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Sandia National Laboratories Annual Compliance Monitoring Parameter Assessment

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Annual Compliance Monitoring
Parameter Assessment

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Executive Summary

The concept of deriving and assessing Compliance Monitoring Parameters (COMPs) is explained in Sandia National Laboratories (SNL) Nuclear Waste Management Program (NWMP) Analysis Plan, AP-069 titled *An Analysis Plan for Annually Deriving Compliance Monitoring Parameters and their Assessments Against Performance Expectations to Meet the Requirements of 40 CFR 194.42*. Eventually, a systematic quantitative database will be established through the implementation of the COMP monitoring program, further strengthening compliance with EPA monitoring requirements. This goal is iterative and continuous. Deriving COMPs trigger values is the first step in assessing the monitoring data, deriving COMPs and evaluating them against PA expectations. Trigger values were derived and documented in the Trigger Value Derivation Report (SNL, 2000). The 1999 annual assessment of each COMP is documented in this record package. With each annual assessment and knowledge gained through ongoing PA activities, the basis for assessing COMPs and assigning trigger values will experience improvements. In some instances a COMP does not have an assigned trigger value because no directly pertinent monitoring data are being obtained. These COMPs are related via an evaluation during the annual COMPs assessment. Other performance measures will be used for such cases, as appropriate.

The Waste Isolation Pilot Plant (WIPP) has many monitoring programs each designed to meet various regulatory and operational safety requirements. The comprehensive monitoring effort is not under the auspice of one program but is comprised of many discrete elements. One element was designed to fulfill the Environmental Protection Agency (EPA) requirements found at 40 CFR Part 191 and 40 CFR Part 194 to monitor the long-term radioactive waste containment performance of the repository. The expected performance of the repository was determined through a Performance Assessment (PA) implemented by SNL for the Department of Energy (DOE). Monitoring parameters that are related to the long-term performance of the repository were identified in a Sensitivity Study[1] (since these parameters fulfill a regulatory function, they were called Compliance Monitoring Parameters so that they would not be confused with similar Performance Assessment parameters).

Existing WIPP monitoring programs are used to gather data and information to develop these COMPs. Ten COMPs were required by EPA, two relating to human activities, five relating to geotechnical performance, two relating to regional hydrology and one relating to the radioactive components of the waste. The EPA also requires DOE to report any negative condition that would indicate the repository will not function as predicted or a condition that is substantially different than the information contained in the most recent compliance application. Annual assessments of COMPs will allow DOE to monitor the predicted performance of the repository and report any condition adverse to the containment performance. This compliance-monitoring program is described in greater detail in DOE's 40 CFR Part 191 and 194 Compliance Monitoring Implementation Plan (MIP, DOE, 1999).

As outlined in the MIP, the Management and Operating Contractor (M&O; currently Westinghouse, Waste Isolation Division) is responsible for implementing the monitoring programs that collect and report the monitoring data. SNL is responsible for assessing the data and compiling the results as they pertain to compliance. SNL is also responsible for making recommendations to improve or change the monitoring programs based on the results. This

[1] Attachment MONPAR to Appendix MON in the CCA (DOE, 1996) documents the analysis of monitoring parameters. The analysis was performed to fulfill 40 CFR 194.42 requirements.

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document reports these results and the recommendations of the 1999 COMPs assessment. The assessment concluded that the COMPs do not indicate a condition adverse to the predicted performance of the repository and as such, no actions are recommended.

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1 Introduction

The WIPP is governed by the EPA's general radioactive waste disposal regulations at 40 CFR Part 191 (EPA, 1993) and the implementing WIPP-specific criteria at 40 CFR Part 194 (EPA, 1996). Monitoring WIPP performance is an assurance requirement of these regulations and is intended to provide additional assurance that the WIPP will protect the public and environment. In the WIPP Compliance Certification Application (CCA; DOE 1996), the DOE made commitments to conduct a number of monitoring activities to comply with the criteria at 40 CFR § 194.42 and to ensure that important deviations from the expected long-term performance of the repository are identified at the earliest possible time. These DOE commitments are represented by ten Compliance Monitoring Parameters (COMP), which are listed in Section 2.

The COMPs are an integral part of the overall WIPP monitoring strategy. The DOE's Monitoring Implementation Plan (MIP, DOE 1999) describes how information and data are extracted from the various WIPP monitoring programs in order to derive or evaluate the COMPs. Collecting and reporting data collected from the WIPP monitoring programs are the responsibilities of the M&O. SNL uses these monitoring data and observations to derive "values" for the ten COMPs, derive data values which indicate potential issues, and evaluate the COMPs against performance expectations for the disposal system. The performance expectations are based on results from the WIPP PA, and its associated scenarios, models, and parameter values that form part of the DOE's Compliance Baseline. The results of the Scientific Advisor's (SA's)[2] evaluation are reported to the DOE via the Office of Regulatory Compliance (ORC). This document reports the results of the 1999 COMPs assessment.

1.2 Monitoring and Evaluation Strategy

The MIP illustrates the process for evaluation of COMP-related monitoring data and observations (Fig 4.2, DOE, 1999). Figure 1.1 (of this document) graphically describes the three basic Compliance Monitoring Program elements which include the Trigger Value generation and reporting function, the Annual COMP Reporting Cycle and the Five-Year Recertification element. The Compliance Monitoring Program is an integrated effort between the M&O, the SA and the DOE. The M&O operates the monitoring systems at the WIPP site and generates the basic data, the SA is responsible for generating the COMPs from the basic data and assessing the results. The CAO oversees and directs the monitoring program to ensure compliance with the EPA monitoring and reporting requirements. The SA is also responsible for the development and maintenance of the Trigger Values. Exceedance of these values represents a point at which further actions are needed, but not necessarily an out-of-compliance condition. This approach guarantees that any condition adverse to expected repository performance is recognized as early as possible, before an out-of-compliance condition actually occurs. These out-of-compliance conditions may include data inconsistent with those of the PA, invalidation of assumptions and arguments used in the screening of Features, Events and Processes (FEPs) or invalidation of models used in PA. The Compliance Monitoring Program is required by the EPA to addresses long-term performance and has been designed to recognize and address conditions that would result in radionuclide releases

[2] Sandia National Laboratory is the Scientific Advisor for the WIPP.

