February 23, 2001

Mr. William T. O'Connor, Jr.
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SUBJECT: FERMI 2 - SITE-SPECIFIC WORKSHEETS FOR USE IN THE NUCLEAR REGULATORY COMMISSION'S SIGNIFICANCE DETERMINATION PROCESS (TAC NO. MA6544)

Dear Mr. O'Connor:

Enclosed, please find the Risk-Informed Inspection Notebook which incorporates the updated Significance Determination Process (SDP) Phase 2 Worksheets that inspectors will be using to characterize and risk-inform inspection findings. This document is one of the key implementation tools of the reactor safety SDP in the reactor oversight process and is also publically available through the Nuclear Regulatory Commission (NRC) ADAMS system.

The 1999 Pilot Plant review effort clearly indicated that significant site-specific design and risk information was not captured in the Phase 2 worksheets forwarded to you last spring. Subsequently, a site visit was conducted by the NRC to verify and update plant equipment configuration data and to collect site-specific risk information from your staff. The enclosed document reflects the results of this visit.

The enclosed Phase 2 Worksheets have incorporated much of the information we obtained during our site visits. The staff encourages further licensee comments where it is identified that the Phase 2 Worksheets give inaccurately low significance determinations. Any comments should be forwarded to the Chief, Probabilistic Safety Assessment Branch, Office of Nuclear Reactor Regulation (NRR). We will continue to assess SDP accuracy and update the document based on continuing experience.

While the enclosed Phase 2 Worksheets have been verified by our staff to include the site-specific data, we will continue to assess its accuracy throughout implementation and update the document based on comments by our inspectors and your staff.

We will coordinate our efforts through your licensing or risk organizations as appropriate. If you have any questions, please contact me at 301-415-2859.

Sincerely,

/RA/

Mohammed A. Shuaibi, Project Manager, Section 1
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-341

Enclosure: Risk-Informed Inspection Notebook

cc w/encl: See next page

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RISK-INFORMED INSPECTION NOTEBOOK FOR

FERMI 2 NUCLEAR PLANT

BWR-4, GE, WITH MARK I CONTAINMENT

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ENCLOSURE

NOTICE

This notebook was developed for the NRC's inspection teams to support risk-informed inspections. The "Reactor Oversight Process Improvement," SECY-99-007A, March 1999 discusses the activities involved in these inspections. The user of this notebook is assumed to be an inspector with an extensive understanding of plant-specific design features and operation. Therefore, the notebook is not a stand-alone document, and may not be suitable for use by non-specialists. It will be periodically updated with new or replacement pages incorporating additional information on this plant. All recommendations for improvement of this document should be forwarded to the Chief, Probabilistic Safety Assessment Branch, NRR, with a copy to the Chief, Inspection Program Branch, NRR.

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ABSTRACT

This notebook contains summary information to support the Significance Determination Process (SDP) in risk-informed inspections for the Fermi 2 Nuclear Plant.

The information includes the following: Categories of Initiating Events Table, Initiators and System Dependency Table, SDP Worksheets, and SDP Event Trees. This information is used by the NRC's inspectors to identify the significance of their findings, i.e., in screening risk-significant findings, consistent with Phase-2 screening in SECY-99-007A. The Categories of Initiating Event Table is used to determine the likelihood rating for the applicable initiating events. The SDP worksheets are used to assess the remaining mitigation capability rating for the applicable initiating event likelihood ratings in identifying the significance of the inspector's findings. The Initiators and System Dependency Table and the SDP Event Trees (the simplified event trees developed in preparing the SDP worksheets) provide additional information supporting the use of SDP worksheets.

The information contained herein is based on the licensee's Individual Plant Examination (IPE) submittal, the updated Probabilistic Risk Assessment (PRA), and system information obtained from the licensee during site visits as part of the review of earlier versions of this notebook. Approaches used to maintain consistency within the SDP, specifically within similar plant types, resulted in sacrificing some plant-specific modeling approaches and details. Such generic considerations, along with changes made in response to plant-specific comments, are summarized.

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1. INFORMATION SUPPORTING SIGNIFICANCE DETERMINATION PROCESS (SDP)

SECY-99-007A (NRC, March 1999) describes the process for making a Phase-2 evaluation of the inspection findings. In Phase 2, the first step is to identify the pertinent core damage scenarios that require further evaluation consistent with the specifics of the inspection findings. To aid in this process, this notebook provides the following information:

1. Estimated Likelihood Rating for Initiating Events Categories
2. Initiator and System Dependency Table
3. Significance Determination Process (SDP) Worksheets
4. SDP Event Trees.

Table 1, Categories of Initiating Events, is used to obtain the estimated likelihood rating for applicable initiating events for the plant for different exposures times for degraded conditions. This Table follows the format of the Table 1 contained in SECY-99-007A. Initiating events are grouped in frequency bins covering one order of magnitude. The table includes the initiating events that should be considered for the plant and for which SDP worksheets are provided. Categorization of the following initiating events is based on industry-average frequency: transients (Reactor Trip) (TRANS); transients without power conversion system (TPCS); large, medium, and small loss of coolant accidents (LLOCA, MLOCA, and SLOCA); inadvertent or stuck open relief valve (IORV or SORV); anticipated transients without scram (ATWS); interfacing systems LOCA (ISLOCA) and LOCA outside containment (LOC). The frequency of the remaining initiating events vary significantly from plant to plant, and accordingly, they are categorized using the plant-specific frequency obtained from the licensee. These initiating events include loss of offsite power (LOOP) and special initiators caused by loss of support systems.

The Initiator and System Dependency Table shows the major dependencies between frontline and support systems, and identifies their involvement in different types of initiators. This table identifies the most risk-significant systems; it is not an exhaustive nor comprehensive compilation of the dependency matrix, as shown in Probabilistic Risk Assessments (PRAs). This table is used to identify the SDP worksheets to be evaluated, corresponding to inspection findings on systems and components.

To evaluate the impact of an inspection finding on the core-damage scenarios, we developed the SDP worksheets. They contain two parts. The first part identifies the functions, the systems, and the combinations thereof that can perform mitigating functions, the number of trains in each system, and the number of trains required (success criteria) for each the initiator. It also characterizes the mitigation capability in terms of the available hardware (e.g., 1 train, 1 multi-train system) and the operator action involved. The second part of the SDP worksheet contains the core-damage accident sequences associated with each initiator; these sequences are based on SDP

event trees. In the parentheses next to each of the sequences the corresponding event tree branch number(s) representing the sequence is included. Multiple branch numbers indicate that the different accident sequences identified by the event tree are merged into one through the Boolean reduction.

SDP worksheets are developed for each initiating event, including “Special Initiators,” which are typically caused by complete or partial loss of support systems. A special initiator typically leads to a reactor scram and degrades some front-line or support systems (e.g., Loss of Service water in BWRs). The SDP worksheets for initiating events that directly lead to core damage are different. Of this type of initiating events, only the interfacing system LOCA (ISLOCA) and LOCA outside containment (LOC) are included. This worksheet identifies the major consequential leak paths and the number of barriers that may fail to cause the initiator to occur.

For the special initiators, we considered those plant-specific initiators whose contribution to the plant’s core damage frequency (CDF) is non-negligible and/or have the potential to be a significant contributor to CDF given an inspection finding on system trains and components. We defined a set of criteria for their inclusion to maintain some consistency across the plants. These conditions are as follows:

1. The special initiator should degrade at least one of the mitigating safety functions changing its mitigation capability in the worksheet. For example, a safety function with two redundant trains, classified as a multi-train system, degrades to an one-train system, to be classified as 1 Train, due to the loss of one of the trains as a result of the special initiator.

2. The special initiators, which degrade the mitigation capability of the accident sequences associated with the initiator from comparable transient sequences by two and higher orders of magnitude, must be considered.

Following the above considerations, the classes of initiators that we consider in this notebook are:

1. Transients with power conversion system (PCS)available, called Transients (Reactor trip) (TRANS),
2. Transients without PCS available, called Transients w/o PCS (TPCS),
3. Small Loss of Coolant Accident (SLOCA),
4. Inadvertent or Stuck-open Power Operated Relief Valve (IORV or SORV),
5. Medium LOCA (MLOCA),
6. Large LOCA (LLOCA),
7. Loss of Offsite Power (LOOP)
8. Anticipated Transients Without Scram (ATWS).

Section 1.3 lists the plant-specific special initiators addressed in this notebook. Examples of special initiators are as follows:

1. LOOP with failure of 1 Emergency AC (LEAC) bus or associated EDG (LEAC),
2. LOOP with stuck open SORV (LORV),

3. Loss of 1 DC Bus (LDC),
4. Loss of component cooling water (LCCW),
5. Loss of instrument air (LIA),
6. Loss of service water (LSW).

The worksheet for the LOOP may include LOOP with emergency AC power (EAC) available and LOOP without EAC, i.e., Station Blackout (SBO). LOOP with partial availability of EAC, i.e., LOOP with loss of a bus of EAC, is covered in a separate worksheet to avoid making the LOOP worksheet too large. LOOP with stuck open SORV is also covered in a separate worksheet, when applicable. In some plants, LOOP with failure of 1 EAC bus and LOOP with stuck-open SORV are large contributors to the plant's core damage frequency (CDF).

Following the SDP worksheets, the SDP event trees corresponding to each of the worksheets are presented. The SDP event trees are simplified event trees developed to define the accident sequences identified in the SDP worksheets. For special initiators whose event tree closely corresponds to another event tree (typically, the Transient(Reactor trip) or Transients w/o PCS event tree) with one or more functions eliminated or degraded, a separate event tree may not be drawn.

We considered the following items in establishing the SDP event trees and the core-damage sequences in the SDP worksheets; Section 2.1 gives additional guidelines and assumptions.

1. Event trees and sequences were developed such that the worksheet contains all the major accident sequences identified by the plant-specific IPEs or PRAs. The special initiators modeled for a plant is based on a review of the special initiators included in the plant IPE/PRA and the information provided by the licensee.

2. The event trees and sequences for each plant took into account the IPE/PRA models and event trees for all similar plants. Any major deviations in one plant from similar plants typically are noted at the end of the worksheet.

3. The event trees and the sequences were designed to capture core-damage scenarios, without including containment-failure probabilities and consequences. Therefore, branches of event trees that are only for the purpose of a Level II PRA analysis are not considered. The resulting sequences are merged using Boolean logic.

4. The simplified event-trees focus on classes of initiators, as defined above. In so doing, many separate event trees in the IPEs often are represented by a single tree. For example, some IPEs define four or more classes of LOCAs rather than the three classes considered here. The sizes of LOCAs for which high-pressure injection is not required are some times divided into two classes; the only difference between them being the need for reactor scram in the smaller break size. Some consolidation of transient event tree may also be done besides defining the special initiators following the criteria defined above.

5. Major actions by the operator during accident scenarios are credited using four categories of Human Error Probabilities (HEPs). They are termed operator action =1 (representing an error probability of 5E-2 to 0.5), operator action=2 (error probability of 5E-3 to 5E-2), operator action=3 (error probability of 5E-4 to 5E-3), and operator action=4 (error probability of 5E-5 to 5E-4). An human action is assigned to a category bin, based on a generic grouping of similar actions among a class of plants. This approach resulted in designation of some actions to a higher bin, even though the IPE/PRA HEP value may have been indicative of a lower category. In such cases, it is noted at the end of the worksheet. On the other hand, if the IPE/PRA HEP value suggests a higher category than that generically assumed, the HEP is assigned to a bin consistent with the IPE/PRA value in recognition of potential plant-specific design; a note is also given in these situations. Operator's actions belonging to category 4, i.e., operator action=4, may only be noted at the bottom of worksheet because, in those cases, equipment failures may have the dominating influence in determining the significance of the findings.

The four sections that follow include the Categories of Initiating Events Table, Initiators and System Dependency Table, SDP Worksheets, and the SDP Event Trees for the Fermi 2 Nuclear Plant.

1.1 INITIATING EVENT LIKELIHOOD RATINGS

Table 1 presents the applicable initiating events for this plant and their estimated likelihood ratings corresponding to the exposure time for degraded conditions. The initiating events are grouped into rows based on their frequency. As mentioned earlier, loss of offsite power and special initiators are assigned to rows using the plant-specific frequency obtained from individual licensees. For other initiating events, industry-average values are used, as per SECY-99-007A.

