Calculation Cover Sheet

Complete only applicable items.

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00		Final Copy

Title: Creating Input Tables From WAPDEG For RIP
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Document Identifier: B00000000-01717-0210-00013 REV 00

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Draft Date: August 10, 1998

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1.0 Purpose

The purpose of this calculation is to create tables for input into RIP ver. 5.18 (Integrated Probabilistic Simulator for Environmental Systems) from WAPDEG ver. 3.06 (Waste Package Degradation) output. This calculation details the creation of the RIP input tables for TSPA-VA REV. 00.

2.0 Method

Based on user-supplied input, the stochastic simulation code WAPDEG is used to generate waste package failure profiles. WAPDEG's inputs include time-varying histories of the temperature and relative humidity at the waste package surface, various temperature and relative humidity thresholds for corrosion initiation, corrosion models, and corrosion model parameter distributions. A waste package may fail either through localized corrosion processes (pitting or crevice corrosion), leading to small pin-hole perforations, or through general corrosion processes leading to much larger "patch" perforations. More detailed discussions of the WAPDEG conceptual model are given elsewhere (CRWMS M&O, 1998a). The waste package failure profiles consist of time-varying measures of the number of pit and patch penetrations on each waste package. This information is abstracted by the WAPDEG post-processor, post306 (CRWMS M&O, 1998b, Appendix D), to produce one RIP input table (Golder Associates, 1998) per WAPDEG simulation. The RIP input table contains:

1) The first failure (pit or patch) versus time curve for the waste packages to be simulated,
2) The average number of pits per failed waste package versus time curve and,
3) The average number of patches per failed waste package versus time curve.

Post306 has two main objectives:

a) It reformats the WAPDEG output to conform to the RIP input format and,
b) It decreases the number of points in each of the curves discussed above (1) through 3)) to approximately 82 (depends on the data being processed), through a process of time averaging.

More detailed discussions of post306 appear elsewhere (CRWMS M&O, 1998b, Appendix D).

3.0 Assumptions

For the calculations involved in attaining a post processed table for input into RIP there are two steps to consider: 1) WAPDEG input and output and; 2) Post processing of WAPDEG output for creation of tables for input to RIP. There are several assumptions necessary to consider for the WAPDEG input and output. The following is a list of assumptions made in this process:

3.1 The variability in waste package degradation in a given repository region is adequately characterized by modeling 400 waste packages. This assumption is based on sensitivity studies performed with the WAPDEG code. This assumption is used in the WAPDEG input files (Section 5.1.1) in the fourth line after the last history file name.

3.2 The total surface area of the waste packages modeled is 298,862.5 cm^2. This is based on the surface area of a 21 PWR (Pressurized Water Reactor) waste package type (Benton, 1997) (TBV-350). The length of this waste package is 5.335 m and the outer diameter is 1.664 m. This total length includes 0.225-m outer barrier extensions, for lifting of the waste package, on each end (i.e., two of them) which are not considered during corrosion modeling. Thus, the waste package surface area modeled (subject to corrosion) is given by:

$$\left[\pi((5.335-2\cdot 0.225)\cdot 1.664)+\frac{\pi}{2}(1.664)^2\right]\cdot(100^2)=298{,}862.5\,\text{cm}^2$$

This assumption is used only in determining the number of patches per waste package in Assumption 3.3.

3.3 Each waste package is composed of 964 patches each 310 cm^2 in area. This patch size was chosen to be consistent with the size of a standard atmospheric corrosion test coupon (ASTM, 1992). This assumption is used in the WAPDEG input files (Section 5.1.1) in the fourth line after the last history file name.

3.4 There are 3,100 pits/patch on both the CAM and CRM yielding a pit density of 10 pits/cm^2. Pits are a modeling construct in WAPDEG where roughness factors and pit growth law parameters are applied. Hemispherical pits assumed in the CAM would overlap (at a 10 pit/cm^2 density) and produce the roughened general corrosion front described by the experts participating in the Waste Package Degradation Expert Elicitation (WPDEE - CRWMS M&O, 1997). This assumption is used in the WAPDEG input files (Section 5.1.1) in the fourth line after the last history file name.

3.5 The top and bottom of the waste package are each defined with an angle of 180°. This is a conservative assumption as the CRM general corrosion rates under dripping are higher than the CRM general corrosion rates in the absence of dripping water (CRWMS M&O, 1998c, 1998d). Dripping or pooling of dripped water can only occur on the top and bottom of the waste package and not along the sides (CRWMS M&O, 1998b). Furthermore, localized corrosion of the CRM initiates only under dripping conditions. This assumption is used in the WAPDEG input files (Section 5.1.1) in the ninth and tenth lines after the last history file name.

3.6 If a waste package is dripped upon, 100% of its surface is contacted by the drips. Again this is a conservative assumption for the same reasons outlined in Assumption 3.5. This assumption is based on the assumption that seeps could move along the waste package length with time, thus potentially wetting the entire waste package surface. This assumption is used in the WAPDEG input files (Section 5.1.1) in the ninth and tenth lines after the last history file name.

3.7 The RH thresholds for humid-air corrosion initiation and transition from humid-air to aqueous corrosion are perfectly rank correlated. The basis for this assumption is that the same factors (microstructural heterogeneity, the presence of salt films on the waste package surface, etc.) responsible for determining the humid-air corrosion initiation threshold would also factor into the determination of the RH threshold for the transition from humid-air to aqueous corrosion. Furthermore, as the CAM lasts only a few thousand years, this assumption has little effect on the overall waste package lifetime. This assumption is used in the [. . . Drip Features] input segments in the WAPDEG input files (Section 5.1.1). This input data is used on the seventh input line following the [No Drip Features] header and/or on the ninth input line after the [Neutral Drip Features] header.

3.8 The CAM pit multiple is represented by a bounded normal distribution with a mean of 1.5 and a standard deviation of 0.25 with a minimum value of 1.0. This assumption is based in part on expert elicitation (CRWMS M&O, 1997) and in part on abstraction/analysis of literature observations (Marsh and Taylor, 1988; Marsh et. al., 1988). This assumption is used in the WAPDEG input files (Section 5.1.1) on the third input line after the [. . . Drip Model, CAM] header(s).

3.9 Galvanic protection is not operative. This assumption is based on the WPDEE (CRWMS M&O, 1997). This assumption is used in the [. . . Drip Features] input segments in the WAPDEG input files (Section 5.1.1). This input data is used on the eighth input line following the [No Drip Features] header and/or on the tenth input line after the [Neutral Drip Features] header.

3.10 The CRM localized corrosion initiation is represented by a temperature threshold, which is distributed uniformly between 80 and 100°C. This assumption is based on the expert elicitation of David Shoesmith (CRWMS M&O, 1997) and is conservative relative to the elicitations of the other experts. This assumption is used in the [Neutral Drip Features] input segment in the WAPDEG input files (Section 5.1.1) on the third and fourth input lines following the [Neutral Drip Features] header.

3.11 The "ArrheniusPit" CRM localized corrosion model (CRWMS M&O 1998g) (TBV-349) appropriately represents localized corrosion degradation of the CRM. The basis for this assumption is that this CRM localized corrosion model received almost universal support from the experts participating in the Waste Package Degradation Expert Elicitation (Pendleton, 1998, TBV-323). This assumption is used in the [Neutral Drip Model, CRM] input segment in the WAPDEG input files (Section 5.1.1) on the eleventh through sixteenth input lines following the [Neutral Drip Model, CRM] header.

3.12 Variability in waste package degradation is represented by dividing the total model variabilities equally among waste package-to-waste package variability and patch-to-patch variability. This assumption is used in the WAPDEG input files (Section 5.1.1) on the third line after the last history filename.

The bases for these assumptions are also extensively discussed elsewhere (CRWMS M&O, 1998a).

There are a few additional assumptions necessary to consider for the post-processing of WAPDEG output. The following is a list of assumptions made in this process:

3.13 If a non-dripping WAPDEG simulation is being post processed (defined by the fifth and sixth characters in the input filename prefix being "nd"), then the waste package diffusion start times (first penetration (pit or patch) in the bottom of the waste package) are considered to be the waste package failure times. The basis for this assumption is the assumption that radionuclide release is considered to occur only from the bottom part of the waste package. This assumption is used internally within Post306.

