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NUCLEAR WASTE MANAGEMENT PROGRAM PROCEDURE

NP 9-2
PARAMETERS
Revision 0

Effective Date: 02/07/02

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	(printed name)	(signature)	date

1.0 Purpose and Scope

This procedure prescribes the processes for developing, documenting, controlling, and changing parameters used in compliance-level and programmatic Performance Assessment (PA) calculations performed by Sandia National Laboratories (SNL) in support of the Waste Isolation Pilot Plant (WIPP) Project. This procedure ensures that the derivation of parameter values is traceable, and that all changes in parameters are controlled and documented.

This procedure applies to all SNL and contractor personnel who participate in the selection, control and documentation of parameter values used in WIPP PA activities.

Acronyms and definitions for terms used in this procedure may be found in the Nuclear Waste Management Program (NWMP) Glossary located at the SNL NWMP On-line documents web site.

1.1 Definitions

Analysis – calculation or set of calculations being run to support compliance decisions (CDs), programmatic decisions (PDs), or for other purposes.

Complementary cumulative distribution function (CCDF) – One minus the cumulative distribution function.

Cumulative distribution function – The sum (or integral as appropriate) of the probability of those values of a random variable that are less than or equal to a specified value.

Compliance Decision (CD) – compliance, certification, or recertification analyses whose output is relied upon to make design, analytical, operational, or compliance-based decisions with respect to the performance of the waste confinement system. These CD results will be used in supporting an application for certification or recertification of a permit or license (e.g., performance assessment, data analysis, parameter development).

Database Administrator (DBA) – The individual responsible for maintaining the parameter database, including its security and maintenance of the data entered into it. The DBA is responsible for the

creation, retrieval, and update rules for the database that make it possible to enter the values correctly.

Delta Distribution - The delta distribution is used to assign probabilities to the elements of some finite set of objects. (Tierney, 1996 ERMS 35268)

Entry Checker – The individual responsible for verifying the data entry of the parameter values into the database.

Lognormal distribution – A probability distribution in which the logarithm of the variable in question follows a normal distribution.

Loguniform distribution – A probability distribution in which the logarithm of the variable in question follows a uniform distribution.

Mean – the expectation of a random variable: i.e., the sum (or integral) of the product of the variable and the PDF over the range of the variable. There is sample mean and mean: the mean, μ, of a distribution is one measure of the central tendency of a distribution, analogous to the arithmetic average of a series of numbers. The sample mean, $\bar{x}$, is the arithmetic average of values in an empirical data set.

Median – The value of a random variable at which its CDF takes the value 0.5; i.e., the 50^{th} percentile point.

Mode – The value of a random variable at which its PDF takes its maximum value. The mode of a set of data is the value in the set that occurs most often.

Normal distribution – a probability distribution in which the PDF is a symmetric, bell shaped curve of bounded amplitude extending from minus infinity to plus infinity. (Tierney, 1990)

Parameters – All numbers or distributions of numbers used as initial input to a PA numerical model. A parameter is defined by its material name and property name.

Parameter error – When incorrect data are used for a parameter in a PA calculation.

Parameter Record – A value or set of values associated with a parameter in the database. Each parameter record must be assigned to a particular analysis when it its values are entered in the WIPP PA Parameter Database.

Parameter Problem – When an incorrect parameter value or values are approved and entered into the parameter database but are remedied before the data are used in a calculation, or when another problem related to a parameter record occurs but can be corrected before the parameter(s) in question are accessed in a calculation.

Performance Assessment (PA) – A term used to denote all analysis activities carried out to (1) evaluate the long-term ability of a repository system to effectively isolate waste by complying with applicable regulatory performance objectives; and (2) to provide the basis for demonstrating regulatory compliance.