Table 1 Categories of Initiating Events for Fermi 2 Nuclear Power Plant

Row	Approximate Frequency	Example Event Type	Estimated Likelihood Rating		
I	> 1 per 1-10 yr	Reactor Trip, Loss of Power Conversion System (Loss of condenser, Closure of MSIVs, Loss of feedwater) (TPCS), LGSW, & LOP1	**A**	**B**	**C**
II	1 per 10-10^2 yr	Loss of offsite power (LOOP), Inadvertent or stuck open SRVs (SORV), LODC, LIA, & LOP2	**B**	**C**	**D**
III	1 per 10^2 - 10^3 yr	Medium LOCA (3 SORVs)	**C**	**D**	**E**
IV	1 per 10^3 - 10^4 yr	Small LOCA (RCS rupture), Medium LOCA (RCS rupture),	**D**	**E**	**F**
V	1 per 10^4 - 10^5 yr	Large LOCA (RCS rupture), ATWS	**E**	**F**	**G**
VI	less than 1 per 10^5 yr	ISLOCA/LOC, Vessel rupture	**F**	**G**	**H**
			> 30 days	**3-30 days**	**< 3 days**
			Exposure Time for Degraded Condition		

Notes:

1. The SDP worksheets for ATWS core damage sequences assume that the ATWS is not recoverable by manual actuation of the reactor trip function or by ARI (for BWRs). Thus, the ATWS frequency to be used by these worksheets must represent the ATWS condition that can only be mitigated by the systems shown in the worksheet (e.g., boration).

2. For Fermi 2 the licensee has separately modeled various numbers of SORVs. One or two SORVs have an initiating event (IE) frequency of 3.3 x10^{-2} per yr. Three SORVs have an initiating event (IE) frequency of 2.0 x10^{-2} per yr. One or two SORVs has the equivalent break size of an SLOCA and three SORVs has the equivalent break size of an MLOCA. Therefore this worksheet has added a more detailed plant-specific coverage of SORVs.

1.2 INITIATORS AND SYSTEM DEPENDENCY

Table 2 provides the list of the systems included in the SDP worksheets, the major components in the systems, and the support system dependencies. The system involvement in different initiating events are noted in the last column.

Table 2 Initiators and System Dependency for Fermi 2 Nuclear Power Plant

Affected System		Major Components	Support Systems	Initiating Event Scenarios
Code	Name			
PCS	Power Conversion System	6 MDPs, 2 TDPs, MOV	4160 VAC, 130 VDC, TBCCW, SA, IAS	Transient (Reactor Trip), SLOCA, & SORV
HPCI	High Pressure Coolant Injection	1 TDP, MOV	260 VDC, Act, Condensate Storage Tank (CST), cond xfer	All but MLOCA and LLOCA
RCIC	Reactor Core Isolation Cooling	1 TDP, MOV	260 VDC, Act, CST, cond xfer	All but MLOCA, LLOCA, & ATWS
SBFW	Standby Feedwater	2 MDPs, MOV	BOP 4160 VAC, 130 VDC, CST, cond xfer	All but LOOP, ATWS, & LODC
SRVs	Safety Relief Valves	15 SRVs, Accumulators	130 VDC, N_2	All but MLOCA, & LLOCA
LPCI	Low Pressure Coolant Injection	4 MDPs, MOV	4160 VAC, 130 VDC, RBCCW / EECW, Act, HVAC (LLOCA only)	All
RHR	Residual Heat Removal	4 MDPs, MOV, 2 Heat Exchangers	4160 VAC, 260 & 130 VDC, RHRSW, RBCCW / EECW	All
CS	Core Spray	4 MDPs, MOV	4160 VAC, 130 VDC, Act, RBCCW / EECW	All
AC	AC Power (non-EDG)	Breakers, Transformers	Offsite power, 130 VDC	All
EDGs	AC Power (EDGs)	4 Engine-Generators	130 VDC, DGSW, Act, FO transfer	LOOP, LOP1, LOP2
FO transfer	EDG fuel oil transfer	MDPs	AC	LOOP, LOP1, & LOP2
CTGs	Alternate AC from Combustion Turbine Generators	1 CTG, circuit breakers, batteries	None (see note 5)	LOOP

Table 2 (Continued)

Affected System		Major Components	Support Systems	Initiating Event Scenarios
Code	**Name**			
DC	DC Power, 260/130 V	Battery	None (Short term - 4 hours) Battery Chargers and AC (long term)	LODC
RHRSW	RHR Service Water	4 MDPs, MOV	4160 VAC, 130 VDC, MDCTs (note 12)	All
DGSW	Diesel Generator Service Water	4 MDPs, MOV	480 VAC, MDCTs	LOOP, LOP1, LOP2
GSW	General Service Water	5 MDPs, strainers	4160 VAC, 130 VDC	LGSW
CRD	Control Rod Drive Hydraulic System	2 MDPs	4160 VAC, 130 VDC, IAS, RBCCW / EECW, cond xfer	Transient (Reactor trip), TPCS, SLOCA, MLOCA, LLOCA, SORV, LODC, LOP1, LOP2
Act	Analogue Transmitter Trip System / Actuation	Instruments, Relays	130 VDC	All
NIAS	Non-interruptible Instrument Air	2 Air Compressors, Valves	480 VAC, RBCCW / EECW	All, but ATWS
SA / IAS	Station Air / Interruptible Air System	3 Compressors, Valves	480 VAC, 130m VDC, TBCCW	LIA
SLC	Standby Liquid Control	2 MDPs, Explosive Valves	480 VAC	ATWS
RBCCW	Reactor Building Closed Cooling Water	3 MDPs, Heat Exchanger	480 VAC, GSW, N_2	All (see note 11)
EECW and EESW	Emergency Equipment Cooling Water & Emergency Equipment Service Water	4 MDPs, MOV, Heat Exchanger	480 VAC, 130 VDC, Act, N_2, MDCTs	All

Table 2 (Continued)

Affected System		Major Components	Support Systems	Initiating Event Scenarios
Code	**Name**			
TBCCW	Turbine Building Component Cooling Water	3 MDPs, Heat Exchanger	480 VAC, 130 VDC, GSW, N_2	All
cond xfer	Condensate Transfer	2 MDPs, CST, MOV	AC, DC, SA, TBCCW, IAS	All (note 14)
CV	Containment Vent	AOVs	IAS or NIAS, 120 VAC	All but ATWS
N_2	Nitrogen System	Accumulators, Receivers	480 & 120 VAC, 130 VDC, IAS	All
HVAC	Heating, Ventilation and Air Conditioning - RHR room coolers	Coolers, Fans	480 VAC, RBCCW / EECW	LLOCA

<u>Notes</u>:

1. Information herein was initially developed from the Fermi 2 IPE dated August, 1992 and Rev. 1, dated 4/28/93 and RAI responses dated 9/22/93 & 6/30/94. The original IPE was developed by Detroit Edison and PLG and was based on an early version of the Riskman computer model. Subsequent to the IPE, the licensee updated their risk model in 1994 and 1995 by adding fault trees and updating to a later version of Riskman. In 1996 more detail was added, including component level modeling. In 1997 the latest version, PSA-97C, was finalized. This document was updated based upon a meeting held on May 25, 2000 between the NRC, Detroit Edison, and BNL at the Fermi 2 site and upon information provided from the updated Fermi 2 PSA dated August, 1997 and titled PSA-97C.

2. The baseline Fermi 2 IPE core damage frequency (CDF) from internal events was 5.7 E-6 events/reactor-year and the Large Early Release Frequency (LERF) was 8.2 E-7 events/reactor year. At Fermi 2 internal floods in the IPE constituted only about 3% of the CDF. The PSA-97C version has an internal events CDF of 7 E-6 events/reactor year.

3. Where we have indicated AC in the Support system column, this means that power can be supplied by either the EDG System or the normal offsite (non-EDG) AC power system. Fermi 2 has three 120 kV feeds from offsite and two 345 kV feeds. Typically for Fermi 2 the safety-related AC equipment can be supplied by either, while the non-safety can only be supplied by non-EDG power. The EDGs are only specifically credited in the LOOP Event Tree. In the last column of the Table for AC power (non-EDG), we have included all IEs (even LOOP) because LOOP has recovery events (RLOOP) that include offsite AC power.

Table 2 (Continued)

4. There are two divisions of emergency power at Fermi 2 and 4 EDGs (11 & 12 for Division I and 13 & 14 for Division II). There are also four combustion turbine generators (CTGs) onsite that can feed Fermi 2. One CTG has black start capability, which feeds ESF Division I and balance of plant (BOP) 120 kV loads.

5. The DC power system is required to operate for 24 hours. Under station blackout (SBO) conditions the batteries are required for 4 hours; no DC load shedding is assumed. For all other transients DC power is required for 24 hours to provide for startup and control of DC equipment and instrumentation.

6. For Fermi 2, one or two stuck open relief valves (SORVs) or safety valves are treated as equivalent to a small break LOCA. A separate worksheet is included for an SORV. Three or more SORVs are considered an MLOCA/LLOCA.

7. SRVs: There are 15 SRVs, of which 5 are used for ADS. An additional two SRVs are configured for operation from the remote shutdown panel (RSP). These seven SRVs have N_2 accumulators. All 15 can be used for manual DEP, provided the N_2 System and its support systems are operable. If not, then only 7 can be used for DEP via their accumulators.

8. There are two turbine bypass valves (TBVs) at Fermi. The total bypass capacity is 25%.

9. In the RHRSW System, there are 4 RHRSW pumps. Division II of RHRSW can be cross-tied to RHR for late injection (LI).

10. Standby Feedwater (SBFW) has 2 motor-driven pumps taking suction from the CST and injecting into the reactor vessel through either of the main FW injection lines. SBFW is powered by the BOP 4160 VAC.

11. The CS pumps are normally cooled by RBCCW. If RBCCW fails, EECW then automatically provides the cooling water. RBCCW is cooled by GSW and EECW is cooled by EESW. Degradation of RBCCW alone may not require evaluation of all worksheets.

12. RHR Complex Support Systems: The RHRSW reservoir is the ultimate heat sink and provides water to DGSW, RHRSW, & EESW pumps. The mechanical draft cooling towers (MDCTs) [also called the RHR cooling towers (RHR CTs)] are provided to cool the RHRSW reservoir.

13. There are two containment venting (CV) flow paths, one from the Drywell and one from the Torus. Both paths are considered a hard-piped vent path. CV from the Torus is preferred. The Torus path passes through 10", 20", and 24" lines and needs NIAS for AOV operation. The Drywell path passes through 10" and 24" lines and needs IAS for AOV operation.

14. The Emergency Hotwell Supply pump is used to provide make-up to the CST and is termed condensate transfer. This condensate transfer is needed for success of the HPCI, RCIC, SBFW, and CRD systems.

1.3 SDP WORKSHEETS

This section presents the SDP worksheets to be used in the Phase 2 evaluation of the inspection findings for the Fermi 2 Nuclear Plant. The SDP worksheets are presented for the following initiating event categories:

1. Transients (Reactor Trip) (TRANS)
2. Transients without PCS (TPCS)
3. Small LOCA (SLOCA)
4. Stuck Open Relief Valve (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Offsite Power (LOOP)
8. Anticipated Transients Without Scram (ATWS)
9. Loss of DC (LODC)
10. Loss of Instrument Air (LIA)
11. Loss of General Service Water (LGSW)
12. Loss Div I Offsite Power (LOP1)
13. Loss Div II Offsite Power (LOP2)
14. Interfacing System LOCA (ISLOCA)/LOCA Outside Containment (LOC)

Table 3.1 SDP Worksheet for Fermi 2 Nuclear Plant — Transients (Reactor Trip) (TRANS)

Estimated Frequency (Table 1 Row) __________ **Exposure Time** _________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Power Conversion System (PCS)	1/4 steam lines, condenser, 1/5 circ. water pump, 1/3 condenser pumps, 1/3 heater feed pumps, 1/2 reactor feed pumps (operator action = 3)
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train) or 1/2 SBFW pumps (operator action = 3)
Depressurization (DEP)	2/15 SRVs manually opened or 1/2 Turbine Bypass Valves (TBVs) (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR (operator action = 1); or [1/2 SBFW pumps or 1/2 CRD pumps] (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TRANS - PCS - CHR - LI (4, 8)			
2 TRANS - PCS - CHR - CV (5, 9)			
3 TRANS - PCS - HPI - LPI (10)			

4 TRANS - PCS - HPI - DEP (11)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. We have grouped together with Reactor Scram simple transients that do not involve a loss of offsite power or the PCS.

2. The HEP for depressurization (DEP) is 4 E-3 for the Fermi 2 PRA.

3. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

4. The HEP for cross connecting RHRSW for injection to the reactor pressure vessel is 0.2 (see Table 3.3-5 of the IPE) and is considered a high stress operator action.