3.14 If a dripping WAPDEG simulation is being post processed (defined by the fifth and sixth characters in the filename prefix being anything other than "nd"), then the waste package advection start times are considered to be the waste package failure times. The advection time is the maximum of the earliest patch failure times amongst the top patches which are dripped upon and amongst bottom patches that are dripped upon or not. This time corresponds to the earliest time at which water can enter the waste package (from the top), interact with the waste form, and then leave the waste package (from the bottom) to enter the near field environment. The bases for this assumption are those mentioned above for Assumption 3.13; radionuclide release is considered to occur only from the bottom part of the waste package. The radionuclide release flux by advection is much greater than that due to diffusion, thus although basing waste package failure on advection time rather than diffusion time is slightly non-conservative, it is considered to yield a more accurate picture of radionuclide release characteristics. This assumption is used internally within Post306.

3.15 The waste package failure times are interpolated semi-logarithmically to the time grid used for WAPDEG's *.bin and *.pat files (where "*" represents the input file name prefix) (CRWMS M&O. 1998b, Appendix D). This is done so that the average number of pits and patches per failed waste package can be calculated at each point of the *.pat and *.bin files' time grid. The interpolation is necessary as the waste package failure curve and the *.bin and *.pat files have different time grids. The basis of this assumption is that time values distributed over several orders of magnitude are well approximated with little loss of information. This assumption is used internally within Post306.

3.16 In the creation of input tables for RIP, it is desirable to decrease the number of data points supplied in the RIP input table. This is accomplished through a process of time averaging. First, the total number of waste packages that have failed during the total simulation time is determined. This value is divided by 80 to determine how many waste packages have failed at each of the 80 time bins (data points) which will be supplied to RIP. The average failure time, number of pits and patches per failed waste package is determined for each of the time bins. These are then written in a file conforming to the RIP table format (see RIP, 1998). Implicit in this process is the assumption that the original data (potentially greater than 80 data points) are well represented by the 80 data points supplied in the RIP input table. The basis for this assumption is the testing undertaken in Appendix D of the

WAPDEG Software Routine Report (CRWMS M&O. 1998b). This assumption is used internally within Post306.

4.0 Use of Computer Software

4.1. Software Approved for QA Work

N/A.

4.2. Software Routines

The software used was WAPDEG ver. 3.06 and its post processor, post306 (CRWMS M&O, 1998b). The following has been obtained from the Software Configuration Secretary (SCS) relative to this software:

Software Name:	WAPDEG
Software Version:	3.06
CSCI Identifier:	30048 v 3.06
Document Identifier:	30048–2999 Rev. 00
Media Identifier:	30048–M04–001 Rev. 00
Software Change Request:	LSBR 160

The WAPDEG simulations were executed on Hewlett-Packard HP-UX 20 workstations (CRWMS-M&O tags 102877, 112515, 108319, 107436, 107437, 108335, 111031). The post processing was accomplished on a Gateway 2000 equipped with a Pentium Pro 200 MHz processor (CRWMS-M&O tag 111033) in a Windows 95 operating system.

WAPDEG ver. 3.06 is an appropriate application because it is able to read input data and produce output files that can be post processed to create tables for input into RIP.

Post306 is an appropriate application because it is able to read input data and post process it to make tables for input into RIP.

5.0 Calculation Inputs

5.1. Description

Wap306 analyzes the inputs (*.inp, *.cdf, *.hst, see below) and creates several output files (*.aux, *.bin, *.cam, *.crm, *.out, *.pat). Post306 reads from the *.bin, *.pat, *.out files of the WAPDEG ver. 3.06 runs and formulates the tables shown in Section 6.0 (CRWMS M&O, 1998b).

The method of producing an output from WAPDEG for input into RIP entails the use of a number of files for the WAPDEG code to read. The following are the files required for WAPDEG:

1) Relative humidity (RH) and temperature histories at the surface of waste packages in a particular region of the repository (organized in bin numbers with file extension *.hst, where * is the filename prefix) (TBV-350).
2) Cumulative Distribution Functions (CDFs) for the temperature threshold (TThresh.cdf) (CRWMS M&O, 1998c) for the onset of corrosion of the CAM (carbon steel outer barrier Corrosion Allowance Material).
3) CDFs for the RH threshold for the onset of humid air corrosion (HARH.cdf) and the transition from humid-air corrosion to aqueous corrosion (AQRH.cdf) (CRWMS M&O, 1998d) for the corrosion allowance material (CAM) outer barrier.
4) Cumulative distribution functions (CDFs) for general corrosion rates under dripping for the inner barrier Corrosion Resistant Material (CRM) (CRWMS M&O, 1998e) at 25, 50, and 100°C (gcrm98T1.cdf, gcrm98T2.cdf, and gcrm98T3.cdf, where T1 is 25°C, T2 is 50°C, and T3 is 100°C).
5) CDFs for the CRM general corrosion rates with no drips (CRWMS M&O, 1998f) at 25, 50, and 100°C (gcrmndT1.cdf, gcrmndT2.cdf, and gcrmndT3.cdf)

These file names and other model parameters are contained in the WAPDEG input file for the particular simulation being executed. The WAPDEG input file (*.inp) is read by wap306 (CRWMS M&O, 1998b). The outputs resulting from WAPDEG simulations are then read by the post processor (post306 (CRWMS M&O, 1998b, Appendix D)) which generates a table in a format appropriate for input into RIP (Golder Associates, 1998). The RIP input table contains:

1) The first failure (pit or patch) versus time curve for the waste packages to be simulated,
2) The average number of pits per failed waste package versus time curve and,
3) The average number of patches per failed waste package versus time curve.

5.1.1. WAPDEG Input Files and Parameters Used

Four WAPDEG input files were used to generate the TSPA-VA REV. 00 base case results; NEsfad100mh.inp, NEsfnd100mh.inp, SCsfad100mh.inp, and SCsfnd100mh.inp. The first two characters of the input file name indicate whether the North East (NE) or South Central (SC) region of the potential repository is being simulated. The next two characters (sf) indicate that the thermohydrologic histories appropriate for spent nuclear fuel are being used (TBV-350). If the next two characters are "nd," a no-drip case is being simulated; if they are "ad," the waste packages are subject to dripping throughout the simulation. The next three characters (100) indicate what percentage of the waste package surface is contacted by drips (if they are present). The next characters (mh) indicate that multiple histories for the relative humidity and temperature at the waste package surface are being used for the waste package groups in the simulation.

