June 8, 2001

Mr. L. W. Myers
Senior Vice President
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Beaver Valley Power Station
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SUBJECT: SITE-SPECIFIC WORKSHEETS FOR USE IN THE NUCLEAR REGULATORY COMMISSION'S SIGNIFICANCE DETERMINATION PROCESS FOR BEAVER VALLEY POWER STATION UNIT NOS. 1 AND 2 (TAC NO. MA6544)

Dear Mr. Myers:

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 will also be publicly available through the Nuclear Regulatory Commission (NRC) external website at http://www.nrc.gov/NRC/IM/index.html.

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 Worksheets give inaccurately low significance determinations. Any comments should be provided to the Document Control Desk, with a copy to the Chief, Probabilistic Safety Assessment Branch, Office of Nuclear Reactor Regulation. 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.

Sincerely,

/RA/

Lawrence J. Burkhart, Project Manager, Section 1
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-334 and 50-412

Enclosures: 1. Risk-Informed Notebook for Beaver Valley Unit 1
2. Risk-Informed Notebook for Beaver Valley Unit 2

cc w/encls: See next page

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RISK-INFORMED INSPECTION NOTEBOOK FOR

BEAVER VALLEY UNIT 1

PWR, WESTINGHOUSE, THREE-LOOP PLANT WITH SUB-ATMOSPHERIC CONTAINMENT

Prepared by

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Enclosure 1

NOTICE

This notebook was developed for the NRC's inspection teams to support risk-informed inspections. The activities involved in these inspections are discussed in "Reactor Oversight Process Improvement," SECY-99-007A, March 1999. 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. This notebook 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 Beaver Valley Unit 1 .

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.

CONTENTS

TABLES

FIGURES

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. The first step in this 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 Event Categories
2. Initiators and System Dependency Table
3. Significance Determination Process (SDP) Worksheets
4. SDP Event Trees.

Table 1, Categories of Initiating Events, is used to estimate the likelihood rating for different initiating events for a given degraded condition and the associated exposure time at the plant. This Table follows the format of Table 1 in SECY-99-007A. Initiating events are grouped in frequency bins that are one order of magnitude apart. The Table includes the initiating events that should be considered for the plant and for which SDP worksheets are provided. The following initiating events are categorized by 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); main steam line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCA (ISLOCA). The frequency of the remaining initiating events vary significantly from plant to plant, and accordingly, they are categorized by plant-specific frequency obtained from the licensee. They include loss of offsite power (LOOP) and special initiators caused by loss of support systems.

The Initiators 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 known in Probabilistic Risk Assessments (PRAs). For pressurized water reactors (PWRs), the support systems/success criteria for Reactor Coolant Pump (RCP) seals are explicitly denoted to assure that the inspection findings on them are properly accounted for. This Table is used to identify the SDP worksheets to be evaluated, corresponding to the inspection's findings on systems and components.

To evaluate the impact of the inspection's findings on the core-damage scenarios, SDP worksheets are provided. There are two sets of SDP worksheets; one for those initiators that can be mitigated by redundant trains of safety systems, and the other for those initiators that cannot be mitigated; however, their occurrence is prevented by several levels of redundant barriers.

The first set of SDP worksheets contain two parts. The first identifies the functions, the systems, or combinations thereof that have mitigating functions, the number of trains in each system, and the number of trains required (success criteria) for 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 parenthesis next to each sequence, the corresponding event-tree branch number(s) representing the sequence is given. Multiple branch numbers indicate that the different accident sequences identified by the event tree have been merged into one through Boolean reduction. The SDP worksheets are developed for each of the initiating event categories, including the "Special Initiators", the exception being those which directly lead to a core damage (the inspections of these initiators are assessed differently; see SECY-99-007A). The special initiators are those that are caused by complete or partial loss of support systems. A special initiator typically leads to a reactor scram and degrades some frontline or support systems (e.g., Loss of CCW in PWRs).

In considering the special initiators, we defined a set of criteria for including them 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 thereby changing its mitigation capability in the worksheet. For example, when a safety function with two redundant trains, classified as a multi-train system, degrades to a one-train system, it is 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 systems/functions associated with the initiator from comparable transient sequences by two and higher orders of magnitude must be considered.

From the above considerations, the following classes of initiators are considered in this notebook:

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. Stuck-open Power Operated Relief Valve (SORV),
5. Medium LOCA (MLOCA),
6. Large LOCA (LLOCA),
7. Steam Generator Tube Rupture (SGTR),
8. Anticipated Transients Without Scram (ATWS), and
9. Main Steam Line Break (MSLB).

Examples of special initiators included in the notebook are as follows:

1. Loss of Offsite Power (LOOP),
2. LOOP with failure of 1 Emergency AC bus or associated EDG (LEAC),
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 includes 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. In some plants, LOOP with failure of 1 EAC bus is a large contributor to the plant's core damage frequency (CDF).

The second set of SDP worksheets addresses those initiators that cannot be mitigated, i.e., can directly lead to core-damage. It currently includes the Interfacing System LOCA (ISLOCA) initiator. ISLOCAs are those initiators that could result in a loss of RCS inventory outside the containment, sometimes referred to as a "V" sequence. In PWRs, this event effectively bypasses the capability to utilize the containment sump recirculation once the RWST has emptied. Also, through bypassing the containment, the radiological consequences may be significant. In PWRs, this typically includes loss of RCS inventory through high- and low-pressure interfaces, such as RHR connections, RCP thermal barrier heat-exchanger, high-pressure injection piping if the design pressure (pump head) is much lower than RCS pressure, and, potentially, through excess letdown heat exchanger. RCS inventory loss through ISLOCA could vary significantly depending on the size of the leak path; some may be recoverable with minimal impact. The SDP worksheet for ISLOCA, therefore, identifies the major consequential leak paths, and the barriers that should fail, allowing the initiator to occur.

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.

The following items were considered in establishing the SDP event trees and the core-damage sequences in the SDP worksheets:

1. Event trees and sequences were developed such that the worksheet contains all the major accident sequences identified by the plant-specific IPEs/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 take into account the IPE/PRA models and event trees for all similar plants. For modeling the response to an initiating event, any major deviations in one plant from similar plants may be 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 developed 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/PRAs often are represented by a single tree. For example, some IPEs/PRAs define four classes of LOCAs rather than the three classes considered here. The sizes of LOCAs for which high-pressure injection is not required are sometimes divided into two classes, the only difference between them being the need for reactor scram in the smaller break size. There may be some consolidation of transient event trees 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 Categories for Initiating Events Table, Initiators and Dependency Table, SDP worksheets, and the SDP event trees for Beaver Valley Unit 1.

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 (binned) into rows based on their frequency. The table includes the initiators and the assigned bins in the SECY-99-007A. The table also includes the plant specific bins for loss of offsite power frequency, and the special initiators caused by loss of support systems.

Table 1 Categories of Initiating Events for Beaver Valley Unit 1

Row	Approximate Frequency	Example Event Type	Estimated Likelihood Rating		
I	> 1 per 1-10 yr	Reactor Trip (Trans), Loss of Power Conversion System (TPCS)	A	B	C
II	1 per 10-10^2 yr	Loss of offsite power (LOOP), Loss of Instrument Air (LOIA), Loss of a 4.2 kV AC Bus (orange or purple) (LAC), Loss of a 125 DC Bus (orange or purple) (LDC)	B	C	D
III	1 per 10^2 - 10^3 yr	SGTR, Stuck open PORV/SRV (SORV), Small LOCA including RCP seal failures (SLOCA), MSLB (outside containment)	C	D	E
IV	1 per 10^3 - 10^4 yr	Medium LOCA (MLOCA), LOOP with loss of one division of emergency AC (LEAC)	D	E	F
V	1 per 10^4 - 10^5 yr	Large LOCA (LLOCA)	E	F	G
VI	less than 1 per 10^5 yr	ATWS, ISLOCA	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. 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). Any inspection finding that represents a loss of capability for manual reactor trip for a postulated ATWS scenario should be evaluated by a risk analyst to consider the probability of a successful manual trip.

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 involvements in different initiating events are noted in the last column.

Table 2. Initiators and System Dependency for Beaver Valley Unit 1

Affected Systems	**Major Components**	**Support Systems**	**Initiating Event Scenarios**
Reactor Coolant Pumps (RCPs)	Pumps 1A, 1B, 1C	Normal AC power, RPCCW, CIA[(1)], SIA[(1)], SSPS, 125 VDC	SLOCA
PORVs	PORV 455 C&D, 456 Block Valves 535, 536, 537	125 V-DC, 480V AC (Block Valves), Containment IA, Backup N_2 (PORV 455 C&D, PORV 456)	All except LLOCA and MLOCA
Main and Dedicated Feed Water (MFW and DFP[(2)])	MFW Pumps P1A, P1B, DFW Pump P4[(2)]	Normal AC power, TPCCW, DC Battery 1-5, SSPS, ERF DG (DFP P4)	Transient, SLOCA, SORV, LOOP, SGTR
Condensate Pump	2 condensate pumps	Normal AC power, TPCCW, Normal 125V DC Supply Battery 1-5	Transient, SLOCA, SORV, SGTR
AFW	2 MDPs	4.16 kV EAC, EDG, 125V DC, SSPS	All except MLOCA and LLOCA
	1 TDP	125V DC, SSPS	
RHR	Pumps P1A, P1B	4.16 kV EAC, EDG, 125V DC, RPCCW, SSPS	SGTR
HHSI[(3)]	Pumps P1A, P1B, P1C[(3)]	4.16 kV EAC, EDG, 125V DC, SSPS, River Water Header	All except LLOCA
Boric Acid Transfer (BAT) Pumps	2 pumps	480V AC	ATWS
LHSI	Pumps P1A, P1B	4.16 kV EAC, EDG, 125V DC, SSPS	All except ATWS
	MOVs	4.16 kV EAC, EDG	
RWST Level	LT 100 A, B, C, D	Vital Bus I, II, III, IV; SSPS	SGTR

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
Quench Spray (QS)	Pumps P1A, P1B	4.16 kV EAC, EDG, 125V DC, SSPS	LLOCA
Recirculation Spray (RS)	Pumps P1A, P1B, P2A, P2B	4.16 kV EAC, EDG, 125V DC, SSPS	All except ATWS
	Hx E1A, E1B, E1C, E1D	River Water Header A, B	
RPCCW	Pump 1A (normally running), Pump 1B (Auto backup), Pump 1C (manual Backup)	4.16 kV EAC, 125V DC, River Water Header, Vital Bus Channel I&II	SLOCA, SGTR
TPCCW	Pump CCP-3A (normally running), Pump-3B (auto backup)	Normal AC power, Normal DC Battery 1-5, Raw Water	All
	Pump WR-P-6A (normally running), Pump WR–6B (auto backup) Pump WR-P-12A (normally running), Pump WR-P-12B (auto backup)	Normal AC power, Normal DC Battery 1-5, Raw Water	
Emergency AC (EAC)	4.16 kV / 480 V-AC Train A, B	Vent. System	LAC
Emergency Diesel Generator (EDG)	EDG 1-1, 1-2	125V DC, River Water Header, EDG Vent. System, SSPS, Vital Bus Channel I, II; fuel oil system	LOOP, LEAC
	ERF DG (Black)	Vent. System, ERF Batteries	LOOP
125 V-DC	Trains A, B; Batteries	4.16 kV EAC, EDG, Vent. System	LDC
Solid State Protection System (SSPS)	Trains A, B	Vital Bus Channel I, II, II, IV; Vent. System	All

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Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
River Water Header	Headers A,B; 3 river water pumps & 2 auxiliary river water pumps[4]	4.16 kV EAC, EDG, 125V DC, SSPS, Vent. System	All
Ventilation System	Chilled water cooling coils, exhaust fans	4.16 kV EAC, EDG, TPCCW, Chilled Water	All
EDG Vent. System	1 Exhaust Fan per room	4.16 kV EAC	LOOP, LEAC
Containment Instrument Air (CIA)	2 containment instrument air compressors	4.16 kV EAC, EDG, Chilled water, SIA	All except LLOCA and MLOCA
Station Instrument Air (SIA)	2 station air compressors	Normal AC power, TPCCW (filtered water system as backup)[5], Normal 125V DC Supply Battery 1-5	LOIA
Chilled Water System		Normal AC power, Normal 125V DC Supply Battery 1-5	All

Notes:

1. The loss of CIA and SIA causes air-operated isolation valves for the RCP thermal barriers, motor, and bearings to fail closed. RCP seal cooling must then be provided by seal injection and the RCPs must be stopped. Loss of power to vital bus channels I & II can result in the RCP thermal barrier cooling isolation valves closings.

2. The dedicated feed pump (FW-P-4) is powered off the 4160V AC ERF Substation bus 1H. The bus is normally supplied from the offsite grid. During a LOOP, the ERF (black) Diesel Generator supplies power to bus 1H.

3. HHSI consists of two trains. HHSI pump P1C can be manually aligned to either train of electric power, but cannot be racked in unless the other charging pump is racked out from the same bus.

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Table 2 (Continued)

4. One river water pump (WR-P-1A) is normally operating. The second river water pump (WR-P-1B) is off and in "auto" position. The third pump (WR-P-1C) is racked out and is in disconnected position. The 1C pump can be manually aligned to either the A or B header. The auxiliary river water pumps (WR-P-9A and WR-P-9B) are in off position.

5. The station air compressors fail on loss of TPCCW. Backup cooling can be provided from the filtered water system.. The station air compressors fail on loss of offsite AC. A third diesel driven compressor can be run manually and locally (Turbine Bldg). The diesel driven compressor is air cooled, but the aftercooler requires TPCCW. Filter water pump 2B provides cooling to the compressor and is manually loaded on ERF diesel.

   The plant internal event (including internal floods) CDF is 6.2E-5/yr.

1.3 SDP WORKSHEETS

This section presents the SDP worksheets to be used in the Phase 2 evaluation of the inspection findings for the Beaver Valley Unit 1 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 PORV (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Offsite Power (LOOP)
8. Steam Generator Tube Rupture (SGTR)
9. Main Steam Line Break (MSLB)
10. Anticipated Transients Without Scram (ATWS)
11. Loss of a 4.2 kV AC Bus (Orange or Purple) (LAC)
12. Loss of a DC Bus (1-1 Orange or 1-2 Purple) (LDC)
13. Loss of Station Instrument Air (LOIA)
14. LOOP with Loss of a 4 kV Bus
15. Containment Bypass LOCA (ISLOCA)

Table 3.1 SDP Worksheet for Beaver Valley 1 — 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)	1/2 Main Feedwater (MFW) trains and 1/2 Condensate pump trains or 1/1 dedicated feed pump (DFP) (operator action = 3) (1)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train)
Early Inv., High Pressure Injection (EIHP)	1/2 Charging pump trains or use of 1 spare charging pump (2) (1 multi-train system).
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (3)
High Pressure Recirculation (HPR)	1/2 charging pump trains with 1/2 LHSI or 1/2 RS (2A or 2B) pumps (1 multi-train system) (4)
Recirculation Spray (RS)	1/2 Inside RS (1A or 1B) pumps or 1/2 Outside RS (2A or 2B) pumps (1 multi-train system) (5)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TRANS - AFW - PCS - RS (4)			
2 TRANS - AFW - PCS - HPR (5)			
3 TRANS - AFW - PCS - FB (6)			
4 TRANS - AFW - PCS - EIHP (7)			

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 dedicated feed pump does not depend on the condensate pumps. The HEP for failure to recover Feedwater or start the dedicated feed pump following failure of the AFW pumps is 3E-04. A credit of 3 is assigned based on survey of similar plants.

(2) The spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

3. The human error probability (HEP) assessed in the IPE (page 3.3-117) for establishing bleed and feed cooling is 1.39E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW and the dedicated feed pump).

4. The transfer to recirculation function receives an automatic signal from the RWST level instruments. Operator action is needed for alignment of RS pumps, in case of failure of the LHSI pumps. The HEP for aligning RS pumps is ~3.0E-3. Heat exchangers are bypassed at BV-1 in HPR, therefore RS function is required for containment heat removal.

5. There are commonalities between the inside and outside recirculation system. Same support systems (electrical supplies and river water headers) apply to both the systems. The mitigation credit is accordingly designated as “1 multi-train system”.

Table 3.2 SDP Worksheet for Beaver Valley 1 — Transients without PCS (TPCS)

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:**
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) with 1/3 SG ASDs or 1/15 SG Safety valves
Early Inv., High Pressure Injection (EIHP)	1/2 Charging pumps or use of 1 spare charging pump (1) (1 multi-train system).
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (2)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 LHSI or 1/ 2 RS (2A or 2B) pumps (1 multi-train system) (3)
Recirculation Spray (RS)	1/2 Inside RS (1A or 1B) pumps or 1/2 Outside RS (2A or 2B) pumps (1 multi-train system) (4)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TPCS - AFW - RS (3)			
2 TPCS - AFW - HPR (4)			
3 TPCS - AFW - FB (5)			
4 TPCS - AFW - EIHP (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.

<u>Notes</u>:

1. The spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

2. The human error probability (HEP) assessed in the IPE (page 3.3-117) for establishing bleed and feed cooling is 1.39E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW and the dedicated feed pump).

3. The transfer to recirculation function receives an automatic signal from the RWST level instruments. Operator action is needed for alignment of RS pumps, in case of failure of the LHSI pumps. The HEP for aligning RS pumps is ~3.0E-3. Heat exchangers are bypassed at BV-1 in HPR, therefore RS function is required for containment heat removal.

4. There are commonalities between the inside and outside recirculation system. Same support systems (electrical supplies and river water headers) apply to both the systems. The mitigation credit is accordingly designated as “1 multi-train system”.

Table 3.3 SDP Worksheet for Beaver Valley Unit 1 — Small LOCA (SLOCA)

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:**
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare pump [1] (1 multi-train system).
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train)
Main Feedwater or Dedicated FWP (FW)	Operator initiates 1/2 main feed pump with 1/2 condensate pump trains or dedicated FP (operator action = 2)
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS using 1/3 SG ASDs and pressurizer sprays (operator action = 3)
Primary Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) [2]
Rapid Depressurization (RAPDEP)	Rapid depressurization using 1/3 SG ASDs, 1/2 LHSI pumps and 2/3 accumulators (operator action = 2) [3]
Low Pressure Recirculation (LPR)	1/2 LHSI trains (1 multi-train system) or ½ outside RS(2A or 2B) pumps for recirculation (operator action = 2) [4]
High Pressure Recirculation (HPR)	1/2 charging pumps with ½ LHSI pumps or ½ RS (2A or 2B) pumps (1 multi-train system) [5]
Recirculation Spray (RS)	1/2 inside RS (1A or 1B) pumps or ½ Outside RS (2A or 2B) pumps (1 multi-train systems) [6]

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SLOCA - RS (2, 5, 8, 11, 14, 18)			
2 SLOCA - LPR (3, 9, 19)			
3 SLOCA - RCSDEP - HPR (6, 12)			

4 SLOCA - AFW - FW - HPR (15)			
5 SLOCA - AFW - FW - FB (16)			
6 SLOCA - EIHP - RAPDEP (20)			
7 SLOCA - EIHP - AFW (21)			
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 spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.
2. The human error probability (HEP) assessed in the IPE (page 3-129) for establishing bleed and feed cooling is 1.39E-2.
3. RCS depressurization if EIHP fails following SLOCA is now credited in the licensee PRA.
4. The transfer to recirculation function receives an automatic signal from the RWST level instruments. The outside RS pumps can be used in lieu of the LHSI pumps.

5. The transfer to recirculation function receives an automatic signal from the RWST level instruments. Operator action is needed for alignment of RS pumps, in case of failure of the LHSI pumps. The HEP for aligning RS pumps is ~3.0E-3. Heat exchangers are bypassed at BV-1 in HPR, therefore RS function is required for containment heat removal.

6. There are commonalities between the inside and outside recirculation system. Same support systems (electrical supplies and river water headers) apply to both the systems. The mitigation credit is accordingly designated as “1 multi-train system”.

Table 3.4 SDP Worksheet for Beaver Valley Unit 1 — Stuck Open PORV (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:**
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare charging pump (1) (1 multi-train system).
Isolation of Small LOCA (BLK)	The closure of the block valve associated with stuck open PORV, limited by hardware failure (1 train)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train)
Main Feedwater or Dedicated FWP (FW)	Operator initiates 1/2 main feed pump with 1/2 condensate pump trains or dedicated FP (operator action = 2)
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS using 1/3 SG ASDs and pressurizer sprays (operator action = 3)
Primary Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (2)
Rapid Depressurization (RAPDEP)	Rapid depressurization using 1/3 SG ASDs, 1/ 2 LHSI pumps and 2/3 accumulators (operator action = 2) (3)
Low Pressure Recirculation (LPR)	1/2 LHSI trains (1 multi-train system) or 1/2 outside RS (2A or 2B) pumps for recirculation (operator action = 2) (4)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 LHSI pumps or 1/2 RS pumps (1 multi-train system) (5)
Recirculation Spray (RS)	1/2 inside RS pumps or 1/2 outside RS pumps (1 multi-train system) (6)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SORV - BLK - RS (2, 5, 8, 11, 14, 18)			
2 SORV - BLK - LPR (3, 9, 19)			
3 SORV - BLK - RCSDEP - HPR (6, 12,15)			

4 SORV - BLK - AFW - FW - HPR (15)			
5 SORV - BLK - AFW - FW - FB (16)			
6 SORV - BLK - EIHP - RAPDEP (20)			
7 SORV - BLK - EIHP - AFW (21)			

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 spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.
2. The human error probability (HEP) assessed in the IPE (page 3-129) for establishing bleed and feed cooling is 1.39E-2.
3. RCS depressurization if EIHP fails following SLOCA is now credited in the licensee PRA.
4. The transfer to recirculation function receives an automatic signal from the RWST level instruments. The outside RS pumps can be used in lieu of the LHSI pumps.