5. Standby Feedwater (SBFW) must be manually operated and can function to provide injection when the reactor vessel is at either high or low pressure. For the transient sequences, the HEP for SBFW operation is 5 E-4. For HPI we have credited this operator action as 3 and for LI as 2, in order to maintain consistency with other BWR-4 plants and with the generic resolutions in Section 2.1.

6. Fermi 2 PRA credits TBVs for DEP and 1 train of PCS for CHR. The Fermi 2 IPE notes that the reactor vessel pressure control procedure has provision for vessel depressurization using the TBVs, ADS valves, SRVs, etc. This worksheet notes the possible use of TBVs for DEP, but does not add extra credit beyond that given to PCS as a whole. Further, PCS is not included on the CHR line.

Table 3.2 SDP Worksheet for Fermi 2 Nuclear Plant — Transients without PCS (TPCS)

Estimated Frequency (Table 1 Row) _________ Exposure Time _________ Table 1 Result (circle): A B C D E F G H

<u>Safety Functions Needed</u>:	<u>Full Creditable Mitigation Capability for Each Safety Function</u>:
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train) or 1/2 SBFW pumps (operator action = 3)
Depressurization (DEP)	2/15 SRVs manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR (operator action = 1); or [1/2 SBFW pumps or 1/2 CRD pumps] (operator action = 2)

<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 TPCS - CHR - LI (3, 7)			
2 TPCS - CHR - CV (4, 8)			
3 TPCS - HPI - LPI (9)			
4 TPCS - HPI - DEP (10)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

<u>Notes</u>:

1. This worksheet is for Transient (without PCS). TPCS includes MSIV closure, turbine trip without bypass, and loss of feedwater. It is assumed that no aspects of the PCS are available for safety functions during the transients evaluated in this event tree and worksheet. This event tree is also used for the five special initiators worksheets in Tables 2.9 through 2.13 (Loss of DC, Loss of Instrument Air, Loss of General Service Water, Loss Div I Offsite Power, and Loss Div II Offsite Power).

2. The HEP for depressurization (DEP) is 4 E-3 for the Fermi 2 PRA.

3. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

4. The HEP for cross connecting RHRSW for injection to the reactor pressure vessel is 0.2 (see Table 3.3-5 of the IPE)

5. Standby Feedwater (SBFW) must be manually operated and can function to provide injection when the reactor vessel is at either high or low pressure. For the transient sequences the HEP for SBFW operation is 5 E-4. For HPI we have credited this operator action as 3 and for LI as 2, in order to maintain consistency with other BWR-4 plants and with the generic resolutions in Section 2.1.

Table 3.3 SDP Worksheet for Fermi 2 Nuclear Plant — Small LOCA (SLOCA)

Estimated Frequency (Table 1 Row) _________ **Exposure Time _________**	**Table 1 Result (circle): A B C D E F G H**
<u>Safety Functions Needed</u>:	**<u>Full Creditable Mitigation Capability for Each Safety Function</u>:**
Power Conversion System (PCS)	1/4 steam lines, condenser, 1/5 circ. water pump, 1/3 condenser pumps, 1/3 heater feed pumps, 1/2 reactor feed pumps (operator action = 2)
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train) or 1/2 SBFW pumps (operator action = 1)
Depressurization (DEP)	2/15 SRVs manually opened or 1/2 Turbine Bypass Valves (TBVs) (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR (operator action = 1); or [1/2 SBFW pumps or 1/2 CRD pumps] (operator action = 1)

<u>Circle Affected Functions</u>	**<u>Recovery of Failed Train</u>**	**<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>**	**<u>Sequence Color</u>**
1 SLOCA - CHR - LI (3, 7, 11)			
2 SLOCA - CHR - CV (4, 8, 12)			
3 SLOCA - PCS - HPI - LPI (13)			
4 SLOCA - PCS - HPI - DEP (14)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. For the SLOCA sequence the HEP for high pressure injection with SBFW is 0.2. Thus, a credit of 1 is given for this operator action.

2. The HEP for depressurization (DEP) is 4 E-3 for the Fermi 2 PRA.

3. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

4. The HEP for cross connecting RHRSW for injection to the reactor pressure vessel is 0.2 (see Table 3.3-5 of the IPE).

5. Fermi 2 PRA credits TBVs for DEP and 1 train of PCS for CHR. This worksheet notes the possible use of TBVs for DEP, but does not add extra credit beyond that given to PCS as a whole. Further, PCS is not included on the CHR line.

Table 3.4 SDP Worksheet for Fermi 2 Nuclear Plant — Stuck Open Relief Valve (SORV)

Estimated Frequency (Table 1 Row) __________ Exposure Time __________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Power Conversion System (PCS)	1/4 steam lines, condenser, 1/5 circ. water pump, 1/3 condenser pumps, 1/3 heater feed pumps, 1/2 reactor feed pumps (operator action = 2)
High Pressure Injection Motor-driven (HPI/MD)	1/2 SBFW pumps (operator action = 1)
High Pressure Injection Steam-driven (HPI/SD)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	1/14 SRVs (plus the SORV) manually opened or 1/2 Turbine Bypass Valves (TBVs) (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR (operator action = 1); or [1/2 SBFW pumps or 1/2 CRD pumps] (operator action = 1)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SORV - CHR - LI (3, 7, 11, 16)			
2 SORV - CHR - CV (4, 8, 12, 17)			
3 SORV - PCS - HPI/MD - LPI (13, 18)			

4 SORV - PCS - HPI/MD - HPI/SD - DEP (19)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:			
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

<u>Notes</u>:

1. This worksheet applies to one or two stuck open or inadvertently open relief valves (IORV or SORV). Three or more SORVs constitute a medium or large LOCA.

2. For DEP need both the SORV and one additional SRV operated manually.

3. HPI success criteria: HPCI & RCIC are only acceptable for HPI in the short term (less than 6 hours). After 6 hours one needs either SBFW or LPI. Therefore, for this sequence we have split HPI into motor-driven and steam-driven. HPI includes both HPI/MD and HPI/SD.

4. For the SORV sequence the HEP for high pressure injection with SBFW is 0.2. Thus, a credit of 1 is given for this operator action.

5. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

6. Fermi 2 PRA credits TBVs for DEP and 1 train of PCS for CHR. This worksheet notes the possible use of TBVs for DEP, but does not add extra credit beyond that given to PCS as a whole. Further, PCS is not included on the CHR line.

Table 3.5 SDP Worksheet for Fermi 2 Nuclear Plant — Medium LOCA (MLOCA)

Estimated Frequency (Table 1 Row) __________ Exposure Time __________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Power Conversion System (PCS)	No credit for PCS in MLOCA.
Early Containment Control (EC)	Passive operation of SP with 12/12 vacuum breakers closed (1 train system)
High Pressure Injection (HPI)	No credit for HPI in MLOCA.
Depressurization (DEP)	Assumed successful.
Low Pressure Injection (LPI)	1/2 RHR pumps in 1/1 trains in LPCI Mode (1 multi-train system); or 1/`1 CS trains with 2/2 pumps per train (1 single train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in the suppression pool cooling (SPC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	[1/2 SBFW pumps and 1/2 CRD pumps] (operator action = 1)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 MLOCA - CHR - LI (3)			
2 MLOCA - CHR - CV (4)			
3 MLOCA - LPI (5)			
4 MLOCA - EC (6)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This worksheet uses the generic term Medium LOCA (MLOCA). Fermi 2 terms this an intermediate LOCA and treats large and intermediate LOCAs together in their success criteria and event trees. Break outside containment (BOC) is treated separately; the BOC initiating event frequency is 4.2 E-4 events per reactor-year and the BOC accident sequence frequency from the Fermi 2 PSA 97C is 4.6 E-8 events/reactor-year.

2. Three or more SORVs are considered an MLOCA/LLOCA.

3. SBFW can be used to supplement LPI, but is insufficient by itself until initial blowdown has stopped and only decay heat boiloff needs to be replaced.

4. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA. For an MLOCA, for CV to be successful the licensee noted that one must also have had successful LPI and have SBFW and CRD available. This is modeled via the event tree and in LI here.

5. Failure of EC/ Suppression Pool (SP) could be due to downcomer vent pipe failures, vacuum breaker (VB) failures, or inadequate SP level. At Fermi there are 12 vacuum breaker lines, each with a single vacuum breaker in it. All twelve must remain closed for success. Fermi has stated that: " Due to the VB design (passively opens on high torus pressure only), the failure probability of one or more VBs to remain closed or reclose during LOCA is considered to be very low (this scenario would require VBs to open against higher drywell pressure). This is coupled with the very low initiating event frequency for LOCA. Therefore, the likelihood of occurrence of core damage due to this postulated situation is very low, and was not modeled in the PSA, and would have a very minor impact on overall CDF if included. Both Drywell and Torus can be vented to atmosphere as required by our severe accident management procedures if required for decay heat removal (the hard vent line has similar capacity as one VB), although this is a high-stress operator action."

6. For MLOCA & LLOCA Fermi 2 assumes that either recirculation loop is failed, thus impacting one train of LPCI, or the break could disable one train of CS.

Table 3.6 SDP Worksheet for Fermi 2 Nuclear Plant — Large LOCA (LLOCA)

Estimated Frequency (Table 1 Row) __________	**Exposure Time __________**	**Table 1 Result (circle): A B C D E F G H**	
Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**		
Low Pressure Injection (LPI)	1/2 RHR pumps in 1/1 trains in LPCI Mode (1 multi-train system); or 1/`1 CS trains with 2/2 pumps per train (1 single train system)		
Early Containment Control (EC)	Passive operation of SP with 12/12 vacuum breakers closed (1 train system)		
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in the suppression pool cooling (SPC) mode (1 multi-train system)		
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)		
Late Inventory, Makeup (LI)	[1/2 SBFW pumps and 1/2 CRD pumps] (operator action = 1)		
Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LLOCA - CHR - LI (3)			
2 LLOCA - CHR - CV (4)			
3 LLOCA - LPI (5)			
4 LLOCA - EC (6)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Fermi 2 treats large and intermediate LOCAs together in their success criteria and event trees.

2. Three or more SORVs are considered an MLOCA/LLOCA.

3. SBFW can be used to supplement LPI, but is insufficient by itself until initial blowdown has stopped and only decay heat boil-off needs to be replaced.

4. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA. For a LLOCA, for CV to be successful the licensee noted that one must also have had successful LPI and have SBFW and CRD available. This is modeled via the event tree and in LI here.

5. Failure of EC/ Suppression Pool (SP) could be due to downcomer vent pipe failures, vacuum breaker failures, or inadequate SP level. At Fermi there are 12 vacuum breaker lines each with a single vacuum breaker in it. All twelve must remain closed for success. See similar note in MLOCA.

6. In the Fermi IPE, there are two un-isolated LOCAs that contribute to CDF: 1. a HPCI/RCIC steam line rupture; and 2. an ISLOCA consisting of a valve failure between the RPV and a low pressure system connected to the RPV. Both of these sequences are un-mitigated LOCAs that lead directly to core damage. Together they constitute 3.5% of total CDF or 2 E-7. The HPCI/RCIC steam line rupture is considered bounding for the main steam line break (MSLB) and a feedwater line break, which are not separately modeled in the IPE.

7. For MLOCA & LLOCA Fermi 2 assumes that either recirculation loop is failed, thus impacting one train of LPCI, or the break could disable one train of CS.

Table 3.7 SDP Worksheet for Fermi 2 Nuclear Plant — Loss of Offsite Power (LOOP)

Estimated Frequency (Table 1 Row) __________ **Exposure Time __________** **Table 1 Result (circle): A B C D E F G H**

<u>**Safety Functions Needed**</u>:	<u>**Full Creditable Mitigation Capability for Each Safety Function**</u>:
Emergency Power (EAC)	1/4 EDGs (1 multi-train system) or 1/1 CTG (operator action = 1)
Recovery of LOOP in 1 hour (RLOOP1)	No credit
Recovery of LOOP in 7 hours (RLOOP7)	Operator action = 1
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	2/15 SRVs manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR (operator action = 1); or [1/2 SBFW pumps or 1/2 CRD pumps] (operator action = 2)

<u>**Circle Affected Functions**</u>	<u>**Recovery of Failed Train**</u>	<u>**Remaining Mitigation Capability Rating for Each Affected Sequence**</u>	<u>**Sequence Color**</u>
1 LOOP - CHR - LI (1, 2, 5)			
2 LOOP - CHR - CV (1, 2, 6)			
3 LOOP - HPI - LPI (1, 2)			
4 LOOP - HPI - DEP (1, 2)			

5 LOOP - EAC - RLOOP1 - HPI (7) SBO sequence			
6 LOOP - EAC - RLOOP7 (8)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

Notes:

1. On an SBO at Fermi 2, the batteries will last a minimum of 4 hrs. Load shedding will extend battery life. The basis of the 7 hours is the 4 hour minimum plus some assumed load shedding plus boil-off time.