1) NEsfad100mh.inp:

```
sf, always drip, 100% dripped on, mult. hst, 6/26/98
No variability/uncertainty splitting

START OF PARAMETERS
3.06                          |Version number of code
12                            |Number of alternate histories
NEsnf00noBFj2204.hst          |History file
15, 0., 0.                    |# packages/group and Temp & RH std deviations
NEsnf01noBFj2204.hst          |History file
59, 0., 0.                    |# packages/group and Temp & RH std deviations
NEsnf10noBFj2204.hst          |History file
6, 0., 0.                     |# packages/group and Temp & RH std deviations
NEsnf11noBFj2204.hst          |History file
120, 0., 0.                   |# packages/group and Temp & RH std deviations
NEsnf12noBFj2204.hst          |History file
1, 0., 0.                     |# packages/group and Temp & RH std deviations
NEsnf21noBFj2204.hst          |History file
60, 0., 0.                    |# packages/group and Temp & RH std deviations
NEsnf22noBFj2204.hst          |History file
16, 0., 0.                    |# packages/group and Temp & RH std deviations
NEsnf31noBFj2204.hst          |History file
26, 0., 0.                    |# packages/group and Temp & RH std deviations
NEsnf32noBFj2204.hst          |History file
50, 0., 0.                    |# packages/group and Temp & RH std deviations
NEsnf42noBFj2204.hst          |History file
36, 0., 0.                    |# packages/group and Temp & RH std deviations
NEsnf52noBFj2204.hst          |History file
9, 0., 0.                     |# packages/group and Temp & RH std deviations
NEsnf62noBFj2204.hst          |History file
2, 0., 0.                     |# packages/group and Temp & RH std deviations
10.0, 2.0                     |Thickness of outer, inner barriers (cm)
75., 0.5                      |% thick to fail CRM, frac variance to packs
400, 964, 3100, 3100          |Number of packs, patches/pack, pits/patch
1.0, 1.e6, 1200               |Bin start time & end time (y), and # of bins
1.e4, 5.e4, 1.e5, 1.e6        |Output times (y) for cumul. pit penetrations
431210                        |Seed for random number generator
0.0, 0.0                      |Max temp, RH change over a time step (C, %RH)
180., 100.                    |Angle defining top(deg), % seeing drips
180., 100.                    |Angle defining bottom(deg), % seeing drips
Fixed                         |Distribution for dripping start time
0.                            |Distribution parameter(s)
Fixed                         |Distribution for dripping stop time
1000000.                      |Distribution parameter(s)
T, F                          |Neutral(T/F) water initially, new water (T/F)
Fixed                         |Distr for time range for ceramic protection
0.0                           |Distribution parameter(s)
[No Drip Model, CAM]          |This segment always required
CAMGeneral+PitMultiples       |CAM corrosion model for no drips
B-Normal                      |Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6         |Mean, StDev, Min, Max
[No Drip Model, CRM]          |This segment always required
CRMGeneralRateOnly            |CRM corrosion model for drips
3, 1.e+6                      |Number of dists (temps), max CRM rate
25.                           |Temp appropriate for dist #1
File                          |Distribution type for #1
gcrmndT1.cdf                  |Distribution parameter (s)
50.                           |Temp appropriate for dist #1
```

File	Distribution type for #1
gcrmndT2.cdf	Distribution parameter (s)
100.	Temp appropriate for dist #2
File	Distribution type for #2
gcrmndT3.cdf	Distribution parameter (s)
[No Drip Features]	This segment always required
File	Distr for thermal protection temperature
TThresh.cdf	Distribution parameter(s)
File	Dist type for humid-air initiation
HARH.cdf	Distribution parameter(s)
File	Dist type for humid-air/aqueous transition
AQRH.cdf	Distribution parameter(s)
1.0	RH correlation factor
0.0, 0.0	Galvanic protect depth %, % patches protected
0.0	Spalling depth as a % of thickness
1.0, 1.0	Multiples for CAM, CRM corrosion rates
[Neutral Drip Model, CAM]	Required if any non-neutral drips can be seen
CAMGeneral+PitMultiples	CAM corrosion model for no drips
B-Normal	Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6	Mean, StDev, Min, Max
[Neutral Drip Model, CRM]	Required if any non-neutral drips can be seen
CRMGenrate+ArrheniusPit	CRM corrosion model for drips
3, 1.e+6	Number of dists (temps), max CRM rate
25.	Temp appropriate for dist #1
File	Distribution type for #1
gcrm98T1.cdf	Distribution parameter (s)
50.	Temp appropriate for dist #1
File	Distribution type for #1
gcrm98T2.cdf	Distribution parameter (s)
100.	Temp appropriate for dist #2
File	Distribution type for #2
gcrm98T3.cdf	Distribution parameter (s)
Normal	Distribution type for A (b0)
11.275, 2.4495	Distribution parameter(s)
Fixed	Distribution type for K (b1)
5.5494e+003	Distribution parameter(s)
Fixed	Distribution type for n
0.5	Distribution parameter(s)
[Neutral Drip Features]	Required if any non-neutral drips can be seen
File	Distr for thermal protection temperature
TThresh.cdf	Distribution parameter(s)
Uniform	Dist type for CRM LC T init
80., 100.	Distribution parameter
File	Dist type for humid-air initiation
HARH.cdf	Distribution parameter(s)
File	Dist type for humid-air/aqueous transition
AQRH.cdf	Distribution parameter(s)
1.0	RH correlation factor
0.0, 0.0	Galvanic protect depth %, % patches protected
0.0	Spalling depth as a % of thickness
1.0, 1.0	Multiples for CAM, CRM corrosion rates

2) NEsfnd100mh.inp:

```
mult hst, snf, m=1.5, no drip, 6/28/98
No variability/uncertainty splitting

START OF PARAMETERS
```

```
3.06                              |Version number of code
12                                 |Number of alternate histories
NEsnf00noBFj2204.hst                 |History file
15, 0., 0.                        |# packages/group and Temp & RH std deviations
NEsnf01noBFj2204.hst                 |History file
59, 0., 0.                          |# packages/group and Temp & RH std deviations
NEsnf10noBFj2204.hst                 |History file
6, 0., 0.                        |# packages/group and Temp & RH std deviations
NEsnf11noBFj2204.hst                 |History file
120, 0., 0.                       |# packages/group and Temp & RH std deviations
NEsnf12noBFj2204.hst                 |History file
1, 0., 0.                        |# packages/group and Temp & RH std deviations
NEsnf21noBFj2204.hst                 |History file
60, 0., 0.                          |# packages/group and Temp & RH std deviations
NEsnf22noBFj2204.hst                 |History file
16, 0., 0.                        |# packages/group and Temp & RH std deviations
NEsnf31noBFj2204.hst                 |History file
26, 0., 0.                       |# packages/group and Temp & RH std deviations
NEsnf32noBFj2204.hst                 |History file
50, 0., 0.                        |# packages/group and Temp & RH std deviations
NEsnf42noBFj2204.hst                 |History file
36, 0., 0.                       |# packages/group and Temp & RH std deviations
NEsnf52noBFj2204.hst                 |History file
9, 0., 0.                        |# packages/group and Temp & RH std deviations
NEsnf62noBFj2204.hst                 |History file
2, 0., 0.                       |# packages/group and Temp & RH std deviations
10.0, 2.0                          |Thickness of outer, inner barriers (cm)
75., 0.5                           |% thick to fail CRM, frac variance to packs
400, 964, 3100, 3100               |Number of packs, patches/pack, pits/patch
1.0, 1.e6, 1200                    |Bin start time & end time (y), and # of bins
1.e4, 1.e5, 5.e5, 1.e6             |Output times (y) for cumul. pit penetrations
431210                               |Seed for random number generator
0.0, 0.0                           |Max temp, RH change over a time step (C, %RH)
180., 0.                           |Angle defining top(deg), % seeing drips
180., 0.                           |Angle defining bottom(deg), % seeing drips
Fixed                              |Distr for time range for ceramic protection
0.0                                |Distribution parameter(s)
[No Drip Model, CAM]               |This segment always required
CAMGeneral+PitMultiples            |CAM corrosion model for no drips
B-Normal                           |Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6              |Mean, StDev, Min, Max
[No Drip Model, CRM]               |This segment always required
CRMGeneralRateOnly                 |CRM corrosion model for drips
3, 1.e+6                           |Number of dists (temps), max CRM rate
25.                                |Temp appropriate for dist #1
File                               |Distribution type for #1
gcrmndT1.cdf                       |Distribution parameter (s)
50.                                |Temp appropriate for dist #1
File                               |Distribution type for #1
gcrmndT2.cdf                       |Distribution parameter (s)
100.                               |Temp appropriate for dist #2
File                               |Distribution type for #2
gcrmndT3.cdf                       |Distribution parameter (s)
[No Drip Features]                 |This segment always required
File                               |Distr for thermal protection temperature
TThresh.cdf                        |Distribution parameter(s)
File                               |Dist type for humid-air initiation
HARH.cdf                           |Distribution parameter(s)
File                               |Dist type for humid-air/aqueous transition
AQRH.cdf                           |Distribution parameter(s)
```

```
1.0                            |RH correlation factor
0.0, 0.0                       |Galvanic protect depth %, % patches protected
0.0                            |Spalling depth as a % of thickness
1.0, 1.0                       |Multiples for CAM, CRM corrosion rates
[Neutral Drip Model, CAM]      |Required if any non-neutral drips can be seen
CAMGeneral+PitMultiples        |CAM corrosion model for no drips
B-Normal                       |Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6          |Mean, StDev, Min, Max
[Neutral Drip Model, CRM]      |Required if any non-neutral drips can be seen
CRMGenrate+ArrheniusPit        |CRM corrosion model for drips
3, 1.e+6                       |Number of dists (temps), max CRM rate
25.                            |Temp appropriate for dist #1
File                           |Distribution type for #1
gcrm98T1.cdf                   |Distribution parameter (s)
50.                            |Temp appropriate for dist #1
File                           |Distribution type for #1
gcrm98T2.cdf                   |Distribution parameter (s)
100.                           |Temp appropriate for dist #2
File                           |Distribution type for #2
gcrm98T3.cdf                   |Distribution parameter (s)
Normal                         |Distribution type for A (b0)
11.275, 2.4495                 |Distribution parameter(s)
Fixed                          |Distribution type for K (b1)
5.5494e+003                    |Distribution parameter(s)
Fixed                          |Distribution type for n
0.5                            |Distribution parameter(s)
[Neutral Drip Features]        |Required if any non-neutral drips can be seen
File                           |Distr for thermal protection temperature
TThresh.cdf                    |Distribution parameter(s)
Uniform                        |Dist type for CRM LC T init
80., 100.                      |Distribution parameter
File                           |Dist type for humid-air initiation
HARH.cdf                       |Distribution parameter(s)
File                           |Dist type for humid-air/aqueous transition
AQRH.cdf                       |Distribution parameter(s)
1.0                            |RH correlation factor
0.0, 0.0                       |Galvanic protect depth %, % patches protected
0.0                            |Spalling depth as a % of thickness
1.0, 1.0                       |Multiples for CAM, CRM corrosion rates
```