5. The transfer to recirculation function receives an automatic signal from the RWST level instruments. Operator action is needed for alignment of RS pumps, in case of failure of the LHSI pumps. The HEP for aligning RS pumps is ~3.0E-3. Heat exchangers are bypassed at BV-1 in HPR, therefore RS function is required for containment heat removal.

6. There are commonalities between the inside and outside recirculation system. Same support systems (electrical supplies and river water headers) apply to both the systems. The mitigation credit is accordingly designated as “1 multi-train system”.

7. No separate event tree is provided. Please refer to the SLOCA event tree.

Table 3.5 SDP Worksheet for Beaver Valley Unit 1 — 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:**
Early Inventory, Accumulators (EIAC)	2/2 remaining accumulators (1 train)
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare charging pump (1) (1 multi-train system).
Low Pressure Injection (LPI)(2)	1/2 LHSI pumps (1 multi-train system)
Low Pressure Recirculation (LPR)(3)	1/2 LHSI pumps (1 multi-train system) or 1/2 RS (2A or 2B) pumps aligned for recirculation (operator action = 2)
Recirculation Spray (RS)	1/2 inside RS (1A or 1B) pumps or 1/2 outside RS (2A or 2B) pumps in spray mode (1 multi-train system)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 MLOCA - RS (2)			
2 MLOCA - LPR (3)			
3. MLOCA - LPI (4)			
4 MLOCA - EIHP (5)			
5. MLOCA - EIAC (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. The spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

2. As per the IPE, both HHSI and LHSI are required for success to cover the full range of medium LOCAs.

3. The transfer to recirculation function receives an automatic signal from the RWST level instruments. The outside RS pumps can be used in lieu of the LHSI pumps.

Table 3.6 SDP Worksheet for Beaver Valley Unit 1 — 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:**
Early Inventory, Accumulators (EIAC)	2/2 remaining accumulators (1 Train)
Early Inventory, LP Injection (LHSI)	1/2 LHSI pump trains (1 multi-train system)
Quench Spray (QS)[(1)]	1/2 QS pumps drawing from RWST (1 multi-train system)
Recirculation Spray (RS)	1/2 inside RS pumps or 1/2 outside RS pumps (1 multi-train system)
Low Pressure Recirculation (LPR)	1/2 LHSI pump trains; auto switchover of cross-over valves (1 multi-train system)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LLOCA - LPR (2)			
2 LLOCA - RS (3)			
3 LLOCA - QS (4)			
4 LLOCA - LHSI (5)			
5 LLOCA - EIAC (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.

Note:

1. A high containment pressure (8 psig) signal initiates both QS pumps. Successful operation of a QS pump is needed to fill the containment sump for required NPSH for both inside and outside RS pumps.

Table 3.7 SDP Worksheet for Beaver Valley Unit 1 — Loss of Offsite Power (LOOP)

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:**
Emergency AC Power (EAC)	1/2 Emergency Diesel Generators (1 multi-train system)
Turbine-driven AFW pump (TDAFW/DFP)	1/1 TDP train of AFW (1 ASD train) or use of DFP using the black EDG (operator action = 1) (1)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) or dedicated feed pump using black EDG (operator action = 1)
Recovery of AC Power in < 2 hrs (REC2)	Operator recovers power within 2 hrs (operator action = 1) (2)
Recovery of AC Power in < 5 hrs (REC5)	Operator recovers power within 5 hrs (operator action = 2) (2, 3)
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare charging pump (1 multi-train system)
Primary Heat Removal (FB)	Operator uses RCS pressurizer 1/3 PORVs and block valves (operator action = 2) (4)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 LHSI pumps or 1/2 RS (2A or 2B) pumps (1 multi-train system) (5)
Recirculation Spray (RS)	1/2 inside RS (1A or 1B)pumps or 1/2 outside RS (2A or 2B) pumps (1 multi-train system) (6)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LOOP - AFW - RS (3)			
2 LOOP - AFW - HPR (4)			
3 LOOP - AFW - FB (5)			
4 LOOP - AFW - EIHP (6)			

5 LOOP - EAC - RS (8,13) (AC recovered)			
6 LOOP - EAC - HPR (9,14) (AC recovered)			
7 LOOP - EAC - EIHP (10,16) (AC recovered)			
8 LOOP - EAC - REC5 (11)			
9 LOOP - EAC - TDAFW/DFP - FB (15) (AC recovered)			
10 LOOP - EAC - TDAFW/DFP - REC2 (17)			

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 use of the dedicated feed pump given failure of the TDAFW pump can be credited when the black EDG is available. An operator action credit of 1 assigned.

2. In IPE, Recovery of AC with AFW, PORV LOCA is assigned a failure probability of 0.15, and Recovery of AC with AFW, No LOCA is assigned a failure probability of 2.2E-2. Using this information, we assigned a credit of 1 for recovery within 2 hrs and a credit of 2 for recovery within 5 hrs.

3. In an SBO situation, a RCP seal LOCA may occur, with subsequent core damage at about 5 hours.
4. The human error probability (HEP) assessed in the IPE (page 3-117) for establishing bleed and feed cooling is 1.39E-2.

5. The transfer to recirculation function receives an automatic signal from the RWST level instruments. Operator action is needed for alignment of RS pumps, in case of failure of the LHSI pumps. The HEP for aligning RS pumps is ~3.0E-3. Heat exchangers are bypassed at BV-1 in HPR, therefore RS function is required for containment heat removal.

6. There are commonalities between the inside and outside recirculation system. Same support systems (electrical supplies and river water headers) apply to both the systems. The mitigation credit is accordingly designated as “1 multi-train system”.

Table 3.8 SDP Worksheet for Beaver Valley Unit 1 — Steam Generator Tube Rupture (SGTR)

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:**
Secondary Heat Removal (SHR)	1/2 MDPs of AFW (1 multi-train system) or 1/1 TDP of AFW (1 ASD Train) or Operator initiates 1/2 main feed pump with 1/2 condensate pump trains or dedicated FP (operator action = 2)
Early Inventory, HP Injection (EIHP)	1/2 charging pump or use of a spare charging pumps (1 multi-train system)
Pressure Equalization (EQ)	Operator isolates the ruptured SG and depressurizes RCS using 1/1 SG ADV (on each SG fed by AFW) or RCS pressurizer PORV (1/3) to less than setpoint of relief valves of SG (operator action = 2) (1)
Feed-and-Bleed (FB)	Operator uses RCS pressurizer PORV and block valves (1/3) (operator action = 2) (2)
Late depressurization and RWST makeup (RWST)	Operator isolates the faulted SG, closes loop stop valve or provides makeup to RWST for HHSI pumps (operator action = 2)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 LHSI pumps or 1/2 RS (2A or 2B) pumps for recirculation (1 multi-train system)
Residual Heat Removal (RHR)	Operator initiates 1/2 RHR pumps (operator action = 3)
Recirculation Spray (RS)	1/2 inside RS (1A or 1B) pumps or 1/2 outside RS (2A or 2B) pumps (1 multi-train system)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SGTR - EQ - RHR (3)			
2 SGTR - EQ - RWST (4)			
3 SGTR - SHR - RS (6)			

4 SGTR - SHR - HPR (7)			
5 SGTR - SHR - EQ (8)			
6 SGTR - SHR - FB (9)			
7 SGTR - EIHP - RHR (11)			
8 SGTR - EIHP - EQ (12)			
9 SGTR - EIHP - SHR (13)			

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. In IPE, the operator failure to depressurize RCS for RHR entry is assigned a probability of 1.6E-3, and the operator failure to isolate ruptured SG and equalize pressure is assigned a probability of 5.1E-3.

2. The human error probability (HEP) assessed in the IPE (page 3-129) for establishing bleed and feed cooling is 1.2E-3.

Table 3.9 SDP Worksheet for Beaver Valley 1 — Main Steam Line Break (MSLB) Outside Containment

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:
Isolation of Break (ISOB)	Closure of 3/3 MSIVs and isolation of feedwater to the affected SG (1 train)
Isolation of 2/3 MSIVs (ISOB1)	Closure of 2/3 MSIVs (1 multi-train system)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) with 1/2 SG ASDs or 1/15 SG Safety valves
Early Inv., High Pressure Injection (EIHP)	1/2 Charging pumps or use of 1 spare charging pump (1) (1 multi-train system).
Stop High Pressure Injection (STEIHP)	Operator terminates high pressure injection (operator action = 2)
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (2)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 LHSI or 1/ 2 RS (2A or 2B) pumps (1 multi-train system) (3)
Recirculation Spray (RS)	1/2 Inside RS (1A or 1B) pumps or 1/2 Outside RS (2A or 2B) pumps (1 multi-train system) (4)

Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 MSLB - ISOB - STEIHP (3)			
2 MSLB - ISOB - AFW - RS (5)			
3 MSLB - ISOB - AFW - HPR (6)			
4 MSLB - ISOB - AFW - FB (7)			
5 MSLB - ISOB - EIHP - AFW (9)			

6 MSLB - ISOB1 (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. The spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

2. The human error probability (HEP) assessed in the IPE (page 3.3-117) for establishing bleed and feed cooling is 1.39E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW and the dedicated feed pump).

3. The transfer to recirculation function receives an automatic signal from the RWST level instruments. Operator action is needed for alignment of RS pumps, in case of failure of the LHSI pumps. The HEP for aligning RS pumps is ~3.0E-3. Heat exchangers are bypassed at BV-1 in HPR, therefore RS function is required for containment heat removal.

4. There are commonalities between the inside and outside recirculation system. Same support systems (electrical supplies and river water headers) apply to both the systems. The mitigation credit is accordingly designated as “1 multi-train system”.

Table 3.10 SDP Worksheet for Beaver Valley Unit 1 — 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:**
Emergency Boration (HPI)	Operator conducts emergency boration using 1/2 charging pumps and ½ Boric Acid Transfer pumps [1] (operator action = 3)
Turbine trip (TTP)	AMSAC trips the turbine (1multi-train system)
Primary Relief (SRV)	3/3 SRVs with 3/3 PORVs [2] open (1 train)
Secondary Heat Removal (AFW)	2/2 MDPs of AFW (1 train) or 1/1 TDP of AFW (1 ASD Train)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 ATWS - HPI (2)			
2 ATWS - SRV (3)			
3 ATWS - AFW (4)			
4 ATWS - TTP (5)			

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 spare charging pump is not credited because sufficient time is not available for its alignment.

2. 3/3 PORVs are only required 13.9% of the time per the current PRA model.

Table 3.11 SDP Worksheet for Beaver Valley 1 — Loss of a 4.2 kV AC Bus (Orange or Purple) (LAC) (1)

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)	1/2 Main Feedwater (MFW) trains and 1/2 Condensate pump trains or dedicated feed pump (DFP) (operator action = 2)		
Secondary Heat Removal (AFW)	1/1 MDAFW trains (1 train) or 1 TDAFW train (1 ASD train)		
Early Inventory, High Pressure Injection (EIHP)	1/1 Charging pumps or use of 1 spare pump (1 train) (3)		
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (2,)		
High Pressure Recirculation (HPR)	1/1 charging pumps with 1/1 LHSI or 1/1 RS 2B pumps (1 train)		
Recirculation Spray (RS)	1/1 Inside RS 1B pumps or 1/1 Outside RS 2B pumps (1 train)		
Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LAC - PCS - AFW - RS (4)			
2 LAC - PCS - AFW - HPR (5)			
3 LAC - PCS - AFW - FB (6)			
4 LAC - PCS - AFW - EIHP (7)			

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 loss of a 4 KV AC Bus does not cause an automatic trip, but is conservatively modeled as an initiating event in the PRA. The estimated frequency for each bus is 4.3E-2/yr. The combined IE frequency is estimated at 8.6E-2/yr. The impact of the initiator is the loss of 1 train of the mitigation systems: 1 AFWMDP train, 1 charging pump train, 2/4 recirculation pump train, and no use of the cross-tie valves for the out of service bus. The block valves are normally open, so the PORV success criteria is unaffected.

2. The human error probability (HEP) assessed in the IPE (page 3.3-117) for establishing bleed and feed cooling is 1.39E-2 (Operator failure to initiate feed and bleed after failure to restore MFW and the dedicated feed pump).

3. The spare charging/HHSI pump can only be brought online if one of the other pumps is racked out from its associated power supply and the spare pump is manually racked into the same power supply. This should be a simple action outside the control room.

4. No separate ET is provided; please refer to the Transient tree.

Table 3.12 SDP Worksheet for Beaver Valley 1 — Loss of a DC Bus (1-1 Orange or 1-2 Purple) (LDC) [(1)]

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:**
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) with 1/15 SG safety valves [(1)]
Early Inventory, High Pressure Injection (EIHP)	1/1 Charging pump train including the use of the spare pump (1 train) [(3)]
Primary Heat Removal, Feed/Bleed (FB)	1/1 PORVs and block valves open for Feed/Bleed (operator action = 2) [(2)]
High Pressure Recirculation (HPR)	1/1 Charging pump train with 1/1 LHSI or 1/ 1 RS (2A or 2B) pumps (1 train) [(4)]
Recirculation Spray (RS)	1/1 Inside RS (1A or 1B) pumps or 1/1 Outside RS (2A or 2B) pumps (1train) [(5)]

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LDC - AFW - RS (3)			
2 LDC - AFW - HPR (4)			
3 LDC - AFW - FB (5)			
4 LDC - AFW - EIHP (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. The loss of a DC Bus results in reactor trip due to loss of feedwater regulating valve control losing MFW and dedicated FW pump. Loss of A train of the DC Bus results in loss of 1 PORV, but the loss of B train of the DC bus results in loss of 2 PORVs. We assume loss of 2 PORVs. In addition, 1 charging pump, 1 river water pump, 1 LHSI, and 2 of the RS pumps (1 inside and 1 outside) pump is lost. AFW is not affected (pumps depend on DC buses 1-3 and 1-4, and not 1-1 and 1-2 which are considered here). The initiating event frequency for loss of a DC Bus is 8.8E-3/yr. Considering loss of both DC Buses the combined IE frequency is 1.7E-02/yr.

2. The human error probability (HEP) assessed in the IPE (page 3.3-117) for establishing bleed and feed cooling is 1.39E-2 (Operator failure to initiate feed and bleed after failure to restore MFW and the dedicated feed pump). The operator action credit of 2 is maintained the same even if 2 of the 3 PORVs are lost.

3. The running charging/HHSI pump will continue running and will not be impacted by possible loss of its DC bus. The third (“spare”) charging pump can be aligned to either bus, provided one of the other pumps is racked out from its respective AC bus. Racking in/out of pumps is considered an operator action with a credit of 1. Charging, LHSI & RS pumps that cannot be immediately started due to loss of associated DC bus, can be manually and locally started by manipulating the breakers at switchgear. Such actions are not credited here.

4. The transfer to recirculation function receives an automatic signal from the RWST level instruments. Operator action is needed for alignment of RS pumps, in case of failure of the LHSI pumps. The HEP for aligning RS pumps is ~3.0E-3. Heat exchangers are bypassed at BV-1 in HPR, therefore RS function is required for containment heat removal.

5. Since the remaining trains of the IRS and ORS share the same support system, the mitigation credit is define as “1 train”.

6. No separate ET is provided. Please refer to the TPCS tree.

Table 3.13 SDP Worksheet for Beaver Valley 1 — Loss of Station Instrument Air (LOIA) (1)

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:
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) with 1/15 SG safety valves
Early Inventory, High Pressure Injection (EIHP)	1/2 Charging pumps or use of 1 spare pump (1 multi-train system)
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed using backup N_2 (operator action = 2) (2)
High Pressure Recirculation (HPR)	1/2 Charging pumps with 1/2 LHSI or 1/2 RS (2A or 2B) pumps (1 multi-train system)
Recirculation Spray (RS)	1/2 Inside RS (1A or 1B) pumps or 1/2 Outside RS (2A or 2B) pumps (1 multi-train system)

Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 LOIA - AFW - RS (3)			
2 LOIA - AFW - HPR (4)			
3 LOIA - AFW - FB (5)			
4 LOIA - AFW - EIHP (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. Loss of instrument air would cause closure of MSIVs, isolation of main feedwater, failure of condenser dump valves, atmospheric dump valves and the "RHI release valve", failure of containment instrument air (thus PORVs will depend on backup nitrogen). Note that the "RHI release valve" can still be operated with a handwheel. The mitigation systems impacted would be AFW bleed path which will depend on SG safety valves, PCS (fail), and FB which can only be conducted using the backup nitrogen supply. The IE frequency is 2.1E-02/yr.

2. All PORVs have a backup N_2 supply. The human error probability (HEP) assessed in the IPE (page 3.3-117) for establishing bleed and feed cooling is 1.39E-2 (Operator failure to initiate feed and bleed after failure to restore MFW and the dedicated feed pump).

3. No separate ET is provided. Please refer to the TPCS tree.

Table 3.14 SDP Worksheet for Beaver Valley Unit 1 — LOOP with Loss of a 4 kV AC Bus [1]

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:**
PORVs Reclose (SORV)	3/3 PORVs reclose (1 train)
Auxiliary Feedwater (AFW)	1/1 MDAFW train (1 train) or 1 TDAFW train (1 ASD train)
Early Inventory, High Pressure Injection (EIHP)	1/1 Charging pump or use of 1 spare pump (1 train)
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed or operator conducts FB using the SORV (operator action = 2) [2]
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS using 1/3 SG ASDs and pressurizer sprays (operator action = 2)
Rapid Depressurization (RAPDEP)	Rapid depressurization using 1/3 SG ASDs, 1/1 LHSI pump and 2/3 accumulators (1 train) [3]
Low Pressure Recirculation (LPR)	1/1 LHSI trains (1 train) or 1/1 outside RS(2A or 2B) pump for recirculation (1 train)
High Pressure Recirculation (HPR)	1/1 charging pumps with 1/1 LHSI or 1/1 RS 2A pumps (1 train)
Recirculation Spray (RS)	1/1 Inside RS 1B pumps or 1/1 Outside RS 2B pumps (1 train)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LEAC - AFW - RS (3, 18)			
2 LEAC - AFW - HPR (4, 19)			
3 LEAC - AFW - FB (5, 20)			

4 LEAC - AFW - EIHP (6, 21)			
5 LEAC - SORV - RS (8,11)			
6 LEAC - SORV - LPR (9,15)			
7 LEAC - SORV - RCSDEP - HPR (12)			
8 LEAC - SORV - EIHP - RS (14)			
9 LEAC - SORV - EIHP - RAPDEP (16)			

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 assumes LOOP with loss of an emergency AC (orange) Bus. This is similar to a LOOP with loss of 1 train of many safety systems (AFW, HHSI, LHSI, RS). One of the block valve also fails open where a stuck-open PORV results in a small LOCA. The initiating event frequency is assumed to be two orders of magnitude lower than that of LOOP.

2. The human error probability (HEP) assessed in the IPE (page 3.3-117) for establishing bleed and feed cooling is 1.39E-2 (Operator failure to initiate feed and bleed after failure to restore MFW and the dedicated feed pump). The HEP for conducting FB using the SORV with the block valve fail open is assumed to be the same.
3. The atmospheric steam dump valves fail on loss of instrument air due to the loss of the offsite power. However, a third diesel-driven compressor can be run manually and locally in the Turbine building. Filter water pump which is loaded on the ERF diesel can provide cooling to the diesel compressor. Also, since only one LHSI train is available for injection in a rapid depressurization, the mitigation credit is limited by the hardware failure of 1 train.

Table 3.15 SDP Worksheet for Beaver Valley 1 — Interfacing System LOCA (ISLOCA)

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

Initiating Pathways: **LHSI to Cold Leg Injection Line**	**Mitigation Capability: Ensure Component Operability for Each Pathway**: Two Check valve in series located inside containment in each of the three injection lines and one motor-operated containment isolation valve (MOV -SI -890C)		
Circle Affected Functions	**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.

Note:

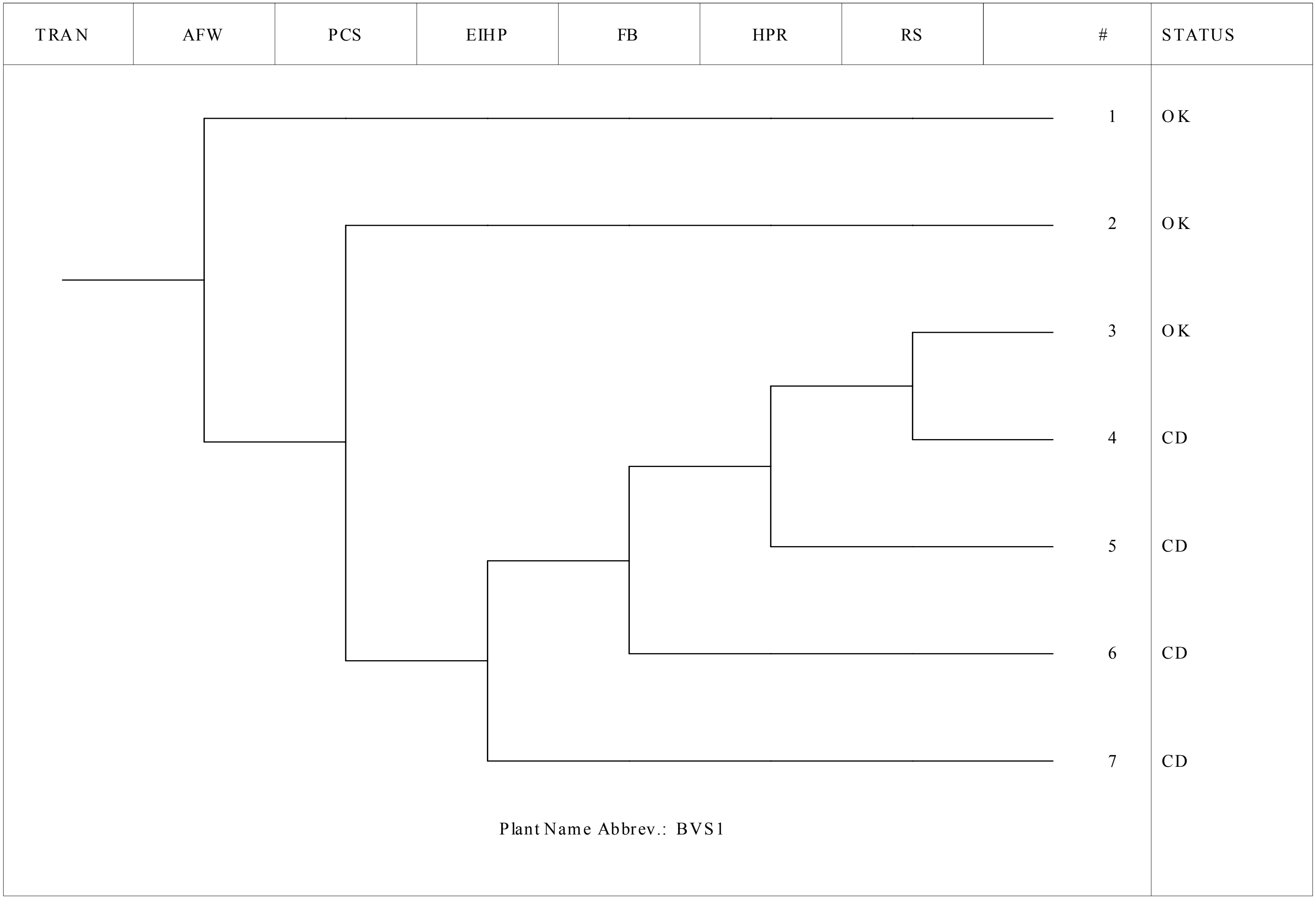
1. Information is based on licensee's PRA. Other sources of ISLOCA are screened out in the PRA.

