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Performance Confirmation Test Plan for Precipitation Monitoring

Prepared for:
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11/6/2007

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11/8/2007

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CHANGE HISTORY

Revision Number	ICN Number	Date of Change	Description of Change
00	00	08/30/2007	Initial issue. This is the initial issue of the Performance Confirmation test plan for precipitation monitoring. A portion of the scope of this test plan was initiated during site characterization and is continued under the auspices of the Performance Confirmation program.
01		11/06/2007	This revision was made in response to conditions of acceptance imposed by the Office of Civilian Radioactive Waste Management. The infiltration model used for performance assessment is insensitive to the synthetic, sampled precipitation distribution values. Meaningful performance-based condition limits cannot be established. The text regarding performance-based condition limits has been rewritten. Changes were too extensive to use change bars.

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ACRONYMS AND ABBREVIATIONS

BSC	Bechtel SAIC Company
DOE	U.S. Department of Energy
ESF	Exploratory Studies Facility
ES&H	Environmental, Safety and Health
FEPs	features, events, and processes
FWP	field work package
LA	license application
magl	meters above ground level
MASSIF	Mass Accounting System for Soil Infiltration and Flow (infiltration model)
NRC	U.S. Nuclear Regulatory Commission
PC	Performance Confirmation
PCTP	performance confirmation test plan
PI	Principal Investigator
PTn	Paintbrush non-welded tuff
QA	quality assurance
QARD	*Quality Assurance Requirements and Description*
RPC	Records Processing Center
TCO	Test Coordination Office
TDMS	Technical Data Management System
TSPA	total system performance assessment
TSw	Topopah Spring welded tuff
UZ	unsaturated zone
YMP	Yucca Mountain Project

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1. INTRODUCTION AND WORK SCOPE

1.1 INTRODUCTION

This document is the performance confirmation test plan (PCTP) for the Performance Confirmation (PC) precipitation monitoring activity. The precipitation monitoring activity is one of 20 testing and monitoring activities documented in *Performance Confirmation Plan* (BSC 2004 [DIRS 172452]). Collectively, the 20 activities make up the PC program described in the plan. Each of the 20 activities will have one or more individual PCTPs. The PC program is required by regulation 10 CFR Part 63 [DIRS 180319], and was started during site characterization (consistent with the regulation), and will continue until permanent closure of the repository (10 CFR 63.131(b) [DIRS 180319]).

The primary goal of the precipitation monitoring activity is to collect, analyze, and report on precipitation rates and quantities data for the purpose of confirming precipitation input data for the infiltration model. This activity was selected because it directly addresses one of the bases for evaluating the performance of the Upper Natural Barrier and the requirements of the regulations. Precipitation serves as the maximum input of water to the repository system from the environment. As such, this activity is important to understanding seepage monitoring activities, and understanding input and output values of the process that carries water from the surface, through the unsaturated zone, and potentially down into the emplacement drifts. Information obtained from precipitation monitoring will be used as input to the unsaturated zone (UZ) flow model for the evaluation of other quantities potentially important to repository performance (e.g., seepage time histories).

The activity as described in *Performance Confirmation Plan* (BSC 2004 [DIRS 172452], Section 3.3.1.1) includes analysis of precipitation composition. Precipitation chemistry is not included in this PCTP because there is no baseline for composition of precipitation at the site surface. PCTPs are intended to test the adequacy of assumptions, data, and analyses that are used in the licensing basis supporting a permit for construction. Precipitation chemistry is identified as a candidate parameter in *Performance Confirmation Plan* (BSC 2004 [DIRS 172452]), which describes the performance confirmation goals at the time of license submittal. There may be valid reasons to develop a baseline of precipitation chemistry in ongoing science programs leading to possible use in future Performance Assessment evaluations. Precipitation chemistry parameters are not input into the infiltration or UZ flow models, and are not part of the licensing basis.

Regulatory requirements for the PC program are specified in 10 CFR 63, Subpart F [DIRS 180319]. Regulatory performance objectives for the overall repository are stated in 10 CFR 63, Subpart E [DIRS 180319]. Guidance for the PC program is also provided in *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274]). A description of the PC program is required in the Safety Analysis Report as part of the license application (LA) (10 CFR 63.21(c)(17) [DIRS 180319]).

Test and monitoring activities for this PCTP are addressed in 10 CFR 63.131 [DIRS 180319], which requires (in part) monitoring and analysis of changes from baseline conditions of parameters that could impact the performance of a repository. This activity will provide precipitation rate and quantity data for the present time period consistent with the most recent update of the infiltration model (SNL 2007 [DIRS 174294]).

10 CFR 63.131(a)(2) [DIRS 180319] requires data or information to indicate, where practicable, whether the natural and engineered systems and components designed or assumed to operate as barriers after permanent closure are functioning as intended and anticipated. This activity will provide data that, along with data from related activities such as seepage monitoring and UZ testing, may provide information on barrier performance.

Data from the precipitation monitoring activity, as well as from the other 19 PC activities, will be evaluated in the context of overall repository performance. During the PC multi-attribute decision analysis process (Snell et al. 2003 [DIRS 166219], Appendix B), a set of PC activities was identified as important to measure repository performance; modifications to the original activity set were made during the course of technical and management reviews, documented in revisions to *Performance Confirmation Plan* (BSC 2004 [DIRS 172452]).

The precipitation monitoring activity was selected for the PC program based on its relevance to infiltration, UZ flux, and seepage. The method selected to address regulatory requirements for repository performance is to ascribe performance to a set of three barriers (e.g., Upper Natural Barrier, the Engineered Barrier System, and the Lower Natural Barrier). Each barrier has been evaluated as to its performance in terms of associated features, events, and processes (FEPs). The bases for their effects on barrier performance are documented in analysis and model reports and in *Postclosure Nuclear Safety Design Bases* (BSC 2006 [DIRS 176566]). This activity is a relatively straightforward continuation of an ongoing activity, which confirms the precipitation data used for infiltration modeling.

This PCTP is written specific to precipitation monitoring in accordance with SCI-PRO-002, *Planning for Science Activities*, with additional information to address the requirements in *Performance Confirmation Plan* (BSC 2004 [DIRS 172452]) and *Quality Assurance Requirements and Description* (QARD) (DOE 2007 [DIRS 182051]). This PCTP contains sufficient information to describe the purpose, objectives, and scope of the precipitation monitoring activity, test methodology, equipment and instrumentation planned for use, data management, and calibration requirements.

1.2 SCOPE OF WORK

1.2.1 Overall Test Objectives

1.2.1.1 Testing and Monitoring Requirements

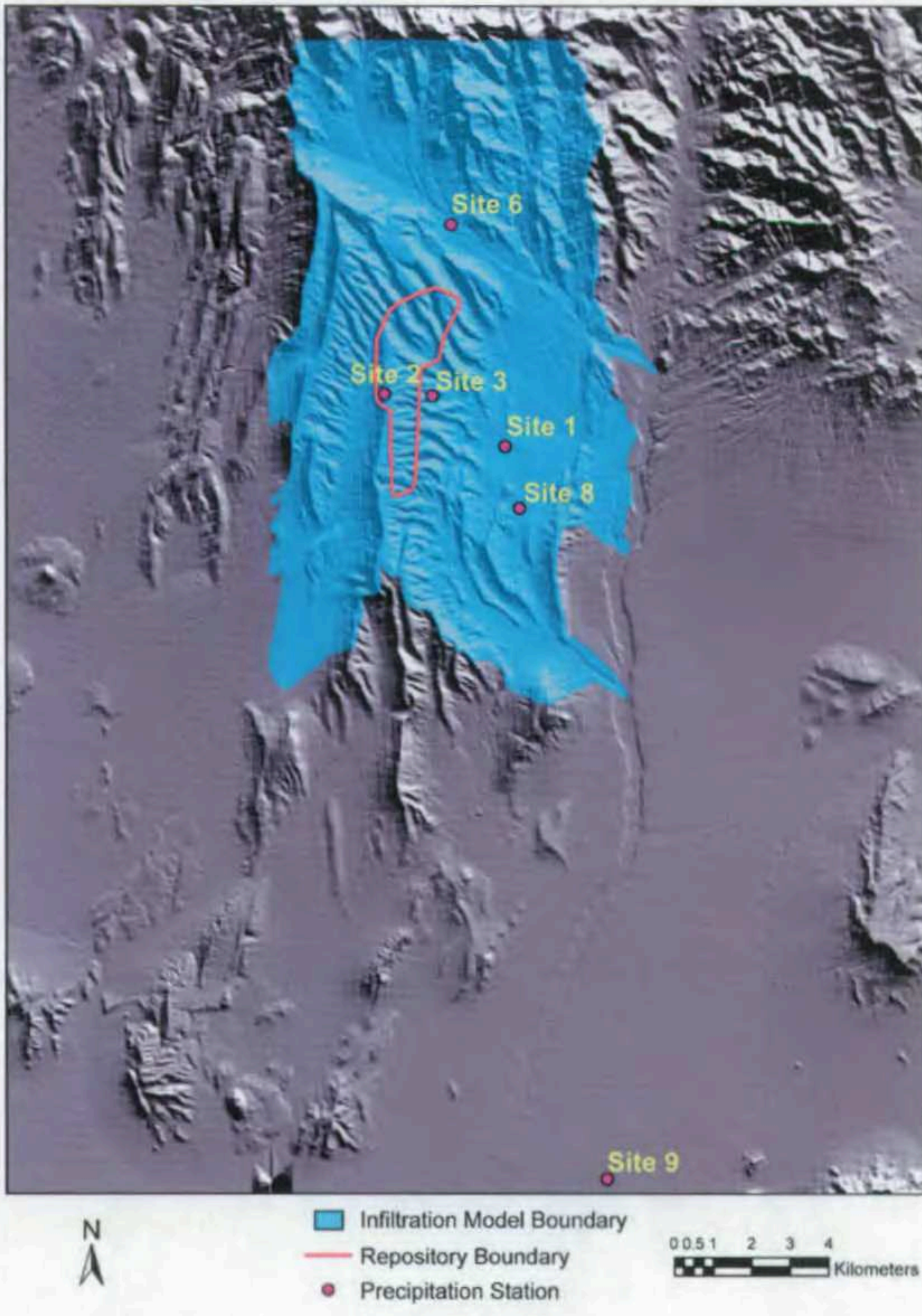
The scope of work for this PCTP is to perform the testing and monitoring required by 10 CFR 63.131 [DIRS 180319]. Precipitation monitoring is expected to continue until closure. The boundary for the responsible organizations is the Technical Data Management System (TDMS). All field testing, equipment procurement, calibration, maintenance, data retrieval, reduction, and transmittal to the TDMS are the responsibility of Bechtel SAIC Company (BSC). BSC procedures control those activities. The PC organization is responsible for all activities that occur once the data are submitted to the TDMS.

The Lead Laboratory PC organization is also responsible for ensuring that work is conducted in accordance with the regulatory requirements and other considerations delineated in the PC program. The PC organization assumes overall project management for the program and central interface between the field testers (the Environmental, Safety, and Health (ES&H) site staff working under Environmental Compliance), performance assessment modelers, and the U.S. Department of Energy (DOE).

1.2.1.2 Testing and Monitoring Objectives

The objective of the testing and monitoring described in this PCTP is to make observations and measurements to confirm the adequacy of the precipitation data inputs to the Yucca Mountain Project (YMP) numerical model that deals with precipitation rate and precipitation quantity at Yucca Mountain. These data could be used to evaluate the performance of the Upper Natural Barrier as it relates to moisture flux and potential seepage at the repository level. This activity is one of a series of PC testing and monitoring activities that addresses the requirements of 10 CFR 63.131 [DIRS 180319] to document that the natural system is functioning as intended, and anticipated, and that baseline conditions associated with repository performance have not significantly changed.