3) SCsfad100mh.inp:

```
snf, always drip, 100%, avg hst
6/28/98, No variability/uncertainty splitting

START OF PARAMETERS
3.06                           |Version number of code
9                               |Number of alternate histories
SCsnf00noBFj2204.hst              |History file
28, 0., 0.                      |# packages/group and Temp & RH std
SCsnf01noBFj2204.hst              |History file
97, 0., 0.                      |# packages/group and Temp & RH std
SCsnf02noBFj2204.hst              |History file
1, 0., 0.                       |# packages/group and Temp & RH std
SCsnf10noBFj2204.hst              |History file
4, 0., 0.                       |# packages/group and Temp & RH std
SCsnf11noBFj2204.hst              |History file
154, 0., 0.                     |# packages/group and Temp & RH std
```

```
SCsnf12noBFj2204.hst             |History file
23, 0., 0.                       |# packages/group and Temp & RH std
SCsnf21noBFj2204.hst             |History file
25, 0., 0.                       |# packages/group and Temp & RH std
SCsnf22noBFj2204.hst             |History file
61, 0., 0.                       |# packages/group and Temp & RH std
SCsnf32noBFj2204.hst             |History file
7, 0., 0.                        |# packages/group and Temp & RH std
10.0, 2.0                        |Thickness of outer, inner barriers (cm)
75., 0.5                         |% thick to fail CRM, frac variance to packs
400, 964, 3100, 3100             |Number of packs, patches/pack, pits/patch
1.0, 1.e6, 1200                  |Bin start time & end time (y), and # of bins
1.e4, 5.e4, 1.e5, 1.e6           |Output times (y) for cumul. pit penetrations
431210                           |Seed for random number generator
0.0, 0.0                         |Max temp, RH change over a time step (C, %RH)
180., 100.                       |Angle defining top(deg), % seeing drips
180., 100.                       |Angle defining bottom(deg), % seeing drips
Fixed                            |Distribution for dripping start time
0.                               |Distribution parameter(s)
Fixed                            |Distribution for dripping stop time
1000000.                         |Distribution parameter(s)
T, F                             |Neutral(T/F) water initially, new water (T/F)
Fixed                            |Distr for time range for ceramic protection
0.0                              |Distribution parameter(s)
[No Drip Model, CAM]             |This segment always required
CAMGeneral+PitMultiples          |CAM corrosion model for no drips
B-Normal                         |Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6            |Mean, StDev, Min, Max
[No Drip Model, CRM]             |This segment always required
CRMGeneralRateOnly               |CRM corrosion model for drips
3, 1.e+6                         |Number of dists (temps), max CRM rate
25.                              |Temp appropriate for dist #1
File                             |Distribution type for #1
gcrmndT1.cdf                     |Distribution parameter (s)
50.                              |Temp appropriate for dist #1
File                             |Distribution type for #1
gcrmndT2.cdf                     |Distribution parameter (s)
100.                             |Temp appropriate for dist #2
File                             |Distribution type for #2
gcrmndT3.cdf                     |Distribution parameter (s)
[No Drip Features]               |This segment always required
File                             |Distr for thermal protection temperature
TThresh.cdf                      |Distribution parameter(s)
File                             |Dist type for humid-air initiation
HARH.cdf                         |Distribution parameter(s)
File                             |Dist type for humid-air/aqueous transition
AQRH.cdf                         |Distribution parameter(s)
1.0                              |RH correlation factor
0.0, 0.0                         |Galvanic protect depth %, % patches protected
0.0                              |Spalling depth as a % of thickness
1.0, 1.0                         |Multiples for CAM, CRM corrosion rates
[Neutral Drip Model, CAM]        |Required if any non-neutral drips can be seen
CAMGeneral+PitMultiples          |CAM corrosion model for no drips
B-Normal                         |Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6            |Mean, StDev, Min, Max
[Neutral Drip Model, CRM]        |Required if any non-neutral drips can be seen
CRMGenrate+ArrheniusPit          |CRM corrosion model for drips
3, 1.e+6                         |Number of dists (temps), max CRM rate
25.                              |Temp appropriate for dist #1
File                             |Distribution type for #1
```

```
gcrm98T1.cdf                      |Distribution parameter (s)
50.                               |Temp appropriate for dist #1
File                              |Distribution type for #1
gcrm98T2.cdf                      |Distribution parameter (s)
100.                              |Temp appropriate for dist #2
File                              |Distribution type for #2
gcrm98T3.cdf                      |Distribution parameter (s)
Normal                            |Distribution type for A (b0)
11.275, 2.4495                    |Distribution parameter(s)
Fixed                             |Distribution type for K (b1)
5.5494e+003                       |Distribution parameter(s)
Fixed                             |Distribution type for n
0.5                               |Distribution parameter(s)
[Neutral Drip Features]           |Required if any non-neutral drips can be seen
File                              |Distr for thermal protection temperature
TThresh.cdf                       |Distribution parameter(s)
Uniform                           |Dist type for CRM LC T init
80., 100.                         |Distribution parameter
File                              |Dist type for humid-air initiation
HARH.cdf                          |Distribution parameter(s)
File                              |Dist type for humid-air/aqueous transition
AQRH.cdf                          |Distribution parameter(s)
1.0                               |RH correlation factor
0.0, 0.0                          |Galvanic protect depth %, % patches protected
0.0                               |Spalling depth as a % of thickness
1.0, 1.0                          |Multiples for CAM, CRM corrosion rates
```

