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Parameter Assessment for 2008

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Acronym List

CBE	charge balance error
CBFO	Carlsbad Field Office
CCA	Compliance Certification Application
CFR	Code of Federal Regulations
CH	contact handled
CI	confidence interval
CL	center line
COMP	compliance monitoring parameter
CP	convergence point
CRA	Compliance Recertification Application
DOE	Department of Energy
DRZ	disturbed rock zone
DTW	depth to water
EPA	Environmental Protection Agency
Ext	extensometer
FEP	feature, event or processes
FWH	freshwater head
GAR	geotechnical analysis report
LWB	Land Withdrawal Boundary
M&OC	management and operating contractor
MB	marker bed
MIP	Compliance Monitoring Implementation Plan
nr	no reading
OHB	observation borehole
PA	performance assessment
PABC	Performance Assessment Baseline Calculation
PAVT	Performance Assessment Verification Test
PD	pressure density
PIP	production-injection packer
RCRA	Resource Conservation and Recover Act
RH	remote handled
SA	scientific advisor
SER	site environmental report
SG	unitless ratio of the water density being measured to that of freshwater
SNL	Sandia National Laboratories
TRU	transuranic
TSD	total dissolved solids
TV	trigger value
WIPP	Waste Isolation Pilot Plant
WLMP	water level monitoring program
WQSP	water quality sampling survey
WRES	Washington Regulatory and Environmental Services
WWIS	WIPP waste information system

Executive Summary

This document reports the ninth annual (2008) derivation and assessment of the Waste Isolation Pilot Plant (WIPP) Compliance Monitoring Parameters (COMPs). The COMPs program is designed to meet certain requirements of the U.S. Environmental Protection Agency's (EPA) long-term disposal regulations (EPA 1993 and 1996). The concept of deriving and assessing COMPs is explained in Sandia National Laboratories (SNL) Activity/Project Specific Procedure, SP 9-8, titled: *Monitoring Parameter Assessment Per 40 CFR 194.42* (SNL 2008a).

The WIPP has many monitoring programs, each designed to meet various regulatory and operational safety requirements. The comprehensive WIPP monitoring effort is not under the auspice of one program, but is comprised of many discrete elements, one of which was designed to fulfill the EPA's long-term disposal requirements found at 40 CFR Part 191 Subparts B and C, and the Certification Criteria at 40 CFR Part 194. Monitoring parameters that are related to the long-term performance of the repository were identified in a monitoring analysis.[1] Since these parameters fulfill a regulatory function, they were termed Compliance Monitoring Parameters so that they would not be confused with similar performance assessment (PA) input parameters.

The Department of Energy (DOE) uses PA to predict the radioactive waste containment performance of the WIPP. COMPs are used to indicate conditions that are not within the PA data ranges, conceptual model assumptions or expectations of the modelers and to alert the project of conditions not accounted for or anticipated. COMPs values and ranges were developed such that exceedances of identified values indicate a condition that is potentially outside PA expectations. These values were appropriately termed "trigger values." Deriving COMPs trigger values (TVs) was the first step in assessing the monitoring data. TVs were derived in 1999 and are documented in the *Trigger Value Derivation Report* (SNL 2000a & 2002a). In some instances, a COMP will not have a TV because sensitivity analysis has demonstrated that PA is insensitive to that parameter or because the parameter is subjective in nature and is not directly related to PA inputs.

This COMPs Report is the third derived after WIPP's recertification (the Compliance Recertification Application (CRA-2004; DOE 2004) was submitted and subsequent WIPP recertification notification in EPA 2006). The EPA requested a new PA in support of the recertification called the Performance Assessment Baseline Calculation (PABC-2004). The PABC-2004 therefore, represents the current compliance baseline. This year's COMPs assessment compares the monitoring parameters against the original certification baseline and the revised PABC-2004 baseline where appropriate. Reference to the appropriate baseline will be highlighted in this report.

Work had been initiated to reassess the compliance monitoring program (per 40 CFR § 194 .42 – see SNL AP-126, Wagner 2005). This reassessment was intended to analyze the impact of WIPP programmatic, operational and regulatory changes on the COMPs program to ensure the program continues to meet the intent of the 194.42 regulatory monitoring requirements. The results of this activity were intended to derive and recommend changes to the COMPs program

[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.

as necessary. Any changes to the compliance monitoring program will require EPA approval through a planned change request. However, the change request containing any potential changes to the COMPs program was rescheduled until after the second recertification.

In the initial Certification Ruling (EPA 1998a), EPA approved 10 COMPs, 2 relating to human activities, 5 relating to geotechnical performance, 2 relating to regional hydrogeology and 1 relating to the radioactive components of the waste. The EPA also requires the DOE to report any condition that would indicate the repository would not function as predicted or a condition that is substantially different from the information contained in the most recent compliance application. The DOE complies with these EPA requirements by conducting periodic assessments of COMPs that 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 Parts 191 and 194 Compliance Monitoring Implementation Plan* (MIP; DOE 2005).

This 2008 COMPs assessment present the results and the recommendations based on the COMPs monitoring data gathered during the reporting cycle. This assessment concludes that the current COMP values do not indicate a condition for which the repository will perform in a manner other than that represented in the WIPP certification PAs.

1 Introduction

The WIPP is governed by the EPA's long-term radioactive waste disposal regulations at 40 CFR Part 191 Subparts B and C (EPA 1993) and the WIPP-specific certification criteria at 40 CFR Part 194 (EPA 1996). Monitoring WIPP performance is an "assurance requirement" of these regulations and is intended to provide assurances that the WIPP will protect the public and environment (see 40 CFR § 191.14). 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 deviations from the expected long-term performance of the repository are identified at the earliest possible time. These DOE commitments are represented by 10 COMPs, which are listed in Section 2.

The COMPs are an integral part of the overall WIPP monitoring strategy. The DOE's *40 CFR Part 191 and 194 Compliance Monitoring Implementation Plan* (MIP; DOE 2005) describes the overall monitoring program and responsibilities for COMPs derivation and assessment. This report documents the results of the reporting year 2008 COMPs assessment (July 1st 2007 to June 30th 2008). This reporting period matches the reporting period of the annual report that addresses 40 CFR § 194.4(b)(4) requirements (EPA 2003). This COMPs assessment follows the program developed under the original certification baseline using data and PA results from the 2004 recertification's Performance Assessment Baseline Calculation (PABC-2004).

1.1 Monitoring and Evaluation Strategy

The Compliance Monitoring Program is an integrated effort between the Management and Operating Contractor (M&OC), the Scientific Advisor (SA) and the DOE Carlsbad Field Office (CBFO). The CBFO oversees and directs the monitoring program to ensure compliance with the EPA monitoring and reporting requirements. The SA is responsible for the development and maintenance of the TVs. An observation beyond the acceptable range of TVs represents a condition that requires further actions, but does not necessarily indicate an out-of-compliance condition. This approach assures that conditions that are not consistent with expected repository performance are recognized as early as possible. These conditions may include data inconsistent with the conceptual models implemented in PA, or invalidation of assumptions and arguments used in the screening of Features, Events and Processes (FEPs) screened into PA.

1.2 Reporting Cycle

The types of changes that must be reported to EPA are defined in 40 CFR §194.4. Under 40 CFR §194.4, changes that differ from the activities or conditions outlined in the latest compliance application are defined as either significant or non-significant based on their potential impact on radionuclide releases. This part of the rule also identified the timeframe to which the DOE is required to report significant and non-significant changes to the EPA. As such, the CCA and the CRA-2004 state in Section 7.2.1 that the results of the monitoring program would be submitted annually (DOE 1996, DOE 2004). Additionally, the recertification requirements at 40 CFR §194.15(a)(2) also require inclusion of all additional monitoring data, analysis and results in the DOE's documentation of continued compliance as submitted in periodic CRAs.

Monitoring data, the associated parameter values and monitoring information must be reported even if the assessment concludes there is no impact on the repository. The annual monitoring data will be compiled and provided to the DOE to fulfill DOE's monitoring reporting requirements to the EPA. The SA's role in the annual reporting task is to use the monitoring data to derive the COMPs, compare the results to repository performance expectations in PA and to use the new and updated information to make any recommendations for modification to the Compliance Baseline.

2 Assessment of COMPs

The compliance monitoring program tracks the following 10 COMPs:

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

A periodic 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."

This section summarizes the results of the 2008 calendar year assessment. In the following sections, each COMP is evaluated and compared to the applicable TV. This assessment is performed under Specific Procedure SP 9-8 (SNL 2008a). A table for each of the ten COMPs is used to summarize the evaluation and shows the COMP derivation, related PA parameters and FEPs, the current value for the COMPs as applicable and the TV.

2.1 Human Activities COMPs

The CCA identifies 10 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

Monitoring activities for Castile brine encounters have identified no new brine encounter during this reporting period. The total of encounters identified since the CCA is 7. These encounters are detailed in Table 2.1. Data used for the CCA were compiled from drilling record searches for the region surrounding the WIPP. The results of this initial search recorded 27 drilling encounters with pressurized brine (water) in the Castile Formation. Of these encounters, 25 were hydrocarbon wells scattered over a wide area in the vicinity of the WIPP site; 2 wells, ERDA 6 and WIPP 12, were drilled in support of the WIPP site characterization effort (see DOE 2008a, Table 7 for a complete listing of brine encounters). 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 to determine if pressurized brine was encountered. Since the CCA, data have been compiled through August 2008. No pressurized Castile brine encounters have been reported in the official drilling records for wells drilled in the New Mexico portion of the Delaware Basin (DOE 2008a).

Of the 7 Castile Brine encounters recorded since the 1996 CCA, 6 were identified when WIPP Site personnel performing field work talked to area drillers. The other encounter was reported by an operator in the Annual Survey of area drillers. All the new encounters are located in areas where Castile Brine is expected to be encountered during the drilling process. Table 2.1 shows all known Castile Brine encounters in the vicinity of the WIPP Site since the CCA.

The impacts of brine encounters are modeled in the PA. The CCA used a 0.08 probability of encountering a Castile brine reservoir. In the Performance Assessment Verification Test (PAVT), the EPA mandated a probability range of 0.01 to 0.60. The new range did not significantly influence the predicted performance of the repository. This range was also used in all recertification PAs including the Compliance Recertification Application (CRA-2004) PA. The EPA also determined in their sensitivity analysis that this parameter (indentified in the PA as PBRINE) does not have a significant impact on PA results (EPA 1998b).

Table 2.1 Well Locations Encountering Brine since the CCA[1]

Number	Location	Well Name and Location	Spud Date	Well Information
1	T21S-R31E-Sec 35	Lost Tank "35" State #4	09/11/2000	Oil Well: Estimated several hundred barrels per hour. Continued drilling.
2	T21S-R31E-Sec 35	Lost Tank "35" State #16	02/06/2002	Oil Well: At 2,705 ft, encountered 1,000 Barrels per hour. Shut-in to get room in reserve pit with pressure of 180 psi. and water flow of 450 barrels per hour. Two days later, no water flow/full returns.
3	T22S-R31E-Sec 2	Graham "AKB"State #8	04/12/2002	Oil Well: Estimated 105 barrels per hour. Continued drilling.
4	T23S-R30E-Sec 1	James Ranch Unit #63	12/23/1999	Oil Well: Sulfur water encountered at 2,900 ft 35 ppm H_2S was reported but quickly dissipated to 3 ppm in a matter of minutes. Continued drilling.
5	T23S-R30E-Sec 1	Hudson "1" Federal #7	01/06/2001	Oil Well: Estimated initial flow at 400 to 500 barrels per hour with a total volume of 600 to 800 barrels. Continued drilling.
6	T22S-R30E-Sec 13	Apache "13" Federal #3	11/26/2003	Oil Well: Encountered strong water flow with blowing air at 2,850-3,315 ft 362 ppm H_2S was reported. Continued drilling.
7	T21S-R31E-Sec 34	Jaque "AQJ" State #7	03/04/2005	Oil Well: Encountered 104 barrels per hour at 2,900 ft. No impact on drilling process.

[1] From DOE 2008a, Table 7.