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. An event tree for the stuck-open PORV is not included since it is similar to the small LOCA event tree. 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. Medium LOCA (MLOCA)
5. Large LOCA (LLOCA)
6. Loss of Power (LOOP)
7. Steam Generator Tube Rupture (SGTR)
8. Main Steam Line Break (MSLB)
9. Anticipated Transients Without Scram (ATWS)
10. Loss of a 4 kV EAC Bus (LEAC)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AFW
PCS
EIHP
FB
HPR
RS
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STATUS
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2 OK
3 OK
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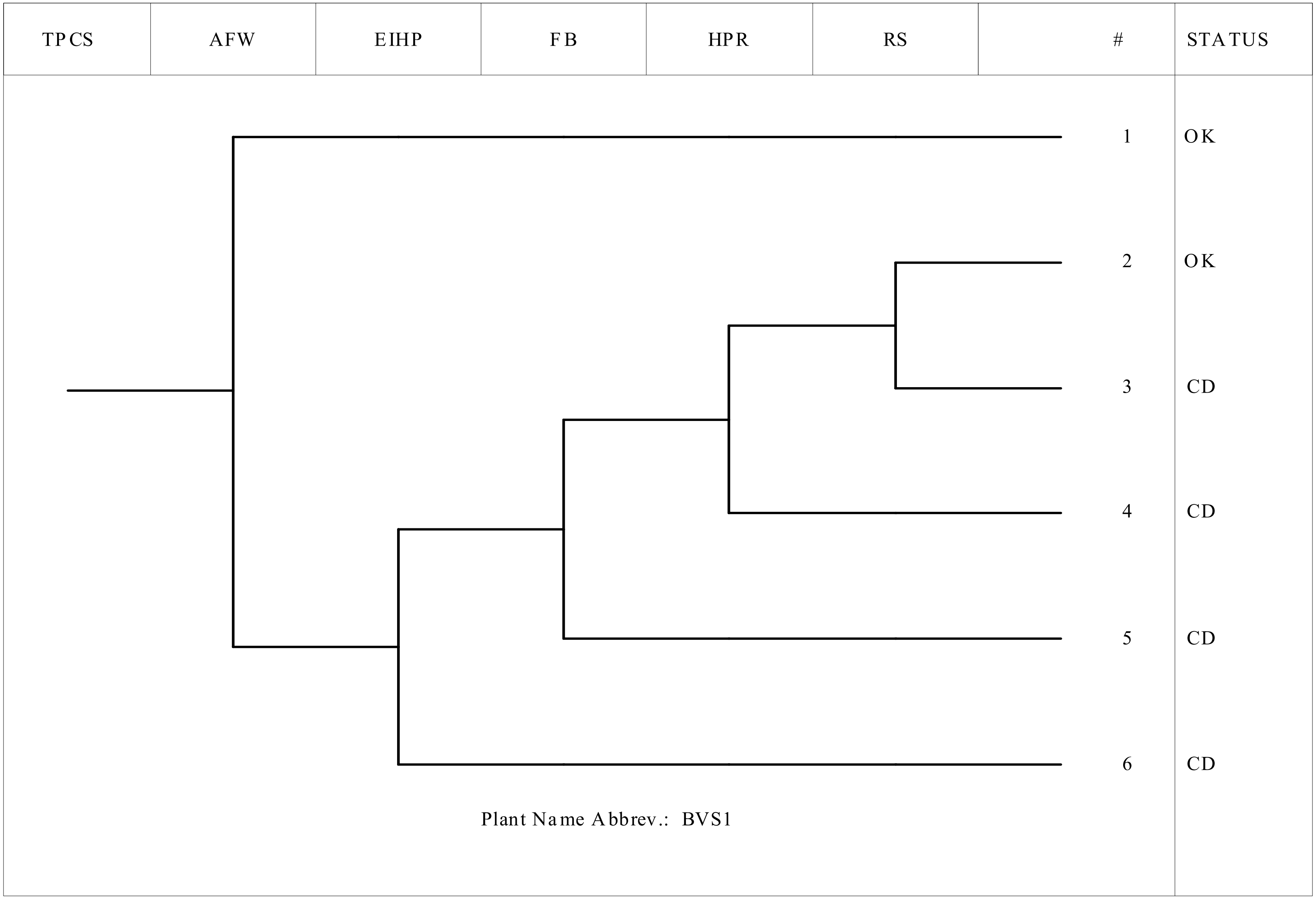
5 CD
6 CD
7 CD
Plant Name Abbrev.: BVS1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AFW
EIHP
FB
HPR
RS
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STATUS
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2
OK
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CD
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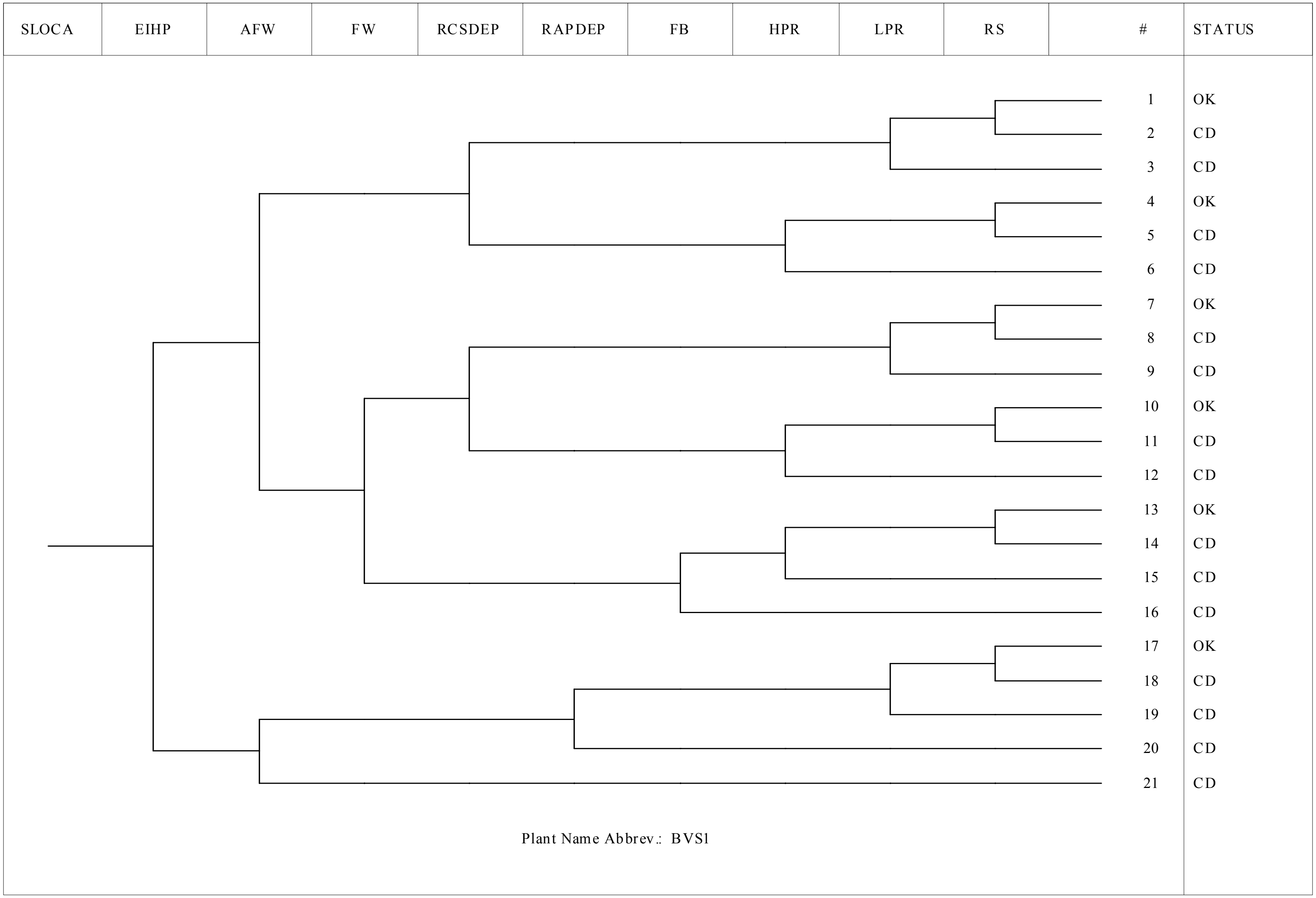
CD
5
CD
6
CD
Plant Name Abbrev.: BVS1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FW
RCSDEP
RAPDEP
FB
HPR
LPR
RS
#
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3 CD
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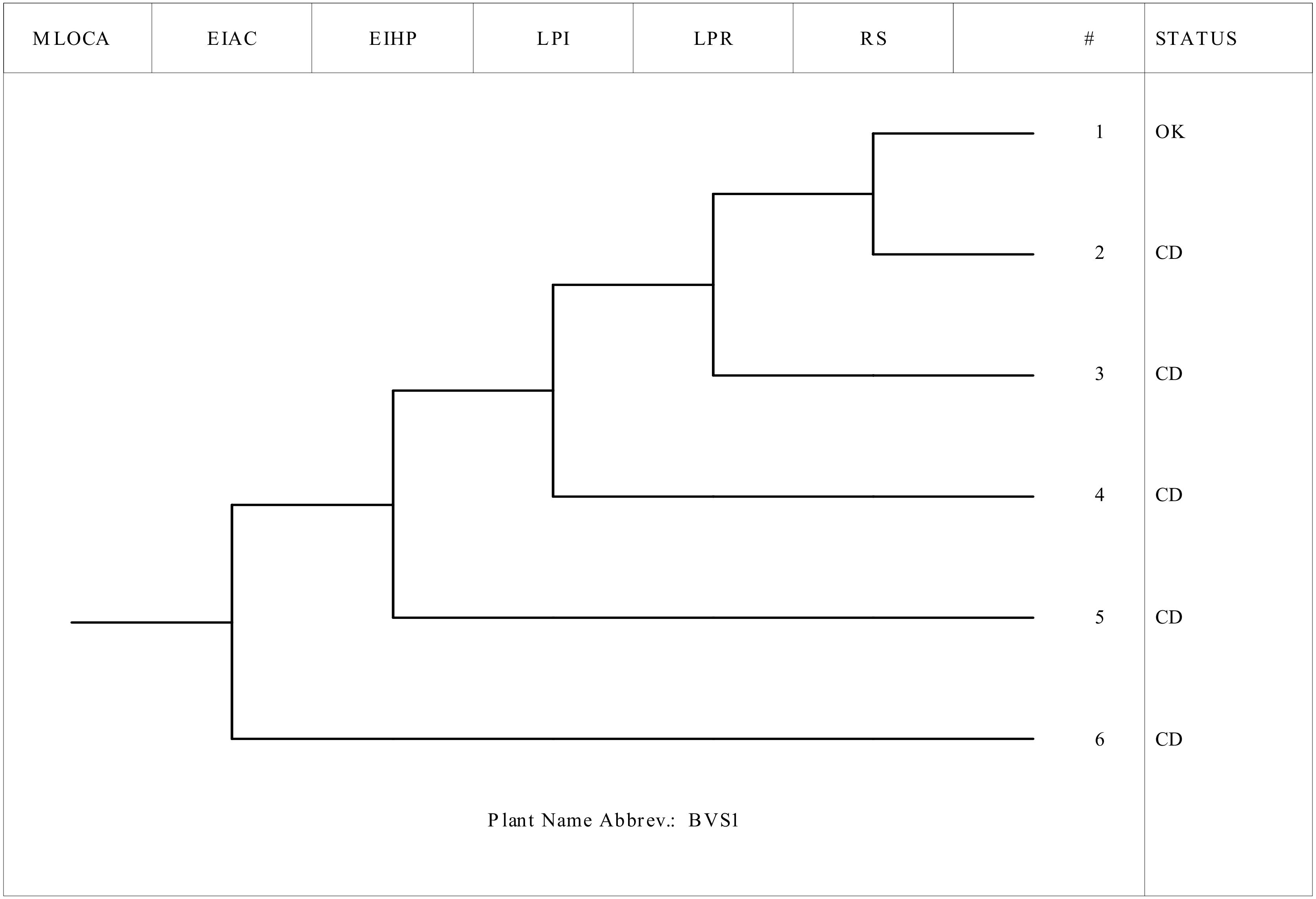
5 CD
6 CD
7 OK
8 CD
9 CD
10 OK
11 CD
12 CD
13 OK
14 CD
15 CD
16 CD
17 OK
18 CD
19 CD
20 CD
21 CD
Plant Name Abbrev.: BVS1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EIHP
LPI
LPR
RS
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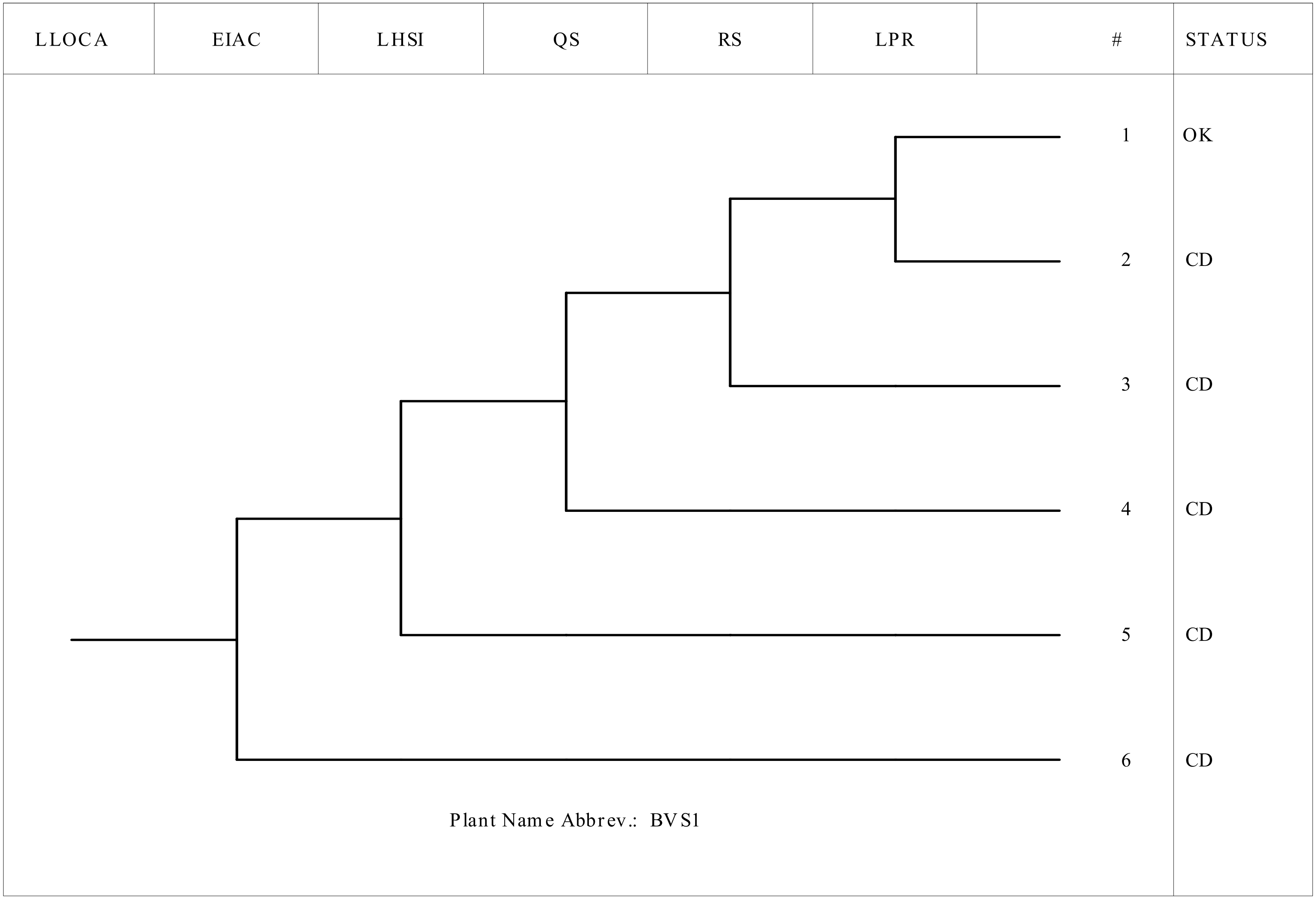
OK
2
CD
3
CD
4
CD
5
CD
6
CD
Plant Name Abbrev.: BVS1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QS
RS
LPR
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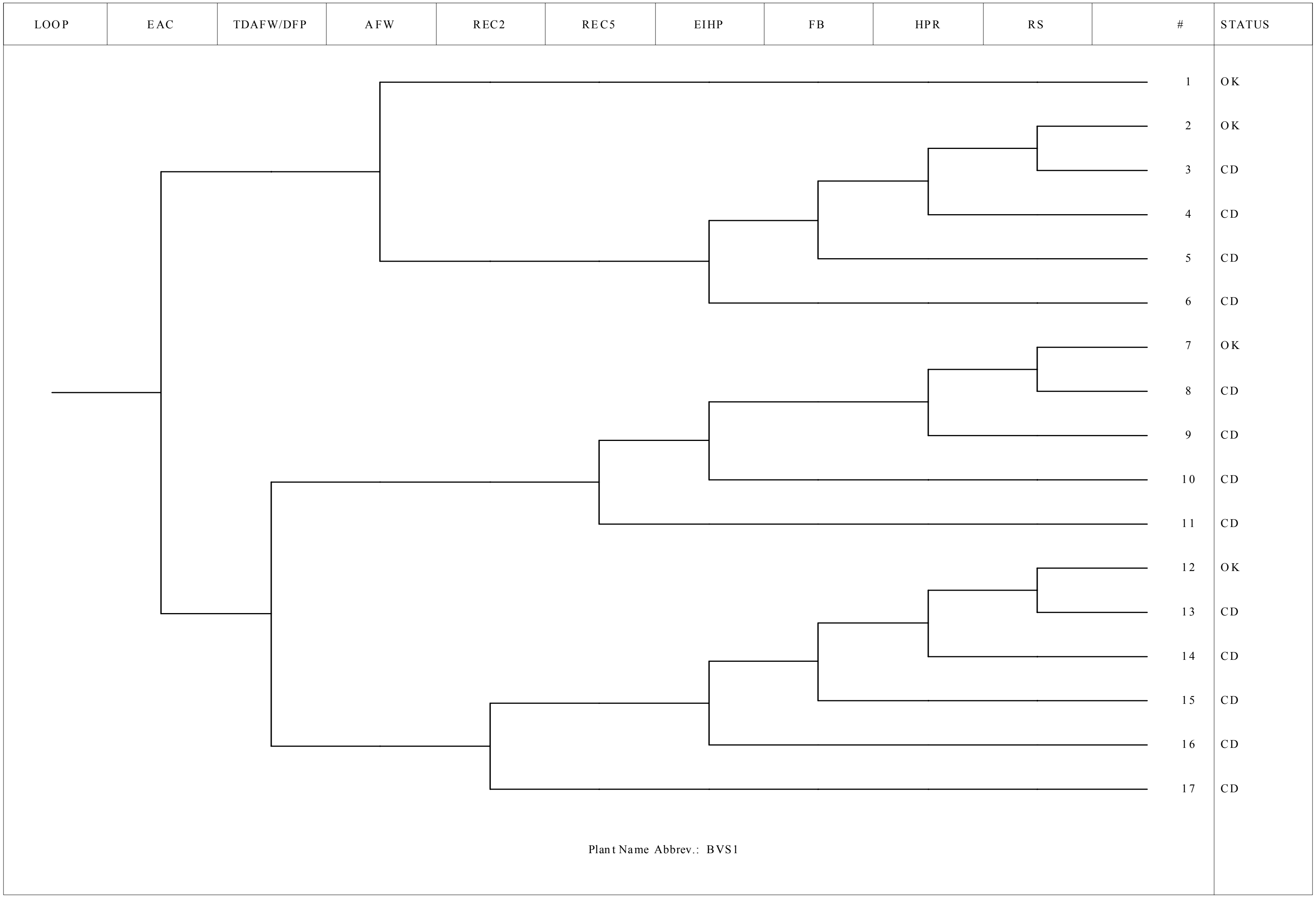
5 CD
6 CD
Plant Name Abbrev.: BVS1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TDAFW/DFP
AFW
REC2
REC5
EIHP
FB
HPR
RS
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4 CD
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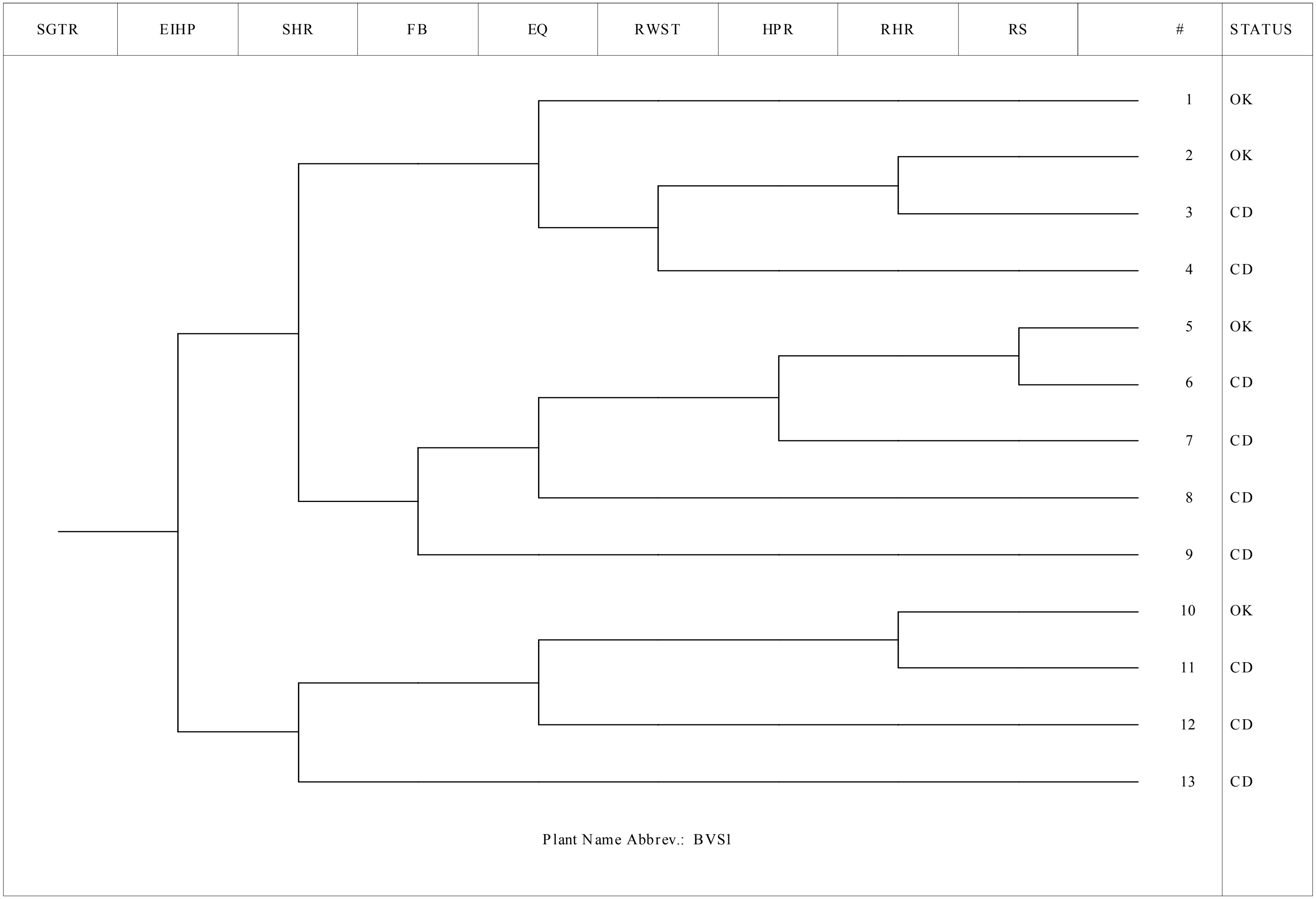
15 CD
16 CD
17 CD
Plant Name Abbrev.: BVS1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SHR
FB
EQ
RWST
HPR
RHR
RS
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11 CD
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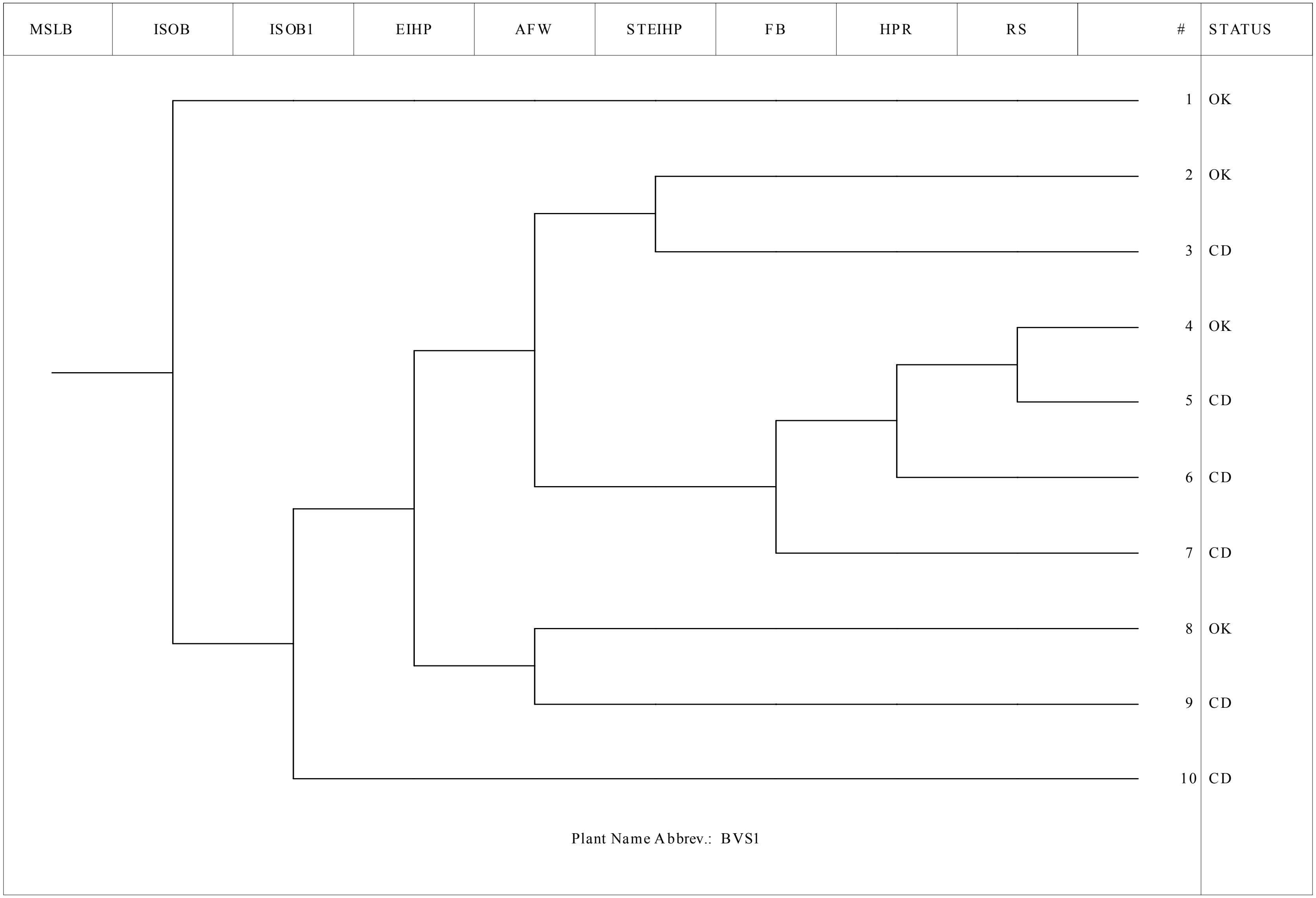
13 CD
Plant Name Abbrev.: BVS1