4) SCsfnd100mh.inp:

```
Average hst, snf, m=1.5, no drip
6/28/98, No variability/uncertainty splitting

START OF PARAMETERS
3.06                              |Version number of code
9                                  |Number of alternate histories
SCsnf00noBFj2204.hst                 |History file
28, 0., 0.                         |# packages/group and Temp & RH std
SCsnf01noBFj2204.hst                 |History file
97, 0., 0.                         |# packages/group and Temp & RH std
SCsnf02noBFj2204.hst                 |History file
1, 0., 0.                         |# packages/group and Temp & RH std
SCsnf10noBFj2204.hst                 |History file
4, 0., 0.                         |# packages/group and Temp & RH std
SCsnf11noBFj2204.hst                 |History file
154, 0., 0.                         |# packages/group and Temp & RH std
SCsnf12noBFj2204.hst                 |History file
23, 0., 0.                         |# packages/group and Temp & RH std
SCsnf21noBFj2204.hst                 |History file
25, 0., 0.                         |# packages/group and Temp & RH std
SCsnf22noBFj2204.hst                 |History file
61, 0., 0.                         |# packages/group and Temp & RH std
SCsnf32noBFj2204.hst                  |History file
7, 0., 0.                         |# packages/group and Temp & RH std
10.0, 2.0                         |Thickness of outer, inner barriers (cm)
75., 0.5                          |% thick to fail CRM, frac variance to packs
400, 964, 3100, 3100              |Number of packs, patches/pack, pits/patch
1.0, 1.e6, 1200                   |Bin start time & end time (y), and # of bins
1.e4, 1.e5, 5.e5, 1.e6            |Output times (y) for cumul. pit penetrations
```

431210	Seed for random number generator
0.0, 0.0	Max temp, RH change over a time step (C, %RH)
180., 0.	Angle defining top(deg), % seeing drips
180., 0.	Angle defining bottom(deg), % seeing drips
Fixed	Distr for time range for ceramic protection
0.0	Distribution parameter(s)
[No Drip Model, CAM]	This segment always required
CAMGeneral+PitMultiples	CAM corrosion model for no drips
B-Normal	Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6	Mean, StDev, Min, Max
[No Drip Model, CRM]	This segment always required
CRMGeneralRateOnly	CRM corrosion model for drips
3, 1.e+6	Number of dists (temps), max CRM rate
25.	Temp appropriate for dist #1
File	Distribution type for #1
gcrmndT1.cdf	Distribution parameter (s)
50.	Temp appropriate for dist #1
File	Distribution type for #1
gcrmndT2.cdf	Distribution parameter (s)
100.	Temp appropriate for dist #2
File	Distribution type for #2
gcrmndT3.cdf	Distribution parameter (s)
[No Drip Features]	This segment always required
File	Distr for thermal protection temperature
TThresh.cdf	Distribution parameter(s)
File	Dist type for humid-air initiation
HARH.cdf	Distribution parameter(s)
File	Dist type for humid-air/aqueous transition
AQRH.cdf	Distribution parameter(s)
1.0	RH correlation factor
0.0, 0.0	Galvanic protect depth %, % patches protected
0.0	Spalling depth as a % of thickness
1.0, 1.0	Multiples for CAM, CRM corrosion rates
[Neutral Drip Model, CAM]	Required if any non-neutral drips can be seen
CAMGeneral+PitMultiples	CAM corrosion model for no drips
B-Normal	Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6	Mean, StDev, Min, Max
[Neutral Drip Model, CRM]	Required if any non-neutral drips can be seen
CRMGenrate+ArrheniusPit	CRM corrosion model for drips
3, 1.e+6	Number of dists (temps), max CRM rate
25.	Temp appropriate for dist #1
File	Distribution type for #1
gcrm98T1.cdf	Distribution parameter (s)
50.	Temp appropriate for dist #1
File	Distribution type for #1
gcrm98T2.cdf	Distribution parameter (s)
100.	Temp appropriate for dist #2
File	Distribution type for #2
gcrm98T3.cdf	Distribution parameter (s)
Normal	Distribution type for A (b0)
11.275, 2.4495	Distribution parameter(s)
Fixed	Distribution type for K (b1)
5.5494e+003	Distribution parameter(s)
Fixed	Distribution type for n
0.5	Distribution parameter(s)
[Neutral Drip Features]	Required if any non-neutral drips can be seen
File	Distr for thermal protection temperature
TThresh.cdf	Distribution parameter(s)
Uniform	Dist type for CRM LC T init
80., 100.	Distribution parameter

```
File                          |Dist type for humid-air initiation
HARH.cdf                      |Distribution parameter(s)
File                          |Dist type for humid-air/aqueous transition
AQRH.cdf                      |Distribution parameter(s)
1.0                           |RH correlation factor
0.0, 0.0                      |Galvanic protect depth %, % patches protected
0.0                           |Spalling depth as a % of thickness
1.0, 1.0                      |Multiples for CAM, CRM corrosion rates
```

All of the text that appears above the 'START OF PARAMETERS' statement is copied into the output file (*.out, where the * represents the input file prefix) and can be used for any additional comments the user feels is necessary to distinguish the output. The relative humidity and temperature history information in the header of the input files for South Central (SC) regions is not correct. It should be "multiple histories."

The version number (3.06) is read and checked against the version of WAPDEG being executed; a mismatch in version numbers will halt program execution. The next line of the input file specifies the number of waste package groups (number of history files, 12 for the NE inputs and 9 for the SC inputs) which will be used to represent local repository conditions (spatial variability in the drift-scale thermohydrology of the repository). The next 24 (NE) or 18 (SC) lines in the input file are composed of 12 (NE) or 9 (SC) pairs of input lines in which the first line specifies the name of the mean history file (*.hst, composed of three columns of data; time, waste package surface temperature, and relative humidity (TBV-350)) to be used for each waste package group followed by a line composed of three values; the number of waste packages that the history file is to be applied to (the number of waste packages in the group), and the standard deviations for allowed variations in T and RH from the waste package group's mean history file. In the TSPA-VA base case there are no variations allowed from the T and RH data given in the history file. The next input lines:

```
10.0, 2.0                     |Thickness of outer, inner barriers (cm)
75., 0.5                      |% thick to fail CRM, frac variance to packs
400, 964, 3100, 3100          |Number of packs, patches/pack, pits/patch
1.0, 1.e6, 1200               |Bin start time & end time (y), and # of bins
1.e4, 1.e5, 5.e5, 1.e6        |Output times (y) for cumul. pit penetrations
431210                        |Seed for random number generator
0.0, 0.0                      |Max temp, RH change over a time step (C, %RH)
```

allow for input of the outer and inner barrier thicknesses in cm. They are 10 and 2 cm thick, respectively (Benton, 1997) (TBV-350). The first value on the next line is related to determination of a 'structural failure time' for the waste package. For each waste package, WAPDEG calculates the average (over all patches) CRM general corrosion depth at each time step. When this average depth exceeds the given percentage (75% in this case) of the total CRM thickness, the waste package can be considered to have structurally collapsed (presumably due to static loads from its own weight, the weight of rock, etc.). This degradation mode is not included in the TSPA-VA Rev.00 base case. WAPDEG still continues to model corrosion after this time and the structural failure time is output (to the *.out file) for possible use in other models. The second value on this line (0.5) allows the user to specify the fraction of the total variability in the various model parameters should be assigned to waste package-to-waste package variability and 1 – (this value) is assigned to patch-to-patch variability.

The line following allows the user to specify the number of waste packages (400), patches/waste package (964), and pits/patch (3,100) in both the CAM and CRM to be simulated. The next line contains three values related to the storing of temporal results (number of pit and patch penetrations with time). The start time corresponds to the beginning of the simulation; if the history file does not contain data for this starting time, the simulation is assumed to start with the earliest time step given in the history file. The same is not true for the end time as a time step is added to the end of the history with the same temperature and relative humidity as the last time step in the history file if the history file does not contain data for the simulation end time. The third value specifies how many (logarithmically distributed) time "bins" are used to store the cumulative pit penetration profiles. In this way, the resolution of the pit penetration profiles reported by WAPDEG is under user control.