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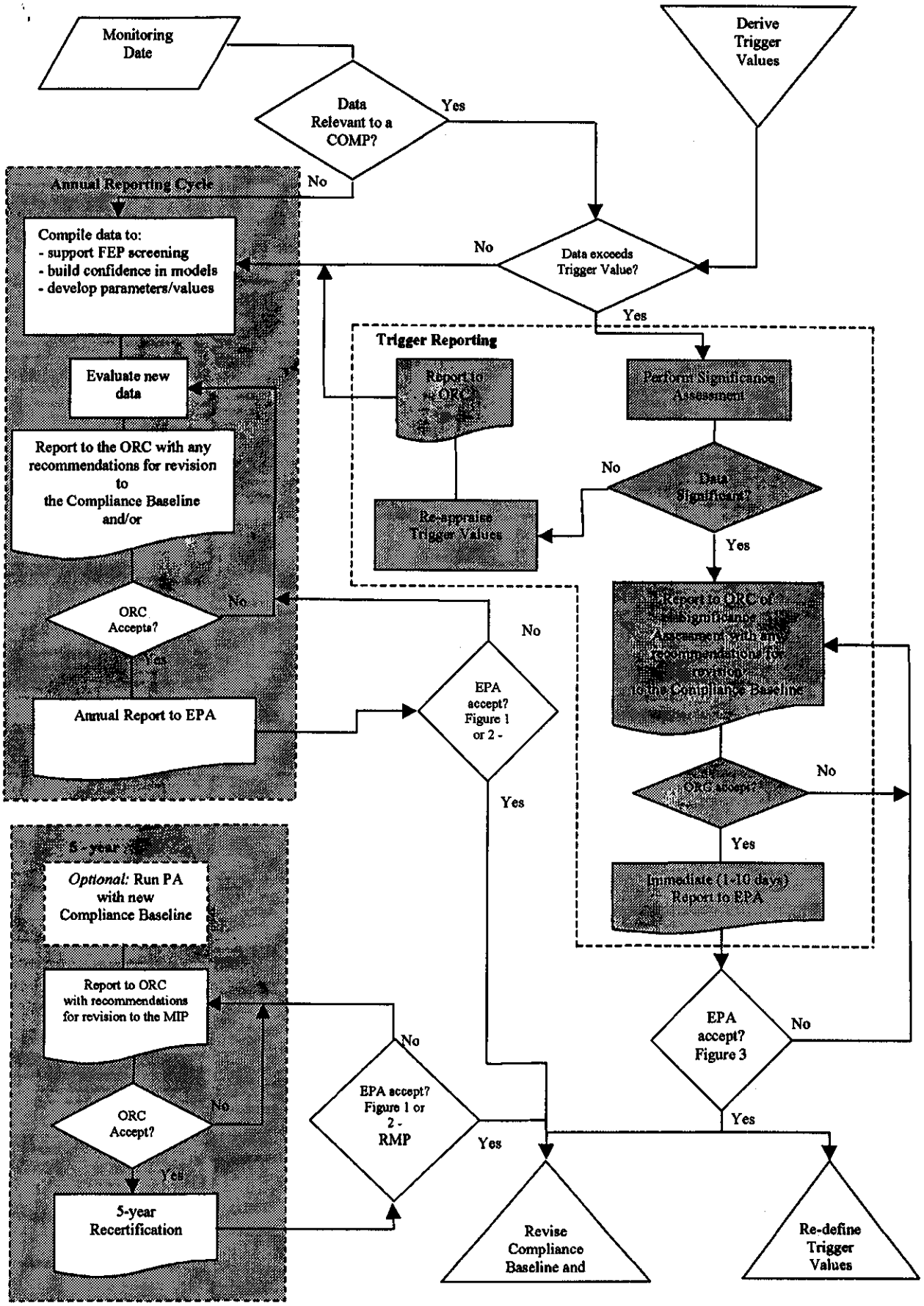

Figure 1.1: Activities Evaluating and Reporting Compliance Monitoring Parameters

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that are above allowable limits from a sealed repository after closure. Therefore, this monitoring is not intended to detect operational releases. The WIPP has many operational monitoring programs design considerations that address operational releases.

1.3 Annual Reporting Cycle

Reporting the results of the annual COMPs assessment to the DOE is necessary to meet EPA monitoring requirements. Under 40 CFR §194.4, the DOE is required to report significant and non-significant changes to the EPA. Monitored parameters that change must be reported even if the assessment concludes there is no impact on the repository. Whether or not the monitoring data agree with expectations, as defined by SA's evaluation, all the data will ultimately be compiled and reported to the DOE to assist in DOE's Annual Reporting Cycle to the EPA. The SA's role in this reporting cycle is to use the monitoring data to derive the COMPs, and to use the new information to make any recommendations for modification to the Compliance Baseline, to monitoring programs, and to Trigger Values.

2 Assessment of COMPs

The compliance monitoring program tracks the following ten COMPs:

1. Drilling Rate
2. Probability of Encountering a Brine Reservoir
3. Waste Activity
4. Subsidence
5. Changes in Groundwater Flow
6. Change in Groundwater Composition
7. Creep Closure
8. Extent of Deformation
9. Initiation of Brittle Deformation
10. Displacement of Deformation Features

In the following section, each COMP is evaluated and compared to the applicable Trigger Value. This assessment is performed under Analysis Plan AP-069 (SNL, 2000a). This section summarizes the results of the 1999 assessments. An annual review of these COMPs is necessary to meet the intent of 40 CFR §191.14 assurance requirements, which states:

> "(b) Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations from expected performance. This monitoring shall be done with techniques that do not jeopardize the isolation of the wastes and shall be conducted until there are no significant concerns to be addressed by further monitoring."

Specifically, AP-069 contains five steps to derive trigger values and assess COMPs. Steps 1 and 2 generate a table that maps COMP related data to PA parameters, FEPs screening arguments, Conceptual Models, Model Assumptions and the M&O organization that generates the data used to derive each COMP. Table 2.1 contains this information which was derived using information in the Compliance Certification Application (DOE, 1996).

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Table 2.1 Monitoring Parameters Required by EPA Compliance Decision, Responsible Program, Trigger Value, Related PA Parameter and Major PA Screening Decision

40 CFR 194 Monitoring Parameter	Responsible Program M&O/*SA* (SA in italics)	Trigger Values	Related Performance Assessment Parameter	Major FEPs Screening Decisions Related to Monitoring
Creep Closure and Stresses	Geotechnical Monitoring Program *Seals and Rock Mechanics and Near Field Programs*	Greater than 1 order of magnitude increase in the rate.	Not directly related to a PA Parameter. *Provides a short-term (operational) observation of the deformational properties of halite and anhydrite. Can provide confidence in the CCA creep closure model.*	*Salt creep, room closure, excavation-induced stress changes, Changes in stress field, pressurization, Consolidation of waste.* *Data from this monitoring program will be evaluated during recertification.*
Extent of Deformation	Geotechnical Monitoring Program *Seals and Rock Mechanics Programs*	Greater than 1 m/year increase.	Not directly related to a PA Parameter. *Provides a short-term observation of the extent of deformation. Can provide confidence in the long term behavior of Disturbed Rock Zone (DRZ) as modeled in CCA and DRZ parameters (e.g., permeability and porosity). Intrinsic shaft DRZ permeability.*	*DRZ, roof falls, Consolidation of seal elements, compaction of waste.*
Initiation of Brittle Deformation	Geotechnical Monitoring Program *Seals and Rock Mechanics Programs*	None	Not directly related to a PA parameter. *Can provide confidence in the anhydrite fracture model implemented in the BRAGFLO code. Provides related repository observation data on initiation or displacement of major brittle deformation features in the roof or surrounding rock.*	*Disruption due to gas effects.*
Displacement of Deformation Features	Geotechnical Monitoring Program *Seals and Rock Mechanics Programs*	Obscured Borehole (qualitative)	Not directly related to a PA Parameter. *Provides related repository operational data on initiation or displacement of major brittle deformation features in the roof or surrounding rock.*	*Seismic activity, creep closure, consolidation of waste.*
Culebra Ground Water Compositions	Ground Water Monitoring Program	TBD	Average Culebra brine composition and matrix distribution coefficient for U(IV,VI), Pu(III,IV), Th(IV), Am(III).	*Groundwater geochemistry, Actinide sorption.*

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40 CFR 194 Monitoring Parameter	Responsible Program M&O/*SA* (SA in italics)	Trigger Values	Related Performance Assessment Parameter	Major FEPs Screening Decisions Related to Monitoring
(Continued from previous page)	*Far Field Program*		*Matrix distribution coefficient is not a sensitive parameter for the CCA PA. Can provide information on well integrity around the site.*	
Change in Culebra Ground Water Flow (Water Level)	Ground Water Monitoring Program *Far Field Program*	TBD	Culebra Transmissivity, Fracture & Matrix Porosity, Fracture Spacing, Dispersivity, & Climate Index. *The CCA modeling allowed the water level to raise to the land surface. Can provide information on well integrity around the site.*	*Groundwater flow and recharge/discharge; Infiltration and Precipitation.*
Drilling Rate	Delaware Basin Monitoring Program *Far Field and Near Field Programs*	53.5 boreholes per km^2 per 10K yrs.	Drilling rate per unit area. *In the CCA the drilling rate was determined to be 46.8 boreholes per square kilometer per 10,000 years.*	*Drilling.*
Probability of Encountering a Castile Brine Reservoir	Delaware Basin Monitoring Program *Far Field and Near Field Programs*	None	Probability of encountering a Castile brine reservoir, reservoir pressure, and volume. *In the CCA, 8% was used, in the PAVT a range of 1 - 60% was used.*	*Drilling fluid flow, Drilling fluid loss, Blowout and Brine reservoirs.*
Subsidence Measurements	Subsidence Monitoring Program *Far Field and Near Field Program*	10 mm/year	Not directly related to a PA Parameter. *Can provide spatial information on surface subsidence (if any) over the influence area of the underground openings during operations.*	*Changes to Ground water flow due to mining effects, Subsidence baseline.*
Waste Activity	WIPP Waste Information System (WWIS) *PA Methodology*	5.1 M Curies (RH Only)	Radionuclide inventory. *In the CCA the SA used the Baseline Inventory Report information scaled to the Land Withdrawal Act (LWA) limits of 6.2 million cubic feet for CH and RH TRU waste and 5.1 million curies for RH TRU waste (limits are listed in table WCA-1 in the CCA)*	*Waste characteristics Radiological, Consolidation of waste, actinide source term.*