MSLB
ISOB
ISOB1
EIHP
AFW
STEIHP
FB
HPR
RS
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5 CD
6 CD
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8 OK
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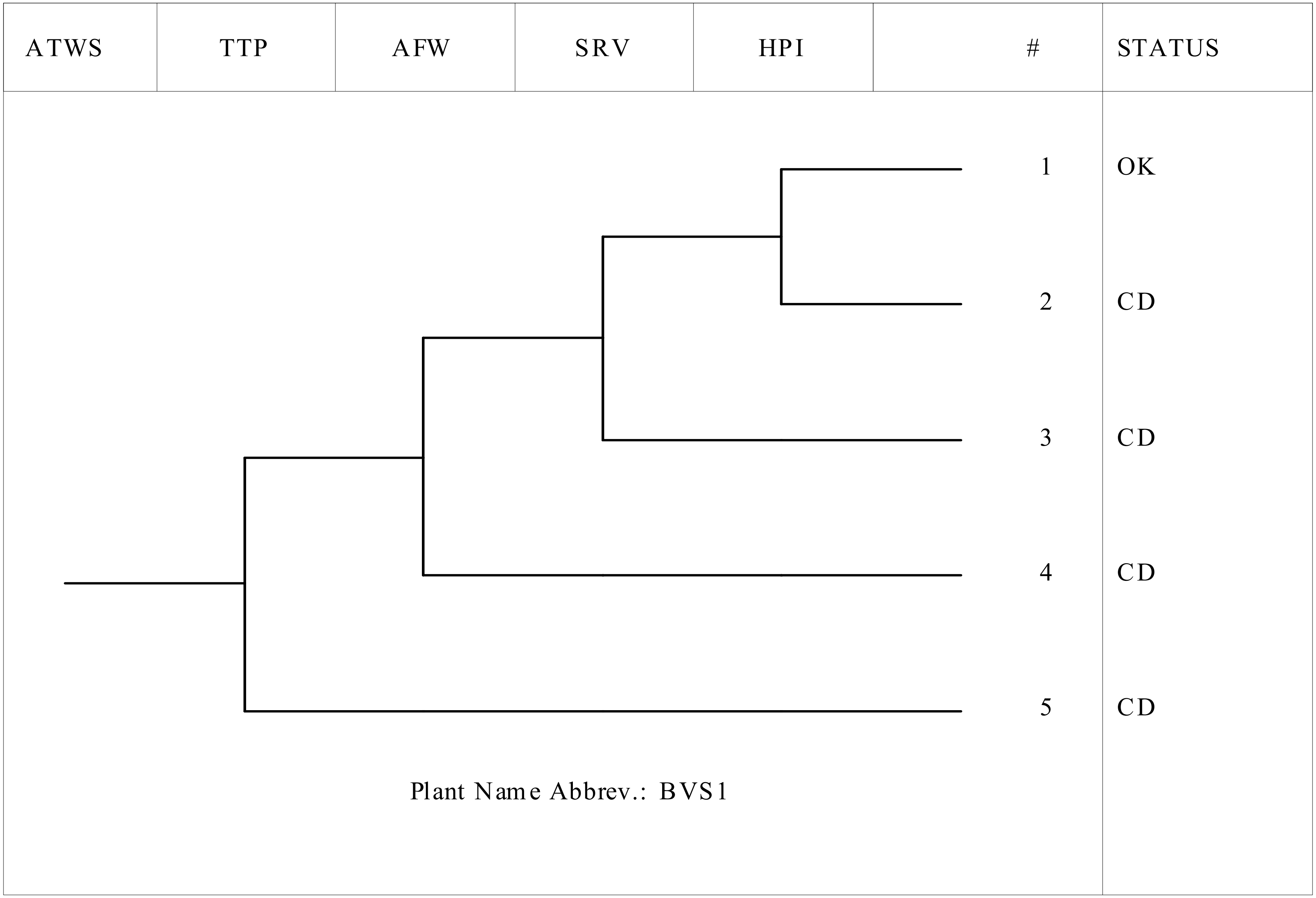
10 CD
Plant Name Abbrev.: BVS1


ATWS
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AFW
SRV
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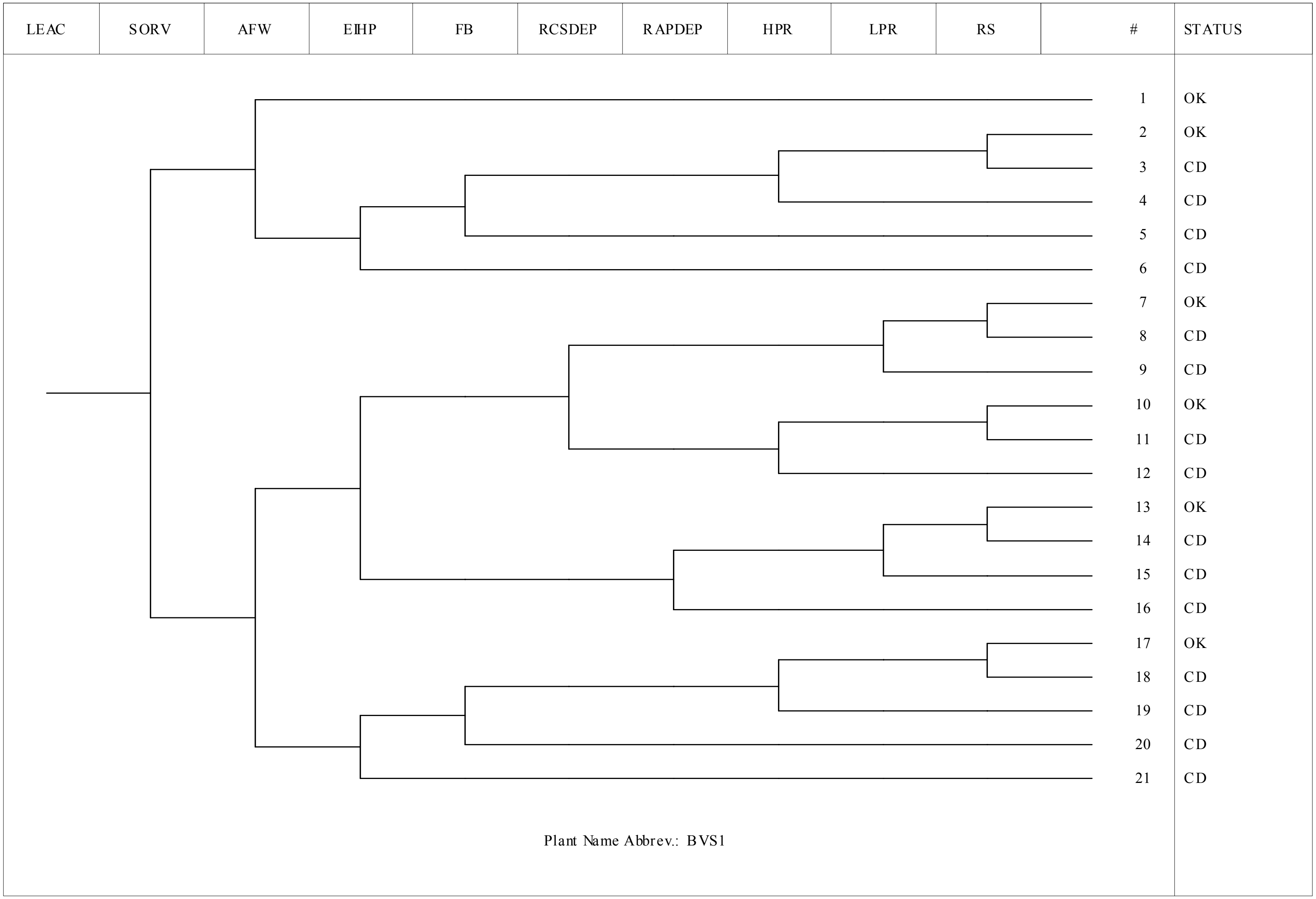
3
CD
4
CD
5
CD
Plant Name Abbrev.: BVS1


LEAC
SORV
AFW
EIHP
FB
RCSDEP
RAPDEP
HPR
LPR
RS
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STATUS
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2 OK
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7 OK
8 CD
9 CD
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11 CD
12 CD
13 OK
14 CD
15 CD
16 CD
17 OK
18 CD
19 CD
20 CD
21 CD
Plant Name Abbrev.: BVS1

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 PWR 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 PWRs 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 (PWRs)

The following generic guidelines and assumptions were used in developing the SDP worksheets for PWRs. These guidelines and assumptions were derived from a review of the licensee's comments, the resolutions of those comments, and the applicability to similar plants.

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 PORV/SRV (SORV), main steam and feedwater line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCAs (ISLOCA) are assigned into rows based on a consideration of the industry-average frequency. Plant-specific frequencies are considered for loss of offsite power (LOOP) and special initiators, and are assigned to the appropriate rows in Table 1.

2. Stuck open PORV/SRV as an IE in PWRs:

This event typically is not modeled in PRAs/IPEs as an initiating event. The failure of the PORVs/SRVs to re-close after opening is typically modeled within the transient event trees subsequent to the initiators. In addition, the intermittent failure or excessive leakage through PORVs as an initiator, albeit with much lower frequency, needed to be considered. To account for such failures and to keep the transient worksheets simple in the SDP, a separate worksheet for the SORV initiator was set up to explicitly model the contribution from such failures. This SDP worksheet, and the associated event tree, is similar to that of SLOCA. The frequency of PORV to re-close depends on the status of pressurizer. If the pressurizer is solid, then the frequency would be higher than the case in which the pressurizer level is maintained. Typically, this depends on early availability of secondary heat removal. However, the frequency for the SORV initiator is generically estimated for all PWR plants in Table 1.

3. Inclusion of special initiators:

The special initiators included in the worksheets are those applicable to this plant. A separate worksheet is included for each of them. The applicable special initiators are primarily based on the plant-specific IPEs/PRAs. In other words, the special initiators included are those modeled in the IPEs/PRAs unless shown to be negligible contributors. In some cases, a particular special initiator may be added for a plant even if it is not included in the IPE/PRA, if it is included in other plants of similar design, and is considered applicable for the plant. However, no attempt is made at this time to have a consistent set of special initiators across similarly designed plants. Except for the interfacing system LOCA (ISLOCA), 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's focus is on the initiating event and the risk implication of the finding can be directly assessed. For ISLOCA, a separate worksheet is included noting the pathways that can lead to it.

4. Inclusion of systems under the support system column of the Initiators and System Dependency Table:

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

5. 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 event tree headings/functions to that included in the Table was not considered necessary.

6. 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 those covered under the Technical Specifications (TS) and the Maintenance Rule (MR). Credits for other components may have been removed in the SDP worksheets.

7. 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 they help to maintain consistency across the SDP worksheets for similar plant designs.

8. Crediting system trains with high unavailability:

Some system component/trains may have unavailability higher than 1E-2, but they are treated similarly to other trains with lower unavailability in the range of 1E-2. In this screening, this approach 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 1E-1.

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

Passive components, namely accumulators, are credited similarly to active components, even though they exhibit higher reliability. Considering the potential for common-cause failures, the reliability of a passive system is not expected to differ by more than an order of magnitude from active systems. Pipe failures were excluded, except as part of initiating events where the appropriate frequency is used. Accordingly, a separate designation for passive components was not considered necessary.

10. Crediting accumulators:

SDP worksheets assume the loss of the accumulator unit associated with the failed leg in LOCA scenarios. Accordingly, in defining the mitigation capability for the accumulators, the worksheets refer to the remaining accumulators. For example, in a plant with 4 accumulators with a success criteria of 1 out of 4, for large LOCA the mitigation capability is defined as 1/3 remaining accumulators (1 multi-train system), assuming the loss of the accumulator in the failed leg. For a plant with a success criteria of 2 out of 4 accumulators, the mitigation capability is defined as 2/3 remaining accumulators (1 multi-train system).

The inspection findings are then assessed as follows (using the example of the plant with 4 accumulators and success criteria of 2 out of 4):

4 Acc. Available	Credit=3
3 Acc. Available (1 Acc. is considered unavailable, based on inspection findings)	Credit=2
< 3 Acc. Available (2 or more Acc. are considered unavailable, Based on inspection findings)	Credit=0

11. Crediting 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.

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

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

13. Dependency among multiple operator actions:

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

14. Crediting the standby high-pressure pump:

The high-pressure injection system in some plants consists of three pumps with two of them auto-aligned and the third spare pump requiring manual action. The mitigating capability then is defined as : 1/2 HPI trains or use of a spare pump (1 multi-train system). Also, a footnote is added to reflect that the use of a spare pump could be given a credit of 1 (i.e.,1E-1) as a recovery action.

15. Emergency AC Power:

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:

a) Describe the success criteria and the mitigation capability of dedicated EDGs.

b) 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.

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

d) 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.

16. Treatment of HPR and LPR:

The operation of both the HPR and LPR rely on the operation of the RHR pumps and the associated heat exchangers. Therefore, failure of LPR could imply failure of both HPR and LPR. A sequence which contains failure of both HPR and LPR as independent events will significantly underestimate the CDF contribution. To properly model this configuration within the SDP worksheets, the following procedure is used. Consider the successful depressurization and use of LPR as the preferred path. HPR is credited when depressurization has failed. In this manner, a sequence containing both HPR and LPR failures together is not generated.

17. SGTR event tree:

Event trees for SGTR vary from plant to plant depending on the size of primary-to-secondary leak, SG relief capacity, and the rate of rapid depressurization. However, there are several common functional steps that are addressed in the SDP worksheet: early isolation of the affected SG, initiation of primary cool-down and depressurization, and prevention of the SG overfill. These actions also include failure to maintain the secondary pressure below that of Main Steam safety valves which could occur either due to the failure of the relief valves to open or the operator's failure to follow the procedure. Failure to perform this task (sometimes referred to as early isolation and equalization) is assumed to cause continuous leakage of primary outside the containment. The success of this step implies the need for high-pressure makeup for a short period, followed by depressurization and cooldown for RHR entry (note, relief valves are assumed to re-close when primary pressure falls below that of the secondary). If the early makeup is not available or the operator fails to perform early isolation and equalization, rapid depressurization to RHR entry is usually assumed. This would typically require some kind of intermediate- or low-pressure makeup. Finally, depending on the size of the Refueling Water Storage Tank (RWST), sometimes it would be necessary to establish makeup to the RWST to allow sufficient time to enter the RHR mode.

