and another represents the impact of hash environment on the alignment.

The installation of the hard pipe connection is assumed to eliminate the nominal alignment action, but the failure associated with harsh environmental conditions was retained.

The hard pipe connection is not assumed to provide any additional benefit for post core damage conditions.

The fire protection system is not seismically qualified, but credit is taken for its use in seismic events to conservatively show an increased benefit for the SAMA.

PRA Model Changes to Model SAMA:

The fault tree was updated to credit the fire protection system in the places where LPCI and LPCS are credited, but the system is failed for the LOCA and IORV initiating event and for water hammer scenarios. In addition, the logic was changed to include the fire protection system injection capability in the early SBO scenarios in which ADS is available for those sequences not impact by the LPCS-LPCI gate.

Model Change(s):

The following changes were made to the fault tree:

- Created new OR gate SAMA18-G1: This gate includes the following existing events and gates:
  - Gate FPS-FAILURE (FIRE PROTECTION SYSTEM FAILURE)
  - Gate IE-SLOCA (SMALL LOCA INITIATING EVENT)
  - Gate LOCA-NOT-S2 (LOCA INITIATORS GREATER THAN SLOCA)
  - Initiating event %TI (INADVERTENTLY OPEN RELIEF VALVE INITIATING EVENT)
  - Basic event 2RHSYLEAKA---L-- (RH TRAIN A FAILS DUE TO EXCESSIVE LEAKAGE FOLLOWING WATER HAMMER)
  - Basic event 2RHSYARUPTFLOOD- (RH TRAIN A WATER HAMMER INDUCED RUPTURE CAUSES FLOODING)
  - Basic event 2RHSYLEAKB---L-- (2RHSYLEAKB---L--
  - Basic event 2RHSYRUPTUREBR-- (RH TRAIN B FAILS DUE TO RUPTURE FOLLOWING WATER HAMMER)
  - Gate SCRAM-FAILS
- Created new OR gate SAMA18-G2: This gate includes the following existing events and gates:
  - Gate FPS-FAILURE (FIRE PROTECTION SYSTEM FAILURE)
  - ADS
- Added new OR gate SAMA18-G1 under the following gates:

  - Existing gate LPCI-LPCS
  - Existing gate LPI-TBRB-FLD
  - Existing gate LPI-FSTB
- Deleted event 2FPOPALGNFPSAH-- (HEP: OPERATOR FAILS TO ALIGN FPS FOLLOWING CONTAINMENT VENT OR FAILURE)
- Added new OR gate SAMA18-G2 under the following gates:
  - ILOC-002P
  - ILOC-008P
- Added existing gate FPS-FAILURE under gate ILOC-006P.

The recovery tree was merged with the updated fault tree logic in order to ensure the recovery logic includes the changes from the SAMA modifications.

<u>Results of SAMA Quantification:</u>

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.36E-06	6.48	$47,858
Percent Change	8.5%	8.9%	10.3%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	5.68E-08	3.14E-01	3.00E-01	$2,763	$2,647
H/I	1.90E-08	9.60E-09	1.08E-01	5.43E-02	$954	$482
M/E	2.14E-07	2.09E-07	1.58E+00	1.54E+00	$9,395	$9,175
M/I	9.27E-07	7.95E-07	3.58E+00	3.07E+00	$32,723	$28,064
L/E	3.88E-07	3.58E-07	8.57E-02	7.91E-02	$124	$114
L/I	1.45E-07	1.25E-07	1.03E-01	8.86E-02	$177	$153
INTACT	7.45E-07	7.23E-07	1.62E-03	1.57E-03	$1	$1
Total	2.58E-06	2.36E-06	7.11E+00	6.48E+00	$53,358	$47,858

Applying the process described in Section F.4 yields an internal events cost-risk of $979,475. After accounting for "round up" of the base internal events cost-risk, this value is $980,292. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{\text{SAMA}} = \$980{,}292 * 5.2 = \$5{,}097{,}518$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 18 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,097,518	$560,082

Based on a $649,194 cost of implementation for LSCS, the net value for this SAMA is -$89,112 ($560,082 - $649,194), which indicates this SAMA is not cost-beneficial.

F.6.17 SAMA 19: PROVIDE REMOTE ALIGNMENT CAPABILITY OF RHRSW TO THE LPCS SYSTEM FOR LOCA MITIGATION

For some LOCA scenarios, CCF plugging of the ECCS suction strainers can fail all ECCS injection. Providing the operators with the ability to cross-tie the RHRSW system to the LPCS system from the MCR would provide a source of makeup to the RPV for cases in which RPV depressurization is available. While more costly than the manual cross-tie evaluated in SAMA 15, the ability to align the cross-tie from the MCR is essential because of the limited time that is available to mitigate the LOCA events (no injection sources available).

In addition, it could potentially serve as a mitigating feature for some post core damage phenomena, such as preventing RPV meltthrough; however, the availability of such a system would generally preclude core damage and the conditions under which it would provide this type of benefit would be limited.

<u>Assumptions:</u>

The action to align the cross-tie occurs in the main control room and can be performed in the time range of 5 minutes and can be used in any scenario in which LPCS is currently credited.

The hardware associated with the use of the RHRSW-LPCS x-tie is not impacted by the reactor building environment.

The breaks outside containment (BOC) and ISLOCA rupture events are large enough to depressurize the RPV to allow low pressure injection without ADS. The ISLOCA leak events require ADS.

The hardware modification was designed to use flow from at least two RHRSW pumps, but one pump is required for success in the SAMA model (to maximize benefit).

The HFE for aligning the cross-tie was treated as an independent event.

PRA Model Changes to Model SAMA:

The inclusion of the RHRSW-LPCS cross-tie required changes to both the main fault tree and the recovery fault tree. The cross-tie was assumed to require the LPCS injection path (existing logic from the LPCS system) and the availability of the RHRSW pumps (existing logic from the RHRSW system). ISLOCAs in the LPCS line were included as failure for the cross tie, as was an event representing the failure to align the cross-tie. The cross-tie logic was added at the sequence level for BOC and ISLOCA sequences where credit was not previously taken for any low pressure injection systems. The logic was also added to the existing fault tree structure in scenarios where venting or containment failure resulted in the loss of injection systems.

Model Change(s):

The following change was made to the main fault tree:

- Created new basic event SAMA19 (FAILURE TO ALIGN RHRSW-LPCS X-TIE): Probability set to 1.0E-03.
- Created new OR gate SAMA19-G1 with the following inputs:
  - Existing gate LPCS-PMP-ISOL
  - Event %ISLOCA-LPCS
  - Existing gate RHRA-SW-FAILURE
  - New event SAMA19
- Created new OR gate SAMA19-G2 with the following inputs:
  - SAMA19-G1
  - ADS
- Added gate SAMA19-G1 to the following gates:
  - LPCI-LPCS

- BOC-003P
- ILOC-009P
- CTFAIL-MU-LPI
- VENT-MU-LPI
- RX2HRDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
- RX10RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
- RX12RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
- RX13RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
- FC-HRDFLR-EXTSRC (HARDWARE FAILURE OF EXTERNAL SOURCES)
- FC-HRDFLR-EXTSRC-SBO (HARDWARE FAILURE OF EXTERNAL SOURCES)

- Added gate SAMA19-G2 to the following gates:
  - ILOC-002P
  - ILOC-008P
  - MU-INJ (While SAMA 19 would not be impacted by harsh environmental conditions, the model structure under gate MU2 where MU-INJ is used will fail the SAMA, but it is a small contributor and is neglected for simplicity.)

The recovery tree was merged with the updated fault tree logic in order to ensure the recovery logic includes the changes from the SAMA modifications.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	1.59E-06	3.00	$22,465
Percent Change	38.4%	57.8%	57.9%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	Freq.$_{BASE}$	Freq.$_{SAMA}$	Dose-Risk$_{BASE}$	Dose-Risk$_{SAMA}$	OECR$_{BASE}$	OECR$_{SAMA}$
H/E-BOC	8.32E-08	8.49E-09	1.34E+00	1.37E-01	$7,222	$737
H/E	5.93E-08	4.90E-08	3.14E-01	2.59E-01	$2,763	$2,283
H/I	1.90E-08	1.72E-08	1.08E-01	9.74E-02	$954	$863
M/E	2.14E-07	1.32E-07	1.58E+00	9.75E-01	$9,395	$5,795
M/I	9.27E-07	3.55E-07	3.58E+00	1.37E+00	$32,723	$12,532
L/E	3.88E-07	3.64E-07	8.57E-02	8.04E-02	$124	$116
L/I	1.45E-07	1.13E-07	1.03E-01	8.01E-02	$177	$138
INTACT	7.45E-07	5.51E-07	1.62E-03	1.20E-03	$1	$0
Total	2.58E-06	1.59E-06	7.11E+00	3.00E+00	$53,358	$22,465

Applying the process described in Section F.4 yields an internal events cost-risk of $471,758. After accounting for "round up" of the base internal events cost-risk, this value is $472,575. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$472,575 * 5.2 = \$2,457,390$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 19 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$2,457,390	$3,200,210

Based on a $2,900,000 cost of implementation for LSCS, the net value for this SAMA is $300,210 ($3,200,210 - $2,900,000), which indicates this SAMA is potentially cost-beneficial.

F.6.18 SAMA 20 IMPROVE VACUUM BREAKER RELIABILITY BY INSTALLING REDUNDANT VALVES IN EACH LINE

For cases in which the vacuum breaker fails to reclose, the vapor suppression capability of the suppression pool is bypassed because an open pathway exists between the wetwell and the drywell. Events that result in a release of reactor inventory into the drywell can rapidly overpressurize containment without the condensing capability of the wetwell and cause a containment breach. Installation of redundant vacuum breakers would reduce the probability of failures that lead to suppression pool bypass.

Assumptions:

It is assumed that implementation of this SAMA will eliminate all failures of the vacuum breakers to reclose.

PRA Model Changes to Model SAMA:

The installation of the redundant vacuum breakers is modeled by setting the probability of the vacuum breakers failing to reclose to 0.0.

It is assumed that there are no negative consequences associated with installing the redundant vacuum breakers (i.e., the failure to open probability of the vacuum breakers is not increased).

Model Change(s):

The following changes were made in the cutsets:

- 2VSVBPC001A--K-- (VACUUM BREAKER 2PC001A FAILS TO RECLOSE DURING ACCIDENT RESPONSE): Probability set to 0.0.
- 2VSVBPC001B--K-- (VACUUM BREAKER 2PC001B FAILS TO RECLOSE DURING ACCIDENT RESPONSE): Probability set to 0.0.
- 2VSVBPC001C--K-- (VACUUM BREAKER 2PC001C FAILS TO RECLOSE DURING ACCIDENT RESPONSE): Probability set to 0.0.
- 2VSVBPC001D--K-- (VACUUM BREAKER 2PC001D FAILS TO RECLOSE DURING ACCIDENT RESPONSE): Probability set to 0.0.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.55E-06	6.98	$52,232
Percent Change	1.2%	1.8%	2.1%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq_{BASE}$	$Freq_{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	3.51E-08	3.14E-01	1.86E-01	$2,763	$1,636
H/I	1.90E-08	1.90E-08	1.08E-01	1.08E-01	$954	$954
M/E	2.14E-07	2.14E-07	1.58E+00	1.58E+00	$9,395	$9,395
M/I	9.27E-07	9.27E-07	3.58E+00	3.58E+00	$32,723	$32,723
L/E	3.88E-07	3.89E-07	8.57E-02	8.60E-02	$124	$124
L/I	1.45E-07	1.45E-07	1.03E-01	1.03E-01	$177	$177
INTACT	7.45E-07	7.38E-07	1.62E-03	1.60E-03	$1	$1
Total	2.58E-06	2.55E-06	7.11E+00	6.98E+00	$53,358	$52,232

Applying the process described in Section F.4 yields an internal events cost-risk of $1,065,514. After accounting for "round up" of the base internal events cost-risk, this value is $1,066,331. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,066,331 * 5.2 = \$5,544,921$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 20 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,544,921	$112,679

Based on a $1,150,000 cost of implementation for LSCS, the net value for this SAMA is -$1,037,321 ($112,679 - $1,150,000), which indicates this SAMA is not cost-beneficial.

F.6.19 SAMA 21 AUTOMATIC ATWS LEVEL CONTROL SYSTEM

For failure to scram conditions, early reduction in RPV level is important to limit the heat load sent to the containment, the reliability of which could be improved by automating the reduction of RPV level to just above -129 inches, ADS inhibit, and the "terminate and prevent" step (to disallow automatic RPV makeup from non-Feedwater sources). The logic would be required to actuate without operator interface and only actuate when the Feedwater system is available and providing makeup to the RPV. This would increase the time available for the operators to perform the other actions required early in ATWS scenarios, such as MSIV low level isolation logic bypass and SBLC initiation.

Assumptions:

This SAMA is assumed to eliminate level control failures, both early and late.

PRA Model Changes to Model SAMA:

The SAMA is modeled by setting the early and late level control actions to 0.0 in the fault tree.

Model Change(s):

The following changes were made in the fault tree:

- 2SLOP-LVLCTRLH-- (HEP: OPERATOR FAILS TO LOWER LEVEL EARLY (ATWS)): Event failure probability set to 0.0.
- 2SLOP-LATELVLH-- (HEP: OPERATOR FAILS TO CONTROL LEVEL LATE IN ATWS (COND PROB)): Event failure probability set to 0.0.
- 2ADOP-INHIB-EH-- (HEP: OPERATOR FAILS TO INHIBIT ADS WITH FEEDWATER AND EARLY LEVEL CONTROL): Event failure probability set to 0.0.
- 2ADOP-INHIBHPH-- (HEP: OPERATOR FAILS TO INHIBIT ADS - ATWS (FW AND MAIN CONDENSER AVAILABLE)): Event failure probability set to 0.0.
- 2ADOPINHIBIT-H-- (HEP: OPERATOR FAILS TO INHIBIT ADS IN ATWS (NO HP INJECTION)): Event failure probability set to 0.0.
- 2ADOP-INHIB-LH-- (HEP: OPERATOR FAILS TO INHIBIT ADS WITH FEEDWATER AND LATE LEVEL CONTROL): Event failure probability set to 0.0.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.22E-06	6.10	$47,165
Percent Change	14.0%	14.2%	11.6%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq_{BASE}$	$Freq_{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	4.74E-08	3.14E-01	2.51E-01	$2,763	$2,209
H/I	1.90E-08	1.90E-08	1.08E-01	1.08E-01	$954	$954
M/E	2.14E-07	9.90E-08	1.58E+00	7.32E-01	$9,395	$4,346
M/I	9.27E-07	9.12E-07	3.58E+00	3.52E+00	$32,723	$32,194
L/E	3.88E-07	1.95E-07	8.57E-02	4.31E-02	$124	$62
L/I	1.45E-07	1.45E-07	1.03E-01	1.03E-01	$177	$177
INTACT	7.45E-07	7.19E-07	1.62E-03	1.56E-03	$1	$1
Total	2.58E-06	2.22E-06	7.11E+00	6.10E+00	$53,358	$47,165

Applying the process described in Section F.4 yields an internal events cost-risk of $953,778. After accounting for "round up" of the base internal events cost-risk, this value is $954,595. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$954{,}595 * 5.2 = \$4{,}963{,}894$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 21 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$4,963,894	$693,706

Based on a $1,481,002 cost of implementation for LSCS, the net value for this SAMA is -$787,296 ($693,706 - $1,481,002), which indicates this SAMA is not cost-beneficial.

F.6.20 SAMA 22 HYDROGEN IGNITORS IN PRIMARY CONTAINMENT

For cases in which containment venting is not adequate to prevent the buildup of combustible gases or when venting has failed, burning the combustible gases before they reach levels where detonation can cause containment failure is a means of reducing the consequences of severe accidents. Providing a means of power during SBO events would improve the capabilities of this system.

Assumptions:

This SAMA is assumed to eliminate combustible gas detonations.

PRA Model Changes to Model SAMA:

The SAMA is modeled by setting the failure probability of hydrogen detonation to 0.0 in the cutsets.

Model Change(s):

The following changes were made in the cutsets:

- 2CZPH-H2-DEFGF-- (HYDROGEN DEFLAGRATION OCCURS GLOBALLY): Event failure probability set to 0.0.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.58E-06	7.07	$53,011
Percent Change	0.0%	0.6%	0.7%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	5.44E-08	3.14E-01	2.88E-01	$2,763	$2,535
H/I	1.90E-08	1.66E-08	1.08E-01	9.40E-02	$954	$833
M/E	2.14E-07	2.14E-07	1.58E+00	1.58E+00	$9,395	$9,395
M/I	9.27E-07	9.27E-07	3.58E+00	3.58E+00	$32,723	$32,723
L/E	3.88E-07	3.89E-07	8.57E-02	8.60E-02	$124	$124
L/I	1.45E-07	1.45E-07	1.03E-01	1.03E-01	$177	$177
INTACT	7.45E-07	7.51E-07	1.62E-03	1.63E-03	$1	$1
Total	2.58E-06	2.58E-06	7.11E+00	7.07E+00	$53,358	$53,011

Applying the process described in Section F.4 yields an internal events cost-risk of $1,080,761. After accounting for "round up" of the base internal events cost-risk, this value is $1,081,578. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1{,}081{,}578 * 5.2 = \$5{,}624{,}206$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 22 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,624,206	$33,394

Based on a $205,000 cost of implementation for LSCS, the net value for this SAMA is -$171,606 ($33,394 - $205,000), which indicates this SAMA is not cost-beneficial.

F.6.21 SAMA 23 ENHANCE FUEL POOL EMERGENCY MAKEUP PUMP AND CONNECTION

For post core damage conditions, a system capable of injecting 1000 gpm or more to the RPV is estimated to be required to prevent reactor vessel meltthrough and core-concrete interactions that can fail the drywell. Replacing the existing Fuel Pool Emergency Makeup Pump with a higher pressure/higher flow pump and creating a permanent connection to the B RHR line could provide this capability. The capability would be similar to that of the local, manual RHRSW/LPCS cross-tie, but it makes use of a diverse system that is not currently considered in the PRA. This SAMA would also potentially be able to prevent core damage in many of the scenarios requiring water to prevent the RPV meltthrough and drywell failure events.

Assumptions:

The hard pipe connection provides a simplified means of aligning injection such that the fuel pool emergency makeup pump can be aligned in time to mitigate loss of all injection scenarios.

No credit is taken for this injection source for scenarios involving loss of inventory from the RPV via LOCAs, IORV events, or leakage after water hammer events. Credit is taken for mitigating isolated interfacing systems LOCAs because the makeup flow rate is low and there is assumed to be adequate time to respond. Credit is taken for these scenarios in post core damage periods because the requirements are different.

The local alignment requirement is assumed to preclude credit for ATWS scenarios.

The upgraded pump is assumed to be backed by the same Division 2 480V AC bus as the existing B pump (bus 236Y).

PRA Model Changes to Model SAMA:

The inclusion of the fuel pool emergency makeup pump cross-tie required changes to be made to both the main fault tree and the recovery fault tree. The cross-tie was assumed to require the RHR B injection path (existing logic from the LPCI system). The logic was added to the existing fault tree structure in scenarios where venting or containment failure resulted in the loss of injection systems.

Model Change(s):

The following change was made to the main fault tree:

- Created new basic event SAMA23 (FAILURE OF ALIGNEMNT, OPERATION, OR HARDWARE FOR EFPMU): Probability set to 1.0E-03.
- Created new OR gate SAMA23-G1 including the following inputs:
  - Gate RHRB-INJ-PATH (RHR TRAIN B INJ PATH FAULTS)
  - Gate IE-SLOCA (SMALL LOCA INITIATING EVENT)
  - Gate LOCA-NOT-S2 (LOCA INITIATORS GREATER THAN SLOCA)
  - Gate 2AP22E-PWR (LOSS OF POWER AT 480 VAC SWGR 236Y)
  - Gate SCRAM-FAILS.
  - New event SAMA23
  - Initiating event %TI (INADVERTENTLY OPEN RELIEF VALVE INITIATING EVENT)
  - Basic event 2RHSYLEAKA---L-- (RH TRAIN A FAILS DUE TO EXCESSIVE LEAKAGE FOLLOWING WATER HAMMER)
  - Basic event 2RHSYARUPTFLOOD- (RH TRAIN A WATER HAMMER INDUCED RUPTURE CAUSES FLOODING)
  - Basic event 2RHSYLEAKB---L-- (RH TRAIN B FAILS DUE TO EXCESSIVE LEAKAGE FOLLOWING WATER HAMMER)
  - Basic event 2RHSYRUPTUREBR-- (RH TRAIN B FAILS DUE TO RUPTURE FOLLOWING WATER HAMMER)
- Created new OR gate SAMA23-G2 with the following inputs:

  - ADS
  - SAMA23-G1
- Added gate SAMA23-G1 to the following gates:
  - LPCI-LPCS
  - CTFAIL-MU-LPI
  - VENT-MU-LPI
- Added new gate SAMA23-G2 to the following gates:
  - ILOC-008P
  - MU-INJ (While SAMA 23 would not be impacted by harsh environmental conditions, the model structure under gate MU2 where MU-INJ is used will fail the SAMA, but it is a small contributor and is neglected for simplicity.)
- Created new OR gate SAMA23-G1-L2 with the following inputs (to allow post core damage credit for LOCA and ATWS cases in which the injection lines would be intact):
  - Gate RHRB-INJ-PATH (RHR TRAIN B INJ PATH FAULTS)
  - Gate 2AP22E-PWR (LOSS OF POWER AT 480 VAC SWGR 236Y)
  - New event SAMA23
  - Basic event 2RHSYLEAKB---L-- (RH TRAIN B FAILS DUE TO EXCESSIVE LEAKAGE FOLLOWING WATER HAMMER)
  - Basic event 2RHSYRUPTUREBR-- (RH TRAIN B FAILS DUE TO RUPTURE FOLLOWING WATER HAMMER)
  - %ISLOCA-RHRB-S (RHR B SDC RETURN LINE ISLOCA)
  - %ISLOCA-RHRB (RHR B INJECTION LINE ISLOCA)
- Added new gate SAMA23-G1-L2 to the following gates
  - RX2HRDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
  - RX10RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
  - RX12RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
  - RX13RDFLR-ALTINJ (HARDWARE FAILURE OF ALTERNATE INJECTION SYSTEMS)
  - FC-HRDFLR-EXTSRC (HARDWARE FAILURE OF EXTERNAL SOURCES)
  - FC-HRDFLR-EXTSRC-SBO (HARDWARE FAILURE OF EXTERNAL SOURCES)

The recovery tree was merged with the updated fault tree logic in order to ensure the recovery logic includes the changes from the SAMA modifications.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	1.89E-06	3.87	$25,797
Percent Change	26.7%	45.6%	51.7%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	4.91E-08	3.14E-01	2.60E-01	$2,763	$2,288
H/I	1.90E-08	8.60E-09	1.08E-01	4.87E-02	$954	$432
M/E	2.14E-07	1.41E-07	1.58E+00	1.04E+00	$9,395	$6,190
M/I	9.27E-07	2.67E-07	3.58E+00	1.03E+00	$32,723	$9,425
L/E	3.88E-07	3.58E-07	8.57E-02	7.91E-02	$124	$114
L/I	1.45E-07	1.02E-07	1.03E-01	7.23E-02	$177	$124
INTACT	7.45E-07	8.81E-07	1.62E-03	1.91E-03	$1	$1
Total	2.58E-06	1.89E-06	7.11E+00	3.87E+00	$53,358	$25,797

Applying the process described in Section F.4 yields an internal events cost-risk of $556,276. After accounting for "round up" of the base internal events cost-risk, this value is $557,093. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$557{,}093 * 5.2 = \$2{,}896{,}884$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 23 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$2,896,884	$2,760,716

Based on a $1,370,000 cost of implementation for LSCS, the net value for this SAMA is $1,390,716 ($2,760,716 - $1,370,000), which indicates this SAMA is potentially cost-beneficial.

F.6.22 SAMA 24 PROVIDE INTER DIVISION 4KV AC CROSS-TIE CAPABILITY

The existing inter-unit cross-tie capability is valuable at LSCS, but additional flexibility could be gained by providing the capability to perform inter-divisional AC cross-ties in accident scenarios (e.g., 241Y to 242Y, or 242Y to 243C).

Assumptions:

Failure to perform the inter-unit cross-tie and the inter-division cross-tie are completely dependent (the same HFE is used for all cross-ties).

Any 4KV emergency bus can be supplied by any other emergency 4kV bus from the same unit.

PRA Model Changes to Model SAMA:

The implementation of the inter-division cross-tie is modeled by including the other two diesel generators from the same unit as potential power supply sources for a given emergency bus.

Model Change(s):

The following changes were made to the division 1 logic under gate 241Y-PWR-SOURCES in the fault tree:

- Under existing gate 241Y-PWR-SOURCES, added new gate SAMA24-G1.
- New gate SAMA24-G1 (X-TIE FROM OTHER DIVISIONS ON SAME UNIT): OR gate with the following inputs:
  - Existing gate 2AP04E-FLT (4KV 241Y FAULTS)
  - Existing event 2ACOP142-242-H-- (HEP: OPERATOR FAILS TO CROSS TIE 4kV BUS TO OTHER UNIT)
  - New gate SAMA24-G2 (OTHER UNIT SOURCES)
- Created new gate SAMA24-G2 (OTHER UNIT SOURCES): AND gate with the following inputs:
  - New gate SAMA24-G3 (242 POWER)
  - New gate SAMA24-G4 (243 POWER)
- Created new gate SAMA24-G3 (242 POWER): OR gate with the following 2 inputs:
  - Existing gate 2AP06E-FLT (4KV 242Y FAULTS)
  - Existing gate DG2A-FAILURE (DG2A FAILURE)

- Created new gate SAMA24-G4 (243 POWER): OR gate with the following 2 inputs)
  - Existing gate 1E243C-FAULTS (4KV BUS 243C FAULTS (2AP07E))
  - Existing gate DG2B-FAILURE (DG2B FAILURE)

The changes made to FLOOD versions of the Division 1 power logic and for the other divisions were similar. The top gates associated with the logic changes are:

- 241Y-PWRSOURCESF
- 242Y-PWR-SOURCES
- 242Y-PWRSOURCESF
- 243C-PWR-SOURCES
- 243C-PWRSOURCESF

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.46E-06	6.73	$50,036
Percent Change	4.7%	5.3%	6.2%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	5.91E-08	3.14E-01	3.13E-01	$2,763	$2,754
H/I	1.90E-08	1.37E-08	1.08E-01	7.75E-02	$954	$688
M/E	2.14E-07	2.11E-07	1.58E+00	1.56E+00	$9,395	$9,263
M/I	9.27E-07	8.45E-07	3.58E+00	3.26E+00	$32,723	$29,829
L/E	3.88E-07	3.87E-07	8.57E-02	8.55E-02	$124	$123
L/I	1.45E-07	1.28E-07	1.03E-01	9.08E-02	$177	$156
INTACT	7.45E-07	7.33E-07	1.62E-03	1.59E-03	$1	$1
Total	2.58E-06	2.46E-06	7.11E+00	6.73E+00	$53,358	$50,036

Applying the process described in Section F.4 yields an internal events cost-risk of $1,022,497. After accounting for "round up" of the base internal events cost-risk, this value is $1,023,314. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,023,314 * 5.2 = \$5,321,233$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 24 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,321,233	$336,367

Based on a $1,824,084 cost of implementation for LSCS, the net value for this SAMA is -$1,487,717 ($336,367 - $1,824,084), which indicates this SAMA is not cost-beneficial.

F.6.23 SAMA 25 PERIODIC TRAINING ON WATER HAMMER SCENARIOS RESULTING FROM A FALSE LOCA SIGNAL

In transient scenarios, even with RHR operating in SPC mode, the DW will still reach 2 psig and a high DW pressure signal will register. When a consequential loss of offsite power occurs with the LOCA signal, this results in a load shed of the emergency buses while the EDGs start, during which time the discharge line of the previously running RHR train will drain to the suppression pool. When the RHR system is reloaded onto the emergency bus and the RHR pump starts, the discharge line will be empty and vulnerable to a water hammer event (PRA specific scenario). Incorporating training on this scenario into the Licensed Operator Cycle Training Plans would institutionalize it in a manner that would help ensure the operators maintain proficiency in addressing these types of scenarios and potentially improve the reliability of the actions required to prevent a water hammer event.

<u>Assumptions:</u>

It is assumed that the implementation of this SAMA would make the action to vent the drywell to prevent the 2 psig signal from registering (2CVOP2INCHVNTH--) highly familiar to the operators. The improvement in the training can be reflected in the PRA by the use of the lower bound ASEP curve in place of the median curve. The change in training would not impact the timing, the PSFs, or the recovery dependencies used in the action assessment such that the updated HEP would be calculated by removing the current ASEP contribution of 6.9E-02 and replacing it with 2.6E-03. This change results in a reduction of the HEP from 9.1E-02 to 2.5E-02.

The JHEPs including the action 2CVOP2INCHVNTH-- are reduced by the ratio of the new HEP to the old HEP (2.5E-02 / 9.1E-02 = 0.27).

PRA Model Changes to Model SAMA:

This SAMA was modeled by changing basic event values in the cutsets to reflect the improved reliability of the drywell venting action for preventing a LOCA signal in non-LOCA cases.

Model Change(s):

The following event probability changes were made to the cutsets:

- 2CVOP2INCHVNTH-- (HEP: OPERATOR FAILS TO OPEN 2" LINES TO MAINTAIN DW PRESSURE BELOW HI DW SETPOINT): HEP changed to 2.5E-02.
- 2RX-CVRHACFP5H-- (JHEP): Set to 3.8E-06.
- 2RX-CV-RH-AC4H-- (JHEP): Set to 7.6E-06.
- 2RX-WHLTRIPL3H-- (JHEP): Set to 1.3E-03.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.44E-06	6.92	$52,887
Percent Change	5.4%	2.7%	0.9%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq_{BASE}$	$Freq_{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	5.82E-08	3.14E-01	3.08E-01	$2,763	$2,712
H/I	1.90E-08	1.90E-08	1.08E-01	1.08E-01	$954	$954

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
M/E	2.14E-07	2.13E-07	1.58E+00	1.57E+00	$9,395	$9,351
M/I	9.27E-07	9.24E-07	3.58E+00	3.57E+00	$32,723	$32,617
L/E	3.88E-07	3.86E-07	8.57E-02	8.53E-03	$124	$12
L/I	1.45E-07	1.43E-07	1.03E-01	1.01E-02	$177	$17
INTACT	7.45E-07	6.14E-07	1.62E-03	1.33E-03	$1	$1
Total	2.58E-06	2.44E-06	7.11E+00	6.92E+00	$53,358	$52,887

Applying the process described in Section F.4 yields an internal events cost-risk of $1,070,541. After accounting for "round up" of the base internal events cost-risk, this value is $1,071,358. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,071,358 * 5.2 = \$5,571,062$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 25 Averted Cost-Risk

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
LSCS Unit 2	$5,657,600	$5,571,062	$86,538

Based on a $112,000 cost of implementation for LSCS, the net value for this SAMA is -$25,462 ($86,538 - $112,000), which indicates this SAMA is not cost-beneficial.

F.6.24 SAMA 27 PRECLUDE EMERGENCY DEPRESSURIZATION WHEN RCIC IS THE ONLY INJECTION SYSTEM AVAILABLE AND PROVIDE LONG TERM DC POWER

For cases where RCIC is the only injection system available, it would be possible to prevent core damage by changing the EOPs to allow RPV pressure to be maintained in the range of 150 to 250 psig even when containment temperature and pressure limits are violated. This would ensure the RCIC steam head is not lost in long term loss of containment heat removal scenarios. Providing a 480V AC generator to supply a battery charger would maintain plant instrumentation and control power, which would improve the reliability of this strategy.

In addition to these changes, it is likely that some additional modifications would be required to maintain RCIC operation in long term SBO cases, such as changing procedures to bypass the

RCIC high containment back pressure turbine trip logic. These changes are assumed to be included as part of this SAMA, but are not added to the cost of implementation.

Assumptions:

This SAMA eliminates the risk associated with scenarios in which RCIC is initially operational in SBO scenarios.

It is assumed that an SORV initiator does not depressurize the RPV to the point where RCIC is unavailable. This conservatively increases the benefit of the SAMA.

Any additional changes required to ensure RCIC is operational in long term SBO scenarios are assumed to be included as part of this SAMA, such as procedure changes to bypass the RCIC high containment back pressure turbine trip logic.

PRA Model Changes to Model SAMA:

The SAMA is modeled by setting the failure probability of sequences in which RCIC is initially operation in an SBO to 0.0 in the cutsets.

Model Change(s):

The following sequence flags were set to 0.0 in the cutsets:

- RCVSEQ-DLOP-025, RCVSEQ-DLOP-028, RCVSEQ-DLOP-030, RCVSEQ-DLOP-032, RCVSEQ-LOOP-025, RCVSEQ-LOOP-028, RCVSEQ-LOOP-030, RCVSEQ-LOOP-032, RCVSEQ-SRVD-028, RCVSEQ-SRVD-031, RCVSEQ-SRVD-035, RCVSEQ-SRVD-038, RCVSEQ-SRVD-040, RCVSEQ-SRVL-028, RCVSEQ-SRVL-031, RCVSEQ-SRVL-035, RCVSEQ-SRVL-038, RCVSEQ-SRVL-040, RCVSEQ-TBFLD-008, RCVSEQ-TBFLD-010, RCVSEQ-TBFLD-013, RCVSEQ-TBFLD-015, RCVSEQ-TBFLD-016, RCVSEQ-TBFLD-017.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	2.47E-06	6.90	$51,607
Percent Change	4.3%	3.0%	3.3%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq_{BASE}$	$Freq_{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	5.92E-08	3.14E-01	3.13E-01	$2,763	$2,759
H/I	1.90E-08	4.60E-09	1.08E-01	2.60E-02	$954	$231
M/E	2.14E-07	2.14E-07	1.58E+00	1.58E+00	$9,395	$9,395
M/I	9.27E-07	8.99E-07	3.58E+00	3.47E+00	$32,723	$31,735
L/E	3.88E-07	3.89E-07	8.57E-02	8.60E-02	$124	$124
L/I	1.45E-07	1.15E-07	1.03E-01	8.15E-02	$177	$140
INTACT	7.45E-07	7.06E-07	1.62E-03	1.53E-03	$1	$1
Total	2.58E-06	2.47E-06	7.11E+00	6.90E+00	$53,358	$51,607

Applying the process described in Section F.4 yields an internal events cost-risk of $1,051,512. After accounting for "round up" of the base internal events cost-risk, this value is $1,052,329. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$1,052,329 * 5.2 = \$5,472,111$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 27 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$5,472,111	$185,489

Based on a $512,000 cost of implementation for LSCS, the net value for this SAMA is -$326,511 ($185,489 - $512,000), which indicates this SAMA is not cost-beneficial.

F.7 SENSITIVITY ANALYSIS

NEI 05-01 recommends that applicants perform sensitivity analyses that evaluate how changes to certain assumptions and uncertainties in the SAMA analysis would affect the cost-benefit analysis outcome. Accordingly, the following uncertainties were further investigated as to their impact on the overall SAMA evaluation:

- Use of a discount rate of 7 percent, instead of 3 percent used in the base case analysis.

- Use of the 95th percentile PRA results in place of the point estimate PRA results.
- Variations in selected MACCS2 input variables.
- Inclusion of the reliable hard pipe vent on potentially cost-beneficial SAMAs

F.7.1 REAL DISCOUNT RATE

The RDR is an estimate of the the rate of return on invested dollars above the rate of inflation. A scenario with a low RDR would require a larger investment of present day dollars to pay for a future expense than a scenario with a relativley high RDR. In a SAMA analysis, large RDRs reduce the averted cost-risk values associated with SAMA implementation relative to low RDRs because the present day dollar investment to pay for accident mitigation would be less.

The baseline SAMA analysis uses an RDR of 3 percent, which could be viewed as conservative given that NUREG/BR-0184 suggests the use of an RDR of 7 percent (NRC 1997). In this sensitivity case, the Phase 1 and Phase 2 results were re-evaluated using the 7 percent RDR suggested in NUREG/BR-0184.

For the Phase 1 analysis, the MACR was recalculated using the methodology outlined in Section F.4, and the SAMA implementation costs were compared to the revised MACR. Based on the reduction of the MACR to $4,087,200 (a 28 percent reduction of the baseline MACR), SAMA 12 would be screened in the Phase 1 analysis due to the use of the 7 percent RDR.

For the Phase 2 analysis, the determination of cost effectiveness changed for one of the Phase 2 SAMAs when the 7 percent RDR was used in lieu of 3 percent, as shown below.

Summary of the Impact of the RDR Value on the Detailed SAMA Analyses

SAMA ID	Implementation Cost (per unit)	Averted Cost Risk (3 percent RDR)	Net Value (3 percent RDR)	Averted Cost Risk (7 percent RDR)	Net Value (7 percent RDR)	Change in Cost Effective-ness?
SAMA 1	$12,940,000	$2,294,729	-$10,645,271	$1,652,654	-$11,287,346	No
SAMA 2	$400,000	$1,305,668	$905,668	$939,687	$539,687	No
SAMA 3	$1,000,000	$935,157	-$64,843	$672,479	-$327,521	No
SAMA 4	$635,242	$622,258	-$12,984	$451,500	-$183,742	No
SAMA 5	$400,000	$355,690	-$44,310	$257,488	-$142,512	No

Summary of the Impact of the RDR Value on the Detailed SAMA Analyses

SAMA ID	Implementation Cost (per unit)	Averted Cost Risk (3 percent RDR)	Net Value (3 percent RDR)	Averted Cost Risk (7 percent RDR)	Net Value (7 percent RDR)	Change in Cost Effective-ness?
SAMA 6	$2,900,000	$79,362	-$2,820,638	$57,231	-$2,842,769	No
SAMA 7	$962,403	$49,488	-$912,915	$38,215	-$924,188	No
SAMA 8	$400,000	$242,190	-$157,810	$174,938	-$225,062	No
SAMA 9	$115,000	$207,865	$92,865	$152,136	$37,136	No
SAMA 10	$260,219	$1,208,038	$947,819	$867,901	$607,682	No
SAMA 11	$217,415	$19,703	-$197,712	$14,695	-$202,720	No
SAMA 14	$489,277	$414,170	-$75,107	$299,780	-$189,497	No
SAMA 15	$1,370,000	$3,154,871	$1,784,871	$2,271,885	$901,885	No
SAMA 16	$475,000	$793,161	$318,161	$572,780	$97,780	No
SAMA 18	$649,194	$560,082	-$89,112	$404,050	-$245,144	No
SAMA 19	$2,900,000	$3,200,210	$300,210	$2,304,775	-$595,225	Yes
SAMA 20	$1,150,000	$112,679	-$1,037,321	$81,073	-$1,068,927	No
SAMA 21	$1,481,002	$693,706	-$787,296	$501,748	-$979,254	No
SAMA 22	$205,000	$33,394	-$171,606	$23,899	-$181,101	No
SAMA 23	$1,370,000	$2,760,716	$1,390,716	$1,985,838	$615,838	No
SAMA 24	$1,824,084	$336,367	-$1,487,717	$242,481	-$1,581,603	No
SAMA 25	$112,000	$86,538	-$25,462	$63,996	-$48,004	No
SAMA 27	$512,000	$185,489	-$326,511	$134,363	-$377,637	No

F.7.2 95TH PERCENTILE PRA RESULTS

The results of the SAMA analysis can be impacted by implementing conservative values from the PRA's uncertainty distribution. If the best estimate failure probability values were consistently lower than the "actual" failure probabilities, the PRA model would underestimate plant risk and yield lower than "actual" averted cost-risk values for potential SAMAs. Re-assessing the cost-benefit calculations using the high end of the failure probability distributions is a means of identifying the impact of having consistently underestimated failure probabilities for plant equipment and operator actions included in the PRA model. This sensitivity uses the Level 1 95th percentile results to examine the impact of uncertainty in the PRA model.

In performing the sensitivity analysis, only the base case was used in determining the appropriate value for the 95th percentile. For those SAMAs that required the addition of new basic events, no new uncertainty distributions were assigned since the design and implementation of each SAMA was arbitrary and was defined by the analysis assumptions. The results of this uncertainty analysis, therefore, show the expected statistical uncertainty of the CDF risk metrics under the assumption that each SAMA was designed and implemented as it was specified in this analysis. All calculations were performed using version 3.0 of the EPRI Uncert software package for the LSCS Unit 2 model.

The results of the uncertainty calculation show that the 95th percentile CDF is 5.52E-06, which is a factor of 2.14 greater than the LSCS 2013A CDF point estimate of 2.58E-06. Therefore, for this analysis, the 95th percentile multiplier derived from the base case is used to examine the change in the cost benefit for each SAMA.

F.7.2.1 PHASE 1 IMPACT

For Phase 1 screening, use of the 95th percentile PRA results will increase the MACR and may prevent the screening of some of the higher cost modifications. However, the impact on the overall SAMA results due to the retention of the higher cost SAMAs for Phase 2 analysis is typically small. This is due to the fact that the benefit obtained from the implementation of those SAMAs must be extremely large in order to be cost-beneficial.

The impact of uncertainty in the PRA results on the Phase 1 SAMA analysis has been examined. The MACR is the primary Phase 1 criterion affected by PRA uncertainty. Thus, this portion of the sensitivity is focused on recalculating the MACR using the 95th percentile PRA results and re-performing the Phase 1 screening process. As discussed above, the 95th PRA results are a factor of 2.14 greater than the point estimate CDF.

In order to simulate the use of the 95th percentile PRA results on the cost benefit calculations, the same scaling factor calculated for the Level 1 results was assumed to apply to the Level 3 results. Because the MACR calculations scale linearly with the CDF, dose-risk, and off-site economic cost-risk, the 95th percentile MACR can be calculated by multiplying the base case MACR by 2.14. This results in a 95th percentile MACR of $12,107,264.

The initial SAMA list has been re-examined using the revised MACR to identify SAMAs that would have been retained for the Phase 2 analysis. Those SAMAs that were previously screened due to costs of implementation that exceeded $5,657,600 are now retained if the costs of implementation are less than $12,107,264. For LSCS, SAMAs 17 and 26 were screened in the Phase 1 analysis based on excessive implementation cost (SAMA 1 will be implemented regardless of cost and it was not screened). Because the SAMA 26 implementation cost is less than the 95th percentile MACR, it has been retained for Phase 2 analysis, as documented below.

F.7.2.1.1 SAMA 26: Seismically Qualified Low Pressure RPV Makeup Capability

For seismic initiators that lead to SBOs and early failure of RCIC, aligning the Fire Protection System to the Feedwater system using fire hoses cannot currently prevent core damage. In order to mitigate these types of events, a hard-piped, seismically qualified low pressure injection pump with a seismically qualified suction source and power source would be required. This would ensure the system would be available in seismic events. In order to ensure it could be rapidly aligned for loss of injection cases, this SAMA includes the ability to align the system from the MCR. For power, a non-safety related, seismically qualified diesel generator would be required to energize the pump and to provide long term battery charger support to maintain RPV level instrumentation and SRV control for low pressure injection. The generator would be permanently installed outside of the Reactor Building and would include remote start capability from the MCR to power the makeup pump. Alignment to the existing safety related battery chargers would be performed manually within 4 hours. Ensuring that this capability would likely be available for seismic events with peak ground accelerations of up to 0.46g would address most of the estimated risk.

Assumptions:

The connection provides a simplified means of aligning injection such that emergency makeup to the RPV can be aligned in time to mitigate loss of all injection scenarios.

No credit is taken for this injection source for scenarios involving loss of inventory from the RPV via LOCAs, IORV events, or leakage after water hammer events. Credit is taken for mitigating isolated interfacing systems LOCAs because the makeup flow rate is low and there is assumed to be adequate time to respond. In addition, this SAMA is credited in the un-isolated interfacing system LOCA leak because of the low makeup requirements.

No power dependencies are assumed for this injection source given that it is backed by its own diesel. The SAMA 26 diesel does supply power to the existing 480V system to support the station battery chargers, but failure of the hardware is assumed to be a small contributor to the overall failure probability and those failures are not explicitly included.

The injection line connects to the Feedwater line, but it is assumed to be tied in downstream of the flow control valves such that there are no dependencies on the Feedwater valve support systems.

Credit is not taken in ATWS events due to limited makeup capacity.

The pump is sized to provide 600 gpm to each unit simultaneously. This flow rate is less than the 1000 gpm required for several post core damage mitigation functions, including preventing RPV meltthrough, preventing drywell failure, containment flooding, and makeup after containment failure. No credit is taken for those functions.

PRA Model Changes to Model SAMA:

The inclusion of the seismically qualified makeup source required changes to be made to both the main fault tree and the recovery fault tree. The logic was added to the existing fault tree structure in scenarios where LPCI and LPCS are credited and where containment failure results in the loss of injection systems due to adverse environmental conditions. Logic was included in the fault tree preclude credit for loss of inventory scenarios where the 600 gpm makeup rate may be inadequate (e.g., LOCA events and makeup to prevent RPV meltthrough).