This activity began during site characterization. Precipitation and other meteorological monitoring is presently conducted at 29 stations located at or near Yucca Mountain. Of the 29 stations, 17 are presently managed and operated by the University of Nevada, Las Vegas, in accordance with SIP-UNLV-030, *Precipitation Monitoring at Yucca Mountain*; 12 stations are presently managed and operated by BSC in accordance with *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]). The Mass Accounting System for Soil Infiltration and Flow (MASSIF) infiltration model used records from a total of ten meteorological stations to estimate future precipitation for the present-day climate. Five out of these ten stations are located in the immediate vicinity of Yucca Mountain and are operated by BSC. The other five stations are located in the greater Yucca Mountain region, including the Nevada Test Site to the north and Amargosa Farms to the south, and are not operated by the YMP. The five Yucca Mountain stations used by the MASSIF model and an additional station (Station 8) have been selected for PC monitoring. These six stations are from a set of stations presently managed and operated by BSC. Because five of these stations were used in MASSIF they represent part of the technical basis for the LA and will provide sufficient spatial coverage to meet the requirements of the precipitation monitoring activity. Figure 1-1 shows the locations of the six stations from which monitoring will be specifically incorporated into the PC program. The collection of precipitation data at the six selected stations will be conducted under this PCTP; the other precipitation and meteorological stations may continue to be monitored under existing scientific investigation plans.



Source: SNL 2007 [DIRS 181519].

Figure 1-1. Schematic Shaded Relief Map Showing the Locations of the Yucca Mountain Performance Confirmation Precipitation Stations

1.2.2 Test Data Uses

The data and information gathered under this PC activity will be used to support confirmation of the bases (e.g., assumptions, analyses, and data) for the infiltration model (precipitation rate and quantity). Precipitation quantity and rate databases were used to derive cumulative probability distributions that were sampled as input to numerical and conceptual models that feed the process and performance assessment models and their abstractions used in the total system performance assessment (TSPA) for the LA (Figure 1-2). Table 1-1 is a data item key to numbers used on Figure 1-2. Because this activity addresses the quantity of water that could potentially reach the waste packages, and thereby possibly impact the waste package integrity potentially affecting radionuclide transport, observations of precipitation rates and quantities were selected as PC inputs.

1.2.3 Test Data/Work Product

The products of the precipitation monitoring activity are the precipitation rate and precipitation quantity. Distribution functions of these two parameters are sampled as input to the Yucca Mountain infiltration model, and therefore they impact the moisture flux in the Topopah Spring welded tuff (TSw) and potential seepage at the repository level. The precipitation rate and quantity data collected at Yucca Mountain and the surrounding area were key parameters used to develop the precipitation input files for the infiltration model. The infiltration model calculates the moisture fluxes that are input to the UZ flow model. The UZ flow model then calculates the moisture flux in the TSw; it is this flux that controls the potential seepage at the repository. The precipitation rate and quantity values used as input to the infiltration model are based on nine climate scenarios (Section 1.5.2.2 for details). The infiltration model simulations include climate scenarios that deal with average, low, and high precipitation periods for the present-day climate (SNL 2007 [DIRS 174294]).

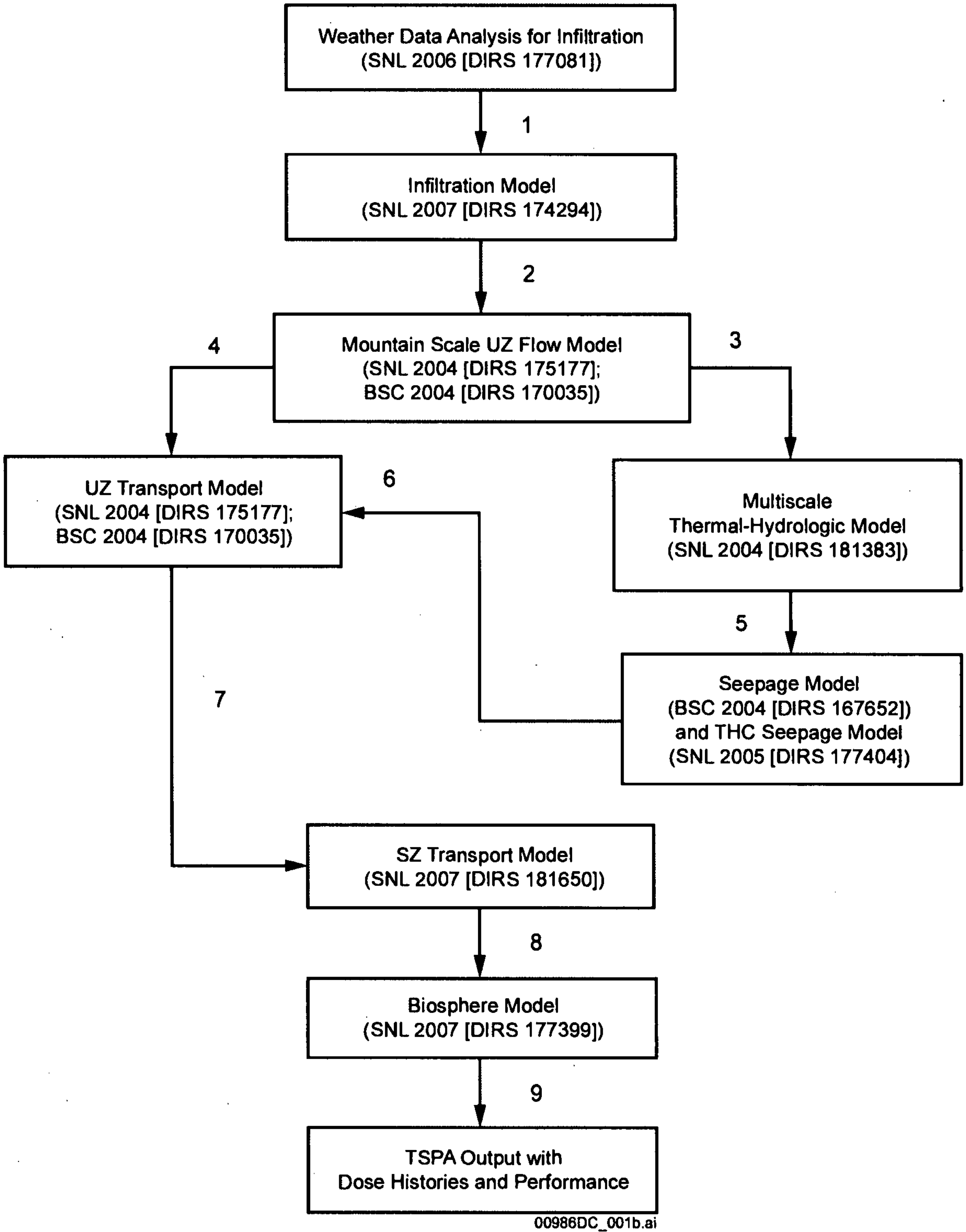


Figure 1-2. Model Input/Output Map

Table 1-1. Data Item Key for Figure 1-2 Model Input/Output Map

Data Item Number	Model Input and Output	Source
1	The climate analysis uses spreadsheets and simple programs to produce the precipitation data for nine climate scenarios (present-day, monsoon, and glacial-transition, each with an upper bound, mean, and lower bound) that are direct feeds to the infiltration model.	SNL 2006 [DIRS 177081]
2	The infiltration model output provides the upper boundary infiltration flux for the UZ flow model for the nine climate scenarios.	SNL 2007 [DIRS 174294]
3	The UZ flow model output is a direct feed to the MSTHM and includes the 3-D numerical grid for the model domain, steady-state liquid-flow fields for the fractures and matrix, and UZ hydrologic properties for the nine climate scenarios.	SNL 2007 [DIRS 175177] SNL 2007 [DIRS 170035]
4	The UZ flow model output is a direct feed to the UZ transport model and includes the 3-D numerical grid for the model domain, steady-state liquid-flow fields for the fractures and matrix, and UZ hydrologic properties for the nine climate scenarios.	SNL 2007 [DIRS 175177] BSC 2004 [DIRS 170035]
5	The MSTHM output includes the UZ flow model outputs plus the percolation flux at the base of the PTn and in-drift thermal-hydrologic environment. The percolation flux defines the water available for seepage.	SNL 2007 [DIRS 181383]
6	The seepage and Engineered Barrier System THC and degradation model outputs are the mass release rates of the radionuclides to the UZ fracture and matrix continuums. These are direct feeds to the UZ transport model.	BSC 2004 [DIRS 167652] SNL 2007 [DIRS 177404]
7	The UZ transport model outputs include the mass release rate of dissolved radionuclides to the SZ and the mass release rates of radionuclides reversibly and irreversibly sorbed on colloids to the SZ. These are direct feeds to the SZ transport model.	BSC 2004 [DIRS 170035]
8	The SZ transport model output is the radionuclide flux at the 18-km accessible environment boundary. These are direct feeds to the biosphere model.	SNL 2007 [DIRS 181650]
9	The biosphere model output includes the annual dose incurred by the RMEI, gross alpha concentration in groundwater, radium concentration in groundwater, and annual beta and photon-emitting dose by daily consumption of 2 liters. These outputs are the final TSPA outputs and are used to estimate dose histories and evaluate repository performance.	SNL 2007 [DIRS 177399]

NOTE: MSTHM = multiscale thermohydrologic model; RMEI = reasonably maximally exposed individual; SZ = saturated zone; THC = thermal-hydrologic chemical; 3-D = three-dimensional.

1.2.4 Test Duration(s)

Precipitation monitoring is an ongoing activity that may continue for the life of the project or until analysis determines that it is no longer necessary.

1.3 MAJOR ACTIVITIES

This PCTP includes a level of detail for plans, instrumentation, testing and monitoring, data collection and analysis, and reporting that can be readily understood and implemented using the details of a field work package (FWP) or technical procedures for deployment. Testing and monitoring details are provided in the appendices to this PCTP.

Additional types of precipitation monitoring instrumentation, or different data collection techniques, may be incorporated as needed. The primary tasks and the sources of testing and monitoring details are listed below.

1.3.1 Primary Tasks

The sequence of tasks covered by this PCTP includes, but is not limited to:

- Developing a list of parameters (see Table 1-2 for parameters and Appendix C for test requirement details).
- Developing a list of instrumentation (Section 2.2 and Appendix C).
- Preparing instrument installation details (Section 2.2).
- Procuring instruments and additional materials (Section 10).
- Preparing and executing calibration requirements (Section 5.2; CO-PRO-1001, *Control of Measuring and Test Equipment*; QA-PRO-1071, *Acceptance of Items and Service*).
- Preparing for installation and upkeep of gauges (see Appendix B and FWP for installation details).
- Installing and servicing electronic equipment (see Appendix B and FWP for installation details).
- Installing and setting up data acquisition systems (see Appendix B and FWP for installation and setup details).
- Conducting data downloads, raw data reduction, analysis, evaluations, and reporting. Details of these activities are covered in the implementing procedures listed in Appendix B and in the documentation of the precipitation activities presented in Appendix C (also Sections 2.3 and 2.4; IT-PRO-0009, *Control of the Electronic Management of Information*; CO-PRO-1001; IT-PRO-0011, *Software Management*).
- Submitting data to the TDMS (Sections 2.3 and 2.4; AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*, or TST-PRO-001, *Submittal and Incorporation of Data to the Technical Data Management System*, as applicable).

1.4 ORGANIZATIONAL RESPONSIBILITIES

This is a field-based monitoring activity requiring integration and support from several YMP entities. These specific interfaces are defined in the implementing FWP, providing specific details on field interactions, data handoffs, and coordination aspects of the fieldwork. Entities currently (pre-construction) having responsibilities associated with this field activity include the PC organization, Performance Assessment organization, BSC Environmental Compliance (an organization under ES&H), BSC Exploratory Studies Facility (ESF) Site Operations, and the

Licensing and Compliance organization. Once a license to construct the repository is obtained, there will be responsibilities for the Repository Construction and Repository Operations organizations that may require revision to this PCTP.