2. The unavailability of the CTG on an SBO is 0.1.

3. The unavailability of RLOOP1 in the Fermi PRA is 0.86 and, therefore, no credit is given for this action in the worksheet. The unavailability of RLOOP7 in the Fermi PRA is 0.56.

4. The first four sequences in the above worksheet have transfers from the LOOP event tree to the TPCS event tree in order to simplify the LOOP event tree.

Table 3.8 SDP Worksheet for Fermi 2 Nuclear Plant — Anticipated Transients Without Scram (ATWS)

Estimated Frequency (Table 1 Row) __________ **Exposure Time** __________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Overpressure Protection (OVERP)	9/15 SRVs (1 multi-train system)
Recirculation Pump Trip (RPT)	Automatic trip of 2/2 recirculation pumps (1 multi-train system)
Reactivity Control (SLC)	Manual initiation of 1/2 SLC pumps (operator action = 2) or [alternate boron injection and operator controls Rx water level and 1/2 TBVs available] (operator action = 1)
Inhibit ADS (INH)	Operator inhibits ADS (operator action = 2)
High Pressure Injection (HPI)	Operator injects with HPCI (1 ADS train) or 1/2 reactor feed pumps (operator action = 0)
Depressurization (DEP)	4/15 SRVs manually opened (operator action = 1) or manually depressurize with 1 train of PCS (1/4 MSIVs, 1/2 TBVs, condenser, and circ. water) (operator action = 0)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Overfill (OVRFL)	Operator prevents overfill by LPI and FW (operator action = 2)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system); or 1 train of PCS (1/4 MSIVs, 1/2 TBVs, condenser, & CW) (operator action = 0)
Containment Venting (CV)	No credit for CV in ATWS events.

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 ATWS - CHR (2, 4)			
2 ATWS - OVRFL (5)			
3 ATWS - HPI - LPI (6)			

4 ATWS - HPI - DEP (7)			
5 ATWS - INH (8)			
6 ATWS - SLC (9)			
7 ATWS - RPT (10)			
8 ATWS - OVERP (11)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

Notes:

1. ATWS scenarios at Fermi 2 constitute about 19% of CDF. ATWS assumes that electrical and mechanical scrams and ARI have all failed.
2. The HEP for depressurization (DEP) is 0.1.
3. Operator action to inject boron with SLC has an HEP of about 0.01. The action for alternate boron is top event BL of the IPE and is controlled by the Fermi 2 EOPs.

4. This worksheet conservatively assumes a loss of PCS transient initiated the ATWS. Additionally, due to generic NRC assumptions, no credit should be given to the PCS when evaluating findings on the worksheet, despite the fact that it is shown in the above table to more closely match the Fermi modeling.

5. The HEP for failure to inhibit ADS in the Fermi PRA is 3 E-2 to 4 E-2.

6. The components credited for CHR in sequences 2 and 4 vary depending on what is needed, i. e., the condenser or cooling of the suppression pool. As an example, in sequence 4 if DEP is by the TBVs, then the PCS is acceptable for CHR. If DEP is by SRVs, then SP cooling is needed for CHR.

Table 3.9 SDP Worksheet for Fermi 2 Nuclear Plant — Loss of BOP DC (LODC)

Estimated Frequency (Table 1 Row) _________ **Exposure Time** _________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	2/15 SRVs manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR (operator action = 1); or 1/2 CRD pumps (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LODC - CHR - LI (3, 7)			
2 LODC - CHR - CV (4, 8)			
3 LODC - HPI - LPI (9)			
4 LODC - HPI - DEP (10)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This worksheet is for Loss of Balance of Plant (BOP) DC Power. This DC has a single division, but both 130 V and 260 VDC power. The IE frequency is 3.1 E-2 events/reactor-year. No separate event tree is provided. Please refer to the TPCS tree.

2. A loss of DC causes a loss of control power for BOP AC power, IAS, TBCCW, GSW, and SBFW. Equipment already running would continue to operate (e.g., GSW and IAS). Due to various complications, PCS is lost; thus, we have used a worksheet similar to TPCS. The ET for TPCS should also be used. Importantly here, the SBFW system cannot be started and is considered lost. Safety related equipment, such as LPCI & CS, are not affected.

3. The HEP for depressurization (DEP) is 4 E-3 for the Fermi 2 PRA.

4. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

5. The HEP for cross connecting RHRSW for injection to the reactor pressure vessel is 0.2 (see Table 3.3-5 of the IPE).

Table 3.10 SDP Worksheet for Fermi 2 Nuclear Plant — Loss of Instrument Air (LIA)

Estimated Frequency (Table 1 Row) _________ **Exposure Time** _________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train) or 1/2 SBFW pumps (operator action = 3)
Depressurization (DEP)	2/7 SRVs manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/1 hard-piped CV paths, torus (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR (operator action = 1); or 1/2 SBFW pumps (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LIA - CHR - LI (3, 7)			
2 LIA - CHR - CV (4, 8)			
3 LIA - HPI - LPI (9)			
4 LIA - HPI - DEP (10)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This worksheet is for Loss of Instrument Air (LIA), including Station Air and the Interruptible Air System (IAS). The IE frequency is 7.2 E-2 events/reactor-year. Please refer to the TPCS tree.

2. LIA causes a loss of PCS, the drywell flow path of containment venting (CV), and the CRD system. Due to various complications, PCS is lost; thus, we have used a worksheet similar to TPCS. The ET for TPCS should also be used. LIA also causes a loss of the supply to the N_2 System, resulting in a loss of the 8 SRVs that do not have accumulators. This means that 7 SRVs remain available.

3. The HEP for depressurization (DEP) is 4 E-3 for the Fermi 2 PRA.

4. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

5. The HEP for cross connecting RHRSW for injection to the reactor pressure vessel is 0.2 (see Table 3.3-5 of the IPE).

6. Standby Feedwater (SBFW) must be manually operated and can function to provide injection when the reactor vessel is at either high or low pressure. For the transient sequences the HEP for SBFW operation is 5 E-4. For HPI we have credited this operator action as 3 and for LI as 2, in order to maintain consistency with other BWR-4 plants and with the generic resolutions in Section 2.1.

Table 3.11 SDP Worksheet for Fermi 2 Nuclear Plant — Loss of General Service Water (LGSW)

Estimated Frequency (Table 1 Row) _________ Exposure Time _________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train) or 1/2 SBFW pumps (operator action = 3)
Depressurization (DEP)	2/7 SRVs manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system); or 2/4 CS pumps (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps, 1/2 RHR HXs, in 1/2 trains and 1/4 RHRSW pumps in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/1 hard-piped CV paths, torus (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR (operator action = 1); or 1/2 SBFW pumps (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LGSW - CHR - LI (3, 7)			
2 LGSW - CHR - CV (4, 8)			
3 LGSW - HPI - LPI (9)			
4 LGSW - HPI - DEP (10)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This worksheet is for Loss of General Service Water (LGSW). The IE frequency is 0.18 events/reactor-year. This worksheet uses the TPCS event tree. The sequence numbers in parentheses are from the TPCS event tree. In the sequences, TPCS has been changed to LGSW.

2. Due to various complications, PCS is lost; thus, we have used a worksheet similar to TPCS. The ET for TPCS should also be used. Additionally, RBCCW, TBCCW, station air, and condensate transfer are lost. On the loss of RBCCW, the EECW/EESW systems will automatically start and operate. This event is very similar to the LIA event.

3. The HEP for depressurization (DEP) is 4 E-3 for the Fermi 2 PRA.

4. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

5. The HEP for cross connecting RHRSW for injection to the reactor pressure vessel is 0.2 (see Table 3.3-5 of the IPE).

6. Standby Feedwater (SBFW) must be manually operated and can function to provide injection when the reactor vessel is at either high or low pressure. For the transient sequences the HEP for SBFW operation is 5 E-4. For HPI we have credited this operator action as 3 and for LI as 2, in order to maintain consistency with other BWR-4 plants and with the generic resolutions in Section 2.1.

Table 3.12 SDP Worksheet for Fermi 2 Nuclear Plant — Loss Div I Offsite Power (LOP1)

Estimated Frequency (Table 1 Row) _________ **Exposure Time** _________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train) or 1/2 SBFW pumps (operator action = 2)
Depressurization (DEP)	2/15 SRVs manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/2 RHR pumps in Div. II or [1/2 RHR pumps in Div. I plus 1/2 EDGs] in LPCI Mode (1 multi-train system); or 2/4 CS pumps [1/2 EDGs required for Div. I CS pumps] (1 multi-train system)
Containment Heat Removal (CHR)	1/2 RHR pumps, 1/1 RHR HX, in Div. II or [1/2 RHR pumps, 1/1 RHR HX, in Div. I plus 1/2 EDGs] and 1/4 RHRSW pumps [1/2 EDGs required for Div. I RHRSW pumps] in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div II RHRSW pumps cross-tied to RHR or [1/2 Div I RHRSW pumps cross-tied to RHR plus 1/2 EDGs] (operator action = 1); or [1/2 SBFW pumps or 1/2 CRD pumps] (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LOP1 - CHR - LI (3, 7)			
2 LOP1 - CHR - CV (4, 8)			
3 LOP1 - HPI - LPI (9)			
4 LOP1 - HPI - DEP (10)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

<u>Notes</u>:

1. This worksheet is for Loss Div I Offsite Power (LOP1). LOP1 is defined as a loss of the three 120 kV AC offsite power supplies (from Shoal, Luzon, and Swan Creek). The 120 kV offsite power normally supplies the ESF Division I buses and the non-ESF (or BOP) Division I loads. The IE frequency is 0.14 events/reactor-year. This worksheet uses the TPCS event tree. The sequence numbers in parentheses are from the TPCS event tree. In the sequences, TPCS has been changed to LOP1.

2. Due to various complications, on LOP1 PCS is lost; thus, we have used a worksheet similar to TPCS. The ET for TPCS should also be used. LOP1 also causes a loss of the circulating water pump house and some portions of the following systems: GSW System, TBCCW System, RBCCW System, and the SA/IAS System. Additionally one of the SBFW pumps loses power; however, this can be cross-connected to be powered from Division II. Therefore operator action credit for SBFW in this case has been decreased from 3 to 2. An important consideration is that the EDGs would need to start in order to supply the Division I ESF loads.

3. The HEP for depressurization (DEP) is 4 E-3 for the Fermi 2 PRA.

4. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

5. The HEP for cross connecting RHRSW for injection to the reactor pressure vessel is 0.2 (see Table 3.3-5 of the IPE).

6. Capability exists to cross tie any of the EDGs between Divisions. Recovery action may be considered for this cross tie.

Table 3.13 SDP Worksheet for Fermi 2 Nuclear Plant — Loss Div II Offsite Power (LOP2)

Estimated Frequency (Table 1 Row) _________ **Exposure Time** _________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train) or 1/2 SBFW pumps (operator action = 3)
Depressurization (DEP)	2/15 SRVs manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/2 RHR pumps in Div. I or [1/2 RHR pumps in Div. II plus 1/2 EDGs] in LPCI Mode (1 multi-train system); or 2/4 CS pumps [1/2 EDGs required for Div. II CS pumps] (1 multi-train system)
Containment Heat Removal (CHR)	1/2 RHR pumps, 1/1 RHR HX, in Div. I or [1/2 RHR pumps, 1/1 RHR HX, in Div. II plus 1/2 EDGs] and 1/4 RHRSW pumps [1/2 EDGs required for Div. II RHRSW pumps] in either the suppression pool cooling (SPC) mode or the shutdown cooling (SDC) mode (1 multi-train system)
Containment Venting (CV)	1/2 hard-piped CV paths, torus or drywell (operator action = 2)
Late Inventory, Makeup (LI)	1/2 Div I RHRSW pumps cross-tied to RHR or [1/2 Div II RHRSW pumps cross-tied to RHR plus 1/2 EDGs] (operator action = 1); or [1/2 SBFW pumps or 1/2 CRD pumps] (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LOP2 - CHR - LI (3, 7)			
2 LOP2 - CHR - CV (4, 8)			
3 LOP2 - HPI - LPI (9)			
4 LOP2 - HPI - DEP (10)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

<u>Notes</u>:

1. This worksheet is for Loss Div II Offsite Power (LOP2). LOP2 is defined as a loss of the two 345 kV AC offsite power supplies (from Brownstone #2 and #3). The 345 kV offsite power normally supplies the ESF Division II buses and the non-ESF (or BOP) Division II loads. The IE frequency is 0.036 events/reactor-year. This worksheet uses the TPCS event tree. The sequence numbers in parentheses are from the TPCS event tree. In the sequences, TPCS has been changed to LOP2.