Model Change(s):

The following change was made to the main fault tree:

- Created new basic event SAMA26 (FAILURE OF SEISMICALLY QUALIFIED INJECTION SOURCE): Probability set to 1.0E-03.
- Created new gate SAMA26-G1: OR gate including event SAMA 26 and the following existing gates:
  - New event SAMA26
  - Gate IE-SLOCA (SMALL LOCA INITIATING EVENT)
  - Gate LOCA-NOT-S2 (LOCA INITIATORS GREATER THAN SLOCA)
  - Initiating event %TI (INADVERTENTLY OPEN RELIEF VALVE INITIATING EVENT)
  - Basic event 2RHSYLEAKA---L-- (RH TRAIN A FAILS DUE TO EXCESSIVE LEAKAGE FOLLOWING WATER HAMMER)

  - Basic event 2RHSYARUPTFLOOD- (RH TRAIN A WATER HAMMER INDUCED RUPTURE CAUSES FLOODING)
  - Basic event 2RHSYLEAKB---L-- (2RHSYLEAKB---L--
  - Basic event 2RHSYRUPTUREBR-- (RH TRAIN B FAILS DUE TO RUPTURE FOLLOWING WATER HAMMER)
  - Gate SCRAM-FAILS
- Created new gate SAMA26-G2: OR gate with the following inputs:
  - Event SAMA26
  - ADS
- Added new gate SAMA26-G1 to the following gates:
  - CTFAIL-MU-LPI
  - VENT-MU-LPI
  - LPCI-LPCS
  - LPI-TBRB-FLD
  - LPI-FSTB
- Added new OR gate SAMA26-G2 to the following gates:
  - ILOC-002P
  - ILOC-008P
- Added event SAMA26 under gate ILOC-006P.
- Under existing gate TD8-RPV:
  - Deleted gate LPCI-LPCS (precludes crediting SAMA26 for the debris cooling function)
  - Added existing gates LPCI and LPCS

The recovery tree was merged with the updated fault tree logic in order to ensure the recovery logic includes the changes from the SAMA modifications.

Results of SAMA Quantification:

The following table summarizes the changes to the internal events CDF, Dose-Risk, and Offsite Economic Cost-Risk resulting from the implementation of this SAMA:

	Internal CDF	Dose-Risk	OECR
Base Value	2.58E-06	7.11	$53,358
SAMA Value	1.85E-06	4.78	$32,652
Percent Change	28.3%	32.8%	38.8%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	$Freq._{BASE}$	$Freq._{SAMA}$	$Dose\text{-}Risk_{BASE}$	$Dose\text{-}Risk_{SAMA}$	$OECR_{BASE}$	$OECR_{SAMA}$
H/E-BOC	8.32E-08	8.32E-08	1.34E+00	1.34E+00	$7,222	$7,223
H/E	5.93E-08	5.89E-08	3.14E-01	3.12E-01	$2,763	$2,745
H/I	1.90E-08	9.30E-09	1.08E-01	5.26E-02	$954	$467
M/E	2.14E-07	1.98E-07	1.58E+00	1.46E+00	$9,395	$8,692
M/I	9.27E-07	3.76E-07	3.58E+00	1.45E+00	$32,723	$13,273
L/E	3.88E-07	3.65E-07	8.57E-02	8.07E-02	$124	$116
L/I	1.45E-07	1.11E-07	1.03E-01	7.87E-02	$177	$135
INTACT	7.45E-07	6.49E-07	1.62E-03	1.41E-03	$1	$1
Total	2.58E-06	1.85E-06	7.11E+00	4.78E+00	$53,358	$32,652

Applying the process described in Section F.4 yields an internal events cost-risk of $685,646. After accounting for "round up" of the base internal events cost-risk, this value is $686,463. The external events contributions are accounted for by multiplying this value by 5.2:

$$\text{Total Cost-Risk}_{SAMA} = \$686,463 * 5.2 = \$3,569,608$$

This information was used as input to the averted cost-risk calculation. The results of this calculation are provided in the following table:

SAMA 26 Averted Cost-Risk			
Unit	**Base Case Cost-Risk**	**Revised Cost-Risk**	**Averted Cost-Risk**
LSCS Unit 2	$5,657,600	$3,569,608	$2,087,992

Based on a $5,984,407 cost of implementation for LSCS, the net value for this SAMA is -$3,896,415 ($2,087,992 - $5,984,407). When the 95th percentile PRA results are used, the averted cost-risk is increased by a factor of 2.14 to $4,468,303, which still yields a negative net value ($4,468,303 - $5,984,407 = -$1,516,104). This SAMA is not cost-beneficial.

F.7.2.2 PHASE 2 IMPACT

As discussed above, a single factor based on the 95th percentile for the base case is used to determine the impact of the cost-benefit analysis for the proposed SAMA candidates. The uncertainty analyses that are available for the Level 1 model are not available (or not used) for the Level 2 and 3 PRA models. In order to simulate the use of the 95th percentile results for the Level 2 and 3 models, the same scaling factor calculated for the Level 1 results was implicitly applied to the dose-risk and offsite economic cost-risk through the application of the multiplier to the base case averted cost-risk values.

The Phase 2 SAMA list was re-examined by multiplying the nominal averted cost-risk by the ratio of the 95th percentile CDF to the point estimate CDF value (see Section 7.2) to identify SAMAs that would be re-characterized as potentially cost-beneficial, i.e., positive net value. Those SAMAs that were previously determined to be not cost-beneficial due to implementation costs exceeding their associated nominal averted cost risk may be potentially cost-beneficial at the revised 95th percentile averted cost risk. In this case, eight additional Phase 2 SAMAs become potentially cost-beneficial (SAMAs 3, 4, 5, 8, 14, 18, 21, and 25).

F.7.2.3 95TH PERCENTILE SUMMARY

The following table provides a summary of the impact of using the 95th percentile PRA results on the detailed cost-benefit calculations that have been performed.

Summary of the Impact of Using the 95th Percentile PRA Results

SAMA ID	Implementation Cost (per unit)	Averted Cost Risk (Base)	Net Value (Base)	Averted Cost Risk (95th Percentile)	Net Value (95th Percentile)	Change in Cost Effective-ness?
SAMA 1	$12,940,000	$2,294,729	-$10,645,271	$4,910,720	-$8,029,280	No
SAMA 2	$400,000	$1,305,668	$905,668	$2,794,130	$2,394,130	No
SAMA 3	$1,000,000	$935,157	-$64,843	$2,001,236	$1,001,236	Yes
SAMA 4	$635,242	$622,258	-$12,984	$1,331,632	$696,390	Yes
SAMA 5	$400,000	$355,690	-$44,310	$761,177	$361,177	Yes
SAMA 6	$2,900,000	$79,362	-$2,820,638	$169,835	-$2,730,165	No
SAMA 7	$962,403	$49,488	-$912,915	$105,904	-$856,499	No
SAMA 8	$400,000	$242,190	-$157,810	$518,287	$118,287	Yes
SAMA 9	$115,000	$207,865	$92,865	$444,831	$329,831	No
SAMA 10	$260,219	$1,208,038	$947,819	$2,585,201	$2,324,982	No
SAMA 11	$217,415	$19,703	-$197,712	$42,164	-$175,251	No
SAMA 12	$4,401,674	$986,929	-$3,414,745	$2,112,028	-$2,289,646	No
SAMA 14	$489,277	$414,170	-$75,107	$886,324	$397,047	Yes
SAMA 15	$1,370,000	$3,154,871	$1,784,871	$6,751,424	$5,381,424	No
SAMA 16	$475,000	$793,161	$318,161	$1,697,365	$1,222,365	No
SAMA 18	$649,194	$560,082	-$89,112	$1,198,575	$549,381	Yes
SAMA 19	$2,900,000	$3,200,210	$300,210	$6,848,449	$3,948,449	No
SAMA 20	$1,150,000	$112,679	-$1,037,321	$241,133	-$908,867	No
SAMA 21	$1,481,002	$693,706	-$787,296	$1,484,531	$3,529	Yes
SAMA 22	$205,000	$33,394	-$171,606	$71,463	-$133,537	No
SAMA 23	$1,370,000	$2,760,716	$1,390,716	$5,907,932	$4,537,932	No
SAMA 24	$1,824,084	$336,367	-$1,487,717	$719,825	-$1,104,259	No
SAMA 25	$112,000	$86,538	-$25,462	$185,191	$73,191	Yes
SAMA 26	$5,984,407	$2,087,992	-$3,896,415	$4,468,303	-$1,516,104	No
SAMA 27	$512,000	$185,489	-$326,511	$396,946	-$115,054	No

When the 95th percentile PRA results were applied to the Phase 1 analysis, the increase in the MACR resulted in the retention of only one SAMAs that was screened in the baseline Phase 1 analysis (SAMA 26). The Phase 2 analysis performed for SAMA 26 using the 95th percentile PRA results confirmed that SAMA 26 is not cost-beneficial.

When the 95th percentile PRA results were applied to the Phase 2 analysis, eight SAMAs (3, 4, 5, 8, 14, 18, 21, and 25) that were previously classified as not cost-effective were determined to be potentially cost-effective. The use of the 95th percentile PRA results is not considered to provide the best assessment of the cost-effectiveness of a SAMA. Instead, it is intended to address the uncertainties inherent in the SAMA analysis. Nonetheless, these additional SAMAs identified as potentially cost-benefical through this sensitivity case (none of which is related to aging management under 10 C.F.R. Part 54) should be further evaluated for possible implementation using current, applicable plant procedures.

F.7.3 MACCS2 INPUT VARIATIONS

The MACCS2 model was developed using the best information available for the LSCS site; however, reasonable changes to modeling assumptions can lead to variations in the Level 3 PRA results. In order to determine how certain assumptions could impact the SAMA results, a sensitivity analysis was performed on parameters that have previously been shown to impact the Level 3 results. These parameters include:

- Meteorological data
- Evacuation timing and speed
- Release height and heat
- Deposition velocity
- Population estimates
- Population resettlement planning
- Generic economic inputs
- Economic rate of return
- Value of farm and non-farm wealth

The risk metrics produced by MACCS2 that are evaluated in the sensitivity analyses are the 50-mile population dose risk and the 50 mile offsite economic cost risk. The subsections below discuss the changes in these results for each of the sensitivity parameters noted above. The final subsection, F.7.3.9, correlates the worst case changes identified in the sensitivity runs to a change in the site's averted cost-risk and discusses the implications of the sensitivity analysis on the SAMA analysis. The results of the individual sensitivity cases are summarized in the following table.

Sensitivity of LSCS Baseline Risk to Parameter Changes

Parameter	Description	Pop. Dose Risk Δ Base (%)	Cost Risk Δ Base (%)
Meteorology	Year 2010 Meteorology	-4%	-9%
	Year 2011 Meteorology	-1%	-6%
Evacuation Time	Evacuation delay time increased from 100 minutes to 200 minutes (factor of 2)	+1%	0%
Evacuation Speed	Average evacuation speed decreased by half from 1.6 m/sec to 0.8 m/sec.	+5%	0%
Release Height	Release height set to ground level (in lieu of mid-height of Reactor Building, 28.0 m).	-2%	-2%
	Release height set to top of Reactor Building, 56.1 m (in lieu of mid-height of containment, 28.0 m).	+2%	+3%
Release Heat	No buoyant plume assumed (0 watts for each plume segment).	+0.1%	-2%
Deposition Velocity	Dry deposition velocity decreased from 0.01 m/sec to 0.003 m/sec	-1%	-31%
Population	Year 2043 population uniformly increased 30%	+29%	+29%
Resettlement Planning	No "Intermediate Phase" resettlement planning (in lieu of 6 months)	+12%	-40%
	1 year "Intermediate Phase" resettlement planning (in lieu of 6 months)	-10%	+40%
Economic Inputs	Generic economic inputs increased (factor of 2)	-3%	+54%
Rate of Return	3% expected rate of return (in lieu of 7%)	+0.7%	-9%
	12% expected rate of return (in lieu of 7%)	-0.3%	+11%
Value of Farm and Non-Farm Wealth	Doubled value of farm wealth (11,937 $/hectare) and non-farm wealth (283,637 $/person) to 23,874 $/hectare and 567,274 $/person, respectively.	+0.4%	+59%

F.7.3.1 METEOROLOGICAL SENSITIVITIES

In addition to the year 2012 base case meteorological data, years 2010 and 2011 were also analyzed. Analysis of year 2010 and 2011 data sets yielded population dose-risks and cost risks that were 1% to 9% less than 2012 results. As no particular criteria have been defined by the industry related to determining which meteorological data set should be used as a base case for a site, the year 2012 data is chosen for LSCS because it represents site meteorological conditions and results in the highest estimated dose risk and cost risk of the three data sets.

F.7.3.2 EVACUATION SENSITIVITIES

The sensitivity of two evacuation parameters was assessed. The delay time to evacuation (increased from 100 minutes to 200 minutes) was found to have a minor impact (approximately 1% increase) on population dose risk. The evacuation speed sensitivity which decreased the average radial evacuation speed by a factor of two (from 1.6 m/sec to 0.8 m/sec) demonstrates a small impact on population dose. The population dose risk increased approximately 5% using the slower evacuation speed. An increase in population dose is the generally expected result for a delayed evacuation or a slower evacuation speed since evacuees would be expected to be exposed to releases for a longer period of time. It is noted that while evacuation assumptions do impact the population dose-risk estimates, they do not impact MACCS2 offsite economic cost-risk estimates because MACCS2-calculated cost-risks are based on land contamination levels which remain unaffected by evacuation assumptions and the number of people evacuating.

F.7.3.3 RELEASE HEIGHT & HEAT SENSITIVITIES

The release height sensitivity cases quantify the impact of the assumption related to the height of the release of the plumes. The baseline case assumes that the releases occur at approximately half the height of the containment building (28.0 m). Releases from higher heights tend to disperse material over a wider geographical region, generally impacting more people and creating larger long term dose and cleanup costs. A ground level release height (0 m) shows a decrease in dose risk and cost risk of 2% and 2%, respectively. A release from the top of containment (56.1 m) shows an increase in dose risk and cost risk of 2% and 3%, respectively. The impacts of release height assumptions are small.

The release heat sensitivity case evaluates the impact of assumptions of thermal plume effects. The base case assumed a heat content of 10 MW per plume segment, except for the intact containment release category where zero plume heat was assumed. The 10 MW per plume segment value is generally bounding for the values used in the NUREG-1150 (NRC 1990a) study as documented in NUREG/CR-4551 (NRC 1990b). Modeling plume heat increases the buoyancy effect of the released plumes and generally has similar impacts as modeling a higher release height. The sensitivity case assumed no thermal plume heat in the releases (i.e., no buoyant plumes). The impacts of assuming no plume heat is a cost risk decrease of 2%. The dose risk was marginally impacted.

F.7.3.4 DEPOSITION VELOCITY

The dry deposition velocity sensitivity case evaluates the impact of the fission product particle size as reflected in the deposition velocity parameter. The base case assumes a deposition velocity of 0.01 m/sec, consistent with the NRC recommendation documented in MACCS2 Sample Problem A (NRC 1998). The sensitivity case uses a deposition velocity of 0.003 m/sec, reflective of a smaller particle size. This 0.003 m/sec value was suggested (but not used) in the Integrated Risk Assessment for LSCS Unit 2 study (NRC 1992c) as a more appropriate value than 1 cm/sec based on published literature. The more recent NRC State-of-the-Art Reactor Consequence Study (NRC 2013b) states that the average deposition velocity used in that analysis is approximately 0.003 m/sec. Assuming a lower deposition velocity results in a decrease in the dose risk and cost risk of 1% and 31%, respectively. This decrease is attributed to smaller particles traveling further and exiting the 50-mile radius SAMA analysis region.

F.7.3.5 POPULATION SENSITIVITY

A population sensitivity case assesses the impact of population assumptions. The base case year 2043 population is uniformly increased by 30% in all grid elements of the 50-mile radius area. This change has a significant impact on the dose risk and cost risk, increasing dose risk and cost risk by 29% and 29%, respectively. This sensitivity case demonstrates a significant dependence upon population estimates. This dependence is expected given that population dose and offsite economic costs are primarily driven by the regional population.

F.7.3.6 RESETTLEMENT PLANNING SENSITIVITIES

The MACCS2 consequence modeling incorporates an "intermediate phase" which depicts the time period following the release and immediate evacuation actions (termed the "early phase") and extends to the time when recovery efforts such as decontamination and resettlement of people are begun (termed the "long term phase"). The intermediate phase thus models the time period when decontamination and resettlement plans are being developed. MACCS2 allows the habitation of land during the intermediate phase unless projected dose criteria are exceeded, in which case individuals are relocated. MACCS2 allows an intermediate phase ranging from no intermediate phase to a maximum of one year. The intermediate phase sensitivities show significant impacts and are therefore discussed further:

- The no intermediate phase resettlement planning case is developed based on the NUREG-1150 (NRC 1990a) modeling approach. The 40% reduction in cost risk seen in the sensitivity results, however, is judged too optimistic in that the land decontamination efforts are modeled as starting one week after the accident (i.e., directly after the early phase ends), such that a significant portion of population relocation costs are omitted. For instance, the costs associated with temporary housing of interdicted individuals while decontamination strategies are developed and decontamination teams are contracted are not accounted for without an intermediate phase. It is believed that the NUREG-1150 studies omitted the intermediate phase because the intermediate phase coding was not validated at that time (NRC 1998). A competing factor is that the population dose increases (12% increase over the base case) because people are allowed to re-occupy the decontaminated land sooner.
- The 1 year intermediate phase resettlement planning case is developed based on the maximum length of time allowed by MACCS2 for the intermediate phase. A long intermediate phase can be unrealistic in that re-occupation of contaminated land is not performed during this phase even if contamination levels decrease (by natural radioactive decay and weathering) to levels which would allow it (i.e., resettlement is evaluated as part of the long term phase, not the intermediate phase). Therefore population relocation costs may be overestimated using a long (i.e., one year) intermediate phase. An intermediate phase of one year shows a 40% increase in cost risk estimates compared with the base case selection of 6 months. The population dose decreased by 10% with a longer intermediate phase due to later resettlement on decontaminated land.

The six month intermediate phase (base case) is judged to be a best estimate approach in that it provides reasonable time for both decontamination and resettlement planning to be performed. The sensitivity cases demonstrate that the six month value used in the base case provides mid-range results for the modeling choices available.

F.7.3.7 GENERIC ECONOMIC INPUTS SENSITIVITY

MACCS2 requires certain site-specific economic data (e.g., fraction of land devoted to farming, annual farm sales, fraction of farm sales resulting from dairy production, and property value of farm and non-farm land) for each of the 160 spatial elements. The site-specific base case values are calculated based on regional economic data.

In addition to these site specific values, standardized economic data are utilized by MACCS2 to address costs associated with per diem living expenses (applied to owners of interdicted properties and relocated populations), relocation costs (for owners of interdicted properties), and decontamination costs. For the LSCS base case, these generic costs are based on values used in the NUREG-1150 study (NRC 1990a) as documented in the NUREG/CR-4551 (NRC 1990b) and updated to July 2013 using the consumer price index.

This sensitivity case is performed to determine the variability in population dose risk and cost risk based on changes to these standardized values. The sensitivity case increases key standardized economic parameters as identified in Table F.7-1. In general, the inputs were arbitrarily increased by factor of 2.0. The increase in these economic parameters resulted in an increase in cost risk of 54% and a decrease in dose risk of about 3%. A significant increase in cost risk is expected since population relocation and decontamination costs are major contributors to total cost as calculated by MACCS2.

F.7.3.8 RATE OF RETURN SENSITIVITIES

One of the economic cost components included in the MACCS2-calculated cost result is the financial loss associated with property and associated improvements (e.g., buildings) not achieving their expected annual rate of return during interdiction periods. A piece of land that is interdicted (i.e., not occupied) for a period of years will not achieve the historical rate of return or the rate of return achieved by other non-impacted properties during the interdiction period. This lack of expected return is an economic loss for the owner / society. The base case assumes a 7% expected rate of return, consistent with NRC guidance (NRC 2004a). A sensitivity case using a 3% expected rate of return shows a decrease in the expected cost risk of approximately 9%. This decrease in cost risk associated with the lower rate or return is expected since there is a lower expectation associated with the land's return on investment. A sensitivity case using a 12% expected rate of return, the value used in NUREG-1150 MACCS2 analyses (NRC 1990b), shows an increase cost risk of approximately 11%. For both sensitivity cases the dose risk changes are minor (<=1%).

F.7.3.9 VALUE OF FARM AND NON-FARM WEALTH SENSITIVITY

This sensitivity assesses the impact of doubling the average farm and non-farm wealth values for the area surrounding LSCS. The Base case wealth PERCHR3 values, 11,937 $/hectare for farm wealth and 283,637 $/person for non-farm wealth, were increased to 23,874 $/hectare and 567,274 $/person, respectively. This increase in the wealth parameters results in a cost risk increase of 59%. The increase in the dose risk is less than 0.5%. The cost risk increases significantly because on a per-person and per-farm basis, more wealth is being impacted. This sensitivity indicates there is significant cost risk dependency associated with farm and non-farm wealth parameters.

F.7.3.10 IMPACT ON SAMA ANALYSIS

Several different Level 3 input parameters are examined as part of the LSCS MACCS2 sensitivity analysis. The primary reason for performing these sensitivity runs is to identify any reasonable changes that could be made to the Level 3 input parameters that would impact the conclusions of the SAMA analysis. While the table in Section F.7.3 summarizes the changes to the dose-risk and OECR estimates for each sensitivity case, it is prudent to consider if any of these changes would result in the retention of the SAMAs that were screened using the baseline results.

Of all the MACCS2 sensitivity cases, the largest dose-risk increase, 29%, occurred in the Population (Year 2043 population uniformly increased 30%) case. The largest OECR increase, 59%, occurred in the Value of Farm and Non-Farm Wealth Input sensitivity case (doubling of farm and non-farm wealth input values). While these changes are not insignificant, they are relatively small compared to the 95^{th} percentile PRA results sensitivity in Section F.7.2, which increases the averted cost-risk values for the SAMAs by over a factor of 2. Therefore, the 95^{th} percentile PRA results sensitivity case is considered to bound this case and no SAMAs would be retained based on this sensitivity that were not already identified in Section F.7.2.

F.7.4 IMPACT OF THE RELIABLE HARD PIPE VENT

The installation of the reliable hard pipe containment vent (SAMA 1) is planned for LSCS, but it was not implemented at the time the SAMA analysis was performed. Accordingly, the PRA model used for this analysis does not credit the hard pipe vent. However, because the hard pipe vent will be in place during the period of extended operation, a sensitivity analysis was performed to identify how the hard pipe vent would impact the SAMA analysis. In order to do this, the SAMA 1 model was used as the new "base" model and the Phase 2 screening analyses were re-performed relative to that model for those SAMAs that were identified as potentially cost-beneficial in section F.7.2. Because implementation of the hard pipe vent reduces risk and would not increase the benefit of any SAMAs, the impact on the SAMAs that were determined to not be cost-beneficial was not examined as part of this sensitivity.

Use of the SAMA 1 model as the base case resulted in a decrease in the MACR from \$5,657,600 to \$3,359,200, which is based on the PRA results documented in Section F.6.1 and the rounding up of the internal events cost-risk in the same manner as the original base case. It was assumed that the change in the baseline PRA results did not impact either the 95th percentile or the external events multiplier. The same factors that were used in the baseline analysis were retained in this analysis to account for the impact of the external events contributions and uncertainty.

The impact on the Phase 2 analysis was determined by performing the calculation/model changes identified for each SAMA in conjunction with the changes identified for SAMA 1. The following table provides a comparison of the Phase 2 results for the nominal plant configuration to the configuration in which the reliable hard pipe containment vent has been implemented. As documented in the "Change in Cost Effectiveness?" column, implementation of the hard pipe vent would make the net values of SAMAs 8, 14, 16, and 21 negative, such that they would no longer be considered as potentially cost-beneficial enhancements.

Impact of Assuming Implementation of the Hard Pipe Vent for the SAMA Base Case

SAMA ID	Implementation Cost (per unit)	Averted Cost Risk (95th percentile)	Net Value (Base)	Averted Cost Risk (95th percentile, SAMA 1 as Base Case)	Net Value (95th percentile, SAMA 1 as Base Case)	Change in Cost Effective-ness?
SAMA 2	\$400,000	\$2,794,130	\$2,394,130	\$1,904,713	\$1,504,713	No
SAMA 3	\$1,000,000	\$2,001,236	\$1,001,236	\$2,001,236	\$1,001,236	NA
SAMA 4	\$635,242	\$1,331,632	\$696,390	\$1,320,438	\$685,196	No
SAMA 5	\$400,000	\$761,177	\$361,177	\$746,922	\$346,922	No
SAMA 8	\$400,000	\$518,287	\$118,287	\$76,693	-\$323,307	Yes
SAMA 9	\$115,000	\$444,831	\$329,831	\$203,409	\$88,409	No
SAMA 10	\$260,219	\$2,585,201	\$2,324,982	\$1,891,527	\$1,631,308	No
SAMA 14	\$489,277	\$886,324	\$397,047	\$300,724	-\$188,554	Yes
SAMA 15	\$1,370,000	\$6,751,424	\$5,381,424	\$3,893,499	\$2,523,499	No
SAMA 16	\$475,000	\$1,697,365	\$1,222,365	\$87,042	-\$387,958	Yes
SAMA 18	\$649,194	\$1,198,575	\$549,381	\$711,546	\$62,352	No
SAMA 19	\$2,900,000	\$6,848,449	\$3,948,449	\$3,989,354	\$1,089,354	No
SAMA 21	\$1,481,002	\$1,484,531	\$3,529	\$1,473,814	-\$7,188	Yes
SAMA 23	\$1,370,000	\$5,907,932	\$4,537,932	\$2,027,055	\$657,055	No
SAMA 25	\$112,000	\$185,191	\$73,191	\$134,771	\$22,771	No

F.8 CONCLUSIONS

Using a SAMA methodology consistent with NEI 05-01, SAMAs 2, 9, 10, 15, 16, 19, and 23 were found to be potentially cost-beneficial in the baseline analysis.

When the 95th percentile PRA results are considered, SAMAs 3, 4, 5, 8, 14, 18, 21, and 25 are also potentially cost-beneficial.

None of the SAMAs identified as potentially cost-beneficial are aging related.

F.8.1 OPTIMAL SAMA SET

While many SAMAs are potentially cost-beneficial for LSCS when considered independently, it should be noted that many SAMAs address similar areas of risk. Implementation of one SAMA may result in a change in the potential benefits of the remaining SAMAs, such that they are no longer cost-beneficial. Review of the potentially cost-beneficial SAMAs can help identify an "optimal" set of SAMAs for implementation; that is, a reduced set of SAMAs that will address the largest risk contributors for the site. For example, the reliable hard pipe containment vent (SAMA 1) is required to be implemented and should be considered as complete for any future considerations. Beginning with this plant enhancement, the remaining set of SAMAs can be reviewed to identify those that would mitigate the contributors not addressed by SAMA 1. It is recognized that there are different combinations of SAMAs that could achieve similar results, but this is a demonstration of a potential approach to interpreting the results of the cost benefit analysis.

Section F.7.4 documents those SAMAs that would remain cost-beneficial after implementation of SAMA 1, but many of those SAMAs address the same areas of risk as other SAMAs and implementation of one would have an impact on the remaining SAMAs. Generally, implementing one SAMA in a group of functionally similar SAMAs would render the remaining SAMAs in the group non-cost-beneficial. The following table categorizes the potentially cost-beneficial SAMAs from Section F.7.4 and discusses the implications of SAMA implementation.

Impact of SAMA Implementation by Functional Group

SAMA Functional Group	SAMA Title	Discussion
Containment Heat Removal/Pressure Control	SAMA 2: Automate Suppression Pool Cooling SAMA 3: Passive Vent Path	As with SBLC initiation and MSIV low level isolation logic bypass, containment venting and SPC initiation are manual actions that are treated in the PRA with dependent failure terms. Implementation of either SAMA would render the remaining SAMA non-cost-beneficial. Both of these SAMAs, however, reduce the control the operators have over plant equipment. The negative impacts of implementation not considered in the PRA model should be given consideration. In addition, the risk reductions associated with these SAMAs are driven by joint human error probabilities, which carry with them a significant degree of uncertainty due to limitations in modeling capabilities. Suppression pool cooling initiation and containment venting are well known and highly trained actions that are considered to be highly reliable and the benefits shown in this analysis for these SAMAs should be considered with these facts in mind.
ATWS Mitigation	SAMA 4: Install a Keylock MSIV Low Level Isolation Bypass Switch SAMA 5: Automate SBLC Injection	There is some overlap in these SAMAs because SBLC initiation and MSIV low level isolation logic bypass are manual actions. The risk model includes dependent failures of both actions and automation of one of the functions would remove the dependent impacts, which are larger than the independent failures of both actions. If SAMA 4 were implemented, SAMA 5 would no longer be cost-beneficial. Implementation of SAMA 5 would reduce the benefit of SAMA 4, but not to the degree where SAMA 4 would not be considered to be potentially cost-beneficial.
Internal Flood Mitigation	SAMA 9: Develop Flood Zone Specific Procedures	This SAMA addresses flood risk and prevents equipment loss that leads to SBO scenarios. Implementation of other potentially cost-beneficial SAMAs would not address this risk, but FLEX changes, such as the installation of a 480V AC generator, would impact the SBO sequences addressed by this SAMA and would make it non-cost-beneficial.

Impact of SAMA Implementation by Functional Group

SAMA Functional Group	SAMA Title	Discussion
RPV Makeup	SAMA 10: Change the Logic to Close the Turbine Driven Feedwater Pump Discharge Valves When the Pumps are Not Running	The addition of an alternate injection source will generally yield a significant risk reduction for a plant. In this case, there is a significant overlap in SAMAs 15 and 19 as they address ISLOCA risk. SAMAs 10, 18, and 23 do not address unisolated ISLOCAs, but do provide injection for other scenarios. Implementation of SAMA 15 would provide almost all of the benefit of SAMA 19 for significantly less cost and would also address most of the scenarios addressed by SAMAs 10, 18, and 23.
	SAMA 15: Tie RHRSW to the LPCS System for ISLOCA Mitigation	
	SAMA 18: Improve the Connection Between the Fire Protection and Feedwater Systems	
	SAMA 19: Provide Remote Alignment Capability of RHRSW to the LPCS System for LOCA Mitigation	
	SAMA 23: Enhance Fuel Pool Emergency Makeup Pump and Connection	
Other	SAMA 25: Periodic Training on Water Hammer Scenarios Resulting from a False LOCA Signal	This is a relatively low cost SAMA that would prevent a break outside of containment scenario. SAMA 15 could potentially address these scenarios and if it were implemented, SAMA 25 would not likely remain cost effective.

While a large number of SAMAs can be considered potentially cost-beneficial for LSCS when considered independently, there is a smaller subset of SAMAs that, if implemented, would render the remaining SAMAs "not cost-beneficial". This subset consists of SAMAs 2, 4, 9, and 15.

F.9 TABLES

Table F.2-1
LSCS PRA Model Update History

Model Change description	Rev.	Date	CDF	LERF	Comments
IPE	IPE	04/94	4.41E-05(1)	(Not Quantified)(2)	Sandia National Laboratories, under contract to the NRC, completed a level 1 and 2 PRA for LaSalle Unit 2 in 1992. This PRA was documented in the multi-volume *Analysis of the LaSalle Unit 2 Nuclear Power Plant: Risk Methods Integration and Evaluation Program (RMIEP)* (SAND92-0575 / NUREG/CR-4832). A summary of the Sandia PRA was submitted to the NRC in April 1994 as LaSalle's response to NRC Generic Letter 88-20, *Individual Plant Examination for Severe Accident Vulnerabilities (IPE)*.
Updated IPE	IPE	1996	1.0E-05(3)	(Not Quantified)(2)	The focus of this effort to address issues raised by the NRC in the 1994 IPE.
Upgrade to the IPE	1999 Rev.0	07/01/99	(See Rev. 1 below)	(See Rev. 1 below)	The purpose of the 1999 LaSalle PRA upgrade was to support plant applications. The 1999 model was documented in two revisions. Revision 0 was issued before System Manager reviews had been completed. These reviews identified corrections for several logic errors and other potential enhancements that were incorporated into Revision 1. Since the Revision 0 model was not used for any applications, the Revision 1 model is referred to as the 1999 model.
Update to the IPE	1999 Rev.1	11/01/99	8.58E-06	1.5E-06	See description of PRA model 1999 Revision 0 above.

Table F.2-1
LSCS PRA Model Update History

Model Change description	Rev.	Date	CDF	LERF	Comments
Upgrade of model for Regulatory Applications	2000A	01/19/00	5.90E-06	1.0E-06	The 2000A model was created in January 2000 initially to support the diesel generators allowed outage time (AOT) extension project. The 2000A model was also used for a NEI / BWROG PSA peer review in April 2000 and to support the risk informed in-service inspection (RI-ISI) project. The NEI peer review team reviewed the 2000A model and found the model suitable for regulatory applications.
Minor Enhancements	2000B	2/25/00	5.90E-06	1.0E-06	The 2000B model included minor enhancements. It was considered to be an interim model and it was not used to support any regulatory applications.
Refinements to internal flooding model and human reliability analysis	2000C	3/20/00	8.20E-06	(Not Quantified)[4]	The 2000C model incorporated changes to the 2000B model based on a revised Turbine Building flood model and an updated LaSalle human reliability analysis (HRA). This model was used to support sensitivity studies performed for the final diesel generators AOT Technical Specification licensing amendment change request
Update to incorporate new data	2001A	08/01/01	5.70E-06	6.72E-07	The 2001A interim model was developed to revise several internal flooding initiating event frequencies based on implementing a pipe inspection program; revise the SCRAM failure probabilities based on new industry data; incorporate updated service water pump success criteria based on LaSalle historical operating practices; and, incorporate other minor enhancements.
Periodic Update in accordance with EGC PRA process	2003A	06/19/03	6.64E-06	3.56E-07	None
Periodic Update in accordance with EGC PRA process	2006A	01/31/07	8.08E-06	3.09E-07	The increase in CDF during the 2003A PRA update was due re-evaluation and expansion of the internal flooding analysis.

Table F.2-1
LSCS PRA Model Update History

Model Change description	Rev.	Date	CDF	LERF	Comments
Refinement of the internal flooding analysis	2006B	05/31/07	3.55E-06	3.00E-07	None
Correction of model error in RHR system fault tree	2006C	01/25/08	3.98E-06	2.97E-07	None
Periodic Update in accordance with EGC PRA process	2011A	03/23/13	2.58E-06	1.30E-07	The decrease in the CDF risk metric from 2006C model was primarily due to the following: 1. Bayesian updates of generic priors from NUREG/CR-6928 for both initiating events (transients) and component failures using the latest LaSalle specific data. 2. The deletion of loss of bus 241Y and 242Y as initiating events because loss of these buses does not result in a scram (previous model conservatism). 3. Refinement of the ECCS water hammer scenarios. 4. Crediting closure of the Reactor Building ventilation check dampers as a potential flood mitigation strategy. 5. The deletion of most coincident maintenance terms as these events did not meet the current definition of the ASME/ANS PRA Standard in that they are not "planned and repetitive."

Table F.2-1
LSCS PRA Model Update History

Model Change description	Rev.	Date	CDF	LERF	Comments
					The decrease in the LERF risk metric was primarily due to: 1. Re-evaluating and categorization of mitigated ATWS (i.e. SLC successfully injected) scenarios with subsequent failure of containment heat removal from Class IV to Class II. 2. Correction of Basic Event 1OPPH-RX-ENVIF—probability from 1.0 to 1E-03. The 1E-03 value is realistic given that the controls/steam sensitive portion of the ADS system is not in the reactor building. 3. The revision to the probability for latest pre-existing containment failure modes (2CNHU-PREINIT) 5E-03 to 2.3E-3 to be consistent with current industry information in EPRI TR101824.
Model expansion from LERF to a full Level 2	2013A	07/24/14	2.58E-06	1.42E-07	Issuance of an application specific model for use in the Severe Accident Mitigation Alternatives (SAMA) Analysis.

Table F.2-2
LSCS 2013A PRA LEVEL 1 CDF CONTRIBUTION BY INITIATING EVENT
(CDF = 2.58E-06/yr at 1E-12/yr TRUNCATION)

Basic Event ID	Description	Frequency (/cr yr)	F-V	Total CDF (/yr)	IE Contrib. CDF (/yr)	CCDP
%TT	TURBINE TRIP WITH BYPASS INITIATING EVENT	7.98E-01	2.18E-01	2.58E-06	5.62E-07	7.32E-07
%DLOOP	DUAL UNIT LOSS OF OFF-SITE POWER INITIATING EVENT	7.95E-03	1.19E-01	2.58E-06	3.07E-07	4.01E-05
%TIA	LOSS OF INSTRUMENT AIR INITIATING EVENT	9.92E-03	1.08E-01	2.58E-06	2.78E-07	2.92E-05
%TC	LOSS OF CONDENSER VACUUM INITIATING EVENT	1.33E-01	1.03E-01	2.58E-06	2.66E-07	2.08E-06
%FSRB12	FPS PIPE RUPTURE IN REACTOR BLDG.	1.05E-04	7.33E-02	2.58E-06	1.89E-07	1.87E-03
%TM	MSIV CLOSURE INITIATING EVENT	5.01E-02	5.30E-02	2.58E-06	1.37E-07	2.83E-06
%TBCCWFACTOR	LOSS OF TBCCW INITIATING EVENT	1.00E+00	4.56E-02	2.58E-06	1.18E-07	1.22E-07
%TF	LOSS OF FEEDWATER INITIATING EVENT	5.65E-02	4.45E-02	2.58E-06	1.15E-07	2.11E-06
%LOOP	LOSS OF OFF-SITE POWER INITIATING EVENT	1.07E-02	2.81E-02	2.58E-06	7.24E-08	7.04E-06
%MS	MANUAL SHUTDOWN INITIATING EVENT	1.01E+00	2.30E-02	2.58E-06	5.93E-08	6.10E-08
%TI	INADVERTENTLY OPEN RELIEF VALVE INITIATING EVENT	2.16E-02	2.27E-02	2.58E-06	5.85E-08	2.82E-06
%TDCA	LOSS OF 125 VDC BUS 2A INITIATING EVENT	5.70E-04	1.96E-02	2.58E-06	5.05E-08	9.21E-05
%TDCAB	LOSS OF 125 VDC BUS 2A AND 2B INITIATING EVENT	3.42E-07	1.53E-02	2.58E-06	3.94E-08	1.20E-01
%ISLOCA-SDC	SDC SUCTION LINE ISLOCA	3.80E-08	1.42E-02	2.58E-06	3.66E-08	1.00E+00
%S2-WA	INIT: SMALL BREAK LOCA - BELOW CORE INSIDE DRYWELL	3.67E-03	1.10E-02	2.58E-06	2.84E-08	8.03E-06

Table F.2-2
LSCS 2013A PRA LEVEL 1 CDF CONTRIBUTION BY INITIATING EVENT
(CDF = 2.58E-06/yr at 1E-12/yr TRUNCATION)

Basic Event ID	Description	Frequency (/cr yr)	F-V	Total CDF (/yr)	IE Contrib. CDF (/yr)	CCDP
%S1-WA	INIT: OTHER MEDIUM BREAK LOCA - BELOW CORE	9.37E-05	8.80E-03	2.58E-06	2.27E-08	2.52E-04
%TDCB	LOSS OF 125 VDC BUS 2B INITIATING EVENT	5.70E-04	8.18E-03	2.58E-06	2.11E-08	3.85E-05
%S1-LP	INIT: MEDIUM BREAK LOCA - BELOW CORE IN LPCI LINE	1.62E-04	7.53E-03	2.58E-06	1.94E-08	1.25E-04
%S2-ST	INIT: SMALL BREAK LOCA - ABOVE CORE INSIDE DRYWELL	3.71E-03	7.21E-03	2.58E-06	1.86E-08	5.21E-06
%TSWFACTOR	LOSS OF SERVICE WATER INITIATING EVENT	1.00E+00	5.76E-03	2.58E-06	1.48E-08	1.54E-08
%RBCCWFACTOR	LOSS OF RBCCW INITIATING EVENT	1.00E+00	5.70E-03	2.58E-06	1.47E-08	1.53E-08
%S1-ST	INIT: OTHER MEDIUM BREAK LOCA - ABOVE CORE	3.09E-04	5.60E-03	2.58E-06	1.44E-08	4.86E-05
%A-ST	LARGE LOCA ABOVE TAF	2.29E-05	3.75E-03	2.58E-06	9.67E-09	4.39E-04
%FSDG1	CSCS PIPE RUPTURE IN DIV. 3 CSCS ROOM	4.06E-07	3.15E-03	2.58E-06	8.12E-09	2.08E-02
%ISLOCA-RHRA	RHR A INJECTION LINE ISLOCA	7.50E-09	2.67E-03	2.58E-06	6.88E-09	9.54E-01
%ISLOCA-RHRA-S	RHR A SDC RETURN LINE ISLOCA	7.50E-09	2.67E-03	2.58E-06	6.88E-09	9.54E-01
%ISLOCA-RHRB	RHR B INJECTION LINE ISLOCA	7.50E-09	2.67E-03	2.58E-06	6.88E-09	9.54E-01
%ISLOCA-RHRB-S	RHR B SDC RETURN LINE ISLOCA	7.50E-09	2.67E-03	2.58E-06	6.88E-09	9.54E-01
%ISLOCA-LPCS	LPCS INJECTION LINE ISLOCA	7.50E-09	2.66E-03	2.58E-06	6.86E-09	9.50E-01
%ISLOCA-RHRC	RHR C INJECTION LINE ISLOCA	7.50E-09	2.66E-03	2.58E-06	6.86E-09	9.50E-01
%A-LP	LARGE LOCA IN LPCI LINE	1.47E-05	2.50E-03	2.58E-06	6.44E-09	4.56E-04
%FSRB2	SW PIPE RUPTURE IN RB AREA 3G	5.07E-07	2.09E-03	2.58E-06	5.39E-09	1.10E-02

Table F.2-2
LSCS 2013A PRA LEVEL 1 CDF CONTRIBUTION BY INITIATING EVENT
(CDF = 2.58E-06/yr at 1E-12/yr TRUNCATION)

Basic Event ID	Description	Frequency (/cr yr)	F-V	Total CDF (/yr)	IE Contrib. CDF (/yr)	CCDP
%A-ADS	INADVERTANT ADS	1.00E-05	1.64E-03	2.58E-06	4.23E-09	4.39E-04
%TAC252	LOSS OF 6.9 kVAC BUS 252 INITIATING EVENT	2.18E-03	1.59E-03	2.58E-06	4.10E-09	1.95E-06
%FSRB5	DGCW 2A PIPE RUPTURE IN U2 RACEWAY	3.37E-06	1.58E-03	2.58E-06	4.07E-09	1.26E-03
%A-WA	LARGE LOCA BELOW TAF	7.52E-06	1.50E-03	2.58E-06	3.87E-09	5.34E-04
%BOC-MS	BREAK OUTSIDE CONTAINMENT IN MAIN STEAM LINE	1.62E-08	1.46E-03	2.58E-06	3.76E-09	2.41E-01
%FSTB2	FPS PIPE RUPTURE IN TURBINE BLDG.	1.05E-04	1.44E-03	2.58E-06	3.71E-09	3.67E-05
%FSTB4	CW COMPONENT RUPTURE IN CONDENSER PIT	2.80E-03	1.40E-03	2.58E-06	3.61E-09	1.34E-06
%FSRB6	DGCW 2B PIPE RUPTURE IN U2 RACEWAY	4.21E-06	1.38E-03	2.58E-06	3.56E-09	8.78E-04
%FSRB3	SW PIPE RUPTURE IN RB AREA 3B1, 3B2, 3C, 3D OR 3F	2.20E-06	1.23E-03	2.58E-06	3.17E-09	1.50E-03
%S1-HP	INIT: MEDIUM BREAK LOCA - ABOVE CORE IN HPCS LINE	3.01E-05	9.65E-04	2.58E-06	2.49E-09	8.59E-05
%FSTB8	CW MANWAY RUPTURE OUTSIDE CONDENSER PIT	2.31E-07	7.95E-04	2.58E-06	2.05E-09	9.22E-03
%FSRB9	DGCW 2A PIPE RUPTURE IN U2 RHR B/C CORNER ROOM	1.69E-06	7.87E-04	2.58E-06	2.03E-09	1.25E-03
%R	EXCESSIVE LARGE LOCA INITIATING EVENT	1.00E-08	7.50E-04	2.58E-06	1.93E-09	2.01E-01
%BOC-RC	BREAK OUTSIDE CONTAINMENT IN RCIC DISCHARGE LINE	7.40E-09	6.67E-04	2.58E-06	1.72E-09	2.42E-01

Table F.2-2
LSCS 2013A PRA LEVEL 1 CDF CONTRIBUTION BY INITIATING EVENT
(CDF = 2.58E-06/yr at 1E-12/yr TRUNCATION)

Basic Event ID	Description	Frequency (/cr yr)	F-V	Total CDF (/yr)	IE Contrib. CDF (/yr)	CCDP
%BOC-RW	BREAK OUTSIDE CONTAINMENT IN RWCU LINE	7.40E-09	6.67E-04	2.58E-06	1.72E-09	2.42E-01
%A-HP	LARGE LOCA IN HPCS LINE	3.64E-06	5.95E-04	2.58E-06	1.53E-09	4.38E-04
%FSTB9	UNISOLABLE SW PIPE RUPTURE OUTSIDE CONDENSER PIT	3.04E-07	5.92E-04	2.58E-06	1.53E-09	5.22E-03
%TAC241X	LOSS OF 4.16 kVAC BUS 241X INITIATING EVENT	2.18E-03	5.73E-04	2.58E-06	1.48E-09	7.04E-07
%TAC242X	LOSS OF 4.16kVAC BUS 242X INITIATING EVENT	2.18E-03	5.27E-04	2.58E-06	1.36E-09	6.48E-07
%TAC251	LOSS OF 6.9 kVAC BUS 251 INITIATING EVENT	2.18E-03	5.16E-04	2.58E-06	1.33E-09	6.34E-07
%A-CS	LARGE LOCA IN LPCS LINE	3.15E-06	5.15E-04	2.58E-06	1.33E-09	4.38E-04
%FSAB2	FPS PIPE RUPTURE IN AUXILIARY BLDG.	3.49E-05	4.69E-04	2.58E-06	1.21E-09	3.60E-05
%FSTB7	SW STANDPIPE RUPTURE OUTSIDE CONDENSER PIT	2.21E-07	4.29E-04	2.58E-06	1.11E-09	5.20E-03
%S1-CS	INIT: MEDIUM BREAK LOCA - ABOVE CORE IN LPCS LINE	2.18E-05	4.10E-04	2.58E-06	1.06E-09	5.04E-05
%FSDG2	FPS PIPE RUPTURE IN DIV. 3 CSCS ROOM	2.79E-05	3.73E-04	2.58E-06	9.62E-10	3.58E-05
%FSRB4	DGCW 0A PIPE RUPTURE IN U2 RACEWAY	1.30E-06	3.66E-04	2.58E-06	9.43E-10	7.54E-04
%FSRB1	SW PIPE RUPTURE IN RB AREA 3E	2.70E-07	2.41E-04	2.58E-06	6.21E-10	2.39E-03
%FSRB8	DGCW 0A PIPE RUPTURE IN U2 LPCS/RCIC CORNER ROOM	6.50E-07	1.83E-04	2.58E-06	4.72E-10	7.54E-04
%FSTB11	DGCW 2B PIPE RUPTURE IN TB BASEMENT	8.43E-06	1.31E-04	2.58E-06	3.38E-10	4.16E-05

Table F.2-2
LSCS 2013A PRA LEVEL 1 CDF CONTRIBUTION BY INITIATING EVENT
(CDF = 2.58E-06/yr at 1E-12/yr TRUNCATION)

Basic Event ID	Description	Frequency (/cr yr)	F-V	Total CDF (/yr)	IE Contrib. CDF (/yr)	CCDP
%FSTB5	DEICING PIPE RUPTURE (UNIT 2)	3.17E-08	1.03E-04	2.58E-06	2.66E-10	8.71E-03
%FSTB6	DEICING PIPE RUPTURE (UNIT 1)	3.17E-08	1.03E-04	2.58E-06	2.66E-10	8.71E-03
%TRLA	MEDIUM RANGE RX WATER REFERENCE LEG A LINE BREAK	2.24E-03	1.02E-04	2.58E-06	2.63E-10	1.22E-07
%TRLB	MEDIUM RANGE RX WATER REFERENCE LEG B LINE BREAK	2.24E-03	1.02E-04	2.58E-06	2.63E-10	1.22E-07
%FSRB11	DIV. 1 RHRSW PIPE RUPTURE IN U2 RHR A CORNER ROOM	2.54E-07	7.15E-05	2.58E-06	1.84E-10	7.54E-04
%BOC-FW	BREAK OUTSIDE CONTAINMENT IN FW DISCHARGE LINE	5.50E-10	4.96E-05	2.58E-06	1.28E-10	2.42E-01
%FSRB10	DIV. 2 RHRSW PIPE RUPTURE IN U2 RHR B/C CORNER ROOM	2.54E-07	4.72E-05	2.58E-06	1.22E-10	4.98E-04
%FSRB7	DIV. 1 RHRSW PIPE RUPTURE IN U2 RACEWAY	1.35E-07	4.58E-05	2.58E-06	1.18E-10	9.09E-04
%FSAB1	SW PIPE RUPTURE IN AUXILIARY BLDG.	3.13E-06	1.17E-05	2.58E-06	3.02E-11	1.00E-05
%BOC-HP	BREAK OUTSIDE CONTAINMENT IN HPCS LINE	1.00E-10	8.73E-06	2.58E-06	2.25E-11	2.34E-01
%FSTB3	CW PIPE RUPTURE IN CONDENSER PIT	2.28E-05	5.74E-06	2.58E-06	1.48E-11	6.75E-07

Table F.2-3
SUMMARY OF LS213A CDF BY ACCIDENT SEQUENCE SUBCLASS
(CDF = 2.58E-06/yr at 1E-12/yr TRUNCATION)

Accident Class Designator	Subclass	Definition	Model 2013A (per Yr)
Class I	A	Accident sequences involving loss of inventory makeup in which the reactor pressure remains high.	8.46E-08
	B	Accident sequences involving a station blackout and loss of coolant inventory makeup. (Class IBE is defined as "Early" Station Blackout events with core damage at less than 4 hours. Class IBL is defined as "Late" Station Blackout events with core damage at greater than 4 hours.)	IBE 3.43E-07 IBL 2.94E-07
	C	Accident sequences involving a loss of coolant inventory induced by an ATWS sequence with containment intact.	1.67E-07
	D	Accident sequences involving a loss of coolant inventory makeup in which reactor pressure has been successfully reduced to 200 psi.	3.53E-08
	E	Accident sequences involving loss of inventory makeup in which the reactor pressure remains high and DC power is unavailable.	(Grouped with Class IA)
Class II	A	Accident sequences involving a loss of containment heat removal with the RPV initially intact; core damage; core damage induced post containment failure.	1.03E-06
	L	Accident sequences involving a loss of containment heat removal with the RPV breached but no initial core damage; core damage induced post containment failure. (Not used)	
	T	Accident sequences involving a loss of containment heat removal with the RPV initially intact; core damage induced post high containment pressure.	
	V	Class IIA and III except that the vent operates as designed; loss of makeup occurs at some time following vent initiation. Suppression pool saturated but intact.	