The PC organization is responsible for ensuring that work is conducted in accordance with the regulatory requirements and other considerations delineated in the PC program. The PC organization assumes overall project management for the program and is the central interface between the field testers (the ES&H site staff working under Environmental Compliance), performance assessment modelers, and DOE. The PC organization is responsible for preparing and approving this PCTP and ensuring communication and agreement between the modelers and field testers.

The BSC ES&H site staff working under Environmental Compliance is responsible for overall field management, coordination, and monitoring of field test activities for precipitation. Their staff and management provided considerable information to this PCTP. This field implementation function works closely with the PC organization to ensure the successful planning and implementation of the program. The ES&H organization is currently responsible for field data collection, reducing the data, and submitting the results to the TDMS. Currently, the data are collected by staff working under the direction of the Site ES&H manager. The data are processed and submitted by staff in Environmental Sciences under the direction of Environmental Compliance. The Performance Assessment modeling and analysis organization (including TSPA) evaluate input parameters used in these process models.

ESF Site Operations comprises several multiple organizations (e.g., Operations, Maintenance, Construction, Field Engineering, and Field Industrial Hygiene staff) that provide infrastructure and access, logistics, craft labor, and emergency response to support testing. At present, all site required interfaces, including access and craft support, are provided by ESF Site Operations.

Integration, data review, and evaluation are performed within the PC organization and applicable Performance Assessment scientific organizations. In the future, a PC integration group will be developed, consistent with *Performance Confirmation Plan* (BSC 2004 [DIRS 172452]), to review PC data and evaluate the overall status of the program. In addition, the integration group will be designed to ensure continuity and integration with other testing and monitoring programs. The group will determine whether the results within PC are interrelated, technically adequate, properly documented, and properly evaluated. This evaluation will ensure that barrier and system performance is assessed in the context of all relevant PC information.

Considerable advances in technology can be expected to occur over the next several decades. A successful PC program will be flexible and include a process to reevaluate, reexamine, and modify PC activities as the state of understanding changes.

1.5 PRE-TEST PREDICTIONS

1.5.1 General

The precipitation monitoring activity provides precipitation rate and quantity data that can be compared with the data inputs to the infiltration model and to the YMP conceptual understanding of infiltration at Yucca Mountain.

The purpose of *Data Analysis for Infiltration Modeling: Extracted Weather Station Data Used to Represent Present-Day and Potential Future Climate Conditions in the Vicinity of Yucca Mountain* (SNL 2006 [DIRS 177081]) was to identify, extract, and reformat weather (meteorological) data that are appropriate for use as input into an infiltration model within the Yucca Mountain region. The analysis used relevant meteorological data (e.g., precipitation and temperature) from source stations and reformatted or converted the data into a form suitable for the generation of meteorological conditions for a 10,000-year future climate in the Yucca Mountain region (DTN: SN0606T0502206.014 [DIRS 179887]).

The YMP conceptual understanding of precipitation at and near Yucca Mountain is based on data collected from 1957 to present. PC precipitation monitoring may be conducted over a longer period (e.g., 100 years), and it is possible that due to the normally expected variance of precipitation values, some of the PC precipitation data will fall outside the range of data values measured to date or included in the stochastic precipitation database used in the infiltration model. PC testing and monitoring activities (including precipitation monitoring) were identified and selected using a multi-attribute decision analysis process. Risk-informed, performance-based criteria were used in the activity evaluation process. While precipitation values are not used directly to evaluate repository performance in TSPA, the range and pattern of precipitation values provides parameters to a stochastic precipitation model that is used to estimate the range and pattern of precipitation in the future. This approach to estimating precipitation in the future was used for the TSPA because it includes rare but potentially significant high precipitation years that have not been measured in the relatively brief period of monitoring. Because precipitation is the only source of water at the land surface and net infiltration is the main source of water that can seep into the repository and lead to radionuclide transport to the saturated zone, precipitation monitoring was selected. Because the stochastic precipitation modeling approach used in the net infiltration model was designed to include a very wide range in future precipitation, there is no need to assign precipitation condition limits for PC monitoring.

The current precipitation data are derived from reports and data packages dealing with infiltration. References that contain precipitation data used in the PC predictions include:

- *Simulation of Net Infiltration for Present-Day and Potential Future Climates* (SNL 2007 [DIRS 174294])
- *Data Analysis for Infiltration Modeling: Extracted Weather Station Data Used to Represent Present-Day and Potential Future Climate Conditions in the Vicinity of Yucca Mountain* (SNL 2006 [DIRS 177081]).

The LA basis is presented in Section 1.5.2.3, which summarizes precipitation values derived from the infiltration model precipitation input values documented in *Simulation of Net Infiltration for Present-Day and Potential Future Climates* (SNL 2007 [DIRS 174294]).

1.5.2 Measurement Justification

1.5.2.1 Relative Importance to TSPA

Precipitation monitoring is not a performance-based activity because precipitation is represented in the TSPA as a stochastic quantity with a large range of uncertainty that significantly exceeds the range in observed values (e.g., total annual precipitation). Its selection for one of the twenty performance confirmation activities was based on the fact that precipitation is the primary source of water that may seep into the repository and lead eventually to radionuclide transport and therefore is important to monitor and understand in the future. However, no performance-based condition limits were assigned to this activity because repository performance estimates from TSPA include low probability, high precipitation years in the calculation of the long-term mean infiltration rate. Furthermore, the long-term mean net infiltration rate was found to be relatively *insensitive* to these extreme years. For example, MASSIF results indicate that about 80% of the long-term mean infiltration for the present-day climate is due to precipitation years with a recurrence period of 10 years and less. The remaining 20% contribution to the long-term mean net infiltration is from precipitation years with a recurrence period of greater than 10 years (SNL 2007 [DIRS 174294], Section 6.5.7.5, Table 6.5.7.5-1, and Figure 6.5.7.5-1). This is because these extreme years have high precipitation (e.g., 1 m/yr) and high infiltration (e.g., 80 mm/yr), but their probability of occurrence is small (1 in 1,000 years) and therefore they have only minor impacts on the long-term mean. Due to the lack of a clear set of measurements which can be tied to a change in the long-term performance of the site, no condition limits are established for precipitation monitoring.

The specific purpose of the infiltration model is to provide a spatial representation, including uncertainty, of the long-term mean annual net infiltration at the Yucca Mountain site during each climate state. The resulting maps of mean annual net infiltration provide input to the updated versions of the following model and analysis reports:

- *UZ Flow Models and Submodels* (SNL 2007 [DIRS 175177])
- *Calibrated Unsaturated Zone Properties* (SNL 2007 [DIRS 179545]).

Information from the infiltration model report indirectly feeds TSPA through its connection with the identified downstream products.

The purpose of this PC activity is to continue to collect precipitation information that can be used to confirm the assumptions and distribution for the present-day stochastic precipitation records used to develop input for the model used in the LA. Performance is unlikely to be impacted by even unexpected precipitation events because other processes in the Upper Natural Barrier that are important to barrier capability (that is, prevent or substantially reduce the rate of movement of water) moderate the impact of precipitation on performance.

Precipitation represents the maximal amount of water available at the surface above the repository, from which a portion is subsequently available to the natural barrier system. Precipitation continues to be monitored because it represents the initial boundary condition of models for flow and transport. This activity is important to understanding seepage and the processes that carry water from the surface through the UZ and potentially to the emplacement drifts. Water is an essential factor in mechanisms of waste degradation and possible radionuclide migration from the repository to the compliance boundary. Documentation of the characteristics of water available to the system is essential to demonstrate knowledge of water flow through Yucca Mountain.

1.5.2.2 Basis for Expected Precipitation Values

This section discusses expected conditions and does not assign condition limits. Precipitation data collected under this activity will be compared to previous data from which the inputs cumulative distribution functions for MASSIF were sampled. Precipitation events will be recorded, entered into records, and reported in the performance confirmation annual report.

Precipitation monitoring at and around the repository site (e.g., Nevada Test Site) began in 1957 and provides the basis for the current understanding of precipitation characteristics at Yucca Mountain. More comprehensive monitoring of precipitation rates and quantities at and near the repository site was begun in 1980 and continues to date. Section 1.5.2.3 presents the PC precipitation monitoring stations along with the actual and expected average annual precipitation. Continuous monitoring is important with regard to trend evaluations to ensure that the precipitation ranges used in the infiltration model remain valid as new data are collected.

Data collected thus far indicate that precipitation rate and quantities are sensitive to elevation (greater annual precipitation at higher elevations) and that precipitation data are relatively consistent for comparable elevations. At present, 6 of the 29 Yucca Mountain precipitation stations have been selected to be included in the PC program. These 6 stations were selected because 5 provide direct precipitation feeds to the infiltration model, and one (station 8) was used for validation (simulating infiltration above the south ramp where seepage was observed). The 6 stations provide sufficient areal coverage and ensure that all relevant geomorphologic features that might impact precipitation are incorporated. The explanation for selection of these particular stations is provided in the weather data analysis report (SNL 2006 [DIRS 177081]). In the future, this number and the station locations may be modified depending on future data analysis, needs, and priorities.

Precipitation provides water for potential infiltration. Instead of taking input directly from multi-decade precipitation records, as had been done for previous infiltration models, precipitation records provided the basis for development of stochastic parameters by parameterizing the general precipitation patterns and characteristics. A stochastic simulation was used to generate a set of simulated precipitation years as input to the calculations. Precipitation observations representing present-day climate were used to develop stochastic model parameters, which are used to simulate long-term precipitation for the site. These derived parameters were used as inputs to a stochastic precipitation simulation, which produced precipitation input files to the infiltration model. Precipitation inputs are selected from 1,000-year stochastic simulations, ensuring that the full range of annual precipitation uncertainty is considered, including years with heavy precipitation.

For the purpose of calculating a long-term mean net infiltration flux for use in TSPA, a stochastic approach to representing daily and annual precipitation was used. This approach simulated the daily frequency of precipitation using a Markov chain Monte Carlo model and represented the daily precipitation amount on days with precipitation as a lognormal distribution. A set of stochastic parameters was defined for this modeling approach by fitting daily precipitation observations from the historical data to the stochastic model using a least-squares approach. These parameters were thus calibrated for each meteorological station and the uncertainty in these parameters was represented with probability distributions. Using the model and sampled stochastic parameter values, daily precipitation for 1,000 randomly simulated years was generated for each of 40 realizations per future climate state. For each MASSIF model run, ten of these 1,000 years were selected (explicitly including low-probability, high-precipitation years) as input, and net infiltration was calculated for each of these ten years separately. A long-term mean annual net infiltration flux for each realization was estimated as a probability-weighted mean of net infiltration calculated for each of the selected years. The uncertainty in this long-term flux is estimated by examining the distribution of the 40 realizations per climate. This somewhat complex approach is described in *Simulation of Net Infiltration for Present-Day and Potential Future Climates* (SNL 2007 [DIRS 174294], Section 6.5.1 and Appendix F).

Expected precipitation ranges were calculated for 100-day and 365-day periods. The 100-day period is important because it relates to low-intensity and long-duration precipitation periods, usually associated with winter storms. A 100-day low-intensity stormy period might result in precipitation volumes that exceed the soil storage capacity (field capacity) and, thereby, increase the possibility for a significant volume of water to move below the zone of evapotranspiration and reach the Paintbrush non-welded tuff (PTn). A large volume of water will reduce the buffer capacity of the PTn, and therefore might result in fluxes into the TSw that could exceed the ranges used in the process models. The annual period is important as a baseline to compare to past data, much of which is analyzed on an annual period, and to identify trends that might indicate changes in precipitation patterns at Yucca Mountain in the future. A summary of precipitation monitoring will be reported in the performance confirmation annual report to DOE.