Programmatic Decision (PD) – programmatic, scoping, or sensitivity analyses associated with programmatic decisions. These analyses may be considered as scoping or screening in that they apply to development, implementation, and testing of improvements to the existing methodology. Scoping calculations include evaluative efforts regarding features, events, and processes (FEPs)

screening, conceptual/mechanistic model evaluation, or assessment of grid adequacy. Sensitivity analyses can focus on testing the impact of alternative modifications for improving capabilities for conducting performance assessments (PAs) and for communicating and explaining the results of a PA.

Probability Density Function – A real-valued function whose integral over any set gives the probability that a random variable has values in this set.

Student's-t distribution – A distribution for the unknown mean value of a parameter (CCA 1996.) The distribution of the random variable which is (very loosely) the "best" that we can do when the variance or true standard deviation is unknown and the sample size is small.

Triangular distribution - A distribution useful for random variables constrained to lie between two fixed limits. This distribution peaks at some value between two limits and is characterized by three parameters: Lower Limit, Central Value (Mode), and Upper Limit. The triangular distribution is defined on the range (a, c) and has mode b. The mode can equal either of the two boundary values. (Iman and Shortencarier 1984)

Uniform distribution – A probability distribution in which the PDF is constant over the range of variable values.

Variance – The square of the standard deviation of the probability distribution; the standard deviation is a measure of the amount of spread of a distribution about its mean. The variance is a measure of the spread in the data. It is computed as the average squared deviation of each number from its mean.

Requester – The requestor is an inclusive term used to for anyone who generates a parameter distribution.

2.0 Implementation Actions

2.1 General

A parameter is any value or distribution of values, or functions used directly or indirectly as initial input to a PA. Parameter distribution values are developed based on experimental data, literature data obtained from journal articles, technical references from reference books, or other source information. A parameter is identified by a distinct combination of material and property names.

The value(s) of a parameter is referred to as a parameter record. Each new or updated parameter value(s) is documented as a separate parameter record in the database.

The parameter/distribution will be developed and documented in accordance with an approved planning document, such as NP 9-1, Analyses, NP 20-1, Test Plans, or NP 20-2, Scientific Notebooks as appropriate

2.1.1 Processed Parameters

A processed parameter is one that has been developed in accordance with all the requirements of the SNL WIPP QA program. Only processed parameters can be used in calculations used to support Compliance Decisions (CDs). A CD calculation is one that is performed to support a WIPP compliance, certification, or re-certification application or decision.

Parameters used in Programmatic Decision (PD) calculations do not require complete Quality Assurance documentation since the scoping, or sensitivity analyses in which they are used apply only to programmatic decisions. A memo explaining the rationale for the parameter value(s) would suffice for PD development, e.g., preliminary results from an experimental program, versus the final experimental results that will be used in any CD calculation.

2.1.2 Parameter Types

There are four types of parameters:

- **Conceptual Model Parameters** are those parameters that may implement a Features Events and Processes (FEPs) or conceptual models and may be based on data resulting from experiments conducted for the WIPP project e.g., physical, chemical, or hydrologic properties of the rock formations, seals, backfills, waste form, or other natural or engineered feature of the WIPP; or they may be based on information derived from appropriate literature.

  To justify the use of a conceptual model parameter based on values obtained from the literature, a Requester must assess the accuracy of the data (comparison to other literature data, professional judgment, etc.), and the relevancy of the literature data for the parameter being developed. The justification must be supported with the appropriate documentation from an analysis plan, test report or scientific notebook as necessary.

  Analogs of existing approved conceptual model parameters may be used. The new analog parameter (i.e., material and property) and the existing parameter will have the same values and documentation. However, a documented justification for making the analogous parameter is required.

- **Numerical Code Parameters** are those required for implementation of numerical modeling codes. The Numerical Modeler will determine numerical code parameters, and gather supporting documentation for the parameter values and will support such a choice in the analyses plan or report where the parameter is used.