Table F.2-3
SUMMARY OF LS213A CDF BY ACCIDENT SEQUENCE SUBCLASS
(CDF = 2.58E-06/yr at 1E-12/yr TRUNCATION)

Accident Class Designator	Subclass	Definition	Model 2013A (per Yr)
Class III (LOCA)	A	Accident sequences leading to core damage conditions initiated by vessel rupture where the containment integrity is not breached in the initial time phase of the accident.	9.62E-10
	B	Accident sequences initiated or resulting in small or medium LOCAs for which the reactor cannot be depressurized prior to core damage occurring.	1.48E-08
	C	Accident sequences initiated or resulting in medium or large LOCAs for which the reactor is a low pressure and no effective injection is available.	9.98E-09
	D	Accident sequences which are initiated by a LOCA or RPV failure and for which the vapor suppression system is inadequate, challenging the containment integrity with subsequent failure of makeup systems.	2.68E-08
Class IV (ATWS)	A	Accident sequences involving failure of adequate shutdown reactivity with the RPV initially intact; core damage induced post containment failure.	4.87E-07
	L	Accident sequences involving a failure of adequate shutdown reactivity with the RPV initially breached (e.g. LOCA or SORV); core damage induced post containment failure.	
	T	Accident sequences involving a failure of adequate shutdown reactivity with the RPV initially intact, core damage induced post high containment pressure. (Not used)	
	V	Class IVA or IVL except that the vent operates as designed; loss of makeup occurs at some time following vent initiation. Suppression pool saturated but intact. (Not used)	
Class V	---	Unisolated LOCA outside containment.	8.33E-08
		Total	2.58E-06

Table F.2-4
Release Severity And Timing Classification Matrix

Release Severity		Release Timing	
Classification Category	**Cs Iodide % in Release**	**Classification Category**	**Time of Initial Release(2) Relative to Time for General Emergency Declaration**
High (H)	Greater than 10	Late (L)	Greater than 24 hours
Medium or Moderate (M)	1 to 10	Intermediate (I)	5 to 24 hours
Low (L)	0.1 to 1	Early (E)	Less than 5 hours
Low-low (LL)	Less than 0.1		
Intact (OK)	Leakage		

Table F.2-5
Release Category Matrix

Time of Release	Magnitude of Release			
	H	**M**	**L**	**LL**
E	H/E	M/E	L/E	LL/E
I	H/I	M/I	L/I	LL/I
L	H/L	M/L	L/L	LL/L

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Table F.2-6
Summary Of LSCS Level 2 Release Categories (/Yr) (1), (2), (3)

Class	CDF	Intact	LL/E	LL/I	LL/L	L/E	L/I	L/L	M/E	M/I	M/L	H/E	H/I	H/L	Total Release
IA	8.46E-08	1.18E-08	N/A	0.00E+00	N/A	3.68E-08	1.08E-08	N/A	1.10E-09	1.67E-08	N/A	7.34E-09	2.05E-10	N/A	7.28E-08
IBE	3.43E-07	2.96E-07	N/A	0.00E+00	N/A	1.85E-08	1.28E-08	N/A	3.07E-09	7.53E-09	N/A	4.53E-09	7.40E-10	N/A	4.72E-08
IBL	2.94E-07	1.57E-07	N/A	0.00E+00	N/A	N/A	8.33E-08	N/A	N/A	3.72E-08	N/A	N/A	1.63E-08	N/A	1.37E-07
IC	1.67E-07	1.44E-07	N/A	0.00E+00	N/A	1.08E-08	9.11E-09	N/A	1.60E-09	5.63E-11	N/A	1.57E-09	0.00E+00	N/A	2.31E-08
ID	3.53E-08	2.98E-09	N/A	0.00E+00	N/A	2.72E-08	0.00E+00	N/A	0.00E+00	4.92E-09	N/A	2.13E-10	0.00E+00	N/A	3.23E-08
II	8.23E-07	2.70E-08	N/A	0.00E+00	N/A	N/A	0.00E+00	N/A	N/A	7.94E-07	N/A	N/A	1.75E-09	N/A	7.96E-07
IIE	4.33E-08	1.77E-08	0.00E+00	N/A	N/A	0.00E+00	N/A	N/A	2.56E-08	N/A	N/A	0.00E+00	N/A	N/A	2.56E-08
IIV	1.60E-07	6.54E-08	N/A	N/A	N/A	N/A	2.65E-08	N/A	N/A	6.79E-08	N/A	N/A	1.62E-10	N/A	9.46E-08
IIVE	8.46E-09	5.86E-09	N/A	N/A	N/A	5.67E-10	N/A	N/A	2.03E-09	N/A	N/A	0.00E+00	N/A	N/A	2.59E-09
IIIA	9.62E-10	2.37E-10	N/A	0.00E+00	N/A	0.00E+00	6.99E-10	N/A	8.82E-12	0.00E+00	N/A	1.73E-11	N/A	N/A	7.25E-10
IIIB	1.49E-08	1.33E-08	N/A	0.00E+00	N/A	0.00E+00	1.32E-09	N/A	1.49E-11	0.00E+00	N/A	2.57E-10	N/A	N/A	1.59E-09
IIIC	9.98E-09	0.00E+00	N/A	0.00E+00	N/A	6.16E-09	4.58E-10	N/A	3.09E-09	2.63E-10	N/A	1.85E-10	N/A	N/A	1.02E-08
IIID	2.68E-08	0.00E+00	N/A	N/A	0.00E+00	0.00E+00	N/A	N/A	0.00E+00	N/A	N/A	2.69E-08	N/A	N/A	2.69E-08
IV	4.88E-07	0.00E+00	0.00E+00	N/A	N/A	2.93E-07	N/A	N/A	1.77E-07	N/A	N/A	1.83E-08	N/A	N/A	4.89E-07
V	8.32E-08	0.00E+00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.32E-08	N/A	N/A	8.32E-08
Total	2.58E-06	7.45E-07	0.00E+00	0.00E+00	0.00E+00	3.88E-07	1.45E-07	N/A	2.14E-07	9.27E-07	N/A	1.42E-07	1.90E-08	N/A	1.84E-06

(1) Based on results of PRAQuant results at the sequence level. Level 2 quantified at a truncation value of 1E-12/yr.

(2) N/A indicates that the accident class did not contribute to release of that specific category.

(3) Numerical differences in column totals may occur due to rounding.

Table F.2-7
Open LSCS PRA 2008 Peer Review Findings and Supporting Requirements Assigned Less Than Capability Category II

Supporting Requirements	Description of Gap[7]	Peer Review Assessment	Impact on SAMA Analysis
AS-B2	The modeling of Station Blackout assumes that, following recovery of offsite power, sufficient mitigating systems will be available to prevent core damage. The availability of mitigating systems should be explicitly considered in the event tree modeling.	Finding	Non-significant quantitative impact. This is an issue related to enhanced modeling for SBO scenarios. PRA results are dominated by failure to recover offsite power. Modeling refinements may result in improved level of detail of results. No significant impact on the SAMA analysis.
SC-B5	While the LS-PSA-003 notebook provides some selected comparison of RMEIP MELCOR results to more recent MAAP runs, there is no documented comparison of how the LSCS success criteria compare to those used for sister plants or other similar comparisons as required for this SR. However, the success criteria used for LSCS appear to be consistent with those of other similar BWRs. The LS-PSA-003 documentation should be enhanced to include a section that compares the LSCS success criteria to those used in the PRAs of other similar BWRs.	Supporting Requirement Not Met	Documentation issue. No quantitative impact. The LSCS PRA Success Criteria Notebook compares MAAP and MELCOR runs. The peer review team desired more comparisons with other plants and other codes. No impact on the SAMA analysis.

7 The gap descriptions are taken from the bases and assessment fields of the LaSalle PRA 2007 Peer Review database provided to Exelon by the review team.

Table F.2-7
Open LSCS PRA 2008 Peer Review Findings and Supporting Requirements Assigned Less Than Capability Category II

Supporting Requirements	Description of Gap[7]	Peer Review Assessment	Impact on SAMA Analysis
SY-A4	System engineer interviews are documented in the respective system notebooks. Operator interviews are documented in the HRA notebook. Each system notebook contains an appendix documenting interviews with system managers, however, there is little mention (if any at all) of walkdowns performed in support of the system analyses. The impression received is that walkdowns were performed some time ago for a much earlier revision but have not been retained in the system notebooks. Interview with plant engineers has been documented. However, plant walkdown details are not provided in the SBLC, CSCS, HPCS and RCIC NBs. PERFORM plant walkdowns with system engineers AND plant operators. Better document the walkdowns performed in support of the PRA and reference those walkdowns in each system notebook to achieve CC II.	Supporting Requirement Met (CC I)	Documentation issue. No quantitative impact. The majority of the LSCS PRA System Notebooks include documented Operator Interviews and Walkdowns. The peer review team desired that every System Notebook include such documentation and that walkdowns be performed with both Ops and Systems personnel on the walkdown. No impact on the SAMA analysis.

Table F.2-7
Open LSCS PRA 2008 Peer Review Findings and Supporting Requirements Assigned Less Than Capability Category II

Supporting Requirements	Description of Gap[7]	Peer Review Assessment	Impact on SAMA Analysis
DA-C8	Basic events used to model the standby status of various plant systems use a mixture of plant-specific operational data and engineering judgment. For the Plant Service Water system and several other systems, standby estimates have been determined from procedures and operating data (see Appendix G of LS-PSA-010). For other components, assumptions are used (e.g., 50% probability of either of two pumps in a system is in standby). So, overall LSCS has some Category II attributes and some Category I attributes. Collect plant-specific data for all of the basic events that reflect standby status to meet Category II requirements.	Supporting Requirement Met (CC I)	Non-significant quantitative impact. The LSCS PRA uses primarily plant-specific information for configuration probabilities. Peer Review team desired that all configuration probabilities used in the PRA be based on plant-specific data. During the 2011 PRA update, plant specific data was gathered and incorporated for all risk significant systems. Plant operating practices were reviewed to incorporate standby and run times for systems with standby pumps. No significant impact on the SAMA analysis.
DA-C10	LS-PSA-010 Component Data Notebook, Appendix C, page C-24 states "No actual data or estimates for these parameters are provided by system managers. Data from the MSPI basis document, Scoping and Performance Criteria Document, and 2003 data notebook is used." However, no discussion of how surveillance tests were used is provided in the PRA. Category I is met, but it is unclear if Category II requirements are met. The documentation should describe how tests were counted to fully meet the requirements of this SR.	Supporting Requirement Met (CC I)	No quantitative impact. For the 2011 PRA update, plant specific data was obtained for all risk significant systems for the data update. This is a documentation issue pertaining to fully describing how the data is obtained and used. The issue remains open for a document enhancement. No impact on the SAMA analysis.

Table F.2-7
Open LSCS PRA 2008 Peer Review Findings and Supporting Requirements Assigned Less Than Capability Category II

Supporting Requirements	Description of Gap[7]	Peer Review Assessment	Impact on SAMA Analysis
IF-C3b	Appendix D addresses flow through drain lines (e.g., 3I4 and 3J5) and addresses doors as well. RG1.200 appends the Cat II requirements to include the potential for barrier unavailability, including maintenance. Barrier unavailability does not appear to have been discussed; however, given the nature of the major flooding scenarios it will probably make little difference. In order to meet the Cat II requirements of RG1.200 . one must address potential unavailability of barriers that affect the propagation of water.	Supporting Requirement Met (CC I)	Documentation issue. No quantitative impact. Flood barrier unavailability is considered and included in the internal flood analysis. Peer review team desired to see more extensive discussions on this topic; however, the team expected any resulting changes to the model results would be non-significant. No significant impact on the SAMA analysis.

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Table F.3-1
County Based Growth Rates 2000 – 2030

County	Growth Rate 2000 – 2030 Percentage
Bureau	14.8%
Cook	11.2%
DeKalb	39.4%
DuPage	14.2%
Ford	12.2%
Grundy	34.1%
Iroquois	15.7%
Kane	67.8%
Kankakee	21.6%
Kendall	55.7%
La Salle	26.8%
Lee	7.8%
Livingston	13.6%
Marshall	8.6%
Mclean	32.1%
Ogle	24.7%
Peoria	5.2%
Putnam	11.0%
Tazewell	29.0%
Will	117.3%
Woodford	31.9%

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Table F.3-2
2000 and 2010 Population Comparison for Counties Within 50 miles of LSCS[8]

County	Approximate Area Fraction Within 50 Miles of LSCS	2000 CENSUS		2010 Projected		2010 CENSUS	
		Total Population	Weighted Population	Total Population	Weighted Population	Total Population	Weighted Population
Bureau	0.65	35,561	23,115	36,427	23,678	34,978	22,736
Cook	0.08	5,386,673	430,934	5,472,429	437,794	5,194,675	415,574
DeKalb	0.65	89,118	57,927	101,735	66,128	105,160	68,354
DuPage	0.45	905,764	407,594	948,549	426,847	916,924	412,616
Ford	0.45	14,272	6,422	14,706	6,618	14,081	6,336
Grundy	1.00	37,599	37,599	41,650	41,650	50,063	50,063
Iroquois	0.30	31,386	9,416	32,524	9,757	29,718	8,915
Kane	0.55	404,834	222,659	516,914	284,303	515,269	283,398
Kankakee	0.85	104,010	88,409	110,659	94,060	113,449	96,432
Kendall	1.00	54,633	54,633	68,588	68,588	114,736	114,736
La Salle	1.00	111,700	111,700	118,385	118,385	113,924	113,924
Lee	0.60	36,118	21,671	36,554	21,932	36,031	21,619
Livingston	1.00	39,743	39,743	40,838	40,838	38,950	38,950
Marshall	0.90	13,209	11,888	13,370	12,033	12,640	11,376

8 The 50-mile population totals in this table do not match the SECPOP2000 generated 50-mile population total (see Table F.3-4) because the numbers in this table assume uniform population distribution. The intent of this table is to show that the projected year 2010 data is more conservative than the year 2010 population data (i.e., indicates a higher population) as applied in this MACCS2 analysis.

Table F.3-2
2000 and 2010 Population Comparison for Counties Within 50 miles of LSCS[8]

County	Approximate Area Fraction Within 50 Miles of LSCS	2000 CENSUS Total Population	2000 CENSUS Weighted Population	2010 Projected Total Population	2010 Projected Weighted Population	2010 CENSUS Total Population	2010 CENSUS Weighted Population
McLean	0.35	150,696	52,744	168,611	59,014	169,572	59,350
Ogle	0.03	51,119	1,534	54,704	1,641	53,497	1,605
Peoria	0.05	183,751	9,188	187,876	9,394	186,494	9,325
Putnam	1.00	6,086	6,086	6,221	6,221	6,006	6,006
Tazewell	0.01	128,175	1,282	139,616	1,396	135,394	1,354
Will	0.90	503,162	452,846	706,639	635,975	677,560	609,804
Woodford	0.80	35,529	28,423	39,362	31,490	38,664	30,931
Total	--	--	2,075,810	--	2,397,741	--	2,383,404

Table F.3-3
Included Transient and Special Facility Population Within a 10-Mile Radius of LSCS, Year 2000[9]

Sector	0-1 mile	1-2 miles	2-3 miles	3-4 miles	4-5 miles	5-10 miles	0-10 miles Total
N	0	0	20	0	1,355	0	1,375
NNE	0	0	0	0	450	598	1,048
NE	0	0	0	0	448	1,241	1,689
ENE	0	125	125	0	0	106	356
E	0	100	100	0	0	0	200
ESE	0	0	1,500	0	0	0	1,500
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	126	126
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	229	229
WSW	0	0	0	0	0	51	51
W	0	0	0	0	0	390	390
WNW	0	0	0	0	0	104	104
NW	0	0	0	0	150	1,016	1,166
NNW	0	0	0	0	0	4,010	4,010
Total	0	225	1,745	0	2,403	7,871	12,244

9 The year 2000 transient (includes employees), seasonal resident, and special facility population is conservatively assumed to be equivalent to the year 2010 transient (includes employees), seasonal resident, and special facility population provided in the LaSalle ETE (ARCADIS 2012).

Table F.3-4
SECPOP2000 Based Residential Population Distribution Within a 50-Mile Radius of LSCS, Year 2000

Sector	0-10 miles	10-20 miles	20-30 miles	30-40 miles	40-50 miles	50-mile Total
N	1,068	4,782	16,711	6,518	48,325	77,404
NNE	1,093	1,084	11,097	109,919	216,180	339,373
NE	2,028	7,387	7,327	145,604	364,745	527,091
ENE	277	10,459	12,728	74,790	127,463	225,717
E	236	4,254	21,318	4,738	57,297	87,843
ESE	381	1,663	2,545	5,455	30,695	40,739
SE	211	5,784	1,026	1,612	4,894	13,527
SSE	258	1,318	1,164	7,774	1,489	12,003
S	411	987	14,033	3,021	4,562	23,014
SSW	252	952	2,145	5,600	6,142	15,091
SW	291	19,153	3,231	4,415	14,464	41,554
WSW	206	1,119	2,480	4,916	11,534	20,255
W	722	1,091	8,690	5,264	4,575	20,342
WNW	443	6,446	27,688	4,455	9,707	48,739
NW	1,547	16,613	1,608	9,826	5,043	34,637
NNW	5,058	1,758	4,565	3,309	4,426	19,116
Total	14,482	84,850	138,356	397,216	911,541	1,546,445

Table F.3-5
2010 Projected Population Distribution within a 50-Mile Radius of LSCS[10]

Sector	0-10 miles	10-20 miles	20-30 miles	30-40 miles	40-50 miles	50-mile Total
N	2,589	5,160	18,766	7,737	57,458	91,710
NNE	2,317	1,288	13,927	139,048	261,145	417,725
NE	4,074	8,237	9,305	202,390	418,727	642,733
ENE	690	11,589	17,310	105,005	166,594	301,188
E	473	4,713	28,523	5,525	64,860	104,094
ESE	2,011	1,836	2,710	5,766	32,138	44,461
SE	231	6,085	1,057	1,662	5,065	14,100
SSE	277	1,358	1,197	7,992	1,537	12,361
S	567	1,015	14,426	3,223	5,073	24,304
SSW	267	980	2,214	6,037	6,848	16,346
SW	551	19,957	3,399	4,786	16,012	44,705
WSW	273	1,186	2,567	4,985	11,834	20,845
W	1,178	1,156	9,116	5,385	4,680	21,515
WNW	580	6,833	29,211	4,566	9,930	51,120
NW	2,876	17,610	1,704	10,150	5,104	37,444
NNW	9,612	1,863	4,912	3,630	4,705	24,722
Total	28,566	90,866	160,344	517,887	1,071,710	1,869,373

10 Population projection for 0-10 miles includes permanent residents, transients (including employees), seasonal residents, and special facilities. This population projection is based on year 2000 census data from SECPOP2000.

Table F.3-6
Projected Population Distribution Within a 10-Mile Radius of LSCS, Year 2043[11]

Sector	0-1 mile	1-2 miles	2-3 miles	3-4 miles	4-5 miles	5-10 miles	0-10 miles Total
N	0	1	28	0	1,934	1,493	3,456
NNE	0	0	0	208	646	2,297	3,151
NE	0	0	0	165	1,236	4,205	5,606
ENE	0	177	177	21	1	565	941
E	0	142	147	37	22	295	643
ESE	0	16	2,123	22	6	538	2,705
SE	0	4	6	17	31	262	320
SSE	0	4	10	25	11	326	376
S	0	7	22	20	9	691	749
SSW	0	0	20	7	21	308	356
SW	4	21	6	7	16	682	736
WSW	0	0	18	21	17	307	363
W	0	25	10	21	27	1,491	1,574
WNW	1	0	26	38	16	693	774
NW	0	15	3	52	400	3,371	3,841
NNW	1	0	40	4	218	12,570	12,833
Total	6	412	2,636	665	4,611	30,094	38,424

11 Population projection for 0-10 miles includes permanent residents, transients (including employees), seasonal residents, and special facilities. This population projection is based on year 2000 census data from SECPOP2000.

Table F.3-7
Projected Population Distribution within a 50-Mile Radius of LSCS, Year 2043[12]

Sector	0-10 miles	10-20 miles	20-30 miles	30-40 miles	40-50 miles	50-mile Total
N	3,456	7,000	26,360	11,702	87,562	136,080
NNE	3,151	1,894	21,448	225,910	401,416	653,819
NE	5,606	11,510	15,612	455,348	628,691	1,116,767
ENE	941	16,099	37,905	245,127	338,890	638,962
E	643	6,548	60,524	8,673	94,937	171,325
ESE	2,705	2,530	3,405	7,122	39,094	54,856
SE	320	7,524	1,243	1,934	6,009	17,030
SSE	376	1,598	1,400	9,351	1,789	14,514
S	749	1,187	16,880	4,018	6,748	29,582
SSW	356	1,155	2,610	7,722	9,231	21,074
SW	736	24,853	4,370	6,197	21,642	57,798
WSW	363	1,584	3,116	5,560	13,448	24,071
W	1,574	1,544	11,641	6,235	5,539	26,533
WNW	774	9,123	38,359	5,464	11,692	65,412
NW	3,841	23,511	2,276	12,250	5,627	47,505
NNW	12,833	2,488	6,652	4,789	5,807	32,569
Total	38,424	120,148	253,801	1,017,402	1,678,122	3,107,897

12 Population projection for 0-10 miles includes permanent residents, transients (including employees), seasonal residents, and special facilities. This population projection is based on year 2000 census data from SECPOP2000.

Table F.3-8
County Specific Land Use and Economic Parameters Inputs

County	Fraction Farm	Fraction Dairy	Farm Sales ($/hectare)	Farm Property Value ($/hectare)	Non-Farm Property Value ($/person)
Bureau	0.860	0.002	1,566	11,275	230,423
Cook	0.014	0.036	4,601	28,720	324,570
DeKalb	0.918	0.013	2,013	12,885	207,349
DuPage	0.038	0.000	4,374	20,877	385,139
Ford	0.871	0.002	1,331	11,055	250,120
Grundy	0.805	0.003	1,206	11,556	226,266
Iroquois	0.948	0.006	1,525	11,217	223,993
Kane	0.578	0.018	2,544	13,552	251,322
Kankakee	0.891	0.008	1,562	12,053	209,476
Kendall	0.814	0.008	1,532	12,032	227,743
LaSalle	0.886	0.001	1,263	11,680	223,468
Lee	0.852	0.002	1,338	11,992	210,685
Livingston	0.941	0.009	1,378	11,538	246,998
Marshall	0.828	0.005	1,215	11,262	241,404
McLean	0.893	0.053	1,339	11,633	254,519
Ogle	0.755	0.015	1,744	12,608	223,703
Peoria	0.654	0.013	1,203	10,798	275,390
Putnam	0.613	0.008	2,557	10,971	246,522
Tazewell	0.793	0.011	1,387	11,230	260,756
Will	0.412	0.013	1,427	15,683	260,590
Woodford	0.854	0.005	1,521	11,812	259,630

Table F.3-9
MACCS2 Economic Parameter Inputs

Variable	Description	Base Case Value
DPRATE[1]	Property depreciation rate (per yr)	0.20
DSRATE[2]	Investment rate of return (per yr)	0.07
EVACST[3]	Daily cost for a person who has been evacuated ($/person-day)	57.51
RELCST[3]	Daily cost for a person who is relocated ($/person-day)	57.51
POPCST[3]	Population relocation cost ($/person)	10,650
CDFRM0[3]	Cost of farm decontamination for two levels of decontamination ($/hectare)[5]	1,198 2,663
TIMDEC[1]	Decontamination time for each level[5]	2&4 months
CDNFRM[3]	Cost of non-farm decontamination per resident person for two levels of decontamination ($/person) [5]	6,390 17,040
DLBCST[3]	Average cost of decontamination labor ($/man-year)	74,550
TFWKF[1]	Time workers spend in farm land contaminated areas[5]	1/10 1/3
TFWKNF[1]	Time workers spend in non-farm land contaminated areas[5]	1/3 1/3
VALWF0[4]	Weighted average value of farm wealth ($/hectare)	11,937
VALWNF[4]	Weighted average value of non-farm wealth ($/person)	283,637

1 Uses NUREG/CR-4551 value (NRC 1990b).

2 DSRATE based on NUREG/BR-0058 (NRC 2004a).

3 These parameters use the NUREG/CR-4551 value (NRC 1990b), updated to July 2013 using the CPI.

4 VALWF0 and VALWNF are based on the 2007 Census of Agriculture (USDA 2009), Bureau of Labor Statistics (BLS 2013) and Bureau of Economic Analysis (BEA 2013) data, updated to July 2013 using the CPI for the counties within 50 miles.

5 Two decontamination levels are modeled. The first value is associated with a dose reduction factor of 3. The second value is associated with a dose reduction factor of 15.

Table F.3-10
COMIDA2 Related Input Parameter Values Used for the LSCS SAMA Analysis

PARAMETER	PARAMETER DESCRIPTION	VALUE EFFECTIVE (Rem)	VALUE THRYOID (Rem)
DOSEMILK	Maximum allowable food ingestion dose from milk crops during the year of the accident	0.25	2.5
DOSEOTHER	Maximum allowable food ingestion dose from non-milk crops during the year of the accident	0.25	2.5
DOSELONG	Maximum allowable long term annual dose to an individual from ingestion of the combination of milk and non-milk crops.	0.50	5.0

Table F.3-11
LSCS Core Inventory

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Co-58	2.15E+16	Te-131m	5.02E+17
Co-60	2.36E+16	Te-132	4.94E+18
Kr-85	4.92E+16	I-131	3.48E+18
Kr-85m	1.07E+18	I-132	5.02E+18
Kr-87	2.10E+18	I-133	7.17E+18
Kr-88	2.97E+18	I-134	7.95E+18
Rb-86	8.27E+15	I-135	6.70E+18
Sr-89	3.59E+18	Xe-133	7.08E+18
Sr-90	3.94E+17	Xe-135	2.79E+18
Sr-91	4.90E+18	Cs-134	9.18E+17
Sr-92	5.18E+18	Cs-136	2.55E+17
Y-90	4.07E+17	Cs-137	5.71E+17
Y-91	4.43E+18	Ba-139	6.56E+18
Y-92	5.19E+18	Ba-140	6.32E+18
Y-93	5.84E+18	La-140	6.46E+18
Zr-95	5.76E+18	La-141	5.99E+18
Zr-97	6.01E+18	La-142	5.85E+18
Nb-95	5.79E+18	Ce-141	5.79E+18
Mo-99	6.55E+18	Ce-143	5.71E+18
Tc-99m	5.73E+18	Ce-144	4.61E+18
Ru-103	5.48E+18	Pr-143	5.54E+18
Ru-105	3.83E+18	Nd-147	2.37E+18
Ru-106	2.27E+18	Np-239	7.15E+19
Rh-105	3.61E+18	Pu-238	2.22E+16
Sb-127	3.80E+17	Pu-239	1.56E+15
Sb-129	1.13E+18	Pu-240	1.69E+15
Te-127	3.77E+17	Pu-241	8.08E+17
Te-127m	5.05E+16	Am-241	1.26E+15
Te-129	1.11E+18	Cm-242	2.92E+17
Te-129m	1.65E+17	Cm-244	3.33E+16

Table F.3-12
MACCS2 Radioisotope Groups vs. LSCS Level 2 Radioisotope Groups

MACCS2 Radioisotope Groups	LSCS Level 2 Radioisotope Groups[4]
Xe/Kr	1 – noble gases
I	2 – CsI
Cs	6 & 2 – CsOH and CsI[3]
Te	3, 10 & 11- TeO_2, Sb[2] & Te_2 [1]
Sr	4 – SrO
Ru	5 – MoO_2 (Mo is included in Ru MACCS category)
La	8 – La_2O_3
Ce	9 & 12 – CeO_2 & UO_2 [1]
Ba	7 – BaO

1 These release fractions are typically negligible compared to others in the group.

2 The mass of Sb in the core is typically much less than the mass of Te.

3 The mass of Cs contained in CsI is typically much less than the mass of Cs contained in CsOH.

4 The LSCS Level 2 radioisotope groups represent the twelve (12) MAAP 4.0.5 radioisotope groups.

Table F.3-13
LSCS Level 2 Source Term Category Summary

Release Category	Description
H/E	High/Early Release
H/I	High/Intermediate Release
H/L	High/Late Release
M/E	Moderate/Early Release
M/I	Moderate/Intermediate Release
M/L	Moderate/Late Release
L/E	Low/Early Release
L/I	Low/Intermediate Release
L/L	Low/Late Release
LL/E	Low-Low/Early Release
LL/I	Low-Low/Intermediate Release
LL/L	Low-Low/Late Release
OK	Containment OK

Table F.3-14
Level 2 End State Bins: Radionuclide Release
Severity and Timing Classification Scheme (Severity, Timing)(1)

Radionuclide Release Severity		Radionuclide Release Timing	
Classification Category	**Cs Iodide % in Release**	**Classification Category**	**Time of Initial Release(2) Relative to Declaration of a General Emergency**
High(4) (H)	Greater than 10%(4)	Late (L)	Greater than 24 hours
Moderate (M)	1% to 10%	Intermediate (I)	E(3) to 24 hours
Low (L)	Less than 1%	Early (E)	Less than E(3), (4) hours
No iodine (OK, Intact Containment)	negligible		

1 Thirteen (13) Level 2 End State Bins: H/E, H/I, H/L, M/E, M/I, M/L, L/E, L/I, L/L, LL/E, LL/I, LL/L, OK, Break Outside Containment (BOC-not shown but would be a H/E),

2 The General Emergency declaration is accident sequence dependent and occurs when EALs are exceeded.

3 Where E hours is less than the time when evacuation is effective (5 hours) for LSCS.

4 Consistent with NUREG/CR-6595 (NRC 1999).

Table F.3-15
Detailed Release Category Results

Endstate	LSCS Unit 2	
	Freq (/yr)	Percent
H/E-BOC	8.32E-08	3.2%
H/E	5.93E-08	2.3%
H/I	1.90E-08	0.7%
M/E	2.14E-07	8.3%
M/I	9.27E-07	35.9%
L/E	3.88E-07	15.0%
L/I	1.45E-07	5.6%
INTACT	7.45E-07	28.9%
Total	2.58E-06	100.0%

Table F.3-16
LSCS Release Category Bins

Release Category	Bin
High Magnitude / Early Release (Accident Class V, Unisolated LOCA Outside Containment)	H/E-BOC
High Magnitude / Early Release (non-BOC release)	H/E
High Magnitude / Intermediate Release High Magnitude / Late Release	H/I
Moderate Magnitude / Early Release	M/E
Moderate Magnitude / Intermediate Release Moderate Magnitude / Late Release	M/I
Low Magnitude / Early Release Low-low Magnitude / Early Release	L/E
Low Magnitude / Intermediate Release Low Magnitude / Late Release Low-low Magnitude / Intermediate Release Low-low Magnitude / Late Release	L/I
Containment Intact	CI

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Table F.3-17
Release Bin MAAP Case Selection

Release Category Bin	MAAP Scenario Assigned	Accident Class	Release Fractions[13] CsI	CsOH	Assignment Rationale
H/E-BOC - High Magnitude / Early Release (Accident Class V, Unisolated LOCA Outside Containment)	LS130528	V	9.4E-1	8.7E-1	MAAP case LS130528 represents an H/E release following a Main Steam Line break outside of containment (Class V BOC frequency of 8.32E-08/yr). This MAAP case adequately represents an H/E release with an unisolated LOCA outside of containment (Class V accident). The break location in this MAAP run does not account for scrubbing from the secondary containment that would occur from the dominant break locations for this release category bin. Timing: The GE is assumed declared at 0.5 hours for a Class V accident due to a conservative 30 minute minimum window assumed for GE declaration. The RPV water level drops below -183" (MSCWLL) within a few minutes, which results in a loss of 2 fission barriers and a potential loss of the third barrier. Containment isolation fails at transient initiation, resulting in an early release.
H/E – High/Early Release	LS130521x	IIID	2.6E-1	2.1E-1	The H/E bin (5.93E-8/yr) represents non-BOC H/E sequences and is dominated by Class IIID (45% of the H/E frequency) and Class IV (ATWS) sequences (31% of H/E frequency). The non-BOC H/E frequency evolves primarily from sequences IIID-009 (45% of the H/E frequency) and IV-041 (23% of H/E frequency). Sequence IIID-009 represents a LOCA event with

13 Radionuclide release fraction to the environment of CsOH (Cesium Hydroxide, FREL(6)) and CsI (Cesium Iodine, FREL(2)) quoted at the end of the MAAP run.

Table F.3-17
Release Bin MAAP Case Selection

Release Category Bin	MAAP Scenario Assigned	Accident Class	Release Fractions[13] CsI	CsOH	Assignment Rationale
					successful RPV depressurization but without successful make-up that leads to containment failure prior to RPV failure. Sequence IV-041 represents an ATWS scenario with successful RPV depressurization and an RPV failure followed by a wetwell water space failure. The Level 2 reference MAAP case for sequence IIID-009 is LS130521x (CsI release fraction (RF) of 2.6E-1). The representative MAAP case for sequence IV-041 is LS130523 (CsI RF of 1.1E-1). Case LS130521x is chosen as the representative case since the IIID-009 sequence dominates the non-BOC H/E frequency and has a CsI RF more representative of an H/E release. <u>Timing</u>: The GE is assumed declared at 0.5 hours for a Class V accident due to a conservative 30 minute minimum window assumed for GE declaration. The RPV water level drops below -183" within a few minutes, which results in a loss of 2 fission barriers and a potential loss of the third barrier. Containment fails at transient initiation due to failure to isolate containment.
H/I - High/Intermediate Release	LS130536x	IBL	4.9E-1	3.0E-1	The H/I bin (1.90E-08/yr) is driven by IBL (85% of the H/I frequency) sequences. The dominant sequence leading to the H/I end state is the IBL-081 sequence (74% of the H/I frequency). The IBL-081 sequence is characterized by a station blackout scenario with unsuccessful RPV depressurization without injection to containment available. Sequence IBL-081 results in

Table F.3-17
Release Bin MAAP Case Selection

Release Category Bin	MAAP Scenario Assigned	Accident Class	Release Fractions[13] CsI	CsOH	Assignment Rationale
					the failure of the drywell due to overpressure. The reference MAAP case for the IBL-081 sequence is LS130536x (CsI RF of 4.9E-1). Case LS130536x is chosen as the representative MAAP case since it represents the most dominant sequence of the release bin. <u>Timing</u>: The GE would be declared at approximately 5.6 hours for the selected MAAP case due to the RPV level rapidly dropping below MSCWLL at that time. Once the level drops below MSCWLL, two fission barriers are lost along with the potential loss of the third barrier. The failure of containment is at 11.1 hours, which is greater than 4 hours and less than 24 hours after the GE is declared.
H/L - High/Late Release	N/A	N/A	N/A	N/A	The H/L bin release frequency was calculated as negligible in the LSCS Level 2 PRA model. This group is subsumed by the H/I end state.
M/E - Moderate/Early Release	LS130524	IV	7.1E-2	8.0E-2	The M/E bin (2.14E-07/yr) is dominated by the Class IV sequences (83% of the M/E frequency). The dominant sequence, IV-014 (68% of the M/E frequency), represents an ATWS scenario with a successful RPV depressurization and RPV failure prior to a wetwell airspace failure. The reference MAAP case for sequence IV-014 is LS130524 (CsI RF of 7.1E-2) LS130524 models a scenario with a wetwell airspace failure prior to RPV failure. However, the dominate sequences represent scenarios with wetwell airspace failure following RPV

Table F.3-17
Release Bin MAAP Case Selection

Release Category Bin	MAAP Scenario Assigned	Accident Class	Release Fractions[13] CsI	CsOH	Assignment Rationale
					failure. The MAAP case is judged adequate to represent the sequences since the impact of a wetwell airspace failure prior to RPV failure has a relatively minor impact on the release fractions. MAAP case LS130524 is chosen as the representative MAAP case since it represents the most dominant sequence (sequence IV-014). <u>Timing:</u> The GE is assumed declared at 0.5 hours for a Class IV accident due to a conservative 30 minute minimum window assumed for GE declaration. The RPV water level drops below -183" within a few minutes, which results in a loss of 2 fission barriers and a potential loss of the third barrier. The containment failure time is 1.7 hours after accident initiation.
M/I - Moderate/ Intermediate Release	LS130516	II	2.9E-2	9.0E-2	The M/I bin (9.27E-07/yr) is dominated by Class II sequences (86% of the M/I frequency). Sequence II-067 (35% of the M/I frequency) represents a loss of decay heat removal scenario with successful RPV depressurization and a failure of the drywell due to drywell overpressure following RPV failure. Sequence II-014 (29% of the M/I frequency) represents a loss of decay heat removal scenario with successful RPV depressurization and a wetwell airspace failure following RPV failure. The representative MAAP case for sequence II-067 is LS130516 (CsI RF of 2.9E-2). The reference MAAP case for sequences II-014 is LS130514 (CsI RF of 9.7E-3).