Actual average annual (station) precipitation is presented in Table 1-2 for Sites 1, 2, 3, 6, and 9 (Section 1.5.2.3). These values represent the mean of the annual precipitation data from these stations, which is from DTN: SN0608WEATHER1.005 [DIRS 177912]. In addition, expected average annual precipitation values are presented in the table. The expected values are calculated in *Simulation of Net Infiltration for Present-Day Infiltration and Potential Future Climates* (SNL 2007 [DIRS 174294], Table F-3).

Table 1-2. Actual and Expected Average Precipitation for the Performance Confirmation Precipitation Stations at and near Yucca Mountain

Station	Elevation (m)	Actual Average Annual Precipitation (mm)	Expected Average Annual Precipitation (mm)
Reference[a]	1,524.0	—	213
Site 1	1,144.0	200.9	156
Site 2	1,478.0	198.5	176
Site 3	1,278.0	223.8	195
Site 6	1,315.0	225.3	196
Site 8[b]	1,123.0	198.1	150
Site 9	839.0	116.0	99

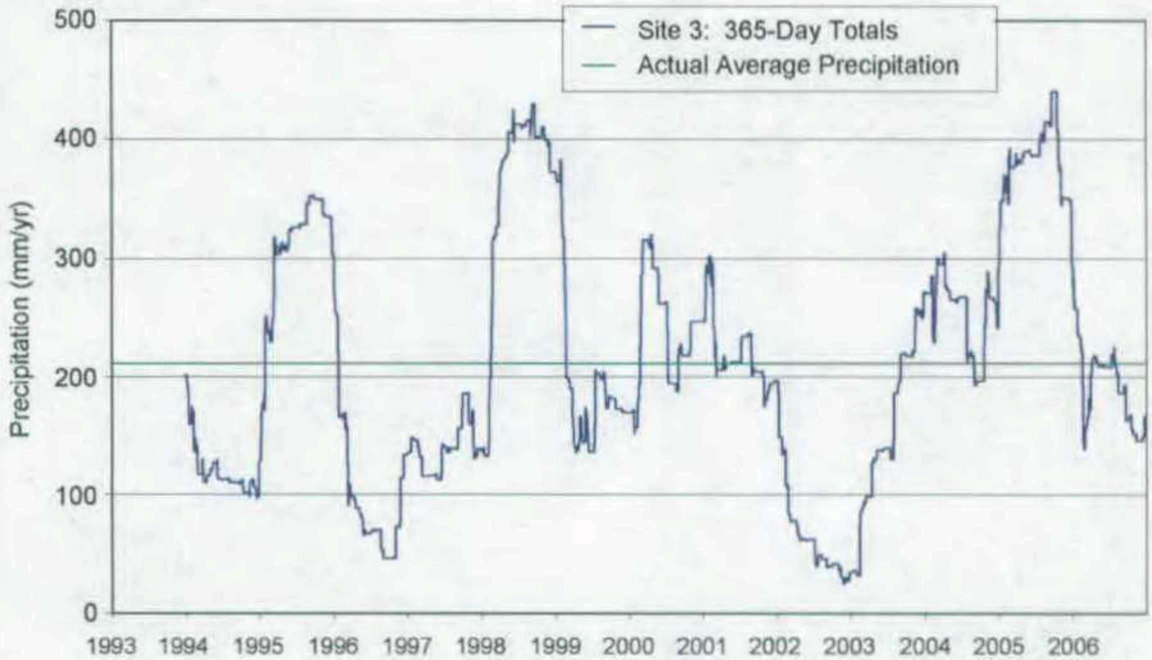
Source: BSC 2007 [DIRS 182591] (actual average precipitation data for Sites 1, 2, 3, 6, 8, and 9, 1994-2006); SNL 2007 [DIRS 174294], Table F-3 (expected average annual precipitation for Sites 1, 2, 3, 6, and 9); DTN: SN0701T0502206.040 [DIRS 182694] (1,000-year records of daily data).

[a] Reference is related to an assumption in the model that precipitation is assumed to occur at the same time in all parts of the domain. The frequency of precipitation is calculated for a reference elevation of 1,524 m and is applied to all cells of the domain. This assumption was necessary because there are insufficient data to predict the spatial distribution of precipitation for each event. In the model each precipitation value is related to elevation of the cell and the reference value. Expected values at each site are tied in the same manner to the reference, based on the elevation of the station, not the historical record at the site.

[b] Expected average annual precipitation for Site 8 is calculated using the same method based on reference value and elevation.

Figure 1-3 shows the actual 365-day data from Site 3. The annual data represent a 365-day moving total rather than a calendar year total. Both 1998 and 2005 experienced very wet periods compared to the average annual precipitation at these sites. For example, in a 23-day period in 1998, Site 3 recorded 183 mm of rainfall, and in a 55-day period in January and February of 2005, Site 3 recorded 174 mm of rainfall. The average annual precipitation for Site 3 is 211 mm (DTN: SN0608WEATHER1.005 [DIRS 177912]).

Section 2.4.3 describes what actions will be taken if extraordinary precipitation trends are observed. In addition to these actions, and based on the expert evaluation of the Principal Investigator (PI) of this PCTP, precipitation data will be evaluated on an annual basis to determine if general trends are expected or unexpected. For example, if several consecutive years have higher than expected precipitation, the re-calculation of stochastic parameters (from DTN: SN0609T0502206.023 [DIRS 182698]) may be conducted to see if the parameter range is still valid.



Source: DTN: SN0608WEATHER1.005 [DIRS 177912].

Figure 1-3. 365-Day Moving Precipitation Total for Site 3

1.5.2.3 Parameter Table

Monitoring activities included in this PCTP will compare measured quantities to values for the parameter listed in Table 1-2. Precipitation rates and quantities are expected to vary spatially because of elevation, slope, orientation, and related factors. Precipitation rate data are currently being collected at 29 different locations at the Yucca Mountain site. Six of these stations will be incorporated into the PC precipitation monitoring activity. Table 1-2 provides actual and calculated (expected) precipitation for the six monitoring stations.

1.5.2.4 Relevance to Requirements

At present, the ongoing analysis by downstream models has not identified adverse results that would differ appreciably from TSPA for Site Recommendation, which implemented a different model. As such, it is unlikely that performance would be impacted by infiltration values that deviate from precipitation values in Table 1-2. Precipitation values significantly larger than average values would not change the selected conceptual models or require consideration of additional conceptual models. However, if the measured precipitation values exhibit a trend of increasing precipitation rates and amounts, it may be necessary to reevaluate their effect on infiltration and subsequent moisture flux at the repository level. Potential impacts to the process models and/or TSPA directly relate to 10 CFR 63.131 [DIRS 180319], which requires the PC program to show that the natural and engineered systems are functioning as intended and anticipated. In addition, the precipitation quantity and distribution data will provide the baseline data to assess and extend the precipitation record at the site.

1.6 QUALITY ASSURANCE

This activity is subject to the requirements of the QARD (DOE 2007 [DIRS 182051]). This PCTP for the precipitation monitoring activity was prepared in accordance with implementing procedure SCI-PRO-002. PCTP requirements specific to PC, as identified in *Performance Confirmation Plan* (BSC 2004 [DIRS 172452]), are added to the contents of SCI-PRO-002, as applicable.

2. SCIENTIFIC APPROACH/TECHNICAL METHODS

2.1 ACTIVITY PURPOSE AND BASIS FOR SELECTION

2.1.1 Activity Purpose

This activity is intended to confirm the adequacy of the precipitation data and YMP conceptual understanding regarding precipitation rate and quantity at and near Yucca Mountain. Precipitation rate is defined as the quantity of precipitation (rain, snow, hail, or sleet) that occurs over a unit area in a unit time. It is commonly expressed as length (depth) per time (e.g., inches per year or centimeters per day). Precipitation quantity is defined as the amount of moisture that falls to the ground as rain, snow, or sleet at a given location within a specific range of time and may be expressed as water equivalents for comparison. It is commonly expressed in millimeters. The precipitation rate and precipitation quantity feed the UZ infiltration model. The predicted moisture flux at the repository level and the water available for seepage are dependent on these precipitation parameters. The PC organization will report these measurements in its annual report. A more complete description for each parameter is included in Appendix C.

2.1.2 Basis for Selection

Precipitation rates and quantities will be used to confirm that the present-day precipitation values used in *Simulation of Net Infiltration for Present-Day and Potential Future Climates* (SNL 2007 [DIRS 174294]) are appropriate. The precipitation data are important because they constitute the maximal amount of water available at the surface in the vicinity of the repository. Along with other input parameters, they are used to determine the moisture flux available for seepage at the repository level.

2.2 TECHNICAL METHODS

Precipitation monitoring has been ongoing at or near Yucca Mountain as part of the Site Characterization Program and Nevada Test Site activities since 1985 and 1957, respectively. Precipitation monitoring may continue through LA, construction, waste emplacement, and operation (BSC 2004 [DIRS 172452]). Figure 1-1 presents a map that shows the locations of the six PC precipitation monitoring stations. Precipitation monitoring for performance confirmation is conducted by BSC personnel using *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]).

2.2.1 Measurement Methods

The precipitation rate is presently monitored at 29 Yucca Mountain stations that are typically equipped with tipping bucket gauges and data loggers and are powered by 12-volt batteries with solar panels. The sites are checked and serviced, and the data collected, at regular intervals according to the schedules in applicable procedures. The six PC precipitation stations will continue operations using the tipping bucket gauges to measure precipitation rate.

The precipitation quantity is presently monitored at 12 of the 29 precipitation stations, typically instrumented with 8-inch NovaLynx 260-2510 storage precipitation gauges. The gauge is equipped with a funnel during most of the year to minimize evaporation between the rain event and the measurement observation. Rainwater or snowmelt is funneled into an inner cylinder located below the funnel; the cross-sectional area of the inner cylinder is approximately one-tenth that of the 8-inch outer funnel diameter for measurement with added resolution. The sites are checked and serviced at regular intervals the same as for precipitation rate above. In addition, the storage gauges are checked following significant precipitation events.

2.2.2 Measurement Locations

Figure 1-1 presents the locations of the six PC precipitation stations. Table 2-1 presents the individual station's latitude, longitude, and elevations.

Table 2-1. Locations and Elevations of the Six Yucca Mountain Performance Confirmation Precipitation Stations

Station ID	Latitude[a] (deg, min, sec)	Longitude[a] (deg, min, sec)	Elevation[b] (m)
Site 1	36° 50' 34"	116° 25' 50"	1,144
Site 2	36° 51' 19"	116° 27' 56"	1,478
Site 3	36° 51' 17"	116° 27' 06"	1,278
Site 6	36° 53' 40"	116° 26' 45"	1,315
Site 8	36° 49' 42"	116° 25' 35"	1,123
Site 9	36° 40' 20"	116° 24' 05"	839

Source: BSC 2007 [DIRS 182591], Table 2-1.

[a] NAD27 (North American Datum of 1927).

[b] Meters above mean sea level.

As described in the previous section, the six PC precipitation sites will be instrumented with two precipitation gauges, one for precipitation rate and one for precipitation quantity. Both gauge types measure increments of 0.01". The tipping-bucket type gauge records the time of the event, while the storage gauge is a single manual measurement at the end of the overall precipitation event. The recording gauge at Site 1 is heated to capture snowfall as it occurs. Some sites also monitor other meteorological parameters that are not necessary for performance confirmation, but could be used in scoping studies or other evaluations.