Table 2.2 Probability of Encountering a Brine Reservoir - 2008:

<table>
<tr><td colspan="5">Trigger Value Derivation</td></tr>
<tr><td>COMP Title:</td><td colspan="4">Probability of Encountering a Castile Brine Reservoir</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Unitless</td></tr>
<tr><td colspan="5">Related Monitoring Data</td></tr>
<tr><td>Monitoring Program</td><td>Monitoring Parameter ID</td><td>Characteristics (e.g., number, observation)</td><td colspan="2">Compliance Baseline Value</td></tr>
<tr><td>DBMP(1)</td><td>NA</td><td>Driller's survey – Field observations</td><td colspan="2">0.01 to .060</td></tr>
<tr><td colspan="5">COMP Derivation Procedure</td></tr>
<tr><td colspan="5">Analysis of encounters of pressurized brine recorded and reported by industry in the 9-township area centered on WIPP.</td></tr>
<tr><td colspan="5">Year 2008 COMP Assessment Value - Reporting Period September 2007 to August 2008</td></tr>
<tr><td colspan="5">No new data reported in State record during the reporting period; No new report from Field Observations. 34 Total Brine Encounters
27 CCA total occurrences before 1996
0 State Record occurrences since 1996
7 Site Personnel/ Drillers Survey occurrences since 1996</td></tr>
<tr><td colspan="5">Related Performance and Compliance Elements</td></tr>
<tr><td>Element Title</td><td>Parameter Type & ID or Model Description</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>Probability of Encountering Brine</td><td>Parameter PRBRINE</td><td>CCA MASS Attachment 18-6 geostatistical study based on area occurrences.

EPA Technical Support Document justified the upper value in their range by rounding up the upper value interpreted from the Time Domain Electromagnetic survey, which suggested a 10 to 55% areal extent.</td><td>0.08

0.01 to 0.60</td><td>Not a sensitive parameter.</td></tr>
<tr><td colspan="5">Monitoring Data Trigger Values</td></tr>
<tr><td>Monitoring Parameter ID</td><td>Trigger Value</td><td colspan="3">Basis</td></tr>
<tr><td>Probability of Encountering a Castile Brine Reservoir</td><td>None</td><td colspan="3">After the DOE proposed the brine reservoir probability as potentially significant in the CCA Appendix MONPAR, the EPA conducted analyses that indicate a lack of significant effects on performance from changes in this parameter. For this reason and since the parameter is evaluated for significant changes at least once annually, no TV is needed.</td></tr>
</table>

(1) Delaware Basin Monitoring Program

2.1.2 Drilling Rate

The drilling rate COMP tracks deep drilling (> 2,150 ft in depth) activities relating to resource exploration and extraction. Boreholes relating to resources include potash and sulfur bore holes, hydrocarbon exploration wells, saltwater disposal wells and water wells drilled in the Delaware Basin. The first drilling rate, reported in the 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 23,102.1 square kilometers (area of the Delaware Basin) divided by 100 years of the observation interval equals the number of boreholes per square kilometer per 10,000 years. The number of deep boreholes over the last 100-year observation period is used in the equation (1896 – June 1995 for the CCA value). 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 1996 to June 2008) increases the rate to 59.8 boreholes per square kilometer per 10,000 years (DOE 2008a).

Table 2.3 Drilling Rates for Each Year since the CCA.

Year	Number of Boreholes Deeper than 2,150 ft for the Applicable 100-year Period	Drilling Rate (bore holes per square kilometer per 10,000 years)
1996 (CCA Value)	10,804	46.8
1997	11,444	49.5
1998	11,616	50.3
1999	11,684	50.6
2000	11,828	51.2
2001	12,056	52.2
2002[1]	12,219	52.9
2002 (revised)	12,139	52.5
2003	12,316	53.3
2004	12,531	54.2
2005	12,819	55.5
2006	13,171	57.0
2007	13,520	58.5
2008	13,824	59.8

As shown in Table 2.3, the drilling rate has risen from 46.8 holes per square kilometer to 59.8 holes per square kilometer since 1996. The rate will continue to climb because of the method used to calculate the rate. Since the first well drilled in the area occurred in 1911, it will be 2011 before one well is dropped from the count and 2014 before the next well is dropped from the count. In the meantime, numerous wells will have been added, increasing the drilling rate.

[1] In Revision 3 of DOE 2008a (dated 2002) and last year's COMPs report DOE 2008b, the drilling rate for 2002 was shown as 52.9, with 12,219 deep boreholes. It was later noted that 80 shallow wells in Texas were listed as being deep. Correcting the classification of the 80 boreholes resulted in a reduction of the drilling rate from 52.9 to 52.5 (DOE 2008a).

When the TV derivation report was written, it was thought that the drilling rate used in PA would not be changed for each recertification (SNL 2000a). However, each recertification updates the drilling rate parameter and effectively accounts for the change in rate. Because the change in the drilling rate is accounted for every 5 years, the concept of applying a TV is unnecessary. Although the drilling rate TV was exceeded in 2004, the exceedance was expected. As discussed in the Delaware Basin Monitoring Annual Report, the drilling rate will continue to rise with each new well drilled until the 100-year window moves to a point in time when there are more older wells removed from consideration than new wells are added. Studies have demonstrated that much higher drilling rates are needed to impact compliance (EEG 1998). For example, in response to a request from EPA (EPA 2004), the SA analyzed the impact of drilling rate on repository performance. This analysis shows that even if the drilling rate were doubled relative to that used for the CRA-2004 PA, the disposal system performance would be well within the release limits set by EPA regulations (Kanney and Kirchner 2004).

Table 2.4 Drilling Rate - 2008:

Trigger Value Derivation				
COMP Title:	Drilling Rate			
COMP Units:	Deep boreholes (i.e., > 2,150 ft deep)/square kilometer/10,000 years			
Related Monitoring Data				
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)		
DBMP	Deep hydrocarbon boreholes drilled	Integer per year		
COMP Derivation Procedure				
(Total number of deep boreholes drilled/number of years of observations (100)) x (10,000/23,102.1) [i.e., over 10,000 years divided by the area of the Delaware Basin in square kilometers]				
Year 2008 COMP Assessment Value - Reporting Period September 1, 2007 to August 31, 2008				
(13,824 boreholes on record for the Delaware Basin) Drilling Rate = 59.8 boreholes per square kilometer per 10,000 yrs.				
Related Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Drilling rate	Parameter LAMBDAD	COMP/10,000 years	5.85 E-03 per square kilometer per year	Cuttings/cavings releases increase proportionally with the drilling rate. Doubling CRA-2004 drilling rate does not exceed compliance limit.
Monitoring Data Trigger Values				
Monitoring Parameter ID	Trigger Value	Basis		
Deep boreholes	NA.	Calculations have shown that doubling the drilling rate does not impact compliance with the EPA release limits (Kanney and Kirchner 2004).		

2.2 Geotechnical COMPs

The CCA lists 10 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

Data needed to derive and evaluate the geotechnical COMPs are available from the most recent annual Geotechnical Analysis Report (GAR; DOE 2008b) and the annual Subsidence Monument Leveling Survey (DOE 2007a). Three of the geotechnical parameters lend themselves to quantification: creep closure, displacement of deformation features and subsidence. In contrast, the extent of deformation and initiation of brittle deformation are qualitative or observational parameters.

The WIPP GARs have been available since 1983 and are currently prepared by the M&OC on an annual basis. The purpose of the GAR is to present and interpret geotechnical data from the underground excavations. These data are obtained as part of a regular monitoring program and are used to characterize current conditions, to compare actual performance to the design assumptions, and to evaluate and forecast the performance of the underground excavations during operations. Additionally, the GAR fulfills various regulatory requirements and through the monitoring program, provides early detection of conditions that could affect operational safety, data to evaluate disposal room closure, and guidance for design changes. Data are presented for specific areas of the facilities including: (1) Shafts and Keys, (2) Shaft Stations, (3) Northern Experimental Area, (4) Access Drifts, and (5) Waste Disposal Areas. Data are acquired using a variety of instruments including convergence points and meters, multipoint borehole extensometers, rockbolt load cells, pressure cells, strain gauges, piezometers and joint meters. All of the geotechnical COMPs involve analyses of deformations/displacements, so the most pertinent data derived from the GAR are convergence and extensometer data. The most recent GAR (DOE 2008b) summarizes data collected from July 2006 through June 2007.

Subsidence monitoring survey reports are also prepared by the M&OC on an annual basis and present the results of leveling surveys performed in 2007 for 9 vertical control loops comprising approximately 15 linear miles traversed over the ground surface of the WIPP site. Elevations are determined for 48 current monuments and 14 National Geodetic Survey vertical control points using digital leveling techniques to achieve Second-Order Class II loop closures or better. The data are used to estimate total subsidence and subsidence rates in fulfillment of regulatory requirements. The most recent survey (DOE 2007a) summarizes data collected between August and December of 2007.

Comparisons between available geotechnical COMP related data and the TVs allow evaluation of the most recent geotechnical observations for the COMPs program. The cited reports and programs provide a good evaluation of all observations where deviations from historical normal occurrences are recorded. This process, as engaged for COMPs assessments, not only focuses attention on monitored parameters, it allows for reassessment of the proposed TVs. Notable deviations are addressed in the GAR and other references, and are reexamined here in the context of COMPs and TVs.

Geotechnical COMPs can be derived from or related to the repository's operational safety monitoring program, which has been implemented to ensure worker and mine safety. By nature, changes in geotechnical conditions evolve slowly; however, they are monitored continuously and reported annually. Since pertinent data from the underground reflect slowly evolving conditions, relationships that correlate to geotechnical COMPs also evolve slowly. Therefore, geotechnical conditions warranting action for operational safety will become evident before such conditions would impact long-term waste isolation. Monitoring underground response allows continuing assessment of conceptual geotechnical models supporting certification. In effect, these annual comparisons of actual geotechnical response with expected response serve to validate or improve models.

2.2.1 Creep Closure

The GAR compiles all geotechnical operational safety data gathered from the underground. The most readily quantifiable geomechanical response in the WIPP underground is creep closure. The GAR routinely measures and reports creep deformation, either from rib-to-rib, roof-to-floor, or extensometer borehole measurements. With the exception of newly mined openings, rates of closure are relatively constant within each zone of interest and usually range from 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 closure rate by the room dimension and converting time into seconds. Nominally these rates are of the order of $1x10^{-10}$ /s and are 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 alert the project to scrutinize the area exhibiting accelerating creep rates.

Extensive GAR data suggest that possible TV 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, indicating a change in the deformational 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 PA assumption confirmation. Therefore, a measured creep rate change over a yearly period constitutes the COMP TV for creep closure. Rate changes are necessarily 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.

The creep closure COMP is addressed by examining the closure rate measured in specific regions of the underground including: (I) Shafts and Shaft Stations and (2) Access Drifts and Waste Disposal Areas. Figure 2.1 shows the current configuration of the WIPP underground with specific elements and regions annotated for reference. Information used for all geotechnical COMPs is derived from the GAR which has a reporting period ending June 2007. For this reporting period, Panels 1 through 4 had been fully excavated and panel 5 was started but not completed. Figure 2.1 shows all areas mined as of June 30, 2007. At that time, waste was being emplaced in panel 4 while panels 1, 2 and 3 waste disposal operations had ceased and the entry drifts had been sealed to prevent access (please note that the reporting period for geotechnical information is through June 2007 such that the reported mining and emplacement activities depicted in Figure 2.1 from the GAR are not as current as the waste activity COMP information, which is through June 2008.