2. Due to various complications, on LOP2, PCS is lost; thus, we have used a worksheet similar to TPCS. The ET for TPCS should also be used. LOP2 also causes a loss of the recirculation MG sets and hence the recirculation pumps, and some portions of the following systems: GSW System, TBCCW System, RBCCW System, and the SA/IAS System. Additionally, one of the SBFW pumps loses power; however, this can be cross-connected to be powered from Division I. Therefore operator action credit for SBFW in this case has been decreased from 3 to 2. An important consideration is that the EDGs would need to start in order to supply the Division II ESF loads.

3. The HEP for depressurization (DEP) is 4 E-3 for the Fermi 2 PRA.

4. The HEP for failure to vent containment (CV) ranges from 0.01 to 0.02 for the Fermi 2 PRA.

5. The HEP for cross connecting RHRSW for injection to the reactor pressure vessel is 0.2 (see Table 3.3-5 of the IPE).

6. Capability exists to cross tie any of the EDGs between Divisions. Recovery action may be considered for this cross tie.

Table 3.14 SDP Worksheet for Fermi 2 — Interfacing System LOCA (ISLOCA)/LOCA Outside Containment (LOC)

Estimated Frequency (Table 1 Row) ________ Exposure Time __________ Table 1 Result (circle): A B C D E F G H

Initiation Pathways:	**Mitigation Capability: Ensure Component Operability for Each Pathway**
ISLOCA Pathways:	
Core Spray Lines	CS inboard isolation valves F005 A & B, CS outboard isolation valves
LPCI Injection Lines	LPCI injection valves F015A & B, LPCI isolation valves
RHR Drop Line	20-inch line with 2 MOVs in parallel and then a third MOV in series
LOC Pathways:	
HPCI Line	Line off of the FW line with a check valve, a normally closed MOV, a normally open MOV
RCIC Line	Line off of the FW line with a check valve, a normally closed MOV, a normally open MOV
RWCU System to Main Condenser and Waste Collector Tank	2 4-inch lines each with 1 normally closed MOV, a leak can be automatically isolated by 2 containment isolation valves
Feedwater Lines	2 feedwater lines each with 3 air-operated check valves, 2 reactor feed pumps each with a discharge check valve & 4 MOVs
Standby FW Line	Line off of the FW line with 3 injection valves (F001, ..)
Main Steam Lines	4 lines each with 2 MSIVs

Circle Affected Component in Pathways	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Pathway**	**Sequence Color**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The initiation pathways and applicable components are defined using generic insights based on NRC studies on ISLOCA, supplemented by plant-specific adjustments. The dominant pathways in the IPE are the CS and LPCI injections lines.

2. This worksheet contains pathways for both ISLOCA and LOC. Licensees typically analyze these events separately.

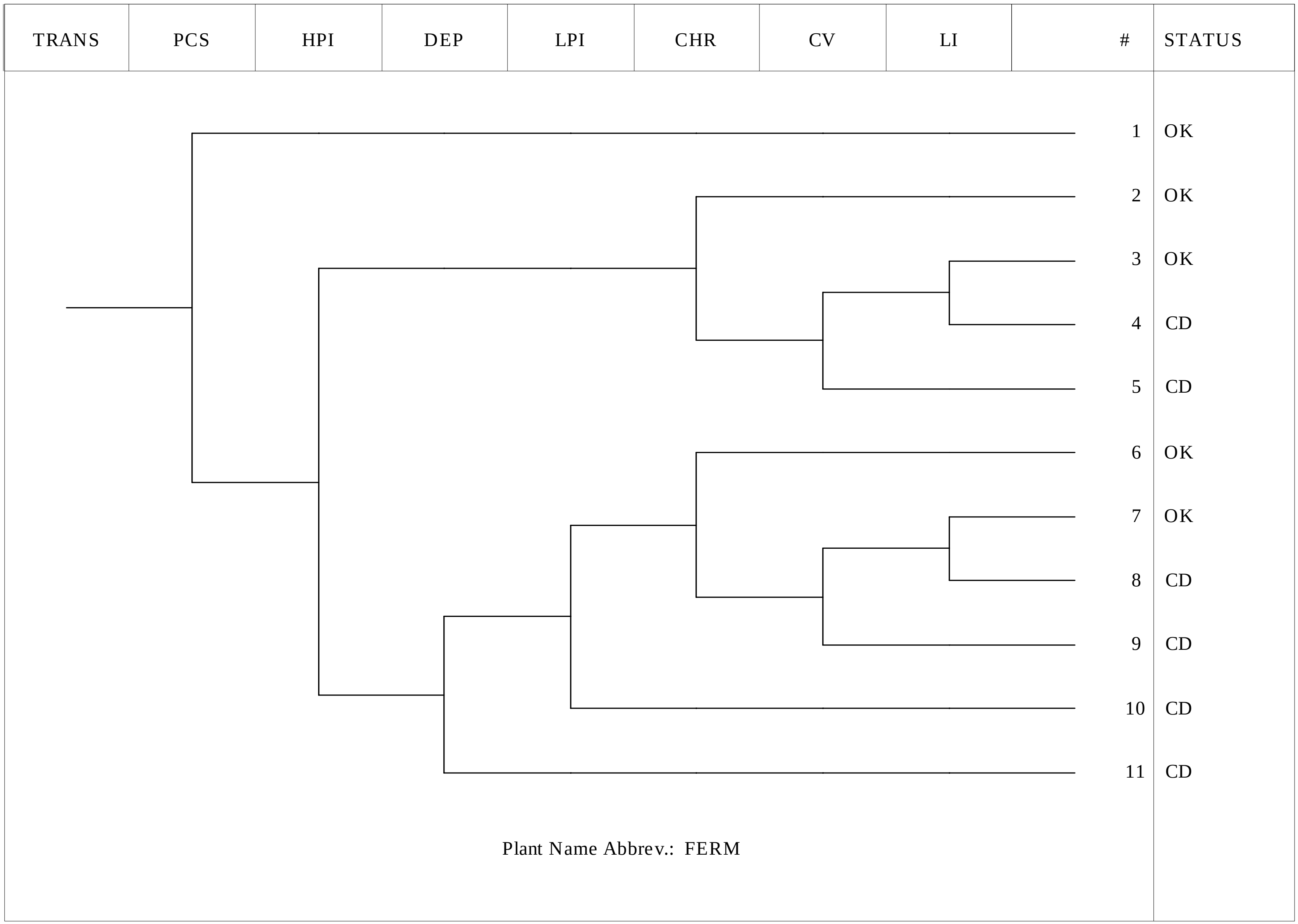
3. The ISLOCA initiating event frequency and accident sequence frequency from the Fermi 2 PSA 97C is 2.8 E-8 events/reactor-year. The Break outside containment (BOC) initiating event frequency is 4.2 E-4 events/reactor-year and the accident sequence frequency from the Fermi 2 PSA 97C is 4.6 E-8 events/reactor-year.

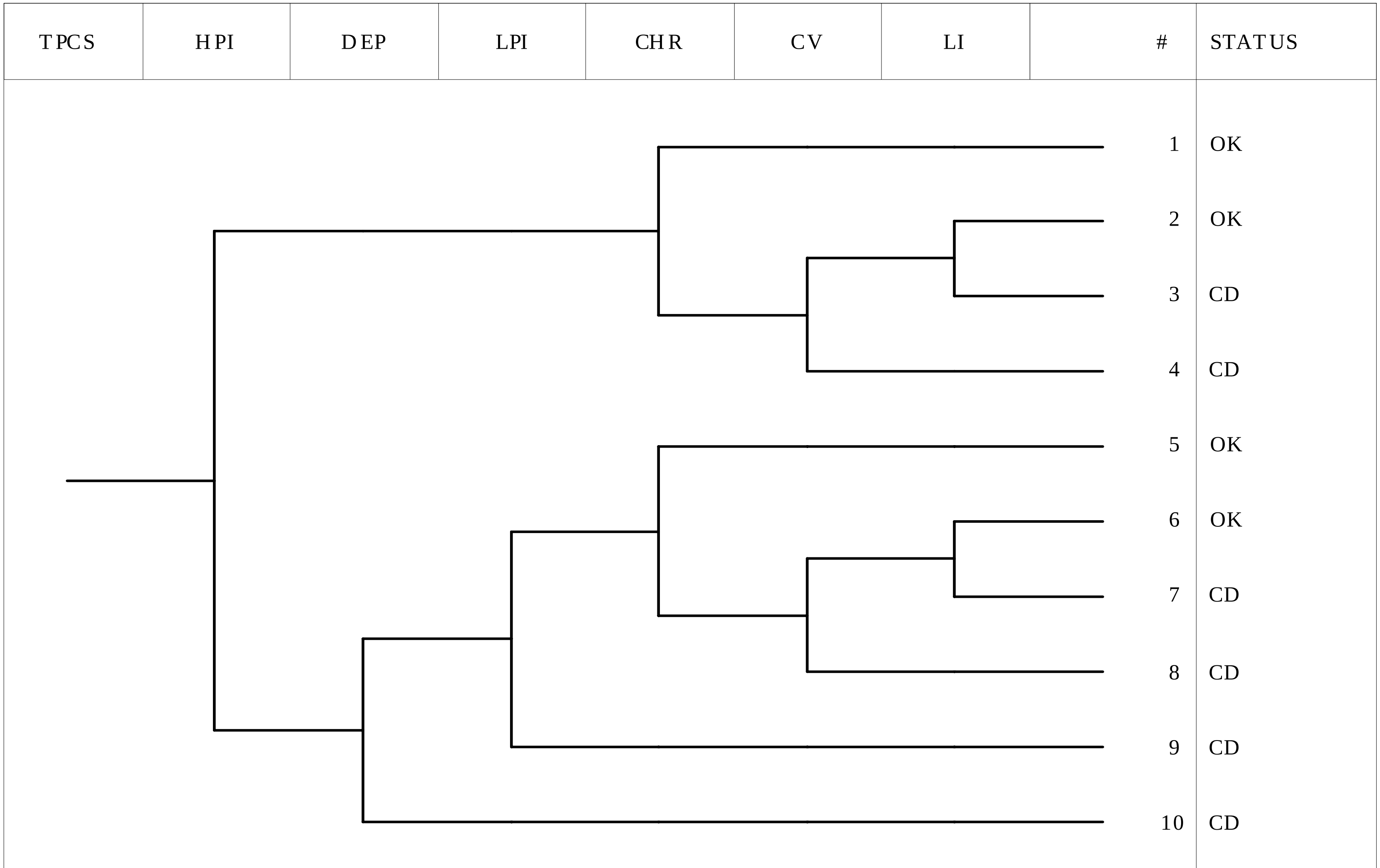
1.4 SDP Event Trees

This section provides the simplified event trees called SDP event trees used to define the accident sequences identified in the SDP worksheets in the previous section. The event tree headings are defined in the corresponding SDP worksheets.