18. ATWS scenarios:

The ATWS SDP worksheet assumes that these scenarios are not recoverable by operator actions, such as a manual trip. The failure of the scram system, therefore, is not recoverable, neither by the actuation of a back-up system nor through the actuation of manual scram. The initiator frequency, therefore, should only account for non-recoverable scrams, such as mechanical failure of the scram rods.

19. 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.

20. RCP seal LOCA in a SBO:

The RCP seal LOCA in a SBO scenario is included in the LOOP worksheet. RCP seal LOCA resulting from loss of support functions is considered only if the loss of support function is a special initiator. The dependencies of RCP seal cooling are identified in Table 2.

21. RCP Seal LOCA for Westinghouse Plants during SBO Scenarios:

The modeling of the RCP seal failures upon loss of cooling and injection as occurs during SBO scenarios has been the subject of many studies (e.g., BNL Technical report W6211-08/99 and NUREG/CR-4906P). These studies are quite complex and assign probabilities of seal failure as a function of time (duration of SBO) and the associated leak rates. The leak rates, in turn, will determine what would be the safe period for recovery of the AC source and the use of SI pumps before core uncovery and damage. On the contrary, the SDP worksheets simplify the analysis of the RCP seal LOCA during the SBO scenarios using the following two assumptions: (1) The probability of catastrophic RCP seal failure is assumed to be 1 if the SBO lasts beyond two hours, and (2) Given a catastrophic seal LOCA, the available time prior to core damage for recovery of offsite power and establishing injection is about two hours. Therefore, in almost all cases, to prevent a core damage, a source of AC should be recovered within 4 hours in SBO scenarios.

22. Tripping the RCP on loss of CCW:

Upon loss of CCW, the motor cooling will be lost. The operation of RCPs without motor cooling could result in overheating and failure of bearings. Bearing failure, in turn, could cause the shaft to vibrate and thereby result in the potential for seal failure if the RCP is not tripped. In Westinghouse plants, the operator is instructed to trip the RCPs early in the scenario (from 2 to 10 minutes after detecting the loss of cooling). Failure to perform this action is conservatively assumed to result in seal failure and, potentially in a LOCA. This failure mechanism (occurrence of seal LOCA) due to failure to trip the RCPs upon loss of cooling is not considered likely in some plants, whereas it has been modeled explicitly in other plants. To ensure consistency, the trip of the RCP pumps are modeled in the SDP worksheets, and the operator failure to do this is assumed to result in a LOCA. In many cases, the failure to trip RCP following a loss of CCW results in core damage.

23. Hot leg/Cold leg switchover:

The hot leg to cold leg switchover during ECCS recirculation is typically done to avoid boron precipitation. This is typically part of the procedure for PWRs during medium and large LOCA scenarios. Some IPEs/PRAs do not consider the failure of this action as relevant to core damage. For plants needing the hot /cold switchover, it usually can only be accomplished with SI pumps and the ECCS recirculation also uses the SI pumps.

2.2 RESOLUTION OF PLANT-SPECIFIC COMMENTS

Modification are made in the document based on the licensee comments. A summary of the important changes is provided below.

1. Comments on the Initiators and System dependency table are used to revise the information in the Table. The Table now includes the updated PRA information.

2. The mitigation capability of the PCS function is revised to clarify that the dedicated feed pump is not dependent on the condensate pump.

3. The high pressure injection function (EIHP) definition is clarified as 1/ 2 charging pump with 1 spare charging pump.

4. The high pressure recirculation (HPR) function is revised as 1/ 2 charging pump with 1/ 2 LHSI pump or with 1/ 2 outside RS pumps. The transfer to recirculation function receives an automatic signal from the RWST level instruments. Heat exchangers are bypassed in HPR, therefore RS is required for containment heat removal.

5. The low pressure recirculation (LPR) function is revised as 1/ 2 LHSI pumps or 1/ 2 outside RS pumps aligned for recirculation. The transfer to recirculation function receives an automatic signal from the RWST level instruments.

6. Makeup to RWST when LPR or HPR fails is not credited in the worksheet. The credit given in the Medium LOCA worksheet in the previous version is removed. This is consistent with approach taken in the SDP worksheets for similar plants.

7. In the LLOCA worksheet, the recirculation spray (RS) and outside recirculation spray (ORS) are lumped together and the note is revised to state that NPSH is needed for both the inside and outside pumps.

8. In the ATWS worksheet, the emergency boration function is revised as 1/ 2 charging pumps.

REFERENCES

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

2. Dusquesne Light Company, "Beaver Valley Power Station, Unit 1 Probabilistic Risk Assessment Individual Plant Examination Report," October 1, 1992.

RISK-INFORMED INSPECTION NOTEBOOK FOR

BEAVER VALLEY UNIT 2

PWR, WESTINGHOUSE, THREE-LOOP PLANT WITH SUB-ATMOSPHERIC CONTAINMENT

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Enclosure 2

NOTICE

This notebook was developed for the NRC's inspection teams to support risk-informed inspections. The activities involved in these inspections are discussed in "Reactor Oversight Process Improvement," SECY-99-007A, March 1999. 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. This notebook 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 Beaver Valley Unit 2.

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. The first step in this 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 Event Categories
2. Initiators and System Dependency Table
3. Significance Determination Process (SDP) Worksheets
4. SDP Event Trees.

Table 1, Categories of Initiating Events, is used to estimate the likelihood rating for different initiating events for a given degraded condition and the associated exposure time at the plant. This Table follows the format of Table 1 in SECY-99-007A. Initiating events are grouped in frequency bins that are one order of magnitude apart. The Table includes the initiating events that should be considered for the plant and for which SDP worksheets are provided. The following initiating events are categorized by 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); main steam line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCA (ISLOCA). The frequency of the remaining initiating events vary significantly from plant to plant, and accordingly, they are categorized by plant-specific frequency obtained from the licensee. They include loss of offsite power (LOOP) and special initiators caused by loss of support systems.

The Initiators 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 known in Probabilistic Risk Assessments (PRAs). For pressurized water reactors (PWRs), the support systems/success criteria for Reactor Coolant Pump (RCP) seals are explicitly denoted to assure that the inspection findings on them are properly accounted for. This Table is used to identify the SDP worksheets to be evaluated, corresponding to the inspection's findings on systems and components.

To evaluate the impact of the inspection's findings on the core-damage scenarios, SDP worksheets are provided. There are two sets of SDP worksheets; one for those initiators that can be mitigated by redundant trains of safety systems, and the other for those initiators that cannot be mitigated; however, their occurrence is prevented by several levels of redundant barriers.

The first set of SDP worksheets contain two parts. The first identifies the functions, the systems, or combinations thereof that have mitigating functions, the number of trains in each system, and the number of trains required (success criteria) for 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 parenthesis next to each sequence, the corresponding event-tree branch number(s) representing the sequence is given. Multiple branch numbers indicate that the different accident sequences identified by the event tree have been merged into one through Boolean reduction. The SDP worksheets are developed for each of the initiating event categories, including the "Special Initiators", the exception being those which directly lead to a core damage (the inspections of these initiators are assessed differently; see SECY-99-007A). The special initiators are those that are caused by complete or partial loss of support systems. A special initiator typically leads to a reactor scram and degrades some frontline or support systems (e.g., Loss of CCW in PWRs).

In considering the special initiators, we defined a set of criteria for including them 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 thereby changing its mitigation capability in the worksheet. For example, when a safety function with two redundant trains, classified as a multi-train system, degrades to a one-train system, it is 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 systems/functions associated with the initiator from comparable transient sequences by two and higher orders of magnitude must be considered.

From the above considerations, the following classes of initiators are considered in this notebook:

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. Stuck-open Power Operated Relief Valve (SORV),
5. Medium LOCA (MLOCA),
6. Large LOCA (LLOCA),
7. Steam Generator Tube Rupture (SGTR),
8. Anticipated Transients Without Scram (ATWS), and
9. Main Steam Line Break (MSLB).

Examples of special initiators included in the notebook are as follows:

1. Loss of Offsite Power (LOOP),
2. LOOP with failure of 1 Emergency AC bus or associated EDG (LEAC),
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 includes 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. In some plants, LOOP with failure of 1 EAC bus is a large contributor to the plant's core damage frequency (CDF).

The second set of SDP worksheets addresses those initiators that cannot be mitigated, i.e., can directly lead to core-damage. It currently includes the Interfacing System LOCA (ISLOCA) initiator. ISLOCAs are those initiators that could result in a loss of RCS inventory outside the containment, sometimes referred to as a "V" sequence. In PWRs, this event effectively bypasses the capability to utilize the containment sump recirculation once the RWST has emptied. Also, through bypassing the containment, the radiological consequences may be significant. In PWRs, this typically includes loss of RCS inventory through high- and low-pressure interfaces, such as RHR connections, RCP thermal barrier heat-exchanger, high-pressure injection piping if the design pressure (pump head) is much lower than RCS pressure, and, potentially, through excess letdown heat exchanger. RCS inventory loss through ISLOCA could vary significantly depending on the size of the leak path; some may be recoverable with minimal impact. The SDP worksheet for ISLOCA, therefore, identifies the major consequential leak paths, and the barriers that should fail, allowing the initiator to occur.

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.

The following items were considered in establishing the SDP event trees and the core-damage sequences in the SDP worksheets:

1. Event trees and sequences were developed such that the worksheet contains all the major accident sequences identified by the plant-specific IPEs/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 take into account the IPE/PRA models and event trees for all similar plants. For modeling the response to an initiating event, any major deviations in one plant from similar plants may be 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 developed 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/PRAs often are represented by a single tree. For example, some IPEs/PRAs define four classes of LOCAs rather than the three classes considered here. The sizes of LOCAs for which high-pressure injection is not required are sometimes divided into two classes, the only difference between them being the need for reactor scram in the smaller break size. There may be some consolidation of transient event trees 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 Categories for Initiating Events Table, Initiators and Dependency Table, SDP worksheets, and the SDP event trees for Beaver Valley Unit 2.

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 (binned) into rows based on their frequency. The table includes the initiators and the assigned bins in the SECY-99-007A. The table also includes the plant specific bins for loss of offsite power frequency, and the special initiators caused by loss of support systems.

Table 1 Categories of Initiating Events for Beaver Valley Unit 2

Row	Approximate Frequency	Example Event Type	Estimated Likelihood Rating		
I	> 1 per 1-10 yr	Reactor Trip (Trans), Loss of Power Conversion System (TPCS)	A	B	C
II	1 per 10-10^2 yr	Loss of offsite power (LOOP), Loss of a 4KV E AC Bus (LAC)	B	C	D
III	1 per 10^2 - 10^3 yr	SGTR, Stuck open PORV/SRV (SORV), Small LOCA including RCP seal failures (SLOCA), MSLB (outside containment), Loss of a DC Bus (LDC), Loss of Service Water Header A or B (LOSW)	C	D	E
IV	1 per 10^3 - 10^4 yr	Medium LOCA (MLOCA), LOOP with loss of one division of emergency AC (LEAC)	D	E	F
V	1 per 10^4 - 10^5 yr	Large LOCA (LLOCA)	E	F	G
VI	less than 1 per 10^5 yr	ATWS , ISLOCA	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. 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). Any inspection finding that represents a loss of capability for manual reactor trip for a

postulated ATWS scenario should be evaluated by a risk analyst to consider the probability of a successful manual trip.

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 involvements in different initiating events are noted in the last column.

Table 2. Initiators and System Dependency for Beaver Valley Unit 2

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
Reactor Coolant Pumps (RCPs)	Pumps 21A, 21B, 21C	Normal AC Power, PCCW, IA/CIA[(1)], Vital Bus I, II	SLOCA
PORVs	PORV 455C&D, 456 Block Valves 535,536,537	125 V-DC, 480V AC (Block Valves), SSPS, Vital Bus Channel I, II, III, & IV	All except LLOCA, and MLOCA
Main Feed Pump (MFW)	MFW Pumps P21A, P21B,	Normal AC Power, DC Battery 1-5, SSPS, Secondary CCW, Normal 125V DC Supply, Batteries 2-5, 2-6, ERF DG (SUP-P24)	TRANS, SLOCA, SORV, SGTR, LAC
Condensate Pump	2 condensate pumps	Normal AC Power, Normal 125V DC Supply Battery 2-5 and 2-6, Secondary CCW	TRANS, SLOCA, SORV, SGTR, LAC
MSIVs	3 MSIVs	125V DC, IA/CIA, SSPS	MSLB
AFWs	2 MDPs	4.16 kV EAC, 125V DC, SW Header B (backup water supply)	All except MLOCA and LLOCA
	1 TDP	125V DC, SSPS, SW Header B (backup water supply)	
RHR	Pumps P21A, P21B	4.16 kV EAC, 125V DC, PCCW, SSPS	SGTR
HHSI [(2)]	Pumps P21A, P21B, P21C [(2)]	4.16 kV EAC, 125V DC, SSPS, SW	All except LLOCA
Boric Acid Transfer (BAT) Pumps	2 pumps	480V AC	ATWS
LHSI	Pumps P21A, P21B	4.16 kV EAC, 125V DC, SSPS	All except ATWS
	MOVs	4.16 kV EAC, SSPS	
RWST Level	LT 104 A, B, C, D	Vital Bus I, II, III, IV; SSPS	SGTR

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
Quench Spray (QS)	Pumps P21A, P21B	4.16 kV EAC, 125V DC,SSPS	LLOCA
Recirculation Spray (RS)	Pumps P21C, P21D	4.16 KV EAC, 125V DC, SSPS	All except ATWS
	Hx E1C, E1D	SW	
PCCW	Pump 1A (normally running), Pump 1B(Auto backup), Pump 1C (manual Backup)	4.16 kV EAC, 125V DC, SW, Vital Bus Channel I & II, IA/CIA [(3)]	SLOCA, SGTR
Emergency AC (EAC)	4.16 kV / 480V AC Train A,B		LAC
Emergency Diesel Generator (EDG)	EDG 2-1, 2-2	125V DC, SW, EDG Ventilation, SSPS	LOOP, LEAC
	ERF DG (Black)	ERF Batteries, Ventilation System	LOOP, TRANS, SLOCA, SORV, SGTR, LAC
125 V-DC	Trains A, B; Batteries	4.16 kV EAC	LDC
Solid State Protection System (SSPS)	Trains A, B	Vital Bus Channel I, II, III & iV	All
Service Water (SW)	Headers A,B; 3 Service Water Pumps and 2 Standby Service Water Pumps[(3)]	4.16 kV EAC, 125V DC, SSPS, Vital Bus I&II, Ventilation System	LOSW
Ventilation System	Chilled Water Cooling Coils, exhaust fans	4.16 kV EAC, Vital Bus I & II	All
EDG Ventilation	2 supply fans and 1 exhaust fan for each diesel area	4.16 kV AC	LOOP, LEAC

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
Instrument Air / Containment Instrument Air (IA/CIA)	2 Station air compressors 2 Containment instrument air compressor	Normal AC Power, Vital Bus I&II, SSPS, SCCW, ERF Diesel(4), Filtered water system(4)	All except LLOCA and MLOCA
Secondary CCW (SCCW)	Pump 2CCS-P21A normally running, Pump 2CCS-P21B for auto backup	Normal AC Power, Vital Bus I &II, SSPS, SW, Normal DC Supply Batteries 2-5 and 2-6	All except LLOCA and MLOCA
Chilled Water System	3 Chilled water pumps and associated chiller unit	Normal AC Power, SW, Normal DC Battery Supplies 2-5 and 2-6	All

Notes:

1. The loss of CIA and SIA causes air-operated isolation valves for the RCP thermal barriers, motor, and bearings to fail closed. RCP seal cooling must then be provided by seal injection from normal charging and the RCPs must be tripped. Loss of power to vital bus channels I & II can result in the RCP thermal barrier cooling isolation valve closing.

2. HHSI consists of two trains. HHSI pump P1C can be manually aligned to either train of electric power and the associated train of SW, but is not normally aligned to either train. It receives start signal from the train aligned to it.

3. Two service water pumps are normally operating. The standby service water pumps are off. The third service water pump may be operated from either 4.16 kV AC bus and can be aligned to either header A or B. The standby service water pumps can be manually loaded, but are not automatically loaded onto the diesels during a loss of offsite power.

4. The non-emergency ERF (black) diesel generator provides a backup power supply for instrument air via the station air compressors , and for the containment instrument air compressors. Station air compressors are automatically aligned to the ERF diesel following a loss of offsite power. Since SCCW is not available following a loss of offsite power, Unit 1 filtered water is aligned to provide backup cooling to the station air compressors. Filtered water pump 1WF-P-2B is powered by black diesel following loss of offsite power.

Table 2 (Continued)

The plant internal event CDF (including internal flood) is 5.9E-5/yr.

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1.3 SDP WORKSHEETS

This section presents the SDP worksheets to be used in the Phase 2 evaluation of the inspection findings for the Beaver Valley Unit 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 PORV (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Offsite Power (LOOP)
8. Steam Generator Tube Rupture (SGTR)
9. Main Steam Line Break (MSLB)
10. Anticipated Transients Without Scram (ATWS)
11. Loss of SW Header A or B
12. LOOP with Loss of One 4 kV Emergency Bus
13. Loss of a 4 kV EAC Bus (LEAC)
14. Loss of a DC Bus (LDC)
15. Interfacing System LOCA (ISLOCA)

Table 3.1 SDP Worksheet for Beaver Valley Unit 2 — 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)	1/2 Main Feedwater (MFW) trains with 1/2 Condensate pump trains (operator action = 3) (1)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train)
Early Inventory, High Pressure Injection (EIHP)	1/2 Charging pumps or use of 1 spare charging pump (1 multi-train system) (2)
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (3)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 RS (2C or 2D) pumps (1 multi-train system) (4)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TRANS - AFW - PCS - HPR (4)			
2 TRANS - AFW - PCS - FB (5)			
3 TRANS - AFW - PCS - EIHP (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.

<u>Notes</u>:

1. The HEP for operator starting the main feed pumps is 1.2E-3.

(2) The spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

(3) The human error probability (HEP) assessed in the IPE (page 3.3-76) for establishing bleed and feed cooling is 3.7E-2 (Operator failure to initiate feed and bleed after failure to restore MFW).

(4) The containment heat removal function at BV-2 is provided by HPR using 1/2 charging pump with 1/2 RS (2C or 2D) pumps. The recirculation spray function provided by RS (2A and 2B) pumps is for containment cooling and do not affect the core damage sequences. The transfer to recirculation function receives an automatic signal from the RWST level instruments.

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Table 3.2 SDP Worksheet for Beaver Valley Unit 2 — Transients without PCS (TPCS)

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:**		
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) using 1/3 steam dump valves or 1/15 SG safety valves or 1/1 heat release valve		
Early Inventory, High Pressure Injection (EIHP)	1/2 Charging pumps or use of 1 spare charging pump (1 multi-train system) (1)		
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (2)		
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 RS (2C or 2D) pumps (1 multi-train system) (3)		
Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TPCS - AFW - HPR (3)			
2 TPCS - AFW - FB (4)			
3 TPCS - AFW - EIHP (5)			

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 spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

(2) The human error probability (HEP) assessed in the IPE (page 3.3-76) for establishing bleed and feed cooling is 3.7E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW).

(3) The containment heat removal function at BV-2 is provided by HPR using 1/2 charging pump with 1/2 RS (2C or 2D) pumps. The recirculation spray function provided by RS (2A and 2B) pumps is for containment cooling and do not affect the core damage sequences. The transfer to recirculation function receives an automatic signal from the RWST level instruments.

Table 3.3 SDP Worksheet for Beaver Valley Unit 2 — Small LOCA (SLOCA)

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:**
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare charging pump (1 multi-train system) (1)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train)
Main Feedwater (FW)	Operator initiates 1/2 main feed pump trains with 1/2 condensate pump trains (operator action = 3)
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS using 2/3 ASDVs or the heat release valve (operator action = 3)
Primary Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (2)
Rapid Depressurization and Injection (RAPDEP)	Rapid depressurization using 1/3 AFW pumps, 2/3 ASDVs, 2/3 accumulators, and 1/2 LHSI pumps (operator action = 2)
Low Pressure Recirculation (LPR)	1/2 RS (2C or 2D) pumps (1 multi-train system) (3)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 RS (2C or 2D) pumps (1 multi-train system) (3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SLOCA - LPR (2, 6, 13)			
2 SLOCA - RCSDEP - HPR (4, 8)			
3 SLOCA - AFW - FW - HPR (10)			

4 SLOCA - AFW - FW - FB (11)			
5 SLOCA - EIHP - RAPDEP (14)			
6 SLOCA - EIHP - AFW (15)			

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 spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

2. The human error probability (HEP) assessed in the IPE (page 3.3 -76) for establishing bleed and feed cooling is 3.7E-2.

3. The transfer to recirculation receives an automatic signal from the RWST level instruments.

Table 3.4 SDP Worksheet for Beaver Valley Unit 2 — Stuck Open PORV (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:**
Isolation of Small LOCA (BLK)	The closure of the block valve associated with stuck open PORV (1 train)
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare charging pump (1 multi-train system) (1)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train)
Main Feedwater (FW)	Operator initiates 1/2 main feed pump trains with 1/2 condensate pump trains (operator action = 3)
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS using 2/3 ASDVs or heat release valve (operator action = 3)
Primary Bleed (FB)	Operator controls feed and bleed using stuck open PORV and block valve (operator action = 2) (2)
Rapid Depressurization (RAPDEP)	Rapid depressurization using 1/3 AFW pumps, 2/3 ASDVs, 2/3 accumulators, and 1/2 LHSI pumps (operator action = 2)
Low Pressure Recirculation (LPR)	1/2 RS (2C or 2D) pumps (1 multi-train system) (3)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 RS (2C or 2D) pumps (1 multi-train system) (3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SORV - BLK - LPR (2, 6, 13)			
2 SORV - BLK - RCSDEP - HPR (4, 8)			
3 SORV - BLK - AFW - FW - HPR (10)			
4 SORV - BLK - AFW - FW - FB (11)			

5 SORV - BLK - EIHP - RAPDEP (14)			
6 SORV - BLK - EIHP - AFW (15)			

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 spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.
2. The human error probability (HEP) assessed in the IPE (page 3.3 -76) for establishing bleed and feed cooling is 3.7E-2.
3. The transfer to recirculation receives an automatic signal from the RWST level instruments.
4. No separate event tree is provided. Please refer to the SLOCA event tree considering the BLK function next to the initiating event. The BLK function is assigned an operator action credit of 2 based on survey of data from similar plants.