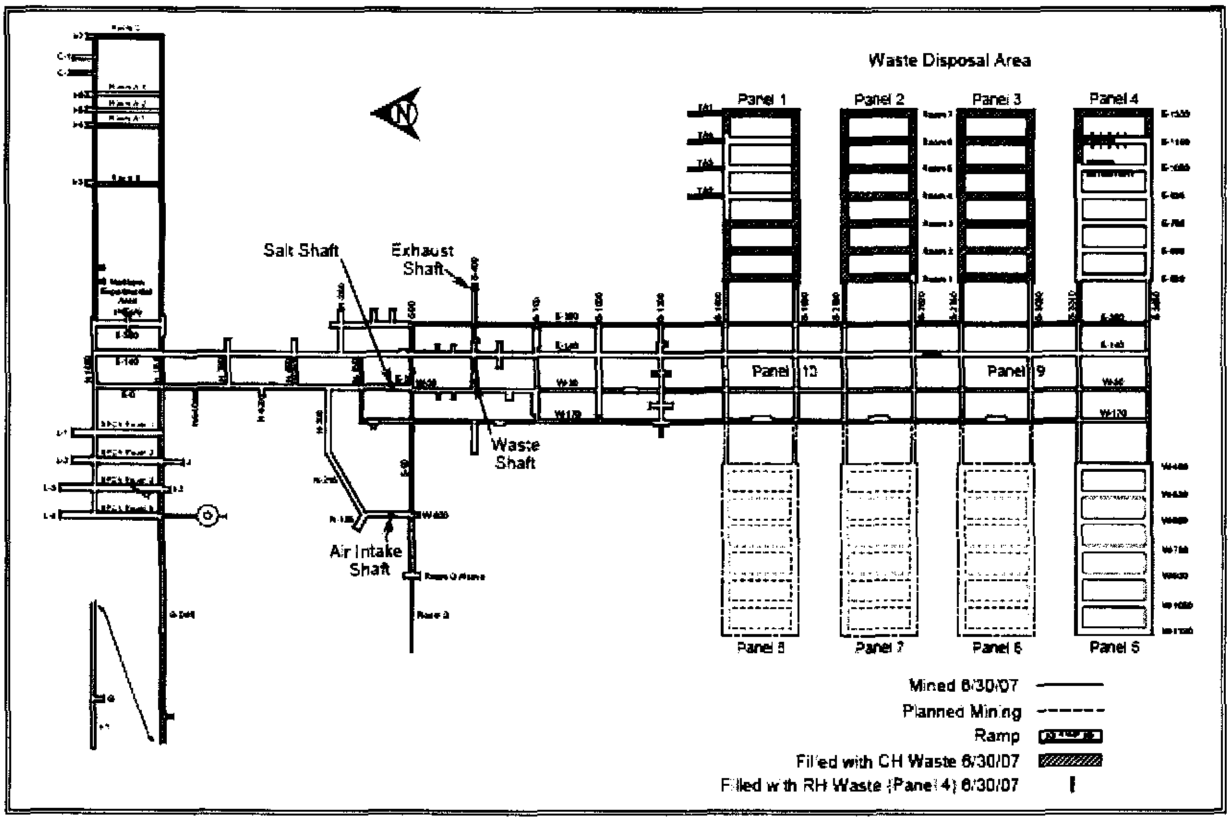


Figure 2. 1 Configuration of the WIPP Underground for Geotechnical COMPs (after DOE 2008b; Reporting Period July 2006 through June 2007).

Shafts and Shaft Stations

The WIPP underground is serviced by 4 vertical shafts including the following: (1) Salt Handling Shaft, (2) Waste Shaft, (3) Exhaust Shaft, and (4) Air Intake Shaft. At the repository level (approximately 650 m below ground surface), enlarged rooms have been excavated around the Salt Handling and Waste shafts to allow for movement of equipment, personnel, mined salt and waste into or out of the facility. The enlarged rooms are called shaft stations and assigned designations consistent with the shaft they service (e.g., Salt Handling Shaft Station).

Shafts. With the exception of the Salt Handling Shaft, the shafts are configured nearly identically. From the ground surface to the top of the Salado Formation, the shafts are lined with non-reinforced concrete. Reinforced concrete keys are cast at the Salado/Rustler interface with the shafts extending through the keys to the Salado. Below the keys, the shafts are essentially "open holes" through the Salado Formation and terminate either at the repository horizon or at sumps that extend approximately 40 m below the repository horizon. In the Salt Handling Shaft, a steel liner is grouted in place from the ground surface to the top of the Salado. Similar to the 3 other shafts, the Salt Handling Shaft is configured with a reinforced concrete key and is "open-hole" to its terminus. For safety purposes, the portions of the open shafts that extend through the Salado are typically supported using wire mesh anchored with rock bolts to contain rock fragments that may become detached from the shaft walls. Within the Salado Formation, the shaft diameters range from 3.65 m to 7.0 m.

Data available for assessing creep closure in the salt surrounding the shafts are derived exclusively from routine inspections and extensometers extending radially from the shaft walls. These data are reported annually in the GAR. The Salt Handling Shaft, Waste Shaft, and Air Intake Shaft are inspected weekly by underground operations personnel. Although the primary purpose of these inspections is to assess the conditions of the hoisting and mechanical equipment, observations are also made to determine the condition of the shaft walls, particularly with respect to water seepage, loose rock, and sloughing. In contrast to the other 3 shafts, the Exhaust Shaft is inspected quarterly using remote-controlled video equipment. These inspections have focused on salt build-up in the Exhaust shaft and the impacts this build-up has on power cabling in the shaft. Based on these visual observations, all 4 shafts are in satisfactory condition and have required only routine ground-control activities during this reporting period.

Shortly after its construction, each shaft was instrumented with extensometers to measure the inward movement of the salt at 3 levels within the Salado Formation. In addition to COMPs assessment, measurements of shaft closure are used periodically as a calibration of calculational models and have been used in shaft seal system design. The approximate depths corresponding to the 3 instrumented levels are 330 m, 480 m and 630 m. Three extensometers are emplaced at each level to form an array. The extensometers comprising each array extend radially outward from the shaft walls and are equally spaced around the perimeter of the shaft wall. Over the years, most of these extensometers have malfunctioned. As a result, reliable data are not available at some locations. The DOE currently has no plans to replace failed instrumentation installed in any of the shafts because monitoring data acquired to date have shown no unusual shaft movements or displacements.

Table 2.5 provides a summary of the current closure rates of the shaft walls based on data reported in the GAR (DOE 2008b). It should be noted that 6 of the 9 extensometers installed in the waste shaft 23 years ago continue to function however no data was collected during the reporting period because of a data logger failure. The type of extensometer is no longer manufactured nor is a compatible data logger. DOE does not plan to replace the logger with an alternate because of compatibility and interface issues. As such, the rate information from the Waste shaft is reported but was not used in this assessment.

Shaft Station. Shaft station openings are typically rectangular in cross-section with heights ranging from approximately 4 to 6 m and widths ranging from 6 to 10 m. Over the life-time of the individual shaft stations, modifications have been made that have altered the dimensions of the openings. In the past, portions of the Salt Handling Shaft Station have been enlarged by removing the roof beam that extended up to anhydrite "b". In the Waste Handling Shaft Station, the walls have been trimmed to enlarge the openings for operational purposes. No major modifications were performed at the shaft stations during this reporting period. Ground control, bolt replacement, bolt trimming and cable shoe anchor replacement were performed as routine maintenance.

The effects of creep on the shaft stations are assessed through visual observations and closure measurements made using extensometers and convergence points. Because of the modifications made over the years, many of the original instrumentation has been removed or relocated. In addition, some instruments have malfunctioned or have been damaged and no longer provide reliable data. Closure rates from existing and functional instrumentation listed in the GAR for the current reporting period (2006-2007) and the previous reporting period (2005-2006) are summarized in Table 2.5. Most of the measurements are for vertical closure. Based on convergence data (excluding the waste shaft), current vertical closure rates range from 0.08 to 1.05 in/yr (0.20 to 2.67 cm/yr); current horizontal closure rates range from 0.25 to 1.55 in/yr (0.64 to 3.94 cm/yr). Dividing closure rates by the average room dimension (approximately 6 meters) and expressing the results in units of 1/sec yields vertical and horizontal creep rates between approximately 1.06×10^{-11}/s to 2.68×10^{-10}/s. These rates are still low and represent typical creep rates for stable openings in salt. An examination of the percentage changes in closure rates shown in Table 2.5 suggests the current shaft station closure rates (where available) are essentially identical to those measured during the previous reporting period. Based on the extensometer and convergence data, as well as the limited maintenance required in the shaft stations during the last year, creep closure associated with the WIPP shaft stations are considered acceptable and meet the TV requiring creep rates to change by less than one-order of magnitude in a one-year period.

Table 2.5 Summary of Closure Rates for WIPP Shafts and Shaft Stations.

Location	Inst. Type[(a)]	Closure Rate (in/yr)[(c)]		Change In Rate (%)
		2005–2006	2006–2007	
Salt Handling Shaft	No extensometers remain functional			
Waste Handling Shaft				
1071 ft (326 m) level, S15W	Ext	-0.003	nr	-
1566 ft (477 m) level, N45W	Ext	-0.010	nr	-
1566 ft (477 m) level, N75E	Ext	nr	nr	-
1566 ft (477 m) level, S15W	Ext	0.010	nr	-
2059 ft (628 m) level, N45W	Ext	-0.025	nr	-
2059 ft (628 m) level, N75E	Ext	0.410	nr	-
2059 ft (628 m) level, S15W	Ext	-0.807	nr	-
Exhaust Shaft	No extensometer data available for 2004-2006			
Salt Handling Shaft Station				
E0 Drift – S30 (Vert)	Ext	nr	nr	-
E0 Drift – S60 (Vert)	Ext	0.03	nr	-
E0 Drift – W12 (Vert CL)	CP	0.50	nr	-
E0 Drift – S18 (Vert. CL)	CP	1.36	1.51	11
E0 Drift – S30 (Vert. CL)	CP	1.46	1.55	6
E0 Drift – S65 (Vert. CL)	CP	1.02	1.15	13
Waste Shaft Station				
S400 Drift – W30 (Vert. CL)	Ext	0.28	0.25	-11
Waste Shaft Brow (North)	Ext	0.08	0.08	0
Waste Shaft Brow (South)	Ext	0.20	0.20	0
S400 Drift – E87	Ext	nr	nr	-
S400 Drift – E30 (Horiz. CL)	CP	0.82	0.91	11
S400 Drift – E90 (Horiz. CL)	CP	0.95	1.05	11
Air Intake Shaft Station				
S65 Drift – W620 (Vert CL)	Ext	0.28	0.25	-11
N95 Drift – W620 (Vert CL)	Ext	0.38	0.34	-11

(a) Instrument Type: Ext = extensometer; CP = convergence point.
(b) CL = Centerline
(c) nr = no reading available

Access Drifts and Waste Disposal Area

Access Drifts. The access drifts comprise the 4 major North-South drifts extending southward from near the Salt Handling Shaft to the entries into the waste disposal panels and several short cross-drifts intersecting these major drifts. The access drifts are typically rectangular in cross-section with heights ranging from 2.4 m to 6.4 m and widths ranging from 4.3 m to 9.2 m.

During the current reporting period (July 2006 to June 2007), excavations of Panel 5 was continuing. Panels 3 and 4 were excavated at a slightly higher stratigraphic position (2.4 m) than either Panels 1 or 2. The roof of these panels coincides with Clay G. As such, Panels 1, 2, 7 and 8 will be at the original horizon and Panels 3, 4, 5 and 6 approximately 2.4 m higher in elevation (roof at Clay G). Trimming, scaling, floor milling and rock bolting operations were performed as necessary during the reporting period. During the reporting period, 26 convergence points were replaced and 4 new points were added because of new mining and ongoing trimming activities.

Assessment of creep closure in the access drifts is made through the examination of extensometer and convergence point data reported annually in the GAR. Table 2.6 summarizes the vertical and horizontal closure data reported in the most recent GAR (DOE 2008b). The table examines percentage changes between closure rates measured during the current and previous annual reporting periods and breaks these percentage changes into ranges (e.g., 0 to 25%; includes negative rates). Extensometer data are based on the displacements of the collar relative to the deepest anchor. The numbers shown in the tables represent the number of instrumented locations located on the drift centerline vertically or at the midpoint horizontally that fall within the range of the indicated percentage change. In general, closure rates accelerations continue to be minor in most locations. Other areas that have shown an increase in closure rates can be directly attributed to mining in Panel 5 and associated drifts. Operationally, areas with greater than 10% increase in closure rate are assessed in greater detail in the GAR to determine the cause of the closure rate increase. Most of these locations are in the south access drift near Panel 5. Increased closure rates were observed in E-140 from S-700 to S-1000 and from S-1300 to S-2750. The increased rates from S-700 to S-1000 can be partially attributed to the effects of a mining in Panel 5 and continued aging and deterioration of the roof beam. The majority of the rate changes comparing the 2006 year's COMP data were negative or near zero which demonstrates that displacements were slowing. For this 2007 and 2008 COMP reports, the majority of the data are in the 0 to 25% range. The maximum closure rates corresponding to these data for the current reporting period are given below:

Maximum Vertical Closure Rates along Access Drift Centerlines:

4.04 cm/yr – based on extensometer data
21.26 cm/yr – based on convergence point data

Maximum Horizontal Clsoure Rate along Access Drift Centerlines:

7.32 cm/yr – based on convergence point data

Using a typical average drift dimension of 5 m and the maximum clsoure rates shown above, the inferred maximum creep rate is approximately $1.35x10^{-10}$/s. This rate is based on the maximum closure which is not representative of the behavior of the system.