Table F.3-17
Release Bin MAAP Case Selection

Release Category Bin	MAAP Scenario Assigned	Accident Class	Release Fractions[13] CsI	CsOH	Assignment Rationale
					Case LS130516 is chosen as the representative MAAP case since it represents the most dominant sequence (sequence II-067). <u>Timing:</u> For Class II sequences the GE is assumed to be declared in the "early" time frame. The GE is assumed to be declared at t=4hrs. The selected MAAP case results in a containment failure at 27.6 hours followed by core damage time of 28.3, greater than 4 and less than 24 hours after the GE is declared.
M/L - Moderate/Late Release	N/A	N/A	N/A	N/A	The M/L bin release frequency was calculated as negligible in the LSCS Level 2 PRA model. This group is subsumed by the M/I end state.
L/E - Low/Early Release	LS130533B	IA	1.1E-3	2.4E-4	The L/E release frequency (3.88E-07/yr) is dominated by the Class IV (75% of the L/E frequency) sequence. Sequence IV-004 (75% of the L/E frequency) represents an ATWS scenario with successful RPV depressurization, arrested core melt in-vessel, and a wetwell airspace failure without suppression pool bypass. The reference MAAP case for sequence IV-004 is case LS130524 (CsI RF of 7.1E-2). However, case LS130524 does not model the core melt arresting in-vessel. If the core melt is arrested in-vessel, the release magnitude would be lower. It should be noted that the reference MAAP cases in the Level 2 analysis are not necessarily exact models of the sequence, but are instead used along with the Level 2 Release Category rules to assign

Table F.3-17
Release Bin MAAP Case Selection

Release Category Bin	MAAP Scenario Assigned	Accident Class	Release Fractions[13] CsI	CsOH	Assignment Rationale
					an appropriate end state to the Level 2 sequence. MAAP case LS130533B (CsI RF of 1.1E-3) represents a loss of RPV injection sequence ending with containment flooding and venting and is judged to adequately represent the L/E release category bin. Timing: The GE is assumed declared at 0.5 hours for a Class IA accident due to a conservative 30 minute minimum window assumed for GE declaration. The RPV water level reaches -183" in that time frame, which results in the loss of 2 fission barriers with a potential loss of the third barrier. The selected MAAP case reaches core damage at 48 minutes followed by successful containment venting at 4.6 hours after accident initiation.
L/I - Low/Intermediate Release	LS130534	ID	4.3E-3	3.5E-3	The L/I bin (1.45E-07/yr) is dominated by the Class IBL (57% of the L/I frequency), and IIV (18% of the L/I frequency) sequences. The dominant sequences are IBL-004 (21% of the L/I frequency) and IIV-004 (18% of the L/I frequency. Sequence IBL-004 represents a station blackout scenario with successful RPV depressurization, arrested core melt in-vessel, and successful containment flooding and venting. Sequence IIV-004 represents a station blackout scenario with successful RPV depressurization, arrested core melt in-vessel, and a wetwell airspace failure without suppression pool bypass. The reference MAAP case for sequence IBL-004 is LS130534 (CsI RF of 5.2E-3). This case models loss of injection, successful depressurization, and

Table F.3-17
Release Bin MAAP Case Selection

Release Category Bin	MAAP Scenario Assigned	Accident Class	Release Fractions[13] CsI	CsOH	Assignment Rationale
					successful containment venting and flooding. However, case LS130534 does not model the core melt arresting in-vessel. If the core melt is arrested in-vessel, the release magnitude would be lower. It should be noted that the reference MAAP cases in the Level 2 analysis are not necessarily exact models of the sequence, but are instead used along with the Level 2 Release Category rules to assign an appropriate end state to the Level 2 sequence. The representative MAAP case for scenario IIV-004 is LS130537 (CsI RF of 2.1E-1). MAAP case LS130534 is chosen as the representative case for this bin since it represents the most dominant sequence (LS130534) and is adequately representative of the L/I category. Timing: The GE is assumed declared at 0.5 hours due to a conservative 30 minute minimum window assumed for GE declaration. The RPV water level would reach -183" in that time frame, which results in the loss of 2 fission barriers with a potential loss of the third barrier. The selected MAAP case reaches core damage at 36 minutes followed by successful containment venting at t=5.3 hrs.
L/L - Low/Late Release	N/A	N/A	N/A	N/A	The L/L bin release frequency was calculated as negligible in the LSCS Level 2 PRA model. This group is subsumed by the L/I end state.
LL/E - Low-Low/Early Release	N/A	N/A	N/A	N/A	The LL/E bin release frequency was calculated as negligible in the LSCS Level 2 PRA model. This group is subsumed by the L/E end state.

Table F.3-17
Release Bin MAAP Case Selection

Release Category Bin	MAAP Scenario Assigned	Accident Class	Release Fractions[13] CsI	CsOH	Assignment Rationale
LL/I - Low-Low/Intermediate Release	N/A	N/A	N/A	N/A	The LL/I bin release frequency was calculated as negligible in the LSCS Level 2 PRA model. This group is subsumed by the L/I end state.
LL/L - Low-Low/Late Release	N/A	N/A	N/A	N/A	The LL/L bin release frequency was calculated as negligible in the LSCS Level 2 PRA model. This group is subsumed by the L/L end state.
CI – Containment Intact	LS130531	OK	8.5E-6	3.9E-6	MAAP case LS130531 is chosen as the MAAP case to represent Tech Spec leakage out of an intact containment (7.45E-07/yr) with no RPV depressurization. This case is chosen over the MAAP case simulating a Tech Spec leakage with successful RPV depressurization (LS130532) as the case with no RPV depressurization has a higher CsI release fraction. Timing: The GE would be declared at 0.5 hours for the selected MAAP case due to the RPV water level reaching -183" in that time frame, which results in the loss of 2 fission barriers with a potential loss of the third barrier. For the selected MAAP case, core damage occurs in 48 minutes with no containment failure.

Table F.3-18
LSCS MAAP 4.0.5 Level 2 Runs to Support SAMA

Case	Description	TAF	ED	MSCWLL (GE)[2]	CD	Vessel Breach	Cont. Failure[1]	NG[1] Release Fraction	CsI (CsOH)[1],[3] Release Fraction	Release Category	Run Time	Comments
LS130528	BOC LLOCA No Injection No ED No SPC or sprays	<1 min	N/A	< 1 min (30 min)	14 min	4.2 hr	N/A BOC on MSL (26" dia.)	1.0	9.4E-1 (8.7E-1)	HE - BOC	40 hr.	Break Outside Containment (26" break on MSL) with no Isolation
LS130521x	Containment Isolation Unsuccessful ($2ft^2$) LLOCA (Water) No Injection No SRVs No SPC or sprays	<1 min	N/A	<1 min (30 min)	7 min	3.2 hr	N/A Containment Isolation Unsuccessful ($2ft^2$)	1.0	2.6E-1 (2.1E-1)	HE	40 hr.	Lower pedestal walls fail when corium sideward erosion distance exceeds thickness of lower pedestal wall at t=16.3 hrs.
LS130536x	SBO DW Head Failure ($2ft^2$) MSIV Closure RCIC for 4 hrs. No SRVs No SPC or Sprays	5.5 hr	N/A	5.6 hr (5.6 hr)	6.4 hr	9.9 hr	11.1 hr	1.0	4.9E-1 (3.0E-1)	HI	48 hr.	Lower pedestal walls fail when corium sideward erosion distance exceeds thickness of lower pedestal wall at t=30 hrs.

Table F.3-18
LSCS MAAP 4.0.5 Level 2 Runs to Support SAMA

Case	Description	TAF	ED	MSCWLL (GE)[2]	CD	Vessel Breach	Cont. Failure[1]	NG[1] Release Fraction	CsI (CsOH)[1],[3] Release Fraction	Release Category	Run Time	Comments
LS130524	WWA Failure ($2ft^2$) ATWS with no SBLC FW, RCIC,LPCI 3 SRVs at -150" No SPC or sprays	6 min	3 SRVs @ 5 min	6 min (30 min)	2.0 hr	6.7 hr	1.7 hr	1.0	7.1E-2 (8.0E-2)	ME	100 hr.	
LS130516	DW head Failure ($2ft^2$) MSIV Closure LPCS 2 SRVs at -150" No SPC or sprays	18 min	2 SRVs @ 17 min	27.1 hr (4.0 hr)[4]	28.3	35.5 hr	27.6 hr	1.0	2.9E-2 (9.0E-2)	MI	100 hr.	
LS130533B	Containment Vent (uncontrolled) Containment Flood MSIV closure No injection No SRVs COND to RPV available at vessel failure	20 min	N/A	25 min (30 min)	48 min	3.2 hr	N/A Containment vented at 60 psig @ 4.6 hr (8" Containment vent)	1.0	1.1E-3 (2.3E-4)	LE	40 hr.	Containment vent at PCPL of 60 psig and left open. Drywell flooded via condensate (3000gpm) through RPV breach. Flooding begins at RPV breach.

Table F.3-18
LSCS MAAP 4.0.5 Level 2 Runs to Support SAMA

Case	Description	TAF	ED	MSCWLL (GE)[2]	CD	Vessel Breach	Cont. Failure[1]	NG[1] Release Fraction	CsI (CsOH)[1],[3] Release Fraction	Release Category	Run Time	Comments
LS130534	Containment Vent (controlled) Containment Flood MSIV closure No injection 2 SRVs at -150" FP to RPV available at vessel failure	19 min	2 SRVs @ 18 min	19 min (30 min)	36 min	4.3 hr	N/A Containment vented and cycled at 60 psig initially @ 5.3 hr (8" Containment vent)	1.0	5.2E-3 (3.8E-3)	LI	80 hr.	Containment vent at PCPL of 60 psig and controlled between 50-60 psig. Drywell flooded via FP through RPV breach. Flooding begins at RPV breach.
LS130531	Containment Intact MSIV closure No injection No SRVs 1 Loop of SPC 1 loop of sprays w/ Hx	20 min	N/A	25 min (30 min)	48 min	3.2 hr	N/A Containment Intact	1.9E-2	8.5E-6 (3.9E-6)	INTACT	60 hr.	Demonstrates no containment failure with sprays and SPC available with RHR HX.

1 Prior to containment failure, a 0.5% drywell gas volume per day leakage is assumed in each of the calculations. This leakage impacts the calculated release fractions of fission products.

2 The General Emergency (GE) declaration is accident sequence dependent and occurs when EALs are exceeded. For LSCS Units 1 and 2, the site would be expected to declare a general emergency if the RPV water level cannot be restored above -183", or when MSCWLL is indicated to the operators. If MAAP 4.0.5 calculates that the PRV water level drops below MSCWLL following an RPV depressurization with adequate injection available to increase the water level above MSCWLL shortly following (e.g., <15 minutes) the depressurization, the EALs are assumed to not be exceeded. The earliest time a GE can be declared is conservatively assumed to be 30 minutes. The GE for each scenario will either be 30 minutes if the time to MSCWLL is shorter than 30 minutes or will be equal to the time to MSCWLL is the time to MSCWLL is greater than 30 minutes.

3 The reported release fractions are based on the release fractions for CsI and CsOH at the end of the MAAP run.

4 General Emergency time determined probabilistically.

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	**H/E**	**H/I**	**M/E**	**M/I**	**L/E**	**L/I**	**INTACT**
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)(1)	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared (2)	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
1) Noble								
Total Release Fraction	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	3.06E-02
Total Plume 1 Release Fraction	1.00E+0	8.16E-1	1.00E+0	1.00E+0	1.00E+0	9.40E-1	5.37E-1	1.18E-3
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	0.00E+0	1.65E-1	0.00E+0	0.00E+0	0.00E+0	3.80E-2	4.62E-1	3.09E-3
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	0.00E+0	1.90E-2	0.00E+0	0.00E+0	0.00E+0	2.20E-2	1.00E-3	2.63E-2
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
2) CsI								
Total Release Fraction	9.37E-01	2.56E-01	4.92E-01	7.15E-02	2.95E-02	1.19E-03	5.19E-03	8.53E-06
Total Plume 1 Release Fraction	8.72E-1	1.93E-1	4.15E-1	8.48E-3	1.28E-2	8.88E-4	2.44E-3	7.50E-6
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	**H/E**	**H/I**	**M/E**	**M/I**	**L/E**	**L/I**	**INTACT**
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)(1)	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared (2)	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	5.80E-2	5.00E-2	5.60E-2	2.31E-2	1.34E-2	2.80E-4	2.50E-3	8.90E-7
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	7.00E-3	1.30E-2	2.10E-2	3.99E-2	3.30E-3	2.00E-5	2.50E-4	1.40E-7
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
3) TeO2								
Total Release Fraction	7.51E-01	2.24E-01	2.77E-01	6.88E-02	5.05E-02	1.01E-03	8.95E-04	4.94E-06
Total Plume 1 Release Fraction	6.85E-1	1.59E-1	1.56E-1	8.55E-3	2.09E-3	9.23E-4	5.75E-4	3.26E-6
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	4.00E-2	9.00E-3	1.19E-1	5.54E-2	1.17E-2	8.00E-5	3.12E-4	1.60E-6
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	2.60E-2	5.60E-2	2.00E-3	4.80E-3	3.67E-2	1.00E-5	8.00E-6	8.00E-8

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	**H/E**	**H/I**	**M/E**	**M/I**	**L/E**	**L/I**	**INTACT**
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)(1)	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared (2)	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
4) SrO								
Total Release Fraction	4.65E-02	5.97E-03	1.07E-02	2.46E-02	7.37E-03	8.35E-06	1.75E-04	6.50E-11
Total Plume 1 Release Fraction	1.07E-02	1.91E-3	5.19E-3	2.46E-2	3.16E-4	7.56E-6	1.59E-4	6.50E-11
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	3.58E-02	2.56E-3	5.50E-3	0.00E+0	7.05E-3	6.50E-7	1.60E-5	0.00E+0
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	0.00	1.50E-3	0.00E+0	0.00E+0	0.00E+0	1.40E-7	0.00E+0	0.00E+0
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
5) MoO2								
Total Release Fraction	4.15E-02	1.16E-02	5.18E-06	3.35E-05	2.64E-05	2.69E-05	4.18E-09	6.97E-10
Total Plume 1 Release Fraction	4.15E-2	1.16E-2	3.33E-6	2.71E-5	2.44E-5	2.15E-5	3.95E-9	6.97E-10

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	**H/E**	**H/I**	**M/E**	**M/I**	**L/E**	**L/I**	**INTACT**
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)[(1)]	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared [(2)]	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	0.00E+0	0.00E+0	1.00E-7	6.30E-6	1.90E-6	4.10E-6	2.30E-10	0.00E+0
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	0.00E+0	0.00E+0	1.75E-6	1.00E-7	1.00E-7	1.30E-6	0.00E+0	0.00E+0
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
6) CsOH								
Total Release Fraction	8.66E-01	2.06E-01	3.02E-01	7.98E-02	8.98E-02	9.48E-04	3.81E-03	3.94E-06
Total Plume 1 Release Fraction	6.85E-1	1.30E-1	1.08E-1	1.20E-2	9.64E-3	8.88E-4	1.53E-3	1.79E-6
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	1.00E-1	1.50E-2	1.86E-1	5.95E-2	3.06E-2	4.90E-5	2.05E-3	1.71E-6
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	**H/E**	**H/I**	**M/E**	**M/I**	**L/E**	**L/I**	**INTACT**
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)(1)	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared (2)	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	8.10E-2	6.10E-2	8.00E-3	8.30E-3	4.96E-2	1.10E-5	2.30E-4	4.40E-7
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
7) BaO								
Total Release Fraction	6.22E-02	1.49E-02	4.74E-03	1.08E-02	3.28E-03	5.12E-05	7.73E-05	2.26E-10
Total Plume 1 Release Fraction	4.74E-2	1.31E-2	2.27E-3	1.07E-2	2.00E-4	4.44E-5	6.97E-5	2.26E-10
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	1.48E-2	1.10E-3	2.46E-3	1.00E-4	3.08E-3	5.40E-6	7.60E-6	0.00E+0
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	0.00E+0	7.00E-4	1.00E-5	0.00E+0	0.00E+0	1.40E-6	0.00E+0	0.00E+0
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	**H/E**	**H/I**	**M/E**	**M/I**	**L/E**	**L/I**	**INTACT**
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)(1)	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared (2)	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
8) La2O3								
Total Release Fraction	4.97E-03	4.52E-04	3.59E-04	2.48E-03	2.06E-04	5.90E-07	1.37E-05	6.26E-12
Total Plume 1 Release Fraction	4.48E-4	1.48E-4	1.25E-4	2.48E-3	2.92E-6	4.10E-7	1.20E-5	6.26E-12
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	4.52E-3	1.62E-4	2.34E-4	0.00E+0	2.03E-4	1.58E-7	1.70E-6	0.00E+0
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	0.00E+0	1.42E-4	0.00E+0	0.00E+0	0.00E+0	2.20E-8	0.00E+0	0.00E+0
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
9) CeO2								
Total Release Fraction	4.10E-02	5.15E-03	7.40E-03	3.24E-02	5.07E-03	8.32E-07	3.21E-04	3.10E-11
Total Plume 1 Release Fraction	6.02E-4	1.62E-4	2.35E-3	3.22E-2	7.20E-5	6.08E-7	2.79E-4	3.10E-11
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	**H/E**	**H/I**	**M/E**	**M/I**	**L/E**	**L/I**	**INTACT**
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)(1)	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared (2)	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	4.04E-2	2.06E-3	5.05E-3	2.00E-4	5.00E-3	2.01E-7	4.20E-5	0.00E+0
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	0.00E+0	2.93E-3	0.00E+0	0.00E+0	0.00E+0	2.30E-8	0.00E+0	0.00E+0
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
10) Sb								
Total Release Fraction	7.88E-01	4.83E-01	2.57E-01	1.24E-01	1.07E-01	4.12E-03	1.86E-03	4.69E-07
Total Plume 1 Release Fraction	6.72E-01	1.60E-01	4.08E-02	5.52E-02	2.20E-02	3.74E-03	1.03E-03	2.55E-07
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	1.02E-01	2.20E-02	9.70E-02	5.30E-02	6.13E-02	8.00E-05	6.80E-04	1.83E-07
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	**H/E**	**H/I**	**M/E**	**M/I**	**L/E**	**L/I**	**INTACT**
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)[(1)]	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared [(2)]	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
Total Plume 3 Release Fraction	1.40E-02	3.01E-01	1.19E-01	1.60E-02	2.40E-02	3.00E-04	1.50E-04	3.10E-08
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
11) Te2								
Total Release Fraction	8.00E-04	1.01E-03	7.61E-03	4.30E-04	1.46E-03	0.00E+00	3.51E-05	6.88E-11
Total Plume 1 Release Fraction	0.00E+00	0.00E+00	6.90E-03	3.21E-04	1.78E-04	0.00E+00	2.61E-05	6.79E-11
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	7.98E-04	5.52E-04	3.90E-04	1.00E-06	1.20E-03	0.00E+00	4.50E-06	5.00E-13
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	2.00E-06	4.60E-04	3.20E-04	1.08E-04	8.00E-05	0.00E+00	4.50E-06	4.00E-13
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00
12) UO2								
Total Release Fraction	2.63E-04	3.02E-05	3.05E-05	1.87E-04	2.32E-05	0.00E+00	9.48E-07	2.86E-14

Table F.3-19
LSCS SOURCE TERM RELEASE SUMMARY

	Release Category							
	H/E-BOC	H/E	H/I	M/E	M/I	L/E	L/I	INTACT
MAAP Case	LS130528	LS130521X	LS130536X	LS130524	LS130516	LS130524B	LS130534	LS130531
Run Duration (hours)[(1)]	40 hr	40 hr	48 hr	100 hr	100 hr	40 hr	80 hr	60 hr
Time (hours) after Scram when GE is declared [(2)]	0.50	0.50	5.60	0.50	4.00	0.50	0.50	0.50
Fission Product Group:								
Total Plume 1 Release Fraction	0.00E+00	0.00E+00	7.68E-06	1.60E-04	1.69E-07	0.00E+00	7.90E-07	2.86E-14
Start of Plume 1 Release (hr)	0.25	0.00	11.00	2.00	27.50	1.50	5.25	1.00
End of Plume 1 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
Total Plume 2 Release Fraction	2.61E-04	9.43E-06	2.11E-05	2.70E-05	2.30E-05	0.00E+00	1.58E-07	0.00E+00
Start of Plume 2 Release (hr)	3.25	1.75	12.00	10.00	37.50	3.50	6.50	5.00
End of Plume 2 Release (hr)	10.00	5.25	18.00	20.00	47.50	4.50	12.50	10.00
Total Plume 3 Release Fraction	2.00E-06	2.08E-05	1.70E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Start of Plume 3 Release (hr)	10.00	5.25	18.00	20.00	57.50	4.50	12.50	10.00
End of Plume 3 Release (hr)	20.00	15.25	28.00	30.00	67.50	14.50	22.50	20.00

1 MAAP evaluation time varies for each MAAP case, based on achieving a plateau of the primary release category bins of concern (i.e., CsI, CsOH).

2 General Emergency declaration based on Emergency Action Level evaluation.

Table F.3-20
MACCS2 Base Case Mean Results Unit 2

Release Category	Dose (p-rem)	Offsite Economic Cost ($)	Freq. (/yr)	Dose-Risk (p-rem/yr)	OECR ($/yr)
H/E-BOC	1.61E+07	8.68E+10	8.32E-08	1.34E+00	7.22E+03
H/E	5.29E+06	4.66E+10	5.93E-08	3.14E-01	2.76E+03
H/I	5.66E+06	5.02E+10	1.90E-08	1.08E-01	9.54E+02
M/E	7.39E+06	4.39E+10	2.14E-07	1.58E+00	9.39E+03
M/I	3.86E+06	3.53E+10	9.27E-07	3.58E+00	3.27E+04
L/E	2.21E+05	3.19E+08	3.88E-07	8.57E-02	1.24E+02
L/I	7.09E+05	1.22E+09	1.45E-07	1.03E-01	1.77E+02
INTACT	2.17E+03	8.57E+05	7.45E-07	1.62E-03	6.38E-01
Frequency Weighted Totals			2.58E-06	7.11E+00	5.34E+04

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Table F.5-1
LSCS Level 1 Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
B--SYAVAILFAC---	9.62E-01	1.00E+30	PLANT AVAILABILITY FACTOR (AVERAGE OF BOTH UNITS)	This is the plant availability factor, which is included in every cutset and provides no insights related to potential means of reducing plant risk. No SAMAs identified.
RCVCL-2	1.00E+00	1.668	ACCIDENT CLASS II MARKER	This event is an accident class marker for loss of containment heat removal scenarios and does not represent any specific failure itself. The top contributors to this accident class are events related to adverse conditions caused by venting (over 70%) and HFEs related to the alignment of SPC (over 30%). LSCS is committed to installing a hard pipe vent, which will essentially eliminate the adverse environment condition in the RB after venting. Because this modification has not yet been implemented and is not reflected in the model or record, it has been designated as SAMA 1 for completeness. While already reliable, automating the initiation of SPC could further improve the reliability of the containment heat removal function (SAMA 2).
2HDOP-HD-VENTH--	9.00E-01	1.397	VENTING CREATES ADVERSE ENV. CONDITIONS FOR ALIGNMENT OF HD	The adverse environmental conditions after venting are caused by the lack of a hard pipe vent. LSCS is committed to installing a hard pipe vent, which will essentially eliminate this issue. Because this modification has not yet been implemented and is not reflected in the current model, it has been designated as SAMA 1 for completeness. This event is also used in the model for scenarios in which venting fails and containment failure results in an adverse environmental conditions. In conjunction with the hard pipe vent, a parallel, passive vent path could provide a means of ensuring that the containment failure occurs through a rupture disk with a scrubbed path from the wetwell (SAMA 3).

Table F.5-1
LSCS Level 1 Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2RPCDRPS-MECHFCC	2.10E-06	1.378	RPS MECHANICAL FAILURE	ATWS contributions are dominated by human control errors, which are represented by a number of HEP marker events and the JHEPs with which they are associated. One of the larger contributors to the scenarios including RPS mechanical failure is the HFE to bypass the low level interlock (~50%). Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Another contributor, at about 20%, is the failure to initiate SBLC. Automating system initiation could reduce these contributors (SAMA 5). Mechanical failure of the RPS itself is non-specific and provides no insights about potential changes that could be made to improve system reliability. No hardware changes have been identified.
2RHRXDHRRECLTH--	4.40E-01	1.304	FAIL TO RECOVERY DECAY HEAT REMOVAL LONG TERM	This event represents the probability of failing to repair the RHR system before PCPL is reached. No credible SAMAs have been identified that could justify a meaningful reduction in the repair probability itself, but there are means available to address other contributors to the scenarios that include this event. Over 80% of the contribution is related to failures resulting from an adverse RB environment cause by containment venting. LSCS is committed to installing a hardened vent (SAMA 1) that will effectively eliminate these types of events (no vent path failure). Of the remaining contributors, CCF

Table F.5-1
LSCS Level 1 Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				plugging of the ECCS suction strainers is significant. Installing a connection from the RHRSW system on the RHR pump suction line could provide a means of back flushing the suction strainer and restoring flow (SAMA 6).
%TT	7.98E-01	1.28	TURBINE TRIP WITH BYPASS INITIATING EVENT	The largest contributors related to this initiating event are ATWS scenarios caused by RPS mechanical failure (~90%). As described in the disposition of event 2RPCDRPS-MECHFCC, the failure mode is non-specific and does not provide insights on how the system might be improved. A more effective approach to reducing the contributions from ATWS scenarios is to install a keylock MSIV low level isolation bypass switch, which would reduce the time required to bypass the interlock and provide more time margin for the actions in ATWS scenarios requiring bypass of the isolation logic. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Automating SBLC initiation could also reduce some of these contributors (SAMA 5).
2SY--RB-CT---F--	1.00E+00	1.235	COND. PROB. OF ECCS FAILURE DUE TO ENV. IN REACTOR BUILDING	This event represents the probability that the harsh RB environment cause by vent duct failure results in malfunction of ECCS equipment. LSCS is committed to installing a hard pipe vent, which will reduce the frequency of vent path failures to the point where they are no longer significant contributors (SAMA 1). No additional SAMAs required.
RCVCL-4A	1.00E+00	1.233	ACCIDENT CLASS IV MARKER	This event is an accident class marker for ATWS events, over 98% of which are linked to mechanical RPS failure.

Table F.5-1
LSCS Level 1 Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				As described in the disposition of event 2RPCDRPS-MECHFCC, the failure mode is non-specific and does not provide insights on how the system might be improved. A more effective approach to reducing the contributions from ATWS scenarios is to install a keylock MSIV low level isolation bypass switch, which would reduce the time required to bypass the isolation logic and provide more time margin the actions in ATWS scenarios requiring the bypass action. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Automating SBLC initiation could also reduce some of these contributors (SAMA 5).
2SY--PWR5PERCF--	1.00E+00	1.228	POWER LEVEL GREATER THAN 3%	This event represents the probability that reactor power is over 3% for failure to scram events (assumed to be true) and is part of the ATWS sequence definition. There are no SAMAs that would address this event itself, but the top contributors are the same as other ATWS scenarios, which are operator action failures related to level/power control. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level

Table F.5-1
LSCS Level 1 Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				further (SAMA 4). Automating SBLC initiation could also reduce some of these contributors (SAMA 5).
2MSOP-AT-LVL-H--	1.00E+00	1.213	HEP: RPV LEVEL LOWERED BELOW LEVEL 1 SETPOINT DURING ATWS	This event represents the probability that reactor water level is lowered below level 1 in ATWS scenarios for which the MSIVs are initially open (i.e., not closed on high DW pressure). The assumed probability of 1.0 reflects the guidance in the EOPs that directs the operators to lower level to below the Level 1 MSIV closure setpoint. This is conservative as it assumes a 100% ATWS and as a result it forces the operators to perform low level MSIV isolation bypass for success. Over 70% of the contributors including this event include failure to bypass the low level MSIV interlock. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). An additional contributor, at just under 20%, is failure to initiate SBLC. Automating SBLC initiation, which is a function available is some other BWRs, could reduce these contributors (SAMA 5).
2MSRXMSIVINLKH--	1.00E+00	1.155	HEP(REC): OPERATOR FAILS TO BYPASS LOW LEVEL MSIV INTERLOCK	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The operator action failure probability is quantitatively accounted for in a JHEP event rather than in this marker event. The marker event may show up in

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				other cutsets with other JHEPs such that the importance of the marker event is the total of all the JHEPs associated with the HFE. The operator action represented by this marker is for the failure to bypass the low level MSIV isolation logic before level is lowered to control power. The high failure probability associated with this action is due to the short response time available and the relatively long time required to perform the action. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
RCVCL-1BE	1.00E+00	1.153	ACCIDENT CLASS IBE MARKER	This event is an accident class marker for LOCA scenarios and does not represent any specific failure itself. Over 90% are related to water hammer induced LOCAs and 55% are water hammer events related to the generation of a LOCA signal when a LOCA condition does not exist. When RHR SPC is placed in service in response to certain transient events that lead to a high DW pressure signal (LOCA signal), the discharge line can drain to the suppression pool in the ~45 seconds between RHR pump load shed and the time it is reloaded on the bus, which sets up a water hammer condition (RHR in SPC mode does not prevent the DW pressure from reaching 2 PSIG). Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				scenarios that set up these water hammer events at LSCS (SAMA 7).
2RHRXSPCINIT-H--	1.00E+00	1.147	HEP(REC): OPERATOR FAILS TO INITIATE SUPPRESSION POOL COOLING (NON-ATWS)	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The action represents the failure to initiate SPC in time to prevent RPV blowdown on HCTL. The SPC initiation action is very reliable and for almost all of the contributors including this event, operator action dependence issues would prevent any SAMAs requiring human action from reducing risk in a meaningful way. For over 80% of the contributors, the total human error probability is either at or very close to the lowest allowable JHEP value. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). Most scenarios with SPC initiation failure also include the failure to vent containment, which represents the remaining means of containment heat removal. This leads to containment failure and an adverse environment in containment that fails ECCS equipment. Currently, venting containment will fail also lead to an adverse containment environment; however, the hard pipe event will prevent the release of containment atmosphere into the RB when venting (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment reactor building (SAMA 3).
2RHRXSPCLATE-H--	1.00E+00	1.145	HEP(REC): OPERATOR FAILS TO INITIATE SPC LATE GIVEN EARLY FAILURE (COND PROB)	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The action represents the failure to initiate SPC in time to preclude the need to vent containment at

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				the PCPL. The SPC initiation action is very reliable and for almost all of the contributors including this event, operator action dependence issues would prevent any SAMAs requiring human action from reducing risk in a meaningful way. For over 80% of the contributors, the total human error probability is either at or very close to the lowest allowable JHEP value. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). Most scenarios with SPC initiation failure also include the failure to vent containment, which represents the remaining means of containment heat removal. This leads to containment failure and an adverse environment in the reactor building that fails ECCS equipment. Currently, venting containment will also lead to an adverse reactor building environment; however, the hard pipe event will prevent the release of containment atmosphere into the RB when venting (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
RCVSEQ-GTR-023	1.00E+00	1.145	ACCIDENT SEQUENCE GTR-023 MARKER	This event is a sequence marker representing scenarios where injection is provided by HPCS after FW failure, but SPC and venting fail. Failure of containment results in consequential failure of RPV injection. In over 99% of the cases, venting causes an adverse environment in the containment, which in most cases, leads to failure of ECCS. The installation of the hard pipe vent (SAMA 1), to which LSCS is committed, will essentially eliminate these types of failures. Operator failure to initiate SPC is a large contributor at about 40% and another way of mitigating these scenarios would be to automate

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				initiation of SPC (SAMA 2).
2RHSY-DRAINSPF--	1.00E+00	1.14	DISCH LINE DRAINS TO SUPPRESSION POOL CREATING A VOID	This event represents the probability that the RHR discharge line will drain to the suppression pool when power is interrupted to the RHR system is when it is running is SPC mode. For about 60% of the contribution, the scenario is related to the generation of a LOCA signal on high DW when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7). Review of the cutsets also shows that over 90% of the contribution includes the HFE for failing to isolate the water hammer LOCA (in the form of JHEPs). However, the independent HEP for this action is low (2.3E-3) and is driven by the time available for response, so changes to training or plant procedures would not have a meaningful impact on the reliability of the action and no additional SAMAs are suggested.
%DLOOP	7.95E-03	1.135	DUAL UNIT LOSS OF OFF-SITE POWER INITIATING EVENT	The contributors to DLOOP are diverse, but over 40% include containment venting events that lead to adverse environmental conditions in the RB. LSCS is committed to installing a hardened vent (SAMA 1) that will effectively eliminate these types of events (no vent path failure). Another contributor is long term SBOs (~25%) where battery depletion fails injection. After installation of a hardened containment vent at LSCS, a viable means of containment heat removal will be available in SBO scenarios. The diesel fire pump is a currently proceduralized injection source that can be used in an SBO, but this low pressure injection source would only be available until the SRVs close after battery depletion (RPV re-pressurization would prevent continued injection). Use of a portable generator to provide long

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				term power to the 125 VDC battery chargers would provide a means of maintaining diesel fire pump makeup indefinitely (SAMA 8).
RCVCL-IBL	1.00E+00	1.129	ACCIDENT CLASS IBL MARKER	This event is an accident class marker for long term SBO scenarios and does not represent any specific failure itself. After installation of a hardened containment vent at LSCS, a viable means of containment heat removal will be available in SBO scenarios. The diesel fire pump is a currently proceduralized injection source that can be used in an SBO, but this low pressure injection source would only be available until the SRVs close after battery depletion (RPV re-pressurization would prevent continued injection). Use of a portable generator to provide long term power to the 125 VDC battery chargers would provide a means of maintaining diesel fire pump makeup indefinitely (SAMA 8). Smaller contributors include fire protection flooding events with failure of the isolation valve between the FPS and the Service Water System (SWS). Other isolation points and mitigation methods are potentially available, but the reliability of flood mitigation could be improved by developing procedures to direct specific actions for specific flood events (SAMA 9).
2CVRXVENT----H--	1.00E+00	1.128	HEP(REC): OPERATOR FAILS TO INITIATE PRIMARY CONTAINMENT VENTING	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The event represents the HFE for initiating the containment vent. The results show that essentially all of the cutsets that include this HFE also include the HFE for initiating SPC and the JHEPs for these events are at the lowest allowable JHEP value. The implication is that the heat removal function is already highly reliable and that current HRA methods cannot reliably assess

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				the failure probabilities of the contributing JHEPs. Because of this, the benefit of changes to reduce these contributors further would be questionable, but eliminating the requirement for the operators to perform these tasks is a mathematical means of demonstrating a reduction in risk. Potential means of accomplishing this goal would be to either automate SPC initiation on high suppression pool temperature (SAMA 2) or by installing a rupture disk in parallel with the remotely controlled hard pipe vent path (SAMA 3).
2RHRX-TRIPLK-H--	1.00E+00	1.125	HEP(REC): OPERATOR FAILS TO DETECT & ISOLATE SMALL RHR FLOOD FROM WATER HAMMER E	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The event represents the failure of operators to isolate a water hammer induced LOCA in the RHR system. For about 2/3 of the contribution, the scenario is related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7). Review of the isolation HEP itself shows that it is driven by the time available for response, so changes to training or plant procedures would not have a meaningful impact on the reliability of the action and no SAMAs related to procedure or training improvements are suggested.
2CN--RUPT-DWBF--	8.58E-02	1.121	DW BODY RUPTURE	This event represents the probability of a drywell failure given containment overpressurization. Over 60% of the contributors are related to the failure to the HFEs for containment vent failure and/or SPC initiation failure. These actions are reliable, but eliminating the requirement for the operators to perform these tasks is a potential means of reducing risk for the scenarios

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				leading to DW rupture. This could be accomplished by either automating SPC initiation on high suppression pool temperature (SAMA 2) or by installing a rupture disk in parallel with the remotely controlled hard pipe vent path (SAMA 3).
%TIA	9.92E-03	1.121	LOSS OF INSTRUMENT AIR INITIATING EVENT	This represents the loss of instrument air initiating event, which is modeled to include the trailer mounted air compressor. The contributors to the loss of instrument air (LOIA) are diverse, but about 30% are related to water hammer induced LOCAs caused by high DW pressure signals in transients. These events could be prevented by altering the LOCA signal to require a coincident low RPV water level signal (SAMA 7). In about 60% of the contributors including %TIA, the ability to vent is failed by the initiator, followed by failure to recover IA, and then containment failure leads to loss of injection due to adverse containment environment. Currently, LSCS has a procedure to direct the use of portable pneumatic bottles to support venting when IA has failed; however, credit is not taken for the procedure due to the potential for vent path rupture and radiation shine. Installation of the reliable hard pipe vent will provide a means of operating the containment vent when normal support systems have failed (SAMA 1).
RCVSEQ-DLOP-041	1.00E+00	1.12	ACCIDENT SEQUENCE DLOP-041 MARKER	This event is an accident sequence marker for LOCA induced LOOP scenarios and does not represent any specific failure itself. For about 70% of the contribution, the scenario is related to the generation of a LOCA signal on high DW when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
OSPR30MIN-GR	8.25E-01	1.12	FAILURE TO RECOVER OSP WITHIN 30 MINUTES (GRID RELATED LOOP EVENT)	This event represents the failure to recover offsite power within 30 minutes for grid related LOOP events. For over 70% of the contribution, the scenario is related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7).
BFPOP-DFPENV1H--	5.00E-01	1.116	HEP: OP FAILS TO ALIGN DFP DUE TO ADVERSE ENV IN TB (VENT TO STEAM TUNNEL)	This event represents the probability that the operators will fail to align RPV injection from the diesel fire pump in an adverse environment caused by either venting or containment failure. The reliable hard pipe vent (SAMA 1) would mitigate over 90% of the scenarios including this event. For about 33% of the initiators, containment vent is successful, but the vent path ruptures and the containment atmosphere enters the RB, TB, and other areas. This evolution will be prevented by the installation of the reliable hard pipe vent because the vent path would not rupture after successful vent. For another 33% of the contributors, the vent capability is disabled by loss of instrument air. The reliable hard pipe vent will provide a means of operating the containment vent after loss of normal support systems and containment overpressurization could be avoided. An additional 25% of the contribution is related to vent failure after LOOP. Again, the reliable hard pipe vent will provide a means of venting after loss of normal support systems, such as power.
%TC	1.33E-01	1.115	LOSS OF CONDENSER VACUUM INITIATING EVENT	For this initiator, about 70% of the contributors are loss of containment heat removal evolutions. About half of these are driven by failure to vent after RHR hardware failure and the other half are related to manual SPC

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				initiation failures. Installation of a rupture disk in parallel with the remotely controlled hard piped vent path would address these cases (SAMA 3). Some of the venting failures are related to vent control failures, which result in loss of ECCS NPSH and/or vent path rupture. Loss of NPSH would be less of an issue with a hard pipe vent because actions could be taken in the RB and TB to align alternate injection after venting. Automating SPC on high pool temperature could also technically mitigate the cases in which SPC fails due to operator error (SAMA 2). The remaining contributors are ATWS sequences, many of which could be mitigated by automating SBLC (SAMA 5) or by installing a MSIV low level isolation bypass switch. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
RCVSEQ-ATW1-037	1.00E+00	1.113	ACCIDENT SEQUENCE ATW1-037 MARKER	This event is an accident sequence marker for ATWS events which include failures of early and late level/power control. Almost all of the contributors include mechanical failure of RPS, but as described in the disposition of event 2RPCDRPS-MECHFCC, the failure mode is non-specific and does not provide insights on how the system might be improved. A more effective approach to reducing the contributions from ATWS scenarios is to install a keylock MSIV low level isolation bypass switch (~75% of the contributors), which would reduce the time required to bypass the isolation logic and provide more time margin for the actions in ATWS scenarios requiring the bypass action. In order to improve the effectiveness of this enhancement, the EOP

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Automating SBLC system initiation could also address about 60% of these contributors (SAMA 5).
2SLRX-LVLCTRLH--	1.00E+00	1.105	HEP(REC): OPERATOR FAILS TO LOWER LEVEL EARLY (ATWS)	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The action itself if for level control in an ATWS, which consists of reducing FW flow into the RPV to reduce power (governed by a "hard card" in the MCR). The HEP for this action is dominated by the result from the time reliability curve and reflects the short available time for cognitive work in the scenario. The "hard card" guidance for level control is considered to streamline the control action as much as is reasonably possible for the existing control configuration. A potentially effective approach to reducing the contributions from ATWS scenarios is to install a keylock MSIV low level isolation bypass switch (~79% of the contributors), which would reduce the time required to bypass the isolation logic and provide more time margin for the actions in ATWS scenarios requiring the bypass action. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Automating SBLC system initiation could also address about 60% of these contributors (SAMA 5).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
DGRECOV-7HR	1.00E+00	1.093	DIESEL GENERATOR RECOVERY WITHIN 7 HOURS	The event represents failure to recover the EDGs by 7 hours, at which time the station batteries are expected to be depleted (with successful load shed). Continued availability of DC power alone would not allow for indefinite RCIC operation, but the use of a portable 480V AC generator to support the SRVs and instrumentation could help maintain low pressure injection (SAMA 8). When considered in conjunction with the planned reliable hard pipe vent (SAMA 1) and fire protection or other injection methods, long term SBO mitigation is possible.
DLOOP-IE-SW	3.84E-01	1.092	COND. PROBABILITY DLOOP DUE TO SEVERE WEATHER EVENT	For the DLOOP initiating event, containment venting is failed due to unavailability of air. In over 50% of the DLOOP contributors, core damage results because containment overpressurization failure leads to loss of injection due to adverse containment environment. Currently, LSCS has a procedure to direct the use of portable pneumatic bottles to support venting when IA has failed; however, credit is not taken for the procedure due to the potential for vent path rupture and radiation shine. Installation of the reliable hard pipe vent will provide a means of operating the containment vent when normal support systems have failed (SAMA 1). In most of the remaining cases, SBO conditions force use of RCIC for injection until battery depletion. Providing a system to maintain DC power alone would not allow for indefinite RCIC operation due to HCTL impingement, but the use of a portable 480V AC generator to support the SRVs and instrumentation could support long term low pressure injection (SAMA 8). When considered in conjunction with the planned reliable hard pipe vent (SAMA 1) and fire protection or other injection methods, long term SBO mitigation is possible.