The next line allows the user to specify up to 4 time values that are of particular interest. For each time value, WAPDEG will report (in the *.out file) the cumulative number of pit and patch penetrations in the time bin that contains the specified time value, and not the actual number of pit and patch penetrations at the exact time value specified. The following input line allows specification of the random number seed used to initialize the random number generator. The next line allows the user to enter the maximum allowed change in T and RH between time steps (0.0, 0.0 causes this option to be ignored). WAPDEG will add time steps to the history file and interpolate T and RH data until these criteria are satisfied. The corrosion models used in WAPDEG require the application of constant environments for the duration of each time step. Through wise application of these values the user may increase the accuracy of the WAPDEG output. The next input lines:

```
180., 100.                    |Angle defining top(deg), % seeing drips
180., 100.                    |Angle defining bottom(deg), % seeing drips
Fixed                         |Distribution for dripping start time
0.                            |Distribution parameter(s)
Fixed                         |Distribution for dripping stop time
1000000.                      |Distribution parameter(s)
T, F                          |Neutral(T/F) water initially, new water (T/F)
```

deal with application of dripping models; the user can enter the angles (degrees) that define the top and bottom of the waste package. The remaining angular range (if any) is defined to be the side of the waste package. The side of the waste package differs from the top or bottom in that it can never be dripped upon and thus never undergoes localized CRM corrosion. WAPDEG allows dripping on a given (top or bottom) patch to start sometime after the beginning of the simulation, to change corrosion model parameters (specified later in the input file as "Chemical" if it were used) sometime after that, and then for dripping to cease. The user must enter the percent of top and bottom patches that are dripped upon. In the TSPA-VA base case dripping simulations, the dripping surface percentage is fixed at a value of one hundred percent and the dripping water never changes chemistry. The word "Neutral" here has nothing to do with the actual water chemistry, it merely serves to identify a group of user-supplied input parameters that appear later in the input file. For the no-dripping WAPDEG simulations, the dripping surface percentage is set to zero and the dripping start, stop, and chemistry change (the last input line above) input lines must not be present in the input file, i.e.,

```
180., 0.                      |Angle defining top(deg), % seeing drips
180., 0.                      |Angle defining bottom(deg), % seeing drips
```

would be used in place of the seven input lines shown previously.

The next input lines:

```
Fixed                            |Distr for time range for ceramic protection
0.0                              |Distribution parameter(s)
```

are concerned with modeling the use of a ceramic coating to offer additional corrosion protection to the waste package. In the current WAPDEG version, the ceramic coating is considered to offer complete corrosion protection to the waste package until it fails. This parameter is not used in the TSPA-VA base case simulations.

The next input segment:

```
[No Drip Model, CAM]             |This segment always required
CAMGeneral+PitMultiples          |CAM corrosion model for no drips
B-Normal                         |Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6            |Mean, StDev, Min, Max
[No Drip Model, CRM]             |This segment always required
CRMGeneralRateOnly               |CRM corrosion model for drips
3, 1.e+6                         |Number of dists (temps), max CRM rate
25.                              |Temp appropriate for dist #1
File                             |Distribution type for #1
gcrmndT1.cdf                     |Distribution parameter (s)
50.                              |Temp appropriate for dist #1
File                             |Distribution type for #1
gcrmndT2.cdf                     |Distribution parameter (s)
100.                             |Temp appropriate for dist #2
File                             |Distribution type for #2
gcrmndT3.cdf                     |Distribution parameter (s)
```

specifies the outer barrier (CAM) and inner barrier (CRM) corrosion models to be used when drips are not present. WAPDEG offers a variety of CAM and CRM models to choose from (CRWMS M&O 1998b). Here we discuss only those used in the TSPA-VA analysis (CRWMS M&O. 1998a).

The CAMGeneral+PitMultiples model for the CAM requires a roughness factor distribution. In the TSPA-VA base case, we make use of a bounded normal distribution with a mean of 1.5, a standard deviation of 0.25, a lower bound of one, and, effectively, no upper bound.

The CRMGeneralRateOnly model (as illustrated in the [No Drip, CRM] general corrosion input segment) requires specification of at least two (at most three) temperatures and general corrosion rate distributions (these can be any of the ones built in to WAPDEG). Here we use the no-drip Alloy 22 general corrosion rates derived in CRWMS M&O, 1998d. WAPDEG 3.06 uses only the first two general corrosion rate distributions entered (CRWMS M&O, 1998b). This oversight was fixed in WAPDEG 3.09 (CRWMS M&O, 1998i). Note that the maximum CRM general corrosion rate is specified just after the number of distributions for the CRMGeneralRateOnly model.

The next set of input lines:

```
[No Drip Features]               |This segment always required
File                             |Distr for thermal protection temperature
TThresh.cdf                      |Distribution parameter(s)
File                             |Dist type for humid-air initiation
HARH.cdf                         |Distribution parameter(s)
```

```
File              |Dist type for humid-air/aqueous transition
AQRH.cdf          |Distribution parameter(s)
1.0               |RH correlation factor
0.0, 0.0          |Galvanic protect depth %, % patches protected
0.0               |Spalling depth as a % of thickness
Fixed             |Dist for multiple for CAM corrosion rate
1.0               |Distribution parameter(s)
Fixed             |Dist for multiple for CRM corrosion rate
1.0               |Distribution parameter(s)
1.0               |Pack variance share for multiples
```

specify the 'No Drip Features.' These features include a distribution for the 'thermal protection temperature,' i.e., the temperature above which no corrosion is allowed to occur. Such a temperature threshold is used primarily because water will not exist in the liquid phase above this temperature, and thus no corrosion should occur. This threshold could be above the typical boiling point of water due to the presence of impurities in the water film on the waste package and variations in water chemistry. In this example, the temperature threshold is read from a file, TThresh.cdf (CRWMS M&O, 1998e), resulting from values elicited from the Waste Package Degradation Expert Elicitation (CRWMS M&O, 1997). WAPDEG also uses relative humidity (RH) thresholds (CRWMS M&O, 1998f) for the onset of both humid-air and aqueous corrosion modes of the CAM.

The next input line allows the user to control the degree to which these RH thresholds are correlated. Entering a value of one forces the humid-air and aqueous RH thresholds into perfect rank correlation, i.e., if the aqueous RH threshold has a Cumulative Probability of 0.56, the humid-air RH threshold with a Cumulative Probability of 0.56 will also be selected.

The 'galvanic protection depth %' specifies the percent of the total CAM thickness that must remain in order for the CAM to afford galvanic protection to the '% of patches protected' of the CRM. In this way the user can control the characteristics of the galvanic protection model used in WAPDEG. The subsequent input line allows specification of how thick a corrosion product film must be before it fails to adhere to the substrate and 'spalls' off the waste package surface. Neither galvanic protection nor spalling are used in the TSPA-VA base case. The 'Multiples for the CAM, CRM corrosion rates' are used in sensitivity studies to allow for modeling of corrosive environments that are considered to be more aggressive (multiples > 1) or more benign (multiples < 1) than those typically modeled in WAPDEG simulations. These are also not used (set to one) in the TSPA-VA base case.

The next three segments of the input file (and the three succeeding these, if there were a drip change time) are quite similar in form to the preceding three. The user enters [Neutral Drip Model, CAM], [Neutral Drip Model, CRM], and [Neutral Drip Features] in much the same manner as was done for the [No Drip . . .] input segments. These may differ in salient parameters such as those used to specify the CRM general corrosion rates (CRWMS M&O 1998c), RH thresholds, etc., but the form of the input is identical to that described above for the [No Drip . . .] sections with a few exceptions.

Immediately after specification of the three CDFs relevant to CRM general corrosion, the user must specify CRM localized corrosion parameters (CRWMS M&O 1998g):

```
Normal            |Distribution type for A (b0)
11.275, 2.4495    |Distribution parameter(s)
```

```
Fixed                          |Distribution type for K (b1)
5.5494e+003                    |Distribution parameter(s)
Fixed                          |Distribution type for n
0.5                            |Distribution parameter(s)
```

Here, A has a mean of 11.275, and a standard deviation of 2.4495, K is equal to 5549.4, and n is 0.5 (Pasupathi, 1997, TBV-349).

The user must also supply two lines of input related to specification of a CRM temperature threshold for initiation of localized corrosion in the [Neutral Drip Features] section:

```
Uniform                        |Dist type for CRM LC T init
80., 100.                      |Distribution parameter
```

These two lines appear immediately after specification of the temperature threshold for corrosion initiation. The CRM temperature threshold for initiation of localized corrosion is implemented such that if the temperature at the waste package surface is below the CRM temperature threshold for initiation of localized corrosion when the CAM is penetrated, no localized CRM corrosion occurs. However, once localized corrosion (pit or crevice corrosion) initiates, it continues regardless of the temperature, although at a temperature dependent rate.