Creep closure associated with the Access Drifts are acceptable and meet the TV requiring creep rates to change by less than one-order of magnitude in a one-year period. High closure rates observed at a few locations have little effect on safety as geotechnical engineering provides continuous ground-control monitoring and remediation on an as-needed basis.

<u>Waste Disposal Area:</u> The Waste Disposal Area is located at the extreme southern end of the WIPP facility and is serviced by the access drifts described above. Eventually, the Waste Disposal Area will include 8 disposal panels, each comprising 7 rooms (the major north-south access drifts servicing the 8 panels will also be used for waste disposal and will make up the

ninth and tenth panels). Panel 1 was constructed in the late 1980s, Panel 2 constructed during the 1999-2000 time period, Panel 3 constructed during the 2002-2004 time period and the completion of Panel 4 during 2006. As of June 30, 2007 (for the GAR reporting period), waste emplacement operations are complete in Panels 1, 2 and 3. Panel 4 is currently being used for waste emplacement while mining operations continue in Panel 5. Figure 2.1 shows the state of waste emplacement and mining for the GAR reporting period.

The waste emplacement rooms are rectangular in cross-section with a height of 4 m and a width of 10 m. Entry drifts that provide access into the disposal rooms are also rectangular with a height of 3.65 m and a width of 4.3 m.

Table 2.6 Summary of Changes in Vertical and Horizontal Closure Rates Measured Along the Centerlines of the WIPP Access Drifts and Waste Disposal Area Openings.

Location	Number of Instrument Locations Where the Indicated Percentage Change has Occurred					
	Percentage Increase in Clsoure Rate for Measurements Made During the 2004-2005 and 2005-2006 Reporting Periods					
	< 0%	0 – 25%	25 – 50%	50 – 75%	75 – 100%	100 – 200%
Access Drifts						
Extensometers[a]						
Vertical	16	5	1	0	0	1
Convergence Points						
Horizontal	23	96	6	4	2	0
Vertical	59	138	16	8	2	3
Waste Disposal Area						
Panel 3:						
Extensometers[a]						
Vertical	1	1	5	2	0	1
Convergence Points						
Horizontal	9	5	0	0	0	0
Vertical	1	2	4	0	0	0
Panel 4						
Extensometers[a]						
Vertical	9	1	0	0	0	0
Convergence Points						
Horizontal	3	0	0	0	0	0
Vertical	42	0	0	0	0	0

(a) Based on displacement of collar relative to deepest anchor.

Assessment of creep closure in the waste disposal area is made through the examination of extensometer and convergence point data reported annually in the GAR. Tables 2.5 and 2.6 (presented previously) summarize, respectively, the vertical and horizontal closure data reported in the most recent GAR (DOE 2008b) for Panel access drifts and Panels 3 and 4 only. Panel 1, 2 and 3 are closed and are no longer accessible. Convergence points and extensometers were installed in Panel 5 and are currently monitored. Since this is the first year for theses data points, no closure rate data can be reported until the 2009 COMPs report. Each table examines percentage changes between closure rates measured during the current and previous reporting periods and breaks these percentage changes into ranges. Only data from instruments located along the drift centerlines are reported here. In addition, extensometer data are based only on displacements of the collar relative to the deepest anchor. The maximum closure rates corresponding to these data are given below.

Maximum Vertical Closure Rates along Waste Disposal Area Centerlines:

28.12 cm/yr – based on convergence point data

21.06 cm/yr – based on extensometer data

Maximum Horizontal Closure Rates along Waste Disposal Area Centerlines:

10.41 cm/yr – based on convergence point data

Using a nominal disposal-area-opening dimension of 8 m and the maximum closure rates shown above the inferred maximum creep rate is approximately 1.11×10^{-10}/sec. Maximum creep rates for the waste disposal areas are all associated with Panel 4, the newest of the panels with at least two years of data. Although data is available from Panel 5 starting in this reporting period, the rates are not based on a one-year comparison of the results and are therefore not included in this discussion. Creep closure associated with the Waste Disposal Areas are very similar to last year's results (28.12 cm/yr versus 28.85 cm/yr) and meet the TV requiring creep rates to change by more than one order of magnitude in a one-year period.

Table 2.7 Creep Closure - 2008:

Trigger Value Derivation				
COMP Title:	Creep Closure			
COMP Units:	Creep Rate (sec^{-1})			
Related Monitoring Data				
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value	
Geotechnical	Closure	Instrumentation located throughout the underground.	Munson-Dawson Constitutive Model	
COMP Derivation Procedure - Reporting Period July 2007 through June 2008				
Evaluate GAR for centerline closure rates, compare to previous year's rate. Account for drift dimensions and convert to creep rate. If creep rate increases by greater than one order of magnitude, initiate technical review.				
Related Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Repository Fluid Flow	Creep Closure	Porosity Surface, waste compaction, characteristics, waste properties, evolution of underground setting	SANTOS, porosity surface calculations	Provides validation of the creep closure model.
Monitoring Data Trigger Values				
Monitoring Parameter ID	Trigger Value	Basis		
Creep Closure	Greater than one order of magnitude increase in creep rate.	A creep rate increase signals potential de-coupling of rock.		

2.2.2 Extent of Deformation

The extent of brittle deformation can have important implications to PA. As modeled in PA, the DRZ releases brine to the disposal room while properties of the DRZ control hydrologic communication between disposal panels. Therefore, extent of deformation relates directly to a conceptual model used in performance determinations. If characteristics could be tracked from inception, the spatial and temporal evolution of the DRZ would provide a validation benchmark for damage calculations. However, monitoring the extent of deformation is qualitative making direct correlations to PA difficult.

Measurements in the GAR include borehole inspections, fracture mapping and borehole logging. These observations are linked closely to other monitoring requirements concerned with initiation of brittle deformation and displacement of deformation features. These monitoring requirements define the characteristics of the DRZ, which help validate the baseline conceptual model, and its flow characteristics. The extent of deformation quantifies the DRZ, a significant element of PA analyses.

The Geotechnical Engineering Department at WIPP has compiled back-fracturing data into a database. The supporting data for the GAR (Volume 2, DOE 2008b) consists of plan and isometric plots of fractures. Fracture development is most continuous parallel to the rooms and near the upper corners. These fractures are designated "low angle fractures" relative to the horizontal axis. The original excavation horizon results in a 2.4-m thick beam of halite between the roof and Clay Seam G. Low-angle fractures arch over rooms and asymptotically connect with Clay Seam G. Although the preponderance of monitoring information derives from the roof (back), buckling extends into the floor to the base of Marker Bed 139, which is located about 2 m below the disposal room floors. Fracture mapping thus far is consistent with expectations and tracks stress trajectories derived from computational work.

Excavation of Panel 3 raises the waste disposal panels by 2.4 m such that the roof of the disposal rooms will be coincident with Clay Seam G and the floor will be an additional 2.4 m above Marker Bed 139. This change will likely alter the typical fracture patterns observed to date and may cause subtle changes in how the DRZ develops. Effects of excavation to Clay G have been evaluated by finite element analyses to assess possible impact to PA (Park and Holland 2003). Their modeling shows that the DRZ does not extend below MB139 at the new horizon, as it does at the original horizon. The rise in repository elevation otherwise causes no discernable change to the porosity surface used in PA.

Data provided in the GAR suggest that brittle deformation extends at least 2.4 m (to Clay Seam G where present) and perhaps as much as 4.5 m (to Clay Seam H) above the roof of the WIPP openings. In addition, brittle deformation extends below the floor of the openings to at least the base of Marker Bed 139 (approximately 2 to 3 m).

Data provided in the 2008 GAR was compared to fracture maps in the previous year's report to determine if fractures exceed the 1m/yr TV. This comparison did not identify data exceeding the TV.

Table 2.8 Extent of Deformation - 2008:

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	Not Established	
COMP Derivation Procedure - Reporting Period July 2006 through June 2007				
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 Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
DRZ Conceptual Model	Micro- and macro-fracturing in the Salado Formation	Constitutive model from laboratory and field databases.	Permeability of DRZ was originally assigned a constant value of $10^{-15} m^2$ for the CCA; per EPA direction, a uniform distribution from 3.16×10^{-13} to $3.98 \times 10^{-20} m^2$ was used for all subsequent PAs	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/y	Coalescence of fractures at depth in rock surrounding drifts will control panel closure functionality and design, as well as discretization of PA models.		

2.2.3 Initiation of Brittle Deformation

Initiation of brittle deformation around WIPP openings is not 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 TVs. This COMP is not directly related to a PA parameter. 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. The ongoing 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 PA calculations. As stated previously, this COMP is qualitative and is not directly related to PA parameters.

Table 2.9 Initiation of Brittle Deformation - 2008:

<table>
<tr><th colspan="5">Trigger Value Derivation</th></tr>
<tr><td>COMP Title:</td><td colspan="4">Initiation of Brittle Deformation</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Qualitative</td></tr>
<tr><td colspan="5">Related Monitoring Data</td></tr>
<tr><td>Monitoring Program</td><td>Monitoring Parameter ID</td><td>Characteristics (e.g., number, observation)</td><td colspan="2">Compliance Baseline Value</td></tr>
<tr><td>Geotechnical</td><td>Closure</td><td>Observational</td><td colspan="2">Not Established</td></tr>
<tr><td colspan="5">COMP Derivation Procedure - Reporting Period July 2006 through June 2007</td></tr>
<tr><td colspan="5">Qualitative and pertinent to operational considerations. Captured qualitatively in association with other COMPs</td></tr>
<tr><td colspan="5">Performance and Compliance Elements</td></tr>
<tr><td>Element Title</td><td>Parameter Type & ID or Model Description</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>Not directly related to PA as currently measured</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td colspan="5">Monitoring Data Trigger Values</td></tr>
<tr><td>Monitoring Parameter ID</td><td>Trigger Value</td><td colspan="3">Basis</td></tr>
<tr><td>Initiation of Brittle Deformation</td><td>None</td><td colspan="3">Qualitative COMPs can be subjective and are not prone to the development of meaningful TVs.</td></tr>
</table>

2.2.4 Displacement of Deformation Features

The displacement of deformation features primarily focuses on those features located in the immediate vicinity of the underground openings, e.g., mining-induced fractures and lithological units within several meters of the roof and floor. As discussed previously, fracture development is most continuous parallel to the openings and near the upper corners. These fractures tend to propagate or migrate by arching over and under the openings and, thus are designated "low-angle fractures" relative to the horizontal axis. Typically, the fractures intersect or asymptotically approach lithologic units such as clay seams and anhydrite stringers. As a result, salt beams are formed. In the roof, the beams are de-coupled from the surrounding formation requiring use of ground support. In the floor, the beams sometimes buckle into the openings requiring floor milling and trimming. Lithologic units of primary interest are Clay G and H. These features are located approximately 2.4 m and 4.5 m respectively, above the roof of Panels 1, 2, 7 and 8. Marker Bed 139 (anhydrite) is located approximately 2 m below the floor of these panels. For Panels 3 through 6, the panels are mined up to Clay G. Clay H is therefore located 2.1 m above the roof of these panels and Marker Bed 139 is located approximately 4.4 m below the panel floors.

Monitoring of these deformation features is accomplished through visual inspection of observation boreholes (OBH) drilled from the openings through the feature of interest. In general, these boreholes are aligned vertically (normal to the roof and floor surfaces) because of the location and orientation of the fractures and lithological units of interest. All of the OBHs are 7.6 cm (3 in) in diameter, and many intersect more than one deformation feature. The ages of the OBHs vary from more than 20 years to recent.