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2ACSYLOOPLOCA---	2.40E-02	1.091	COND PROB OF A LOOP GIVEN A LOCA SIGNAL	For over 90% of the contributors that include a consequential LOOP after a LOCA signal, the scenario is related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7).
2FWRXMOV10AB-H--	1.00E+00	1.087	HEP(REC): OPERATOR FAILS TO CLOSE THE TDRFP DISCHARGE MOVS 2FW010A & B	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The action itself is for closing the turbine driven feedwater pump discharge valves in time to prevent RPV overfill or hotwell depletion. The flow control for these pumps is provided by pump speed control rather than regulating valve and when the pumps are tripped, the flowpath remains open. When reactor pressure is reduced, flow from the condensate pumps or heater drain system can flow in an uncontrolled manner into the RPV. The HEP is driven by the time reliability component and the execution component for two valve closures, which presents limited opportunity for improvement, but even if the HEP could be lowered, over 75% of the contribution including the event is linked to JHEPs at the lowest allowable JHEP value, so no reduction could be realized for those cases. The JHEPs including this action also include failure to manually initiate SPC. The frequency of these contributors could be reduced by changing the logic to auto close the TDRFP discharge valves when the pumps are tripped or are not running (SAMA 10).
2CVRX2INCHVNTH--	1.00E+00	1.086	HEP(REC) :OPERATOR FAILS TO OPEN 2" LINES TO MAINTAIN DW	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. For over 93% of the contributors that

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
			PRESSURE BELOW HI DW SE	include this HFE, the scenario is related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7).
2RHRX-LOCA---H--	1.00E+00	1.082	HEP(REC): OPERATORS FAIL TO PREVENT RHR AUTO START WITH LOCA SIGNAL AT T=0	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The HFE itself is for preventing start of RHR before the system is reloaded onto the emergency bus after it is shed in LOCA/LOOP case. Failure to do so sets up a water hammer condition because the discharge line may drain to the suppression pool while the RHR pump is being re-sequenced onto the emergency bus. Because there is less than one minute to respond to the circumstances requiring the action to prevent RHR start, no credit is taken for the action and the potential for HEP improvement is limited. The scenarios that include this HFE are all related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7).
%FSRB12	1.05E-04	1.079	FPS PIPE RUPTURE IN REACTOR BLDG.	This initiator is a fire protection system rupture in the reactor building that results in failure of ECCS equipment required to prevent core damage. About 80% of the contributors for this initiating event include fire protection flooding events with failure of the isolation valve between the FPS and the SWS. Other isolation points and mitigation methods are potentially available, but

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				they are not credited due to the limited guidance that is available. The reliability of flood mitigation could be improved by developing procedures to direct specific actions for specific flood events (SAMA 9). Most of the remaining contribution is from the failure to trip the fire protection pumps in time to prevent equipment damage in the RB. Providing a manual trip override switch for the fire pumps in the MCR would reduce the time required to shut down the fire pump. If procedures were developed to direct isolation of the FP070 and FP080 valves in conjunction with the MCR trip capability, the time required to terminate the reactor building fire protection floods would be significantly reduced and the reliability of the mitigation action would be improved (SAMA 11).
RCVSEQ-TBRBFL-017	1.00E+00	1.078	ACCIDENT SEQUENCE TBRBFL-017 MARKER	This event is an accident sequence marker for fire protection floods in the reactor building and does not represent any specific failure itself. It is completely tied to three cutsets in which either the SWS to FPS isolation valves fail to close or the FPS pump trip fails. Other isolation points and mitigation methods are potentially available, but they are not credited due to the limited guidance that is available. The reliability of flood mitigation could be improved by developing procedures to direct specific actions for specific flood events (SAMA 9). Most of the remaining contribution is from the failure to trip the fire protection pumps in time to prevent equipment damage in the RB. Providing a manual trip override switch for the fire pumps in the MCR would reduce the time required to shut down the fire pump. If procedures were developed to direct isolation of the FP070 and FP080 valves in conjunction with the MCR trip capability, the time required to terminate the reactor building fire protection floods would be significantly

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				reduced and the reliability of the mitigation action would be improved (SAMA 11).
2CN-LEAK-WWAF--	1.17E-01	1.076	WW AIRSPACE LEAK	This event represents the probability of containment failure in the suppression pool airspace on containment overpressurization. Venting failure, which leads to containment failure, is split between human error and support system unavailability. For the cases with operator error, the action is almost always paired with failure to initiate SPC. These actions are reliable, but eliminating the requirement for the operators to perform these tasks is a potential means of reducing risk for the scenarios leading to WW rupture. This could be accomplished by either automating SPC initiation on high suppression pool temperature (SAMA 2) or by installing a rupture disk in parallel with the remotely controlled hard pipe vent path (SAMA 3). The reliable hard pipe vent will not only prevent rupture of the vent path, but will also provide a means of venting containment when normal support systems are unavailable (SAMA 1).
2RX-WHLTRIPL3H--	4.70E-03	1.076	2CVOP2INCHVNTH-- 2RHOP-LOCA---H-- 2RHOP-TRIPLK-H--	This event is a JHEP representing the failure to vent the DW to prevent a high containment pressure/LOCA signal, failure to prevent start of RHR after reload of the emergency bus after LOOP, and failure to isolate the water hammer induced LOCA. Over 94% of the scenarios that include this JHFE are related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7).
2CN--RUPT-WWAF--	1.11E-01	1.072	WW AIR SPACE RUPTURE	This event represents the probability of containment

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				failure in the suppression pool airspace on containment overpressurization. Venting failure, which leads to containment failure, is split between human error and support system unavailability. For the cases with operator error, the action is almost always paired with failure to initiate SPC. These actions are reliable, but eliminating the requirement for the operators to perform these tasks is a potential means of reducing risk for the scenarios leading to WW rupture. This could be accomplished by either automating SPC initiation on high suppression pool temperature (SAMA 2) or by installing a rupture disk in parallel with the remotely controlled hard pipe vent path (SAMA 3). The reliable hard pipe vent will not only prevent rupture of the vent path, but will also provide a means of venting containment when normal support systems are unavailable (SAMA 1).
2IARXRCOVERIAH--	1.00E-01	1.07	HEP: OP FAILS TO RESTORE IA / SA FOR VENTING (NON LOOP OR DLOOP)	This event represents the failure to repair IA/SA after it has failed, which is part of the initiating event in 99% of contributors in which it is included. The initiating event includes failures of the portable air compressor, so use of that component is not a separate option that could be used to mitigate these scenarios. The reliable hard pipe vent will provide a means of venting after loss of normal support systems, such as air or power (SAMA 1).
RCVCL-1C	1.00E+00	1.069	ACCIDENT CLASS IC MARKER	This event is an accident class marker for mitigated ATWS events without adequate makeup and does not represent any specific failure itself. In about 60% of the cases, failure to bypass the MSIV low level isolation logic results in loss of the power conversion system. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). The remaining contributors are mostly comprised of HFEs related to depressurization failure. HPCS is generally available, but not used because of reactivity issues related to the injection location. If a cross-tie line were installed between HPCS and the FW injection line, an alternate means of providing high pressure injection to the core could be provided for ATWS scenarios (SAMA 12).
RCVSEQ-GTR-013	1.00E+00	1.065	ACCIDENT SEQUENCE GTR-013 MARKER	This event is an accident sequence marker for loss of containment heat removal cases where venting failure lead to containment rupture and subsequent injection system failure. About 2/3 of the contributors are driven by operator failure to vent after RHR hardware failure and the other 1/3 are related to operator failure to vent after manual SPC initiation failures. Installation of a rupture disk in parallel with the remotely controlled hard piped vent path would address these cases (SAMA 3). Automating SPC on high pool temperature could also mathematically mitigate the cases in which SPC fails due to operator error (SAMA 2), although HRA methodology limitations make the true benefits difficult to assess.
2RHSYLEAKB---L--	9.00E-02	1.056	RH TRAIN B FAILS DUE TO EXCESSIVE LEAKAGE FOLLOWING WATER HAMMER	This event represents the probability that a leak large enough to fail the corresponding RHR train occurs after a water hammer event. For about 70% of the contribution, the scenario is related to the generation of

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7). Review of the cutsets also shows that over 90% of the contribution includes the HFE for failing to isolate the water hammer LOCA (in the form of JHEPs). However, the independent HEP for this action is low (2.3E-3) and is driven by the time available for response, so changes to training or plant procedures would not have a meaningful impact on the reliability of the action and no additional SAMAs are suggested.
2RHSYLEAKA---L--	9.00E-02	1.056	RH TRAIN A FAILS DUE TO EXCESSIVE LEAKAGE FOLLOWING WATER HAMMER	This event is represents the probability that a leak large enough to fail the corresponding RHR train occurs after a water hammer event. For about 70% of the contribution, the scenario is related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7). Review of the cutsets also shows that over 90% of the contribution includes the HFE for failing to isolate the water hammer LOCA (in the form of JHEPs). However, the independent HEP for this action is low (2.3E-3) and is driven by the time available for response, so changes to training or plant procedures would not have a meaningful impact on the reliability of the action and no additional SAMAs are suggested.
%TM	5.01E-02	1.056	MSIV CLOSURE INITIATING EVENT	About half of the contributors for the MSIV closure initiators result in containment failure after failure to initiate SPC. While already reliable, automating the

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				initiation of SPC could further improve the reliability of the containment heat removal function (SAMA 2). Most scenarios with SPC initiation failure also include the failure to vent containment, which represents the remaining means of containment heat removal. This leads to containment failure and an adverse environment in the reactor building that fails ECCS equipment. Currently, venting containment will also lead to an adverse reactor building environment; however, the hard pipe event will prevent the release of containment atmosphere into the RB when venting (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3). The remaining contributors are mostly related to ATWS caused by 2RPCDRPS-MECHFCC, which is addressed separately on this list.
RCVSEQ-DLOP-014	1.00E+00	1.055	ACCIDENT SEQUENCE DLOP-014 MARKER	This event is an accident sequence marker for long term DLOOP events with loss of containment heat removal and containment vent failure, which leads to containment rupture. Venting failures are primarily caused by the initiating event, which fails the support systems for the current containment vent design. The reliable hard pipe vent will provide a means of operating the containment vent after loss of normal support systems and containment overpressurization could be avoided (SAMA 1).
2SLRX-IN-LATEH--	1.00E+00	1.055	HEP(REC): OPERATOR FAILS TO INITIATE SBLC LATE (COND PROB)	Failure to initiate SBLC could be mitigated by automating SBLC initiation (SAMA 5). About 2/3 of the contributors including SBLC initiation failure also include failure to bypass the low level MSIV interlock. Installing a keylock MSIV low level isolation bypass switch would

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
2MSOPMSIVINLKH--	7.00E-01	1.054	HEP: OPERATOR FAILS TO BYPASS LOW LEVEL MSIV INTERLOCK	Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions (SAMA 4).
OSPR20HR-SW	1.33E-01	1.051	FAILURE TO RECOVER OSP WITHIN 20 HOURS (SEVERE WEATHER LOOP EVENT)	OSPR20HR-SW represents the failure to recover offsite power by 20 hours after a severe weather induced LOOP. Over 90% of the contributors including this event are from sequence DLOP-014, which are long term DLOOP events with loss of containment heat removal and containment vent failure. These conditions lead to containment rupture. The venting failures are primarily caused by the initiating event, which fails the support systems for the current containment vent design. The reliable hard pipe vent will provide a means of operating the containment vent after loss of normal support systems and containment overpressurization could be avoided (SAMA 1).
2ADRX-INHIBITH--	1.00E+00	1.049	HEP(REC): OPERATORS INHIBIT ADS FOR NON-ATWS ACCIDENT SCENARIO	This action represents the probability that the operators will, contrary to procedure, inhibit ADS in non-ATWS scenarios. The operator interviews suggest that they are all very familiar with the LSCS EOPs and the fact that LSCS deviates from the BWROG EPG/SAGs, that they

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				are well trained on the procedure, and that the procedures and cues for how to address ADS are clear. Plant experience shows, however, that ADS inhibit may occur in non-ATWS scenarios. No training or procedure enhancements have been identified that could significantly reduce the probability of inhibiting ADS in non-ATWS scenarios. In addition, this type of error is an "error of commission", for which there are no generally accepted quantification methods. For LSCS, it is based on plant operating experience. About 80% of the contributors that include this event also include failures to initiate SPC. Failure to initiate SPC could be mitigated by automating SPC initiation on high SPC temperature (SAMA 2); however, the true benefit of this enhancement is difficult to assess because the dominant human reliability terms are limited by the lowest allowable JHEP value.
2CVOPVENT----H--	6.60E-03	1.049	HEP: OPERATOR FAILS TO INITIATE PRIMARY CONTAINMENT VENTING	This event represents the independent failure probability of the containment venting action, which means that the contributors including this action either contain no other HFEs or that the venting failure is independent of other HFEs in the evolution. The independent action for venting is relatively reliable; the operators are familiar with the action, are well trained on the action, and the procedures directing the action are clear. The HEP is dominated by the execution failure probability, which includes contributors from the many jumper installation steps. The reliable hard pipe vent (SAMA 1) will simplify the containment venting process and reduce the risk of these contributors. In conjunction with the hard pipe vent, a parallel, passive vent path could provide a means of ensuring that the containment failure occurs through a rupture disk with a scrubbed path from the wetwell (SAMA 3) in the event that manual venting fails.

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
%TBCCWFACTOR	1.00E+00	1.048	LOSS OF TBCCW INITIATING EVENT	This event is an initiating event marker used to identify the failures from the loss of TBCCW initiating event fault tree. For about 80% of the contribution, the scenario is related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7).
%TF	5.65E-02	1.047	LOSS OF FEEDWATER INITIATING EVENT	Loss of FW events include diverse contributors, but about 45% include failures to vent containment. To mitigate manual venting failures, a parallel, passive vent path could be installed in conjunction with the hard pipe vent (SAMA 1) to provide a means of ensuring that the containment failure occurs through a rupture disk with a scrubbed path from the wetwell (SAMA 3). About 1/3 of the contribution includes failure to manually initiate SPC, which could be mitigated by automating SPC initiation (SAMA 2). However, the true benefits of this enhancement and SAMA 3 are difficult to assess because the dominant human reliability terms are limited by the lowest allowable JHEP value. About 30% of the contributors are ATWS scenarios. Installing a low level isolation bypass switch in the MCR (SAMA 4) would provide a means of reducing the risk of these scenarios.
2RHRX-SPCVD--H--	1.00E+00	1.046	HEP(REC): OPERATORS START RHR WITHOUT FILL AND VENT	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. In this case, the event represents the failure to fill and vent an ECCS system before starting the pumps after an evolution where the discharge line has been drained. For scenarios in which a LOOP occurs when RHR is in operation (for SPC, generally), the piping will drain to the suppression pool and the lines

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				must be re-filled before restarting the pump to prevent water hammer. The independent HEP for this action is conservatively quantified as 2.5E-02. The action is not time stressed given that the available diagnosis time is over 3 hours and the main contributor to the HEP is the execution component. The HRA for the fill and vent action includes some steps that would not be performed in an accident scenario (those that require drywell entry) and it does not credit a check of the RHR discharge pressure alarm to identify fill and vent failures. This is a proceduralized check that would identify conditions in which the fill and vent process was performed incorrectly. If this check were to be credited, the independent HEP would be reduced by over an order of magnitude and because this HEP is the lead HEP in the dependent action assessments, the JHEPs would be similarly be reduced. These events are not considered to be significant contributors and no SAMAs are suggested.
2CN--LEAK-DWBF--	7.46E-02	1.046	DW BODY LEAK	About half of the contributors with DW body leaks occur after failure to initiate SPC. While already reliable, automating the initiation of SPC could further improve the reliability of the containment heat removal function (SAMA 2). Most scenarios with SPC initiation failure also include the failure to vent containment, which represents the remaining means of containment heat removal. This leads to containment failure and an adverse environment in the reactor building that fails ECCS equipment. Currently, venting containment will also lead to an adverse reactor building environment; however, the hard pipe event will prevent the release of containment atmosphere into the RB when venting (SAMA 1). For the remaining half of the contributors that lead to DW body leaks, venting is failed by the initiating

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				event. If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
2SLRX-LATELVLH--	1.00E+00	1.044	HEP(REC): OPERATOR FAILS TO CONTROL LEVEL LATE IN ATWS (COND PROB)	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The HFE itself is for controlling level adequately to reduce reactivity and ultimately prevent violation of the PCP. Over 99% of the contributors that include level control failures also include the HFE to bypass the low level interlock. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
2ADRX-TRANS--H--	1.00E+00	1.043	HEP(REC): OPERATOR FAILS TO MANUALLY DEPRESSURIZE THE RPV (TRANSIENT)	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The HFE itself represents the failure to depressurize the RPV in a transient after incorrectly inhibiting ADS. The operators are well trained on depressurization and on not inhibiting ADS in non-ATWS scenarios and no procedure changes or training enhancements have been identified that could have a meaningful impact on the action reliabilities. In about 90% of the scenarios in which depressurization failure

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				occurs, the action is required because failure to initiate SPC leads to containment failure and subsequent loss of the operating high pressure injection system. These evolutions could be mitigated by automating SPC initiation (SAMA 2). However, the true benefits of this enhancement are difficult to assess because the dominant human reliability terms are limited by the lowest allowable JHEP value.
2SY--VENT1---FCC	9.99E-03	1.042	CCF OF HPCS & CRD & LPCI & LPCS GIVEN VENT TO STEAM TUNNEL	This event represents the probability that the cited injection systems fail due to an adverse environment caused by venting. In over 93% of the contribution, venting is successfully performed, but the pathway fails. The reliable hard pipe vent will address these scenarios (SAMA 1).
2RX-WH-V-TPL2H--	1.30E-03	1.041	2RHOP-SPCVD--H-- 2RHOP-TRIPLK-H--	This event is a joint HEP for the actions to 1) fill/vent RHR prior to system start after a discharge leg draindown, and 2) locate and isolate a leak caused by the water hammer event from system start. For scenarios in which a LOOP occurs when RHR is in operation (for SPC, generally), the piping will drain to the suppression pool and the lines must be re-filled before restarting the pump to prevent water hammer. The independent HEP for this action is conservatively quantified as 2.5E-02. The action is not time stressed given that the available diagnosis time is over 3 hours and the main contributor to the HEP is the execution component. The HRA for the fill and vent action includes some steps that would not be performed in an accident scenario (those that require drywell entry) and it does not credit a check of the RHR discharge pressure alarm to identify fill and vent failures. This is a proceduralized check that would identify conditions in which the fill and vent process was performed

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				incorrectly. If this check were to be credited, the independent HEP would be reduced by over an order of magnitude and because this HEP is the lead HEP in the dependent action assessments, the JHEPs would be similarly be reduced. These events are not considered to be significant contributors and no SAMAs are suggested.
RCVSEQ-ATW1-031	1.00E+00	1.039	ACCIDENT SEQUENCE ATW1-031 MARKER	This event is an accident sequence marker for ATWS scenarios with loss of the condenser. About 70% of the contributors include failure to bypass the low level MSIV isolation logic. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
2RHSYSTARTB-----	5.00E-01	1.038	RH TRAIN B IS PLACED INTO OPERATION FOLLOWING A TRANSIENT	This event represents the probability that the RHR B train will be placed in service after a transient to respond to the requirement for containment heat removal. The events are related to water hammer induced LOCAs, which for the contributors including this event are related to the generation of a LOCA signal when a LOCA condition does not exist. When RHR SPC is placed in service in response to certain transient events that lead to a high DW pressure signal (LOCA signal), the discharge line can drain to the suppression pool in the ~45 seconds between RHR pump load shed and the

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				time it is reloaded on the bus, which sets up a water hammer condition. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up these water hammer events at LSCS (SAMA 7).
2RHSYSTARTA-----	5.00E-01	1.038	RH TRAIN A IS PLACED INTO OPERATION FOLLOWING A TRANSIENT	This event represents the probability that the RHR A train will be placed in service after a transient to respond to the requirement for containment heat removal. The events are related to water hammer induced LOCAs, which for the contributors including this event are related to the generation of a LOCA signal when a LOCA condition does not exist. When RHR SPC is placed in service in response to certain transient events that lead to a high DW pressure signal (LOCA signal), the discharge line can drain to the suppression pool in the ~45 seconds between RHR pump load shed and the time it is reloaded on the bus, which sets up a water hammer condition. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up these water hammer events at LSCS (SAMA 7).
2CVOP-VNTCNT-H--	7.20E-02	1.037	HEP: OPERATOR FAILS TO CONTROL VENT WITHIN PROCEDURALIZED PRESSURE BAND	This HFE represents the independent failure probability for controlling venting to maintain pressure between 50 and 60 psig to both 1) prevent vent path failure and 2) to maintain NPSH for ECCS injection. The HEP is dominated by the cognitive time reliability curve contribution, which is based on the assumption that 5 minutes are available between the cue and the end of the system window, and a 1 minute manipulation time. This is a conservative representation of the time available for the cognitive work because, as stated in the HRA, there are many hours available prior to venting during which preparations for the action can be made.

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				Ultimately, the reliable hard pipe vent will mitigate these events (SAMA 1). The hardened vent path will preclude the need for this action for vent path protection. In addition, without vent path failures, there will be no adverse environmental conditions to prevent alignment of alternate injection systems if NPSH is lost on the operating ECCS.
RCVSEQ-GTR-011	1.00E+00	1.035	ACCIDENT SEQUENCE GTR-011 MARKER	This event is an accident sequence marker for loss of condenser transient scenarios with loss of containment heat removal and successful containment vent, which leads to an adverse RB environment due to vent duct rupture and injection system failure. The reliable hard pipe vent will mitigate failure of the vent path and mitigate these scenarios (SAMA 1). The loss of decay heat removal contributors are diverse, but some contributors could be eliminated by automating SPC initiation (SAMA 2).
RCVCL-1A	1.00E+00	1.034	ACCIDENT CLASS IA MARKER	This accident class is for loss of injection with the RPV at high pressure. Over 83% of the contributions are related to 125V DC power failures, most of which are related to 125V DC bus failures with a smaller contribution from CCF of all five 125V battery chargers. These failures could be mitigated by providing a portable DC source and a means of connecting it to ESF DC distribution panel 1(2)11Y to support RCIC operation and long term RPV depressurization and with FPS injection (SAMA 14).
RCVCL-5	1.00E+00	1.033	ACCIDENT CLASS V MARKER	This accident class is for containment bypass scenarios, over 90% of which are related to ISLOCA events in the RHR and LPCS systems. Failure to isolate the pathway is the dominant contributor, which leads directly to core damage due to lack of a long term inventory makeup source. A potential means of providing an indefinite

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				source of RPV makeup would be to tie the LPCS system to the RHRSW system and use the RHRSW pumps to provide injection flow to the RPV (SAMA 15).
2RX-SL-MS2--3H--	4.70E-02	1.033	2SLOP-LVLCTRLH-- 2MSOPMSIVINLKH-- 2SLOP-LATELVLH--	This joint HEP represents failure to bypass the MSIV low level isolation logic, early level control, and late level control in ATWS events. The high failure probability associated with the action to bypass the MSIV low level isolation logic is due to the short response time available and the relatively long time required to perform the action. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
BFPRX-DFPENV-H--	1.00E+00	1.032	HEP(REC): OP FAILS TO ALIGN DFP DUE TO ADVERSE ENV IN TB (VENT TO RB OR CNTNMT F	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The event is always combined with failure to initiate SPC. The SPC initiation action is very reliable and for almost all of the contributors including this event, operator action dependence issues would prevent any SAMAs requiring human action from reducing risk in a meaningful way. In these cases, the total human error probability is either at or very close to the lowest allowable JHEP value. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). Most scenarios with SPC

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				initiation failure also include the failure to vent containment, which represents the remaining means of containment heat removal. This leads to containment failure and an adverse environment in the reactor building (RB) and/or turbine building (TB) that prevents DFP alignment. Currently, venting containment can also lead to an adverse environment outside of containment; however, the hard pipe event will prevent the release of containment atmosphere into the RB and/or TB when venting (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
2RX-SL-MS1--3H--	4.50E-02	1.031	2SLOP-LVLCTRLH-- 2MSOPMSIVINLKH-- 2SLOP-IN-LATEH--	This joint HEP represents failure to bypass the MSIV low level isolation logic, early level control, and late SBLC injection in ATWS events. The high failure probability associated with the action to bypass the MSIV low level isolation logic is due to the short response time available and the relatively long time required to perform the action. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Automating SBLC initiation could also reduce some of these contributors (SAMA 5).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2RHPPISLOCA--R--	1.00E+00	1.031	RH LOW PRESSURE PIPING RUPTURES DURING ISLOCA EVENT	This event is related to ISLOCA events in the RHR and LPCS systems, 97% of which are linked to failure of the MOV to isolate (leads directly to core damage due to lack of a long term inventory makeup source). A potential means of providing an indefinite source of RPV makeup would be to tie the LPCS system to the RHRSW system and use the RHRSW pumps to provide injection flow to the RPV (SAMA 15).
1FPXV-1FP058-K--	7.43E-04	1.031	L.O. MANUAL VALVE 1FP058 FTC	About 97% of the contributors including this event are attributable to a single cutset in which a fire protection pipe breaks in the reactor building and 1FP058 fails to close. Other isolation points and mitigation methods are potentially available, but they are not credited due to the limited guidance that is available. The reliability of flood mitigation could be improved by developing procedures to direct specific actions for specific flood events (SAMA 9).
2FPXV-2FP058-K--	7.43E-04	1.031	L.O. MANUAL VALVE 2FP058 FTC	About 97% of the contributors including this event are attributable to a single cutset in which a fire protection pipe breaks in the reactor building and 2FP058 fails to close. Other isolation points and mitigation methods are potentially available, but they are not credited due to the limited guidance that is available. The reliability of flood mitigation could be improved by developing procedures to direct specific actions for specific flood events (SAMA 9).
RCVSEQ-ATW1-032	1.00E+00	1.031	ACCIDENT SEQUENCE ATW1-032 MARKER	Over 80% of this sequence is related to one cutset in which the failure to bypass the MSIV isolation logic fails in conjunction with failure to terminate and prevent injection that leads to subsequent overfill. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
2DGFN-VY06C--X--	3.29E-03	1.031	UNIT 2 DIV 2 CSCS ROOM COOLER FAN 2VY06C FAILS TO RUN	This event fails the room cooling for the RHRSW C and D pumps, which fails RHR train B. For these fan failures, portable fans could provide temporary, alternate room cooling. Room heatup calculations would be required as part of this effort to demonstrate that the portable fans could provide adequate cooling (SAMA 16). The contributors including this event are diverse, but over 60% is related to failure to align Heater Drain makeup due to adverse RB environment related to containment venting failure (due to direct operator action failure, failure to align a support system, or vent control failures). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3). SAMA 3 is contingent on the implementation of SAMA 1.
2FWRXTDRFPS--H--	1.00E+00	1.031	HEP(REC): OPERATOR FAILS TO MANUALLY RESET LEVEL 8 TRIP OR RESTART FW	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The HFE itself represents the failure to reset the Level 8 trip and restart the MDFW pump. In over 80% of the cases, the HFE is combined with failures to start SPC and to vent containment. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				pool temperature in non-LOCA scenarios (SAMA 2). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3). SAMA 3 is contingent on the implementation of SAMA 1.
2VYFNSEVY03CBX--	3.29E-03	1.03	VY SE CORNER ROOM (RHR B & C) COOLING FAN 2VY03C FAILS TO RUN	The RHR pump motors depend on the ECCS Equipment Area Ventilation System (VY) to maintain pump cubicle temperatures within qualification limits. Previous LSCS evaluations could not demonstrate that portable fans would provide adequate cooling for the RB corner rooms when the normal cooling system failed; therefore, portable cooling equipment is not proposed here. Over 60% of the contribution is associated with loss of injection capability caused by failure of venting support systems or the failure of the vent path. However, the reliable hard pipe containment vent will reduce support system dependencies that contribute to the failure scenarios including these contributors and the implementation of SAMA 1 will mitigate many of the contributors (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3). SAMA 3 is contingent on the implementation of SAMA 1.
2RHMV-BREAK--F--	9.50E-01	1.03	MOV FAILS TO ISOLATE WITH OR WITHOUT OPERATOR ACTION	The event represents the isolation failure probability of the MOV that failed as part of the ISLOCA initiating event (in the RHR and LPCS systems). Failure to isolate leads directly to core damage due to lack of a long term inventory makeup source. A potential means of providing an indefinite source of RPV makeup would

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				be to tie the LPCS system to the RHRSW system and use the RHRSW pumps to provide injection flow to the RPV (SAMA 15).
RCVSEQ-ILOC-009	1.00E+00	1.03	ACCIDENT SEQUENCE ILOC-009 MARKER	This sequence is completely tied to event 2RHMV-BREAK--F-- and the same disposition is applicable.
2FPRXALGNFPSAH--	1.00E+00	1.029	HEP(REC): OPERATOR FAILS TO ALIGN FPS FOLLOWING CONTAINMENT VENT OR FAILURE	This event is an operator action marker that is used in cutsets where the associated HFE (containment venting) is combined with other HFEs. The results show that essentially all of the cutsets that include this HFE also include the HFE for initiating SPC and the JHEPs for these events are at the lowest allowable JHEP value. The implication is that the heat removal function is already highly reliable and that current HRA methods cannot reliably assess the failure probabilities of the contributing JHEPs. Because of this, the benefit of changes to reduce these contributors further would be questionable, but eliminating the requirement for the operators to perform these tasks is mathematical means of demonstrating a reduction in risk. Potential means of accomplishing this goal would be to either automate SPC initiation on high suppression pool temperature (SAMA 2) or by installing a rupture disk in parallel with the remotely controlled hard pipe vent path (SAMA 3).
%LOOP	1.07E-02	1.029	LOSS OF OFF-SITE POWER INITIATING EVENT	Over 70% of the LOOP contribution is related to water hammer-LOCA scenarios resulting from the start of RHR without first properly filling and venting the system. For scenarios in which a LOOP occurs when RHR is in operation (for SPC, generally), the piping will drain to the suppression pool and the lines must be re-filled before restarting the pump to prevent water hammer. The independent HEP for this action is conservatively quantified as 2.5E-02. The action is not time stressed given that the available diagnosis time is over 3 hours

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				and the main contributor to the HEP is the execution component. The HRA for the fill and vent action includes some steps that would not be performed in an accident scenario (those that require drywell entry) and it does not credit a check of the RHR discharge pressure alarm to identify fill and vent failures. This is a proceduralized check that would identify conditions in which the fill and vent process was performed incorrectly. If this check were to be credited, the independent HEP would be reduced by over an order of magnitude and because this HEP is the lead HEP in the dependent action assessments, the JHEPs would be similarly be reduced. These events are not considered to be significant contributors and no SAMAs are suggested.
RCVSEQ-GTR-058	1.00E+00	1.029	ACCIDENT SEQUENCE GTR-058 MARKER	This sequence is for loss of injection and high pressure core melt scenarios, which are dominated by DC bus and battery charger failures. These failures could be mitigated by providing a portable DC source and a means of connecting it to ESF DC distribution panel 1(2)11Y to support RCIC operation and long term RPV depressurization and with FPS injection (SAMA 14).
BWTOPWTHXSTBYH--	1.00E+00	1.027	HEP: OP FAILS TO ALIGN STANDBY TBCCW HX TRAIN	This event is an operator action marker that is used in cutsets where the associated HFE (align standby TBCCW Hx) is combined with other HFEs. About 80% of the contributors including this event are related to the generation of a LOCA signal on high DW pressure when an actual LOCA does not exist. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up water hammer events at LSCS (SAMA 7). Review of the cutsets also shows that almost all of those cases also include the HFE for failing to

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				isolate the water hammer LOCA (in the form of JHEPs). However, the independent HEP for this action is low (2.3E-3) and is driven by the time available for response, so changes to training or plant procedures would not have a meaningful impact on the reliability of the action and no additional SAMAs are suggested.
2ADRXOVERFL-EH--	1.00E+00	1.027	HEP(REC): OPERATOR FAILS TO PREVENT RPV OVERFILL (DEPRESS/FW/EARLY LEVEL CONTROL	Over 92% of the contributors including this event (terminated and prevent injection) are related to one cutset that also includes failure to bypass the MSIV low level isolation logic as part of a joint HEP. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
2RX--MS-AD-32H--	3.90E-02	1.027	2MSOPMSIVINLKH-- 2ADOPOVERFL-EH--	This is the joint HEP representing the failure to bypass the MSIV low level isolation logic in conjunction with failure to terminate and prevent injection that leads to subsequent overfill. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
RCVSEQ-GTR-028	1.00E+00	1.027	ACCIDENT SEQUENCE GTR-028 MARKER	This event is a sequence marker representing scenarios where injection is provided by HPCS after FW failure, but depressurization, SPC and venting fail. The SPC initiation action is very reliable and for almost all of the contributors including this event, operator action dependence issues would prevent any SAMAs requiring human action from reducing risk in a meaningful way. For most of the contributors, the total human error probability is either at or very close to the lowest allowable JHEP value. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). Most scenarios with SPC initiation failure also include the failure to vent containment, which represents the remaining means of containment heat removal. This leads to containment failure and an adverse environment in the reactor building that fails ECCS equipment. Currently, venting containment will also lead to an adverse reactor building environment; however, the hard pipe event will prevent the release of containment atmosphere into the RB when venting (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
2CVSYVNT-ATWSF--	1.00E+00	1.027	CONTAINMENT VENT CONSERVATIVELY NOT CREDITED FOR ATWS	The containment vent path is not credited for ATWS events due to the potential for the vent path to fail and create adverse conditions in the reactor building. The reliable containment hard pipe vent would provide a

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				viable vent path for non-ATWS scenarios, but it is not designed to remove ATWS heat loads. Increasing the capacity of the reliable containment hard pipe vent would provide an additional means of containment heat removal in ATWS scenarios (SAMA 17). Other means of improving the reliability of the mitigating functions include automating SBLC initiation (SAMA 5) and installing a keylock switch for the MSIV low level isolation bypass (SAMA 4).
OSPR7HR-SW	2.80E-01	1.026	FAILURE TO RECOVER OSP WITHIN 7 HOURS (SEVERE WEATHER LOOP EVENT)	The contributors to long term LOOP events are diverse, but a means of mitigating these scenarios is to provide a portable 480V AC generator to supply a battery charger for SRV support (SAMA 8). In conjunction with the installation of SAMA 1 for reliable heat removal, ensuring SRV operation would allow the diesel fire pumps to provide low pressure RPV makeup.
2WTHE2WT01AA-PYR	5.24E-03	1.025	WT HX 2WT01AA FAILS DUE TO PLUGGING (YEARLY)	This event is a heat exchanger plugging event that leads to an initiating event that results in a high DW pressure signal when combined with other failures. Over 75% are related to water hammer induced LOCAs related to the generation of a LOCA signal when a LOCA condition does not exist. When RHR SPC is placed in service in response to certain transient events that lead to a high DW pressure signal (LOCA signal), the discharge line can drain to the suppression pool in the ~45 seconds between RHR pump load shed and the time it is reloaded on the bus, which sets up a water hammer condition. Modification of the LOCA signal logic to require both high DW pressure AND low RPV water level for initiation could prevent the scenarios that set up these water hammer events at LSCS (SAMA 7).
2SLOP-LVLCTRLH--	2.70E-01	1.025	HEP: OPERATOR FAILS TO LOWER LEVEL EARLY	Level and power control actions are tied together in ATWS scenarios. The limited time available for

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
			(ATWS)	response is the dominant performance shaping factor (PSF) controlling the relatively large level control HEP. Automating SBLC initiation (SAMA 5) is a potential means of improving the reliability of the SBLC injection function. Failure to bypass the low level MSIV isolation logic is also a contributor, which could be reduced by the installation of a keylock switch for logic bypass. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). The installation of an automatic ATWS level control system that reduces level to just above -129 inches, inhibits ADS, and performs the "terminate and prevent" step (to disallow other non-feedwater RPV injection) could improve the reliability of the level reduction action and provide additional time for the operators to perform other required actions (SAMA 21).
RCVSEQ-DLOP-030	1.00E+00	1.024	ACCIDENT SEQUENCE DLOP-030 MARKER	These are SBO sequences in which RCIC operates until battery depletion at about 7 hours. The contributors to long term LOOP events are diverse, but a means of mitigating these scenarios is to provide a portable 480V AC generator to supply a battery charger for SRV support (SAMA 8). In conjunction with the installation of SAMA 1 for reliable heat removal, ensuring SRV operation would allow the diesel fire pumps to provide low pressure RPV makeup.
%MS	1.01E+00	1.024	MANUAL SHUTDOWN INITIATING EVENT	This event is an initiating event for manual shutdown. The top contributors for manual shutdown events are related to adverse RB conditions caused by venting/duct rupture or by containment failure after venting failure

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				(over 73%). Over 50% of the total manual shutdown contributors include failure to initiate SPC. LSCS is committed to installing a hard pipe vent, which will essentially eliminate the adverse environment condition in the RB after venting. Because this modification has not yet been implemented and is not reflected in the model or record, it has been designated as SAMA 1 for completeness. While already reliable, automating the initiation of SPC could further improve the reliability of the containment heat removal function (SAMA 2). Installation of a rupture disk in parallel with the normal hard pipe vent path could reduce the contribution from vent failures (SAMA 3).
%TI	2.16E-02	1.023	INADVERTENTLY OPEN RELIEF VALVE INITIATING EVENT	In over 70% of the IORV scenarios, the SRV successfully recloses on reduced pressure. About half of the %TI contribution is related to the failure to initiate SPC and containment venting. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). Most scenarios with SPC initiation failure also include the failure to vent containment, which represents the remaining means of containment heat removal. This leads to containment failure and an adverse environment in containment that fails ECCS equipment. Currently, venting containment will fail also lead to an adverse containment environment; however, the hard pipe vent will prevent the release of containment atmosphere into the RB when venting (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
RCVSEQ-ATW1-040	1.00E+00	1.022	ACCIDENT SEQUENCE ATW1-040 MARKER	These sequences are for mitigated ATWS events with high pressure core melt. Over 40% of the contributors are related to the failure to close the turbine driven reactor driven feedwater pump (TDRFP) discharge MOVs (leading to loss of condensate/FW). The action itself is for closing the TDRFP discharge valves in time to prevent RPV overfill or hotwell depletion. The flow control for these pumps is provided by pump speed control rather than regulating valve and when the pumps are tripped, the flowpath remains open. When reactor pressure is reduced, flow from the condensate pumps or heater drain system can flow in an uncontrolled manner into the RPV. The frequency of these contributors could be reduced by changing the logic to auto close the TDRFP discharge valves when the pumps are tripped or are not running (SAMA 10). Another means of mitigating these sequences would be to provide an additional means of high pressure injection in an ATWS by installing cross-tie between HPCS and the FW injection line (SAMA 12).
2DGPMCSDG2A--M--	3.10E-03	1.022	DG2A COOLING WATER PUMP 2DG01P TRAIN MUA	About 80% of the contributors including this event are loss of containment heat removal cases, most of which lead to an adverse environment in the RB due to containment failure or vent duct failure. The hard pipe vent will prevent the release of containment atmosphere into the RB when venting (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
2RHSYOPERATEB---	2.50E-02	1.021	RH TRAIN B IS IN OPERATION PRIOR TO A LOOP / DLOOP EVENT	These events represent the probability that RHR is in operation at the time of the initiating event and are related to water hammer-LOCA scenarios resulting from

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				the start of RHR without first properly filling and venting the system. For scenarios in which a initiating event occurs when RHR is in operation (for SPC, generally), the piping will drain to the suppression pool and the lines must be re-filled before restarting the pump to prevent water hammer. The independent HEP for fill and vent is conservatively quantified as 2.5E-02. The action is not time stressed given that the available diagnosis time is over 3 hours and the main contributor to the HEP is the execution component. The HRA for the fill and vent action includes some steps that would not be performed in an accident scenario (those that require drywell entry) and it does not credit a check of the RHR discharge pressure alarm to identify fill and vent failures. This is a proceduralized check that would identify conditions in which the fill and vent process was performed incorrectly. If this check were to be credited, the independent HEP would be reduced by over an order of magnitude and because this HEP is the lead HEP in the dependent action assessments, the JHEPs would be similarly be reduced. These events are not considered to be significant contributors and no SAMAs are suggested.
2RHSYOPERATEA---	2.50E-02	1.021	RH TRAIN A IS IN OPERATION PRIOR TO A LOOP / DLOOP EVENT	Same as for 2RHSYOPERATEB---.
2RX-FWADRHCV6H--	5.00E-07	1.021	2FWOPMOV10AB-H-- 2ADOP-INHIBITH-- 2ADOP-TRANS--H-- 2RHOPSPCINIT-H-- 2CVOPVEN	This is the joint HEP representing the failure of multiple operator actions, including SPC initiation. Because the value of this joint HEP is set at the lowest allowable JHEP value, SAMAs that require additional operator actions would not have a measurable impact on risk. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				pool temperature in non-LOCA scenarios (SAMA 2).
RCVSEQ-LOOP-041	1.00E+00	1.02	ACCIDENT SEQUENCE LOOP-041 MARKER	This event is an accident sequence marker for LOOP events with early injection failure. Over 85% of the contribution is related to water hammer-LOCA scenarios resulting from the start of RHR without first properly filling and venting the system (all LOOP events). For scenarios in which a LOOP occurs when RHR is in operation (for SPC, generally), the piping will drain to the suppression pool and the lines must be re-filled before restarting the pump to prevent water hammer. The independent HEP for this action is conservatively quantified as 2.5E-02. The action is not time stressed given that the available diagnosis time is over 3 hours and the main contributor to the HEP is the execution component. The HRA for the fill and vent action includes some steps that would not be performed in an accident scenario (those that require drywell entry) and it does not credit a check of the RHR discharge pressure alarm to identify fill and vent failures. This is a proceduralized check that would identify conditions in which the fill and vent process was performed incorrectly. If this check were to be credited, the independent HEP would be reduced by over an order of magnitude and because this HEP is the lead HEP in the dependent action assessments, the JHEPs would be similarly be reduced. These events are not considered to be significant contributors and no SAMAs are suggested.
2SLRX-IN-ERLYH--	1.00E+00	1.02	HEP(REC): OPERATOR FAILS TO INITIATE SBLC EARLY	This event is an operator action marker that is used in cutsets where the associated HFE (SBLC initiation) is combined with other HFEs. In most cases, it is combined with the failure to bypass the low level MSIV isolation logic. Installing a keylock MSIV low level

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Automating SBLC system initiation could also reduce these contributors (SAMA 5).
RCVSEQ-ATW1-036	1.00E+00	1.02	ACCIDENT SEQUENCE ATW1-036 MARKER	This event is an accident sequence marker for loss of condenser ATWS events with failures of ADS inhibit and early SBLC injection/level control. Operator failures to inject SBLC and to bypass low level MSIV isolation logic are both large contributors at about 75% each. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Automating SBLC system initiation could also reduce these contributors (SAMA 5).
%TDCA	5.70E-04	1.02	LOSS OF 125 VDC BUS 2A INITIATING EVENT	This is an initiating event representing the loss of the "A" train ESF DC bus, which essentially eliminates an entire division of equipment. The failures contributing to core

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				damage in conjunction with this event are diverse and the most effective means of mitigating the scenario would be to bypass the bus failure. This could be accomplished by providing a portable generator with DC output that could be connected to distribution panel 1(2)11Y. This would support RCIC and SRV operation, which if combined with SAMA 1, would provide a long term means of providing RPV makeup via FPS injection.
1DGFN-VY05C--X--	3.29E-03	1.02	UNIT 1 DIV 1 CSCS ROOM COOLER FAN 1VY05C FAIL TO RUN	Failure of cooler fan 1VY05C results in failure of the 0DGCWP pump, which supplies cooling water to the 2A RHR pump room coolers and leads to failure of the 2A RHR pump. Installation of a portable fan for temporary cooling could prevent failure of the 0DGCWP pump and subsequent RHR pump failure. Room heatup calculations would be required as part of this effort to demonstrate that the portable fans could provide adequate cooling (SAMA 16).
2ACSYLOOPNLOCA--	2.40E-03	1.019	COND PROB OF A LOOP GIVEN NO LOCA SIGNAL	For consequential LOOP events without a LOCA, the contributors to core damage are diverse. SBO event with failure of injection comprise about half of the contribution and water hammer LOCAs contribute to about 30% of the total. Early injection capability could be enhanced for the SBO cases if a hard pipe connection were installed between the Fire Protection and Feedwater systems. If a permanent connection between the systems is undesirable, a short, flexible connecting hose could potentially be maintained out of the flowpath provided that rapid alignment could be demonstrated (SAMA 18). As described for sequence marker RCVSEQ-LOOP-041, the HEP for fill and vent does not credit available checking mechanisms, which, if credited, would significantly reduce the water hammer contribution and no SAMAs are required to address

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				those scenarios.
2ADOP-FW--AT-H--	2.70E-02	1.019	HEP: OPERATOR FAILS TO MANUALLY DEPRESSURIZE THE RPV - ATWS (FW AVAILABLE)	This event represents the failure to depressurize the RPV in ATWS scenarios after initially inhibiting depressurization. In these cases, there is an automatic depressurization function, but it has been successfully bypassed as part of accident mitigation. In over 67% of these cases, this action is required due to the failure to bypass the low level MSIV isolation bypass logic. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
2RX-FWRHCVF15H--	5.00E-07	1.019	2FWOPMOV10AB-H-- 2RHOPSPCINIT-H-- 2CVOPVENT----H-- 2RHOPSPCLATE-H-- 2FPOPALG	This event is a joint HEP that addresses several actions, including SPC initiation and containment venting. The joint HEP is at the lowest allowable JHEP value, implying that operator action dependence issues would prevent any SAMAs requiring human action from reducing risk in a meaningful way. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
2RX-FWRHCVF35H--	5.00E-07	1.019	2FWOPMOV10AB-H--	This event is a joint HEP that addresses several actions,

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
			2RHOPSPCINIT-H-- 2CVOPVENT----H-- 2RHOPSPCLATE-H-- BFPOP-DF	including SPC initiation and containment venting. The joint HEP is at the lowest allowable JHEP value, implying that operator action dependence issues would prevent any SAMAs requiring human action from reducing risk in a meaningful way. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
RCVSEQ-ATW1-034	1.00E+00	1.018	ACCIDENT SEQUENCE ATW1-034 MARKER	This event is an accident sequence marker for ATWS scenarios with early SBLC or level control failures. In about 70% of the cases, the operators fail to bypass the low level MSIV isolation logic. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Another contributor, at about 25%, is the failure to initiate SBLC. Automating system initiation could reduce these contributors (SAMA 5).
2RX--LVL-SL-2H--	6.50E-02	1.018	2SLOP-LVLCTRLH-- 2SLOP-IN-LATEH--	This event is a joint HEP that addresses failure to control level early and to inject SBLC late. Automating SBLC injection would mitigate these scenarios (SAMA 5). The installation of an automatic ATWS level control system

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				that reduces level to just above -129 inches, inhibits ADS, and performs the "terminate and prevent" step (to disallow other non-feedwater RPV injection) could improve the reliability of the level reduction action and provide additional time for the operators to perform other required actions (SAMA 21).
DLOOP-IE-GR	3.72E-01	1.017	COND. PROB. DLOOP DUE TO GRID RELATED EVENT	This event represents the prob. that a DLOOP event is related to a grid failure. About 40% of the contribution is related to water hammer-LOCAs resulting from the start of RHR without first properly filling and venting the system. For scenarios in which a LOOP occurs when RHR is in operation (for SPC, generally), the piping will drain to the SP and the lines must be re-filled before restarting the pump to prevent water hammer. The HEP for this action is conservatively quantified as 2.5E-02. The HFE is not time stressed given that the available diagnosis time is over 3 hours and the main contributor to the HEP is the execution component. The HRA for the fill and vent action includes some steps that would not be performed in an accident scenario (those that require drywell entry) and it does not credit a check of the RHR discharge press. alarm to identify errors. This is a proceduralized check that would identify fill and vent failures. If this check were to be credited, the HEP would be reduced by over an order of magnitude and because this HEP is the lead HEP in the dependent action assessments, the JHEPs would be similarly be reduced. These events are not considered to be significant contributors and no SAMAs are suggested. A majority of the remaining contributors are long term SBO events. These could be addressed by providing a portable generator to support the battery chargers (SAMA 8) in combination with the hard pipe vent (SAMA 1).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2PLASRECLOSE-F--	8.50E-01	1.017	SRVs SUCCESSFULLY RECLOSED ON REDUCED PRESSURE	About 58% of the contribution associated with IORV events in which the SRV recloses on reduced pressure include failure of the operator to initiate SPC. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). Most scenarios with SPC initiation failure also include the failure to vent containment, which represents the remaining means of containment heat removal. This leads to containment failure and an adverse environment in the reactor building that fails ECCS equipment. Currently, venting containment will also lead to an adverse reactor building environment; however, the hard pipe vent will prevent the release of containment atmosphere into the RB when venting (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
OSPR30MIN-SW	7.73E-01	1.017	FAILURE TO RECOVER OSP WITHIN 30 MIN. (SEVERE WEATHER LOOP EVENT)	This event represents the probability of failing to recover offsite power for a severe weather related LOOP in 30 minutes. About 70% of the contribution is related to water hammer-LOCAs resulting from the start of RHR without first properly filling and venting the system. For scenarios in which a LOOP occurs when RHR is in operation (for SPC, generally), the piping will drain to the SP and the lines must be re-filled before restarting the pump to prevent water hammer. The HEP for this action is conservatively quantified as 2.5E-02. The HFE is not time stressed given that the available diagnosis time is over 3 hours and the main contributor to the HEP is the execution component. The HRA for the fill and vent action includes some steps that would not be performed