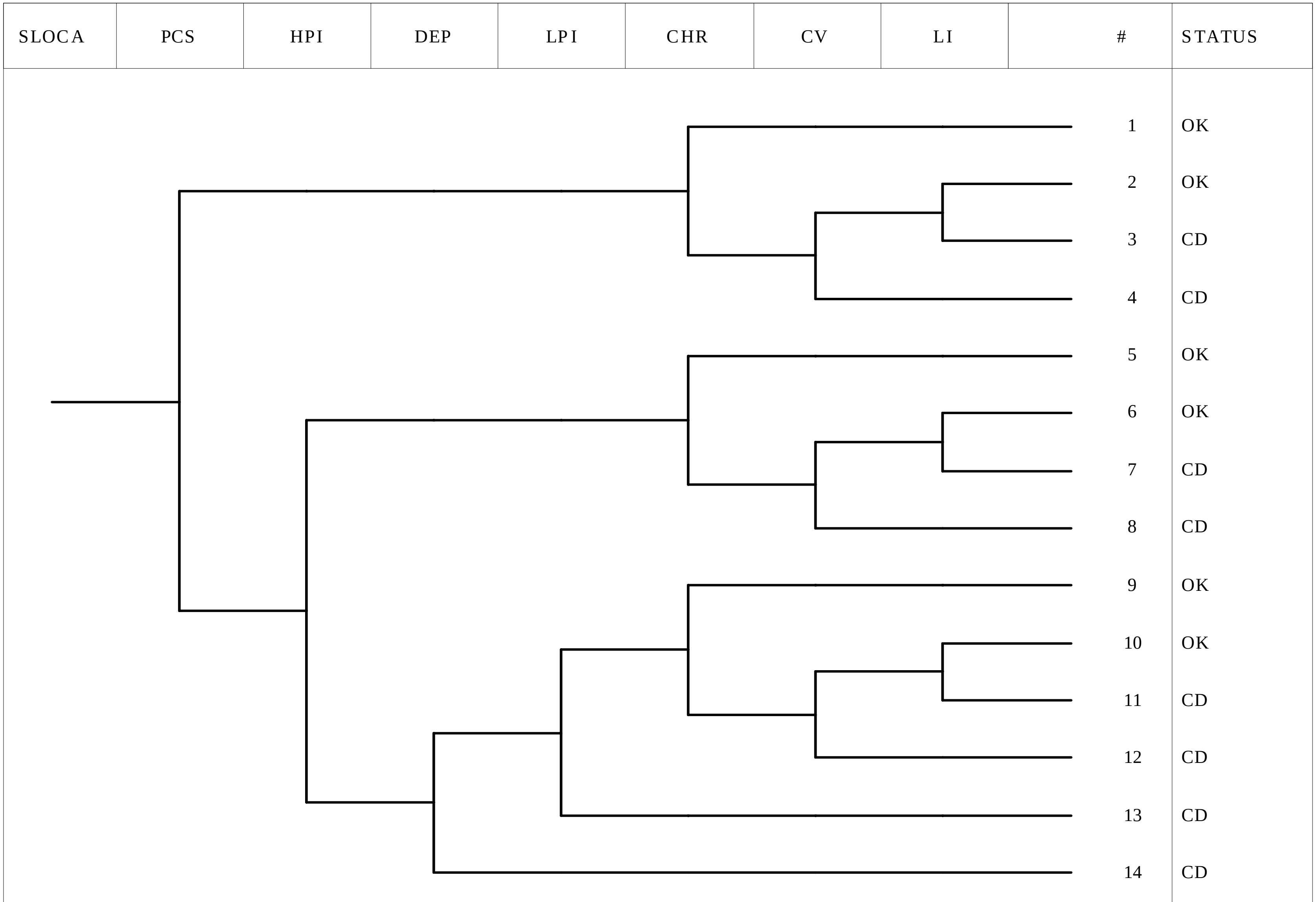
The following event trees are included:

1. Transients (Reactor Trip) (TRANS)
2. Transients without PCS (TPCS)
3. Small LOCA (SLOCA)
4. Stuck Open Relief Valve (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Offsite Power (LOOP)
8. Anticipated Transients Without Scram (ATWS)

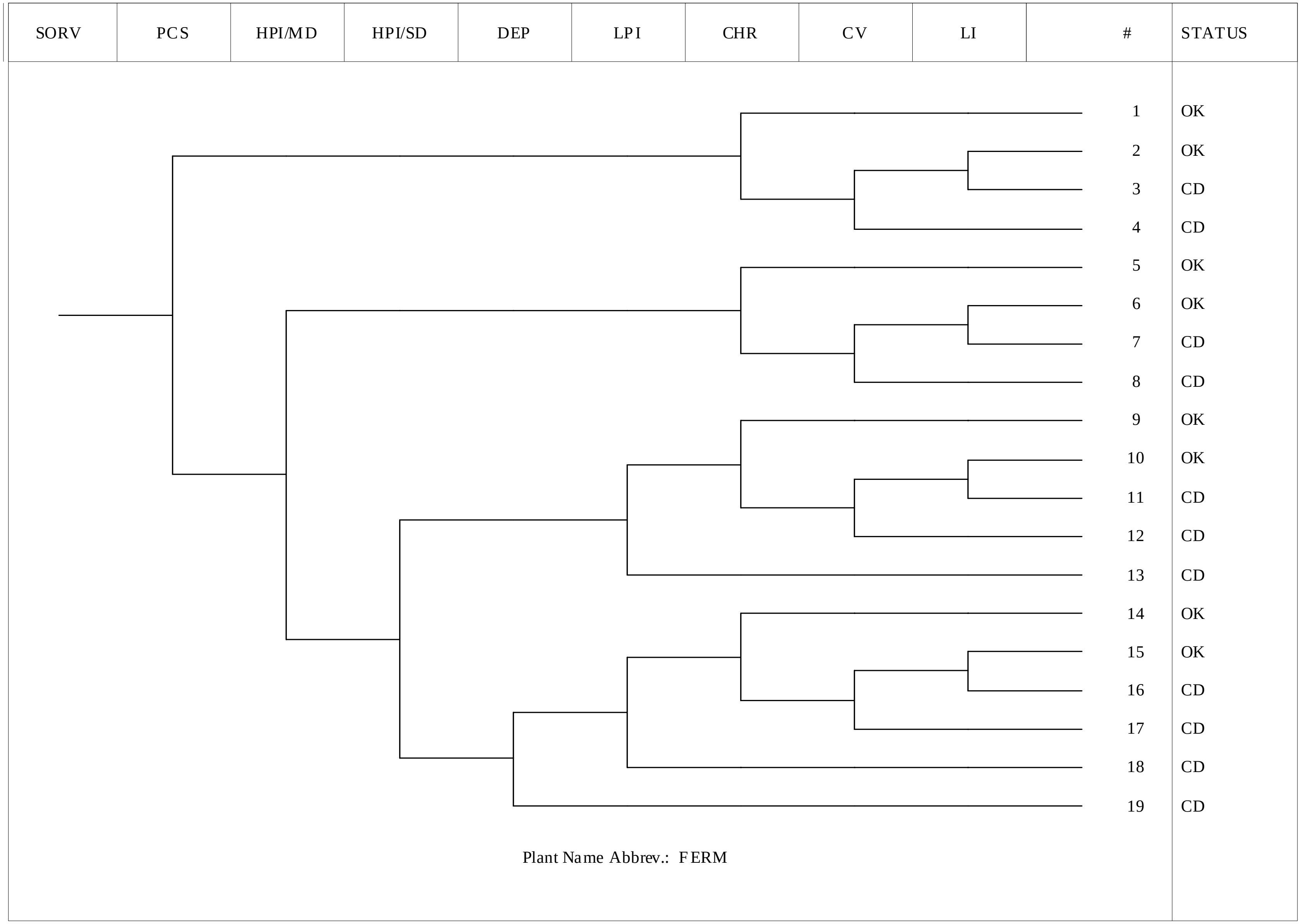

TRANS
PCS
HPI
DEP
LPI
CHR
CV
LI
#
STATUS
1 OK
2 OK
3 OK
4 CD
5 CD
6 OK
7 OK
8 CD
9 CD
10 CD
11 CD
Plant Name Abbrev.: FERM



Plant Name Abbrev.: FERM



Plant Name Abbrev.: FERM


SORV
PCS
HPI/MD
HPI/SD
DEP
LPI
CHR
CV
LI
#
STATUS
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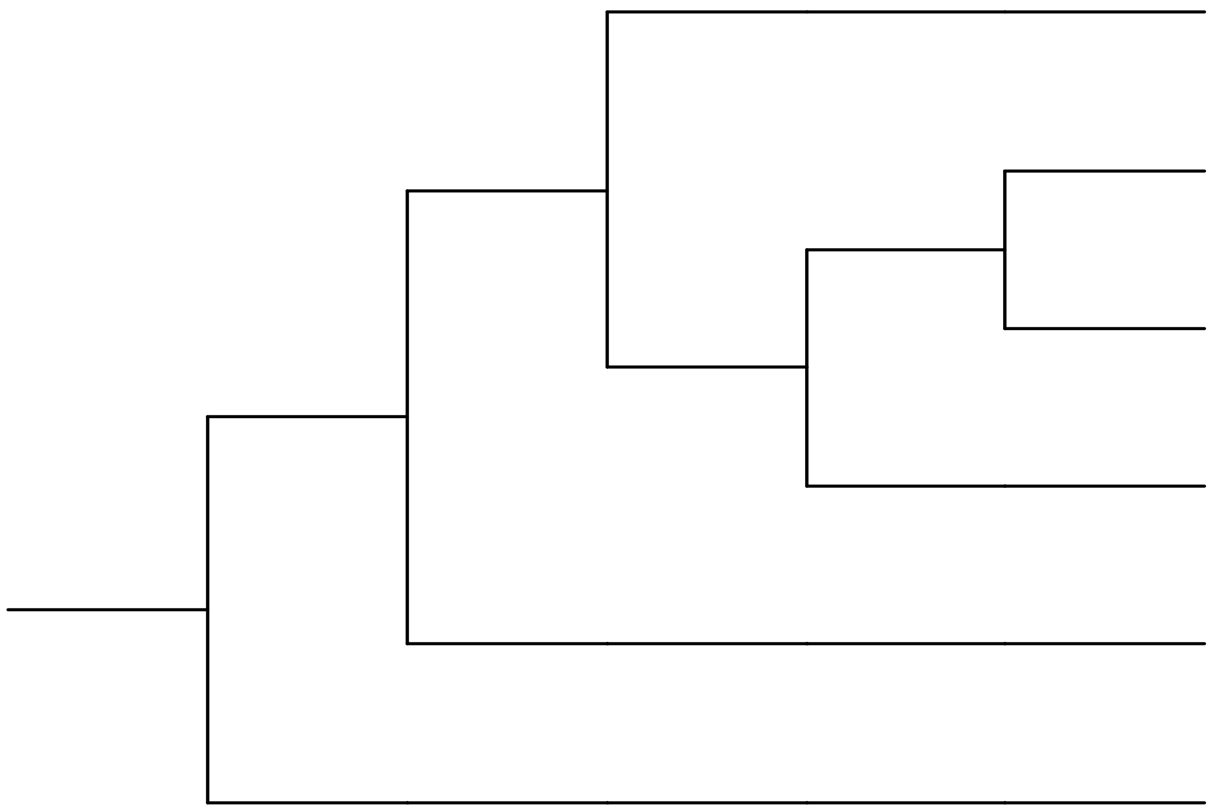
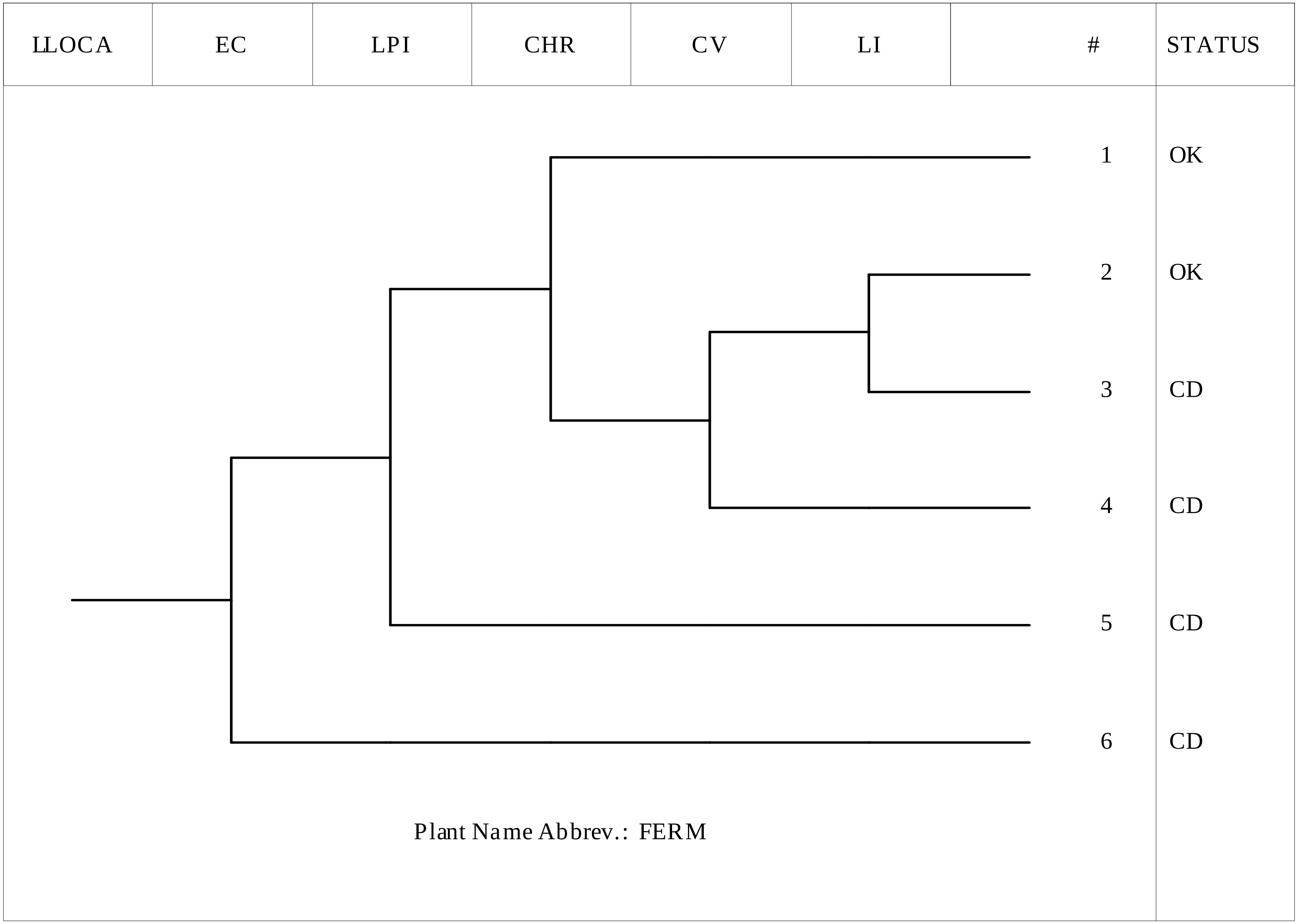
2 OK
3 CD
4 CD
5 OK
6 OK
7 CD
8 CD
9 OK
10 OK
11 CD
12 CD
13 CD
14 OK
15 OK
16 CD
17 CD
18 CD
19 CD
Plant Name Abbrev.: FERM