- **Reference Parameters** represent precisely known, tabulated physical constants, such as the half-life of a radionuclide or the gravitational constant. They are obtained from standard engineering or reference science books. The Requester will record the exact source from which the value was extracted. The Requester may round the value provided by the source, however this action must be justified and documented.

- **Inventory Parameters** represent the inventory of waste to be emplaced in the WIPP. This is defined in the WIPP Transuranic Waste Baseline Inventory Report (BIR). The Requester must determine and record the BIR version used.

All inputs and input sources for all parameter types are to be justified in the Analysis record as required in Section 4 of Appendix B of NP 9-1.

2.2 Parameter Development

Parameter development may involve one or more of the following actions: generating experimental data, retrieving literature or technical reference data, or deriving numeric values from a statistical analysis of experimental or literature values (e.g. fitting the data to a distribution, determining the mean, median, and standard deviation of that distribution).

The plan for which the parameter is required can generate several reports. One of the analysis reports should include a discussion as to why the chosen distribution was picked and should follow the flow chart below for assigning values to parameters. The WIPP PA uses probability distributions to represent both stochastic (i.e., aleatory) uncertainty and subjective (i.e., epistemic) uncertainty. This is an important distinction and should be clear in the minds of individuals when they assign distributions.

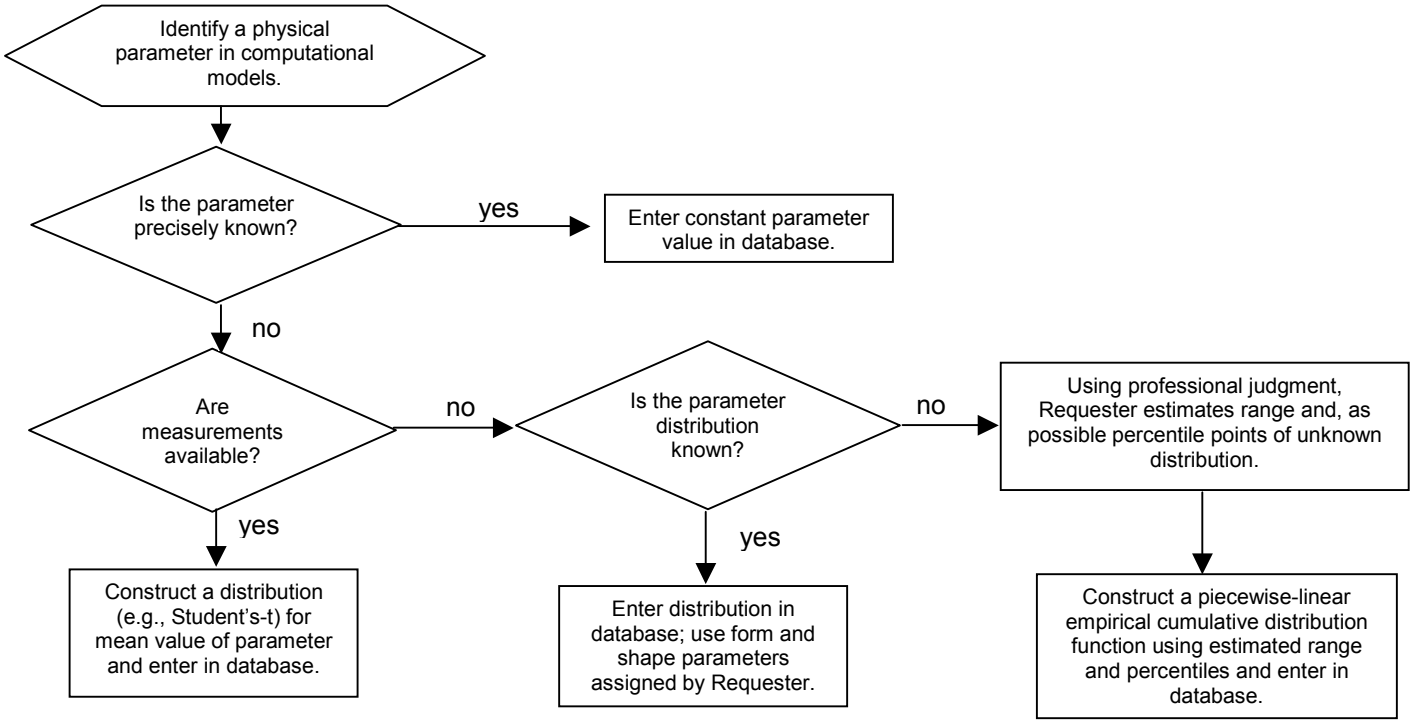

Figure 1. Conceptualization of process for assigning values to parameters
(modified from Helton et. al. 2000)

To establish a new parameter, after conducting the analyses for establishing the parameter, the Requester shall document information describing the parameter/distribution on a Parameter data entry form, Form NP 9-2-1 (Appendix A). The planning document followed during the development of the parameter/distribution shall be referenced. Once a Form NP 9-2-1 is generated, the requester shall sign and date it and obtain a dated consensus signature from the Technical reviewer (when possible should be the same reviewer who approved the original parameter assignment following NP 9-1, NP 20-1 or NP 20-2 as appropriate) and the PA Manager along with a copy of any applicable source documentation.