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				in an accident scenario (those that require drywell entry) and it does not credit a check of the RHR discharge press. alarm to identify errors. This is a proceduralized check that would identify fill and vent failures. If this check were to be credited, the HEP would be reduced by over an order of magnitude and because this HEP is the lead HEP in the dependent action assessments, the JHEPs would be similarly be reduced. These events are not considered to be significant contributors and no SAMAs are suggested.
2RX--RH-CV--3H--	1.50E-06	1.017	2RHOPSPCINIT-H-- 2CVOPVENT----H-- 2RHOPSPCLATE-H--	This event is a joint HEP that addresses SPC initiation and containment venting. The joint HEP is near the lowest allowable JHEP value, implying that operator action dependence issues would prevent any SAMAs requiring human action from reducing risk in a meaningful way. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3).
2HDOP-HD-ERLYH--	1.00E+00	1.016	HEP: OPERATOR FAILS TO ALIGN HEATER DRAIN FOR INJECTION (EARLY TIME FRAME)	This event represents the HEP for aligning the heater drain pumps for early injection. The HEP is 1.0 due to the lengthy time required for alignment. Early injection capability could be enhanced for this scenario as well as for SBO cases if a hard pipe connection were installed between the Fire Protection and Feedwater systems. If a permanent connection between the systems is undesirable, a short, flexible connecting hose could potentially be maintained out of the flowpath provided that rapid alignment could be demonstrated (SAMA 18).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2VYFNNWVY01--X--	3.29E-03	1.016	VY NW CORNER ROOM (RHR A) COOLING FAN 2VY01C FAILS TO RUN	Loss of the cooling fan in the northwest (NW) corner room results in the loss of RHR pump "A" due to overheating. Previous LSCS evaluations could not demonstrate that portable fans would provide adequate cooling for the RB corner rooms when the normal cooling system failed; therefore, portable cooling equipment is not proposed here. Over 60% of the contribution is associated with loss of injection capability caused by failure of venting support systems or the failure of the vent path. However, the reliable hard pipe containment vent will reduce support system dependencies that contribute to the failure scenarios including these contributors and the implementation of SAMA 1 will mitigate many of the contributors (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3). SAMA 3 is contingent on the implementation of SAMA 1.
2DGFN-VY05C--X--	3.29E-03	1.016	UNIT 2 DIV 1 CSCS ROOM COOLER FAN 2VY05C FAIL TO RUN	Failure of cooler fan 2VY05C results in failure of the 2A and 2B RHRSW pumps, which supply cooling water to the 2A RHR pump and the 2A RHR heat exchanger. Installation of a portable fan for temporary cooling could prevent failure of the 2A and 2B RHRSW pumps and subsequent RHR pump failure (SAMA 16).
2RHPME12C002BM--	2.97E-03	1.016	RH TRAIN 2B (2E12-C002B) MUA	This event represents the maintenance unavailability of the RHR 2B pump. The contributors to other RHR train failures are diverse, but venting failures (and subsequent containment failures that lead to loss of RPV makeup) are mostly due to support system unavailability, which will be addressed by the reliable containment hard pipe vent (SAMA 1). Other contributors include cases in

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				which containment venting is successful, but vent duct failure leads to adverse conditions in the RB and subsequent injection failure. These cases would also be mitigated by the reliable containment hard pipe vent.
%TDCAB	3.42E-07	1.016	LOSS OF 125 VDC BUS 2A AND 2B INITIATING EVENT	About 85% of the contribution for the loss of DC bus 2A and 2B initiating event is related to the case in which the 125V HPCS DC bus also fails (bus 213). In these cases, there is no 125V DC power available to support either injection or RPV depressurization. These failures could be mitigated by providing a portable DC source and a means of connecting it to ESF DC distribution panel 1(2)11Y to support RCIC operation and long term RPV depressurization and with FPS injection (SAMA 14).
2DCRX2A2A2B--H--	7.10E-01	1.016	HEP: OP FAILS TO RCVR BATT BUS 2A GIVEN LOSS OF BUS 2A AND 2B IE	This event is related to the initiating event %TDCAB and SAMA 14 is also applicable.
2DCRX2B2A2B--H--	7.10E-01	1.016	HEP: OP FAILS TO RCVR BATT BUS 2B GIVEN LOSS OF BUS 2A AND 2B IE	This event is related to the initiating event %TDCAB and SAMA 14 is also applicable.
2FPOPMANTRIP1H--	4.10E-01	1.015	HEP: OPERATOR FAILS TO TRIP FPS FOR FPS BREAK (SHORT TIME FRAME)	Over 93% of the contribution associated with the failure to trip the FPS pumps in the short term comes from a cutset in which it is combined with long term FPS trip failure (where over 13 hours are available for diagnosis). For such an extended time available for response, the mitigation action is highly reliable and it is inconceivable that the FPS pumps would not be tripped and the SW system connection valves isolated. SAMAs that require manual actions to isolate or terminate the flood would have a limited benefit for these contributors due to operator dependence issues. The reliability of the FPS flood mitigation action, could, however, be improved by simplifying the process. This could be accomplished by

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				providing a means of tripping the FPS diesel fire pumps from the MCR combined with flood zone specific procedures to direct remote isolation of FPS valves (SAMA 11).
2ADRX-ADS-AT-H--	1.00E+00	1.015	HEP(REC): OPERATOR FAILS TO MANUALLY DEPRESSURIZE THE RPV-ATWS (NO FW AVAIL)	This event is an operator action marker that is used in cutsets where the associated HFE (manual depressurization) is combined with other HFEs. This action is required because the ADS function is inhibited for ATWS. The independent HEP for depressurization is dominated by the ASEP cognitive contribution and is based on the short response time available. About 75% of the contributors including this event also include failure to bypass the MSIV low level interlock. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
2CD--2CD01AMS---	3.00E-02	1.015	COND PROBY MAN SHTDWN REQD FOR MAIN CONDENSER 2CD01A MAINT	The top contributors including this event are related to adverse conditions caused by failure to vent or venting (over 75%) and HFEs related to the alignment of SPC (over 50%). In conjunction with the hard pipe vent, a parallel, passive vent path could provide a means of ensuring that the containment failure occurs through a rupture disk with a scrubbed path from the wetwell (SAMA 3). While already reliable, automating the initiation of SPC could further improve the reliability of

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				the containment heat removal function (SAMA 2).
2ADRXOVERFL-LH--	1.00E+00	1.015	HEP(REC): OPERATOR FAILS TO PREVENT RPV OVERFILL (DEPRESS/FW/LATE LEVEL CONTROL)	About 70% of the contributors including this event (terminated and prevent injection) are related to one cutset that also includes failure to bypass the MSIV low level isolation logic as part of a joint HEP. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
%ISLOCA-SDC	3.80E-08	1.014	SDC SUCTION LINE ISLOCA	Failure to isolate the pathway is the dominant contributor for this ISLOCA event, which leads directly to core damage due to lack of a long term inventory makeup source. A potential means of providing an indefinite source of RPV makeup would be to tie the LPCS system to the RHRSW system and use the RHRSW pumps to provide injection flow to the RPV (SAMA 15).
BFPOP-DFPENV-H--	1.00E-01	1.014	HEP: OP FAILS TO ALIGN DFP DUE TO ADVERSE ENV IN TB (VENT TO RB OR CNTNMT FAIL)	This event is the independent HEP for the alignment of DFP injection when the RB conditions are adverse due to containment failure or vent path failure. These cases will be addressed by the reliable containment hard pipe vent. SAMA 1 will provide a vent path capable of withstanding the pressures associated with containment venting. For the cases in which venting fails, it is generally due to support system failure. SAMA 1 eliminates the support system dependencies that currently exist for containment venting. No SAMAs

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				required.
2FPOPMANTRIP4H--	8.80E-04	1.014	HEP: OPERATOR FAILS TO TRIP FPS GIVEN FAILURE OF SHORT TIME FRAME (COND PROB)	All of the contribution associated with the failure to trip the FPS pumps in the short term comes from a cutset in which it is combined with long term FPS trip failure (where over 13 hours are available for diagnosis). For such an extended time available for response, the mitigation action is highly reliable and it is inconceivable that the FPS pumps would not be tripped and the SW system connection valves isolated. SAMAs that require manual actions to isolate or terminate the flood would have a limited benefit for these contributors due to operator dependence issues. The reliability of the FPS flood mitigation action, could, however, be improved by simplifying the process. This could be accomplished by providing a means of tripping the FPS diesel fire pumps from the MCR combined with flood zone specific procedures to direct remote isolation of FPS valves (SAMA 11).
BDGPMCSTRN0A-M--	3.10E-03	1.014	DG0 COOLING WATER PUMP 0DG01P TRAIN MUA	This event is related to loss of decay heat removal scenarios. The 0DGCWP pump supplies cooling water to the 2A RHR pump room coolers and its unavailability leads to failure of the 2A RHR pump. Previous LSCS evaluations could not demonstrate that portable fans would provide adequate cooling for the RB corner rooms when the normal cooling system failed; therefore, portable cooling equipment is not proposed here. Over 70% of the contribution is associated with loss of injection capability caused by failure of venting support systems or the failure of the vent path. However, the reliable hard pipe containment vent will reduce support system dependencies that contribute to the failure scenarios including these contributors and the implementation of SAMA 1 will mitigate many of the

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				contributors (SAMA 1). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3). SAMA 3 is contingent on the implementation of SAMA 1.
2ACRX-AC-CBS-H--	1.00E+00	1.014	HEP(REC): OPERATOR FAILS TO CLOSE BREAKER TO 4KV BUS AFTER OFFSITE AC POWER RECO	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. In about 50% of the contributors, the JHEP is driven by the chronologically first HEP (DG 0 alignment), which is conservatively based on a timing scenario in which there is no RPV makeup; however, in most of the cases in which the JHEP is applied, HPCS is available and there would be many hours available for DG 0 alignment rather than 30 minutes. The treatment is conservative and if the time window reflected HPCS availability, these combinations would not be significant and no SAMAs are required. In the other case, the HEP is combined with failure to initiate SPC, which could be addressed by automating SPC initiation in non-LOCA scenarios (SAMA 2).
RCVCL-1D	1.00E+00	1.014	ACCIDENT CLASS ID MARKER	This event is an accident class marker for loss of RPV makeup at high pressure scenarios and does not represent any specific failure itself. Many of these cases are loss of DC scenarios, most of which are related to 125V DC bus failures. These failures could be mitigated by providing a portable DC source and a means of connecting it to ESF DC distribution panel 1(2)11Y to support RCIC operation and long term RPV depressurization and with FPS injection (SAMA 14).
2ADOPRPVLEVELH--	1.80E-02	1.013	HEP: OPERATOR CONTROLS RPV LEVEL TOO LOW (LOW	This is the independent HFE for failing to maintain level high enough in ATWS events, although about 65% of the combination is from its combination with failure to

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
			PRESSURE - ATWS)	bypass the low level MSIV isolation logic. A JHEP was not used in the model for the action pair because the independent combination yields essentially the same results as the JHEP; however, installing a keylock bypass on the low level MSIV isolation logic is a potential means of reducing the frequency of these scenarios. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4).
OSPR30MIN-SWYD	5.95E-01	1.013	FAILURE TO RECOVER OSP WITHIN 30 MIN. (SWYD CENTERED EVENT)	The failure to recover offsite power in 30 minutes, as represented by this event, is important in induced LOCA scenarios. For scenarios in which a LOOP occurs when RHR is in operation (for SPC, generally), the piping will drain to the suppression pool and the lines must be re-filled before restarting the pump to prevent water hammer (about 80% of the contribution). The independent HEP for this action is conservatively quantified as 2.5E-02. The action is not time stressed given that the available diagnosis time is over 3 hours and the main contributor to the HEP is the execution component. The HRA for the fill and vent action includes some steps that would not be performed in an accident scenario (those that require drywell entry) and it does not credit a check of the RHR discharge pressure alarm to identify fill and vent failures. This is a proceduralized check that would identify conditions in which the fill and vent process was performed incorrectly. If this check were to be credited, the independent HEP would be reduced by over an order of magnitude and because this HEP is the lead HEP in the

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				dependent action assessments, the JHEPs would be similarly be reduced. These events are not considered to be significant contributors and no SAMAs are suggested.
RCVSEQ-ATW1-041	1.00E+00	1.013	ACCIDENT SEQUENCE ATW1-041 MARKER	This event is an accident sequence marker for ATWS scenarios and does not represent any specific failure itself. About 65% of the contribution is related to the failure to close the turbine driven feedwater pump discharge valves in time to prevent RPV overfill or hotwell depletion. The flow control for these pumps is provided by pump speed control rather than regulating valve and when the pumps are tripped, the flowpath remains open. When reactor pressure is reduced, flow from the condensate pumps or heater drain system can flow in an uncontrolled manner into the RPV. The HEP is driven by the time reliability component and the execution component for two valve closures, which presents limited opportunity for improvement. The frequency of these contributors could be reduced by changing the logic to auto close the TDRFP discharge valves when the pumps are tripped or are not running (SAMA 10).
2DCBSCOND213CF--	2.00E-01	1.013	COND PROB OF FAIL OF DIV 3 125 VDC BUS GIVEN LOSS OF DIVs 1 & 2 DC IE	There is one cutset that includes this event, which is a scenario initiated by loss of DC bus 2A and 2B. In these cases, there is no 125V DC power available to support either injection or RPV depressurization. These failures could be mitigated by providing a portable DC source and a means of connecting it to ESF DC distribution panel 1(2)11Y to support RCIC operation and long term RPV depressurization and with FPS injection (SAMA 14).
BDGHUCDG0---H--	8.00E-03	1.013	PRE-HEP: OPERATOR MISALIGNS 0 DG SPEED	This event is a pre-initiator HFE that results in the failure of the 0 EDG. About 80% of these cases are long term

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
			DROOP	SBOs in which high pressure injection is initially available and depressurization is available. Containment venting fails primarily due to support system unavailability and leads to the failure of RPV makeup. The reliable hard pipe containment vent will mitigate these scenarios by providing a means of venting without support systems (SAMA 1).
2CNFLMLLOCA--PCC	1.00E-04	1.013	CCF (PLUGGING) OF ECCS SUCT STRAINERS (LOCA)	For common cause failure (CCF) of the ECCS suction strainers, the implication is that the suppression pool is unavailable due to debris issues. These top contributors including this event are medium LOCA events with breaks both above and below TAF. Installing a connection from the RHRSW system on the RHR pump suction line could provide a means of back flushing the suction strainer and restoring flow (SAMA 6), but there may be time limitations that would prevent this from being successful. Providing the capability to align RHRSW to the LPCS pumps from the MCR is a means of rapidly providing alternate flow for core cooling (SAMA 19). For the dominant contributors, depressurization is available.
2HCHUF038----H--	8.00E-03	1.012	PRE-HEP: OPERATOR MISALIGNS HPCS AND LEAVES 2E22-F038 CLOSED AFTER MAINT.	The event represents a pre-initiator HFE in which the in-containment manual injection isolation valve is left closed (not recoverable in an accident scenario). In a majority of cases, the depressurization function is available, but a means of injection is not available due to lack of AC or DC power combined with other random failures. Improving the connection between the fire protection and Feedwater systems so that injection can be aligned rapidly would mitigate many of these contributors (SAMA 18).
%S2-WA	3.67E-03	1.011	INIT: SMALL BREAK LOCA - BELOW CORE INSIDE	The contributors for this small LOCA initiating event are diverse, but potential mitigating measures include SAMA

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
			DRYWELL	1 for preventing vent pathway failure and providing a rapid means of aligning RHRSW to LPCS for injection (SAMA 19).
2RHPME12C002AM--	2.97E-03	1.011	RH TRAIN 2A (2E12-C002A) MUA	For cases in which RHR train 2A is unavailable due to maintenance, most of the containment vent and vent path failures would be addressed by SAMA 1. Containment vent failure due to support system unavailability would be addressed by the capability of the reliable hard pipe vent to be operated without support systems. The failure of the vent path would be addressed by SAMA 1 because the hard pipe vent is designed to accommodate containment pressure during a vent action.
RCVSEQ-GTR-057	1.00E+00	1.011	ACCIDENT SEQUENCE GTR-057 MARKER	This event is an accident sequence marker for transient scenarios with failure of high and low pressure injection. About 50% of the contributors are related to the failure to close the TDRFP discharge MOVs (leading to loss of condensate/FW). The action itself if for closing the turbine driven feedwater pump discharge valves in time to prevent RPV overfill or hotwell depletion. The flow control for these pumps is provided by pump speed control rather than regulating valve and when the pumps are tripped, the flowpath remains open. When reactor pressure is reduced, flow from the condensate pumps or heater drain system can flow in an uncontrolled manner into the RPV. The frequency of these contributors could be reduced by changing the logic to auto close the TDRFP discharge valves when the pumps are tripped or are not running (SAMA 10). An alternative approach would be to enhance the fire protection system connection to the FW system to provide an alternate means of early injection when depressurization is possible (SAMA 18).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
RCVSEQ-DLOP-032	1.00E+00	1.011	ACCIDENT SEQUENCE DLOP-032 MARKER	This event is an accident sequence marker for long term SBO scenarios in which RCIC initially operates but fails after battery depletion. After installation of a hardened containment vent at LSCS, a viable means of containment heat removal will be available in SBO scenarios. The diesel fire pump is a currently proceduralized injection source that can be used in an SBO, but this low pressure injection source would only be available until the SRVs close after battery depletion (RPV re-pressurization would prevent continued injection). Use of a portable generator to provide long term power to the 125 VDC battery chargers would provide a means of maintaining diesel fire pump makeup indefinitely (SAMA 8).
RCVCL-3D	1.00E+00	1.01	ACCIDENT CLASS IIID MARKER	This event is an accident class marker for large LOCA scenarios with failure of vapor suppression and does not represent any specific failure itself. The results are dominated by failures of the vacuum breakers to re-close. The existing vacuum breakers are reliable, but a potential means of reducing the frequency of these types of scenarios would be to install redundant vacuum breakers in each of the lines (SAMA 20)
2RX-SL-MS3-23H--	1.50E-02	1.01	2SLOP-IN-ERLYH-- 2MSOPMSIVINLKH-- 2SLOP-LATELVLH--	This is the joint HEP representing the failure of multiple operator actions, including failure of bypass the low level MSIV isolation logic, early SBLC initiation, and late level control. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and provide more time margin for the actions in ATWS scenarios requiring isolation bypass, thereby improving the reliability of the human control actions. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). Automating SBLC system initiation is another means of reducing the frequency of these contributors (SAMA 5). The installation of an automatic ATWS level control system that reduces level to just above -129 inches, inhibits ADS, and performs the "terminate and prevent" step (to disallow other non-feedwater RPV injection) could improve the reliability of the level reduction action and provide additional time for the operators to perform other required actions (SAMA 21).
2MSAVMSIVTRIPF--	1.00E-02	1.01	COND PROB OF MSIV ISOL FOLLOWING A TRIP	Over 50% of the contributors associated with the conditional probability of MSIV closure after trip include a failure to initiate SPC. While already reliable, automating the initiation of SPC could further improve the reliability of the containment heat removal function (SAMA 2). There are also additional cases in which venting fails after hardware related failures of containment heat removal. In conjunction with the hard pipe vent, a parallel, passive vent path could provide a means of ensuring that the containment failure occurs through a rupture disk with a scrubbed path from the wetwell (SAMA 3).
2CN--RUPT-WWWF--	1.83E-02	1.01	WW RUPTURE BELOW WATER LINE	For the scenarios including wetwell failures below the water line, about half of the contributors include the JHEP for failing to initiate SPC and containment venting. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). For the other half of the contributors, the support systems required for venting are failed, which will be mitigated by implementation of SAMA 1.

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
BDGDGU1DG0---F--	5.00E-01	1.01	DIESEL GENERATOR DG0 AUTO CLOSES TO UNIT 1 (50% OF THE TIME)	This event represents the probability that the undervoltage signal will first register for Unit 1 in a DLOOP event and that DG 0 will auto align to Unit 1. In these cases, the operator must manually align DG 0 power to Unit 2. Over 96% of the contributors including this event also include failure to manually align DG 0 to Unit 2. Almost 70% of the contributors also include failure to restore offsite AC power after recovery. In these cases, containment venting for heat removal fails due to support system unavailability, which could be mitigated by SAMA 1 because of the capability to vent without support systems.
2MSOPMSIVINLKHSU	3.00E-01	1.01	HEP: OP SUCCESSFULLY BYPASSES MSIV LOW LEVEL INTERLOCK	This event represent the probability that the operators successfully bypass the low level MSIV isolation logic in an ATWS. The top contributor (~65%) is that late level control fails after this success followed by failure to initiate SBLC. The action for level control is about 1/3 cognitive and 2/3 execution failure, which is driven by the relatively large number of steps required to control the FW system. These controls are familiar to the operators and the execution error may be conservative, but a potential means of reducing these types of failures would be to automate the initial ATWS power and level control steps. The installation of an automatic ATWS level control system that reduces level to just above -129 inches, inhibits ADS, and performs the "terminate and prevent" step (to disallow other non-feedwater RPV injection) could improve the reliability of the level reduction action and provide additional time for the operators to perform other required actions (SAMA 21).
2DGDM-VY04Y--D--	1.14E-03	1.01	UNIT 2 DIV 2 CSCS ROOM COOLING DAMPER 2VY04Y FAILS TO OPEN	This damper failure in the Unit 2 CSCS Division 2 vault leads to the loss of room cooling and ultimately, the failure of the RHRSW 2C, RHRSW 2D, and 2A DGCW

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				pumps. Providing an alternate means of room cooling, such as with portable fans, could prevent failure of the equipment in the vault (SAMA 16).
2DGDM-VY05Y--K--	1.14E-03	1.01	UNIT 2 DIV 2 CSCS ROOM COOLING DAMPER 2VY05Y FAILS TO CLOSE	This damper failure in the Unit 2 CSCS Division 2 vault leads to the loss of room cooling and ultimately, the failure of the RHRSW 2C, RHRSW 2D, and 2A DGCW pumps. Providing an alternate means of room cooling, such as with portable fans, could prevent failure of the equipment in the vault (SAMA 16).
2DGDM-VY06Y--D--	1.14E-03	1.01	UNIT 2 DIV 2 CSCS ROOM COOLING DAMPER 2VY06Y FAILS TO OPEN	This damper failure in the Unit 2 CSCS Division 2 vault leads to the loss of room cooling and ultimately, the failure of the RHRSW 2C, RHRSW 2D, and 2A DGCW pumps. Providing an alternate means of room cooling, such as with portable fans, could prevent failure of the equipment in the vault (SAMA 16).

Table F.5-2a
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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
LERF	1.00E+00	3.127	PROBABILITY OF A LARGE, EARLY RELEASE (CLASS V)	This is a marker event for cutsets that result in LERF from the containment bypass sequence. Over 91% are related to event 2RHMV-BREAK--F--, which is addressed in the Level 1 importance review.
LERF-IVLERF-V	1.00E+00	3.127	LEVEL 2 LERF-V ENDSTATE	This is a recovery flag marker that is completely tied to the LERF flag. Over 91% are related to event 2RHMV-BREAK--F--, which is addressed in the Level 1 importance review.
RCVCL-5	1.00E+00	3.127	ACCIDENT CLASS V MARKER	Addressed in the Level 1 Importance Review.
2RHMV-BREAK--F--	9.50E-01	2.632	MOV FAILS TO ISOLATE WITH OR WITHOUT OPERATOR ACTION	Addressed in the Level 1 Importance Review.
2RHPPISLOCA--R--	1.00E+00	2.632	RH LOW PRESSURE PIPING RUPTURES DURING ISLOCA EVENT	Addressed in the Level 1 Importance Review.
RCVSEQ-ILOC-009	1.00E+00	2.632	ACCIDENT SEQUENCE ILOC-009 MARKER	Addressed in the Level 1 Importance Review.
%ISLOCA-SDC	3.80E-08	1.396	SDC SUCTION LINE ISLOCA	Addressed in the Level 1 Importance Review.
2NCPHNCF-----F--	1.00E+00	1.228	LARGE CONTAINMENT FAILURE CLASS IIV, IIID, OR IV	This is a marker event for large containment failure scenarios. Over 50% are related to vapor suppression failures resulting from the failure of a vacuum breaker to reclose. These events could be mitigated by installing redundant vacuum breakers in each line (SAMA 20). Another 40% are related to ATWS events, which are addressed on the Level 1 list by SAMAs 4, 5, and 21. This is generally true for all of the ATWS related events in the Level 2 importance lists. Combustible gas venting failure occurs for these cases, but the large containment failures are not linked to hydrogen detonation/deflagration, but rather to overpressurization. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure (SAMA 17).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2GVPHCMBSTGASF--	1.00E+00	1.182	COMBUSTIBLE GAS VENTING FAILS	About 50% of the contributors including this event are related to ATWS scenarios while most of the remaining half are related to station blackout scenarios. In ATWS cases, the containment vent capacity is not capable of keeping up with combustible gas generation while for SBO scenarios, venting is not currently possible due to lack of power for the containment vent valves. The installation of the reliable containment hard pipe vent (SAMA 1) will address support system failures for SBO cases and allow venting. For ATWS scenarios, most containment failures are related to overpressurization rather than hydrogen detonation/deflagration. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment overpressure and by providing a means of venting combustible gases (SAMA 17). Alternatively, hydrogen detonation could be prevented by the installation of hydrogen ignitors (SAMA 22).

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2GVPH-INERT--X--	9.90E-01	1.163	CONTAINMENT INERTED; VENTING NOT REQUIRED	This event identifies scenarios in which the containment remains inerted and combustible gas venting is not required. In these cases, phenomena other than combustible gas explosions lead to containment failure. About 70% of the contribution is related to the failure of the vacuum breakers to re-close resulting in a vapor suppression failure. These failures could be mitigated by installing redundant vacuum breakers in each line (SAMA 20). The failure to arrest core melt in-vessel is associated with these same contributors. In these cases, RPV makeup is failed as a consequence of containment failure, either due to harsh reactor building environment or by injection line damage caused by containment failure. Prevention of containment failure is considered to be the most effective means of mitigating these cases and SAMA 20 is again relevant. A large portion of the remaining cases are associated with DC bus failures, which could be addressed by providing a DC generator with the capability to directly power the RCIC distribution panel (SAMA 14).
RX11	1.00E+00	1.125	FAILURE TO ARREST CORE MELT IN-VESSEL (CLASS IIIA, IIID AND IV OP=F)	This is a marker event designating the failure to terminate core melt in the RPV (i.e., the core melts through the vessel) for Class IIIA, IIID, and IV scenarios. About 90% of the contribution is related to large LOCA events in which the failure of the vacuum breakers to re-close results in a vapor suppression failure. In these cases, RPV makeup is failed as a consequence of containment failure, either due to harsh reactor building environment or by injection line damage caused by containment failure. These failures could be mitigated by installing redundant vacuum breakers in each line (SAMA 20). SAMA 15 suggests the connection of RHRSW to LPCS for alternate injection, but even though the RHRSW pumps may survive, it is not clear that the injection line would be available after containment failure.

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
DIF	1.00E+00	1.124	DW NOT INTACT (CLASS IIID)	This is a marker event designating the failure the Drywell for class IIID scenarios. About 90% of the contribution is related to large LOCA events in which the failure of the vacuum breakers to re-close results in a vapor suppression failure. In these cases, RPV makeup is failed as a consequence of containment failure, either due to harsh reactor building environment or by injection line damage caused by containment failure. These failures could be mitigated by installing redundant vacuum breakers in each line (SAMA 20). SAMA 15 suggests the connection of RHRSW to LPCS for alternate injection, but even though the RHRSW pumps may survive, it is not clear that the injection line would be available after containment failure.
RCVCL-3D	1.00E+00	1.124	ACCIDENT CLASS IIID MARKER	Addressed in the Level 1 Importance Review.
CZF	1.00E+00	1.122	CONTAINMENT NOT INTACT BEFORE RPV BREACH (CLASS IIID)	This is a marker event designating that the containment is failed prior to RPV breach for class IIID scenarios. About 90% of the contribution is related to large LOCA events in which the failure of the vacuum breakers to re-close results in a vapor suppression failure. In these cases, RPV makeup is failed as a consequence of containment failure, either due to harsh reactor building environment or by injection line damage caused by containment failure. These failures could be mitigated by installing redundant vacuum breakers in each line (SAMA 20). SAMA 15 suggests the connection of RHRSW to LPCS for alternate injection, but even though the RHRSW pumps may survive, it is not clear that the injection line would be available after containment failure.

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2OPAD-ALTRNT-F--	1.00E+00	1.11	ALTERNATE DEPRESS. METHODS NOT CREDITED	This event represents the failure of depressurization of the RPV through the RCIC steam lines or through the MSIVs. The RCIC steam lines are not credited because the capacity is not large enough and the MSIVs are not credited due to the time required to re-open them. However, the main contributors for these scenarios are SBOs and in these scenarios, while air could be supplied by the trailer mounted compressor, there would not be power to operate the MSIVs, among other things. The depressurization function could be restored in these cases by providing a portable DC source that could directly power panel 1(2)11Y to support Division 1 ADS and to potentially extend the operation of RCIC (SAMA 14).
2OPPH-PRESBK-F--	8.00E-01	1.11	PRESSURE TRANSIENT DOES NOT FAIL MECHANICAL SYSTEMS	This is a marker event for scenarios in which pressure transients do not fail the RCS pressure boundary (RPV not depressurized from mechanical failures after a pressure transient). The events are tied to the scenarios that include the event 2OPAD-ALTRNT-F--, which could be mitigated by providing a portable DC source that could directly power panel 1(2)11Y to support Division 1 ADS and to potentially extend the operation of RCIC (SAMA 14).
2OPPH-SORV---F--	5.50E-01	1.11	SRVs DO NOT FAIL OPEN DURING CORE MELT PROGRESSION	This is a marker event for scenarios in which the consequences of core melt do not fail the SRVs open (RPV not depressurized from a stuck open SRV after core melt). The events are tied to the scenarios that include the event 2OPAD-ALTRNT-F--, which could be mitigated by providing a portable DC source that could directly power panel 1(2)11Y to support Division 1 ADS and to potentially extend the operation of RCIC (SAMA 14).

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2OPPH-TEMPBK-F--	7.00E-01	1.11	HIGH PRIM SYS TEMP DOES NOT CAUSE FAIL OF RCS PRESS. BOUND	This is a marker event for scenarios in which the high temperatures of core melt do not fail the RCS pressure boundary (RPV not depressurized from failed recirc pump seals, for example). The events are tied to the scenarios that include the event 2OPAD-ALTRNT-F--, which could be mitigated by providing a portable DC source that could directly power panel 1(2)11Y to support Division 1 ADS and to potentially extend the operation of RCIC (SAMA 14).
RCVSEQ-LL-ST-016	1.00E+00	1.103	ACCIDENT SEQUENCE LL-ST-016 MARKER	This event is a sequence marker representing scenarios where large LOCAs above TAF have occurred with vapor suppression failure. For this sequence, over 90% of the risk is associated with the failure of the vacuum breakers to re-close, which results in a vapor suppression failure. These failures could be mitigated by installing redundant vacuum breakers in each line (SAMA 20).
2RPCDRPS-MECHFCC	2.10E-06	1.087	RPS MECHANICAL FAILURE	Addressed in the Level 1 Importance Review.
RCVCL-4A	1.00E+00	1.081	ACCIDENT CLASS IV MARKER	Addressed in the Level 1 Importance Review.
1RBPH-RB-----F--	1.00E+00	1.075	SOURCE TERM IS NOT REDUCED BY REACTOR ENCLOSURE	The event represents the probability that the magnitude of the radioactive release will be reduced due to its passage through the RB. Considerations include gravitational settling of radionuclides, SBGT scrubbing, and scrubbing of release through a water pool. No credit is currently taken for this source term reduction mechanism. There is a potential that additional analysis could justify some type of reduction for releases through the RB, but 90% of the scenarios including this event are related large containment failures (mostly not related to hydrogen detonation). Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment overpressure (SAMA 17).
%DLOOP	7.95E-03	1.075	DUAL UNIT LOSS OF OFF-SITE POWER INITIATING EVENT	Addressed in the Level 1 Importance Review.

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
DI4-NOT	9.90E-01	1.074	DW INTACT (CLASS IV)	This is a marker event designating that the Drywell has not failed for class IV scenarios. In all of the cases including this event, combustible gas venting fails and containment failure occurs in the wetwell. The venting failure is related to the assumption that the vent capacity is not capable of keeping up with combustible gas generation. The Level 1 ATWS mitigation SAMAs, such as SAMAs 4 and 5, would provide a means of reducing the frequency of the contributors associated with this event. For ATWS scenarios, most containment failures are related to overpressurization rather than hydrogen detonation/deflagration. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment overpressure (SAMA 17).
2TDOP-RECLPS2H--	1.00E+00	1.072	OPERATOR FAILS TO RECOVER LOW PRESSURE SYSTEMS	This event represents the failure to recover low pressure systems for injection to the containment to prevent drywell failure. These are all SBO scenarios in which the low pressure systems would not have power to function. Fire water is not considered because of its low flow rate (1000 gpm required), which would be reduced from its nominal flow rate by containment pressurization. No credit is currently taken in the Level 1 model for fire protection injection due to the inability to maintain the SRVs open (and if the SRVs could be held open, the inability to perform containment vent to prevent high containment pressure would result in SRV closure due to containment pressurization). Implementation of SAMA 1 combined with the use of a portable 480V AC generator to support SRV operation (SAMA 8) would prevent core damage in these scenarios such that containment flooding would not be required.
RCVCL-IBL	1.00E+00	1.071	ACCIDENT CLASS IBL MARKER	Addressed in the Level 1 Importance Review.

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
DLOOP-IE-SW	3.84E-01	1.067	COND. PROBABILITY DLOOP DUE TO SEVERE WEATHER EVENT	Addressed in the Level 1 Importance Review.
TD6	1.00E+00	1.066	WATER INJECTION TO CONT. UNAVAIL. (CLASS II AND OP=S)	The TD6 description indicates that it is used to represent the failure to provide injection to the containment in class II events, but the model also applies it to class IV events and in quantification, it is always paired with ATWS in the "high" release categories. The TD6 failure probability is set to 1.0 because all injection systems were previously asked in the tree and were determined to be failed, which may be caused by harsh reactor building environment from containment failure or by injection line disruption on containment failure (although, energetic containment failures are not large contributors for this case). In these cases, 100% of the contribution is associated with large containment failures, which are assumed for ATWS events due to the inability of the vent to accommodate the ATWS heat loads. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17). Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
DGRECOV-7HR	1.00E+00	1.062	DIESEL GENERATOR RECOVERY WITHIN 7 HOURS	Addressed in the Level 1 Importance Review.

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2SYPPBOCINRB-R--	2.34E-01	1.062	BOC INITIATING EVENT PIPE BREAK OCCURS BELOW TAF (OUTSIDE STEAM TUNNEL)	These events are related to breaks outside of containment below TAF. In these cases, an unlimited injection supply would be required to maintain core cooling. This could potentially be provided by connecting RHRSW to the LPCS injection line. Water could be sprayed onto the core to maintain core cooling and in the event that reactor building flooding causes support system damage, the flood water could potentially submerge the break point and provide some scrubbing of the release (SAMA 15).
RCVSEQ-BOC-003	1.00E+00	1.062	ACCIDENT SEQUENCE BOC-003 MARKER	This sequence marker is completely tied to event 2SYPPBOCINRB-R--.
%TT	7.98E-01	1.061	TURBINE TRIP WITH BYPASS INITIATING EVENT	Addressed in the Level 1 Importance Review.
WW4	9.00E-02	1.061	WW FAILURE BELOW WATER LINE (CLASS IV)	This event represents the probability of wetwell failure below the water line for ATWS scenarios. In these cases, 100% of the contribution is associated with large containment failures, which are assumed for ATWS events due to the inability of the vent to accommodate the ATWS heat loads. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure (SAMA 17).
%ISLOCA-LPCS	7.50E-09	1.059	LPCS INJECTION LINE ISLOCA	This event is an ISLOCA initiating event. All of the contribution is associated with event 2RHMV-BREAK--F--, which is addressed in the Level 1 importance review.
%ISLOCA-RHRA	7.50E-09	1.059	RHR A INJECTION LINE ISLOCA	This event is an ISLOCA initiating event. All of the contribution is associated with event 2RHMV-BREAK--F--, which is addressed in the Level 1 importance review.
%ISLOCA-RHRA-S	7.50E-09	1.059	RHR A SDC RETURN LINE ISLOCA	This event is an ISLOCA initiating event. All of the contribution is associated with event 2RHMV-BREAK--F--, which is addressed in the Level 1 importance review.
%ISLOCA-RHRB	7.50E-09	1.059	RHR B INJECTION LINE ISLOCA	This event is an ISLOCA initiating event. All of the contribution is associated with event 2RHMV-BREAK--F--, which is addressed in the Level 1 importance review.
%ISLOCA-RHRB-S	7.50E-09	1.059	RHR B SDC RETURN LINE ISLOCA	This event is an ISLOCA initiating event. All of the contribution is associated with event 2RHMV-BREAK--F--,

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
				which is addressed in the Level 1 importance review.
%ISLOCA-RHRC	7.50E-09	1.059	RHR C INJECTION LINE ISLOCA	This event is an ISLOCA initiating event. All of the contribution is associated with event 2RHMV-BREAK--F--, which is addressed in the Level 1 importance review.
OSPR7HR-SW	2.80E-01	1.059	FAILURE TO RECOVER OSP WITHIN 7 HOURS (SEVERE WEATHER LOOP EVENT)	Addressed in the Level 1 Importance Review.
2SY--PWR5PERCF--	1.00E+00	1.056	POWER LEVEL GREATER THAN 3%	Addressed in the Level 1 Importance Review.
1RXPH-EQPRX2-F--	1.00E+00	1.056	INDUCED FAILURE OF EQUIPMENT IN RX. BLDG. (LARGE WW FAILURE)	This event represents the probability that required equipment located in the reactor building fails after a large wetwell failure. These are about 90% ATWS cases in which the containment vent is not capable of preventing overpressurization failure. In large containment failure scenarios, injection line piping that passes through the containment is also assumed to be damaged in energetic containment failures. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17). In many of these post core damage ATWS scenarios, RPV depressurization is available and energetic containment failure has not occurred. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2RX-IBL-OPS-WTHR	7.03E-01	1.054	FAILURE TO RECOVER AC POWER FOR IBE DURING RX TIME FRAME-WTHR	This event represents the probability of failure to recover AC power in the time frame required to provide RPV makeup to prevent RPV melt-through (with RPV depressurization successful). In these SBO cases, core damage has occurred because of the inability to provide RPV makeup in long term SBOs. No credit is currently taken in the Level 1 model for fire protection injection in these cases due to the inability to maintain the SRVs open (and if the SRVs could be held open, the inability to perform containment vent to prevent high containment pressure would result in SRV closure due to containment pressurization). Implementation of SAMA 1 combined with the use of a portable 480V AC generator to support SRV operation (SAMA 8) would prevent core damage in these scenarios.
2MSOP-AT-LVL-H--	1.00E+00	1.053	HEP: RPV LEVEL LOWERED BELOW LEVEL 1 SETPOINT DURING ATWS	Addressed in the Level 1 Importance Review.
2TD-IBL-OPF-WTHR	9.33E-01	1.051	FAILURE TO RECOVER AC POWER FOR IBL DURING TD TIME FRAME (OP=S) WTHR	This event represents the probability of failure to recover AC power in the time frame required to provide RPV makeup to prevent drywell failure (with RPV depressurization failure). In these SBO cases, core damage has occurred because of the inability to provide RPV makeup in long term SBOs. No credit is currently taken in the Level 1 model for fire protection injection in these cases due to the inability to maintain the SRVs open (and if the SRVs could be held open, the inability to perform containment vent to prevent high containment pressure would result in SRV closure due to containment pressurization). Implementation of SAMA 1 combined with the use of a portable 480V AC generator to support SRV operation (SAMA 8) would prevent core damage in these scenarios.
2MSRXMSIVINLKH--	1.00E+00	1.046	HEP(REC): OPERATOR FAILS TO BYPASS LOW LEVEL MSIV INTERLOCK	Addressed in the Level 1 Importance Review.

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
%A-ST	2.29E-05	1.041	LARGE LOCA ABOVE TAF	This is an initiating event for large LOCAs above TAF. Over 90% are related to vapor suppression failures resulting from the failure of a vacuum breaker to reclose. These events could be mitigated by installing redundant vacuum breakers in each line (SAMA 20).
2OPOP-RE-ACPRH--	1.00E+00	1.04	OPERATOR FAILS TO RESTORE AC POWER DURING BOIL-OFF	This event represents the probability of failure to recover AC power in the time frame when the RCS inventory is boiling off. In these SBO cases, core damage has occurred because of the inability to provide RPV makeup in long term SBOs. No credit is currently taken in the Level 1 model for fire protection injection in these cases due to the inability to maintain the SRVs open (and if the SRVs could be held open, the inability to perform containment vent to prevent high containment pressure would result in SRV closure due to containment pressurization). Implementation of SAMA 1 combined with the use of a portable 480V AC generator to support SRV operation (SAMA 8) would prevent core damage in these scenarios.
RCVSEQ-DLOP-030	1.00E+00	1.038	ACCIDENT SEQUENCE DLOP-030 MARKER	Addressed in the Level 1 Importance Review.
2SLRX-LVLCTRLH--	1.00E+00	1.034	HEP(REC): OPERATOR FAILS TO LOWER LEVEL EARLY (ATWS)	Addressed in the Level 1 Importance Review.

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
1RXPH-FIRESYSF--	1.00E+00	1.034	FIRE SYSTEM UNAVAILABLE	This event represents the probability that the fire protection system would not be available to provide makeup to prevent RPV meltthrough. The disqualifying factor for fire protection is the requirement to provide 1000 gpm. About 80% of these scenarios are ATWS scenarios and even if a hard piped fire protection connection were installed, it would not likely be capable of preventing core damage. In many of these post core damage ATWS scenarios, however, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).

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LSCS "High" Importance List Review

EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
2RXOP-TERMINJH--	1.00E-01	1.032	OPERATOR INTERVENES AND TERMINATES INJECTION	This is an "error of commission" event representing the probability that the operators will erroneously terminate RPV makeup when RPV makeup is still required to prevent RPV melt-through. Since the time of the Three Mile Island accident, procedures and training have improved significantly, but injection termination has been included in the model because it is a high profile evolution. No accepted HRA methodology has been established to quantify the probability of errors of commission and there are no clear, quantifiable benefits that could be calculated from further improving procedures and training. Instead, steps to mitigate other portions of the accident sequence are suggested. ATWS events contribute to over 60% of the risk for these scenarios and could be mitigated by same SAMAs identified on the Level 1 list (e.g., 4, 5, and 21) and the containment overpressure failures could be prevented by the installation of a hard pipe containment vent capable of accommodating the ATWS heat loads (SAMA 17). The long term SBOs (18% of contribution) could be addressed by implementation of SAMA 1 combined with the use of a portable 480V AC generator to support SRV operation (SAMA 8) and would prevent core damage in these scenarios.
%BOC-MS	1.62E-08	1.032	BREAK OUTSIDE CONTAINMENT IN MAIN STEAM LINE	These events are related to breaks outside of containment below TAF. In these cases, an unlimited injection supply would be required to maintain core cooling. This could potentially be provided by connecting RHRSW to the LPCS injection line. Water could be sprayed onto the core to maintain core cooling and in the event that reactor building flooding causes support system damage, the flood water could potentially submerge the break point and provide some scrubbing of the release (SAMA 15).
RCVCL-1A	1.00E+00	1.032	ACCIDENT CLASS IA MARKER	Addressed in the Level 1 Importance Review.

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EVENT NAME	PROBABILITY	RRW	DESCRIPTION	POTENTIAL SAMAS
RCVSEQ-GTR-058	1.00E+00	1.031	ACCIDENT SEQUENCE GTR-058 MARKER	Addressed in the Level 1 Importance Review.
2CZPH-DEIN-O2F--	1.00E-02	1.03	CONTAINMENT DEINERTED OR O2 INTRODUCED	This basic event represents the probability that the containment is de-inerted or that oxygen has been introduced. The event is relevant to early containment failure scenarios caused by hydrogen detonation. Hydrogen detonation could be prevented by the installation of hydrogen ignitors (SAMA 22).
2CZPH-H2-DEFGF--	1.00E+00	1.03	HYDROGEN DEFLAGRATION OCCURS GLOBALLY	This basic event represents the probability that hydrogen detonation occurs when the containment becomes de-inerted. The event is relevant to early containment failure scenarios caused by the hydrogen detonation event. Hydrogen detonation could be prevented by the installation of hydrogen ignitors (SAMA 22).
2CZPH-STMINRTF--	5.00E-01	1.03	CONTAINMENT NOT STEAM INERTED	This basic event represents the probability that the containment is not steam inerted in scenarios where normal nitrogen inertion has failed. The event is relevant to early containment failure scenarios caused by hydrogen detonation. Hydrogen detonation could be prevented by the installation of hydrogen ignitors (SAMA 22).