The stations monitored for performance confirmation are managed and operated by BSC as part of their meteorological monitoring program (BSC 2006 [DIRS 176722]). As part of the meteorological program, measurements beyond precipitation quantity and rates are recorded, but are not required as part of the performance confirmation monitoring.

Site 1 (NTS-60) is located in the west-central portion of Midway Valley. Site 1 is representative of the area of the proposed repository surface facilities. Site 1 also includes a 60-m tall tower, instrumented at two levels with wind and temperature sensors 10 and 60 m above ground level (magl). Horizontal wind speed and direction are measured at both levels, and vertical wind speed is measured at 10 magl. Temperature, relative humidity, and solar radiation sensors are located at 2 magl, and barometric pressure is nominally located at the surface.

Site 2 (Yucca Mountain) is on the Yucca Mountain ridge crest, toward the north end of the ridge. Site 2 is 4 km west-northwest of Site 1. Site 2 includes a tower instrumented at 10 magl with wind and temperature sensors virtually the same as those at Site 1 (except those at 60 magl), and the remaining other measurements. Site 9 is a similar configuration as Site 2.

Site 3 (Coyote Wash) is in a narrow wash typical of the east side of Yucca Mountain. Site 3 is 1.6 km east of the Yucca Mountain site. Site 3 has temperature and relative humidity sensors at 2 magl.

Site 6 (WT-6) is at the WT-6 exploratory well pad, in the upper end of Yucca Wash, near the boundary line between the Nevada Test Site and the Nellis Air Force Range land. Site 6 is 6.1 km north-northwest of Site 1. Site 6 has temperature and relative humidity sensors at 2 magl.

Site 8 (Knothead Gap) is in a topographic saddle east of Bow Ridge, in the southern end of Midway Valley, and is 1.7 km south-southwest of Site 1. This location is one km east of the South Portal of the ESF. Site 8 has temperature and relative humidity sensors at 2 magl.

Site 9 (Gate 510) is on the southern border of the Nevada Test Site, 3 km north of the commercial area on highway U.S. 95 in Amargosa Valley. Site 9 is 19 km south-southeast of Site 1. Site 9 includes a tower instrumented at 10 magl with wind and temperature sensors, the same as Site 2, and virtually the same as those at Site 1 (except those at 60 magl), and the remaining other measurements.

2.2.3 Measurement Timing

The monitoring sites will be checked and serviced on a regular schedule (approximately monthly) and following significant precipitation events. The monitoring staff is located on site full time and checks stations after an event has been noted on the next regular shift.

2.2.4 Test Method Implementation Documents

The Test Coordination Office (TCO) will prepare field work packages and work authorizations in accordance with TST-PRO-006, *Testing Work Implementation and Control*, as needed for control of conduct of the fieldwork.

The FWPs typically contain the following information:

- Purpose and scope of the test
- Roles and responsibilities of interfacing organizations
- Project requirements for quality-affecting and site-disturbing testing activities
- Planned tracer, fluid, and materials usage
- Controls resulting from evaluations of potential impact from the activities on waste isolation and test-to-test interference
- Environmental, safety, and health controls
- Identification and mitigation of hazards associated with the test to be performed
- Records requirements for the test.

FWPs are typically not required for the laboratory testing portion of activities because they do not impact the site and are controlled under the testing laboratory facility safety and health plans, chemical hygiene plans, and technical procedures. Because acquisition of field data has been an ongoing BSC operation, it is likely not to require FWPs from the TCO.

2.3 DATA ACQUISITION, DATA ANALYSIS, AND REPORTING OF RESULTS

2.3.1 Data Acquisition

Data acquisition is the responsibility of BSC and controlled by applicable procedures detailed in *Technical Work Plan for: Meteorological Monitoring and Data Analysis.* (BSC 2006 [DIRS 176722]). Currently, the precipitation rate data collection activity utilizes transfer storage modules that interface with the onsite data loggers. Tests and checks on equipment are conducted using procedures EV-PRO-5001, *Tests and Checks of Meteorological Measuring and Test Equipment*, and EV-PRO-5002, *Tests, Checks, and Performance Audits of Meteorological Equipment.* Routine operations are conducted using procedure EV-PRO-5003, *Routine Operations and Maintenance of Meteorological Equipment.* The communication between the transfer storage module and the downloading of data to the network is done using a software program (PC208W) developed by the manufacturer of the data loggers (Campbell Scientific, Inc.). All electronic data are handled per the requirements of IT-PRO-0009 and documented in the applicable field and laboratory procedures (Appendix B). Once downloaded, the data are processed according to EV-PRO-5004, *Meteorological Data Processing.* The data are then either compiled via Microsoft Excel spreadsheets or a Microsoft Access database (for tipping bucket information). When verified, the data are transmitted to the TDMS by BSC per the requirements of AP-SIII.3Q. As technological advances are made in equipment and methods described in this PCTP, the PCTP will be revised to incorporate these changes to improve efficiency and data quality.

Field technicians will check equipment and hardware, as described in technical procedures EV-PRO-5001, EV-PRO-5002, and EV-PRO-5003 to identify areas where data collection errors might have occurred. The field test staff will determine if the data are acceptable, in cases of apparent erroneous data collection, after inspection of the data collection hardware and monitoring equipment.

2.3.2 Data Analysis

Initial data analysis and submittal to the TDMS is the responsibility of BSC and controlled by applicable procedures detailed in *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]). The primary responsibility for data analysis after it has been submitted to the TDMS rests with the PI. The following steps will routinely be performed annually unless an unexpected condition occurs (see Section 2.4):

- Confirmation that applicable data acquisition procedures have been followed
- Confirmation that calibration of the relevant instrumentation system(s) is in accordance with applicable procedures
- Review of parameter data against the current parameter baseline
- Review for trends
- For parameter data which are outside the expected range or for which there are apparent developing trends, review the data in accordance with Section 2.4 below.

2.3.3 Data Reporting

Data reporting will be as follows:

- All data will be submitted to the TDMS by BSC in accordance with AP-SIII.3Q.
- Data and data evaluations performed under this PCTP will be included in a regular annual report prepared by the PC organization.
- Internal and interim special reports will be prepared as needed to support the PC program.
- Unexpected results will be evaluated and reported as discussed in Section 2.4.

2.4 UNEXPECTED TEST RESULTS, CONDITIONS, AND OFF-NORMAL EVENTS

2.4.1 General Provisions

The PC program is designed to confirm that key parameters used in process models and the TSPA remain as expected and to detect values or trends that deviate from the expected ranges. Predicting long-term performance for the repository at Yucca Mountain is complex and of long duration, so that some deviations from expectations will probably occur. Documentation, tracking, and management of deviations are the responsibility of the PC manager. If unusually high precipitation rates or total quantities become apparent over time, they will be reported in the performance confirmation annual report, which will include an assessment of impact to the licensing basis. This PCTP includes provisions for evaluation and reporting to the U.S. Nuclear Regulatory Commission (NRC) according to requirements embodied in AP-REG-009, *Reportable Geologic Conditions*.

2.4.2 Reporting Bases

The PC program produces an annual report to the DOE. The reporting protocol will call attention to situations that are unusual, and an assessment of the potential significance of the deviation will be conducted.

In cases where the evaluation process requires sampling over time, such as precipitation quantity, it is possible to observe the time evolution of estimated parameter values and associated uncertainty bands. The time series of reduced data can be analyzed to determine whether there is evidence of a trend that, if it were to continue, would eventually challenge assumptions supporting the LA or adversely impact repository operations. If such a trend is identified, action will be initiated to evaluate possible consequences.

2.4.3 Exceedance of Expected Conditions

Precipitation monitoring does not include reportable or condition limits as will be found in most performance confirmation testing and monitoring plans. Precipitation will be continuously monitored, evaluated, and reported to the Office of Civilian Radioactive Waste Management in the performance confirmation annual report. At some future date based upon agreement between the Office of the Chief Scientist staff and Lead Lab performance confirmation staff, the PI will update the calculation of the stochastic parameters (from DTN: SN0609T0502206.023 [DIRS182698]) by adding the new weather records from the monitored stations to the parameter calculation. The PI will compare the elevation-corrected, updated values to the distribution used to represent present-day climate in Table 6.5.5.1-1 of *Simulation of Net Infiltration for Present-Day and Potential Future Climates* (SNL 2007 [DIRS 174294]). If the uncertainty range is exceeded using new weather data, then a new statistical analysis of all present-day climate datasets would update the precipitation inputs to the MASSIF model. Depending upon YMP priorities, the Office of the Chief Scientist and Lead Lab personnel may decide to perform new infiltration calculations and compare them to those in DTN: SN0609T0502206.023 [DIRS182698].

2.5 FEATURES, EVENTS, AND PROCESSES

Data from the precipitation PC activity are linked with five FEPs (BSC 2005 [DIRS 174191]). The five FEPs are: (1) FEP 1.3.01.00.0a, Climate Change; (2) FEP 2.3.11.03.0a, Infiltration and Recharge; (3) FEP 1.4.01.01.0a, Climate Modification Increases Recharge; (4) FEP 2.3.11.01.0a, Precipitation; and (5) FEP 2.3.11.02.0a, Surface Runoff and Evapostranspiration.

2.6 MODELS OR ADDITIONAL ANALYSIS

Not applicable. No modeling or scientific analysis will be conducted under this PCTP.

3. INDUSTRY STANDARDS, FEDERAL REGULATIONS, DOE ORDERS, REQUIREMENTS, AND ACCEPTANCE AND COMPLETION CRITERIA

3.1 INDUSTRY STANDARDS

Industry standards will generally be applied to specific parameter test methods and are identified in the specific test procedures or relevant FWPs. For laboratory tests, any standards will be identified in relevant laboratory procedures. The monitoring program uses operating equipment to measure conditions and collect data, and test equipment to calibrate and check the operating equipment. The calibrations and checks are performed using standards that comply with CO-PRO-1001. The procedure requires that the calibration standards are either traceable to nationally recognized standards, such as those provided by the National Institute of Standards and Technology, or demonstrate justification for use of another standard.

The YMP meteorological monitoring program, which supplied the data used as a baseline for this performance confirmation activity, was designed and operated to comply with NRC monitoring guidance. Prior to approval of the revision, voluntary consensus standards ANSI/ANS 3.11-2000 [DIRS 151842] and ANSI/ANS-3.11-2005 [DIRS 177557] were used for guidance on modern equipment not contained in Section C of the original Regulatory Guide 1.23 [DIRS 103640]. The revision to Regulatory Guide 1.23 [DIRS 181945], in March 2007, did not significantly change measurement requirements, but data recording methods were modernized. Revision 1 included more information on monitoring in complex terrain and for instrument exposures.

3.2 FEDERAL REGULATIONS, DOE ORDERS, AND REQUIREMENTS

Federal regulations, DOE orders, and other regulatory requirements are captured in conformance with the procedure RQ-PRO-1000, *Managing Requirements*, and are documented in the Dynamic Object Oriented Requirements System. The system has allocated the applicable PC (and flowdown PCTP) requirements to the Postclosure Activities Organization.

Regulatory requirements for the PC program are specified in 10 CFR 63, Subpart F [DIRS 180319]. Guidance for the PC program also is provided in *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274]). The purpose and objectives of the PC program, as stated in 10 CFR 63.102(m) [DIRS 180319], are that:

> a performance confirmation program is conducted to evaluate the adequacy of assumptions, data, and analyses that led to the findings that permitted construction of the repository and subsequent emplacement of the wastes. Key geotechnical and design parameters, including any interactions between natural and engineered systems and components, will be monitored throughout site characterization, construction, emplacement, and operation to identify any significant changes in the conditions assumed in the LA that may affect compliance with the performance objectives specified at 63.113(b) and (c).

No additional DOE orders or requirements are applicable.