The requester will submit NP Form 9-2-1 to the Database Administrator (DBA) to perform the data entry. Once the entry has been completed, the DBA will sign and date the form, and pass the form on to an Entry Checker to verify that the values in the database are identical to those on the form. The verification shall consist of a manual inspection of a data print out from the database of the parameter and all information pertaining to it. When the database values are verified, the form shall be signed and dated by the entry checker, the database print out attached, and the package returned to a QA Reviewer. The QA Reviewer shall review the entire parameter record package (PRP), verify it is complete, and submit the PRP to the Records Center in accordance NP 17-1 (Records).

2.2.1 Parameter distributions

For the development of a parameter when not a constant, the Requester may need to derive numeric values from a statistical analysis of a series of data. Probability distributions are used to characterize

the uncertainty concerning a parameter value; these distributions include: uniform, cumulative, triangular, Student's-t, delta, normal, loguniform, log cumulative, lognormal. To characterize a particular distribution, the Requester will determine: the range (of a pair of numbers describing the minimum and maximum values of the parameter), mean (central tendency of a distribution of a series of numbers), median (50^{th} percentile of a distribution), and mode [only for triangular (as required by the database), the most probable value of the uncertain parameter], as applicable.

The analysis report from which the parameter was developed should include a discussion as to why the distribution was chosen. The table below provides a general determination of when the different distributions are normally used. The table is guidance only and is not meant to prescribe a distribution for every possible scenario. The specific basis for selecting the type of statistical distribution shall be documented in your analysis report, test report or scientific notebook as appropriate.