Table F.5-2b
LSCS "ME" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
1RBPH-RB-----F--	1.00E+00	24.061	SOURCE TERM IS NOT REDUCED BY REACTOR ENCLOSURE	The event represents the probability that the magnitude of the radioactive release will be reduced due to its passage through the RB. Considerations include gravitational settling of radionuclides, SBGT scrubbing, and scrubbing of release through a water pool. No credit is currently taken for this source term reduction mechanism. There is a potential that additional analysis could justify some type of reduction for releases through the RB, but over 85% of the scenarios including this event are related large containment failures in ATWS events (mostly not related to hydrogen detonation). Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment overpressure (SAMA 17).
2GVPHCMBSTGASF--	1.00E+00	24.061	COMBUSTIBLE GAS VENTING FAILS	Over 85% of the contributors including this event are related to ATWS scenarios. In ATWS cases, the containment vent capacity is not capable of keeping up with combustible gas generation and venting is assumed to fail. These containment failures are related to overpressurization rather than hydrogen detonation/deflagration. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment overpressure and by providing a means of venting combustible gases (SAMA 17).
2NCPHNCF-----F--	1.00E+00	6.198	LARGE CONTAINMENT FAILURE CLASS IIV, IIID, OR IV	This is a marker event for large containment failure scenarios. The events are all related to ATWS events in which the containment fails because of the inability of the vent to accommodate ATWS loads. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure (SAMA 17).
RCVCL-4A	1.00E+00	5.854	ACCIDENT CLASS IV MARKER	Addressed in the Level 1 Importance Review.
2RPCDRPS-MECHFCC	2.10E-06	5.761	RPS MECHANICAL FAILURE	Addressed in the Level 1 Importance Review.

Table F.5-2b
LSCS "ME" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
DI4-NOT	9.90E-01	5.392	DW INTACT (CLASS IV)	This event represents the probability that containment failure does not occur in the drywell. The events are all related to ATWS events in which the containment fails because of the inability of the vent to accommodate ATWS loads. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure (SAMA 17).
TD6	1.00E+00	4.63	WATER INJECTION TO CONT. UNAVAIL. (CLASS II AND OP=S)	The TD6 description indicates that it is used to represent the failure to provide injection to the containment in class II events, but the model also applies it to class IV events and in quantification, over 85% of the contribution is linked with ATWS in the "medium-early" release category. The TD6 failure probability is set to 1.0 because all injection systems were previously asked in the tree and were determined to be failed, which may be caused by harsh reactor building environment from containment failure or by injection line disruption on containment failure (although, energetic containment failures are not large contributors for this case). In these ATWS cases, all of the contribution is associated with large containment failures, which are assumed for ATWS events due to the inability of the vent to accommodate the ATWS heat loads. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17). Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).

Table F.5-2b
LSCS "ME" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
WW4-NOT	9.10E-01	3.123	WW FAILURE ABOVE WATER LINE (CLASS IV)	This event represents the probability of wetwell failure below the water line for ATWS scenarios. In these cases, 100% of the contribution is associated with large containment failures, which are assumed for ATWS events due to the inability of the vent to accommodate the ATWS heat loads. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure (SAMA 17).
%TT	7.98E-01	2.374	TURBINE TRIP WITH BYPASS INITIATING EVENT	Addressed in the Level 1 Importance Review.
1RXPH-EQPRX2-F--	1.00E+00	2.337	INDUCED FAILURE OF EQUIPMENT IN RX. BLDG. (LARGE WW FAILURE)	This event represents the probability that required equipment located in the reactor building fails after a large wetwell failure. These are over 85% ATWS cases in which the containment vent is not capable of preventing overpressurization failure. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17). In many of these post core damage ATWS scenarios, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2SY--PWR5PERCF--	1.00E+00	2.123	POWER LEVEL GREATER THAN 3%	Addressed in the Level 1 Importance Review.
2MSOP-AT-LVL-H--	1.00E+00	1.999	HEP: RPV LEVEL LOWERED BELOW LEVEL 1 SETPOINT DURING ATWS	Addressed in the Level 1 Importance Review.
2MSRXMSIVINLKH--	1.00E+00	1.868	HEP(REC): OPERATOR FAILS TO BYPASS LOW LEVEL MSIV INTERLOCK	Addressed in the Level 1 Importance Review.

Table F.5-2b
LSCS "ME" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
1RXPH-FIRESYSF--	1.00E+00	1.579	FIRE SYSTEM UNAVAILABLE	This event represents the probability that the fire protection system would not be available to provide makeup to prevent RPV meltthrough. The disqualifying factor for fire protection is the requirement to provide 1000 gpm. Over 70% of these scenarios are ATWS scenarios and even if a hard piped fire protection connection were installed, it would not likely be capable of preventing core damage. In many of these post core damage ATWS scenarios, however, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2SLRX-LVLCTRLH--	1.00E+00	1.574	HEP(REC): OPERATOR FAILS TO LOWER LEVEL EARLY (ATWS)	Addressed in the Level 1 Importance Review.
RCVSEQ-ATW1-037	1.00E+00	1.457	ACCIDENT SEQUENCE ATW1-037 MARKER	Addressed in the Level 1 Importance Review.
2RXOP-ALTINJ-H--	1.00E-01	1.281	OPERATOR FAILS TO ALIGN INJECTION TO THE REACTOR VESSEL PRIOR TO VESSEL MELTING	This event represents the probability that alternate injection would not be aligned in time to provide makeup to prevent RPV meltthrough. The condensate system is technically considered, but the HRA conservatively uses the complex alignment of fire water injection as the execution basis for the action. In many of these post core damage ATWS scenarios, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).

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Event Name	Probability	RRW	Description	Potential SAMAs
2SLRX-IN-LATEH--	1.00E+00	1.277	HEP(REC): OPERATOR FAILS TO INITIATE SBLC LATE (COND PROB)	Addressed in the Level 1 Importance Review.
2RXOP-TERMINJH--	1.00E-01	1.27	OPERATOR INTERVENES AND TERMINATES INJECTION	This is an "error of commission" event representing the probability that the operators will erroneously terminate RPV makeup when RPV makeup is still required to prevent RPV melt-through. Since the time of the Three Mile Island accident, procedures and training have improved significantly, but injection termination has been included in the model because it is a high profile evolution. No accepted HRA methodology has been established to quantify the probability of errors of commission and there are no clear, quantifiable benefits that could be calculated from further improving procedures and training. Instead, steps to mitigate other portions of the accident sequence are suggested. ATWS events contribute to over 95% of the risk for these scenarios and could be mitigated by same SAMAs identified on the Level 1 list (e.g., 4, 5, and 21) and the containment overpressure failures could be prevented by the installation of a hard pipe containment vent capable of accommodating the ATWS heat loads (SAMA 17).
2FWRXMOV10AB-H--	1.00E+00	1.219	HEP(REC): OPERATOR FAILS TO CLOSE THE TDRFP DISCHARGE MOVS 2FW010A & B	Addressed in the Level 1 Importance Review.
2SLRX-LATELVLH--	1.00E+00	1.187	HEP(REC): OPERATOR FAILS TO CONTROL LEVEL LATE IN ATWS (COND PROB)	Addressed in the Level 1 Importance Review.
RCVSEQ-ATW1-041	1.00E+00	1.183	ACCIDENT SEQUENCE ATW1-041 MARKER	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
RX12-NOT	6.70E-01	1.178	CORE MELT ARRESTED IN-VESSEL (CLASS IV, OP=S)	This event represents the probability that injection was aligned in time to provide makeup to prevent RPV meltthrough. These are all ATWS cases in which the containment vent is not capable of preventing overpressurization failure. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17).
WW4	9.00E-02	1.156	WW FAILURE BELOW WATER LINE (CLASS IV)	This event represents the probability of wetwell failure below the water line for ATWS scenarios. In these cases, 100% of the contribution is associated with large containment failures, which are assumed for ATWS events due to the inability of the vent to accommodate the ATWS heat loads. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure (SAMA 17).
RCVCL-2	1.00E+00	1.148	ACCIDENT CLASS II MARKER	Addressed in the Level 1 Importance Review.
GEN-EMERG	5.00E-02	1.148	GENERAL EMERGENCY NOT DECLARED	The event represents the probability that a general emergency will be declared in time to provide adequate evacuation time for the public. In these cases, it has failed and the result in an "early" release. This probability is not driven by any plant specific characteristics and no insights are available to that would allow specific changes to plant procedures or training to improve the reliability of the action. About 60% of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). Also, about 50% of the contribution is related to the failure to close the turbine driven pump discharge valves after the pumps are shut down. The frequency of these contributors could be reduced by changing the logic to auto close the TDRFP discharge valves when the pumps are tripped or are not running (SAMA 10).

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Event Name	Probability	RRW	Description	Potential SAMAs
2NCPHNC3-----F--	1.00E+00	1.136	LARGE CONTAINMENT FAILURE CLASS IIA OR IIL	This event represents the probability of large containment failure for class IIA or IIL sequences. Over 60% of the contributors include operator failures to initiate SPC and containment venting. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3). Reactor vessel meltthrough also occurs in over 75% of these cases due to harsh reactor building conditions. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2RX-SL-MS2--3H--	4.70E-02	1.134	2SLOP-LVLCTRLH-- 2MSOPMSIVINLKH-- 2SLOP-LATELVLH--	Addressed in the Level 1 Importance Review.
2RX-SL-MS1--3H--	4.50E-02	1.127	2SLOP-LVLCTRLH-- 2MSOPMSIVINLKH-- 2SLOP-IN-LATEH--	Addressed in the Level 1 Importance Review.
%TC	1.33E-01	1.116	LOSS OF CONDENSER VACUUM INITIATING EVENT	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
RCVSEQ-ATW1-046	1.00E+00	1.103	ACCIDENT SEQUENCE ATW1-046 MARKER	This event is a sequence marker representing ATWS scenarios in which SBLC injection/level control fails, feedwater fails, and the condenser fails. Makeup to the RPV and containment have also failed to prevent vessel melt-through and drywell failure. These are all ATWS cases in which the containment vent is not capable of preventing overpressurization failure. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17). In many of these post core damage ATWS scenarios, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
RCVSEQ-ATW1-032	1.00E+00	1.102	ACCIDENT SEQUENCE ATW1-032 MARKER	Addressed in the Level 1 Importance Review.
2RX--LVL-SL-2H--	6.50E-02	1.095	2SLOP-LVLCTRLH-- 2SLOP-IN-LATEH--	Addressed in the Level 1 Importance Review.
2SY--RB-CT---F--	1.00E+00	1.09	COND. PROB. OF ECCS FAILURE DUE TO ENV. IN REACTOR BUILDING	Addressed in the Level 1 Importance Review.
2ADRXOVERFL-EH--	1.00E+00	1.089	HEP(REC): OPERATOR FAILS TO PREVENT RPV OVERFILL (DEPRESS/FW/EARLY LEVEL CONTROL	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
2ADRXOVERFLEEH--	1.00E+00	1.089	HEP(REC): OPERATOR FAILS TO PREVENT RPV OVERFILL (DEPRESS/NO FW AVAIL)	This event is an operator action marker that is used in cutsets where the associated HFE is combined with other HFEs. The action itself if for preventing uncontrolled injection in an ATWS and not overfilling when level is restored after successful SBLC injection. In this release category, about 85% of the contributors also include the failure of the operators to close the turbine driven feedwater pump discharge valves after the pumps are shut down. Automating level control and the "terminate and prevent" action is a potential means of addressing the risk associated with this action (SAMA 21). Alternatively, the frequency of these contributors could be reduced by changing the logic to auto close the TDRFP discharge valves when the pumps are tripped or are not running (SAMA 10).
2RX--MS-AD-32H--	3.90E-02	1.088	2MSOPMSIVINLKH-- 2ADOPOVERFL-EH--	Addressed in the Level 1 Importance Review.
2RHRXSPCINIT-H--	1.00E+00	1.087	HEP(REC): OPERATOR FAILS TO INITIATE SUPPRESSION POOL COOLING (NON-ATWS)	Addressed in the Level 1 Importance Review.
2RHRXSPCLATE-H--	1.00E+00	1.087	HEP(REC): OPERATOR FAILS TO INITIATE SPC LATE GIVEN EARLY FAILURE (COND PROB)	Addressed in the Level 1 Importance Review.
2HDOP-HD-VENTH--	9.00E-01	1.086	VENTING CREATES ADVERSE ENV. CONDITIONS FOR ALIGNMENT OF HD	Addressed in the Level 1 Importance Review.
2CVRXVENT----H--	1.00E+00	1.079	HEP(REC): OPERATOR FAILS TO INITIATE PRIMARY CONTAINMENT VENTING	Addressed in the Level 1 Importance Review.
2SLRX-IN-ERLYH--	1.00E+00	1.076	HEP(REC): OPERATOR FAILS TO INITIATE SBLC EARLY	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
2RX--AD-FW--2H--	7.10E-03	1.074	2ADOPOVERFLEEH-- 2FWOPMOV10AB-H--	This event is a JHEP representing the failure to control level after SBLC injection and to close the turbine driven pump discharge valves after the pumps are shut down. Automating level control and the "terminate and prevent" action is a potential means of addressing the risk associated with this action (SAMA 21). Alternatively, the frequency of these contributors could be reduced by changing the logic to auto close the TDRFP discharge valves when the pumps are tripped or are not running (SAMA 10).
2MSOPMSIVINLKH--	7.00E-01	1.069	HEP: OPERATOR FAILS TO BYPASS LOW LEVEL MSIV INTERLOCK	Addressed in the Level 1 Importance Review.
DI1	5.00E-01	1.067	DW NOT INTACT (CLASS II OR WHEN RX = S)	This event represents the probability that the drywell has failed in Class II scenarios. Over 60% of the contributors include operator failures to initiate SPC and containment venting. A potential means of reducing risk for these scenarios would be to automate SPC initiation on high suppression pool temperature in non-LOCA scenarios (SAMA 2). If a rupture disk were installed in parallel with the remotely operated hard pipe containment vent valve, it would provide a passive means of heat removal that would not compromise the equipment in the reactor building (SAMA 3). Reactor vessel meltthrough also occurs in over 75% of these cases due to harsh reactor building conditions. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
RCVSEQ-ATW1-036	1.00E+00	1.064	ACCIDENT SEQUENCE ATW1-036 MARKER	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
2FWOPMOV10AB-H--	4.20E-02	1.063	HEP: OPERATOR FAILS TO CLOSE THE TDRFP DISCHARGE MOVS 2FW010A & B	Addressed in the Level 1 Importance Review for the equivalent marker event that is used when it is included in JHEPs (2FWRXMOV10AB-H--).
DI1-NOT	5.00E-01	1.061	DW INTACT (CLASS II OR WHEN RX = S)	This event represents the probability that the drywell does not fail given that the core melt was arrested in-vessel. In over 90% of the cases, the containment failure occurs in the wetwell air space due to overpressurization. Around 65% of the contributors are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). In about 35% of the cases, SAMA 1 will provide a means of venting even when support systems have failed.
RCVSEQ-GTR-023	1.00E+00	1.056	ACCIDENT SEQUENCE GTR-023 MARKER	Addressed in the Level 1 Importance Review.
WW1-NOT	8.60E-01	1.055	WW FAILURE ABOVE WATER LINE (CLASS II OR RX = S)	This event represents the probability that the wetwell failure occurs above the waterline given that the core melt was arrested in-vessel. About 65% of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). For the cases where vent failure occurs due to support system failures, the reliable hard pipe vent will provide a means of venting (SAMA 1).

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Event Name	Probability	RRW	Description	Potential SAMAs
2ADRXINHIBIT-H--	1.00E+00	1.053	HEP(REC): OPERATOR FAILS TO INHIBIT ADS IN ATWS (NO HP INJECTION)	This event is an operator action marker that is used in cutsets where the associated HFE (inhibit ADS in ATWS) is combined with other HFEs. The significance of this action would be reduced if the ATWS response actions were automated (SAMA 21). Additionally, these are all ATWS cases in which the containment vent is not capable of preventing overpressurization failure. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17). In many of these post core damage ATWS scenarios, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2SLOP-LVLCTRLH--	2.70E-01	1.049	HEP: OPERATOR FAILS TO LOWER LEVEL EARLY (ATWS)	Addressed in the Level 1 Importance Review.
%TIA	9.92E-03	1.048	LOSS OF INSTRUMENT AIR INITIATING EVENT	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
2SLOP-LATELVLH--	1.20E-01	1.047	HEP: OPERATOR FAILS TO CONTROL LEVEL LATE IN ATWS (COND PROB)	The limited time available for response is dominant PSF controlling the relatively large level control HEP. The installation of an automatic ATWS level control system that reduces level to just above -129 inches, inhibits ADS, and performs the "terminate and prevent" step (to disallow other non-feedwater RPV injection) could improve the reliability of the level reduction action and provide additional time for the operators to perform other required actions (SAMA 21). Failure to arrest core melt in-vessel is also a Level 2 contributor. In many of these post core damage ATWS scenarios, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
%TF	5.65E-02	1.047	LOSS OF FEEDWATER INITIATING EVENT	Addressed in the Level 1 Importance Review.
2ADRXOVERFL-LH--	1.00E+00	1.046	HEP(REC): OPERATOR FAILS TO PREVENT RPV OVERFILL (DEPRESS/FW/LATE LEVEL CONTROL)	Addressed in the Level 1 Importance Review.
%TM	5.01E-02	1.044	MSIV CLOSURE INITIATING EVENT	Addressed in the Level 1 Importance Review.
%DLOOP	7.95E-03	1.041	DUAL UNIT LOSS OF OFF-SITE POWER INITIATING EVENT	Addressed in the Level 1 Importance Review.
2RHRXDHRRECLTH--	4.40E-01	1.04	FAIL TO RECOVERY DECAY HEAT REMOVAL LONG TERM	Addressed in the Level 1 Importance Review.
2RX-SL-MS3-23H--	1.50E-02	1.039	2SLOP-IN-ERLYH-- 2MSOPMSIVINLKH-- 2SLOP-LATELVLH--	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
2RX-AD-FWMS-3H--	3.70E-03	1.036	2ADOPINHIBIT-H-- 2FWOPMOV10AB-H-- 2MSOPMSIVINLKH--	This joint HEP represents failure to bypass the MSIV low level isolation logic, inhibit ADS, and close the turbine driven feedwater pump discharge valves after shutdown. The high failure probability associated with the action to bypass the MSIV low level isolation logic is due to the short response time available and the relatively long time required to perform the action. Installing a keylock MSIV low level isolation bypass switch would reduce the time required for this action and improve the reliability of the action. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further (SAMA 4). The frequency of these contributors could be reduced by changing the logic to auto close the TDRFP discharge valves when the pumps are tripped or are not running (SAMA 10).
2MSOPMSIVINLKHSU	3.00E-01	1.036	HEP: OP SUCCESSFULLY BYPASSES MSIV LOW LEVEL INTERLOCK	Addressed in the Level 1 Importance Review.
2SPPHSUPPBYPSF--	1.00E+00	1.034	SUPPRESSION POOL BYPASSED	The event represents cases in which the release bypasses the suppression pool. This can be due to events such as drywell failure and downcomer failure. For about 45% of the cases, the drywell failures are from ATWS related overpressurization. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17). The remaining cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3).
2CN-LEAK-WWAF--	1.17E-01	1.033	WW AIRSPACE LEAK	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
2FWAV2FW005--M--	1.34E-02	1.033	FW MDRFP 2FW01PC FEED REG AOV 2FW005 MUA	This event represents the maintenance unavailability of the motor driven feedwater pump regulating valve. This unavailability mostly impacts ATWS cases where it is used to control level. Subsequent level control failure and overfill lead to core damage and containment failure occurs due to overpressure. Automating level control and the "terminate and prevent" action is a potential means of addressing the risk associated with this event (SAMA 21). Providing an ATWS sized hard pipe vent would also mitigate these events by preventing containment failure (SAMA 17).
2ADRX-INHIBITH--	1.00E+00	1.032	HEP(REC): OPERATORS INHIBIT ADS FOR NON-ATWS ACCIDENT SCENARIO	Addressed in the Level 1 Importance Review.
2ADRX-TRANS--H--	1.00E+00	1.032	HEP(REC): OPERATOR FAILS TO MANUALLY DEPRESSURIZE THE RPV (TRANSIENT)	Addressed in the Level 1 Importance Review.
2CN--RUPT-WWAF--	1.11E-01	1.031	WW AIR SPACE RUPTURE	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
RCVSEQ-ATW1-028	1.00E+00	1.031	ACCIDENT SEQUENCE ATW1-028 MARKER	This event is a sequence marker representing ATWS scenarios in which SBLC injection/level control fails and the condenser fails. Makeup to the RPV and containment has also failed to prevent vessel melt-through and drywell failure. These are all ATWS cases in which the containment vent is not capable of preventing overpressurization failure and the equipment in the reactor building fails when the containment fails. Subsequent operator errors and limited alternate injection capabilities fail to prevent RPV meltthrough. Providing an ATWS sized hard pipe vent would mitigate these events by preventing containment failure and the subsequent loss of injection systems (SAMA 17). In many of these post core damage ATWS scenarios, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).

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Event Name	Probability	RRW	Description	Potential SAMAs
2GVPHCMBSTGASF--	1.00E+00	24.673	COMBUSTIBLE GAS VENTING FAILS	Over 95% of the contributors including this event are Class II scenarios. Currently, containment venting for combustible gas control is assumed to fail during Class II sequences due to system dependencies (i.e., instrument air). Even though combustible gas venting fails, the containment failure mode is overpressurization rather than hydrogen detonation/deflagration. Implementation of the reliable containment hard pipe vent will provide a viable vent pathway and mitigate many of these scenarios, particularly those in which venting is failed due to support system failure. The contribution related to the failure of the operators to vent (approximately 40%) would require automated SPC initiation to avoid overpressurization (SAMA 2) or a passive containment vent (SAMA 3).
1RBPH-RB-----F--	1.00E+00	16.735	SOURCE TERM IS NOT REDUCED BY REACTOR ENCLOSURE	The event represents the probability that the magnitude of the radioactive release will be reduced due to its passage through the RB. Considerations include gravitational settling of radionuclides, SBGT scrubbing, and scrubbing of release through a water pool. No credit is currently taken for this source term reduction mechanism. There is a potential that additional analysis could justify some type of reduction for releases through the RB, but 99% of the scenarios including this event are Class II overpressurization scenarios. Implementation of the reliable containment hard pipe vent will provide a viable vent pathway and mitigate many of these scenarios, particularly those in which venting is failed due to support system failure or failure to control pressure during venting. The contribution related to the failure of the operators to vent (approximately 40%) would require automated SPC initiation to avoid overpressurization (SAMA 2) or a passive containment vent (SAMA 3).
RCVCL-2	1.00E+00	14.268	ACCIDENT CLASS II MARKER	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
GEN-EMERG-S	9.50E-01	14.251	GENERAL EMERGENCY DECLARED	The event represents the probability that a general emergency will be declared in time to provide adequate evacuation time for the public. In these cases, it has failed and the result in an "early" release. This probability is not driven by any plant specific characteristics and no insights are available to that would allow specific changes to plant procedures or training to improve the reliability of the action. About 40% of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). Other contributors include support systems failures for which the reliable containment hard pipe vent would be an effective means of preventing containment failure (SAMA 1).
2NCPHNC3-----F--	1.00E+00	6.973	LARGE CONTAINMENT FAILURE CLASS IIA OR IIL	These are typical Class II scenarios that lead to containment failure due to overpressurization. Currently, containment venting for combustible gas control is assumed to fail during Class II sequences due to system dependencies (i.e., instrument air). Even though combustible gas venting fails, the containment failure mode is overpressurization rather than hydrogen detonation/deflagration. Implementation of the reliable containment hard pipe vent will provide a viable vent pathway and mitigate many of these scenarios, particularly those in which venting is failed due to support system failure. The contribution related to the failure of the operators to vent (approximately 40%) would require automated SPC initiation to avoid overpressurization (SAMA 2) or a passive containment vent (SAMA 3).
TD6	1.00E+00	3.984	WATER INJECTION TO CONT. UNAVAIL. (CLASS II AND OP=S)	The TD6 description indicates that it is used to represent the failure to provide injection to the containment in class II events. The TD6 failure probability is set to 1.0 because all injection systems were previously asked in the tree and were determined to be failed, which may be caused by harsh reactor building environment from containment failure or by injection line disruption on containment failure (although,

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Event Name	Probability	RRW	Description	Potential SAMAs
				energetic containment failures are not large contributors for this case). The reliable containment hard pipe vent would provide a viable vent path for many of these cases. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
1RXPH-EQPRX2-F--	1.00E+00	3.051	INDUCED FAILURE OF EQUIPMENT IN RX. BLDG. (LARGE WW FAILURE)	This event represents the probability that required equipment located in the reactor building fails after a large wetwell failure. These are all Class II cases in which the containment vent has failed due to operator error or support system failures. Implementation of the reliable containment hard pipe vent will provide a viable vent pathway and mitigate many of these scenarios, particularly those in which venting is failed due to support system failure. The contribution related to the failure of the operators to vent (approximately 35%) would require automated SPC initiation to avoid overpressurization (SAMA 2) or a passive containment vent (SAMA 3). Other cases would be addressed by the reliable hard pipe containment vent (SAMA 1). Injection from sources outside of the reactor building could also mitigate these scenarios. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2HDOP-HD-VENTH--	9.00E-01	2.772	VENTING CREATES ADVERSE ENV. CONDITIONS FOR ALIGNMENT OF HD	Addressed in the Level 1 Importance Review.

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Event Name	Probability	RRW	Description	Potential SAMAs
1RXPH-FIRESYSF--	1.00E+00	2.478	FIRE SYSTEM UNAVAILABLE	This event represents the probability that the fire protection system would not be available to provide makeup to prevent RPV meltthrough. The disqualifying factor for fire protection is the requirement to provide 1000 gpm. In a majority of these Class II scenarios, however, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2SY--RB-CT---F--	1.00E+00	2.325	COND. PROB. OF ECCS FAILURE DUE TO ENV. IN REACTOR BUILDING	Addressed in the Level 1 Importance Review.
2RHRXDHRRECLTH--	4.40E-01	1.927	FAIL TO RECOVERY DECAY HEAT REMOVAL LONG TERM	Addressed in the Level 1 Importance Review.
DI1	5.00E-01	1.792	DW NOT INTACT (CLASS II OR WHEN RX = S)	This event represents the probability that the wetwell failure occurs above the waterline given that the core melt was arrested in-vessel. About 40% of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). For the cases where vent failure occurs due to support system failures, the reliable hard pipe vent will provide a means of venting (SAMA 1). In a majority of these Class II scenarios, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).

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Event Name	Probability	RRW	Description	Potential SAMAs
DI1-NOT	5.00E-01	1.729	DW INTACT (CLASS II OR WHEN RX = S)	This event represents the probability that the drywell does not fail given that the core melt was arrested in-vessel. In about 90% of the cases, the containment failure occurs in the wetwell air space due to overpressurization. About half of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). The other half are related to support system failures that could be mitigated by the reliable hard pipe vent (SAMA 1), which does not require support systems to operate.
2RHRXSPCINIT-H--	1.00E+00	1.639	HEP(REC): OPERATOR FAILS TO INITIATE SUPPRESSION POOL COOLING (NON-ATWS)	Addressed in the Level 1 Importance Review.
2RHRXSPCLATE-H--	1.00E+00	1.627	HEP(REC): OPERATOR FAILS TO INITIATE SPC LATE GIVEN EARLY FAILURE (COND PROB)	Addressed in the Level 1 Importance Review.
RCVSEQ-GTR-023	1.00E+00	1.604	ACCIDENT SEQUENCE GTR-023 MARKER	Addressed in the Level 1 Importance Review.
WW1-NOT	8.60E-01	1.598	WW FAILURE ABOVE WATER LINE (CLASS II OR RX = S)	This event represents the probability that the wetwell failure occurs above the waterline given that the core melt was arrested in-vessel. About 40% of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). For the cases where vent failure occurs due to support system failures, the reliable hard pipe vent will provide a means of venting (SAMA 1).
2CVRXVENT----H--	1.00E+00	1.537	HEP(REC): OPERATOR FAILS TO INITIATE PRIMARY CONTAINMENT VENTING	Addressed in the Level 1 Importance Review.
2FWRXMOV10AB-H--	1.00E+00	1.382	HEP(REC): OPERATOR FAILS TO CLOSE THE TDRFP DISCHARGE MOVS 2FW010A & B	Addressed in the Level 1 Importance Review.

Table F.5-2c
LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
BFPOP-DFPENV1H--	5.00E-01	1.308	HEP: OP FAILS TO ALIGN DFP DUE TO ADVERSE ENV IN TB (VENT TO STEAM TUNNEL)	Addressed in the Level 1 Importance Review.
2CN--RUPT-DWBF--	8.58E-02	1.289	DW BODY RUPTURE	Addressed in the Level 1 Importance Review.
%TIA	9.92E-03	1.287	LOSS OF INSTRUMENT AIR INITIATING EVENT	Addressed in the Level 1 Importance Review.
%DLOOP	7.95E-03	1.275	DUAL UNIT LOSS OF OFF-SITE POWER INITIATING EVENT	Addressed in the Level 1 Importance Review.
2CN-LEAK-WWAF--	1.17E-01	1.271	WW AIRSPACE LEAK	Addressed in the Level 1 Importance Review.
2IARXRCOVERIAH--	1.00E-01	1.268	HEP: OP FAILS TO RESTORE IA / SA FOR VENTING (NON LOOP OR DLOOP)	Addressed in the Level 1 Importance Review.
2CN--RUPT-WWAF--	1.11E-01	1.254	WW AIR SPACE RUPTURE	Addressed in the Level 1 Importance Review.
DGRECOV-7HR	1.00E+00	1.218	DIESEL GENERATOR RECOVERY WITHIN 7 HOURS	Addressed in the Level 1 Importance Review.
DLOOP-IE-SW	3.84E-01	1.216	COND. PROBABILITY DLOOP DUE TO SEVERE WEATHER EVENT	Addressed in the Level 1 Importance Review.
RCVSEQ-DLOP-014	1.00E+00	1.19	ACCIDENT SEQUENCE DLOP-014 MARKER	Addressed in the Level 1 Importance Review.
%TC	1.33E-01	1.181	LOSS OF CONDENSER VACUUM INITIATING EVENT	Addressed in the Level 1 Importance Review.
2ADRX-INHIBITH--	1.00E+00	1.176	HEP(REC): OPERATORS INHIBIT ADS FOR NON-ATWS ACCIDENT SCENARIO	Addressed in the Level 1 Importance Review.
2ADRX-TRANS--H--	1.00E+00	1.175	HEP(REC): OPERATOR FAILS TO MANUALLY DEPRESSURIZE THE RPV (TRANSIENT)	Addressed in the Level 1 Importance Review.
OSPR20HR-SW	1.33E-01	1.172	FAILURE TO RECOVER OSP WITHIN 20 HOURS (SEVERE WEATHER LOOP EVENT)	Addressed in the Level 1 Importance Review.

Table F.5-2c
LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
RX10-II-NOT	2.00E-01	1.169	CORE MELT ARRESTED IN-VESSEL (CLASS II, OP=S)	This event represents the probability that injection is aligned in time to prevent the core from melting through the RPV. These are all Class II scenarios in which containment overpressurization has led to a large containment failure. About 40% of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). For the cases where vent failure occurs due to support system failures, the reliable hard pipe vent will provide a means of venting (SAMA 1). Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2SPPHSUPPBYPSF--	1.00E+00	1.168	SUPPRESSION POOL BYPASSED	The event represents cases in which the release bypasses the suppression pool. This can be due to events such as drywell failure and downcomer failure. In these cases, bypass is conservatively assumed even though the Drywell is intact in about 50% of the contributors and combustible gas venting has failed. The scenarios are all Class II evolutions in which failure of heat removal leads to containment failure. About 40% of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). For the cases where vent failure occurs due to support system failures, the reliable hard pipe vent will provide a means of venting (SAMA 1).
2CN--LEAK-DWBF--	7.46E-02	1.15	DW BODY LEAK	Addressed in the Level 1 Importance Review.
RCVSEQ-GTR-028	1.00E+00	1.127	ACCIDENT SEQUENCE GTR-028 MARKER	Addressed in the Level 1 Importance Review.

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LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
2RX-FWADRHCV6H--	5.00E-07	1.12	2FWOPMOV10AB-H-- 2ADOP-INHIBITH-- 2ADOP-TRANS--H-- 2RHOPSPCINIT-H-- 2CVOPVEN	Addressed in the Level 1 Importance Review.
2FPRXALGNFPSAH--	1.00E+00	1.098	HEP(REC): OPERATOR FAILS TO ALIGN FPS FOLLOWING CONTAINMENT VENT OR FAILURE	Addressed in the Level 1 Importance Review.
BFPRX-DFPENV-H--	1.00E+00	1.097	HEP(REC): OP FAILS TO ALIGN DFP DUE TO ADVERSE ENV IN TB (VENT TO RB OR CNTNMT F	Addressed in the Level 1 Importance Review.
2RXOP-TERMINJH--	1.00E-01	1.088	OPERATOR INTERVENES AND TERMINATES INJECTION	This is an "error of commission" event representing the probability that the operators will erroneously terminate RPV makeup when RPV makeup is still required to prevent RPV melt-through. Since the time of the Three Mile Island accident, procedures and training have improved significantly, but injection termination has been included in the model because it is a high profile evolution. No accepted HRA methodology has been established to quantify the probability of errors of commission and there are no clear, quantifiable benefits that could be calculated from further improving procedures and training. Instead, steps to mitigate other portions of the accident sequence are suggested. Class II events contribute to over 90% of the risk for these scenarios and could be mitigated by same SAMAs identified on the Level 1 list (e.g., 1, 2, and 3).
2RXOP-ALTINJ-H--	1.00E-01	1.084	OPERATOR FAILS TO ALIGN INJECTION TO THE REACTOR VESSEL PRIOR TO VESSEL MELTING	This event represents the probability that alternate injection would not be aligned in time to provide makeup to prevent RPV meltthrough. The condensate system is technically considered, but the HRA conservatively uses the complex alignment of fire water injection as the execution basis for the action. In many of these post core damage ATWS scenarios, RPV depressurization is available. Installation of a cross-connect between RHRSW and LPCS that would

Table F.5-2c
LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
				provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2NCPHNCF-----F--	1.00E+00	1.079	LARGE CONTAINMENT FAILURE CLASS IIV, IIID, OR IV	This is a marker event for large containment failure scenarios. Over 70% of these cases are those in which containment venting is successful and the failure of the vent pathway leads to harsh reactor building conditions and subsequent failure of the injection systems in the area. The reliable hard pipe containment vent will prevent these failures (SAMA 1).
DI3-NOT	1.00E+00	1.079	DW INTACT (CLASS IIV)	This is a marker event for cases in which the drywell remains intact. Over 70% of these cases are those in which containment venting is successful and the failure of the vent pathway leads to harsh reactor building conditions and subsequent failure of the injection systems in the area. The reliable hard pipe containment vent will prevent these failures (SAMA 1).
WW3-NOT	1.00E+00	1.079	WW FAILURE ABOVE WATER LINE (CLASS IIV)	This is a marker event for cases in which the wetwell fails in the air space (above the waterline). Over 70% of these cases are those in which containment venting is successful and the failure of the vent pathway leads to harsh reactor building conditions and subsequent failure of the injection systems in the area. The reliable hard pipe containment vent will prevent these failures (SAMA 1).
%TM	5.01E-02	1.076	MSIV CLOSURE INITIATING EVENT	Addressed in the Level 1 Importance Review.
2RX-FWRHCVF15H--	5.00E-07	1.074	2FWOPMOV10AB-H-- 2RHOPSPCINIT-H-- 2CVOPVENT----H-- 2RHOPSPCLATE-H--	Addressed in the Level 1 Importance Review.

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LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
			2FPOPALG	
2RX-FWRHCVF35H--	5.00E-07	1.074	2FWOPMOV10AB-H-- 2RHOPSPCINIT-H-- 2CVOPVENT----H-- 2RHOPSPCLATE-H-- BFPOP-DF	Addressed in the Level 1 Importance Review.
RCVSEQ-GTR-013	1.00E+00	1.069	ACCIDENT SEQUENCE GTR-013 MARKER	Addressed in the Level 1 Importance Review.
%TF	5.65E-02	1.066	LOSS OF FEEDWATER INITIATING EVENT	Addressed in the Level 1 Importance Review.
2OPAD-ALTRNT-F--	1.00E+00	1.065	ALTERNATE DEPRESS. METHODS NOT CREDITED	This event represents the failure of depressurization of the RPV through the RCIC steam lines or through the MSIVs. The RCIC steam lines are not credited because the capacity is not large enough and the MSIVs are not credited due to the time required to re-open them. The main contributors leading to the failure of normal depressurization methods are the operator errors of improperly inhibiting ADS and failing to manually depressurize the RCS, SBO scenarios that deplete DC power, and DC bus failures. The depressurization function could be restored in DC power failure scenarios by providing a portable DC source that could directly power panel 1(2)11Y (SAMA 14). No specific improvements have been identified that could significantly reduce the probability of improperly inhibiting ADS in non-ATWS scenarios.
2OPPH-PRESBK-F--	8.00E-01	1.065	PRESSURE TRANSIENT DOES NOT FAIL MECHANICAL SYSTEMS	This is a marker event for scenarios in which pressure transients do not fail the RCS pressure boundary (RPV not depressurized from mechanical failures after a pressure transient). The events are tied to the scenarios that include the event 2OPAD-ALTRNT-F--, which could be mitigated by providing a portable DC source that could directly power panel 1(2)11Y (SAMA 14).

Table F.5-2c
LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
2OPPH-SORV---F--	5.50E-01	1.065	SRVs DO NOT FAIL OPEN DURING CORE MELT PROGRESSION	This is a marker event for scenarios in which the consequences of core melt do not fail the SRVs open (RPV not depressurized from a stuck open SRV after core melt). The events are tied to the scenarios that include the event 2OPAD-ALTRNT-F--, which could be mitigated by providing a portable DC source that could directly power panel 1(2)11Y (SAMA 14).
2OPPH-TEMPBK-F--	7.00E-01	1.065	HIGH PRIM SYS TEMP DOES NOT CAUSE FAIL OF RCS PRESS. BOUND	This is a marker event for scenarios in which the high temperatures of core melt do not fail the RCS pressure boundary (RPV not depressurized from failed recirc pump seals, for example). The events are tied to the scenarios that include the event 2OPAD-ALTRNT-F--, which could be mitigated by providing a portable DC source that could directly power panel 1(2)11Y (SAMA 14).
2ACRX-AC-CBS-H--	1.00E+00	1.057	HEP(REC): OPERATOR FAILS TO CLOSE BREAKER TO 4KV BUS AFTER OFFSITE AC POWER RECO	Addressed in the Level 1 Importance Review.
2DGFN-VY06C--X--	3.29E-03	1.057	UNIT 2 DIV 2 CSCS ROOM COOLER FAN 2VY06C FAILS TO RUN	Addressed in the Level 1 Importance Review.
2VYFNSEVY03CBX--	3.29E-03	1.056	VY SE CORNER ROOM (RHR B & C) COOLING FAN 2VY03C FAILS TO RUN	Addressed in the Level 1 Importance Review.
%MS	1.01E+00	1.053	MANUAL SHUTDOWN INITIATING EVENT	Addressed in the Level 1 Importance Review.
WW1	1.40E-01	1.05	WW FAILURE BELOW WATER LINE (CLASS II OR RX = S)	This event represents the probability that the wetwell failure occurs above the waterline given that the core melt was arrested in-vessel. About 50% of these cases are related to the failure to initiate SPC and to vent containment, which could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3). For the cases where vent failure occurs due to support system failures, the reliable hard pipe vent will provide a means of venting (SAMA 1).

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LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
%TT	7.98E-01	1.049	TURBINE TRIP WITH BYPASS INITIATING EVENT	Addressed in the Level 1 Importance Review.
RCVCL-IBL	1.00E+00	1.042	ACCIDENT CLASS IBL MARKER	Addressed in the Level 1 Importance Review.
2DGPMCSDG2A--M--	3.10E-03	1.041	DG2A COOLING WATER PUMP 2DG01P TRAIN MUA	Addressed in the Level 1 Importance Review.
2CVOPVENT----H--	6.60E-03	1.038	HEP: OPERATOR FAILS TO INITIATE PRIMARY CONTAINMENT VENTING	Addressed in the Level 1 Importance Review.
RX9	1.00E+00	1.038	FAILURE TO ARREST CORE MELT IN-VESSEL (CLASS II, OP=F)	This event represents the probability that RPV meltthrough is prevented in cases where RPV depressurization has failed (all Class II scenarios). The main contributors leading to the failure of normal depressurization methods are the operator errors of improperly inhibiting ADS and failing to manually depressurize the RCS (about 80% of the contribution). No specific improvements have been identified that could significantly reduce the probability of improperly inhibiting ADS in non-ATWS scenarios and in most cases, the probability of the JHEPs including this actions are already set to the lowest allowable value for a JHEP (further improvements in human reliability would not be credited). These scenarios could be mitigated by automating SPC initiation (SAMA 2) or by including a passive vent in the hard pipe vent design (SAMA 3).

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LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
TD5	1.00E+00	1.038	WATER INJECTION TO CONT. UNAVAIL. (CLASS II AND OP=F, OR IIID,IV)	The TD5 description indicates that it is used to represent the failure to provide injection to the containment in class II, IIID, or IV events. The TD5 failure probability is set to 1.0 because all injection systems were previously asked in the tree and were determined to be failed, which may be caused by harsh reactor building environment from containment failure or by injection line disruption on containment failure (although, energetic containment failures are not large contributors for this case). The contributors including the TD5 event are essentially the same as those for RX9, but after vessel meltthrough, low pressure systems could be used for injection due to reduced RCS pressure. Installation of a cross-connect between RHRSW and LPCS that would provide a high flow, low pressure makeup system that is not currently available (SAMA 15). Alternatively, the Fuel Pool Emergency Makeup System could be modified to include a higher pressure/higher capacity pump and a permanent connection to the RHR "B" line could be installed with manual isolation valves (SAMA 23).
2RHPME12C002BM--	2.97E-03	1.034	RH TRAIN 2B (2E12-C002B) MUA	Addressed in the Level 1 Importance Review.
RCVSEQ-DLOP-021	1.00E+00	1.034	ACCIDENT SEQUENCE DLOP-021 MARKER	This event is an accident sequence marker for dual unit LOOP events with initial success of the HPCS system and no heat removal. Venting failure results in a harsh reactor building environment, which subsequently fails HPCS. In these cases, venting is failed by support system failures, which would be mitigated by the reliable hard pipe vent (SAMA 1) given that it does not rely on support systems for operation.
BFPOP-DFPENV-H--	1.00E-01	1.033	HEP: OP FAILS TO ALIGN DFP DUE TO ADVERSE ENV IN TB (VENT TO RB OR CNTNMT FAIL)	Addressed in the Level 1 Importance Review.
1DGFN-VY05C--X--	3.29E-03	1.033	UNIT 1 DIV 1 CSCS ROOM COOLER FAN 1VY05C FAIL TO	Addressed in the Level 1 Importance Review.

Table F.5-2c
LSCS "MI" Importance List Review

Event Name	Probability	RRW	Description	Potential SAMAs
			RUN	
OP5-NOT	7.05E-01	1.033	SUCCESSFULLY DEPRESSURIZE RPV (CLASS IBL)	This event represents the probability that the RPV is depressurized in long term SBOs. The OP5 gate includes, among other things, the probabilities that induced LOCAs do not occur. For the NOT version of the OP5 contributor, one or more of these events has likely occurred to depressurize the RPV. SBO events, in general, were addressed in the Level 1 importance review.
2FWRXTDRFPS--H--	1.00E+00	1.031	HEP(REC): OPERATOR FAILS TO MANUALLY RESET LEVEL 8 TRIP OR RESTART FW	Addressed in the Level 1 Importance Review.
2VYFNNWVY01--X--	3.29E-03	1.031	VY NW CORNER ROOM (RHR A) COOLING FAN 2VY01C FAILS TO RUN	Addressed in the Level 1 Importance Review.
2DGFN-VY05C--X--	3.29E-03	1.031	UNIT 2 DIV 1 CSCS ROOM COOLER FAN 2VY05C FAIL TO RUN	Addressed in the Level 1 Importance Review.
2CD--2CD01AMS---	3.00E-02	1.03	COND PROBY MAN SHTDWN REQD FOR MAIN CONDENSER 2CD01A MAINT	Addressed in the Level 1 Importance Review.
2CVSYVNT-ATWSF--	1.00E+00	1.03	CONTAINMENT VENT CONSERVATIVELY NOT CREDITED FOR ATWS	Addressed in the Level 1 Importance Review.
2SY--VENT1---FCC	9.99E-03	1.03	CCF OF HPCS & CRD & LPCI & LPCS GIVEN VENT TO STEAM TUNNEL	Addressed in the Level 1 Importance Review.
2RPCDRPS-MECHFCC	2.10E-06	1.03	RPS MECHANICAL FAILURE	Addressed in the Level 1 Importance Review.