The deformation features in OBHs are classified as: 1) offsets, 2) separations, 3) rough spots, and 4) hang-ups. Of the 4 features, offsets are the principle metric for this COMP and are quantified by visually estimating the degree of borehole occlusion created by the offset. The direction of offset along displacement features is defined as the movement of the stratum nearer the observer relative to the stratum farther from the observer. Typically, the nearer stratum moves toward the center of the excavation. Based on previous observations in the underground, the magnitude of offset is usually greater in boreholes located near the ribs as compared to boreholes located along the centerline of openings.

Due to the lack of accessibility to closed panels, all OBHs in Panels 1 through 3 are no longer monitored. There are a total of 184 OBHs monitored during this reporting period. These OBHs are located in the panels and access drifts. Forty-eight OBHs in Panel 4, and 41 in Panel 5, had been drilled over the time period reported in the 2008 GAR. In both Panels 4 and 5, the greatest separations were associated with clay "H" and anhydrite "a". Eight OBHs in Panel 4 and 3 holes in Panel 5 had fractures associated with anhydrite stringers in the lower portion (first 3 feet) of the roof beam. Thirty-seven of the 48 OBHs in Panel 4 and 2 of the 41 holes in Panel 5 showed some offset. OBHs in Panel 4 rooms 6 and 7 are not accessible due to waste emplacement. Based on the current data available from the GAR, 5 (<3 % of the total) OBHs were fully occluded. The TV for displacement of deformation features is the observation of a fully occluded borehole. Exceedance of the TV is not a cause for concern given that no significant impact on safety or performance has occurred in those locations where the TV has been exceeded. However, to limit the formation of low angle fractures and de-coupled beams over the roof, the elevation of Panel 3 and future disposal panels (i.e., Panels 3, 4, 5, and 6) have been raised approximately 2.4 m so the roof will then coincide with Clay G. This horizon change was implemented to improve ground control. As such, the horizon change will change the expected deformation and displacement behavior.

Displacement of deformation features has been useful for implementation of ground control alternatives (i.e., horizon change to Clay G). Displacement features complement observation of brittle deformation initiation and corroborate estimates of the extent of deformation.

Table 2.10 Displacement of Deformation Features - 2008:

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 - Reporting Period July 2006 through June 2007				
Observational – Lateral deformation across boreholes.				
Related Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Not directly related to PA	N/A	N/A	N/A	N/A
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.		

2.2.5 Subsidence

Subsidence is currently monitored via elevation determination of 48 existing monuments and 14 of the National Geodetic Survey's vertical control points. To address EPA monitoring requirements, the most recent survey results (DOE 2007a) are reviewed and compared to derived TVs. Because of the low extraction ratio and the relatively deep emplacement horizon (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. In contrast, calculations show that the maximum subsidence predicted directly above the WIPP waste emplacement panels is 0.62 m assuming emplacement of CH-TRU waste and no backfill (Backfill Engineering Analysis Report (WID 1994). Further considerations, such as calculations of room closure, suggest that essentially all surface subsidence would occur during the first few centuries following construction of the WIPP, so the maximal vertical displacement rates would be approximately 0.002 m/yr (0.006 ft/yr). Obviously, these predicted rates could be higher or lower depending on mining activities as well as other factors such as time. Because the vertical elevation changes are very small, survey accuracy, expressed as the vertical closure of an individual loop times the square root of the loop length, is of primary importance. For the current subsidence surveys, a Second-Order Class II loop closure accuracy of 8 millimeters times the square root of the length of the loop in kilometers (or 0.033 feet times the square root of the loop in miles) or better was achieved in all cases.

Three monuments have also been included in various annual surveys, but were not included in the current surveys because the monuments no longer exist (last surveyed in 2003, monuments S-17 & S-18 are under a salt pile) or have been physically disturbed (PT-31, last surveyed in 2003). Historically, the surveys were conducted by private companies under subcontract to DOE; however, since 1993, the WIPP M&OC has conducted the surveys using a set of standardized methods. Starting with the 2002 survey, the M&OC has been following WIPP procedure, WP 09-ES4001 (WTS 2002).

The current surveys comprise 9 leveling loops containing as few as 5 to as many as 10 monuments/control points per loop as shown in Figure 2.2 (Surveys of Loop 1 benchmarks have been discontinued because only 2 benchmarks comprise this loop and these benchmarks are redundant to other survey loops). Elevations are referenced to Monument S-37 located approximately 7,700 ft north of the most northerly boundary of the WIPP underground excavation. This location is considered to be far enough from the WIPP facility to be unaffected by excavation-induced subsidence expected directly above and near the WIPP underground. The elevation of S-37 has been fixed for all of the subsidence leveling surveys conducted since 1993. Survey accuracy for all loops was within the allowable limits (DOE 2007a). Adjusted elevations are determined for every monument/control point by proportioning the vertical closure error for each survey loop to the monuments/control points comprising the loop. The proportions are based on the number of instrument setups and distance between adjacent points within a survey loop.

The adjusted elevations for each monument/control point are plotted as functions of time to assess subsidence trends. Figures 2.3 through 2.7 provide, respectively, elevations for selected monuments including those located (1) directly above the first waste emplacement panel, (2) directly above the second waste emplacement panel, (3) directly above the north experimental area, (4) near the salt handling shaft, and (5) outside the repository footprint of the WIPP underground excavation. As expected, subsidence is occurring directly above the underground openings (Figures 2.3 through 2.6); however the magnitude of the subsidence above the openings is small ranging from about -0.10 ft to -0.20 ft. The highest rate of change in observed subsidence has occurred in the time period from 1987 to 1993, but as discussed above, consistent surveying practices were not implemented until 1993 so some of the observed elevation changes may be related to differences in methodology rather than subsidence.

Elevations of survey points located directly above Waste Emplacement Panel 1 were stable during the 1994 to 1998 surveys, as shown in Figure 2.3. However, when the excavation of Panel 2 was initiated in 1999, the elevations of the survey points above Panel 1 began to decrease with time in a nearly linear manner. These higher rates of subsidence were anticipated because the excavation of new panels caused a redistribution of stress in the salt around Panel 1, leading to higher creep rates in the salt and higher convergence rates of panel rooms. Based on three-dimensional modeling conducted by Patchet et al. (2001), the convergence rates within Panel 1 were predicted to increase by as much as 60 to 96 percent as a result of the mining of Panel 2. A manifestation of these higher convergence rates is higher subsidence rates at the surface, particularly above Panel 1. Higher subsidence rates were also expected directly above Panel 2 because of the excavation of the next consecutive panel. Figure 2.4 shows that the elevations of the survey points located above Panel 2 also began to decrease immediately following the initiation of Panel 2 excavation in 1999. With the completion of the Panel 2 excavation in October 2000, subsidence rates of survey points located above both Panel 1 and Panel 2 slowed as indicated by the 2002 survey results shown in Figures 2.3 and 2.4, but then accelerated again in 2003 (particularly above Panel 2) as a result of the excavation of Panel 3 and its access drifts. This general trend has continued as more panels are mined.

As time passes, subsidence is expected to be most pronounced directly above the WIPP underground excavations and will be minimal away from the repository footprint. Early results suggest this pattern is already occurring. Comparing Figures 2.3 and 2.4 for points over the panels with points above the salt handling shaft and northern experimental area (Figures 2.5 and 2.6) show the trend of decreasing subsidence leading away from the excavated panels (Figure 2.7). This trend is also seen in Figures 2.8 through 2.10 for the following subsidence profiles (see also plan view in Figure 2.2):

- Section A-A′, North-South section extending through the WIPP site
- Section B-B′, North-South section extending from the north experimental area through the south emplacement panels
- Section C-C′, East-West section extending through Panel 1

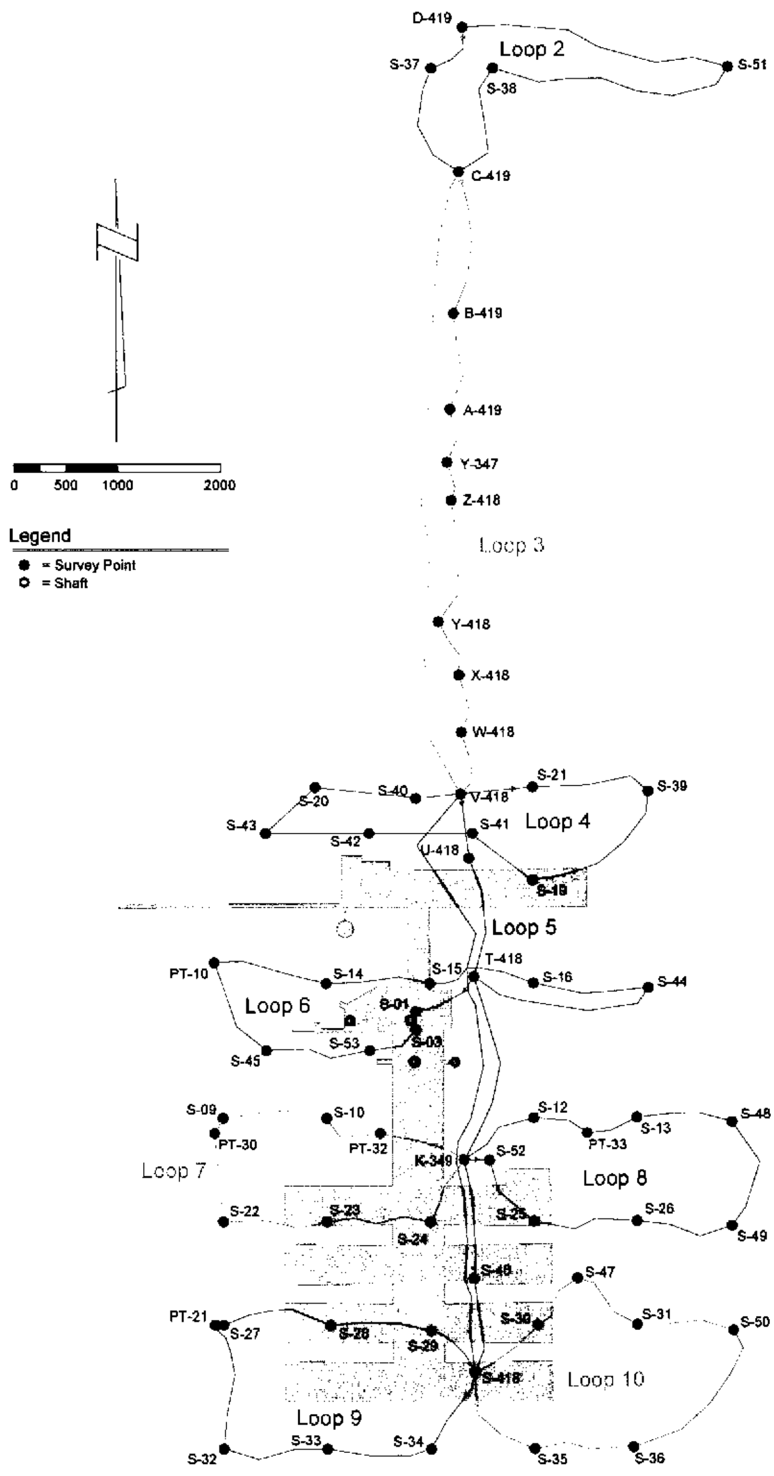


Figure 2. 2 Monuments and vertical control points comprising WIPP subsidence survey loops.

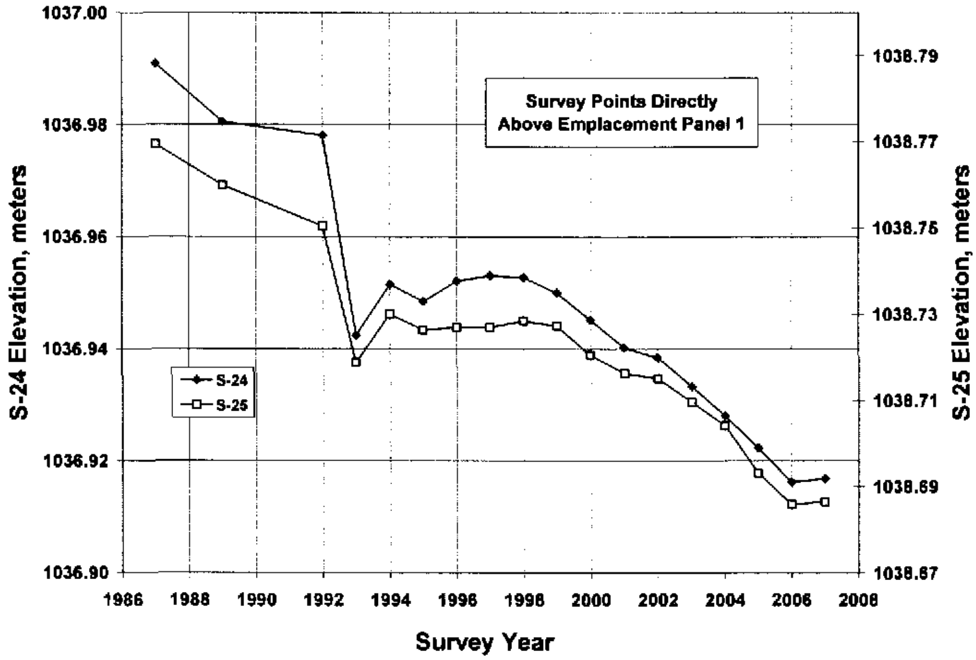


Figure 2. 3 Elevations of WIPP monuments S-24 and S-25 located directly above emplacement Panel 1.