Distribution Name	When to use it
Uniform	Use of the uniform distribution is appropriate when all that is known about a parameter is its range (a, b); the uniform distribution is the Maximum Entropy distribution under these circumstances (Tierney 1990).
Cumulative	A simple form of the cumulative distribution is used when the range (a, c) of the parameter is known and the analyst believes that his or her best estimate value, b, is also the median (or 50th percentile) of the unknown distribution. In this case, the subjectively determined percentile points take the form: (a, 0.0), (b, 0.5), (c, 1.0) (Tierney 1990). The cumulative distribution is the Maximum Entropy distribution associated with a set of percentile points (x1,P1), (x2,P2), ..., (xN, PN), no matter how that set of percentile points is obtained (that is, independent of whether the points are empirically or subjectively derived) (Tierney 1990)
Triangular	Use of the triangular distribution is appropriate when the range, (a, c), of the parameter is known and the analyst believes that his or her best estimate value, b, is also the mode (or most probable value) of the unknown distribution. (1996 CCA)
Student's-t	The Student's-t distribution applies when there are few measurements, say 3<N<10. For large N, say N>20, there is little difference between the t-distribution and a normal distribution with the same mean and standard deviation. (1996 CCA)
Delta	The delta distribution is used to assign probabilities to the elements of some set of objects.
Normal	Use of the normal distribution is appropriate when it is known that the parameter is the sum of independent, identically-distributed random variables (this is seldom the case in practice) and there are a sufficient number of measurements of the parameter (N > 10) to make accurate, unbiased estimates of the mean (μ) and variance (s2) (Tierney 1990). This does not apply to the representation of epistemic uncertainty.
Loguniform	Use of the loguniform distribution is appropriate when all that is known about a parameter is its range (a, b): that is, the range (a, b) spans many orders of magnitude. (1996 CCA)
Logcumulative	Use of the logcumulative is appropriate when the independent variable is Y, where Y = log X. As with the cumulative distribution, this distribution is described by a set of N ordered pairs. (1996 CCA)
Lognormal	As with the normal distribution, the lognormal distribution requires low and high range values. These values are in logarithmic form and are utilized in a normal distribution to determine a mean (μ) and a variance (s2), which in turn are used to identify the expected value and variance for the lognormal distribution (Iman and Shortencarier 1984).
Constant	Use if the parameter is precisely known.

2.3 Changing Parameter Values and Justification

When a change to an existing parameter value or justification is required the change shall be proposed by the Requester by completing Parameter Data Entry Form NP 9-2-1 and checking either "Change in Value" or "Change in Justification," then proceed to update the parameter following the process indicated in section 2.2 of this procedure. Abbreviated material and property names should never be modified (they can only be modified if they have never been accessed in an analysis). Definitions and the actual name can be modified to fix spelling and grammar errors, but no change should be made to substantially alter the definition of the (material or property) so that it becomes something else. After the update the Requester submits the form to the QA reviewer. The QA Reviewer shall review the entire parameter record package (PRP), verify it is complete, and submit the PRP to the Records Center in accordance NP 17-1 (Records).

2.4 Problem Reporting

When a problem with a parameter value(s) or the data entry form (typographical errors on the form are not part of error reporting and will be handled through Section 2.3) is detected, the individual detecting the problem shall initiate a Parameter Problem Report (Form NP 9-2-2). After documenting the problem, this individual will sign and date the form, and submit the form to a QA Reviewer. The QA Reviewer will review the form with the Requester and the PA Manager to determine whether in fact it is a problem with the value or supporting justification. For errors the Requester and the PA Manager sign and date the form, and then update the parameter, as applicable, following the process indicated in section 2.3 and 2.2 of this procedure. Together with QA, the Requester shall designate whether or not an impact assessment is required and, in cases where one is not required, justify why not. In cases where an impact assessment is required, NP 16-1 (Corrective Action) shall be followed. After the update the DBA submits the form to the QA reviewer. The QA Reviewer shall review the entire Problem Report verify it is complete, and submit it to the Records Center in accordance NP 17-1 (Records).

2.5 References

- Tierney, M.S., "Constructing probability distributions of uncertain variables in models of the performance of the Waste Isolation Pilot Plant: the 1990 performance simulations." SAND 90-2510
- Helton, J.C., Martell, M.A., Tierney, M.S. " Characterization of subjective uncertainty in the 1996 performance assessment for the Waste isolation Pilot Plant." Reliability Engineering & System Safety69 (2000) 191-204
- Iman, R.L., and Shortencarier, M.J. 1984. A FORTRAN 77 Program and User's Guide for the Generation of Latin Hypercube and Random Samples for Use With Computer Models. SAND83-2365, Sandia National Laboratories, Albuquerque, NM
- 1996 CCA Appendix PAR 2.1 Distribution Types and Applications
- NP 9-1, Analyses
- NP 16-1, Corrective Action
- NP 17-1, Records
- NP 20-1, Test Plans
- NP 20-2, Scientific Notebooks