3.3 ACCURACY, PRECISION, AND REPRESENTATIVENESS

Accuracy, precision, and representativeness are addressed in Appendix C. Sources of error or uncertainty in the data, testing, or monitoring activities associated with this PCTP will be identified and mitigated in technical procedures used for field implementation.

3.4 ACCEPTANCE/COMPLETION CRITERIA

The 10 CFR Part 63 general requirements for performance confirmation are documented in *Performance Confirmation Plan* (BSC 2004 [DIRS 172452], Table 2-1). *Performance Confirmation Plan* (BSC 2004 [DIRS 172452]) lists precipitation monitoring as an activity important in the determination that the barriers are functioning as intended and anticipated. The acceptance criterion is detailed in *Performance Confirmation Plan* (BSC 2004 [DIRS 172452], Table 2-2), which requires that "natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure are functioning as intended and expected."

The data acceptance and completion criteria are covered in the data collection, data reduction, and data evaluation and reporting requirements for each test parameter. Details are provided in Sections 2.3 and 2.4. Precipitation monitoring may continue up to repository closure. Acceptance criteria for data collected will be based on the specifications listed in Appendix C. In summary, this activity requires the collection, reduction, recording, and submittal of precipitation data collected at and near the repository. Routine annual reporting and special reports to the DOE and NRC covering unexpected events are required.

In addition, in accordance with 10 CFR 63.51 [DIRS 180319], the license amendment for permanent closure of the repository "must include any PC data collected under the program required by subpart F, and pertinent to compliance with § 63.113."

3.5 REQUIREMENTS MANAGEMENT SYSTEM

Requirements for performance confirmation derive from 10 CFR Part 63 [DIRS 180319] as noted above. Implementation of high-level requirements for PC is handled through *Performance Confirmation Plan* (BSC 2004 [DIRS 172452]).

3.6 DERIVED REQUIREMENTS

There are no applicable derived requirements.

3.7 IMPLEMENTING DOCUMENTS

This PCTP is the implementing document for performance. Sampling precipitation rate and quantity will be conducted following *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]) and FWP-SB-99-001, *Field Activities in Support of Meteorological Programs*. No non-Q work is associated with this activity and there are no new procedures required. Sampling and monitoring by other organizations (e.g., the U.S. Geological

Survey, the Nevada Test Site, the National Oceanic and Atmospheric Administration, and the University of Nevada at Las Vegas) are conducted at meteorological stations that may or may not be Q, but are not considered part of this PC activity and not controlled by this PCTP. A full listing of generally applicable implementing procedures is provided in Appendix B.

4. FIELD AND LABORATORY SYSTEMS AND EQUIPMENT

4.1 MAJOR SYSTEMS AND EQUIPMENT

A general description of the precipitation monitoring system and equipment is presented in Section 2.2. A more detailed explanation is provided in Appendix C. Procedures governing the performance of the field and laboratory work are documented in Appendix B.

4.2 CALIBRATION REQUIREMENTS

Calibration will be performed on equipment in accordance with the requirements provided in Section 3.2 and in CO-PRO-1001, EV-PRO-5001, EV-PRO-5002, and EV-PRO-5003, as appropriate.

5. RECORDS

The governing procedures for field and laboratory work are identified in Appendix B. These procedures identify the specific records that will be generated. Records of all testing and monitoring work performed under this PCTP and the associated field and laboratory procedures will be prepared and submitted to the TDMS in accordance with AP-SIII.3Q or TST-PRO-001.

6. QUALITY VERIFICATIONS

The PC program, including this precipitation monitoring activity, will be conducted in compliance with 10 CFR 63, Subpart F, including 10 CFR 63.142 [DIRS 180319]. Any additional quality verifications will be conducted as prescribed by the QARD (DOE 2007 [DIRS 182051]). No quality assurance (QA) verification, other than regularly scheduled audits and surveillances, is required during the execution of this PCTP. Special hold points, if needed, will be detailed in the FWP for each test parameter. These will include the requirements associated with internal reviews and the NRC reporting and reviews described in Sections 2.3 and 2.4.

7. QARD REQUIREMENTS, PREREQUISITES, ELECTRONIC INFORMATION, ENVIRONMENTAL CONTROLS, SPECIAL TRAINING AND PERSONNEL QUALIFICATIONS

7.1 QARD REQUIREMENTS

All work presently documented under this PCTP will be conducted in accordance with the QARD (DOE 2007 [DIRS 182051]) because the activities described are relevant to repository performance. Any non-Q work performed under this PCTP will be conducted in accordance with the Augmented Quality Assurance Program.

7.2 PREREQUISITES

Precipitation data collection is ongoing because this work is a continuation of site characterization activities. The governing procedures are documented in Appendix B. In the future, these governing procedures and methods will be incorporated into the PC program. No additional prerequisite activities have been identified in this PCTP that are not currently defined and executed as part of the test implementation process. If prerequisite activities are identified, they will be included in the relevant technical procedures.

7.3 CONTROL OF ELECTRONIC MANAGEMENT OF INFORMATION

The meteorological monitoring and data analysis program (conducted by BSC) includes the electronic storage and transfer of data. A process control evaluation was performed in accordance with LP-SV.1Q-BSC (currently IT-PRO-009), *Control of the Electronic Management of Information*, which showed satisfactory controls in place through the data handling line procedures and can be found linked to the most recent revision of *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]).

Electronic management of information under this PCTP is controlled by IM-PRO-0002, *Control of the Electronic Management of Information*, and documented in the checklist presented in Appendix D. Details for the data control are presently, and will continue to be, controlled by applicable field and laboratory procedures (Appendix B).

7.4 ENVIRONMENTAL CONTROLS

Environmental controls are not expected to be applicable to precipitation monitoring; however, if they are found to be applicable, they will be detailed in the test parameter FWPs.

7.5 SPECIAL TRAINING AND PERSONNEL QUALIFICATIONS

Special training or personnel qualifications will be detailed in the FWP or testing laboratory procedure for each test parameter, as required. Two levels of personnel safety hazards and controls exist in the precipitation monitoring and analysis program. Standard office practices apply to work in the offices (in the field and Summerlin complex). The field monitoring work contains certain low risks associated with personnel working with tools and being exposed to environmental conditions. The risks associated with the field monitoring work are incorporated into line procedures according to integrated safety management principles and YMP guidance.

8. SOFTWARE

Standard commercial office software approved by the Office of Civilian Radioactive Waste Management is used in this activity. This includes, but is not limited to: (1) The suite of software associated with Microsoft Office (MS Word, MS Excel, MS Access, MS PowerPoint), and (2) Lotus Notes (as e-mail for records management purposes). The software used to operate the data loggers and to download and transfer data is PC208W (PC208W V. 3.2 [DIRS 182487], STN: 10739-3.2-00) and is qualified. The on-site data logger produces input files that are controlled within the routine operations line procedure. Continuous use software is not used under this PCTP.

The EFPData software routine (EFPData V. 4.2.1 [DIRS 182486], 10420-4.2.1-00) imports the raw data files into a database by date and time according to data type and monitoring site. The routine also identifies missing data periods and "flags" (highlights the data to an operator) data that exceed expected threshold values. It also performs atmospheric humidity calculations to convert relative humidity to dew-point temperature. The routine is also used to edit the database during data validation, and the edits are documented in a separate file. This routine was developed in accordance with LP-SI.11Q-BSC (currently IT-PRO-0011), *Software Management*, and is qualified software that is maintained on the software baseline. Microsoft Access 2000 and Excel software are used for data storage and manipulation. Neither software package requires a software tracking number.

Software is used to verify the correct transfer of electronic data. The checking is described in the line procedures controlling the data transfer operations.

Should any additional Q software be deemed necessary to conduct this work, the applicable controls of either IT-PRO-0011 or IM-PRO-003, *Software Management*, as appropriate to the organization, will be addressed. Data checking is described in the line procedures controlling the data transfer operations. The onsite data logger produces input files that are controlled within the routine operations line procedure. Acquired software that is embedded in the equipment or integral to the operations, maintenance, or calibration of measuring and test equipment that has not been developed or modified is tested and controlled in accordance with CO-PRO-1001.

9. ORGANIZATIONAL INTERFACES

Organizational interfaces are identified in Section 1.4 of this PCTP.

10. PROCUREMENT

Required procurement activities will be conducted in accordance with PM-PRO-001, *Procurement Documents,* for activities under the Lead Laboratory. Procurements for precipitation monitoring consist of purchases of equipment to replace old instrumentation and subcontract services for calibration. Procurements executed by BSC are controlled by EG-PRO-3DP-G06B-00001, *Material Requisitions*. Subcontracts or technical service agreements for the calibration of instrumentation are processed through EG-PRO-3DP-G06B-00002, *Subcontracts*; EG-PRO-3DP-G04B-00057, *Technical Service Contracts*; PR-PRO-5.01, *Simplified Procurement*; and LP-4.1Q-OCRWM, *Procurement Actions*. The acceptability and documentation of acceptance for procured items or services are processed through QA-PRO-1071.

11. REFERENCES

The following references are cited in this document (exclusive of those that are implementing procedures). Implementing procedures are listed in Appendix B.

11.1 DOCUMENTS CITED

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172452 BSC 2004. *Performance Confirmation Plan.* TDR-PCS-SE-000001 REV 05. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041122.0002.

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179545 SNL 2007. *Calibrated Unsaturated Zone Properties.* ANL-NBS-HS-000058 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070530.0013.

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181650 SNL 2007. *Saturated Zone Flow and Transport Model Abstraction.* MDL-NBS-HS-000021 REV 03 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20050808.0004; DOC.20070913.0002.

174294 SNL 2007. *Simulation of Net Infiltration for Present-Day and Potential Future Climates.* MDL-NBS-HS-000023 REV 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070530.0014.

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103640 Regulatory Guide 1.23, Rev. 0. 1972. *Onsite Meteorological Programs.* Washington, D.C.: U.S. Atomic Energy Commission. TIC: 2937.

181945 Regulatory Guide 1.23, Rev. 1. 2007. *Meteorological Monitoring Programs for Nuclear Power Plants.* Washington, D.C.: U. S. Nuclear Regulatory Commission. Internet Accessible.

11.3 DATA LISTED BY DATA TRACKING NUMBER

177912 SN0608WEATHER1.005. Temperature, Precipitation, Wind Speed, Relative Humidity, Dew Point Temperatures, and Barometric Pressure Data Collected from 1993-2004 Measured at Yucca Mountain Weather Stations 1,2,3,6, and 9. Submittal date: 08/23/2006.

179887 SN0606T0502206.014. Calculated Weather Summary for Present Day and Future Climates. Submittal date: 06/07/2006.

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182694 SN0701T0502206.040. Calculated Weather Summary for the Present-Day Climate, Rev 1. Submittal date: 01/10/2007.

11.4 SOFTWARE CODES

182486 EFPData V. 4.2.1. 2004. WINDOWS 2000. STN: 10420-4.2.1-00.

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APPENDIX A
GLOSSARY

APPENDIX A—GLOSSARY

Accessible environment—Any point outside of the controlled area, including (1) atmosphere (including the atmosphere above the surface area of the controlled area), (2) land surfaces, (3) surface waters, (4) oceans, and (5) lithosphere.

Accuracy—The degree to which a calculation, measurement, or set of measurements agree with a true value or an accepted reference value.

Barrier—Any material, structure, or feature that, for a period to be determined by the NRC, prevents or substantially reduces the rate of movement of water or radionuclides from the Yucca Mountain repository to the accessible environment, or prevents the release or substantially reduces the release rate of radionuclides from the waste. For example, a barrier may be a geologic feature, an engineered structure, a canister, a waste form with physical and chemical characteristics that significantly decrease the mobility of radionuclides, or a material placed over and around the waste, provided that the material substantially delays movement of water or radionuclides.