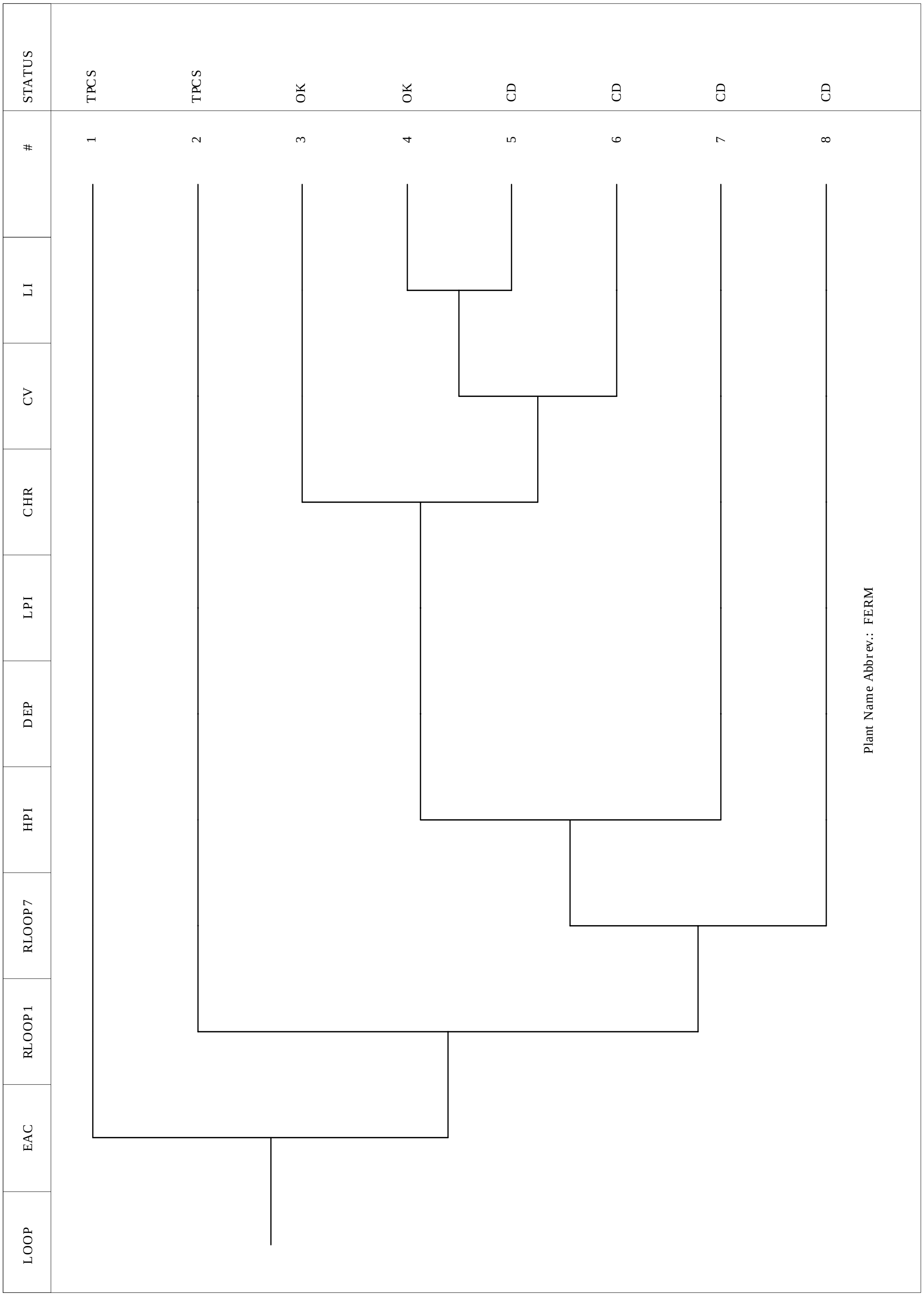
MLOCA	EC	LPI	CHR	CV	LI	#	STATUS



#	STATUS
1	OK
2	OK
3	CD
4	CD
5	CD
6	CD

Plant Name Abbrev.: FERM


LLOCA
EC
LPI
CHR
CV
LI
#
STATUS
1 OK
2 OK
3 CD
4 CD
5 CD
6 CD
Plant Name Abbrev.: FERM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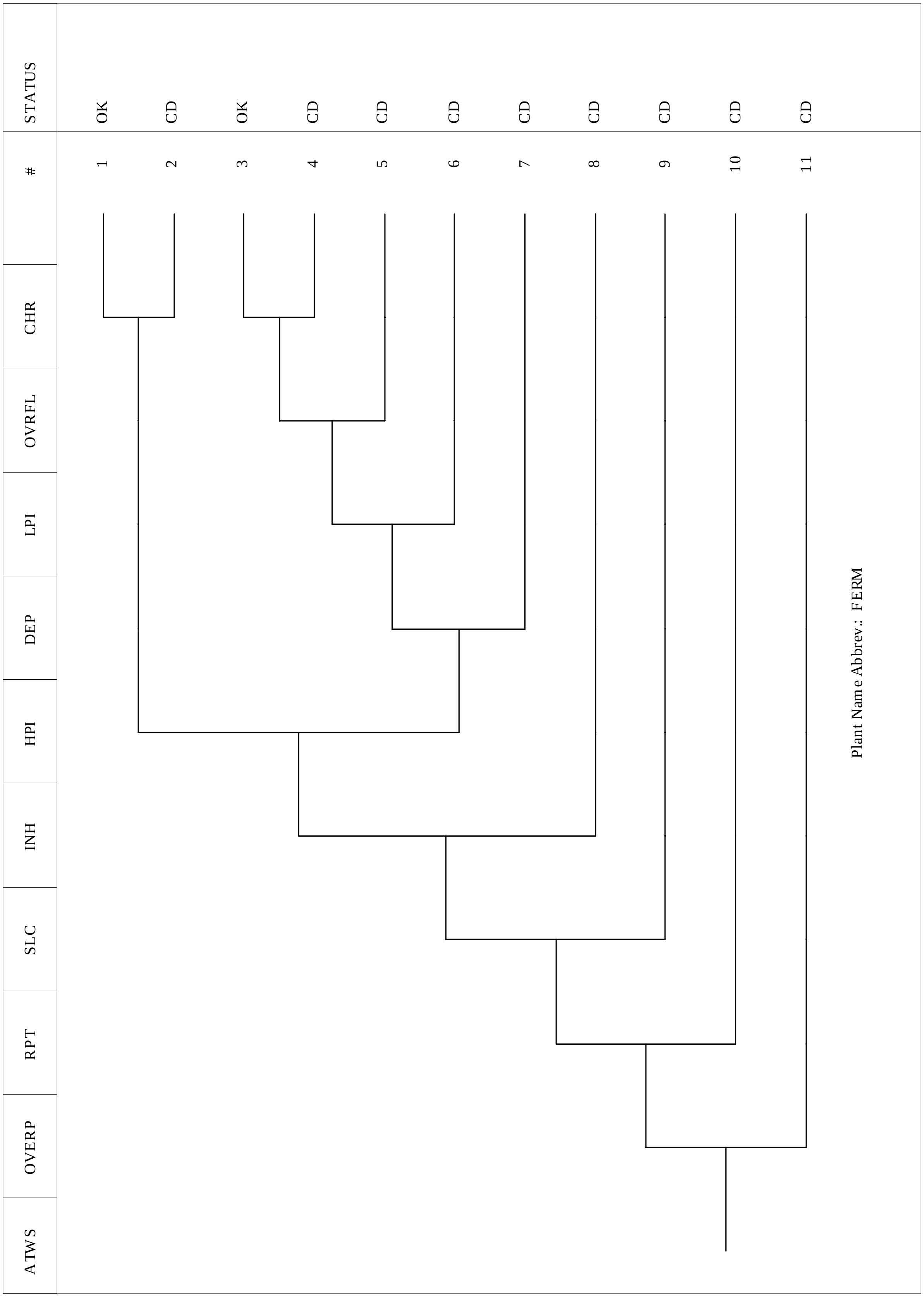
#
LI
CV
CHR
LPI
DEP
HPI
RLOOP7
RLOOP1
EAC
LOOP
TPCS 1
TPCS 2
OK 3
OK 4
CD 5
CD 6
CD 7
CD 8
Plant Name Abbrev.: FERM



ATWS
OVERP
RPT
SLC
INH
HPI
DEP
LPI
OVRFL
CHR
#
STATUS
1 OK
2 CD
3 OK
4 CD
5 CD
6 CD
7 CD
8 CD
9 CD
10 CD
11 CD
Plant Name Abbrev.: FERM

2. RESOLUTION AND DISPOSITION OF COMMENTS

This section is composed of two subsections. Subsection 2.1 summarizes the generic assumptions that were used for developing the SDP worksheets for the BWR plants. These guidelines were based on the plant-specific comments provided by the licensee on the draft SDP worksheets and further examination of the applicability of those comments to similar plants. These assumptions which are used as guidelines for developing the SDP worksheets help the reader better understand the worksheets' scope and limitations. The generic guidelines and assumptions for BWRs are given here. Subsection 2.2 documents the plant-specific comments received on the draft version of the material included in this notebook and their resolution.

2.1 GENERIC GUIDELINES AND ASSUMPTIONS (BWRs)

Initiating Event Likelihood Rating Table

1. Assignment of plant-specific IEs into frequency rows:

Transient (Reactor trip) (TRANS), transients without PCS (TPCS), small, medium, and large LOCA (SLOCA, MLOCA, LLOCA), inadvertent or stuck-open SRVs (IORV), anticipated transients without scram (ATWS), interfacing system LOCA (ISLOCA), and LOCA outside containment (LOC) are assigned into rows based on consideration of industry-average frequency. Plant-specific frequencies can be different, but are not considered. Plant-specific frequencies for LOOP and special initiators are used to assign these initiating events.

2. Inclusion of special initiators:

The special initiators included in the worksheets are those applicable for the plant. A separate worksheet is included for each of the applicable special initiators. The applicable special initiators are primarily based on the plant-specific IPEs. In other words, the special initiator included are those modeled in the IPEs unless it is shown to be a negligible contributor. In some cases, in considering plants of similar design, a particular special initiator may be added for a plant even if it is not included in the IPE if such an initiator is included in other plants of similar design and is considered applicable for the plant. Except for the interfacing system LOCA (ISLOCA) and LOCA outside containment (LOC), if the occurrence of the special initiator results in a core damage, i.e., no mitigation capability exists for the initiating event, then a separate worksheet is not developed. For such cases, the inspection focus is on the initiating event and the risk implication of the inspection finding can be directly assessed. For ISLOCA and LOC, a separate worksheet is included noting the pathways that can lead to these events.