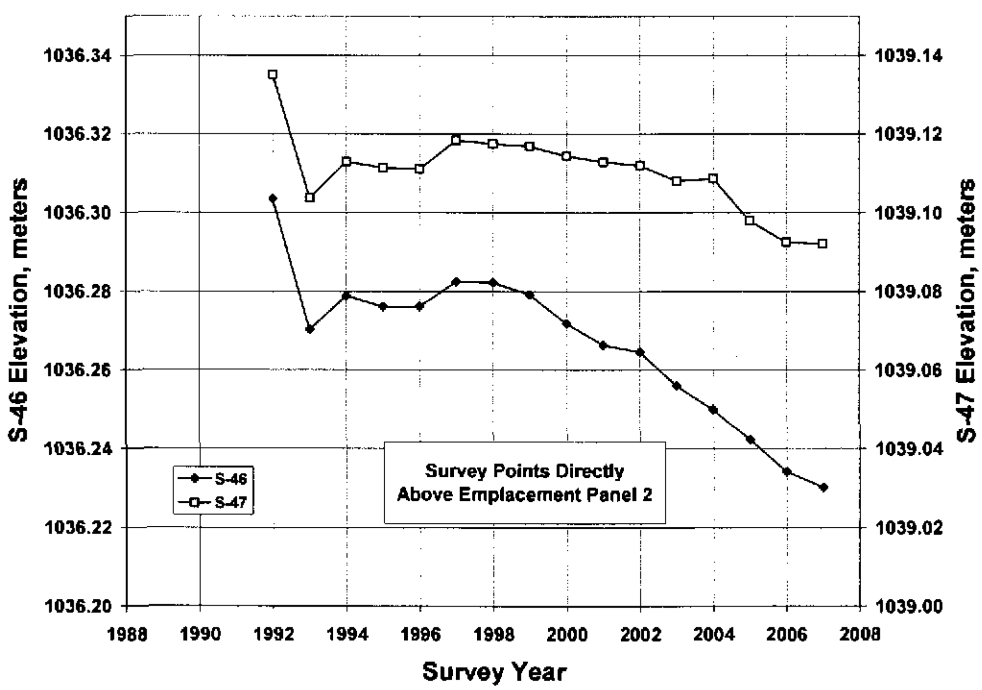


Figure 2. 4 Elevations of WIPP monuments S-46 and S-47 located directly above emplacement Panel 2.

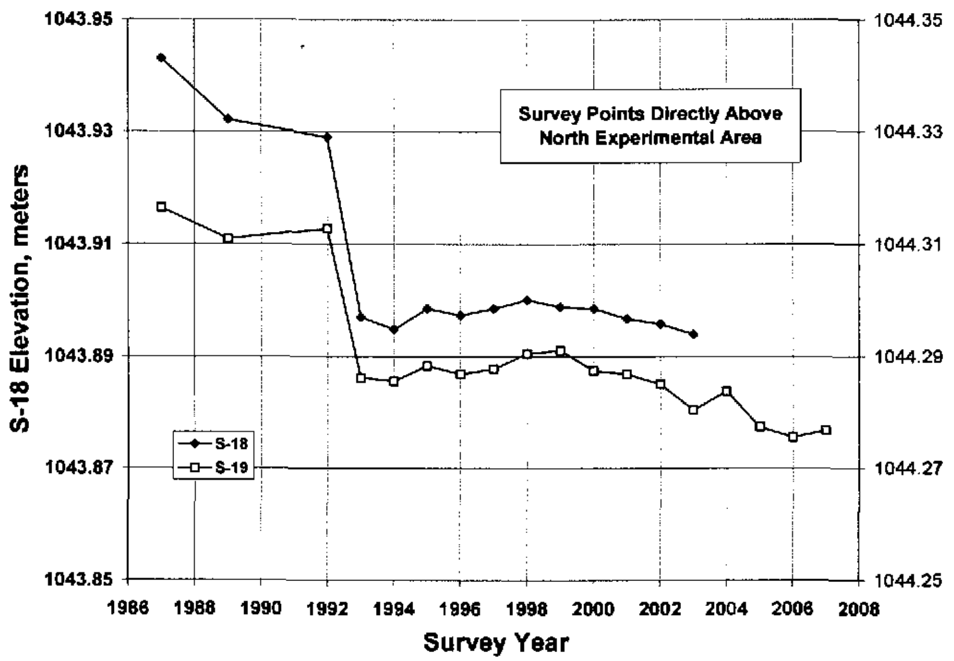


Figure 2. 5 Elevations of WIPP monuments S-18 and S-19 located directly above the north experimental area.

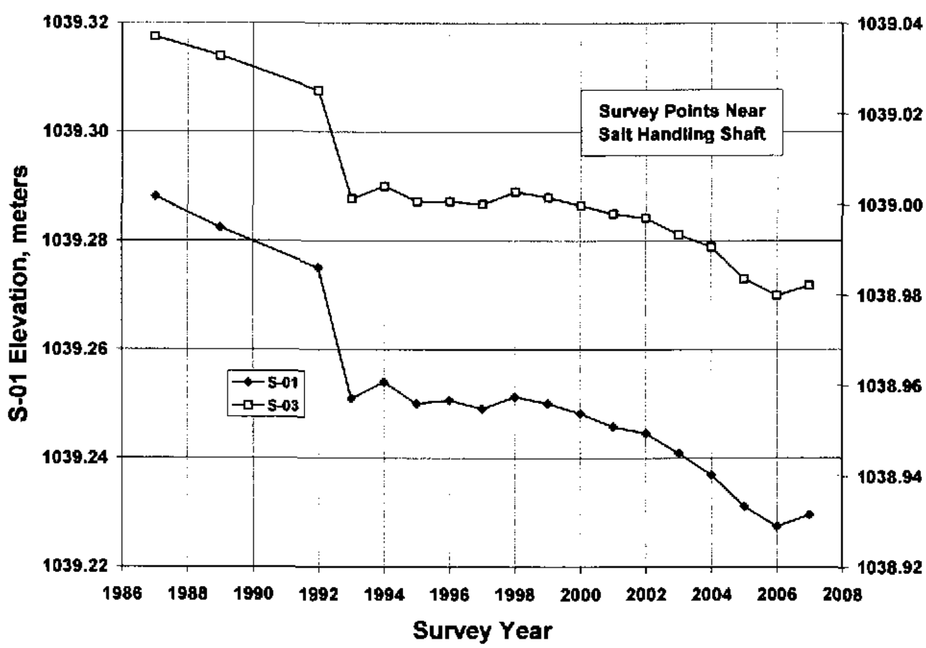


Figure 2. 6 Elevations of WIPP monuments S-01 and S-03 located near the Salt Handling Shaft.

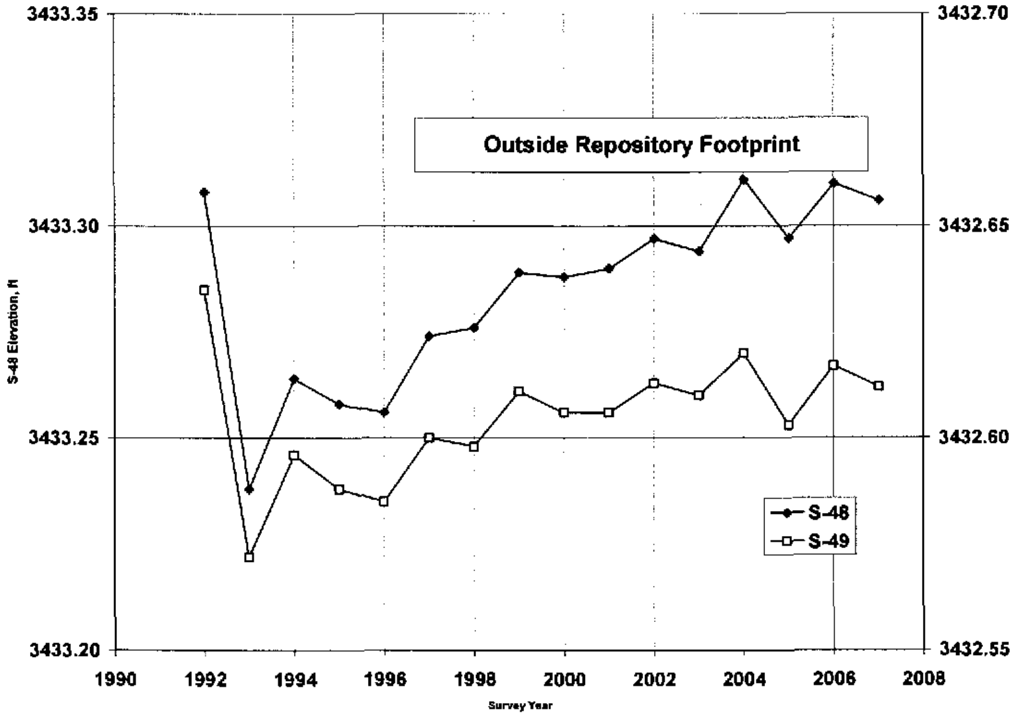


Figure 2. 7 Elevations of WIPP monuments S-48 and S-49 located outside the repository footprint.

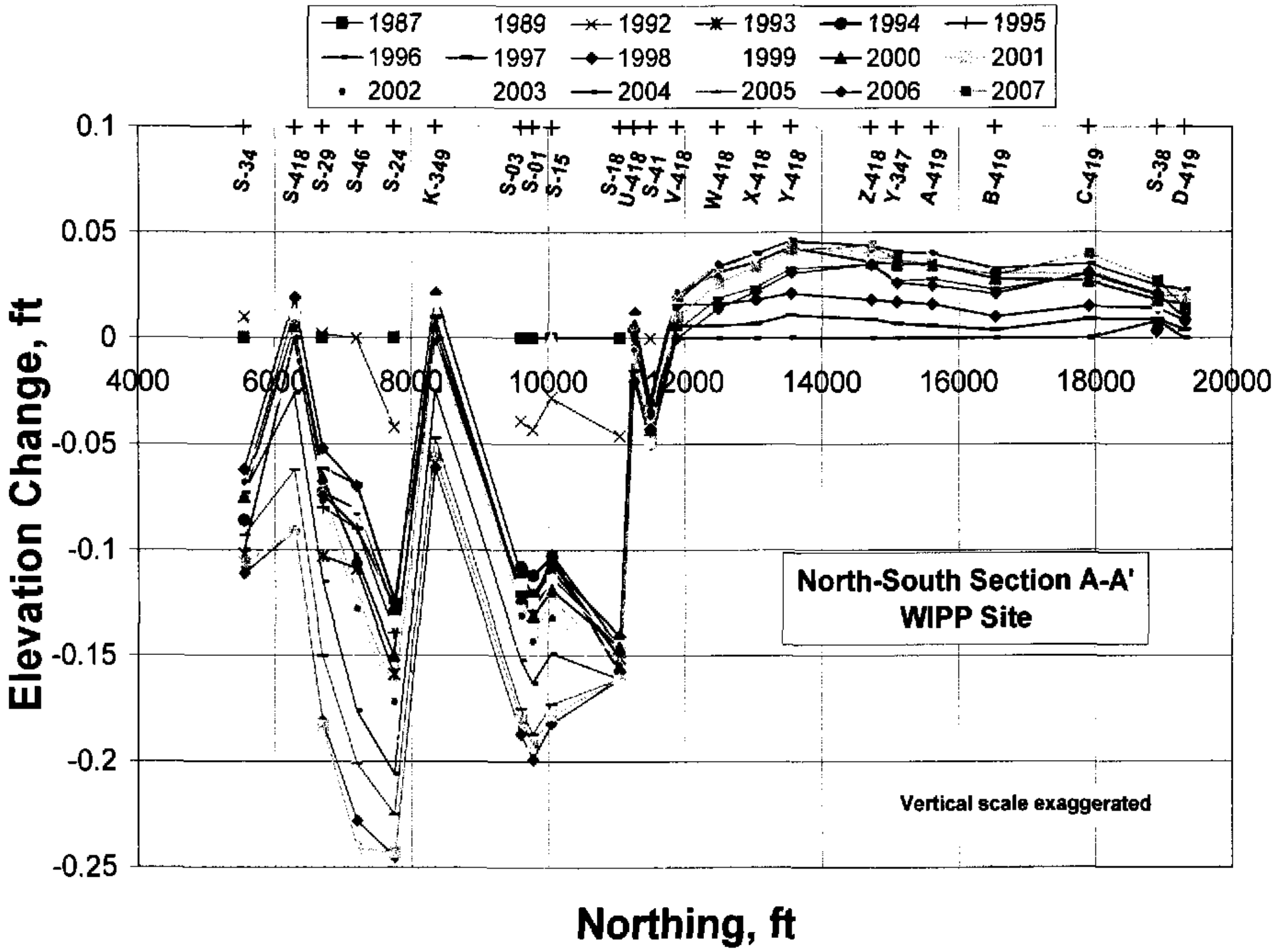


Figure 2. 8 North-South subsidence profile A-A'.