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2.1 Human Activities COMPs

The CCA lists ten COMPs that the DOE is required to monitor and assess during the WIPP operational period. Two of these parameters monitor "Human Activities" in the WIPP vicinity which include:

- Probability of Encountering a Castile Brine Reservoir
- Drilling Rate

2.1.1 Probability of Encountering a Castile Brine Reservoir

No new data have been generated concerning this COMP. The CCA data were compiled from record searches of drilling data. The results of this search recorded 27 drilling encounters with pressurized brine in the Castile Formation. Of these encounters, 25 were hydrocarbon wells scattered over a wide area in the vicinity of the WIPP site. Two wells, ERDA 6 and WIPP 12 were drilled in support of the WIPP site characterization effort. The Delaware Basin Drilling Surveillance Program reviews the well files of all new wells drilled in the New Mexico portion of the Delaware Basin each year looking for instances of Castile brine encounters. The program also sends out an annual survey to operators of new wells asking if they encountered pressurized brine during the drilling process. Since the CCA data were generated through September 1999, no other pressurized Castile brine encounters have been found in the New Mexico portion of the Delaware Basin (WID, 1999a). Since there is no new information that would change the COMP, there is no impact on the assumption or predictions in the CCA for the probability of encountering pressurized brine in the Castile Formation.

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Probability of Encountering a Brine Reservoir:

Trigger Value Derivation			
COMP Title:	Probability of Encountering a Castile Brine Reservoir		
COMP Units:	Unitless		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
DBMP		Driller's Survey – observations	0.08 constant – CCA
COMP Derivation Procedure			
Analysis of intercepts of pressurized brine recorded and reported by industry in the 9-township area centered on WIPP.			

Related PA Elements				
Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
Probability of Encountering Brine	Parameter PRBRINE ID # 3493	CCA MASS Attachment 18-6 geostatistical study based on area occurrences. EPA TSD justified the upper value in their range by rounding up the upper value interpreted from the TDEM survey, which suggested a 10 to 55% areal extent.	0.08 0.01 to 0.60	Not a sensitive parameter.

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Probability of Encountering a Castile Brine Reservoir	None	After the DOE proposed the brine reservoir probability as potentially significant in the CCA Appendix MONPAR, the EPA conducted and analyses that indicate a lack of significant effects on performance from changes in this parameter. Since no value of this parameter can significantly affect the performance of the disposal system predicted by the CCA PA and since the parameter is evaluated at least once annually, no trigger value is needed.

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2.1.2 Drilling Rate

The drilling rate COMP monitors human intrusion activities relating to resource extraction. Drilled boreholes relating to resources include potash and sulfur core holes, hydrocarbon exploration, saltwater disposal and water wells. The drilling rate reported in the Compliance CCA was determined using an equation provided in 40 CFR Part 194. The formula is as follows: number of deep holes times 10,000 years divided by 100 years (1896 - 1996). Deep holes were defined as any resource hole that terminated at a depth equal to or greater than the repository depth. The rate reported in the CCA using this equation was 46.8 boreholes per square kilometer over 10,000 years. Including the time period after the CCA (June 1995 to August 1999) increases the rate to 50.6 boreholes per square kilometer per 10,000 years. This increase is within PA expectations and has no effect on predicted repository performance. The Trigger Value for this COMP is not based on calculated performance because an order of magnitude change in the drilling rate does not result in an out-of-compliance condition. However, the FEPs related assumptions used in the CCA may be effected by increases in the drilling rate. For this reason, a Trigger Value of 53.5 was chosen so that when this rate was reached, the FEPs related arguments would be revisited to assure that there is no impact to the original arguments. It should be stated that an exceedence of this Trigger Value is not an indication of an out-of-compliance condition but is a point at which further analysis is needed to refine the baseline of the compliance-monitoring program.

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Drilling Rate:

Trigger Value Derivation			
COMP Title:	Drilling Rate		
COMP Units:	Deep boreholes (i.e., > 2,150 feet deep)/square kilometer/10,000 years		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number observation)	Compliance Baseline Value
DBMP	Deep hydrocarbon boreholes drilled	Integer per year	10,640 per 100 years
DBMP	Deep sulfur coreholes drilled	Integer per year	89 per 100 years
DBMP	Deep potash coreholes drilled	Integer per year	19 per 100 years
DBMP	Deep stratigraphic core tests drilled	Integer per year	56 per 100 years (excluding WIPP test holes)
DBMP	Other deep boreholes drilled	Integer per year	0
COMP Derivation Procedure			
(Total number of deep boreholes drilled/number of years of observations) x (10,000/23,102.1) [i.e., over 10,000 years divided by the area of the Delaware Basin in square kilometers]			

Related PA Elements				
Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
Drilling rate	Parameter LAMBDAD #3494	COMP/10,000 years	4.68E-03 per km^2 per year	23-fold increase over 10,000 years exceeds release limits at 0.1 *probability* (EEG 1998). Proportional increase in cuttings/ cavings releases.

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Deep boreholes drilled (derived from the sum of the five monitoring parameters given above)	53.5 boreholes per km^2 per 10K yrs.	CCA direct releases are sensitive to drilling rate changes, however only a dramatic and improbable change in drilling rate could affect containment of radionuclides. The sensitivity of FEP screening decisions to changes in drilling assumptions has not been evaluated to date. There is little information upon which to justify the choice of a trigger value based on FEP screening decisions. A change of drilling rate greater than 10% (i.e., greater than 53.5 boreholes per square kilometer per 10,000 years) is considered prudent as a trigger value to revisit the low-consequence assumptions associated with the effects of abandoned boreholes on fluid flow and climatic changes used to construct the performance assessment calculations.

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2.2 Geotechnical COMPs

The CCA lists ten monitoring parameters that the DOE is required to monitor and assess during the WIPP operational period. Five of these parameters are considered "geotechnical" in nature and include:

- Creep Closure
- Extent of Deformation
- Initiation of Brittle Deformation
- Displacement of Deformation Features
- Subsidence

The primary sources for evaluation of geotechnical COMPs are addresses in the annual Geotechnical Analysis Report for July 1997 to June 1998 (GAR; WID 1999b) and the annual Subsidence Monument Leveling Survey (WID, 1998). Data from these two reports are evaluated relative to the COMPs and compared to "Trigger Values".

Geotechnical COMPs can be derived from or related to the repository's operational safety monitoring program performed to ensure worker and mine safety. By nature, changes in geotechnical conditions evolve slowly, however, they are monitored on a continual basis. Since pertinent data from the underground reflect slowly evolving conditions, relationships that correlate to geotechnical COMPs also evolve slowly. Geotechnical conditions warranting action for operational safety will become evident before such conditions would impact long-term waste isolation. The value of monitoring the underground rests with continuing reassurance that conceptual geotechnical models supporting certification are realistic and well conceived. In effect, these annual comparisons of geotechnical response to expectations serve to validate or improve models. Annual reviews allow discovery of conditions or trends that lay outside expectations. In principal, the annual geotechnical analysis seeks trends or conditions that are "off normal." At this early stage of the repository history, the WIPP monitoring program is establishing parametric values, rates, conditions or observations that would signal further evaluation. It needs to be re-emphasized that conditions beyond normal or outside expectations do not automatically impact compliance determinations. Conditions differing from expectations alert the geotechnical program to scrutinize incoming data more closely and to make assessments of possible performance impact.