To gain a deeper understanding of the WAPDEG code, the interested reader is directed to the Software Routine Report for WAPDEG (CRWMS M&O 1998b).

5.2. Procedure

To run the WAPDEG simulations on the Hewlett-Packard HP-UX 20 workstations, it is necessary to create a directory containing all the necessary input files as well as the program itself (i.e., wap306). First it is necessary to compile the code in Fortran 77 in order to make it executable. This is done by typing, f77 +O2 wap306.f -o <*filename*> on the UNIX command line. After compiling the program and importing all the above mentioned inputs, run the code by typing the name of the executable (in this case, wap306) on the UNIX command line and entering the name of the input file, i.e., NEsfad100mh.inp. If there are a large number of input files to be run, it is possible to run them sequentially using the UNIX script file, batchwpdg (CRWMS M&O 1998b, Appendix C).

The 'raw' output from WAPDEG consists of five files: a *.out file, a *.pat file, a *.bin file, a *.crm file, and a *.aux file (where * = the input file (*.inp) name prefix). These files are included in the electronic media supporting this calculation (CRWMS M&O, 1998h) and their content and format are discussed in the WAPDEG Software Routine Report (CRWMS M&O, 1998b, Section 4.1). Only the *.out (waste package failure curves), *.pat (cumulative number of patch penetrations for each waste package), and *.bin (cumulative number of pit penetrations for each waste package) files are used to create the RIP input tables.

In order to create the tables for input to RIP, post306 is executed in a Windows DOS window within the same directory as the output files from WAPDEG (i.e., *.bin, *.pat, *.out). The program prompts the user for the particular filename prefix that is common to the WAPDEG simulation output files to be post processed. After the program post processes the WAPDEG output, it prompts the user to enter a table number thus creating the tables shown in Section 6.0. The output from the post processor consists of three files; *.asc, *.dat, and table.txx, where xx represents the user-input table number. These files are included in the electronic media supporting this calculation (CRWMS M&O 1998h) and their content and format are discussed in the WAPDEG Software Routine Report (CRWMS M&O, 1998b, Appendix D).

6.0 Results

As this calculation uses input data and assumptions that are "to be verified" (TBV-350) as well as the results of several other calculations that use input data and assumptions that are "to be verified" (CRWMS M&O 1998c through 1998g, TBV 95, 311, 323, and 349) the results of this calculation should be considered "to be verified." The RIP input tables presented below are also included in the electronic media supporting this calculation (CRWMS M&O 1998h) and their content and format are discussed in the RIP - Theory Manual and User's Guide (Golder Associates, 1998).

Below are shown the final RIP input tables for TSPA-VA base case REV. 00 created from WAPDEG version 3.06 and post processed by Post306.

NE-SNF-Dripping Case - table.t01

```
! From wapdeg file: NEsfad100mh
! From wapdeg version: 3.06
! sf, always drip, 100% dripped on, mult. hst, 6/26/98
! No variability/uncertainty splitting
!
! START OF PARAMETERS
2
3 82
1 2 3
     0.0000
  8221.4265
 11481.3642
 17621.9854
 21148.9000
 23448.5031
 26018.8312
 30416.6549
 35925.5046
 44020.7936
 51893.7581
 55922.1609
 60271.9334
 65330.3708
 69186.1538
 74163.7813
 79436.3331
 81753.6583
 84632.2676
 87600.6231
 89641.1038
 91201.0839
 92257.1427
 93865.7589
 96609.3562
 98855.3095
100000.0000
101157.9454
```

105953.4550
112206.8028
115480.1118
117489.7555
118850.2227
120226.4435
123747.3699
127350.3081
129570.8165
133358.0351
138044.5254
143726.2112
148767.2022
154005.4100
159406.9292
164066.2259
168852.3835
171790.8387
175800.1284
180928.5887
184077.2001
186208.7137
188364.9089
190546.0718
192752.4913
196113.3668
199526.2315
203005.2154
207733.8143
211348.9040
213796.2090
216271.8524
220042.8167
225168.2723
231749.7039
242693.1748
251188.6432
258544.9011
269165.3724
281875.6515
298577.8339
318114.8515
334980.2389
342767.7865
356930.7339
382458.1720
398107.1706
421882.8437
476258.7133
527939.2425
579078.4824
732241.1528
896569.4675
1000000.0000

0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0065	0.3406	2.1008
0.0176	0.6783	5.9304
0.0290	0.4396	6.3432
0.0456	0.2748	5.1257
0.0549	0.2291	5.5135
0.0686	0.1824	5.9157
0.0815	0.1537	6.6558
0.0915	0.1367	7.6595
0.1032	0.1213	8.5835
0.1169	0.1070	8.5851
0.1320	0.0947	9.0072
0.1412	0.1011	10.6269

0.1564	0.0960	10.9901
0.1654	0.1159	11.9210
0.1821	0.1099	12.7122
0.1955	0.1023	12.8606
0.2055	0.1064	13.6106
0.2188	0.1142	14.1921
0.2308	0.1083	14.7705
0.2495	0.1102	14.5912
0.2609	0.1150	14.4418
0.2675	0.1401	14.9307
0.2822	0.1447	15.5018
0.3084	0.1540	15.1503
0.3135	0.1515	15.4715
0.3203	0.1639	15.5874
0.3268	0.2670	17.0103
0.3405	0.1346	18.7265
0.3591	0.1463	18.9402
0.3767	0.1394	18.6999
0.3839	0.1368	18.7153
0.3927	0.1337	18.7665
0.4040	0.1623	19.3713
0.4234	0.1712	19.8454
0.4294	0.1921	20.2638
0.4384	0.2791	21.0156
0.4500	0.4191	22.0391
0.4635	0.3470	23.0576
0.4790	0.2451	23.8855
0.4902	0.4018	24.9547
0.5035	0.6176	25.8439
0.5132	0.3214	26.8708
0.5266	0.4342	28.1724
0.5415	0.5863	28.5532
0.5508	1.0198	29.6750
0.5653	0.6506	31.5159
0.5835	0.4713	32.3637
0.6008	0.5992	32.6542
0.6110	0.9943	33.3968
0.6206	0.6123	34.1980
0.6275	1.0677	35.0058
0.6395	1.4433	36.2309
0.6581	1.8235	36.9139
0.6637	1.1174	38.3982
0.6732	0.4952	40.4611
0.6931	0.3246	41.0051
0.7017	0.3385	41.5818
0.7112	0.3902	42.0424
0.7214	0.5299	43.0337
0.7346	1.0742	44.2079
0.7447	0.8248	46.0063
0.7553	0.9370	48.8585
0.7726	0.6569	50.3998
0.7829	0.4636	51.7200
0.7933	0.9268	53.9907
0.8052	0.5520	56.3549
0.8166	0.7697	59.3021
0.8288	0.6568	62.4633
0.8426	0.7629	64.7057
0.8580	1.4569	64.9119
0.8661	0.7490	66.8419
0.8789	1.6763	69.9986
0.8958	1.2252	71.0568
0.9022	1.6194	74.1417
0.9140	1.5212	81.0134
0.9270	0.6100	86.8211
0.9404	0.6645	91.4935
0.9480	0.5847	100.5434
0.9635	0.2530	102.8425
0.9825	0.2545	102.3664