Baseline—A set of information (developed from site characterization data, modeling assumptions or results, design bases and specifications, other relevant analogue or technical information) and analysis of that information on those parameters selected to be monitored, tested, evaluated, or observed during the performance confirmation program. The baseline is the standard to which comparisons are made, by parameter, to evaluate performance confirmation data.

Baseline condition—A set of critical observations or data used for comparison or a control. When hypothesis testing is applied to performance confirmation decisions, data are used to choose between a presumed baseline condition and an alternative condition. Baseline conditions are also referred to as the baseline for statistical comparisons. Deviations from the baseline do not necessarily impact performance, only where the trend is unexpected or they exceed a predetermined decision point (action level) based on performance assessment sensitivity analysis.

Condition limit—The discrete value(s) or trend(s) outside (upper or lower) the expected range that results in more detailed evaluation and potentially additional sampling (including adversely developing trends as defined in the test plans). The exceedance of a condition limit may cause a decision-maker to choose one of the alternative actions (e.g., conclusion of compliance or noncompliance). The condition limit is defined during the planning phase of a data collection activity (based on that parameter's importance to performance); it is not calculated from the sampling data. Condition limits for parameters will be discussed in the PCTP, if applicable for that activity.

Confirmation or to confirm—In the context of the performance confirmation program, confirmation means to evaluate the adequacy of assumptions, data, and analyses that led to the findings that permitted construction of the repository and subsequent emplacement of the wastes.

Design bases—Information that identifies the specific functions to be performed by items and the specific values or ranges of values chosen for controlling parameters as reference bounds for design.

Disposal—The emplacement of radioactive waste in a geologic repository with the intent of leaving it there permanently.

Drift—The near-horizontal underground excavations from the shaft(s) or ramp(s) to the other excavations such as alcoves and rooms. The term includes excavations for emplacement (emplacement drifts) and access (access mains).

Emplacement—The placement and positioning of spent nuclear fuel or high-level radioactive fuel (i.e., waste packages) in prepared locations within excavations of a geologic repository.

Emplacement drift—A drift in which waste packages are placed.

Engineered Barrier System—The waste packages, including engineered components and systems other than the waste package (e.g., drip shields), and the underground facility.

Expected range—The range of values for an input parameter, including factors to account for variability, that is most likely expected based on historical test data, material standards, or calculated values.

Experiment—A test under controlled conditions.

Exploratory Studies Facility—An underground facility at Yucca Mountain used for performing site characterization studies. The facility includes a 7.9-km (4.9-mi) main loop (tunnel), 2.8-km (1.7-mi) Enhanced Characterization of the Repository Block Cross-Drift, and a number of alcoves used for site characterization tests such as the Drift Scale Test.

Feature—A natural barrier structure, characteristic, process, or condition that functions to prevent or reduce the movement of water or prevent the release or substantially reduce the release rate of radionuclides.

Geologic repository—A system that is intended to be used for, or may be used for, the disposal of radioactive waste in excavated geologic media. A geologic repository includes the geologic repository operations area, and the portion of the geologic setting that provides isolation of the radioactive waste.

Geologic repository operations area—A high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

Model—A representation of a system, process, or phenomenon, along with hypotheses required to describe the process or system or to explain the phenomenon, often mathematically. Model development typically progresses from conceptual models to mathematical models.

Monitoring—To keep track of systematically with a view to collecting information and to analyze or sample, especially on a regular or ongoing basis. In performance confirmation, monitoring is generally long-term observation or sampling for a parameter or set of parameters.

Parameter—Scientific data, performance assessment data, or engineering technical information that represent physical or chemical properties, consisting of an assigned variable name and generally represented by a value or range of values. Select parameters that potentially are subject to varied interpretation and selection of multiple values, and subject to multiple uses for various technical products within the Project, reside in the Technical Data Management System.

Performance assessment—An analysis that: (1) identifies the features, events, processes (except human intrusion), and sequences of events and processes (except human intrusion) that might affect the Yucca Mountain disposal system and their probabilities of occurring during 10,000 years after closure; (2) examines the effects of those features, events, processes, and sequences of events and processes upon the performance of the Yucca Mountain disposal system; and (3) estimates the annual dose incurred by the reasonably maximally exposed individual, including the associated uncertainties, as a result of releases caused by all significant features, events, processes, and sequences of events and processes, weighted by their probability of occurrence.

Performance confirmation—The program of tests, experiments, and analyses conducted to evaluate the accuracy and adequacy of the information used to demonstrate compliance with the postclosure performance objectives in Subpart E of 10 CFR Part 63 [DIRS 180319].

Permanent closure—Final backfilling of the underground facility, if appropriate, and the sealing of shafts, ramps, and boreholes.

Precipitation quantity—The amount of moisture that falls to the ground as rain, snow, or sleet at a given location within a specific range of time, may be expressed as water equivalents for comparison. Commonly expressed in millimeters or cubic centimeters

Precipitation rate—The quantity of precipitation (rain, snow, hail, or sleet) that occurs over a unit area in a unit time. Commonly expressed as length per time (e.g., inches per year or centimeters per day).

Process model—A mathematical model that represents an event, phenomenon, process, or component or series of events, phenomena, processes, or components. A process model may undergo an abstraction for incorporation into a system model.

Risk-informed, performance-based—An approach to decision-making whereby risk insights are considered together with other factors to establish requirements that better focus attention on design, operation, and performance issues commensurate with their importance to public heath and safety.

Seepage—The flow of the groundwater in fractures or pore spaces of permeable rock to an open space in the rock; the percolation flux that enters an underground opening.

Significance—An effect is said to be significant if the value of the statistic used to test it lies outside defined limits; that is to say, if the hypothesis that the effect is not present is rejected. A test of significance is one that, by use of a test statistic, purports to provide a test of the hypothesis that the effect is absent. By extension, the critical values of the statistics are themselves called significant.

Site—That area surrounding the geologic repository operations area for which DOE exercises authority over its use in accordance with the provisions of 10 CFR Part 63 [DIRS 180319].

Site characterization—The program of exploration and research, both in the laboratory and in the field, that is undertaken to establish the geologic conditions and the ranges of parameters of a particular site that are relevant to the implementing documents.

Performance confirmation test plan (PCTP)—A test plan developed to support the tests, experiments, and analyses of the performance confirmation program. PCTPs are distinct from other types of test plans that will be generated for planning and executing tests that are used to verify conformance of an item to specified requirements, or to demonstrate satisfactory performance for service. Examples of such preclosure testing include prototype qualification tests, production tests, proof tests prior to installation, construction tests, and preoperational tests.

Total system performance assessment—A risk assessment that quantitatively estimates how the proposed Yucca Mountain repository system performs in the future under the influence of specific features, events, and processes, incorporating uncertainty in the models and data. Its purposes are: (1) provide the basis for predicting system behavior and for testing that behavior against safety measures in the form of regulatory standards, (2) provide the results of total system performance assessment analyses and sensitivity studies, (3) provide guidance to site characterization and repository design activities, and (4) help prioritize testing and selection of the most effective design options.

Trend—A long-term movement in an ordered series that may be regarded, together with the oscillation and random component, as generating the observed values.

Uncertainty—A quantitative or qualitative measure of how well a mathematical model represents a system, process, or phenomenon; or the interval above and below the measurement, parameter, or result that contains the true value. There are two types of uncertainty: (1) Stochastic (or aleatory) uncertainty caused by the random variability in a process or phenomenon, and (2) State-of-knowledge (or epistemic) uncertainty, which results from a lack of complete information about physical phenomena. State-of-knowledge uncertainty is further divided into: (i) Parameter uncertainty, which results from imperfect knowledge about the inputs to analytical models; (ii) Model uncertainty, which is caused by imperfect models of physical systems, resulting from simplifying assumptions or an incomplete identification of the system modeled; and (iii) Completeness uncertainty, which refers to the uncertainty as to whether the important physical phenomena, relationships (coupling), and events have been considered.

Underground facility—The underground structure, backfill materials, if any, and openings that penetrate the underground structure (e.g., ramps, shafts, and boreholes, including their seals).

Unsaturated zone—The zone between the land surface and the regional water table. Generally, fluid pressure in this zone is less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. The fluid pressure locally may be greater than atmospheric beneath flooded areas or in perched water bodies.

Variability—Refers to the observed difference attributed to heterogeneity or diversity in a population. Sources of variability are the results of natural random processes and stem from the differences among the elements of a population. Variability is not usually reducible by further measurement but can be better estimated by increased sampling based on the understood or assumed distribution in the parameter's physical attributes.

Waste package—The waste form and any containers, shielding, packing, and other absorbent materials immediately surrounding an individual waste container.

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APPENDIX B
APPLICABLE PROCEDURES

APPENDIX B—APPLICABLE PROCEDURES

B.1. TEST PLANS

RQ-PRO-1000, *Managing Requirements*
SCI-PRO-002, *Planning for Science Activities*

B.2. TEST CONTROLS

IM-PRO-002, *Control of the Electronic Management of Information*
IM-PRO-003, *Software Management*
IT-PRO-0009, *Control of the Electronic Management of Information*
IT-PRO-0011, *Software Management*
OP-PRO-9101, *Work Control Process*
TST-PRO-006, *Testing Work Implementation and Control*

B.3. RECORD CONTROLS

AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*
TST-PRO-001, *Submittal and Incorporation of Data to the Technical Data Management System*

B.4. EQUIPMENT/INSTRUMENT CALIBRATION RECORDS AND DATA PROCESSING

CO-PRO-1001, *Control of Measuring and Test Equipment*
QA-PRO-1071, *Acceptance of Items and Services*
EV-PRO-5001, *Tests and Checks of Meteorological Measuring and Test Equipment*
EV-PRO-5002, *Tests, Checks, and Performance Audits of Meteorological Equipment*
EV-PRO-5003, *Routine Operations and Maintenance of Meteorological Equipment*
EV-PRO-5004, *Meteorological Data Processing*

B.5. NONCONFORMANCES AND CORRECTIVE ACTIONS

AP-16.1Q, *Condition Reporting and Resolution*

B.6. PROCUREMENT

EG-PRO-3DP-G06B-00002, *Subcontracts*
EG-PRO-3DP-G04B-00057, *Technical Service Contracts*
EG-PRO-3DP-G06B-00001, *Material Requisitions*
LP-4.1Q-OCRWM, *Procurement Actions*
PM-PRO-001, *Procurement Documents*
PR-PRO-5.01, *Simplified Procurement*

B.7 ANNUAL AND INTERIM REPORTING

AP-REG-009, *Reportable Geologic Conditions*
LS-PRO-001, *Technical Reports*
PA-PRO-0313, *Technical Reports*

APPENDIX C
PARAMETER TEST METHODS

APPENDIX C—PARAMETER TEST METHODS

C1. INTRODUCTION

In accordance with the requirements specified in SCI-PRO-002, this appendix provides additional detail for the precipitation monitoring activity. Further test parameter details are provided in Sections C10 through C11. This activity is conducted to evaluate the adequacy of assumptions, data, and analyses, associated with precipitation that led to the findings that permitted construction of the repository and subsequent emplacement of the wastes.

C2. PRODUCT SUPPORTED

The precipitation monitoring activity monitors precipitation rate and quantity as they relate to accuracy and performance of the infiltration model (SNL 2007 [DIRS 174294]). Following technical review, data are submitted by BSC to the TDMS (Sections 3.3 and 3.4) and summarized in the Performance Confirmation Annual Report (TDR-MGR-MD-000058, produced once a year after September 2007).

C3. QA CONTROLS AND INTEGRATED SAFETY

These activities will be performed in full compliance with the Office of Civilian Radioactive Waste Management QA requirements and the QARD (DOE 2007 [DIRS 182051]), including the Integrated Safety Management Program.

Applicable QA procedures, including those associated with preparing and implementing this PCTP, are listed in Appendix B.