Displacement, deformation, closure, and fracture evolve slowly. Therefore, annual assessment of the geotechnical COMPs will adequately address conditions that would be of concern for predicting repository performance or that are related to long-term regulatory compliance. This document contains the initial geotechnical monitoring assessment report since disposal operations began. Implementation and evaluation of possible trigger events, features, phenomena, trends, and conditions that would warrant further actions will be refined as experience is gained.
This first annual assessment of Geotechnical COMPs provided the opportunity to review parameters and phenomena in the context of the EPA rule. Essentially, the SA has evaluated the practicality of implementing the program and attempted to develop a baseline against which future geotechnical assessments will be guided.

2.2.1 Creep Closure:

The GAR, which is published annually, compiles all geotechnical operational safety data gathered from the underground. The GAR routinely measures and reports creep deformation, either from

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rib-to-rib, roof-to-floor, or extensometer borehole measurements. In the GAR, elements and regions of the underground are discussed by area including the shafts, the shaft stations, drifts, north experiment area, and the waste disposal area. Rates of closure are relatively constant within each zone of interest and usually range about 1-5 cm/yr. A closure rate in terms of cm/yr can be expressed as a global or nominal creep rate by dividing the displacement by the room dimension and converting time into seconds. Nominally these rates are of the order of $1x10^{-10}$ sec^{-1} and is quite steady over significant periods. From experience, increases and decreases of rates such as these might vary by 20 percent without undue concern. Therefore the "trigger value" for creep deformation was set as one order of magnitude increase in creep rate. Such a rate increase would clearly alert the geotechnical staff to scrutinize the area exhibiting accelerating creep rates. Tertiary creep is an expected (eventually) phenomenon and its manifestation would help validate predictive capabilities of the computational models.

Extensive GAR data suggest that possible trigger values could be derived from creep rate changes. The WIPP underground is very stable, relative to most operating production mines, and deformation is steady for long periods. However, under certain conditions, creep rates accelerate which indicates a structural change of the deformation processes. Arching of microfractures to an overlying clay seam might create the onset of the roof beam de-coupling, and increase the measured closure rate. Phenomena of fracture coalescence and DRZ growth comprise important elements of compliance confirmation. Therefore, a measured creep rate change over a yearly period constitutes the COMP trigger value for creep closure. Rate changes would necessarily be evaluated on a case-by-case basis since closure is related to many factors such as age of the opening, location in the room or drift, convergence history, recent excavations, and geometry of the excavations.

Four shafts connect the surface with the WIPP underground facility. Weekly inspections are conducted on the Salt Handling Shaft, the Waste Handling Shaft, and the Air Intake Shaft. The Exhaust Shaft is examined quarterly using a remote video. Radial creep closure measurements from multi-point extensometers are made in the Salado Formation below the key at three nominally equal elevations (approximately 330 m level, the 480 m level and the 630m level). Measurements on shaft closure are used periodically as a calibration of calculational models, and have been used in shaft seal system design. Creep rate measurements most impactive to performance are observed in a vertical orientation along openings of greatest dimensions and ages, such as the shaft station and disposal rooms. The greatest potential for instability having an impact to operations and compliance might be discerned from vertical creep closure data.

The salt handling station vertical closure rates have remained consistent for the last four years. Likewise, extensometers (268, 277 and 279) indicate a steady creep rate near the waste shaft station. The largest amount of *total* vertical convergence (as measured by a convergence point array over the last 10.3 years) is located at E90. Vertical closure rates along the E90 drift are slowly decreasing a few percentage points per year. Access drifts in the central underground are extensively instrumented for convergence as a primary means of identifying potential ground control problems. In access drifts, convergence rates are specific to structural analysis. Closure rate increases greater than 10 % are rechecked. Of the 415 radial convergence point pairs, 19 pairs have a calculated convergence rate increase greater than 10%. Further inspection shows that although the rates are increasing, the rates themselves are low (1 to 2 cm per year).

Accelerating creep rates and roof collapse have been experienced in the Northern Experimental Area as part of planned, structural evaluations. Most of the north end remains stable, with the

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exception of SPDV Room 4. Here, closure rates have increased 50% over this reporting period. This closure rate is a manifestation of fracturing which now decouples the roof beam. Closure rates increase because of roof beam flexure and fracture. Likewise, fracturing adds to the closure rates observed in the waste disposal areas. These results allow improvement of the creep model, as fracture and DRZ development impact performance during operations and during the regulatory period. Continued monitoring and concomitant improvements to creep closure-modeling tools improve calculational viability.

Based on the information in the most recent GAR, creep rates in the underground are well within normal and expected ranges for this reporting period.

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Creep Closure:

Trigger Value Derivation			
COMP Title:	Creep Closure		
COMP Units:	Closure Rate (sec^{-1})		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g. number, observation)	Compliance Baseline Value
Geotechnical	Closure	Instrumentation through out the underground.	Munson-Dawson (MD) Constitutive Model
COMP Derivation Procedure			
Annually evaluate GAR for centerline closure rates, compare to previous year's rate. If closure rate increases by greater than one order of magnitude, initiate technical review.			

Related PA Elements				
Element Title	Type & ID	Derivation Procedure	Compliance Baseline	Impact of Change
PA Grid	Creep Closure	Porosity Surface Waste Compaction Characteristics Waste Properties Evolution of underground setting	MD Model	Provides validation of the CCA creep closure model.

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Creep Closure	Greater than one order of magnitude increase in closure rate.	Closure rate increase signals potential de-coupling of rock.

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2.2.2 Extent of Deformation:

The extent of brittle deformation is quantifiable as it defines spatial and temporal evolution of the DRZ. Measurements in the GAR include visual examinations, readings from borehole extensometers, and feeler gauges. These observations are linked closely to other monitoring requirements concerned with initiation of brittle deformation and displacement of deformation features. These monitoring requirements define characteristics of the DRZ which could validate the baseline conceptual model, its flow characteristics, saturation and de-watering. The extent of deformation quantifies the DRZ, a significant element of performance assessment analyses.

Extent of brittle deformation comprises one of the key geotechnical experimental programs being undertaken cooperatively between the SA and the M&O. A test plan, *Disturbed Rock Zone Characterization,* TP 99-04 (SNL, 1999) outlines underground geophysical experiments to delineate physical and hydrological properties of the DRZ. The extent of brittle deformation was modeled explicitly in the compliance performance assessment calculations. Therefore, this information will substantiate changes to the PA grid, DRZ hydrological properties, and boundary conditions relevant to constitutive modeling. The geoscience program described in the GAR includes excavation characteristics determined from fracture mapping and logging of fracture offsets in open boreholes. Lateral displacements evident in occluded boreholes comprise a key observation relative to deformation features (a separate monitoring requirement).

Active field testing, as outlined in TP 99-04, is just beginning implementation. Underground reconnaissance by the DRZ field team allowed visual observation of the nature and extent of deformation. Because WIPP operations have practical experience with the fracture and decoupling near the roof clay seams, the team was able to view the normal extent of deformation. In the ensuing field work, visual evidence will be used as a guide for permeability measurements, moisture content, and other features. At this stage, no observations beyond normal were encountered for this COMP.

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Extent of Deformation:

Trigger Value Derivation			
COMP Title	Extent of Deformation		
COMP Units	Areal extent (length, direction)		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Geotechnical	Displacement	Meters	Room geometry
COMP Derivation Procedure			
Extent of deformation deduced from borehole extensometers, feeler gauges, and visual inspections are examined yearly for active cross sections. Anomalous growth is determined by comparison.			

Related PA Elements				
Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
PA Grid	DRZ (shaft) DRZ (panel closure systems)	Constitutive model from laboratory and field databases.	Permeability around panel closures was assigned a constant value of $10^{-15}m^2$	DRZ spatial and temporal properties have important PA implications for permeability to gas, brine and two-phase flow.