Table 3.5 SDP Worksheet for Beaver Valley Unit 2 — 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:**
Early Inventory, Accumulators (EIAC)	2/2 remaining accumulators (1 train)
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare charging pump (1 multi-train system).
Low Pressure Injection (LPI)[(1)]	1/2 LHSI pumps (1 multi-train system)
Low Pressure Recirculation (LPR)	1/2 RS (2C or 2D) pumps aligned for recirculation (1 multi-train system) [(2)]

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 MLOCA - LPR (2)			
2 MLOCA - LPI (3)			
3 MLOCA - EIHP (4)			
4 MLOCA - EIAC (5)			

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. As per the IPE, both HHSI and LHSI are required for success to cover the full range of medium LOCAs.
2. The transfer to recirculation receives an automatic signal from the RWST level instruments.

Table 3.6 SDP Worksheet for Beaver Valley Unit 2 — 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**:
Earlt Inventory, Accumulators (EIAC)	2/2 Accumulators (1 Train)
Early Inventory, LP Injection (LHSI)	1/2 LHSI pump trains (1 multi-train system)
Quench Spray (QS)[(1)]	1/2 QS pumps drawing from RWST (1 multi-train system)
Low Pressure Recirculation (LPR)	1/2 RS (2C or 2D) pumps (1 multi-train system)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LLOCA - LPR (2)			
2 LLOCA - QS (3)			
4 LLOCA - LHSI (4)			
5 LLOCA - EIAC (5)			

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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. A high containment pressure (8 psig) signal initiates both QS pumps. Successful operation of a QS pump is needed to fill the containment sump for required NPSH for RS pumps.

Table 3.7 SDP Worksheet for Beaver Valley Unit 2 — Loss of Offsite Power (LOOP)

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:**
Emergency AC Power (EAC)	1/2 Emergency Diesel Generators (1 multi-train system)
Turbine-driven AFW pump (TDAFW)	1/1 TDPAFW train (1 ASD train) [(1)]
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train)
Recovery of AC Power in < 2 hrs (REC2)	Operator recovers AC power within 2 hrs (operator action = 1) [(1)]
Recovery of AC Power in < 5 hrs (REC5)	Operator recovers Ac power within 5 hrs (operator action = 2) [(1,2)]
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare charging pump (1 multi-train system) [(4)]
Primary Heat Removal (FB)	Operator uses RCS pressurizer 1/3 PORVs and block valves (operator action = 2) [(3)]
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 RS (2C or 2D) pumps (1 multi-train system) [(5)]

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LOOP - AFW - HPR (3)			
2 LOOP - AFW - FB (4)			
3 LOOP - AFW - EIHP (5)			
4 LOOP - EAC - HPR (7,11) (AC recovered)			
5 LOOP - EAC - EIHP (8,13) (AC recovered)			

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6 LOOP - EAC - REC5 (9)			
7 LOOP - EAC - TDAFW - FB (12) (AC recovered)			
8 LOOP - EAC - TDAFW - REC2 (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. In IPE, Recovery of AC with AFW, PORV LOCA is assigned a failure probability of 0.12, and Recovery of AC with AFW, No LOCA is assigned a failure probability of 5.0E-3.

2. In an SBO situation, an RCP seal LOCA may occur, with subsequent core damage at about 5 hours.

3. The human error probability (HEP) assessed in the IPE (page 3.3 -75) for establishing bleed and feed cooling is 4.3E-3.

4. The spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

5. The transfer to recirculation receives an automatic signal from the RWST level instruments.

Table 3.8 SDP Worksheet for Beaver Valley Unit 2 — Steam Generator Tube Rupture (SGTR)

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:**
Secondary Heat Removal (SHR)	1/2 MDPs of AFW (1 multi-train system) or 1/1 TDP of AFW (1 ASD Train)
Early Inventory, HP Injection (EIHP)	1/2 charging pumps or use of 1 spare charging pump (1 multi-train system)
Pressure Equalization (EQ)	Operator isolates the ruptured SG and depressurizes RCS using 2/2 ASDVs to less than setpoint of relief valves of SG (operator action = 3) (1)
Feed-and-Bleed (FB)	Operator uses RCS pressurizer PORV and block valves (1/3) (operator action=2) (2)
Late depressurization and RWST makeup (RWST)	Operator depressurizes RCS and provides makeup to RWST for HHSI pumps (operator action = 1)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 RS (2C or 2D) pumps for recirculation (1 multi-train system)
Residual Heat Removal (RHR)	Operator depressurizes RCS and initiates 1/2 RHR pumps (operator action = 3) (3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SGTR - EQ - RHR (3)			
2 SGTR - EQ - RWST (4)			
3 SGTR - SHR - HPR (6)			
4 SGTR - SHR - EQ (7)			
5 SGTR - SHR - FB (8)			

6 SGTR - EIHP - RHR (10)			
7 SGTR - EIHP - EQ (11)			
8 SGTR - EIHP - SHR (12)			
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. The operator failure to isolate ruptured SG and equalize pressure is assigned a probability of 1.5E-3. An operator action credit of 2 is assigned based on a survey of similar plants. In this action, 2 of 2 ASDVs are assumed to be required for success. The ruptured SG is isolated, and consequently, its ASDV and the heat release valve are assumed to be unvavailable.

2. The human error probability (HEP) assessed in the IPE (page 3.3-75) for establishing bleed and feed cooling is 4.3E-3.

3. In IPE, the operator failure to depressurize RCS for RHR entry is assigned a probability of 1.2E-3.

Table 3.9 SDP Worksheet for Beaver Valley Unit 2 — Main Steam Line Break (MSLB)

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:**
Isolation of the Break (ISOB)	Closure of 3/3 MSIVs and Isolation of feedwater to the affected SG (1 train)
Isolation of 2/3 MSIVs (ISOB1)	Closure of 2/3 MSIVs (1 multi-train system)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) using 1/2 steam dump valves or 1/15 SG safety valves or 1/1 heat release valve
Early Inventory, High Pressure Injection (EIHP)	1/2 Charging pumps or use of 1 spare charging pump (1 multi-train system) (1)
Stop High Pressure Injection (STEIHP)	Operator terminated high pressure Injection (operator action = 2)
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (2)
High Pressure Recirculation (HPR)	1/2 charging pumps with 1/2 RS (2C or 2D) pumps (1 multi-train system) (3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 MSLB - ISOB - STEIHP (3)			
2 MSLB - ISOB - AFW - HPR (5)			
3 MSLB - ISOB - AFW - FB (6)			
4 MSLB - ISOB - EIHP - AFW (8)			

5 MSLB - ISOB1 (9)			

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 spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

(2) The human error probability (HEP) assessed in the IPE (page 3.3-76) for establishing bleed and feed cooling is 3.7E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW).

(3) The containment heat removal function at BV-2 is provided by HPR using 1/2 charging pump with 1/2 RS (2C or 2D) pumps. The recirculation spray function provided by RS (2A and 2B) pumps is for containment cooling and do not affect the core damage sequences. The transfer to recirculation function receives an automatic signal from the RWST level instruments.

Table 3.10 SDP Worksheet for Beaver Valley Unit 2 — 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:**
Emergency Boration (HPI)	Operator conducts emergency boration using 1/ 2 BATs and 1/2 charging pumps (2) (operator action = 3)
Turbine trip (TTP)	AMSAC trips the turbine (1 multi-train system)
Primary Relief (SRV)	3/3 SRVs with 3/3 PORVs (1) open (1 train)
Secondary Heat Removal (AFW)	2/2 MDPs of AFW (1 train) or 1/1 TDP of AFW (1 ASD Train)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 ATWS - HPI (2)			
2 ATWS - SRV (3)			
3 ATWS - AFW (4)			
4 ATWS - TTP (5)			

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. 3/3 PORVs are only required 13.9% of the time per the current PRA model.

2. It is considered that enough time is not available to align the spare charging pump. Accordingly, the emergency boration uses 1 out of 2 charging pump.

Table 3.11 SDP Worksheet for Beaver Valley 2 — Loss of SW Header A or B [1]

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:**		
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train)		
Early Inventory, High Pressure Injection (EIHP)	1/1 Charging pump train or use of 1 spare charging pump (1train) [3]		
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) [2]		
High Pressure Recirculation (HPR)	1/1 charging pump train with 1/1 RS (2C or 2D) pump (1train)		
Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LOSW - AFW - HPR (3)			
2 LOSW - AFW - FB (4)			
4 LOSW - AFW - EIHP (5)			

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. Loss of both headers leads to core damage. Loss of either SW header leads to loss of CCS which eventually leads to loss of MFW as the MFW pumps require CCS cooling. Loss of CCS will also cause a loss of instrument air which will also fail MFW (via closure of FW valves and MSIVs). Loss of IA will close MSIVs within 30 minutes. Loss of IA is recoverable via switchover of compressor cooling to filtered water (simple operator action). Loss of 1 SW header will result in loss of 1 charging pump train and 1 RS train. Loss of service water header B results in a loss of the backup water supply for AFW, which is considered to have minimal impact and is not considered here. The initiating event frequency for 1 header is 2.5E-3/yr. The combined frequency for both the headers is 5E-3/yr.

2. The human error probability (HEP) assessed in the IPE (page 3.3-76) for establishing bleed and feed cooling is 3.7E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW).

3. The spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

4. No separate ET is provoded. Please refer to the TPCS tree.

Table 3.12 SDP Worksheet for Beaver Valley Unit 2 — LOOP with Loss of One 4 kV Emergency Bus [1] (LEAC)

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:**
PORVs Reclose (SORV)	3/3 PORVs reclose (1 train)
Auxiliary Feedwater (AFW)	1/1 MDAFW trains (1 train) or 1/1 TDAFW train (1 ASD train) using 1/15 SG safety valves or 1/1 heat release valve
Early Inventory, High Pressure Injection (EIHP)	1/1 Charging pump or use of 1 spare charging pump (1 train) [2]
Primary Heat Removal, Feed/Bleed (FB)	Operator conducts feed/bleed using 1/3 PORVs and block valves or the stuck-open PORV (operator action = 2) [3]
High Pressure Recirculation (HPR)	1/1 charging pump with 1/1 RS (2C or 2D) pump (1 train) [4]
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS using the heat release valve (operator action = 3)
Rapid Depressurization and Injection (RAPDEP)	Rapid depressurization using 1/2 AFW pumps, 1/1 heat release valve, 2/3 accumulators, and 1/1 LHSI pumps (1 train) [4]
Low Pressure Recirculation (LPR)	1 / 1 RS (2C or 2D) pumps (1 train)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LEAC - AFW - HPR (3, 14)			
2 LEAC - AFW - FB (4, 15)			
3 LEAC - AFW - EIHP(5, 16)			

4 LEAC - SORV - LPR (7, 11)			
5 LEAC - SORV - RCSDEP - HPR (9)			
6 LEAC - SORV - EIHP - RAPDEP (12)			

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 assumes LOOP with loss of emergency AC (orange) bus. This is similar to a LOOP with loss of 1 train of many safety system (AFW, HHSI, LHSI, RS). In addition, power to ASDVs and block valves are lost. A stuck-open relief valve results in a small LOCA scenario. The frequency of this initiating event is assumed to be two orders of magnitude lower than that for LOOP.

2. The spare charging can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the spare charging pump.

3. The human error probability (HEP) assessed in the IPE (page 3.3-76) for establishing bleed and feed cooling is 3.7E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW).

4. The credit for this function is limited by 1 train of hardware (1/1 LHIS train) available.

Table 3.13 SDP Worksheet for Beaver Valley 2 — Loss of a 4 kV EAC Bus (LAC) (1)

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:**
Early Inventory, High Pressure Injection (EIHP)	1/1 Charging pumps or use of 1 spare pump (1 train)
Secondary Heat Removal (AFW)	1/1 MDAFW trains (1train) or 1 TDAFW train (1 ASD train) using 1/1 heat release valve or 1/15 safety valves
Primary Heat Removal, Feed/Bleed (FB)	1/3 PORVs and block valves open for Feed/Bleed (operator action = 2) (2)
High Pressure Recirculation (HPR)	1/1 charging pumps with 1/1 RS (2C or 2D) pumps (1 train)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LAC - AFW - HPR (3)			
3 LAC - AFW - FB (4)			
4 LAC - AFW - EIHP (5)			

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. Loss of a 4 kV bus will cause loss of associated train of emergency equipment (i.e., Loss of 1 train of HHSI, AFW, and RS system).The loss of a 4 kV Bus leads to loss of one service water header which leads to loss secondary component cooling water system (CCS) and a plant trip. The impact between the orange and the purple power is fairly symmetrical except some minor asymmetries in PORV block valves and steam release. The orange bus leads to loss of two PORV block valves. 3 ASDVs are lost on loss of the orange bus. We model here the orange bus. The heat release valve is lost on loss of the purple bus, but it can be manually opened using a hydraulic pump. Note that DC failures will follow AC failures upon battery depletion. Status of AC buses is alarmed and indicated in the main control room in a multitude of ways. Also, equipment that is running on the affected bus will trip and have to be started from the opposite bus (charging, CCP). This may cause a trip in itself. The initiating event frequency for the loss of 1 Bus is 1.3E-2/yr; and the combined frequency is 2.6E-2/yr.

2. The human error probability (HEP) assessed in the IPE (page 3.3-76) for establishing bleed and feed cooling is 3.7E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW).

3. No separate event tree is provided. Please refer to the TPCS tree.

Table 3.14 SDP Worksheet for Beaver Valley Unit 2 — Loss of a DC Bus (LDC) [1]

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:**
Secondary Heat Removal (AFW)	1/1 MDAFW trains (1 train) or 1 TDAFW train (1 ASD train) using 1/3 steam dump valves or 1/1 heat release valve or1/15 safety valves
Early Inventory, High Pressure Injection (EIHP)	1/1 Charging pump or use of 1 spare charging pump (1 train) [3]
Primary Heat Removal, Feed/Bleed (FB)	1/2 PORVs and block valves open for Feed/Bleed (operator action = 2) [2,]
High Pressure Recirculation (HPR)	1/1 charging pump with 1/1 RS (2C or 2D) pumps (1 train)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LDC - AFW - HPR (3)			
2 LDC - AFW - FB (4)			
3 LDC - AFW - EIHP (5)			

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 loss of a Dc bus , MSIVs isolate and feedwater control and bypass valves close isolating MFW . This results in TT and reactor trip. (Note: A loss of the other DC bus (orange) will not cause MFW isolation, but will cause MSIV closure). Control power for 1 train of the safety systems (AFW, HHSI &RS) are lost. For the purple bus, 1 of the 3 PORVs fail, but for the orange bus 2 of the three PORVs fail. We model here the purple bus because it causes the loss of the MFW.

   Initiating Event Frequency (combining both the buses): 6E-3/yr.

2. The human error probability (HEP) assessed in the IPE (page 3.3-76) for establishing bleed and feed cooling is 3.7E-2 (Operator failure to to initiate feed and bleed after failure to restore MFW and the startup feed pump).

3. One train of each system loses start capability, but they can be manually started at the switchgear. In addition, in order to use charging pump C, one of the other CPs must be manually racked out at switchgear and CP C manually racked in.

4. No separate ET is provided. Please refer to the TPCS tree.

Table 3.15 SDP Worksheet for Beaver Valley 2 — Interfacing System LOCA (ISLOCA)

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

Initiating Pathways:	**Mitigation Capability: Ensure Component Operability for Each Pathway**:
Cold leg to LHSI Injection Lines	Two Check valve in series located inside containment in each of the three injection lines and two paths with one check valve and normally open motor-operated valve (MOV8888A and 8888B)

Circle Affected Functions	**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.

Note:

1. Information is based on licensee’s PRA. Other sources of ISLOCA are not screened out in the PRA.

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. An event tree for the stuck-open PORV is not included since it is similar to the small LOCA event tree. 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. Medium LOCA (MLOCA)
5. Large LOCA (LLOCA)
6. Loss of Offsite (LOOP)
7. Steam Generator Tube Rupture (SGTR)
8. Main Steam Line Break (MSLB)
9. Anticipated Transients Without Scram (ATWS)
10. Loss of a 4 kV EAC Bus (LEAC)

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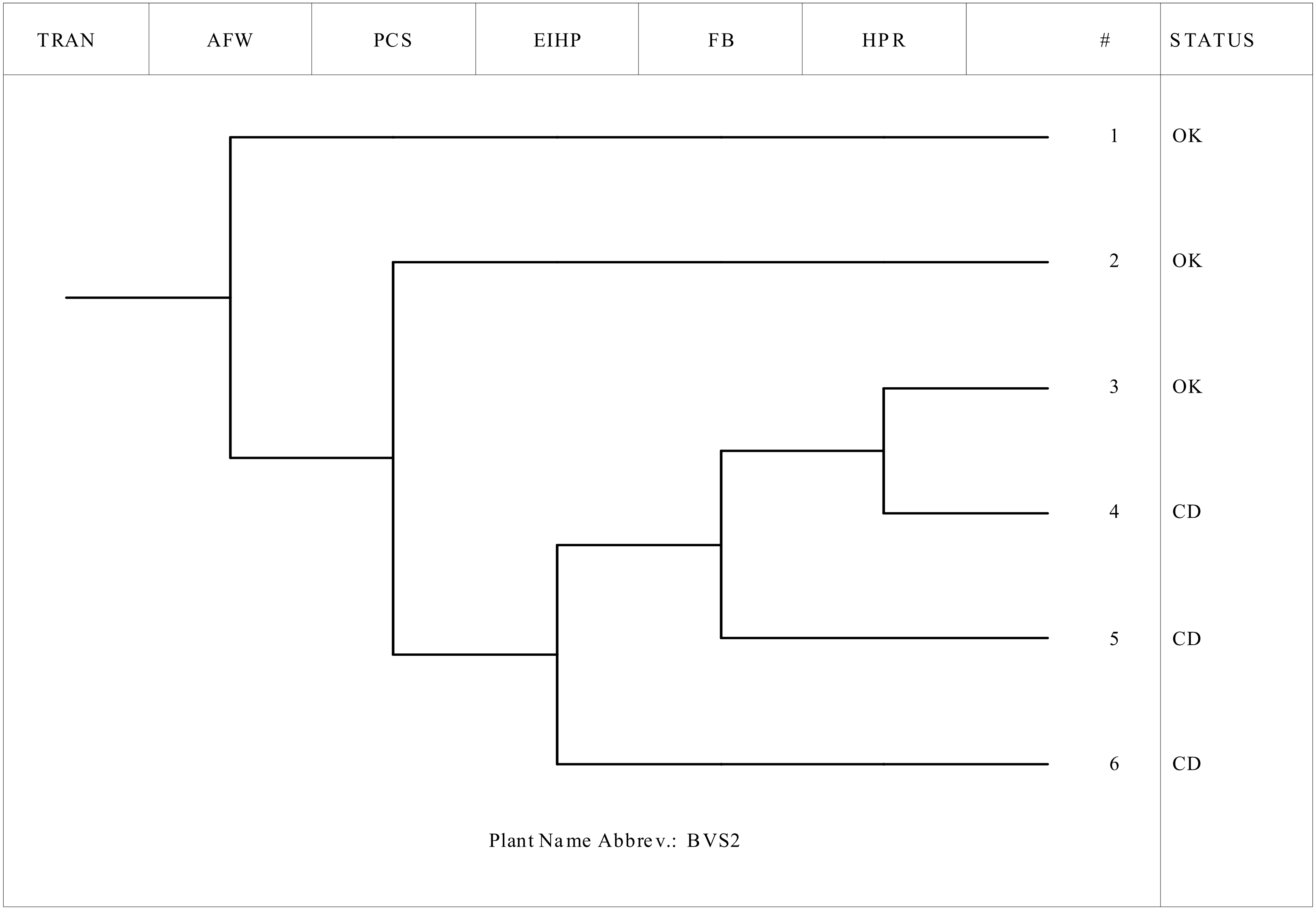