3. Inadvertent or stuck open relief valve as an IE in BWRs:

Many IPEs/PRAs model this event as a separate initiating event. Also, the failure of the SRVs to re-close after opening can be modeled within the transient tree. In the SDP worksheet, these events are modeled in a separate worksheet (and, are not included in the transient worksheets) considering both inadvertent opening and failure to re-close. We typically consider a single valve is stuck or inadvertently open. The frequency of this initiator is generically estimated for all BWR plants. This IE may behave similar to a small or medium LOCA depending on the valve size, and the mitigation capability is addressed accordingly.

4. LOCA outside containment (LOC):

A LOCA outside of containment (LOC) can be caused by a break in a few types of lines such as Main Steam or Feedwater. LOC is treated differently among the IPEs. Separate ETs are usually not developed in the IPEs for LOCs. Thus, credit is usually not taken for mitigating actions. LOC sequences typically have a core damage frequency in the E-8 range. As such, LOCs are included

together with ISLOCAs in a separate summary type SDP worksheet. Plant specific notes are included to explain how the particular IPE has addressed LOCs.

Initiating Event and System Dependency Table

1. Inclusion of systems under the support system column:

This table shows the support systems for the support and frontline systems. Partial dependency, which usually is a backup system, is not expected to be included. If included, they should be so noted. The intent is to include only the support system and not the systems supporting the support system, i.e., those systems whose failure will result in failure of the system being supported. Sometimes, some subsystems on which inspection findings may be noted have been included as a support system, e.g., EDG fuel oil transfer pump as a support system for EDGs.

2. Coverage of system/components and functions included in the SDP worksheets:

The Initiators and System Dependency Table includes systems and components which are included in the SDP worksheets and those which can affect the performance of these systems and components. One to one matching of the ET headings/functions to that included in the Table was not considered necessary.

SDP Worksheets and Event Trees

1. Crediting of non-safety related equipment:

SDP worksheets credit or include safety-related equipment and also, non-safety related equipment as used in defining the accident sequences leading to core damage. In defining the success criteria for the functions needed, the components included are typically those covered under the Technical Specifications (TS) and the Maintenance Rule (MR). No evaluation was performed to assure that the components included in the worksheets are covered under TS or MR. However, if a component was included in the worksheet, and the licensee requested its removal, it may not have been removed if it is considered that the components is included in either TS or MR.

2. No credit for certain plant-specific mitigation capability:

The significance determination process (SDP) screens inspection findings for Phase 3 evaluations. Some conservative assumptions are made which result in not crediting some plant-specific features. Such assumptions are usually based on comparisons with plants of similar design and to maintain consistency across the SDP worksheets of similar plant designs.

3. Crediting system trains with high unavailability

Some system component/trains may have unavailability higher than 1E-2, but they are treated in a manner similar to other trains with lower unavailability in the range of 1E-2. In this screening approach, this is considered adequate to keep the process simple. An exception is made for steam-driven components which are designated as automatic steam driven (ASD) train with a credit of 1, i.e., an unavailability in the range of !E-1.

4. Treating passive components (of high reliability) same as active components:

Passive components, namely isolation condensers in some BWRs, are credited similar to active components. The reliability of these components are not expected to differ (from that of active components) by more than an order of magnitude. Pipe failures have been excluded in this process except as part of initiating events where appropriate frequency is used. Accordingly, a separate designation for passive components was not considered necessary.

5. Defining credits for operator actions:

The operator's actions modeled in the worksheets are categorized as follows: operator action=1 representing an error probability of 5E-2 to 0.5; operator action=2 representing an error probability of 5E-3 to 5E-2; operator action=3 representing an error probability of 5E-4 to 5E-3; and operator action=4 representing an error probability of 5E-5 to 5E-4. Actions with error probability > 0.5 are not credited. Thus, operator actions are associated with credits of 1, 2, 3, or 4. Since there is large variability in similar actions among different plants, a survey of the error probability across plants of similar design was used to categorize different operator actions. From this survey, similar actions across plants of similar design are assigned the same credit. If a plant uses a lower credit or recommends a lower credit for a particular action compared to our assessment of similar action based on plant survey, then the lower credit is assigned. An operator's action with a credit of 4, i.e., operator action=4, is noted at the bottom of the worksheet; the corresponding hardware failure, e.g., 1 multi-train system, is defined in the mitigating function.

6. Difference between plant-specific values and SDP designated credits for operator actions:

As noted, operator actions are assigned to a particular category based on review of similar actions for similar design plants. This results in some differences between plant-specific HEP values and credit for the action in the worksheet. The plant-specific values are usually noted at the bottom of the worksheet, when available.

7. Dependency among multiple operator actions:

IPEs or PRAs, in general, account for dependencies among multiple operator actions that may be applicable. In this SDP screening approach, if multiple actions are involved in one function, then the credit for the function is designated as one operator action considering the dependency involved.

8. Crediting late injection (LI) following failure of containment heat removal (CHR), i.e., suppression pool cooling:

Following successful high or low pressure injection, suppression pool cooling is modeled. Upon failure of suppression pool cooling, containment venting (CV) is considered followed by late injection. Late injection is credited if containment venting is successful. Further, LI is required following CV success. The suction sources for the LI systems credited are different from the suppression pool. HPCI, LPCI, and CS are not credited in late injection. No credit is given for LI following failure of CV. The survival probability is low and such details are not considered in the screening approach here.

9. Combining late injection (LI) with low pressure injection (LPI) or containment venting (CV):

In some modeling approaches, LI is combined with LPI or CV. In the SDP worksheet approach here, these functions are separate. As discussed above, LPI and LI use different suction sources, and CV and LI may be two different categories of operator actions. In these respects, for some plants, SDP event trees may be different than the plant-specific trees.

10. Crediting condensate trains as part of multiple functions: power conversion system (PCS), low pressure injection (LPI), and late injection (LI):

Typically, condensate trains can be used as an LPI and LI source in addition to its use as part of the power conversion system. However, crediting the same train in multiple functions can result in underestimation of the risk impact of an inspection finding in the SDP screening approach since it does not account for these types of dependencies in defining the accident sequences. To simplify the process and to avoid underestimation, condensate train is not credited in LPI, but may be credited in LI.

11. Modeling vapor suppression success in different LOCA worksheets:

Vacuum breakers typically must remain closed following a LOCA to avoid containment failure and core damage. Some plants justify that vapor suppression is not needed for SLOCA. These sequences typically have low frequency and are not among the important contributors. However, an inspection finding on these vacuum breakers may make these sequences a dominant contributor. Accordingly, success of vapor suppression is included in the SDP worksheets. It is included for all three LOCA worksheets (LLOCA, MLOCA, and SLOCA); for plants presenting justification that they are not needed in a SLOCA appropriate modifications are made.

12. ATWS with successful PCS as a stable plant state:

Some plants model a stable plant state when PCS is successful following an ATWS. Following our comparison of similarly designed plants, such credits are not given.

13. Modeling different EDG configurations, SBO diesel, and cross-ties:

Different capabilities for on-site emergency AC power exist at different plant sites. To treat them consistently across plants, they are typically combined into a single emergency AC (EAC) function. The dedicated EDGs are credited following the standard convention used in the worksheets for equipment (1 dedicated EDG is 1 train; 2 or more dedicated EDGs is 1 multi-train system). The use of the swing EDG or the SBO EDG requires operator action. The full mitigating capability for emergency AC could include dedicated Emergency Diesel Generators (EDG), Swing EDG, SBO EDG, and finally, nearby fossil-power plants. The following guidelines are used in the SDP modeling of the Emergency AC power capability:

1. Describe the success criteria and the mitigation capability of dedicated EDGs.

2. Assign a mitigating capability of “operator action=1" for a swing EDG. The SDP worksheet assumes that the swing EDG is aligned to the other unit at the time of the

LOOP (in a sense a dual unit LOOP is assumed). The operator, therefore, should trip, transfer, re-start, and load the swing EDG.

3. Assign a mitigating capability of “operator action=1" for an SBO EDG similar to the swing EDG. Note, some of the plants do not take credit for an SBO EDG for non-fire initiators. In these cases, credit is not given.

4. Do not credit the nearby power station as a backup to EDGs. The offsite power source from such a station could also be affected by the underlying cause for the LOOP. As an example, overhead cables connecting the station to the nuclear power plant also could have been damaged due to the bad weather which caused the LOOP. This level of detail should be left for a Phase 3 analysis.

14. Recovery of losses of offsite power:

Recovery of losses of offsite power is assigned an operator-action category even though it is usually dominated by a recovery of offsite AC, independent of plant activities. Furthermore, the probability of recovery of offsite power in “X” hours (for example 4 hours) given it is not recovered earlier (for example, in the 1st hour) would be different from recovery in 4 hours with no condition. The SDP worksheet uses a simplified approach for treating recovery of AC by denoting it as an operator action=1 or 2 depending upon the HEP used in the IPE/PRA. A footnote highlighting the actual value used in the IPE/PRA is provided, when available.

15. Mitigation capability for containment heat removal:

The mitigation capability for containment heat removal (CHR) function is considered dominated by the hardware failure of the RHR pumps. The applicable operator action is categorized as an operator action with a credit 4, i.e., operator action=4. For this situation, the function is defined as 1 multi-train system since the operator action involved is considered routine and reliable, and is assigned a credit of 4. No other operator action in the worksheets is generically assigned this high credit.

16. Crediting CRD pumps as an alternate high pressure injection source:

In many plants, CRD pumps can be used as a high pressure injection source following successful operation of HPCI or RCIC for a period of time, approximately 1 to 2 hours. In some plants, CRD system is enhanced where it can be directly used and does not need the successful operation of other HPI sources. In the worksheets, if the CRD pumps require prior successful operation of HPCI or RCIC as a success criteria, then CRD is not credited as a separate high pressure injection source. If the CRD can be used and does not require successful operation of HPCI or RCIC, then it is credited as a separate success path within the HPI function.

2.2 RESOLUTION OF PLANT-SPECIFIC COMMENTS

Changes to this document were based upon a meeting held on May 25, 2000 between the NRC, Detroit Edison, and BNL at the Fermi 2 site and upon information provided from the updated Fermi 2 PSA dated August, 1997 and titled PSA-97C. The comments and related changes are grouped into three areas below: major changes, changes to Table 1, and changes to the worksheets.

Major Changes

Updated Table 1, the worksheets, and the event trees (ETs) based upon information received on the design and modeling of the containment venting (CV) system, the related impact of CV on LPI, and the need for LI after successful venting.

Developed worksheets on the following five special initiators: Loss of DC, Loss of Instrument Air, Loss of General Service Water, Loss Div I Offsite Power, and Loss Div II Offsite Power.

Changes to Table 1, System Dependency Table

Added more detail on AC and DC power systems.

Added a row for the N_2 System.

Added condensate transfer as a support system to HPCI, RCIC, SBFW, and CRD.

Made a few changes to the support systems and major components.

Made several minor editorial changes.

Changes to Worksheets

Made minor changes to success criteria for PCS.

Changed the number of SRVs required for DEP from 1 to 2 in most sequences (except 4 in ATWS).

The licensee requested that credit be added for SBFW to LPI, however this was not added due to double counting of adding it to both HPI and LPI functions. Added credit for CRD and SBFW to LI. Also, on MLOCA & LLOCA the licensee specified that CV was to be successful if SBFW and CRD were available and if LPI was successful. LPI was addressed via the ET model. SBFW and CRD were addressed via the LI function.

Added credit for RCIC and SBFW as HPI for the SORV sequence.

Added credit for successful CV and LI; and added the CHR - LI core damage sequence.

Deleted credit for condensate as part of LPI or LI. Condensate transfer is used as a support system to HPCI, RCIC, SBFW, and CRD.

Updated the HEP information for operator actions.

Deleted the requirement for EC on SORV sequences. Also on the SORV sequences, added more detail on HPI and noted the difference in success criteria between steam-driven and motor-driven HPI.

Adjusted the LOOP ET and sequences.

Added a requirement for ADS inhibit on ATWS sequences. Clarified the reactivity control mitigating systems for ATWS.

Confirmed the need for all vacuum breakers to remain closed for the MLOCA and LLOCA sequences.

REFERENCES

1. NRC SECY-99-007A, Recommendations for Reactor Oversight Process Improvements (Follow-up to SECY-99-007), March 22, 1999.

2. Detroit Edison, "Fermi 2 Nuclear Plant Individual Plant Examination Submittal Report," dated August, 1992 and Rev. 1, dated 4/28/93, and RAI responses dated 9/22/93 and 6/30/94.

3. Detroit Edison updated Probabilistic Safety Analysis, PSA-97C, dated August, 1997.