3.0 Records

The following records, generated through implementation of this procedure, shall be prepared and submitted to the SNL WIPP Records Center in accordance with NP 17-1 (Records):

QA Record	Preparer	Records Submitter
• Form NP 9-2-1	Requester	QA Reviewer
• Form NP 9-2-2	Requester	QA Reviewer

4.0 Appendices

Appendix A: Form NP 9-2-1, Parameter Data Entry
Appendix B: Form NP 9-2-2, Parameter Problem Report

Appendix A

NUCLEAR WASTE MANAGEMENT PROGRAM Sandia National Laboratories	**Parameter Data Entry** (used for documenting the creation, change in value, justification, and approval of parameters)	**Form Number: NP 9-2-1** **Page 1 of 1**

New Creation: ☐ Yes ☐ No Change in Value: ☐ Yes ☐ No Change in Justification: ☐ Yes ☐ No

Was the data supporting this parameter developed under the SNL WIPP QA Program: ☐ Yes ☐ No

Parameter Description:	Parameter Type:

Units:	Usage:
Material Name:	Property Name:
Abbreviated Name:	Abbreviated Name:
Description:	Description:

Associated Analysis: (CCA, PAVT, etc.)	

Calculated Statistics	**Data Values Supporting Distribution or Constant Value**
Distribution:	
Mean:	
Mode: (triangular distribution only)	
Median:	
Std. Deviation:	
Minimum:	
Maximum:	

Citation(s) for Justification Document(s) (attach pages as necessary) to be developed per the SNL QA program and are provided here as references only.

Planning Document ERMS	Source Document ERMS	Source Date	Source Author	Source Title

Concurrence

Requester (Print, Sign and Date)

Technical Reviewer (Print, Sign and Date)

PA Manager (Print, Sign and Date)

QA Reviewer (Print, Sign and Date)

Data Entry

DBA (Print)

DBA (Sign and Date)

Record Date

Entry Check

Entry Checker (Print)

Entry Checker (Sign and Date)

Instructions for NP 9-2-1

The parameter data entry form is used to transition from the analysis of the parameter assignment to the data entry of the parameter database. All the information on this form should come from the analysis report from which the parameter assignment is made.

New Creation, Change in Value, Change in Justification – Select whether this is an entirely new parameter or whether this is an update to the value or to the source documentation which includes updates to the form entries.

Data supporting this parameter is developed under the SNL WIPP QA Program – Indicate yes or no as to whether or not this parameter has been developed and is approved for use in a compliance decision calculation (CD).

Units – The physical unit of measurement of the parameter value(s). Where appropriate, parameter values should be given in SI units.

Usage – Select the usage type of this parameter. Usage types are meant to further communicate the intended use of the parameter assignment. Parameter usages can be but are not excluded to

Usage	Description
Design Criteria	Based on engineering data or regulation (e.g., # of barrels, footprint of repository, etc.)
Code of Federal Regulations (CFR) Criteria	Developed based on CFR's
Universal Constant	Textbook/handbook value (general engineering knowledge)
Conversion Factor	Values used to convert from one unit to another (e.g., # seconds in a year)
Numerical	Parameters needed so that the computer codes will run
Process Flag	Indicate what type of processing is to occur inside a computer code
Reporting	Specify what information a numerical code should report on, with what frequency, etc.
Auxiliary	Initial, Boundary, and Well conditions

Parameter Description – Provide a parameter description that defines the parameter and, where appropriate, explains the role of the parameter in the modeling.

Parameter Type – Select either Conceptual Model, Numerical Model, Reference or Inventory parameters see Section 2.1.2 for further explanation of parameter types.