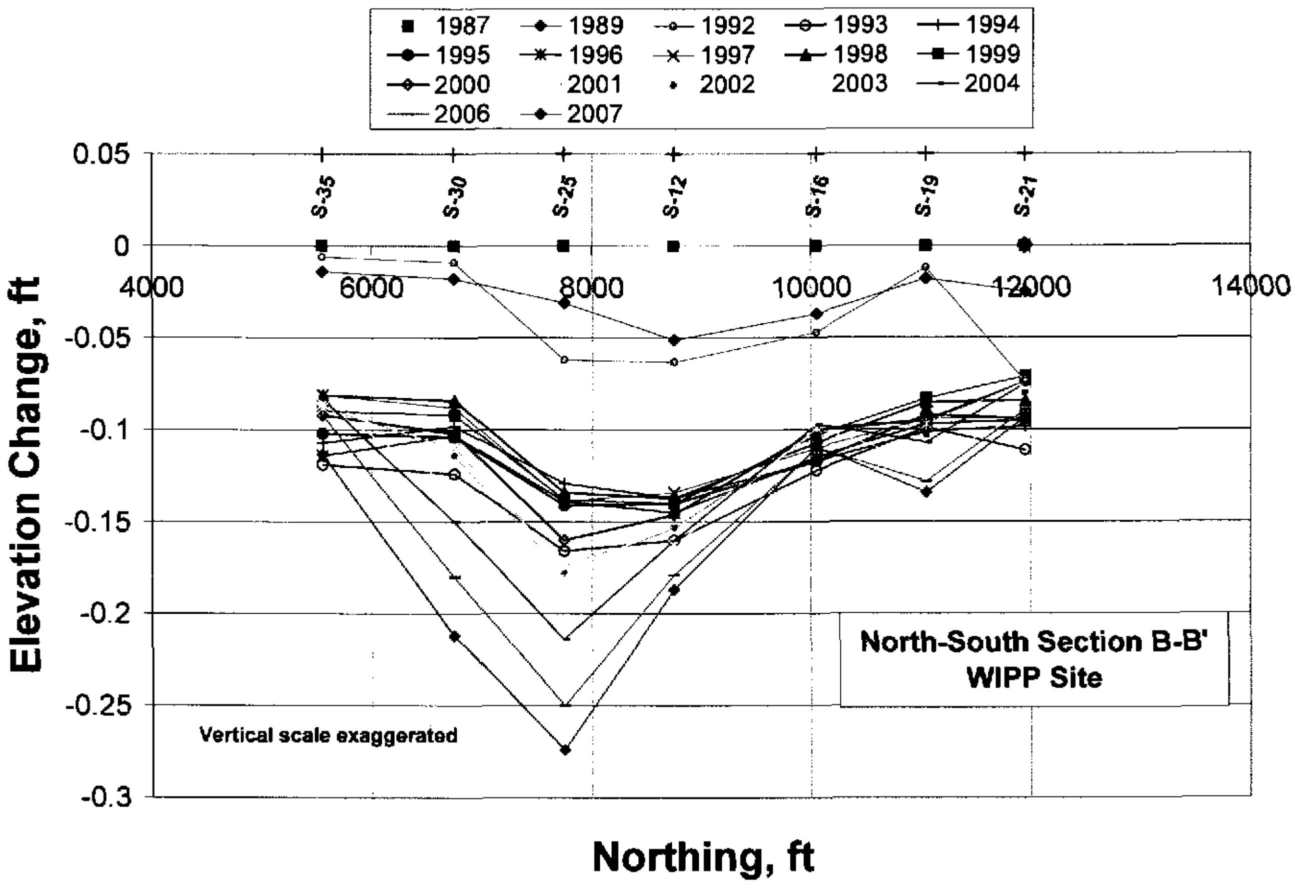


Figure 2. 9 North-South subsidence profile B-B'.

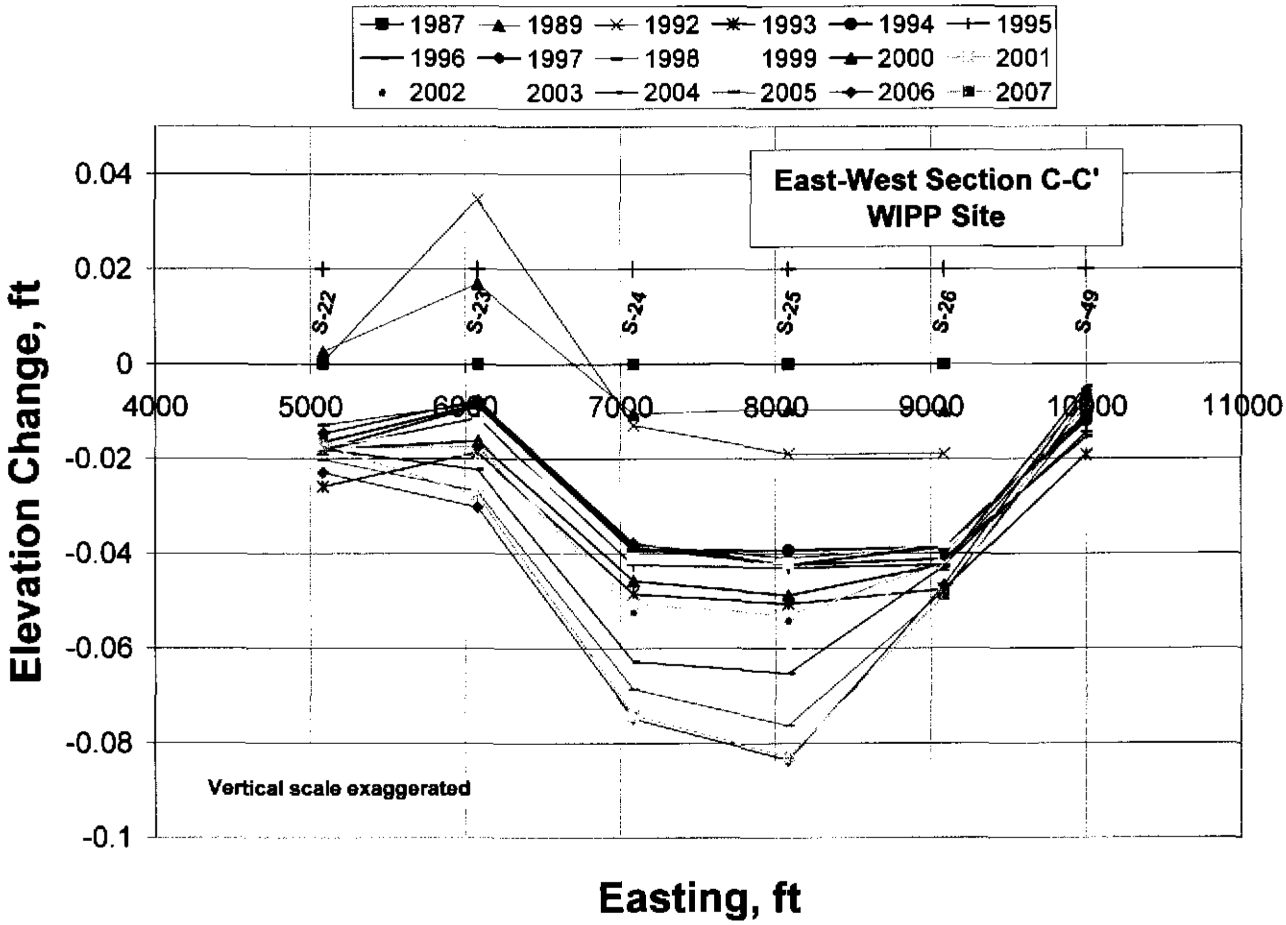


Figure 2. 10 East-West subsidence profile C-C′.

The elevation changes of individual monuments shown in figures 2.8 through 2.10 are referenced to the elevations determined from the annual surveys that first incorporated the monument so, in some cases, direct temporal comparisons between pairs of monuments cannot be made. For example, only 29 monuments were included in the 1987 survey, while 50 and 65 monuments were included in the 1992 and 1996 surveys, respectively. Although direct comparisons cannot always be made, several observations are possible including:

1. The most significant subsidence (greater than - 0.20 ft) occurs above the waste panels (monuments PT-33, S-23, S-24, S-25, S-30 and S-48), with slightly less subsidence (-0.18 ft) near the shafts (Monuments S-14, S-15 and S-16) above the waste panels (S-29) and adjacent to Panel 1 (S-12).
2. The highest subsidence rates measured for the 2006-2007 surveys correspond to benchmarks located southeast of the shafts at marker S-09 which had a rate of approximately $6x10^{-3}$ m/yr. Markers S-22, S-27, S-32 and PT-21, located around the newly excavated Panel 5 had a rate of approximately $5x10^{-3}$ m/yr.
3. The effects of subsidence extend away from the repository footprint approximately 1,000 to 1,500 ft (e.g., S-26, see Figures 2.2 and 2.10).

Furthermore, total subsidence and subsidence rates are small, and are approximately at the resolution level of the survey accuracy. The benchmarks with the highest rates are seen above the mined panels and have increased since the mining of Panels 3, 4 and 5. Based on the latest survey data, subsidence rates of the ground surface at the WIPP have not exceeded the $1x10^{-2}$ m/yr TV. No additional activities are recommended at this time.

Table 2.11 Subsidence - 2008:

Trigger Value Derivation	
COMP Title:	Subsidence
COMP 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	Elevation of 62 original monitoring monuments	Decimal (meters)	Not Established
Subsidence Monitoring Leveling Survey	Change in elevation over year	Decimal (meters)	Not Established

COMP Derivation Procedure – 2008; Data acquired between August and December of 2007

Survey data from annual WIPP Subsidence Monument Leveling are evaluated. Elevations of 62 monitoring monuments are compared to determine change.

Related Performance and Compliance Elements

Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Subsidence	FEP [W-23]	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 0.62 m 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 (CRA-2004 Appendix PA Attachment SCR , Section SCR-6.3.1.4) – this is within range modeled in the PA. Predicted WIPP subsidence is below that predicted for the effects of potash mining (0.62 m vs.1.5 m; DOE 2004).

Monitoring Data Trigger Values

Monitoring Parameter ID	Trigger Value	**Basis**
Change in elevation per year	1.0×10^{-2} m (3.25×10^{-3} ft) per year subsidence	Based on the most conservative prediction by analyses referenced in the CCA.