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Fractures at depth	Growth of 1 m/year	Coalescence of fractures at depth in rock surrounding drifts will control panel closure functionality and design, as well as discretization of PA models.

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2.2.3 Initiation of Brittle Deformation:

Initiation of brittle deformation around WIPP openings is not being directly measured and is therefore a qualitative observational parameter. By definition, qualitative COMPS can be subjective and are not prone to the development of well-defined trigger values. Brittle deformation eventually leads to features that are measured as part of geotechnical monitoring requirements, such as the extent and displacement of deformation features. Initiation of brittle deformation is expected to begin immediately upon creation of an opening. Initiation and growth of the DRZ are fundamental observational goals of TP 99-04, as discussed above. The ongoing cooperative geophysical program will help quantify damage evolution around WIPP openings. Initiation and growth of damaged rock zones are important considerations to operational period panel closures as well as compliance performance assessment calculations. Based on field observations, including the reshaping of Room 7, of Panel 1 for the first receipt of waste, brittle deformation is widely experienced by MB 139 as the floor heaves. Owing to the lithology and structural setting, brittle anhydrite response, as witnessed, is expected. Such observations help quantify modeling assumptions, but are routine and anticipated.

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Initiation of Brittle Deformation:

Trigger Value Derivation			
COMP Title:	Initiation of Brittle Deformation		
COMP Units:	Qualitative		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g. number, observation)	Compliance Baseline Value
Geotechnical	Closure	Observational	Operational and Remedial
COMP Derivation Procedure			
Qualitative and pertinent to operational considerations. Captured qualitatively in association with other COMPs			

Related PA Elements				
Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
Not directly related to PA	NA	NA	NA	NA

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Initiation of Brittle Deformation	None	Qualitative COMPs can be subjective and are not prone to the development of meaningful trigger values.

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2.2.4 Displacement of Deformation Features:

The displacement of deformation features largely occurs vertically via crack openings and laterally by shear along clay seams. Extensive deformational features may include occlusion of observational borehole diameters. A "trigger value" from a monitoring viewpoint has been proposed: lateral displacement sufficient to close the full diameter of an observational borehole. The GAR geoscience program currently logs fractures and offsets in boreholes. Roof observations usually intersect clay seams G and H, while floor observations penetrate clay E below Marker Bed 139. Obscured boreholes have been identified as a "trigger" basis for technical evaluation of consequences.

WIPP geotechnical personnel possess historical knowledge of the WIPP underground, and continually assess deformation features, assess roof bolt behaviors, and perform caliper fracture mapping. These qualitative assessments are reported in the GAR and are used along with information from the other geotechnical COMPs to evaluate conditions.

The current situation in the underground includes disposal rooms, which have remained open for over 10 years. This condition allows direct observations of displacements that ordinarily would occur as rooms are being filled. New excavation is beginning for the second panel. The underground DRZ work will now have the opportunity to examine the natural evolution of displacement features. In effect, this program is establishing the baseline of normal and expected deformation in the WIPP underground.

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Displacement of Deformation Features:

Trigger Value Derivation			
COMP Title:	Displacement of Deformation Features		
COMP Units:	Length		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Geotechnical	Delta D/D_o	Observational	Not established
COMP Derivation Procedure			
Observational – Lateral deformation across boreholes.,			
Related PA Elements			
Element Title	Type and ID	Derivation Procedures	Compliance Baseline	Impact of Change
Monitoring Data Trigger Values			
Monitoring Parameter ID	Trigger Value	Basis	
Borehole diameter closure	Obscured observational borehole	If lateral displacement is sufficient to close diameter of observational borehole, technical evaluation of consequences will be initiated.	

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2.2.5 Subsidence:

Subsidence is monitored via elevation determination of 52 existing monuments and 14 of the National Geodetic Survey's vertical control points. To address EPA monitoring requirements, the most recent survey results (WIPP Subsidence Monument Leveling Survey, 1998) are reviewed and compared to possible "trigger values." Because of the low extraction ratio and a depth of 650 m, subsidence over the WIPP is expected to be much lower and slower than over potash mines. Maximum observed subsidence over potash mines near the WIPP is 1.5 m, occurring over a time period of months to a few years. Calculations show that the maximum subsidence figure for the WIPP assuming emplacement of CH-TRU waste and no backfill is 0.62 m (Backfill Engineering Analysis Report [BEAR; WID, 1994]) above the waste emplacement panels. Further considerations, such as calculations of closure, project that essentially all surface subsidence would occur during the first few centuries. If subsidence rates can be observed by way of monument survey, displacements would be very small. This fact is taken into consideration as a Second Order Class II loop closure accuracy (8mm/km) was achieved in all cases. Survey accuracy is discussed in terms of closure of the loop times the square root of the loop length.

Subsidence data (in feet) are available from 1986 to 1998 in several of the ten survey loops. Survey accuracy was very high, with monuments (for example D-419) generally closing to within 0.01 ft. Survey station S-01, proximal to the salt handling shaft, subsided 0.1 ft between 1986 and 1993. Thereafter, there has been no measured elevation change. Over the north experimental area, S-18 for example, results are identical to S-01 within survey accuracy. Over the disposal area near Panel 1, S-25 has subsided 0.1 ft since excavation, while S-48 and S-49 (well removed from the repository footprint but on the same survey loop) subsided half as much. Elevation surveys provide valuable baseline data and high accuracy. Although quite small, perceptible subsidence trends are appearing. As additional mining occurs during WIPP disposal operations, these trends are likely to increase subsidence magnitude. Any significant increases in subsidence will be evident by comparison to this well established baseline.

At this time, all subsidence magnitudes are small, and are approximately at the resolution level of the survey accuracy. These minor amounts of subsidence are expected and well within normal ranges.

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Subsidence:

Trigger Value Derivation			
CMPMP Title:	Subsidence		
CMPMP Units:	Change in surface elevation in meters per year		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g. number/observation)	Compliance Baseline Value
Subsidence Monitoring Leveling Survey (SMP)	Elevation of 52 monitoring benchmarks	Decimal (meters)	
SMP	National Geodetic Survey (NGS) results	Decimal (meters)	Powers, 1993
SMP	Change in elevation over year	Decimal (meters)	-
SMP	Total change in elevation since excavation of the WIPP	Decimal (meters)	1996 NGS elevation - 1981 NGS elevation (from Powers, 1993)
COMP Derivation Procedure			
Two contour plots of the 52 monitoring benchmarks, showing (Elevation this year – Elevation last year), and (Elevation – Baseline Elevation). Maximum value of (Elevation last year – Elevation last year) from the 52 monitoring benchmarks.			

Related PA Elements				
Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
Subsidence	FEP [W2.023]	Predictions are of low consequence to the calculated performance of the disposal system – based on WID (1994) analysis and EPA treatment of mining.	Maximum total subsidence of 0.62m above the WIPP.	Predicted subsidence will not exceed existing surface relief of 3 m – i.e., it will not affect drainage. Predicted subsidence may cause an order of magnitude rise in Culebra hydraulic conductivity (CCA Appendix SCR, Section 2.3.4) – this is within range modeled in the PA. Predicted WIPP subsidence is below that predicted for the effects of potash mining (.62m vs.1.5 m; EPA 1996).

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Change in elevation per year	1.0×10^{-2} m per year subsidence	Based on the most conservative prediction by analyses referenced in the CCA.

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2.2.6 Geotechnical COMPs Concluding Remarks

Requirements for geotechnical monitoring are being integrated with a longstanding geotechnical analysis program implemented by the managing and operating contractor. Geotechnical results will influence compliance evaluations. Expectations are that well constrained geotechnical models will enhance WIPP performance assessments while reducing uncertainties. Characteristics of the underground setting were approximated in the compliance determination calculations. Often, properties and parameters used in the CCA contained unnecessarily large uncertainties. The geotechnical monitoring program required by the EPA will improve our knowledge and modeling of many impactive features of the underground setting.