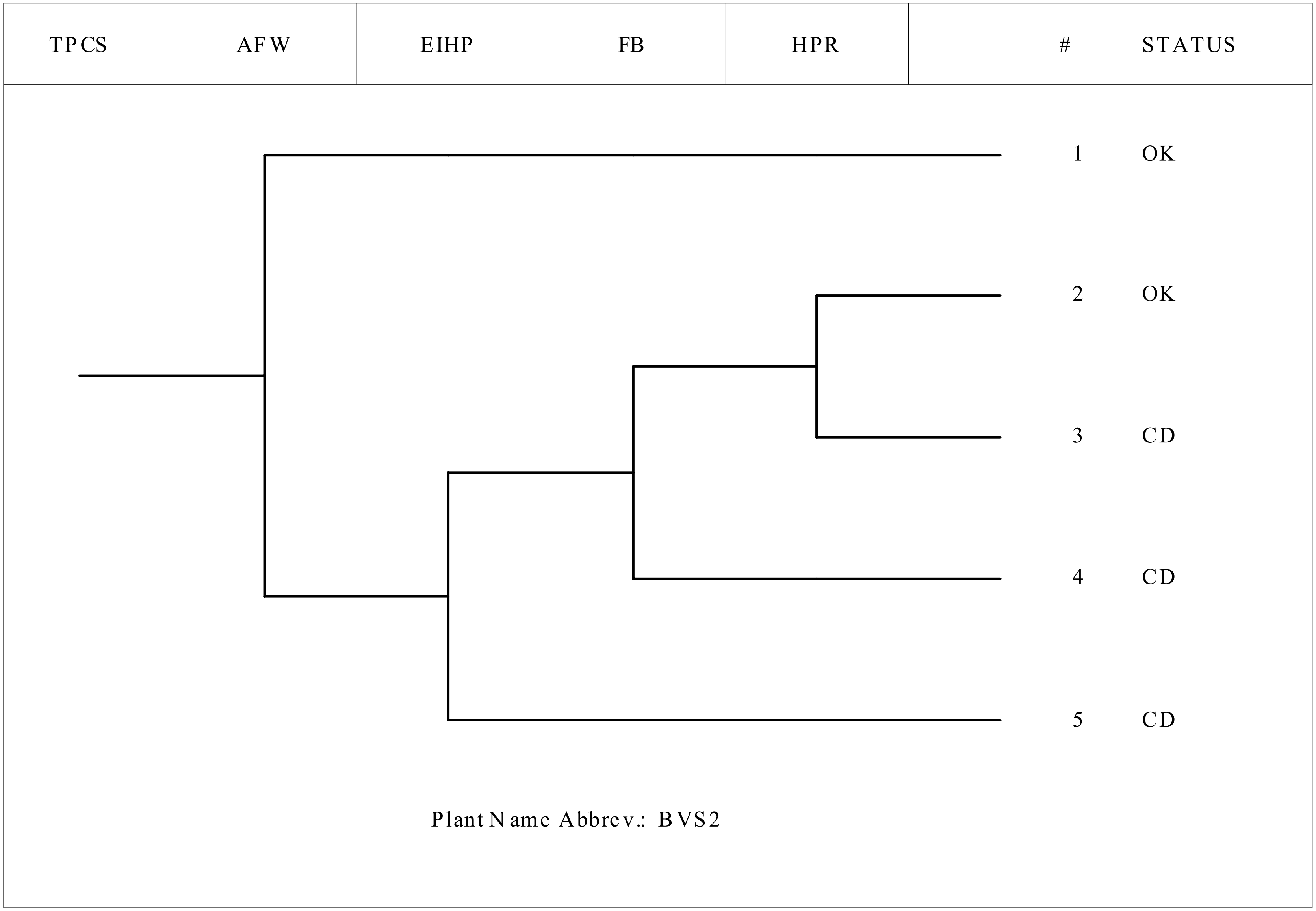
TPCS
AFW
EIHP
FB
HPR
#
STATUS
1
OK
2
OK
3
CD
4
CD
5
CD
Plant Name Abbrev.: BVS2

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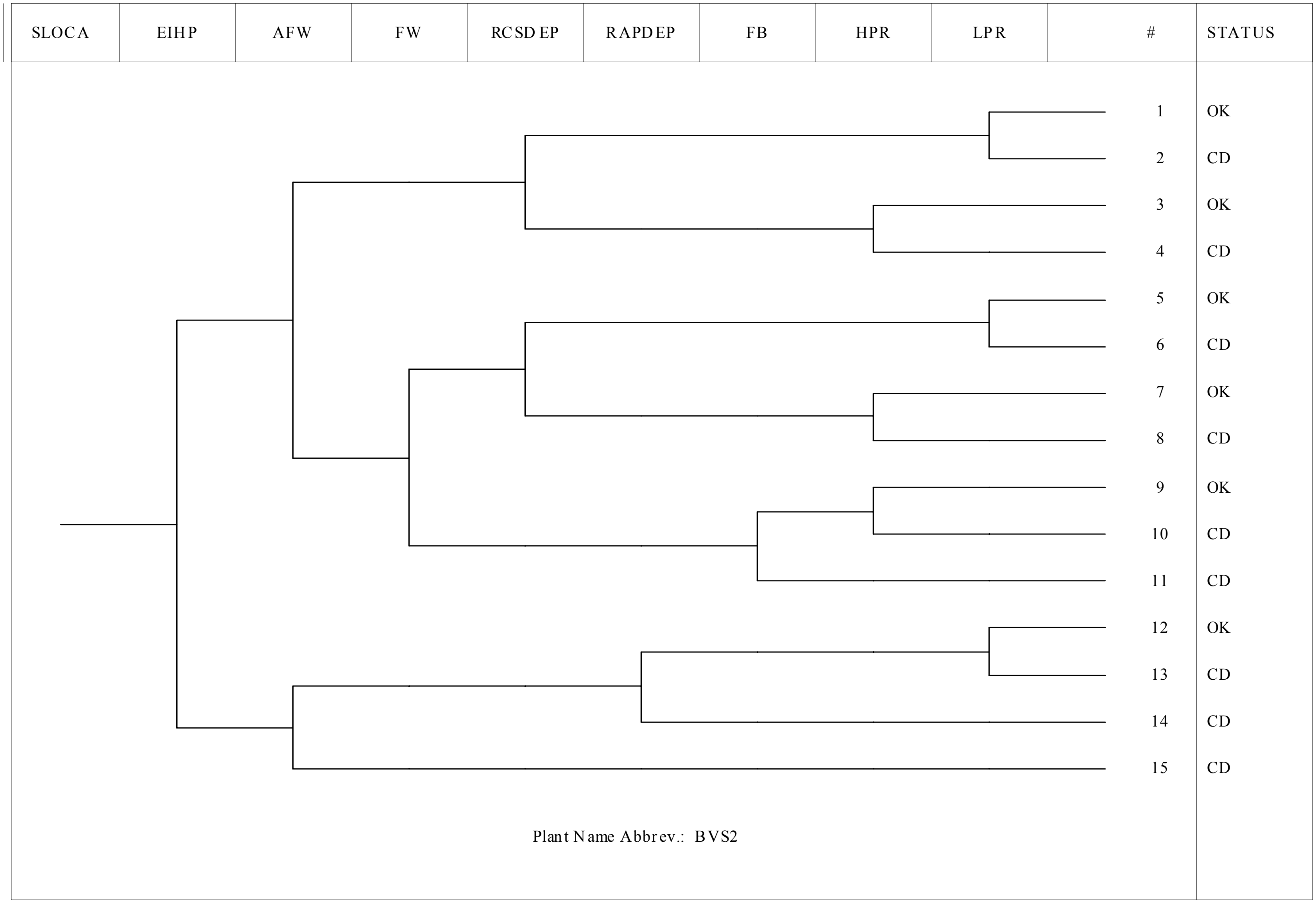
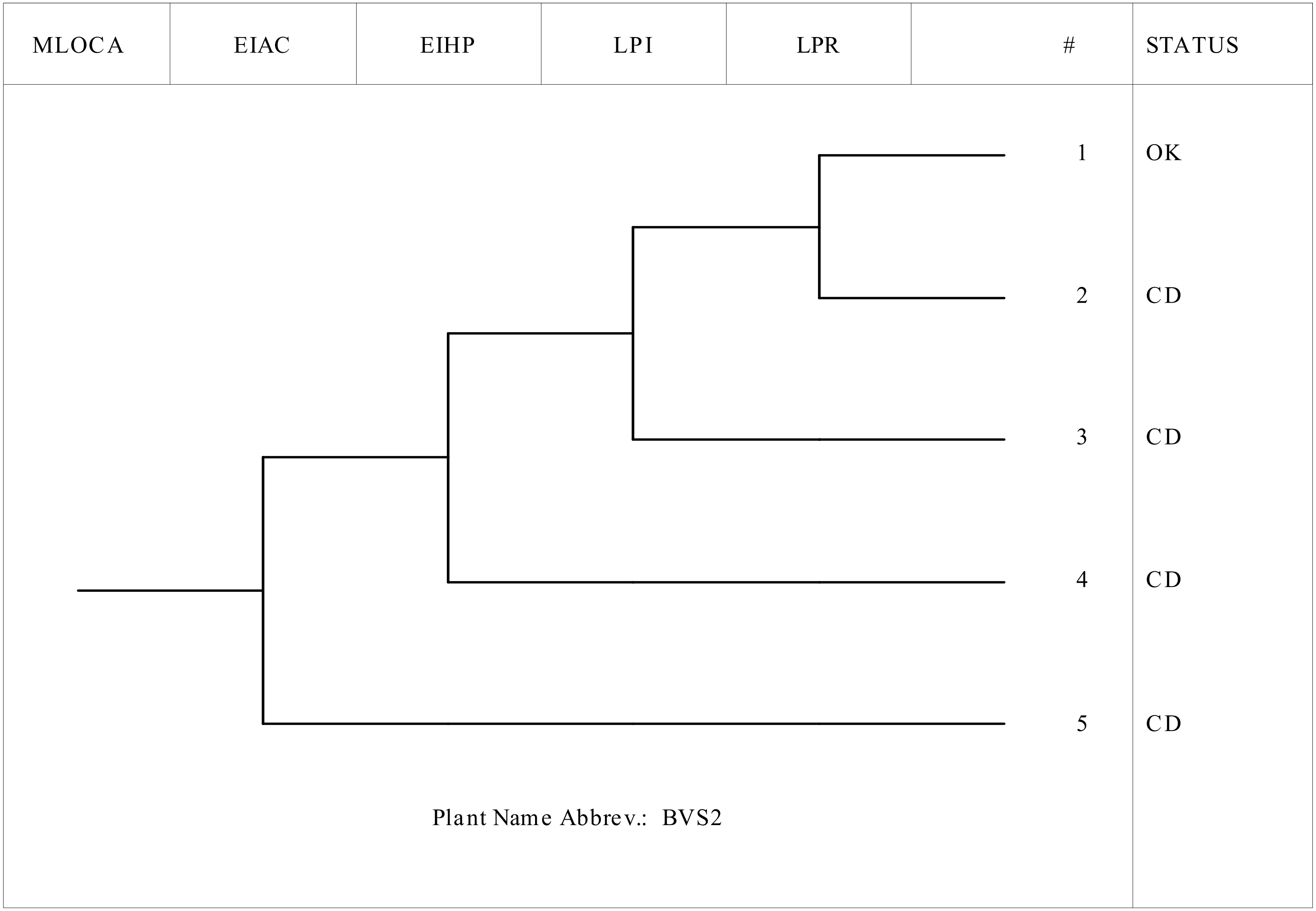
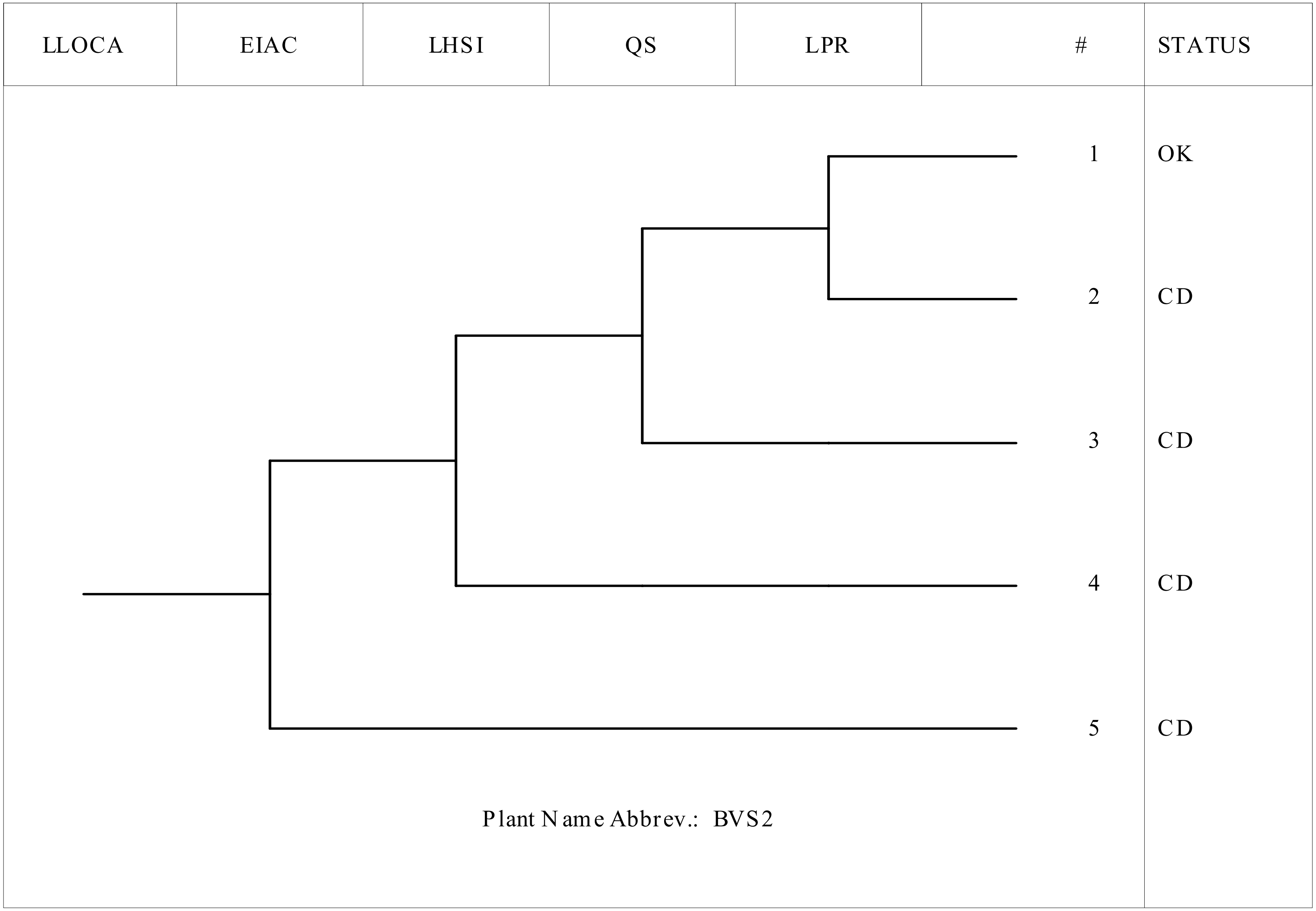
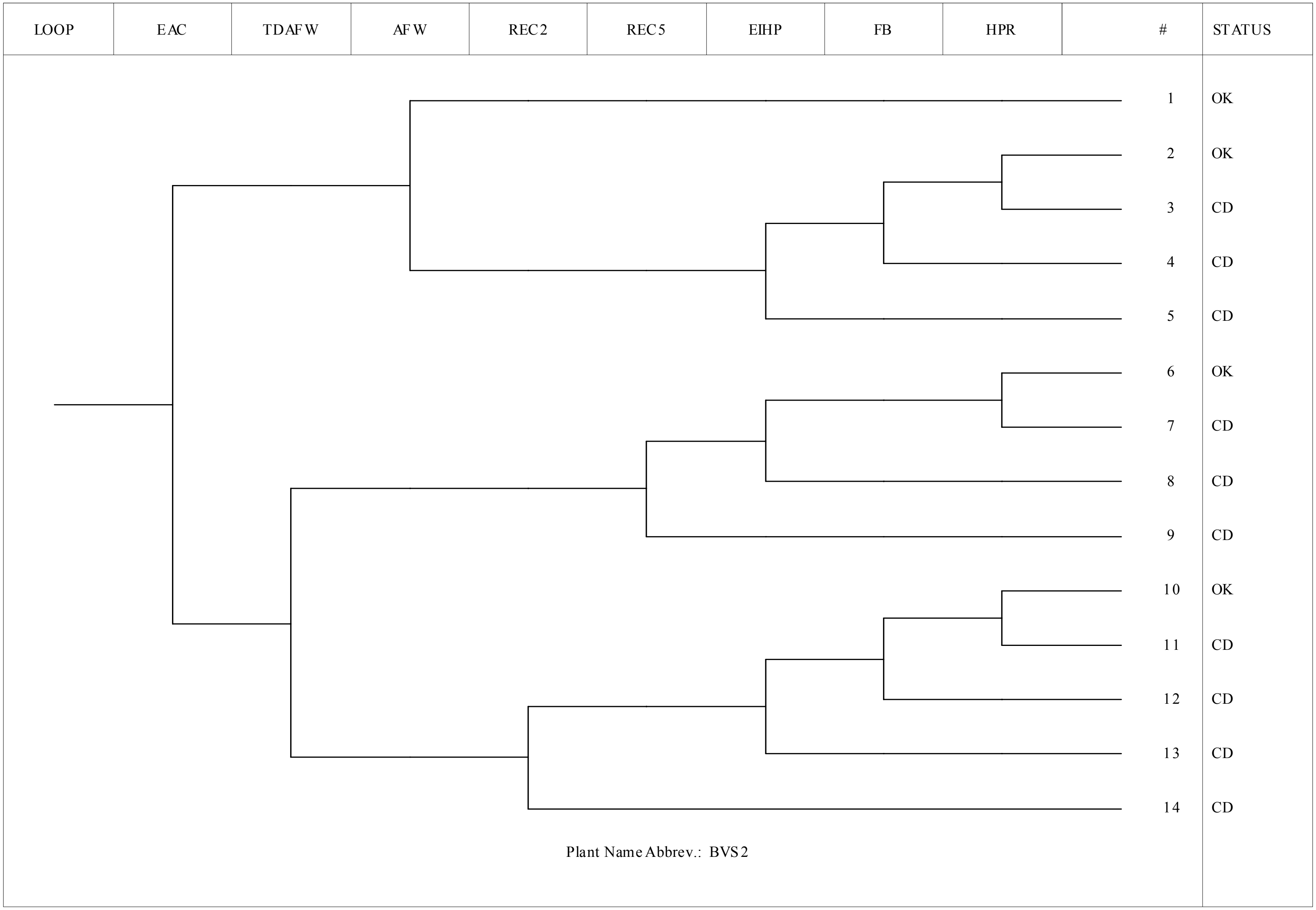


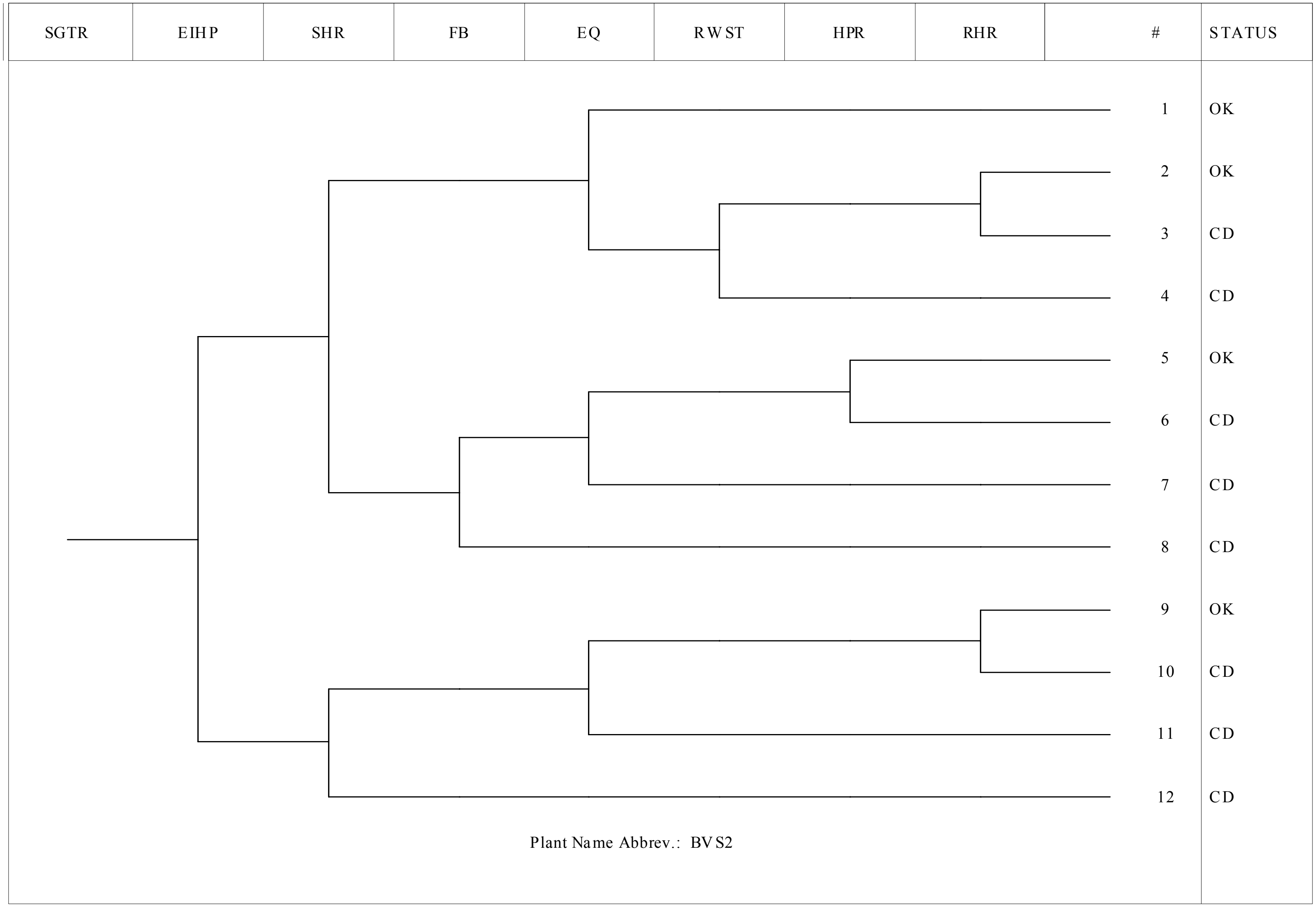


Beaver Valley 2 - 47 - Rev. 0, May 3, 2001



Beaver Valley 2 - 48 - Rev. 0, May 3, 2001


LOOP
EAC
TDAFW
AFW
REC2
REC5
EIHP
FB
HPR
#
STATUS
1 OK
2 OK
3 CD
4 CD
5 CD
6 OK
7 CD
8 CD
9 CD
10 OK
11 CD
12 CD
13 CD
14 CD
Plant Name Abbrev.: BVS2