Material and Property Name, Abbreviated Name and Description – Provide a definition of the material and property to be created. The label describes the performance assessment model parameter name for the physical or operational meaning for the parameter (for example, SAT_RBRN means residual brine saturation). The material and property name can only be changed to fix spelling or grammar errors and they should never be modified to become something else.

Associated Analysis – Associate the parameter with an Analysis Calculation (e.g., CCA, PAVT etc.) usually defined by a NP 9-1 Analysis Plan and defined by the calculation manager or designee.

Calculated Statistics – Identify the mean, median (or mode in the case of a triangular distribution), maximum, minimum, and standard deviation of the parameter distribution.

Data Values Supporting Distribution or Constant Value. **–** Input the basis for the parameter value(s) or parameter distribution, or the constant value as appropriate.

Justification Document(s) - Justification sources are to be developed per the SNL QA program and are provided here as references only. Identify the documents that provide the objective evidence of the parameters creation, value or justification change. The source of the parameter value and the rationale for the parameter's distribution should help clarify the use of a particular parameter. Parameter Record Sources are

Source	Description
Experimental Program	Experimental Data
Technical Literature	Values compiled from technical literature
Computer Code	Data output from a computer Code (e.g., FMT, NUTS etc.,)
Abstraction	Derived from other information source or data
Inventory Report	Any data used directly off an inventory report
Assumption	Any assumption made against base data
EPA mandate	Any change mandated by the EPA

Other relevant background information is also included in this section, where clarification is appropriate.

ERMS for Planning Document – Input the Record Centers unique identifier for the planning document under which this parameter was initiated (e.g., Analysis Plan, Test Plan, etc.,). All parameter development will follow NP 9-1, Analyses, NP 20-1, Test Plans, or NP 20-2, Scientific Notebooks as appropriate.

Concurrence – Approval of the parameter review team (Requester, Technical Reviewer, PA Manager, and QA Reviewer)

Data Entry – Database management activities for entering data into the parameter database by the database administrator (DBA) and entry checker.

Appendix B

NUCLEAR WASTE MANAGEMENT PROGRAM Sandia National Laboratories	**Parameter Problem Report (PPR)**	**Form Number: NP 9-2-2** **Page 1 of 1**

Material Abbreviated Name: _____

Property Abbreviated Name: _____

Associated Analysis:
(CCA, PAVT, etc.) _____

Record Date: _____

Description of Problem

Concurrence of Problem

_____ PPR Initiator (Print, Sign and Date)

_____ Requester (Print, Sign and Date)

Condition Adverse to Quality? ☐ Yes ☐ No (Initiate NP 16 –1 if yes)

Problem resolution and justification for no condition adverse to quality

Concurrence

_____ PA Manager (Print)

_____ SNL WIPP PA Manager (Sign and Date)

_____ QA Staff (Print, Sign and Date)

_____ Parameter Problem Report No. (PPR)

Instructions for NP 9-2-2

Material and Property Abbreviated Name– Provide the abbreviated name of the material and property for which there is a problem. The label describes the performance assessment model parameter name for the physical or operational meaning for the parameter (for example, SAT_RBRN means residual brine saturation).

Associated Analysis – Associate the parameter with an Analysis Calculation (e.g., CCA, PAVT etc.) usually defined by a NP 9-1 Analysis Plan. Supplied by the PA Manager or designate.

Record Date – Enter the date the problem was identified

Description of Problem – Enter a description of the issue

Concurrence of Problem Signatures – PPR Initiator and Requester concurrence with the problem report.

Condition Adverse to Quality – Together with QA determine whether or not this warrants a CAR per NP 16-1.

Problem resolution and justification for Condition not Adverse to Quality – Document the resolution steps needed to correct the problem and provide a justification for any problems or errors that do not warrant a CAR.

Concurrence Signatures – QA and PA Manager concurrence with the problem or error.

Parameter Problem Report No. (PPR #) – The PPR number is a unique identifier assigned by the QA reviewer and takes the form of year - number (e.g., 2002-014.)