2.3 Hydrological COMPs

The CCA lists ten monitoring parameters that the DOE is required to monitor and assess during the WIPP operational period. Two of these parameters are considered "Hydrological" in nature and include:

- Change in Culebra Water Composition
- Change in Culebra Ground Water Flow

The SA has reviewed the data collected by the M&O in 1998 under the Groundwater Surveillance Program (GSP). The GSP has two components: the Water Quality Sampling Program (WQSP) and Water-Level Monitoring Program (WLMP). WQSP data are reported in the WIPP Site Environmental Report Calendar Year 1998 (WID, 1999c) and WLMP data are reported in monthly memoranda from the M&O to the SA.

2.3.1 Change in Culebra Water Composition

Water Quality Sampling Program (WQSP)
Under the WQSP, WID collected water samples twice (sampling rounds 6 and 7) in 1988 from seven wells, denoted WQSP-1 through 6 and WQSP-6A. WQSP-1 through 6 are completed to the Culebra Dolomite Member of the Rustler Formation and WQSP-6A is completed to the Dewey Lake Redbeds. Flow and transport in the Dewey Lake is not modeled in PA because FEP screening showed it was unimportant. Nevertheless, the Dewey Lake water quality is monitored because it might help to increase the understanding of Dewey Lake hydrology. The water samples were analyzed in duplicate for major and minor elements and hazardous constituents per the WIPP Ground Water Monitoring Program Plan, (GWMP; WID, 1999d).

The Culebra is not a source of drinking water, so Culebra water quality is not of concern in an immediate, health sense. Instead, Culebra water quality is important because of what it implies about the nature of the flow system. Solute concentrations differ widely among wells across the WIPP site, reflecting local equilibrium, diffusion, and, perhaps most importantly, slow transport. The conceptual model for the Culebra presented in the CCA and implemented in PA numerical models is that of a confined aquifer with solute travel times across the WIPP site on the order of tens of thousands of years. In such a system, no changes in water quality at an individual well outside the range of normal analytical uncertainty and noise should be observed during the WIPP operational phase of a few decades duration. If sustained and statistically significant changes in the concentrations of major ionic species (Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, SO_4^{2-}, HCO_3^-) were observed, this would imply that water was moving faster through the Culebra than was consistent with our

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models. Stability of major ion concentrations, on the other hand, is consistent with and supports the SA's models. Thus, our evaluation of the water-quality data focuses on the stability of major ion concentrations.

We define stability as meaning that the concentration of an ion remains within the 95% confidence interval (mean +/- 1.96 standard deviations) established from the baseline measurements at a well, assuming a normal distribution of concentrations. The baseline was established from the first five rounds of sampling in the WQSP wells, which were performed between 1995 and 1997. The baseline data are presented in the Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Report (Crawley and Nagy, 1998). For the purposes of this evaluation, we have eliminated a small number of measurements from the baselines for WQSP-5, 6, and 6A for reasons discussed below. Eliminating these values is always conservative in that it reduces the "stable" range of concentrations for the affected parameters.

A charge-balance error, defined as the difference between the positive and negative charges from the ions in solution divided by the sum of the positive and negative charges, was also calculated for each analysis. Charge-balance errors are useful in evaluating the reliability of an analysis because water must be electrically neutral. Charge-balance errors are rarely zero because of inherent inaccuracy in analytical procedures, but a reliable analysis should not have a charge-balance error exceeding five percent (Freeze and Cherry, 1979). Charge-balance errors in excess of five percent imply either that the analysis of one or more ions is inaccurate (most common) or that a significant ion has been overlooked (rare). Analytical results and charge-balance errors for rounds 6 and 7 of sampling are presented in Table 2.3 with the 95% confidence intervals derived from the baseline data.

WQSP-1

All major ions were within the 95% confidence intervals for round 6 sampling at WQSP-1 and the charge-balance error was an acceptable –2.7% (Table 2.3). For round 7, concentrations of potassium exceeded the 95% confidence interval for both duplicates. However, round 7 potassium concentrations also exceeded the 95% confidence intervals at WQSP-2, WQSP-4, WQSP-5, and WQSP-6A, leading us to suspect either a change in analytical procedure or a problem at the analytical laboratory. The duplicate potassium analyses from WQSP-1 also differed by 10%, another indication of analytical difficulties. One of the duplicate analyses of sodium for round 7 was slightly below the 95% confidence interval. This probably represents an analytical error, as the other analysis showed sodium to be well within the 95% confidence interval. Inclusion of the low value in the charge-balance calculation resulted in a charge-balance error of –5.7%, reflecting a cation deficiency in the analysis. All other major ions were within their 95% confidence intervals for round 7. Both potassium and sodium concentrations will be watched in future rounds of sampling to determine if the round 7 results represent real changes in concentrations, or just anomalous measurements. At the present time, we believe the water quality to be stable at WQSP-1.

WQSP-2

All major ions were within the 95% confidence intervals for round 6 sampling at WQSP-2 except for individual duplicates for sodium and alkalinity (Table 2.3). The round 6 charge-balance error was an acceptable –1.7%. The alkalinity concentration for one sample was slightly (2 mg/L) below the 95% confidence interval, while the duplicate concentration was within that interval. For sodium, one analysis showed the concentration to be slightly above the 95% confidence interval while the duplicate analysis showed the concentration to be right at the upper limit. In contrast,

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both sodium analyses for round 7 showed concentrations well below the 95% confidence interval. These low reported concentrations cause the round 7 charge-balance error to be –18.8%, leading us to question their reliability. Both potassium concentrations for round 7 exceeded the 95% confidence interval. All other ions had concentrations within the 95% confidence intervals for round 7 sampling of WQSP-2. In summary, the water quality was considered to be stable at WQSP-2 and round 7 analyses are suspect due to analytical errors in the data.

WQSP-3

For round 6 sampling at WQSP-3, all major ion concentrations were within 95% confidence intervals except for magnesium, and the charge-balance error was an excellent –0.6% (Table 2.3). Both magnesium analyses exceeded the 95% confidence intervals. For the round 7 sampling, only one of the magnesium analyses exceeded the 95% confidence interval, and that analysis showed a concentration 19% higher than the duplicate analysis, indicating analytical difficulties. The only other analysis from the round 7 sampling to have a concentration outside the 95% confidence intervals was one of the sodium duplicates. One of the duplicates had a reported concentration below the 95% confidence interval, 18% lower than the other. Inclusion of this low value in the charge-balance calculation led to a charge-balance error for round 7 of –8.5%, causes doubt about its accuracy. Magnesium concentrations will be watched in future rounds of sampling to determine if the round 6 and possibly 7 results represent real changes in concentration, or just anomalous measurements. At the present time, the water quality is believed to be stable at WQSP-3.

WQSP-4

For round 6 sampling at WQSP-4, one of the chloride duplicates, both sulfate duplicates, and both sodium duplicates had concentrations outside the 95% confidence intervals (Table 2.3). The chloride and sulfate concentrations fell below the 95% confidence intervals, while the sodium concentrations were above. Primarily because of the high sodium concentrations, the charge-balance error was +3.1%, one of only five positive charge-balance errors from the 49 analyses conducted to date for this sampling program. For round 7, one of the sodium duplicates had a concentration within the 95% confidence interval while the other had a reported concentration 15% lower that fell below that interval. Thus, the accuracy of the anomalous sodium concentrations is in question. Round 7 concentrations outside the 95% confidence intervals were also noted for both chloride duplicates (too low), one sulfate duplicate (too low), one calcium duplicate (too high), one magnesium duplicate (too high), and both potassium duplicates (too high). The calcium and magnesium concentrations were 11% and 15% higher, respectively, than the duplicate concentrations that fell within the 95% confidence intervals, suggesting analytical difficulties. The reported potassium concentrations appear to be too high by a factor of two, and may reflect a calculational error associated with dilution of the sample before analysis. Because the low chloride concentrations are offset by the low sodium duplicate concentration, the round 7 charge-balance error is only –4.7%. This error would increase to –5.3% if potassium concentrations were halved. Both chloride and sulfate concentrations will be watched in future rounds of sampling to determine if the rounds 6 and 7 results represent real changes in concentrations, or just anomalous measurements. At the present time, the water quality appears stable at WQSP-4.