Table F.5-3a
Approximated RMIEP Seismic CDF Results

Accident Sequence	Earthquake Level (g PGA) Level 1 (0.18-0.27)	Level 2 (0.27-0.36)	Level 3 (0.36-0.46)	Level 4 (0.46-0.58)	Level 5 (0.58-0.73)	Level 6 (>0.73)	Accident Sequence Total (per year)
Large-LOCA-1	1.9E-11	8.4E-12	5.0E-12	3.0E-12	1.8E-12	1.1E-12	3.8E-11
Large-LOCA-2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Large-LOCA-3	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Medium-LOCA-1	7.2E-10	3.2E-10	1.9E-10	1.1E-10	6.9E-11	4.2E-11	1.4E-09
Medium-LOCA-2	7.9E-10	2.3E-10	9.4E-11	4.4E-11	2.1E-11	1.2E-11	1.2E-09
Medium-LOCA-3	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Medium-LOCA-4	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Small-LOCA-1	4.7E-09	1.9E-09	9.8E-10	4.7E-10	2.3E-10	8.8E-11	8.4E-09
Small-LOCA-2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Small-LOCA-3	1.5E-08	7.0E-09	4.1E-09	2.4E-09	1.5E-09	9.3E-10	3.1E-08
Small-LOCA-4	1.8E-08	4.9E-09	2.1E-09	9.9E-10	4.8E-10	2.5E-10	2.6E-08
Small-LOCA-5	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Small-LOCA-6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LOSP-Trans-1	3.9E-08	1.6E-08	8.0E-09	4.0E-09	1.8E-09	7.2E-10	6.9E-08
LOSP-Trans-2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LOSP-Trans-3	1.3E-07	5.8E-08	3.3E-08	2.0E-08	1.2E-08	7.5E-09	2.6E-07
LOSP-Trans-4	1.4E-07	4.1E-08	1.7E-08	8.0E-09	4.0E-09	2.1E-09	2.1E-07
LOSP-Trans-5	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LOSP-Trans-6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LOSP-Trans-7	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Interval Total (per year)	3.5E-07	1.3E-07	6.5E-08	3.6E-08	2.0E-08	1.2E-08	Grand Total 6.1E-07

Table F.5-3b
RMIEP Seismic CDF Results Updated with the LSCS 2013 Seismic Hazard Curve

Accident Sequence	Earthquake Level (g PGA) Level 1 (0.18-0.27)	Level 2 (0.27-0.36)	Level 3 (0.36-0.46)	Level 4 (0.46-0.58)	Level 5 (0.58-0.73)	Level 6 (>0.73)	Accident Sequence Total (per year)
Large-LOCA-1	1.4E-11	8.8E-12	7.0E-12	5.3E-12	4.0E-12	5.1E-12	4.4E-11
Large-LOCA-2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Large-LOCA-3	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Medium-LOCA-1	5.4E-10	3.3E-10	2.6E-10	2.0E-10	1.5E-10	1.9E-10	1.7E-09
Medium-LOCA-2	6.0E-10	2.4E-10	1.3E-10	7.9E-11	4.6E-11	5.6E-11	1.1E-09
Medium-LOCA-3	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Medium-LOCA-4	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Small-LOCA-1	3.6E-09	2.0E-09	1.4E-09	8.5E-10	5.1E-10	4.1E-10	8.7E-09
Small-LOCA-2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Small-LOCA-3	1.2E-08	7.3E-09	5.7E-09	4.4E-09	3.3E-09	4.3E-09	3.7E-08
Small-LOCA-4	1.3E-08	5.2E-09	2.9E-09	1.8E-09	1.1E-09	1.2E-09	2.5E-08
Small-LOCA-5	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Small-LOCA-6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LOSP-Trans-1	2.9E-08	1.6E-08	1.1E-08	7.2E-09	4.0E-09	3.3E-09	7.1E-08
LOSP-Trans-2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LOSP-Trans-3	1.0E-07	6.1E-08	4.7E-08	3.6E-08	2.7E-08	3.5E-08	3.0E-07
LOSP-Trans-4	1.1E-07	4.2E-08	2.3E-08	1.4E-08	8.8E-09	9.7E-09	2.1E-07
LOSP-Trans-5	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LOSP-Trans-6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LOSP-Trans-7	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Interval Total (per year)	2.7E-07	1.3E-07	9.2E-08	6.4E-08	4.5E-08	5.4E-08	Grand Total 6.6E-07

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
1	Install Reliable Hard Pipe Containment Vent	This is already a commitment for LSCS, but it has not yet been installed and is not modeled in the PRA. This SAMA, which will prevent vent path failure within the reactor building and will provide a means of safely operating the containment vent when normal support systems are unavailable (non-adverse environment for use of portable pneumatic supply or manual valve operation). This SAMA is used to track this enhancement in the analysis and to facilitate the interpretation of the results.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $12.94 million (S&L 2014). This LSCS estimate does not include contingency costs.	Implementation is planned. Evaluated in the Phase II analysis to document the impact of implementation.
2	Automate Suppression Pool Cooling Initiation	Suppression pool cooling initiation is a reliable action, but for non-LOCA events, automating SPC initiation on high suppression pool temperature could further improve the reliability of the containment heat removal function.	LSCS Level 1 and 2 Importance Review	$400,000 (TVA, 2003)	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
3	Passive Vent Path	For loss of containment heat removal scenarios, the reliability of the containment venting function could be improved by installing a passive vent path. If the suppression chamber vent path were equipped with a rupture disk in parallel with the remotely operated vent path, a scrubbed release path would be available to prevent containment failure in the event that normal venting fails. The rupture disk failure pressure would have to be less than the ultimate containment strength to ensure it would rupture before the containment, but consideration could also be given to a lower pressure to ensure SRVs could remain operable to support low pressure injection in loss of containment heat removal cases. Effectiveness is contingent on the implementation of the hard pipe vent.	LSCS Level 1 and 2 Importance Review	The cost of a passive vent was estimated to cost $1,000,000 at Oyster Creek (AmerGen 2005).	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
4	Install a Keylock MSIV Low Level Isolation Bypass Switch	Operator errors are some of the largest contributors to ATWS scenarios, which are complicated by the short times available for response. One of the more time limited actions in these scenarios is the action to bypass the MSIV low level isolation signal, which is currently an action that requires the installation of jumpers. Providing a switch in the MCR that would bypass the isolation logic would simplify the bypass action and provide more time margin for the power/level control actions for these scenarios. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $635,242 (S&L 2014).	Implementation cost is less than MACR. Retain for Phase II analysis.
5	Automate SBLC Initiation	ATWS events rely on timely initiation of the SBLC system for mitigation. A potential means of improving the reliability of this function would be to automate system initiation, as is that case at Limerick Generation Station.	LSCS Level 1 and 2 Importance Review	The cost of automating SBLC operation at Browns Ferry was estimated to be $400,000 (TVA, 2003)	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
6	Create ECCS Suction Strainer Backflush Capability with RHRSW	For some LOCA contributors, common cause plugging of the ECCS suction strainers fails makeup/heat removal. Connecting the RHRSW system to the RHR pump suction line upstream of the F004A/B valves could provide a means of backflushing the system in conjunction with steps to close the F004A/B valves during the backflush.	LSCS Level 1 and 2 Importance Review	$2,900,000 (NMC 2005) Note: Palisades developed this cost for installing a fire water to SW x-tie, operable from MCR. Because this SAMA must mitigate LOCAs, rapid alignment is required and control from the MCR is considered to be required.	Implementation cost is less than MACR. Retain for Phase II analysis.
7	Water Hammer Prevention	Alter the LOCA signal logic to require both high drywell pressure AND low water level for initiation. This will prevent LOCA signals in transient scenarios where high DW pressure alone can cause consequential LOOP events and drain the discharge line of an RHR train running in SPC mode (PRA specific scenario). This could also have the added benefit of simplifying the operators' response to loss of offsite power events where the LOOP signal has caused the EDGs to start and load and an ECCS signal is subsequently received due to loss of containment cooling (high drywell pressure). In this LOOP-delayed LOCA scenario, the operators are required to take many actions to handle the automatic actuations that occur due to the LOCA signal. This scenario is not specifically modeled in the PRA.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $962,403 (S&L 2014).	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
8	Obtain a 480V AC Portable Generator to Supply the 125V DC Battery Chargers and Proceduralize its Use	For long term SBO scenarios, the hardened containment vent that LSCS is committed to install will provide a means of containment heat removal, but the battery life is currently assumed to be limited to about 7 hours in the PRA model. After battery depletion, the SRVs will close and the RPV will re-pressurize and prevent injection with a low pressure system, such as the fire protection system. Use of a portable generator to provide power to the 125V DC battery chargers would provide a means of maintaining the SRVs open, energize critical instrumentation, and ensure RPV pressure remains low enough for use of low pressure alternate makeup systems.	LSCS Level 1 and 2 Importance Review	The cost of a portable 480V AC generation was estimated by Ginna to be $400,000 (RG&E 2002)	Implementation cost is less than MACR. Retain for Phase II analysis.
9	Develop Flood Zone Specific Procedures	The reliability of the internal flood mitigation actions could be improved by developing location and system specific flood response procedures. For example, for fire protection floods in the reactor building, developing procedures that direct the isolation of the FP070 and FP080 valves could significantly reduce the time required to terminate reactor building floods from the fire protection system. Increasing the time margin for the operators to respond to the floods would improve the likelihood of preventing damage to critical ECCS equipment.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $115,000 (S&L 2014).	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
10	Change the Logic to Close the Turbine Driven Feedwater Pump Discharge Valves When the Pumps are Not Running	In cases where the turbine driven FW pumps are tripped or are malfunctioning, it is currently necessary to manually isolate the pump discharge valves to prevent hotwell depletion and/or RPV overfill when RPV pressure is reduced. Failure to control the valves can make the hotwell unavailable as a suction source for other injection systems or flood the steam lines, which may lead to the unavailability of RCIC. Changing the system logic to automatically close the valves when the pumps trip or are not running would reduce the likelihood of uncontrolled injection (no RPV overfill from the Condensate/CB pumps when pressure is reduced).	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $260,219 (S&L 2014).	Implementation cost is less than MACR. Retain for Phase II analysis.
11	Provide the Capability to Trip the FPS Pumps from the MCR	The reliability of the internal flood mitigation actions could be improved by providing the capability to trip the fire protection system pumps from the MCR. Currently, is it is necessary to for an operator to travel to the Lake Screen House to locally trip the fire protection pumps to eliminate that system's flow. Increasing the time margin for the operators to respond to the floods would improve the likelihood of preventing damage to critical ECCS equipment. It is assumed that this change would be accompanied by a procedure update that would include directions to remotely isolate valves 0FP070 and 0FP080 for Service Water isolation to ensure that the	LSCS Level 1 and 2 Importance Review	The cost of installing pump trip controls for the fire protection pumps in the Byron control room was estimated to be $217,415 (Exelon 2014).	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
		time benefits associated with the MCR pump control switches are fully realized.			
12	Cross-tie the HPCS and FW Injection Lines for ATWS Mitigation	The use of HPCS is not allowed for ATWS due to reactivity issues, but installing a cross-tie between the HPCS and FW injection lines would provide another means of supplying high pressure injection to the RPV in ATWS scenarios.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $4,401,674 (S&L 2014)	Implementation cost is less than MACR. Retain for Phase II analysis.
13	Not Used.	NA	NA	NA	
14	Provide a Portable DC Source to Support RCIC and SRV Operation	For scenarios with 125V DC bus faults, providing a means for a portable generator with DC output to supply 125V ESF DC distribution panel 1(2)11Y would support RCIC operation and long term SRV operation with Fire Protection System injection.	LSCS Level 1 and 2 Importance Review	Brunswick estimated the cost of a generator with DC output to be $489,277 (CPL 2004).	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
15	Tie RHRSW to the LPCS System for ISLOCA Mitigation	ISLOCA events are dominated by isolation failures in which there are no long term RPV makeup sources. Providing a hard pipe connection with manual valves between the RHRSW system and the LPCS system would provide a source of makeup to the RPV for cases in which RPV depressurization is available.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $1,366,982 (S&L 2014).	Implementation cost is less than MACR. Retain for Phase II analysis.
16	Provide Portable Fans for Alternate Room Cooling in the Core Standby Cooling System Vaults	Pump cubicle cooling fan or damper failures can result in the failure of the pumps in the Core Standby Cooling System vaults after heat up. Providing portable fans (and potentially temporary ductwork) could prevent failure by providing a temporary, alternate source of cubicle cooling. Room heat up calculations would be required as part of this effort to demonstrate that the portable fans could provide adequate cooling.	LSCS Level 1 and 2 Importance Review	Salem estimated the cost of providing portable fans for alternate room cooling to be $475,000 (PSEG 2009). Note: Includes portable fans and ducts as well as procedures and training, but not room heat up analysis.	Implementation cost is less than MACR. Retain for Phase II analysis.
17	Install ATWS Sized Reliable Containment Hard Pipe Vent	Containment venting is not credited as a heat removal path for ATWS scenarios because it is likely to result in severe conditions in the reactor building due to duct failure. The reliable containment hard pipe vent would provide a viable vent path for non-ATWS scenarios, but it is not designed to remove ATWS heat loads. Increasing the capacity of the reliable containment hard pipe vent would provide an additional means of containment heat removal in ATWS scenarios.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $17,900,000 (S&L 2014).	Implementation cost is greater than the MACR. Screened from further analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
18	Improve the Connection Between the Fire Protection and Feedwater Systems	For SBO cases with failure of RCIC, aligning the Fire Protection System to the Feedwater system using fire hoses cannot prevent core damage, primarily due to a lengthy alignment time. This time could be reduced by providing a hard pipe connection between the two systems. If a permanent connection between the systems is undesirable, a short, flexible connecting hose could potentially be maintained out of the flowpath provided that rapid alignment could be demonstrated.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $649,194 (S&L 2014).	Implementation cost is less than MACR. Retain for Phase II analysis.
19	Provide Remote Alignment Capability of RHRSW to the LPCS System for LOCA Mitigation	For some LOCA scenarios, CCF plugging of the ECCS suction strainers can fail all ECCS injection. Providing the operators with the ability to cross-tie the RHRSW system to the LPCS system from the MCR would provide a source of makeup to the RPV for cases in which RPV depressurization is available.	LSCS Level 1 and 2 Importance Review	Palisades estimated the cost of providing a remotely operated fire water to service water cross-tie to be $2,900,000 (NMC 2005). Note: Because this SAMA must mitigate LOCAs, rapid alignment is required and control from the MCR is considered to be a necessary feature of the design.	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
20	Improve Vacuum Breaker Reliability by Installing Redundant Valves in Each Line	For cases in which the vacuum breaker fails to reclose, the vapor suppression capability of the suppression pool is bypassed because an open pathway exists between the wetwell and the drywell. Events that result in a release of reactor inventory into the drywell can rapidly overpressurize containment without the condensing capability of the wetwell and cause a containment breach. Installation of redundant vacuum breakers would reduce the probability of failures that lead to suppression pool bypass. A potential drawback of adding a vacuum breaker in series with the existing vacuum breakers is that the "failure to open" probability of the path would be increased.	LSCS Level 1 and 2 Importance Review	Oyster Creek estimated a cost of $2 million to install an additional Vacuum breaker in the 7 torus to drywell lines to address this issue (AmerGen 2005). For LSCS, 4 vacuum breakers would be required in the drywell to wetwell pathways. The cost of implementation is assumed to be proportional to the number of vacuum breakers, which implies a cost of about $1,150,000 for LSCS.	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
21	Automatic ATWS Level Control System	For failure to scram conditions, early reduction in RPV level is important to limit the heat load sent to the containment, the reliability of which could be improved by automating the reduction of RPV level to just above -129 inches, ADS inhibit, and the "terminate and prevent" step (to disallow automatic RPV makeup from non-Feedwater sources). The logic would be required to actuate without operator interface and only actuate when the Feedwater system is available and providing makeup to the RPV. This would increase the time available for the operators to perform the other actions required early in ATWS scenarios, such as MSIV low level isolation logic bypass and SBLC initiation.	LSCS Level 1 and 2 Importance Review	The LSCS specific cost estimate for implementation of this SAMA is $1,481,002 (S&L 2014)	Implementation cost is less than MACR. Retain for Phase II analysis.
22	Hydrogen Igniters in Primary Containment	For cases in which containment venting is not adequate to prevent the buildup of combustible gases or when venting has failed, burning the combustible gases before they reach levels where detonation can cause containment failure is a means of reducing the consequences of severe accidents. Providing a means of power during SBO events would improve the capabilities of this system.	LSCS Level 1 and 2 Importance Review	McGuire estimated the cost of providing a generator to supply power to the existing igniters in SBO scenarios to be $205,000 (NRC 2002). For LSCS, the igniters themselves would be required in addition to an SBO power source, but this is used as a lower bound estimate for LSCS.	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
23	Enhance Fuel Pool Emergency Makeup Pump and Connection	For post core damage conditions, a system capable of injecting 1000 gpm or more to the RPV is estimated to be required to prevent reactor vessel meltthrough and core-concrete interactions that can fail the drywell. Replacing the existing Fuel Pool Emergency Makeup Pump with a higher pressure/higher flow pump and creating a permanent connection to the B RHR line could provide this capability. The capability would be similar to that of the RHRSW/LPCS cross-tie, but it makes use of a diverse system that is not currently considered in the PRA. This SAMA would also potentially be able to prevent core damage in many of the scenarios requiring water to prevent the RPV meltthrough and drywell failure events.	LSCS Level 1 and 2 Importance Review	This SAMA, like SAMA 15, requires a manually aligned cross-tie from a pump in the CSCS vault to a low pressure ECCS system for alternate injection. SAMA 23 also requires a new, higher capacity pump, but the $1,366,982 cost of SAMA 15 is used as a surrogate for this SAMA without escalation for an additional pump.	Implementation cost is less than MACR. Retain for Phase II analysis.
24	Provide Inter Division 4kV AC Cross-Tie Capability	The existing inter-unit cross-tie capability is valuable at LSCS, but additional flexibility could be gained by providing the capability to perform inter-divisional AC cross-ties in accident scenarios (e.g., 241Y to 242Y, or 242Y to 243C).	Industry Review/Fire Review	The LSCS specific cost estimate for implementation of this SAMA is $1,824,084 (S&L 2014).	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
25	Periodic Training on Water Hammer Scenarios Resulting from a False LOCA Signal	In transient scenarios, even with RHR operating in SPC mode, the DW will still reach 2 psig and a high DW pressure signal will register. When a consequential loss of offsite power occurs with the LOCA signal, this results in a load shed of the emergency buses while the EDGs start, during which time the discharge line of the previously running RHR train will drain to the suppression pool. When the RHR system is reloaded onto the emergency bus and the RHR pump starts, the discharge line will be empty and vulnerable to a water hammer event (PRA specific scenario). Incorporating training on this scenario into the Licensed Operator Cycle Training Plans would institutionalize it in a manner that would help ensure the operators maintain proficiency in addressing these types of scenarios and potentially improve the reliability of the actions required to prevent a water hammer event.	Industry Review	Cooper estimated the cost of providing enhanced ISLOCA training to be $112,000 (NPPD 2008). This is assumed to approximate the cost of providing water hammer training for LSCS.	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
26	Seismically Qualified Low Pressure RPV Makeup Capability	For seismic initiators that lead to SBOs and early failure of RCIC, aligning the Fire Protection System to the Feedwater system using fire hoses cannot currently prevent core damage. In order to mitigate these types of events, a hard-piped, seismically qualified low pressure injection pump with a seismically qualified suction source and power source would be required. This would ensure the system would be available in seismic events. In order to ensure it could be rapidly aligned for loss of injection cases, this SAMA includes the ability to align the system from the MCR. For power, a non-safety related, seismically qualified diesel generator would be required to energize the pump and to provide long term battery charger support to maintain RPV level instrumentation and SRV control for low pressure injection. The generator would be permanently installed outside of the Reactor Building and include remote start capability from the MCR to power the makeup pump. Alignment to the existing safety related battery chargers would be performed manually and possible within 4 hours. Ensuring that this capability would likely be available for seismic events with peak ground accelerations of up to 0.46g would address most of the estimated risk.	External Events Review	The LSCS specific cost estimate for implementation of this SAMA is $5,984,407 (S&L 2014).	Implementation cost is greater than the MACR. Screened from further analysis.

Table F.5-4
LSCS Phase 1 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate (per unit)	Phase 1 Baseline Disposition
27	Preclude Emergency Depressurization When RCIC is the Only Injection System Available and Provide Long Term DC Power	For cases where RCIC is the only injection system available, it would be possible to prevent core damage by changing the EOPs to allow RPV pressure to be maintained in the range of 150 to 250 psig even when containment temperature and pressure limits are violated. This would ensure the RCIC steam head is not lost in long term loss of containment heat removal scenarios. Providing a 480V AC generator to supply a battery charger would maintain plant instrumentation and control power, which would improve the reliability of this strategy.	External Events Review	Cooper estimated the cost of providing enhanced ISLOCA training to be $112,000 (NPPD 2008). This is assumed to approximate the cost of providing training for the long term use of RCIC without suppression pool cooling for LSCS. The cost of the 480V AC generator to support a battery charger was estimated by Ginna to be $400,000 (RG&E 2002). The total cost is sum of these components, or $512,000.	Implementation cost is less than MACR. Retain for Phase II analysis.

Table F.6-1
LSCS Phase 2 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase 2 Baseline Disposition
1	Install Reliable Hard Pipe Containment Vent	This is already a commitment for LSCS, but it has not yet been installed and is not modeled in the PRA. This SAMA, which will prevent vent path failure within the reactor building and will provide a means of safely operating the containment vent when normal support systems are unavailable (non-adverse environment for use of portable pneumatic supply or manual valve operation). This SAMA is used to track this enhancement in the analysis and to facilitate the interpretation of the results.	LSCS Level 1 and 2 Importance Review	Not Applicable: Implementation is planned independent of SAMA analysis. The phase 2 quantification results are documented in section F.6.1 to provide an estimate of the impact of the SAMA and to support sensitivity calculations in Section F.7.
2	Automate Suppression Pool Cooling Initiation	Suppression pool cooling initiation is a reliable action, but for non-LOCA events, automating SPC initiation on high suppression pool temperature could further improve the reliability of the containment heat removal function.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is positive and is classified as potentially "cost-beneficial".
3	Passive Vent Path	For loss of containment heat removal scenarios, the reliability of the containment venting function could be improved by installing a passive vent path. If the suppression chamber vent path were equipped with a rupture disk in parallel with the remotely operated vent path, a scrubbed release path would be available to prevent containment failure in the event that normal venting fails. The rupture disk failure pressure would have to be less than the ultimate containment strength to ensure it would rupture before the containment, but consideration could also be given to a lower pressure to ensure SRVs could remain operable to support low pressure injection in loss of containment heat removal cases. Effectiveness is contingent on the implementation of the hard pipe vent.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".

Table F.6-1
LSCS Phase 2 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase 2 Baseline Disposition
4	Install a Keylock MSIV Low Level Isolation Bypass Switch	Operator errors are some of the largest contributors to ATWS scenarios, which are complicated by the short times available for response. One of the more time limited actions in these scenarios is the action to bypass the MSIV low level isolation signal, which is currently an action that requires the installation of jumpers. Providing a switch in the MCR that would bypass the isolation logic would simplify the bypass action and provide more time margin for the power/level control actions for these scenarios. In order to improve the effectiveness of this enhancement, the EOP step that directs RPV level reduction should be modified such that the operators immediately lower level to a control band above the MSIV closure setpoint and then include a decision point, including bypassing interlock, before lowering level further.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
5	Automate SBLC Initiation	ATWS events rely on timely initiation of the SBLC system for mitigation. A potential means of improving the reliability of this function would be to automate system initiation, as is that case at Limerick Generation Station.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
6	Create ECCS Suction Strainer Backflush Capability with RHRSW	For some LOCA contributors, common cause plugging of the ECCS suction strainers fails makeup/heat removal. Connecting the RHRSW system to the RHR pump suction line upstream of the F004A/B valves could provide a means of backflushing the system in conjunction with steps to close the F004A/B valves during the backflush.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".

Table F.6-1
LSCS Phase 2 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase 2 Baseline Disposition
7	Water Hammer Prevention	Alter the LOCA signal logic to require both high drywell pressure AND low water level for initiation. This will prevent LOCA signals in transient scenarios where high DW pressure alone can cause consequential LOOP events and drain the discharge line of an RHR train running in SPC mode (PRA specific scenario). This could also have the added benefit of simplifying the operators' response to loss of offsite power events where the LOOP signal has caused the EDGs to start and load and an ECCS signal is subsequently received due to loss of containment cooling (high drywell pressure). In this LOOP-delayed LOCA scenario, the operators are required to take many actions to handle the automatic actuations that occur due to the LOCA signal. This scenario is not specifically modeled in the PRA.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
8	Obtain a 480V AC Portable Generator to Supply the 125V DC Battery Chargers and Proceduralize its Use	For long term SBO scenarios, the hardened containment vent that LSCS is committed to install will provide a means of containment heat removal, but the battery life is currently assumed to be limited to about 7 hours in the PRA model. After battery depletion, the SRVs will close and the RPV will re-pressurize and prevent injection with a low pressure system, such as the fire protection system. Use of a portable generator to provide power to the 125V DC battery chargers would provide a means of maintaining the SRVs open, energize critical instrumentation, and ensure RPV pressure remains low enough for use of low pressure alternate makeup systems.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".

Table F.6-1
LSCS Phase 2 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase 2 Baseline Disposition
9	Develop Flood Zone Specific Procedures	The reliability of the internal flood mitigation actions could be improved by developing location and system specific flood response procedures. For example, for fire protection floods in the reactor building, developing procedures that direct the isolation of the FP070 and FP080 valves could significantly reduce the time required to terminate reactor building floods from the fire protection system. Increasing the time margin for the operators to respond to the floods would improve the likelihood of preventing damage to critical ECCS equipment.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is positive and is classified as potentially "cost-beneficial".
10	Change the Logic to Close the Turbine Driven Feedwater Pump Discharge Valves When the Pumps are Not Running	In cases where the turbine driven FW pumps are tripped or are malfunctioning, it is currently necessary to manually isolate the pump discharge valves to prevent hotwell depletion and/or RPV overfill when RPV pressure is reduced. Failure to control the valves can make the hotwell unavailable as a suction source for other injection systems or flood the steam lines, which may lead to the unavailability of RCIC. Changing the system logic to automatically close the valves when the pumps trip or are not running would reduce the likelihood of uncontrolled injection (no RPV overfill from the Condensate/CB pumps when pressure is reduced).	LSCS Level 1 and 2 Importance Review	This SAMA's net value is positive and is classified as potentially "cost-beneficial".
11	Provide the Capability to Trip the FPS Pumps from the MCR	The reliability of the internal flood mitigation actions could be improved by providing the capability to trip the fire protection system pumps from the MCR. Currently, is it is necessary to for an operator to travel to the Lake Screen House to locally trip the fire protection pumps to eliminate that system's flow. Increasing the time margin for the operators to respond to the floods would improve the likelihood of preventing damage to critical ECCS equipment. It is assumed that this change would be accompanied by a procedure update that would include directions to remotely isolate valves 0FP070 and 0FP080 for Service Water isolation to ensure that the time benefits	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".

Table F.6-1
LSCS Phase 2 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase 2 Baseline Disposition
		associated with the MCR pump control switches are fully realized.		
14	Provide a Portable DC Source to Support RCIC and SRV Operation	For scenarios with 125V DC bus faults, providing a means for a portable generator with DC output to supply 125V ESF DC distribution panel 1(2)11Y would support RCIC operation and long term SRV operation with Fire Protection System injection.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
15	Tie RHRSW to the LPCS System for ISLOCA Mitigation	ISLOCA events are dominated by isolation failures in which there are no long term RPV makeup sources. Providing a hard pipe connection with manual valves between the RHRSW system and the LPCS system would provide a source of makeup to the RPV for cases in which RPV depressurization is available.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is positive and is classified as potentially "cost-beneficial".
16	Provide Portable Fans for Alternate Room Cooling in the Core Standby Cooling System Vaults	Pump cubicle cooling fan or damper failures can result in the failure of the pumps in the Core Standby Cooling System vaults after heat up. Providing portable fans (and potentially temporary ductwork) could prevent failure by providing a temporary, alternate source of cubicle cooling. Room heat up calculations would be required as part of this effort to demonstrate that the portable fans could provide adequate cooling.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is positive and is classified as potentially "cost-beneficial".

Table F.6-1
LSCS Phase 2 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase 2 Baseline Disposition
18	Improve the Connection Between the Fire Protection and Feedwater Systems	For SBO cases with failure of RCIC, aligning the Fire Protection System to the Feedwater system using fire hoses cannot prevent core damage, primarily due to a lengthy alignment time. This time could be reduced by providing a hard pipe connection between the two systems. If a permanent connection between the systems is undesirable, a short, flexible connecting hose could potentially be maintained out of the flowpath provided that rapid alignment could be demonstrated.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
19	Provide Remote Alignment Capability of RHRSW to the LPCS System for LOCA Mitigation	For some LOCA scenarios, CCF plugging of the ECCS suction strainers can fail all ECCS injection. Providing the operators with the ability to cross-tie the RHRSW system to the LPCS system from the MCR would provide a source of makeup to the RPV for cases in which RPV depressurization is available.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is positive and is classified as potentially "cost-beneficial".
20	Improve Vacuum Breaker Reliability by Installing Redundant Valves in Each Line	For cases in which the vacuum breaker fails to reclose, the vapor suppression capability of the suppression pool is bypassed because an open pathway exists between the wetwell and the drywell. Events that result in a release of reactor inventory into the drywell can rapidly overpressurize containment without the condensing capability of the wetwell and cause a containment breach. Installation of redundant vacuum breakers would reduce the probability of failures that lead to suppression pool bypass. A potential drawback of adding a vacuum breaker in series with the existing vacuum breakers is that the "failure to open" probability of the path would be increased.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".

Table F.6-1
LSCS Phase 2 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase 2 Baseline Disposition
21	Automatic ATWS Level Control System	For failure to scram conditions, early reduction in RPV level is important to limit the heat load sent to the containment, the reliability of which could be improved by automating the reduction of RPV level to just above -129 inches, ADS inhibit, and the "terminate and prevent" step (to disallow automatic RPV makeup from non-Feedwater sources). The logic would be required to actuate without operator interface and only actuate when the Feedwater system is available and providing makeup to the RPV. This would increase the time available for the operators to perform the other actions required early in ATWS scenarios, such as MSIV low level isolation logic bypass and SBLC initiation.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
22	Hydrogen Igniters in Primary Containment	For cases in which containment venting is not adequate to prevent the buildup of combustible gases or when venting has failed, burning the combustible gases before they reach levels where detonation can cause containment failure is a means of reducing the consequences of severe accidents. Providing a means of power during SBO events would improve the capabilities of this system.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
23	Enhance Fuel Pool Emergency Makeup Pump and Connection	For post core damage conditions, a system capable of injecting 1000 gpm or more to the RPV is estimated to be required to prevent reactor vessel meltthrough and core-concrete interactions that can fail the drywell. Replacing the existing Fuel Pool Emergency Makeup Pump with a higher pressure/higher flow pump and creating a permanent connection to the B RHR line could provide this capability. The capability would be similar to that of the RHRSW/LPCS cross-tie, but it makes use of a diverse system that is not currently considered in the PRA. This SAMA would also potentially be able to prevent core damage in many of the scenarios requiring water to prevent the RPV meltthrough and drywell failure events.	LSCS Level 1 and 2 Importance Review	This SAMA's net value is positive and is classified as potentially "cost-beneficial".

Table F.6-1
LSCS Phase 2 SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase 2 Baseline Disposition
24	Provide Inter Division 4kV AC Cross-Tie Capability	The existing inter-unit cross-tie capability is valuable at LSCS, but additional flexibility could be gained by providing the capability to perform inter-divisional AC cross-ties in accident scenarios (e.g., 241Y to 242Y, or 242Y to 243C).	Industry Review/Fire Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
25	Periodic Training on Water Hammer Scenarios Resulting from a False LOCA Signal	In transient scenarios, even with RHR operating in SPC mode, the DW will still reach 2 psig and a high DW pressure signal will register. When a consequential loss of offsite power occurs with the LOCA signal, this results in a load shed of the emergency buses while the EDGs start, during which time the discharge line of the previously running RHR train will drain to the suppression pool. When the RHR system is reloaded onto the emergency bus and the RHR pump starts, the discharge line will be empty and vulnerable to a water hammer event (PRA specific scenario). Incorporating training on this scenario into the Licensed Operator Cycle Training Plans would institutionalize it in a manner that would help ensure the operators maintain proficiency in addressing these types of scenarios and potentially improve the reliability of the actions required to prevent a water hammer event.	Industry Review	This SAMA's net value is negative and is classified as not "cost-beneficial".
27	Preclude Emergency Depressurization When RCIC is the Only Injection System Available and Provide Long Term DC Power	For cases where RCIC is the only injection system available, it would be possible to prevent core damage by changing the EOPs to allow RPV pressure to be maintained in the range of 150 to 250 psig even when containment temperature and pressure limits are violated. This would ensure the RCIC steam head is not lost in long term loss of containment heat removal scenarios. Providing a 480V AC generator to supply a battery charger would maintain plant instrumentation and control power, which would improve the reliability of this strategy.	External Events Review	This SAMA's net value is negative and is classified as not "cost-beneficial".

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Table F.7-1
MACCS2 ECONOMIC PARAMETERS INPUTS FOR LASCHR3

Variable	Description	Base Case Value	LASCHR3
DPRATE[1]	Property depreciation rate (per yr)	0.20	0.20
DSRATE[2]	Investment rate of return (per yr)	0.07	0.07
EVACST[3]	Daily cost for a person who has been evacuated ($/person-day)	57.51	115.02
RELCST[3]	Daily cost for a person who is relocated ($/person-day)	57.51	115.02
POPCST[3]	Population relocation cost ($/person)	10,650	21,300
TIMDEC[1]	Decontamination time for each level[5]	2 & 4 months	2 & 12 months
CDFRM0[3]	Cost of farm decontamination for two levels of decontamination ($/hectare)[5]	1,198 2,663	2,396 5,326
CDNFRM[3]	Cost of non-farm decontamination per resident person for two levels of decontamination ($/person)[5]	6,390 17,040	12,780 34,080
DLBCST[3]	Average cost of decontamination labor ($/man-year)	74,550	149,100
TFWKF[1]	Time workers spend in Farm land contaminated areas[5]	1/10 1/3	1/4 1/4
TFWKNF[1]	Time workers spend in Non-Farm land contaminated areas[5]	1/3 1/3	1/4 1/4
VALWF0[4]	Weighted average value of farm wealth ($/hectare)	11,937	11,937
VALWNF[4]	Weighted average value of non-farm wealth ($/person)	283,637	283,637

1 Uses NUREG/CR-4551 value (NRC 1990b).

2 DSRATE based on NUREG/BR-0058 (NRC 2004a).

3 These parameters use the NUREG/CR-4551 value (NRC 1990b), updated to July 2013 using the CPI.

4 VALWF0 and VALWNF are based on the 2007 Census of Agriculture (USDA 2009), Bureau of Labor Statistics (BLS 2013) and Bureau of Economic Analysis (BEA 2013) data, updated to July 2013 using the CPI for the counties within 50 miles.

5 Two decontamination levels are modeled. The first value is associated with a dose reduction factor of 3. The second value is associated with a dose reduction factor of 15.

F.10 FIGURES

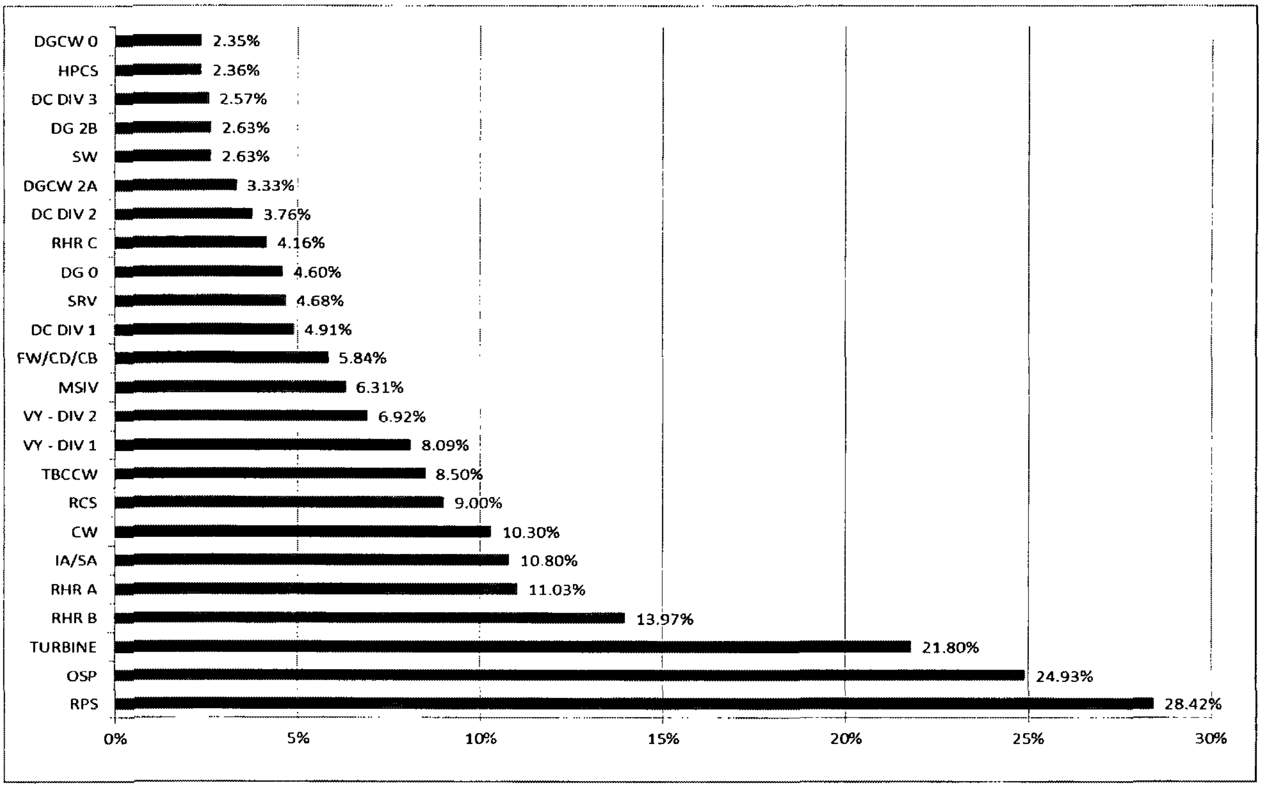

Figure F.2-1
LS213A System, Train, Component Fussell-Vesely Importance Measure

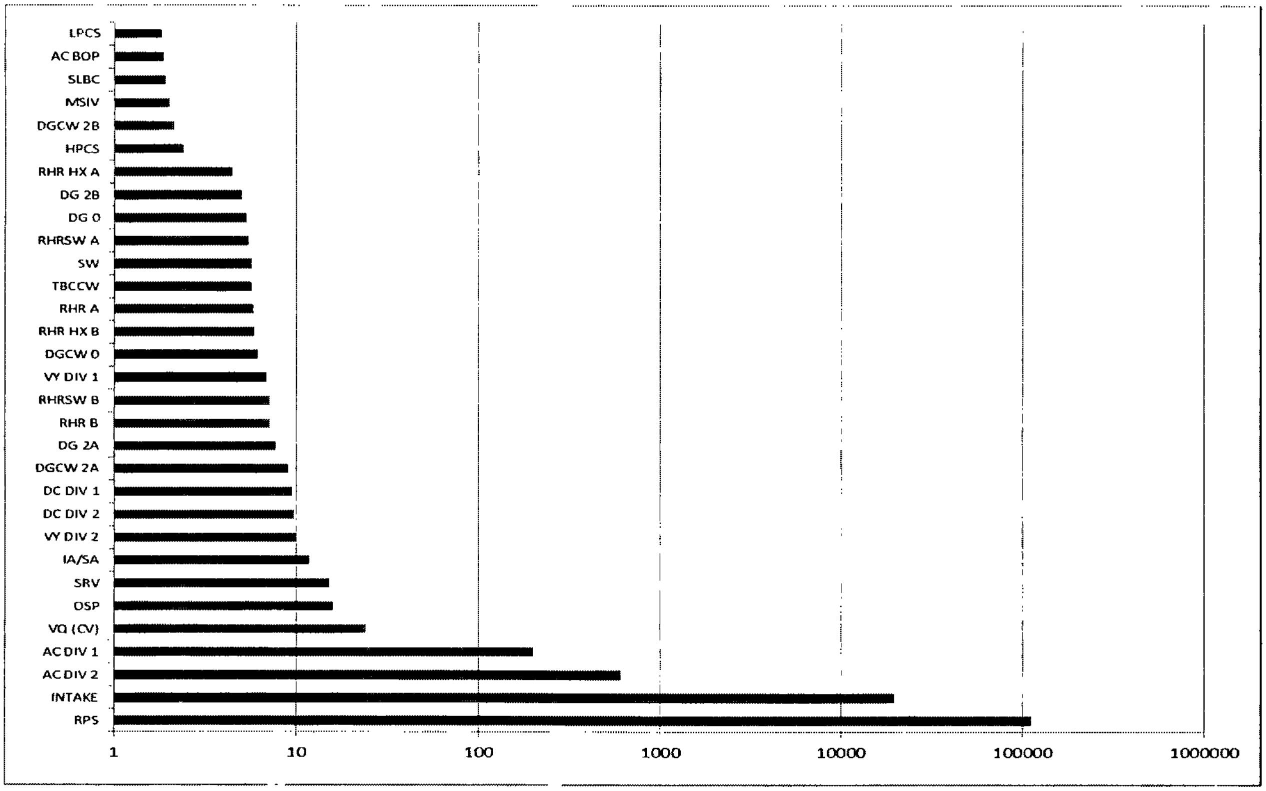

Figure F.2-2
LS213A System, Train, Component RAW Importance Measure

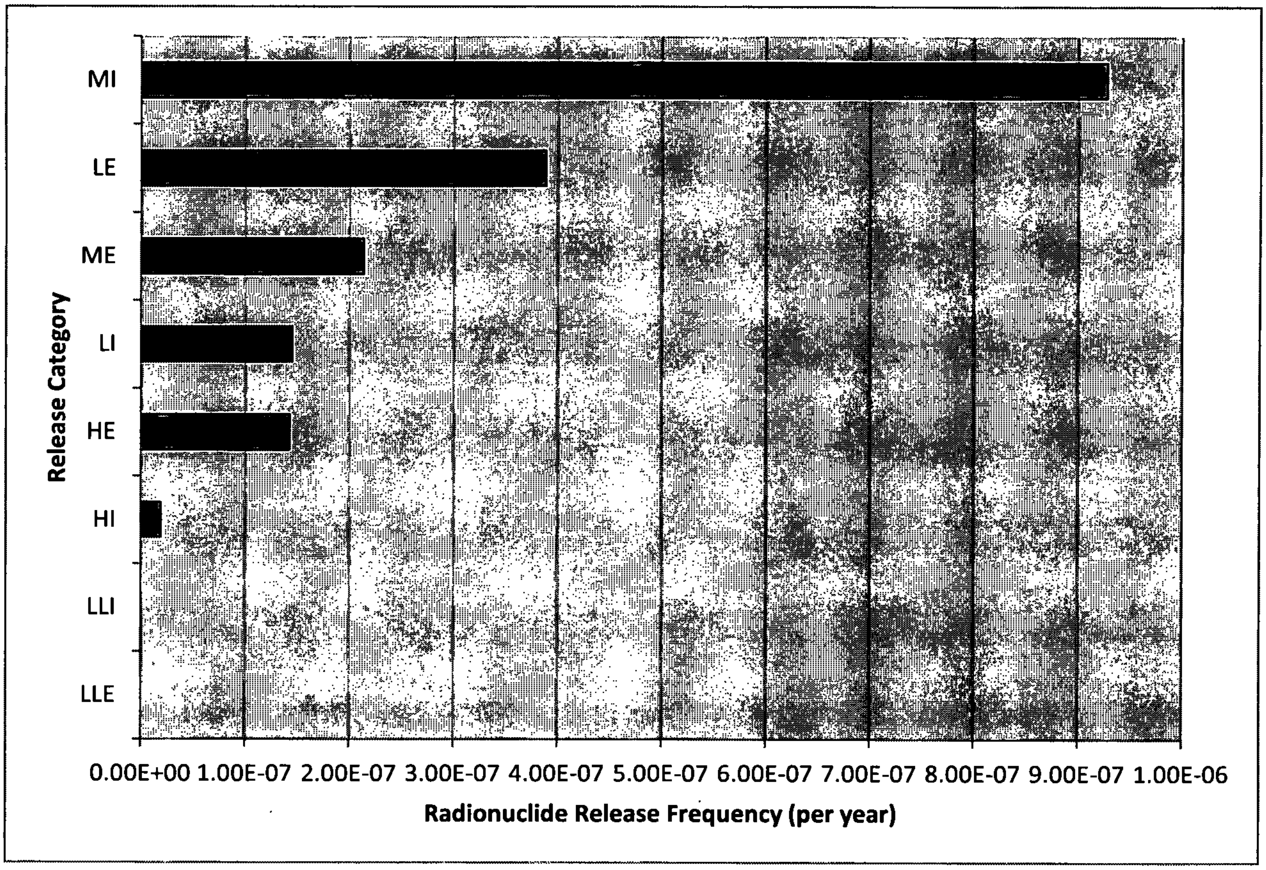

Figure F.2-3
Summary of Release Magnitudes
Summary of LSCS Level 2 Release Categories (/cr-yr)

Legend:

HE – High Early

HI – High Intermediate

ME – Medium Early

MI – Medium Intermediate

LE – Low Early

LI – Low Intermediate

LLE – Low-low Early

LLI – Low-low Intermediate

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