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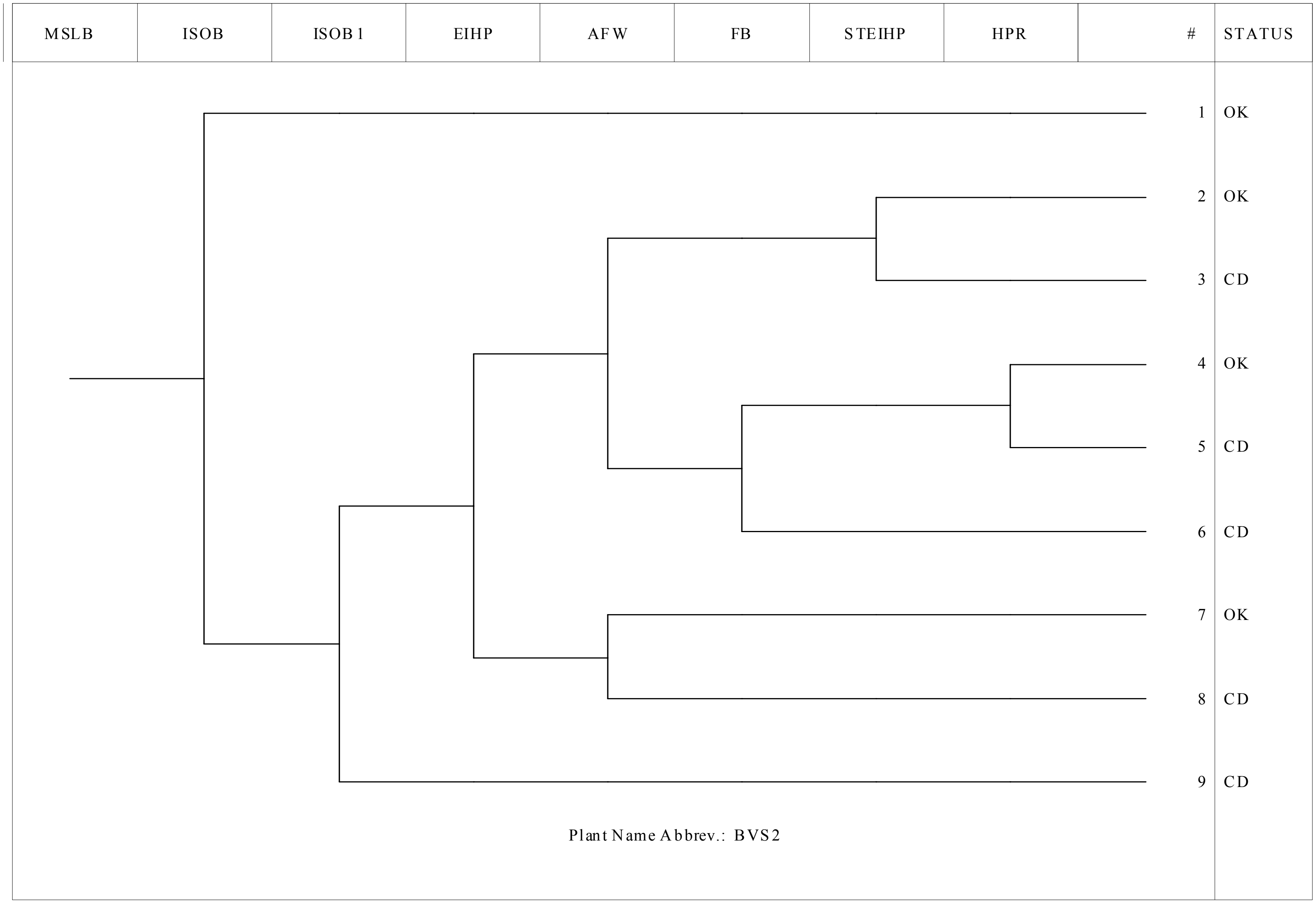
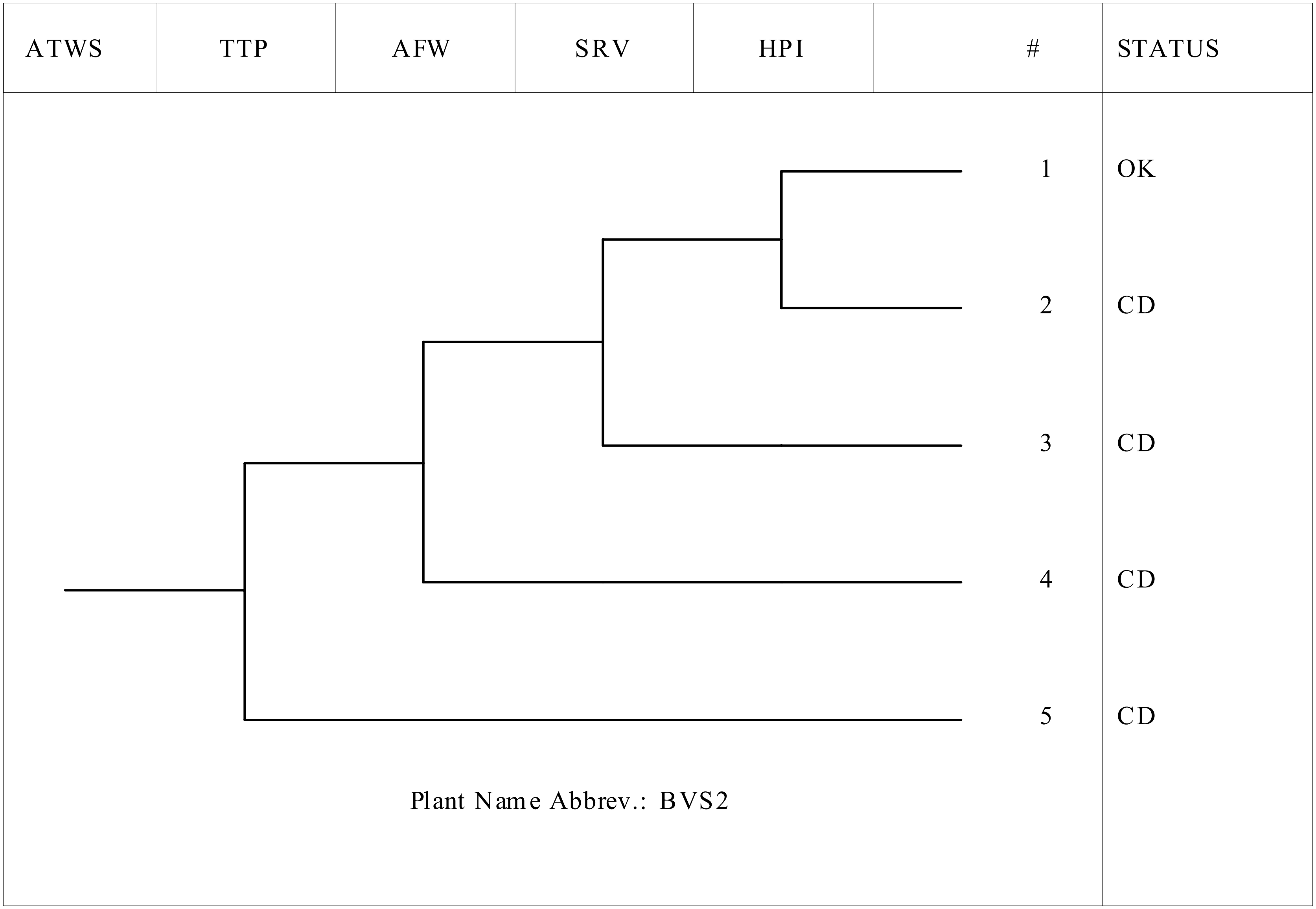

MSLB
ISOB
ISOB1
EIHP
AFW
FB
STEIHP
HPR
#
STATUS
1 OK
2 OK
3 CD
4 OK
5 CD
6 CD
7 OK
8 CD
9 CD
Plant Name Abbrev.: BVS2


ATWS
TTP
AFW
SRV
HPI
#
STATUS
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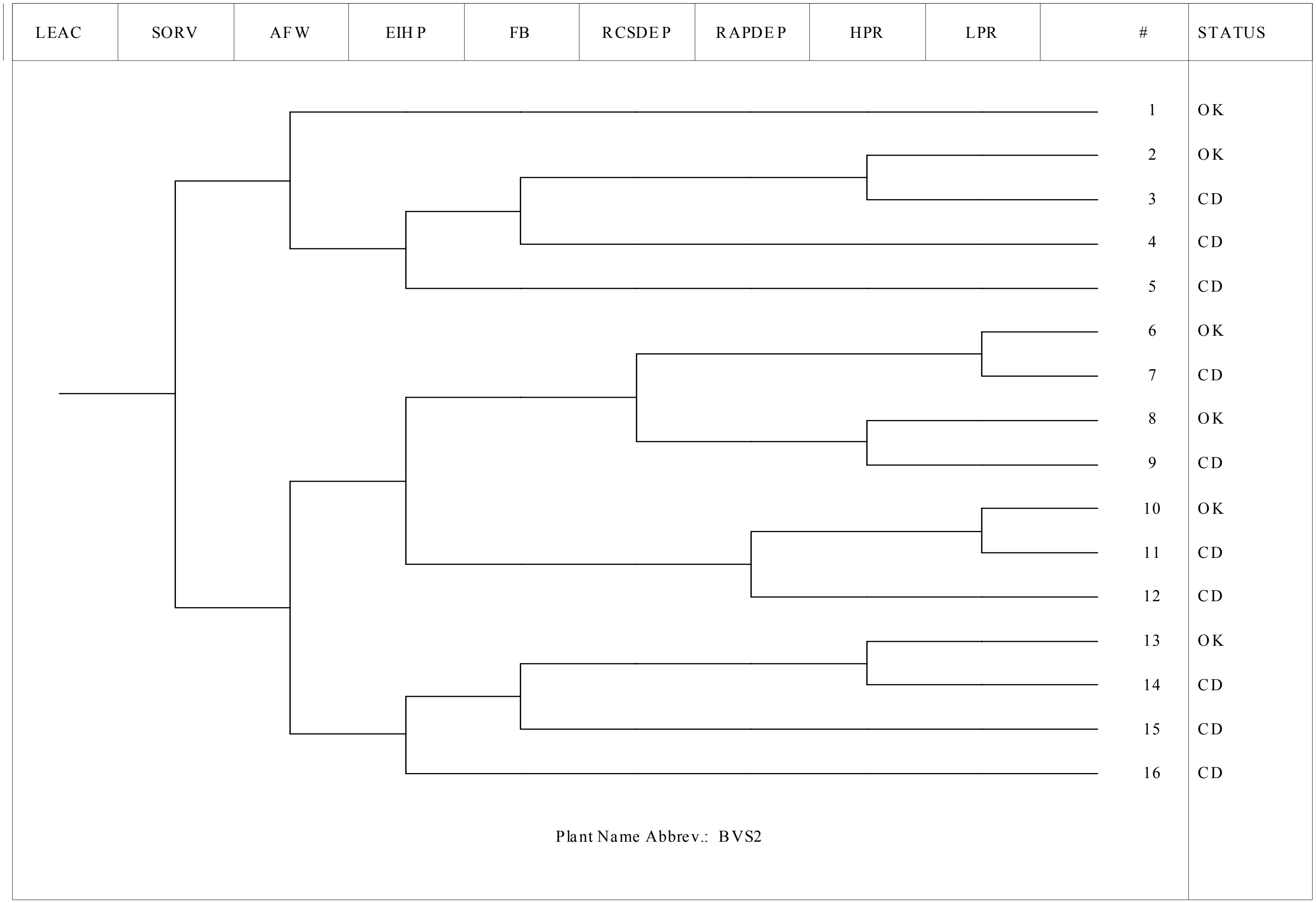
OK
2
CD
3
CD
4
CD
5
CD
Plant Name Abbrev.: BVS2



Beaver Valley 2 - 53 - Rev. 0, May 3, 2001

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 PWR 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 PWRs 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 (PWRs)

The following generic guidelines and assumptions were used in developing the SDP worksheets for PWRs. These guidelines and assumptions were derived from a review of the licensee's comments, the resolutions of those comments, and the applicability to similar plants.

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 PORV/SRV (SORV), main steam and feedwater line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCAs (ISLOCA) are assigned into rows based on a consideration of the industry-average frequency. Plant-specific frequencies are considered for loss of offsite power (LOOP) and special initiators, and are assigned to the appropriate rows in Table 1.

2. Stuck open PORV/SRV as an IE in PWRs:

This event typically is not modeled in PRAs/IPEs as an initiating event. The failure of the PORVs/SRVs to re-close after opening is typically modeled within the transient event trees subsequent to the initiators. In addition, the intermittent failure or excessive leakage through PORVs as an initiator, albeit with much lower frequency, needed to be considered. To account for such failures and to keep the transient worksheets simple in the SDP, a separate worksheet for the SORV initiator was set up to explicitly model the contribution from such failures. This SDP worksheet, and the associated event tree, is similar to that of SLOCA. The frequency of PORV to re-close depends on the status of pressurizer. If the pressurizer is solid, then the frequency would be higher than the case in which the pressurizer level is maintained. Typically, this depends on early availability of secondary heat removal. However, the frequency for the SORV initiator is generically estimated for all PWR plants in Table 1.

3. Inclusion of special initiators:

The special initiators included in the worksheets are those applicable to this plant. A separate worksheet is included for each of them. The applicable special initiators are primarily based on the plant-specific IPEs/PRAs. In other words, the special initiators included are those modeled in the IPEs/PRAs unless shown to be negligible contributors. In some cases, a particular special initiator may be added for a plant even if it is not included in the IPE/PRA, if it is included in other plants of similar design, and is considered applicable for the plant. However, no attempt is made at this time to have a consistent set of special initiators across similarly designed plants. Except for the interfacing system LOCA (ISLOCA), 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's focus is on the initiating event and the risk implication of the finding can be directly assessed. For ISLOCA, a separate worksheet is included noting the pathways that can lead to it.

4. Inclusion of systems under the support system column of the Initiators and System Dependency Table:

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

5. 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 event tree headings/functions to that included in the Table was not considered necessary.

6. 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 those covered under the Technical Specifications (TS) and the Maintenance Rule (MR). Credits for other components may have been removed in the SDP worksheets.

7. 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 they help to maintain consistency across the SDP worksheets for similar plant designs.

8. Crediting system trains with high unavailability:

Some system component/trains may have unavailability higher than 1E-2, but they are treated similarly to other trains with lower unavailability in the range of 1E-2. In this screening, this approach 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 1E-1.

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

Passive components, namely accumulators, are credited similarly to active components, even though they exhibit higher reliability. Considering the potential for common-cause failures, the reliability of a passive system is not expected to differ by more than an order of magnitude from active systems. Pipe failures were excluded, except as part of initiating events where the appropriate frequency is used. Accordingly, a separate designation for passive components was not considered necessary.

10. Crediting accumulators:

SDP worksheets assume the loss of the accumulator unit associated with the failed leg in LOCA scenarios. Accordingly, in defining the mitigation capability for the accumulators, the worksheets refer to the remaining accumulators. For example, in a plant with 4 accumulators with a success criteria of 1 out of 4, for large LOCA the mitigation capability is defined as 1/3 remaining accumulators (1 multi-train system), assuming the loss of the accumulator in the failed leg. For a plant with a success criteria of 2 out of 4 accumulators, the mitigation capability is defined as 2/3 remaining accumulators (1 multi-train system).

The inspection findings are then assessed as follows (using the example of the plant with 4 accumulators and success criteria of 2 out of 4):

4 Acc. Available	Credit=3
3 Acc. Available (1 Acc. is considered unavailable, based on inspection findings)	Credit=2
< 3 Acc. Available (2 or more Acc. are considered unavailable, Based on inspection findings)	Credit=0

11. Crediting 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.

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

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

13. Dependency among multiple operator actions:

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

14. Crediting the standby high-pressure pump:

The high-pressure injection system in some plants consists of three pumps with two of them auto-aligned and the third spare pump requiring manual action. The mitigating capability then is defined as : 1/2 HPI trains or use of a spare pump (1 multi-train system). Also, a footnote is added to reflect that the use of a spare pump could be given a credit of 1 (i.e.,1E-1) as a recovery action.

15. Emergency AC Power:

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:

a) Describe the success criteria and the mitigation capability of dedicated EDGs.

b) 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.

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

d) 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.

16. Treatment of HPR and LPR:

The operation of both the HPR and LPR rely on the operation of the RHR pumps and the associated heat exchangers. Therefore, failure of LPR could imply failure of both HPR and LPR. A sequence which contains failure of both HPR and LPR as independent events will significantly underestimate the CDF contribution. To properly model this configuration within the SDP worksheets, the following procedure is used. Consider the successful depressurization and use of LPR as the preferred path. HPR is credited when depressurization has failed. In this manner, a sequence containing both HPR and LPR failures together is not generated.

17. SGTR event tree:

Event trees for SGTR vary from plant to plant depending on the size of primary-to-secondary leak, SG relief capacity, and the rate of rapid depressurization. However, there are several common functional steps that are addressed in the SDP worksheet: early isolation of the affected SG, initiation of primary cool-down and depressurization, and prevention of the SG overfill. These actions also include failure to maintain the secondary pressure below that of Main Steam safety valves which could occur either due to the failure of the relief valves to open or the operator's failure to follow the procedure. Failure to perform this task (sometimes referred to as early isolation and equalization) is assumed to cause continuous leakage of primary outside the containment. The success of this step implies the need for high-pressure makeup for a short period, followed by depressurization and cooldown for RHR entry (note, relief valves are assumed to re-close when primary pressure falls below that of the secondary). If the early makeup is not available or the operator fails to perform early isolation and equalization, rapid depressurization to RHR entry is usually assumed. This would typically require some kind of intermediate- or low-pressure makeup. Finally, depending on the size of the Refueling Water Storage Tank (RWST), sometimes it would be necessary to establish makeup to the RWST to allow sufficient time to enter the RHR mode.

18. ATWS scenarios:

The ATWS SDP worksheet assumes that these scenarios are not recoverable by operator actions, such as a manual trip. The failure of the scram system, therefore, is not recoverable, neither by the actuation of a back-up system nor through the actuation of manual scram. The initiator frequency, therefore, should only account for non-recoverable scrams, such as mechanical failure of the scram rods.

19. 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.

20. RCP seal LOCA in a SBO:

The RCP seal LOCA in a SBO scenario is included in the LOOP worksheet. RCP seal LOCA resulting from loss of support functions is considered only if the loss of support function is a special initiator. The dependencies of RCP seal cooling are identified in Table 2.

21. RCP Seal LOCA for Westinghouse Plants during SBO Scenarios:

The modeling of the RCP seal failures upon loss of cooling and injection as occurs during SBO scenarios has been the subject of many studies (e.g., BNL Technical report W6211-08/99 and NUREG/CR-4906P). These studies are quite complex and assign probabilities of seal failure as a function of time (duration of SBO) and the associated leak rates. The leak rates, in turn, will determine what would be the safe period for recovery of the AC source and the use of SI pumps before core uncovery and damage. On the contrary, the SDP worksheets simplify the analysis of the RCP seal LOCA during the SBO scenarios using the following two assumptions: (1) The probability of catastrophic RCP seal failure is assumed to be 1 if the SBO lasts beyond two hours, and (2) Given a catastrophic seal LOCA, the available time prior to core damage for recovery of offsite power and establishing injection is about two hours. Therefore, in almost all cases, to prevent a core damage, a source of AC should be recovered within 4 hours in SBO scenarios.

22. Tripping the RCP on loss of CCW:

Upon loss of CCW, the motor cooling will be lost. The operation of RCPs without motor cooling could result in overheating and failure of bearings. Bearing failure, in turn, could cause the shaft to vibrate and thereby result in the potential for seal failure if the RCP is not tripped. In Westinghouse plants, the operator is instructed to trip the RCPs early in the scenario (from 2 to 10 minutes after detecting the loss of cooling). Failure to perform this action is conservatively assumed to result in seal failure and, potentially in a LOCA. This failure mechanism (occurrence of seal LOCA) due to failure to trip the RCPs upon loss of cooling is not considered likely in some plants, whereas it has been modeled explicitly in other plants. To ensure consistency, the trip of the RCP pumps are modeled in the SDP worksheets, and the operator failure to do this is assumed to result in a LOCA. In many cases, the failure to trip RCP following a loss of CCW results in core damage.

23. Hot leg/Cold leg switchover:

The hot leg to cold leg switchover during ECCS recirculation is typically done to avoid boron precipitation. This is typically part of the procedure for PWRs during medium and large LOCA scenarios. Some IPEs/PRAs do not consider the failure of this action as relevant to core damage. For plants needing the hot /cold switchover, it usually can only be accomplished with SI pumps and the ECCS recirculation also uses the SI pumps.

2.2 RESOLUTION OF PLANT- SPECIFIC COMMENTS

1. The Start Up Pump (SUP) has been removed from the mitigation capability. It is no longer maintained at the plant and is not modeled in the PRA.

2. The high pressure injection system has one spare pump in addition to the two charging pumps with auto initiation. The spare pump is credited as defined in the generic guidelines and assumptions.

3. The recirculation spray (RS) function provided by the RS (2A and 2B) pumps is for containment cooling only and has no effect on the core damage. Accordingly, it is removed from the mitigation capability in defining the core damage sequences.

4. The emergency boration uses 1/ 2 charging pumps since there is not enough time to align the spare charging pump.

5. A number of changes made to the Initiators and System dependency table as per licensee inputs.

REFERENCES

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

2. Dusquesne Light Company, "Beaver valley Power Station Unit 2 Probabilistic Risk Assessment Individual Plant Examination Report," March 17, 1992.

3. Dusquesne Light Company, "Beaver Valley Power Station Unit 2 Response to NRC RAI," October 26, 1992.