WQSP-5

For round 6 sampling of WQSP-5, concentrations outside the 95% confidence intervals were found for one chloride duplicate (too low), both sodium duplicates (too high), both magnesium duplicates (too high), and both potassium duplicates (too high), with an associated charge-balance error of

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+3.8% (Table 2.3). The anomalous chloride concentration was 11% lower than the duplicate concentration that fell within the 95% confidence interval. For definition of the baseline 95% confidence interval for sodium at WQSP-5, one of the round 4 duplicate analyses was excluded. The concentration reported for this analysis was 32% lower than that of the other duplicate, and over eleven standard deviations below the mean defined by the remaining nine baseline analyses. Although both round 6 sodium concentrations were above the 95% confidence interval, both round 7 concentrations were within this level. Thus, there is no cause for concern with the round 6 sodium results. For round 7, both magnesium and potassium duplicates again had concentrations exceeding the 95% confidence intervals, as did single duplicates of chloride and calcium. The high chloride concentration was 19% higher than the duplicate concentration that fell within the 95% confidence interval, and caused the round 7 charge-balance error to be -8.4%. Both magnesium and potassium concentrations will be watched in future rounds of sampling to determine if the rounds 6 and 7 results represent real changes in concentrations, or just anomalous measurements. Because no other parameters seem to be changing, the water quality is stable at WQSP-5.

WQSP-6

For definition of the baseline 95% confidence intervals for chloride, sulfate, sodium, and magnesium at WQSP-6, the round 1 duplicate analyses were excluded. The concentrations of those ions reported for the round 1 analyses were all higher than any values reported since, and three to 39 standard deviations above the means defined by the remaining eight baseline analyses. Even with the narrowing of the confidence intervals caused by excluding those round 1 analyses, all reported concentrations for both rounds 6 and 7 fell within the 95% confidence intervals except for the alkalinity duplicates from round 6 and one magnesium duplicate from round 7 (Table 2.3). The round 6 alkalinity concentrations were identical, and only 2 mg/L below the established confidence interval, while one of the round 7 magnesium duplicates was 1 mg/L below the confidence interval. The charge-balance error for round 6 was only +0.2%, but that for round 7 was –9.6%. The round 7 charge-balance error is largely attributable to sodium concentrations being as low as ever observed. Overall, the WQSP-6 water quality appears to be extremely stable.

WQSP-6A

For definition of the baseline 95% confidence intervals for chloride and magnesium at WQSP-6A, the round 1 duplicate analyses were excluded. The concentrations of those ions reported for the round 1 analyses were all higher than any values reported since, and three to nearly six standard deviations above the means defined by the remaining eight baseline analyses.

With this narrowing of the 95% confidence interval for magnesium, both round 6 duplicates and one round 7 duplicate were 1 to 2 mg/L above the upper limit (Table 2.3). No other ion concentrations were outside their 95% confidence intervals for round 6, and only the potassium duplicates exceeded their confidence interval (by 2 mg/L) for round 7. Charge-balance errors were only +1.7% and –2.1% for rounds 6 and 7, respectively. Thus, water quality appears to be very stable at WQSP-6A.

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Table 2.3. Rounds 6 and 7 Ion Concentrations and Baseline 95% Confidence Intervals

Well	Sample	Cl^- Conc. (mg/L)	SO_4^{2-} Conc. (mg/L)	HCO_3^- Conc. (mg/L)	Na^+ Conc. (mg/L)	Ca^{2+} Conc. (mg/L)	Mg^{2+} Conc. (mg/L)	K^+ Conc. (mg/L)	Charge-Balance Error (%)
WQSP-1	Round 6	37600/34500	4400/4350	-/-	19800/20000	1610/1660	1080/1130	467/487	-2.7
	Round 7	34000/33000	4900/4400	50/50	17550/**16500**	1710/1570	1140/1060	**710/640**	-5.7
	95% C.I.	32300-37700	4090-5880	46-54	17100-20600	1440-1860	898-1210	438-506	
WQSP-2	Round 6	35500/35300	5280/5260	**43**/48	**21000**/20300	1540/1510	1060/1040	481/473	-1.7
	Round 7	37000/35000	5400/5000	46/48	**13400/14300**	1380/1460	950/1000	**580/600**	-18.8
	95% C.I.	30500-39600	4750-6440	45-53	17400-20300	1280-1570	820-1100	391-498	
WQSP-3	Round 6	125000/125000	6770/6770	33/33	74900/77700	1380/1410	**2340/2400**	1460/1500	-0.6
	Round 7	120000/130000	7400/7200	31/31	**58000**/71000	1200/1500	2100/**2500**	1300/1600	-8.5
	95% C.I.	115000-148000	6210-7910	27-45	68000-80300	1030-1550	1730-2220	1190-1750	
WQSP-4	Round 6	57100/**55800**	**6020/5820**	38/38	**37300/37300**	1600/1600	1280/1280	760/760	+3.1
	Round 7	**53000/55000**	**6000**/6100	44/42	31700/**26900**	1560/**1740**	1230/**1420**	**1370/1440**	-4.7
	95% C.I.	56800-62600	6040-7840	29-46	29800-35900	1420-1720	985-1290	622-793	
WQSP-5	Round 6	15300/**13600**	4970/4370	48/48	**10500/10100**	1040/992	**485/468**	**304/301**	+3.8
	Round 7	**19000**/16000	5400/5000	48/50	9560/9140	**1100**/1030	**508/484**	**360/340**	-8.4
	95% C.I.	14100-16500	4110-6090	41-56	8680-9730*	944-1040	409-457	279-295	
WQSP-6	Round 6	6070/6050	4660/4610	**43/43**	4890/4830	714/704	219/219	161/170	+0.2
	Round 7	6000/6000	4800/4900	46/48	4050/3800	680/633	200/**194**	144/137	-9.6
	95% C.I.	5490-6470*	4250-5090*	45-56	3590-5650*	561-770	195-219*	127-206	
WQSP-6A	Round 6	644/624	1950/1890	103/103	335/334	649/661	**173/174**	4.5/4.4	+1.7
	Round 7	770/680	2100/1900	100/100	313/334	646/674	166/**173**	**7.5/7.5**	-2.1
	95% C.I.	486-772*	1550-2630	98-113	257-355	523-722	141-172*	3.6-5.4	

Bold signifies outside 95% confidence interval
*see text for baseline definition

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Changes in Groundwater Composition:

Trigger Value Derivation			
COMP Title:	Groundwater Composition		
COMP Units:	Various – mg/l pCi/l		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Groundwater Monitoring	Composition	Semi-annual chemical and radionuclide analysis	ASER for calendar year 1995
COMP Derivation Procedure			
Annually evaluate ASER data and compare to previous years and baseline information			

Related PA Elements				
Element Title	Type & ID	Derivation Procedure	Compliance Baseline	Impact of Change
Brine Chemistry Actinide solubility	Indirect	Conceptual models	Indirect – The average Culebra brine composition is not used.	Provides validation of the various CCA models, potentially significant with respect to solubility assumptions/redox.

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Change in Culebra Groundwater Composition	TBD	

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2.3.2 Change in Culebra Ground Water Flow (Water Level)

Under the Water-Level Monitoring Program (WLMP), WID made monthly water-level measurements in 60 wells, four of which are completed to two horizons, and quarterly water-level measurements in 16 wells. Culebra water levels were measured in 60 of these wells. Water levels in the Magenta Member of the Rustler Formation were measured in nine wells. Water levels in the unnamed lower member of the Rustler and/or across the Rustler-Salado contact were measured in three wells. Dewey Lake water levels and Santa Rosa water levels were each measured in three wells, and water levels in the Forty-niner Member of the Rustler and the Bell Canyon were each measured in single wells.