C4. PURPOSE OF THIS TEST PARAMETER METHODS PLAN

The purpose of this plan is to detail the equipment, designs, and methodologies for acquisition of the precipitation test parameters (rate and quantity).

C5. WORK SCOPE

C5.1 Product Output

The products from this activity will include, but not be limited to, test parameter data, instrument installation records, and calibration records. All records and acquired data resulting from this activity will be compiled and archived in the TDMS and Records Processing Center (RPC) in accordance with the procedures identified in Appendix B. The types of data to be collected include:

- Spatial and temporal precipitation rates
- Spatial and temporal precipitation quantity.

C5.2 Responsibilities

Overall technical direction for the installation, monitoring, execution, customer interface, and technical data management activities will be the responsibility of the manager of the PC organization. The PC organization will also designate the PI for this testing activity. The PI or his or her designees will be responsible for the technical direction of the installation and monitoring activities. The TCO manager will be responsible for field support staffing, FWPs, and test work authorizations, if needed.

C5.3 Schedule

See Sections C10 through C11 for schedule information. Timing of data downloads and sample collections may be refined by the PI depending on project needs.

C6. SCIENTIFIC APPROACH/TECHNICAL METHODS

Details on the technical methods used for the ongoing and future implementation of the precipitation monitoring activity are described in *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]) and EV-PRO-5003. The methods may change as new technologies are developed and in response to changing Project requirements.

C6.1 Pretest Predictions

Pretest predictions are the expected values presented in Table 1-2 and discussed in Section 1.5.

C6.2 Technical Methodology

The relevant technical methods and specific technical procedures for the individual precipitation parameters are provided in Sections C1 and C2.

C6.3 Instrument Installation and Layouts

Typical instrument installation and layout details are provided in *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]) and EV-PRO-5003, for individual parameters.

C6.4 Data Acquisition

The precipitation rate monitoring will use a tipping bucket sensor paired with a battery/solar powered Campbell Scientific data logger. The data logger will provide power to the tipping bucket sensor, monitor the sensor output, and store the electronic data in a data storage module. The precipitation rate data will be collected on a regular cycle (monthly or quarterly) using a portable computer. Precipitation quantity monitoring will use NovaLynx Storage Rain Gauges. Measurements will be collected manually on a regular cycle (weekly or semiweekly) and following large precipitation events.

All data handling will be performed per the requirements documented in the field and laboratory procedures (Appendix B). Once downloaded, the data will be compiled via Microsoft Excel spreadsheets and transmitted (following prescribed reviews) to the TDMS per the requirements of TST-PRO-001.

C6.5 Software

Campbell Scientific PC208W software, Microsoft Access software, and Microsoft Excel software are required to support this program. The Campbell Scientific PC208W software has been qualified under IT-PRO-0011 and the Campbell Scientific PC208W Software Management Report. PC208W is utility software used to configure and download data from the Campbell Scientific data loggers.

Microsoft Access and Microsoft Excel spreadsheets are utilized consistent with the requirements of IT-PRO-0011. Acquired and developed electronic data shall be handled according to the requirements detailed in this PCTP and consistent with the requirements of IT-PRO-0009.

C6.6 Accuracy and Precision

To ensure that the collected data meets the Project needs, the instruments will be calibrated in accordance with applicable procedures (Appendix B). The instruments for this activity will either be calibrated in accordance with CO-PRO-1001 and EV-PRO-5002, or procured from vendors qualified by the Project for this purpose.

The expected measurement accuracy will be based on manufacturer specifications and the calibration procedures of qualified vendors.

C6.7 Handling of Unexpected Results and Conditions

Unexpected results will be handled as described in Section 2.4.

C7. INTERFACE CONTROL

Interface controls will be as described in Section 2.3 and the FWP for this activity.

C8. MANDATORY HOLD POINTS

No mandatory hold points will be associated with this activity.

C9. SECURITY

Facility and data security will be provided by the DOE/Nevada Operations Office Safeguard and Security Division and YMP/BSC Security Department. All work performed on the site will be performed in compliance with the security requirements of those organizations.

C10. PRECIPITATION RATE MONITORING

C10.1 Introduction and Scope

Sections 1.5.2 and 2.1.2 and Table 1-2 identify a requirement for precipitation rate monitoring at Yucca Mountain. This requirement will be addressed below and in accordance with other relevant sections of this PCTP.

C10.2 Precipitation Rate Stations

Figure 1-1 and Table 2-1 present the six PC precipitation stations. All six of these stations will monitor precipitation rate.

C10.3 Instrumentation

The six precipitation stations are presently instrumented to measure precipitation rate with a tipping bucket gauge (Qualimetrics, WeatherMeasure, or Climatronics), a Campbell Scientific data logger (CR10 or CR23x) and storage module, and a 12-Volt battery charger with solar panel. The precipitation rate instruments were originally installed in accordance with an early version of YMP-USGS-HP-180 R1-M1, *Field Measurement of Precipitation Using a Tipping Bucket Rain Gauge.* The Qualimetrics tipping bucket rain gauges are either Model 6011-B or Model 6041-B with the propane heater. Model 6041-B with the propane heater allows the system to accurately measure the precipitation equivalent of snow. One PC precipitation station (Site 1) uses a WeatherMeasure 8" tipping bucket rain gauge. The WeatherMeasure gauge is heated, allowing it to accurately measure snowfall. A few stations use a Climatronics 8" tipping bucket rain gauge. The tipping bucket gauges use a twin bucket mechanism that allow the buckets to tip back and forth, closing a switch, as rainfall fills one bucket at a time. The switch closure sends an electronic signal to the pulse counter on the Campbell data logger. Each tip corresponds to approximately 0.01 inches (0.254 mm) of precipitation. All work is conducted in accordance with EV-PRO-5003. The Campbell Scientific data loggers are calibrated every two years and documented in accordance with CO-PRO-1001.

WeatherMeasure P511E Tipping Bucket Rain Gauge

Resolution: 0.01 inches (90.254 mm)
Accuracy: ± 10%

Qualimetrics 6011-B and 6041-B Tipping Bucket Rain Gauges

Resolution: 0.01 inches (0.254 mm)
Accuracy: ± 10%

Climatronics 100097 Tipping Bucket Rain Gauge

Resolution: 0.01 inches (0.254 mm)
Accuracy: ± 10%

Campbell Scientific 23X Data Logger

Analog Input: 24 single-end, 12 differential
Accuracy: –0.1% FSR (–25°C to 50°C)
Scan Rate: once per second

Campbell Scientific CR10 Data Logger

Analog Input: 12 single-end, 6 differential
Accuracy: ± 0.1% FSR (–25°C to 50°C)
Scan Rate: once per second

C10.4 Communications and Data Handling

Data are retrieved from each station by replacing the transfer storage modules. Those modules are then returned to a location where they can be connected to a network computer using the Campbell Scientific software code PC208W. As stated in Section C6.5, the Campbell Scientific PC208W software has been qualified under IT-PRO-0011. The data are managed in accordance with IT-PRO-0009 and EV-PRO-5004. The data are edited, reviewed, and submitted to the RPC.

C11. PRECIPITATION QUANTITY MONITORING

C11.1 Introduction and Scope

Sections 1.5.2 and 2.1.2 and Table 1-2 identify a requirement for precipitation quantity monitoring at Yucca Mountain. This requirement will be addressed below and in accordance with other relevant sections of this PCTP.

C11.2 Precipitation Quantity Stations

Figure 1-1 and Table 2-1 present the six PC precipitation stations. All six of these stations will monitor precipitation quantity.

C11.3 Instrumentation

The precipitation stations will be instrumented to measure precipitation quantity using an 8" NovaLynx 260-2510 Storage Rain Gauge (12 of the 15 stations are presently instrumented). The upper portion of the NovaLynx Storage Rain Gauge funnel is cylindrical in shape and turned to a sharp edge. Rainwater or snowmelt is funneled into a receiver located below the funnel. All work is conducted in accordance with EV-PRO-5003 and EV-PRO-5002.

NovaLynx 260-2510 Storage Rain Gauge

Orifice:	8.0 inches (203 mm)
Resolution:	0.01 inches (0.254 mm)
Capacity:	20.0 inches (500 mm)

C11.4 Communications and Data Handling

The precipitation quantity data are collected by hand; no electronic components are used. The amount of water stored in the gauge is measured using a dipstick and provides a water quantity for the preceding time period (time from the last measurement to present). The data are collected in accordance with EV-PRO-5003. The data are managed in accordance with EV-PRO-5004. The data are edited, reviewed, and submitted to the RPC. Station measurements are variable, dependent on the amount of rainfall, but generally range from one to several weeks.

APPENDIX D
PROCESS CONTROL EVALUATION FOR THE ELECTRONIC MANAGEMENT OF INFORMATION

APPENDIX D—PROCESS CONTROL EVALUATION FOR THE ELECTRONIC MANAGEMENT OF INFORMATION

Process Control Evaluation for the Electronic Management of Information

Complete only applicable items.

QA: QA
Page 1 of 1

A. Procedure/Work Activity Identification (check one)

☐ Procedure (identify process procedure number, title, revision and ICN level being evaluated), or

☒ Work Activity (identify by work package number, Technical Work Plan, technical product, etc., including title and revision)

WP # S30111 – TWP-MGR-MM-000002 REV01 – Perfomance Confirmation Test Plan for Precipitation Monitoring

B1. Processes/Process Functions/Work Activities Evaluation

		Yes	No
1.	Will, or does, the process/process function/work activity depend on a form of electronic media to store, maintain, retrieve, modify, update, or transmit information?	☒	☐
2.	Will, or does, the process/process function/work activity manage, control, or use an electronic database, spreadsheet, set of files, or other holding system for information?	☒	☐
3.	Will, or does, the process/process function/work activity transfer information electronically from one location to another? (The method may be File Transfer Protocol, electronic download, tape to tape, disk to disk, etc.)	☒	☐
4.	Will, or does, the process/process function/work activity produce any Sensitive Unclassified electronic information?	☐	☒

If the answers to Section B1 are all "No", process in accordance with Step 6.1.2G.

B2. Processes/Process Functions/Work Activities Compliance Evaluation

		Yes	No	N/A
1.	If any Sensitive Unclassified electronic information is produced, are the process controls in accordance with Sandia Corporate processes	☒	☐	☒
2.	Does the procedure or work activity document provide adequate controls to protect information from damage and destruction for its prescribed lifetime?	☒	☐	☐
3.	Does the procedure or work activity document provide adequate controls to ensure that information is readily retrievable?	☒	☐	☐
4.	Does the procedure or work activity document provide adequate controls to describe how information will be stored with respect to media, conditions, location, retention time, security, and access?	☒	☐	☐
5.	Does the procedure or work activity document provide adequate controls to properly identify storage and transfer media as to source, physical and logical format, and relevant date?	☒	☐	☐
6.	Does the procedure or work activity document provide adequate controls to ensure completeness and accuracy of the information input and any subsequent changes?	☒	☐	☐
7.	Does the procedure or work activity document provide adequate access to controls to maintain the security and integrity of the information?	☒	☐	☐
8.	Does the procedure or work activity document provide adequate controls to ensure that transfers are error free or within a defined permissible error rate? (e.g., copying raw information from notebook to electronic information form, electronic media to another electronic media, or File Transfer Protocols)	☒	☐	☐

If the answers to Section B2 are all "Yes", process in accordance with Step 6.1.2G. Mark "N/A" for those items that are not applicable to the specific process or work activity.

C. Results of Evaluation

Provide a summary of the "as-is condition," proposed remedial actions, and expected completion date of document revision, for each item in Section B2 that was indicated as "No."

Responsible Manager		Date
Frank D. Hansen	[signature]	10/17/07

IM-PRO-002.1-R1

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