NE-SNF-No Dripping Case - table.t02

```
! From wapdeg file: NEsfnd100mh
! From wapdeg version: 3.06
! mult hst, snf, m=1.5, no drip, 6/28/98
! No variability/uncertainty splitting
!
! START OF PARAMETERS
2
3 36
1 2 3
     0.0000
  683910.6473
  683911.6473
  691830.9709
  699841.9960
  707945.7844
  716143.4102
  724435.9601
  732824.5331
  741310.2413
  749894.2093
  758577.5750
  767361.4894
  776247.1166
  785235.6346
  794328.2347
  803526.1222
  812830.5162
  822242.6499
  831763.7711
  841395.1416
  851138.0382
  860993.7522
  870963.5900
  881048.8730
  891250.9381
  901571.1376
  912010.8394
  922571.4272
  933254.3008
  944060.8763
  954992.5860
  966050.8790
  977237.2210
  988553.0947
 1000000.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0060    0.0000    2.0844
    0.0120    0.0000    1.8776
    0.0198    0.0000    2.1454
    0.0288    0.0000    3.4689
    0.0507    0.0000    2.7614
    0.0657    0.0000    2.8917
    0.0837    0.0000    2.8966
    0.0954    0.0000    3.0931
    0.1086    0.0000    3.0854
    0.1151    0.0000    3.4752
    0.1240    0.0000    3.5072
    0.1310    0.0000    3.9490
    0.1450    0.0000    3.9484
    0.1557    0.0000    4.0290
    0.1606    0.0000    4.1862
    0.1676    0.0000    4.3417
    0.1725    0.0000    4.5369
```

0.1819	0.0000	4.6462
0.1885	0.0000	4.7620
0.1953	0.0000	4.9282
0.2002	0.0000	5.1578
0.2047	0.0000	5.3602
0.2151	0.0000	5.3002
0.2181	0.0000	5.4909
0.2201	0.0000	5.7145
0.2223	0.0000	5.8693
0.2269	0.0000	6.1040
0.2329	0.0000	6.1829
0.2421	0.0000	6.2263
0.2440	0.0000	6.3844
0.2465	0.0000	6.5730
0.2491	0.0000	6.7247
0.2550	0.0000	6.7648
0.3150	0.0000	5.4762

SC-SNF-Dripping Case - table.t03

```
! From wapdeg file: SCsfad100mh
! From wapdeg version: 3.06
! snf, always drip, 100%, avg hst
! 6/28/98, No variability/uncertainty splitting
!
! START OF PARAMETERS
2
3 82
1 2 3
      0.0000
  12160.8600
  13844.1304
  18594.1539
  23464.0447
  26619.0079
  29012.4193
  32774.5801
  39184.2421
  47109.8206
  54032.0066
  58557.6912
  63112.4621
  67617.2592
  72041.6988
  77194.0710
  80817.8319
  83180.0521
  86103.1793
  88614.9906
  90679.0988
  92257.1427
  93325.4301
  94952.6731
  97164.4050
  99427.6547
 101157.9454
 102921.7579
 107166.1338
 113516.1264
 117489.7555
 118850.2227
 120226.4435
 122322.7386
 125898.1035
 128824.9552
 131071.1759
 135686.2929
```

140445.2953		
144550.3635		
150499.8189		
156682.0294		
160324.5391		
165019.7699		
170807.6020		
173780.0829		
177835.7980		
183023.6430		
186208.7137		
188364.9089		
190546.0718		
192752.4913		
194984.4600		
197242.2736		
200681.4339		
205355.9050		
210139.2585		
213796.2090		
216271.8524		
218776.1624		
222590.7924		
229096.8870		
237147.8480		
245481.7372		
252642.9569		
261538.7099		
272282.1605		
286803.1685		
303763.7721		
319931.9131		
336927.1258		
348744.3622		
363126.1816		
386886.8289		
402717.0343		
426768.0168		
481773.5293		
534052.4909		
585783.8952		
754408.3067		
927974.3609		
1000000.0000		
0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0074	0.0000	1.9961
0.0158	0.0000	5.6992
0.0327	0.0000	5.6920
0.0444	0.0296	5.7599
0.0559	0.0737	5.5665
0.0686	0.0730	5.8431
0.0819	0.1059	6.7279
0.0916	1.0331	7.7368
0.1035	0.0726	8.5442
0.1183	0.0635	8.6771
0.1317	0.1081	9.5211
0.1426	0.1471	10.7742
0.1542	0.3086	11.4305
0.1663	1.5981	12.2357
0.1803	0.1178	12.8671
0.1958	0.1403	12.9178
0.2070	0.1969	13.5982
0.2197	0.3240	14.1526
0.2332	0.8327	14.6024
0.2514	0.2387	14.3917
0.2612	0.3542	14.3577
0.2684	0.4316	14.8794

0.2776	0.0585	15.4259
0.2984	0.0628	15.3394
0.3103	0.0644	15.4912
0.3176	0.0826	15.8199
0.3274	0.1678	16.8782
0.3416	0.0366	18.5598
0.3726	0.0335	18.2703
0.3745	0.0467	18.5894
0.3827	0.0457	18.6313
0.3918	0.0510	18.8304
0.4055	0.0617	19.3933
0.4237	0.0649	19.5973
0.4284	0.0729	20.1543
0.4372	0.0957	21.2025
0.4518	0.1162	22.0389
0.4633	0.1403	22.5931
0.4763	0.2303	23.7732
0.4900	0.6017	24.9686
0.5034	0.6307	25.3955
0.5131	0.2961	26.4344
0.5266	0.5097	28.1268
0.5389	0.2783	28.7436
0.5481	1.0901	29.9293
0.5693	2.1024	31.5531
0.5870	0.1278	32.5221
0.6055	0.1486	32.8668
0.6098	0.1763	33.8370
0.6223	0.2491	34.3952
0.6291	0.4888	35.2831
0.6411	0.1638	35.8612
0.6515	0.1886	36.9900
0.6624	0.1339	38.9037
0.6781	0.2959	40.3916
0.6897	0.1160	41.4037
0.7080	0.1271	41.3449
0.7120	0.1510	42.1196
0.7232	0.1832	43.0416
0.7336	0.3349	44.7681
0.7454	0.5885	46.8166
0.7564	0.2322	48.7363
0.7717	0.8675	49.8935
0.7829	0.4756	51.6145
0.7909	0.2192	54.0333
0.8041	0.5025	56.6072
0.8156	0.6728	59.5227
0.8270	0.5638	61.9606
0.8401	0.5995	64.2780
0.8566	0.7964	65.1042
0.8672	0.3403	66.7914
0.8779	0.6725	69.7417
0.8940	0.4614	70.8779
0.9021	0.6406	73.7782
0.9136	0.3784	80.6011
0.9257	0.2095	86.3440
0.9392	0.4621	90.9035
0.9477	0.2058	100.2938
0.9635	0.0473	102.4898
0.9825	0.0967	101.4427

SC-SNF-No Dripping Case - table.t04

! From wapdeg file: SCsfnd100mh
! From wapdeg version: 3.06
! Average hst, snf, m=1.5, no drip
! 6/28/98, No variability/uncertainty splitting
!
! START OF PARAMETERS

2
3 29
1 2 3
0.0000
741309.2413
741310.2413
749894.2093
758577.5750
767361.4894
776247.1166
785235.6346
794328.2347
803526.1222
812830.5162
822242.6499
831763.7711
841395.1416
851138.0382
860993.7522
870963.5900
881048.8730
891250.9381
901571.1376
912010.8394
922571.4272
933254.3008
944060.8763
954992.5860
966050.8790
977237.2210
988553.0947
1000000.0000

0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0104	0.0000	3.8537
0.0214	0.0000	3.2637
0.0365	0.0000	2.3982
0.0450	0.0000	2.4461
0.0597	0.0000	2.8036
0.0761	0.0000	2.6924
0.0936	0.0000	2.7504
0.1057	0.0000	2.7917
0.1116	0.0000	3.0465
0.1222	0.0000	3.2312
0.1330	0.0000	3.3831
0.1438	0.0000	3.5300
0.1515	0.0000	3.5805
0.1546	0.0000	4.0111
0.1638	0.0000	4.1204
0.1682	0.0000	4.2500
0.1696	0.0000	4.4948
0.1808	0.0000	4.4930
0.1867	0.0000	4.6862
0.1953	0.0000	4.8377
0.2045	0.0000	4.9278
0.2081	0.0000	5.0699
0.2092	0.0000	5.2583
0.2137	0.0000	5.3699
0.2194	0.0000	5.4250
0.2274	0.0000	5.5188
0.2900	0.0000	4.3276

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8.0 Attachments

N/A.