Water levels in most of the Culebra wells were stable within 1 or 2 ft during 1998. The Culebra water level in WIPP-30, north of the WIPP site, rose by nearly 5 ft from January to March 1998 and then declined steadily for the remainder of the year. Similar, although of lower magnitude, changes were observed at nearby wells DOE-2, WQSP-1, WQSP-2, WIPP-13, H-6b, and H-18. The cause of the water-level rise in this region is unknown, but may be a response to drilling-fluid loss while drilling petroleum exploration wells in the vicinity of WIPP-30.

Culebra water levels in DOE-2 fluctuated by as much as 6 ft between August and December 1998 in response to a bridge plug failure in the well casing. Culebra water levels in wells near the center of the WIPP site (e.g., H-1, ERDA-9, WIPP-21) generally rose by 2 to 3 ft as part of a long-term recovery response to shaft sealing. Culebra water levels in H-9b oscillated by slightly more than 2 ft. The cause of the fluctuations is unknown, but is under investigation. Culebra water levels in Cabin Baby-1 rose by approximately 2 ft in a continuing response to the replacement of a failed bridge plug in late 1994. The Culebra water level in P-18 rose by 5 ft in 1998, continuing a rise of unknown origin dating back to 1977. It is speculated that the casing in P-18 may not be well cemented, and that the measured water levels reflect leakage from horizons above the Culebra.

The changes in Culebra water levels observed in 1998 have not resulted in hydraulic gradients across the WIPP site exceeding those considered in the PA calculations performed for the CCA, nor have they altered the direction of flow in the Culebra. All of the measured changes are minor and of no significance to PA.

Water levels in the Magenta changed by less than 1 ft in all wells monitored except for H-1, H-2b1, and H-3b1 in 1998. The water level in H-1 rose by approximately 40 ft due to a leak in the well casing. This rise propagated to H-2b1 and H-3b1, where water levels rose by approximately 3.6 ft and 4.4 ft, respectively. These water-level rises should dissipate once the casing in H-1 is repaired, and are of no significance to PA.

Water levels were stable within 1 ft in two of the three Dewey Lake wells, two of the three Rustler-Salado wells, the three Santa Rosa wells, and the Forty-niner well. The Dewey Lake water level in H-16 dropped by 11 ft in 1998, but this represents a recovery from the well being accidentally filled with rain water. The water level from the unnamed lower member and Rustler-Salado contact in H-16 experienced a net decrease of approximately 2.5 ft, continuing an oscillatory downward trend that started around 1990, believed to be related to very slow leakage into the WIPP shafts.

The Bell Canyon water level in AEC-8 increased by approximately 14 ft in 1998, continuing a rise of unknown origin dating back to 1993. The cause of this rise is currently under investigation.

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In summary, a complete review of the data collected under the WLMP shows that the water-level changes that have occurred do not have any significance to PA.

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Changes in Groundwater Flow:

Trigger Value Derivation			
COMP Title:	Changes in Groundwater Flow		
COMP Units:	Inferred from water level data		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g. number, observation)	Compliance Baseline Value
Groundwater Monitoring	Head and Topography	Monthly water-level measurements.	Indirect
COMP Derivation Procedure			
Annual assessment from ASER data.			

Related PA Elements				
Element Title	Type & ID	Derivation Procedure	Compliance Baseline	Impact of Change
Groundwater conceptual model Transmissivity Fields				Provides validation of the various CCA models - T-Field assumptions and groundwater basin model.

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Change in Culebra Groundwater Flow	TBD	Monthly comparisons with previous data and annual data comparisons with baseline and ASER data

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2.3.3 Hydrological Geotechnical COMPs Concluding Remarks

Our evaluation of the water-quality data collected in 1998 shows that major ion concentrations are generally stable at all seven sampled wells. Most of the reported concentrations that fall outside the baseline 95% confidence intervals appear random and probably reflect analytical problems. Chloride concentrations at WQSP-4, magnesium concentrations at WQSP-3, 5, and 6A, and potassium concentrations at WQSP-5 will be observed in coming years to determine if the data from WQSP rounds 6 and 7 reflect actual trends, analytical problems or just measurement anomalies.

No water-level changes have been observed in any horizon that are of concern to PA. Water-level fluctuations in the Culebra at H-9 and the water-level rise in the Bell Canyon at AEC-8 are under investigation.

2.4 Waste Activity COMP

The CCA lists ten COMPs that the DOE is required to monitor and assess during the WIPP operational period. One of these parameters monitor "Waste Activity" of the emplaced waste and is thus entitled:

- Waste Activity

Waste activity and other data are tracked in the WIPP Waste Information System (WWIS). This system is used to ensure waste meets all WIPP specific requirements prior to approval and shipment to WIPP. Data contained in the WWIS includes such things as, container number, generator location, waste stream information, assay date, disposal date, nondestructive examination information, Pu^{239} fissile gram equivalent, radionuclide activity and uncertainty, radionuclide mass and uncertainty, TRU alpha activity and uncertainty, cellulostic, plastics and rubber quantities, verification data, verification method, visual examination of container information and WAC certification data. This information is contained in an accessible database, which can generate reports on demand. A report is generated annually with the waste activity COMP data.

2.4.1 Waste Activity

Only a limited amount of waste has been emplaced in the WIPP as of September, 1999. A total of 1,278 55-gallon drum equivalents of CH TRU are currently stored at WIPP from five of the 569 anticipated waste streams. As discussed in the Trigger Value Derivation Report, Waste Activity COMPs assessments are not performed until half of a panel is filled since small quantities do not yield statistically valid assessments (1,278 drum equivalents or 9,474 ft^3 represents only 0.15% of the total WIPP volume capacity of 6.2 million cubic feet). There are no recognized reportable issues associated with this COMP. No changes to the monitoring program are recommendation.

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Waste Activity:

Trigger Value Derivation			
CMPMP Title:	Waste Activity		
CMPMP Units:	Curies		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
WWIS	Radionuclide activity per container and volume	Curies per container. Container volume.	Appendix P of CCA Appendix BIR (DOE, 1996) by waste stream.
Waste emplacement records	Location of waste in panels	Coordinates and number of containers (or volume in cubic meters).	None.
COMP Derivation Procedure			
Map of waste activity distribution in each panel. Total curie content of emplaced CH-TRU and RH-TRU waste. *[Total radionuclide inventories reported annually by WWIS]*			

Related PA Elements				
Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
Radionuclide inventories	Parameter	Product of waste stream content and volume scaled up to the LWA limits.	Table PAR-41 and Table 4-8 of the CCA.	May affect direct brine releases for those radionuclides that become inventory-limited during a PA simulation.
Activity of waste intersected for cuttings and cavings releases.	Parameter	Function of waste stream volumes and activities	Figure 6-31 of the CCA	Cuttings are a significant contributor to releases. Therefore, an increase in activity of intersected waste is potentially significant.
WIPP-scale average activity for spallings releases	Parameter	Average of all CH-TRU waste only.	-	Spallings are a significant contributor to releases. Therefore, an increase in average activity of intersected waste is potentially significant.

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Waste emplacement records	Panel half-full	Check that PA assumptions about waste activity will remain valid as remainder of panel is filled and verify random emplacement assumptions.
Total emplaced RH-TRU waste activity	5.1 million curies	LWA emplacement limit reached. Administrative controls address these limits.

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3 COMPs Assessment Conclusion

The WIPP became operational in 1999, accepting its first shipment of TRU waste. This event initiated the operational period monitoring program designed to meet the assurance requirements of the EPA radioactive waste certification decision. This monitoring program was designed to further validate the data, parameters and assumptions used to predict WIPP radioactive waste containment performance. The monitoring program was intended to identify conditions that could potentially cause radioactive release above the allowable 40 CFR 191 release limits. Since releases above these limits cannot occur during the operational period of WIPP, the monitoring program looks at monitorable aspects of the disposal system and compares them to performance assessment expectations. Ten monitoring parameters are assessed annually to these expectations. The results of this assessment are documented in this report and conclude that there are no COMPs data or results that are unexpected. Also, at this time, the results do no merit modification to the monitoring program. No changes to any aspect of the compliance-monitoring program are recommended.

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