2.3 Hydrological COMPs

As stated in the previous sections, the Compliance Recertification Application (CRA) lists 10 monitoring parameters that the DOE is required to monitor and assess during the WIPP operational period (DOE 2004). Two of these parameters are considered hydrological in nature and include:

- Changes in Culebra Water Composition
- Changes in Culebra Groundwater Flow

The SA has reviewed the data collected by the MOC during 2007 under the Groundwater Surveillance Program (DOE 2003), which is comprised of two components:

- The Water Quality Sampling Program (WQSP)
- The Water-Level Monitoring Program (WLMP)

WQSP and WLMP data are reported in the Waste Isolation Pilot Plant Annual Site Environmental Report (SER) for 2007 (DOE 2008c). Additionally, WLMP data are also reported in monthly memoranda from the MOC to the SA.

2.3.1 Changes in Culebra Water Composition

2.3.1.1 Water Quality Sampling Program (WQSP)

Under the current WQSP, 7 wells are sampled by the MOC. Six of the wells (WQSP-1 through 6) are completed to the Culebra Dolomite Member of the Rustler Formation and the seventh (WQSP-6a) is completed to the Dewey Lake Formation (Figure 2.11). All the WQSP wells are located within the WIPP Land Withdrawal Act boundary (LWB). WQSP-1, 2, and 3 are situated hydraulically up-gradient (north) of the WIPP surface facilities and WQSP-4, 5, and 6 are situated down-gradient (south) of the WIPP surface facilities. The Dewey Lake, to which WQSP-6a is completed, bears water only in the southern portion of the WIPP site and farther to the south.

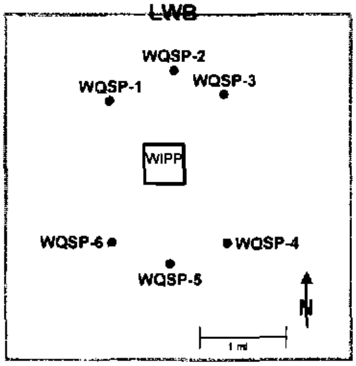


Figure 2.11 Map showing locations of WQSP wells in relation to the WIPP surface facilities and the LWB. Note: WQSP-6a is on the same well pad as WQSP-6.

Flow and transport in the Dewey Lake are not modeled explicitly in PA because PA modeling shows no radionuclides reach the Dewey Lake and the sorptive quality of the Dewey Lake would be expected to retard migration of any radionuclides that did reach the unit. Nevertheless, the Dewey Lake water quality is monitored because it might help to increase the understanding of WIPP area hydrology.

The Culebra is modeled for PA because it is the most transmissive, saturated water-bearing zone in the WIPP vicinity. It is not, however, a source of drinking water; therefore, 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 for the Culebra differ widely among wells across the WIPP site, reflecting local equilibrium, diffusion, and, perhaps most importantly, transport rate. The conceptual model for the Culebra presented in the CRA (DOE 2004) 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 PA models. Stability of major ion concentrations, on the other hand, is consistent with and supports the SA's Culebra transport conceptual model. Thus, this evaluation of the water-quality data focuses on the stability of major ion concentrations.

2.3.1.1.1 Water Quality Sampling

Two water samples (a primary and a duplicate) are collected from each WQSP well twice per year, in the spring and again in the fall. Water sampling procedures are outlined in the WIPP Strategic Plan for Groundwater Monitoring (DOE 2003) and are summarized here.

Samples are collected by the MOC using a submersible pump (each well has its own dedicated pump) that is set at the mid-formation level. Water samples are collected in serial and final. Serial samples are taken at regular intervals while the well is being pumped and analyzed in a mobile field laboratory to determine when water chemistry has stabilized using the parameters of temperature, Eh, pH, alkalinity, chloride, divalent cations, and total iron. The final sample is collected when water quality has stabilized to within ±5% of the field parameter average. Final samples are collected in the appropriate containers (e.g., preserved versus unpreserved) for each particular analysis, placed in coolers, and delivered to the analytical laboratory within a day of collection.

2.3.1.1.2 Laboratory Analysis

The MOC collects samples to be analyzed for volatiles, total organic halogens, total organic carbon, semi-volatiles, metals, and general chemistry. For this report, only the results from the metals and general chemistry samples are discussed. In the field, the general chemistry samples are not preserved, metals samples are preserved with nitric acid, and neither sample is filtered.

TraceAnalysis, Inc. of Lubbock, TX is responsible for analysis of the water samples submitted by the MOC (and has been since round 7). The samples are analyzed using a variety of published and accepted U.S. Environmental Protection Agency methods. In the lab, metals samples are analyzed for total cations (e.g., Na^+, Ca^{2+}, Mg^{2+}, K^+) and general chemistry samples are analyzed for chloride (Cl^-), sulfate (SO_4^{2-}), alkalinity (i.e., bicarbonate; HCO_3^-), total dissolved solids (TDS), density, and other constituents that are not reported here.

2.3.1.1.3 Data Analysis

The results of the WQSP analyses are compared to baseline results in order to determine stability, which is defined as a condition where the concentration of a given ion remains within its derived 95% confidence interval (CI; mean ± two standard deviations) established from the baseline measurements at a well, assuming a normal distribution of concentrations. The original baseline was defined by the first 5 rounds of sampling in the WQSP wells conducted between July 1995 and September 1997 (Crawley and Nagy 1998). The baseline was revised in 2000, expanding from the first 5 rounds to the first 10 rounds of sampling, which were performed between July 1995 and May 2000, before the first receipt of RCRA-regulated waste at WIPP. The baseline data are presented in the WIPP Resource Conservation and Recovery Act Background Quality Baseline Report (Crawley and Nagy 1998) and in Addendum 1 to that report (IT Corporation 2000). For the purposes of this evaluation, a small number of measurements have been eliminated from the baselines for WQSP-3, 5, 6, and 6a. The reasons for eliminating these values are discussed in detail in the COMPs assessment report for data collected in the year 2000 (SNL 2000). The elimination of these values is always conservative in that it reduces the "stable" range of concentrations for the affected parameters. The 95% CIs derived from the baseline data (SNL 2002a) are presented in Table 2.6.

Based on the baseline analysis described above, a TV for Culebra groundwater composition has been defined. A TV is defined as the condition where both primary and duplicate analyses for any major ion fall outside the 95% CI for 3 consecutive sampling periods. When and if this criterion is met, the project will evaluate the sampling and analytical procedures to see if the apparent change in groundwater composition can be explained by procedural changes or irregularities. If the change appears to reflect conditions in the Culebra accurately, the SA will investigate what effects the changes might have on the conceptualization and modeling of the Culebra and, if appropriate, the model will be revised to be consistent with the new information.

In addition to the above analyses, a charge-balance error (CBE), 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 using the average of the primary and duplicate sample (unless otherwise noted in the Results section). A CBE is useful in evaluating the reliability of an analysis because water must be electrically neutral. CBE is rarely zero because of inherent inaccuracy in analytical procedures, but a reliable analysis should not have a CBE exceeding ±5% (Freeze and Cherry 1979). A CBE in excess of ±5% implies either that the analysis of one or more ions is inaccurate (most common) or that a significant ion has been overlooked (rare). The variation between the values obtained for the "sample" and "duplicate" analyses of individual ions is also considered. Generally speaking, this variation should be less than 10 percent. Greater variation indicates a potential problem with one or both analyses. Analytical results and CBE for rounds 24 and 25 of sampling are presented in Table 2.5.

2.3.1.2 Results

WQSP results for sampling rounds 24 and 25 conducted in 2007 are reported in the 2007 SER (DOE 2008c). The reported major ion concentrations are listed in Table 2.5. Sampling round 24 was conducted between March and May and round 25 was conducted between September and November.

Table 2.12 Rounds 24 and 25 major ion concentrations and charge-balance errors, with a baseline 95% CI defined for each major ion.

Well I.D.	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 24	***44000***/*39400*	5340/5290	*72/54*	**24700/26100**	1890/1880	**1220**/1200	588/583	3.6
	Round 25	36000/36600	4710/4730	46/48	19000/20400	1720/1750	1090/1100	**761**/704	-3.2
	95% C.I.	31100-39600	4060-5600	45-54	15900-21100	1380-2030	939-1210	322-730	
WQSP-2	Round 24	*37300*/***41700***	6140/6200	46/48	22200/21400	1650/1630	1100/1100	513/508	-2.0
	Round 25	36500/37300	5590/5740	***74/130***	*22000/18100*	*1610/1340*	*1070/888*	***848***/*626*	**-5.2**
	95% C.I.	31800-39000	4550-6380	43-53	14100-22300	1230-1770	852-1120	318-649	
WQSP-3	Round 24	*136000/145000*	**8580/9330**	42/38	**96400/92800**	***2020***/*1790*	***3190/2810***	***2000/1770***	4.2
	Round 25	*136000*/***184000***	**8110/8130**	*30/38*	77800/82500	1380/1440	2200/2310	**2000**/2160	-2.7
	95% C.I.	114000-145000	6420-7870	23-51	62600-82700[c]	1090-1620	1730-2500	2060-3150[a]	
WQSP-4	Round 24	**75600/79200**	**9130/9270**	40/38	***39600***/*33500*	*1600/1420*	*1180/1030*	*1020/908*	**-14.3**
	Round 25	**67000/64000**	7240/7160	*40/46*	**42400/38800**	1650/1600	1210/1170	896/888	-0.7
	95% C.I.	53400-63000	5620-7720	31-46	28100-37800	1420-1790	973-1410	832-1550[b]	
WQSP-5	Round 24	17100/17000	**6410/6390**	50/52	10200/**11200**	1010/1040	431/456	368/376	-4.4
	Round 25	16000/16600	5790/5870	*56/46*	**11300/11000**	1140/1140	487/483	355/354	0.7
	95% C.I.	13400-17600	4060-5940	42-54	7980-10400[c]	902-1180	389-535	171-523	
WQSP-6	Round 24	5930/5980	**5820/5940**	48/50	5210/5190	679/704	**188**/196	180/184	-1.7
	Round 25	**5130**/5550	4700/4640	52/50	4850/5240	721/730	218/219	182/186	**5.7**
	95% C.I.	5470-6380[c]	4240-5120[c]	41-54	3610-5380[c]	586-777	189-233[c]	113-245	
WQSP-6a	Round 24	484/461	2170/2130	102/104	**243/236**	606/589	148/149	3.77/3.86	**-6.4**
	Round 25	***350***/*516*	*1950/2290*	**112/120**	**241/247**	606/625	158/162	4.58/4.65	-3.2
	95% C.I.	444-770[c]	1610-2440	97-111	253-354	554-718	146-185	1.8-9.2	

Bold signifies outside 95% confidence interval or charge-balance error ≥5%
Italics signifies sample and duplicate analyses differ by more than 10%
[a] baseline defined from rounds 8-10
[b] baseline defined from rounds 7-10
[c] baseline definition excludes anomalous values

2.3.1.2.1 WQSP-1

Concentrations of most of the major ions were within their respective 95% CIs for round 24. Exceptions include: the concentrations of chloride and alkalinity in the primary sample, both of which were >10% different from concentrations measured in the duplicate sample; sodium concentrations in both samples; and the magnesium concentration in the primary sample, which was only slightly higher than its upper 95% CI. The CBE was +3.6% for round 24 indicating a surplus of cations (probably due to the anomalously high sodium concentrations) and/or a deficit of anions (Note: the CBE for round 24 was calculated after the primary concentrations of chloride and alkalinity were removed, as they were >10% different from the duplicate concentrations and outside the 95% CI).

For round 25, concentrations measured in both the primary and duplicate samples were within their respective 95% CIs, except for the potassium concentration measured in the primary sample, which was slightly higher than its upper 95% CI threshold. The CBE was -3.2% for round 25, indicating a surplus of anions or a deficit of cations.

2.3.1.2.2 WQSP-2

For round 24, concentrations measured in both the primary and duplicate samples were within their respective 95% CIs, except for the chloride concentration measured in the duplicate sample, which was nearly 12% higher than the concentration measured in the primary sample. The CBE for round 24 was -2.0% indicating a surplus of anions and/or a deficit of cations (Note: the CBE for round 24 was calculated after the duplicate concentration of chloride was removed as it was >10% different from the primary concentration and outside the 95% CI, which improved the CBE).

Concentrations of almost all of the major ions were within their respective 95% CIs for round 25. The exceptions include: alkalinity concentrations in both samples, which were much higher than their upper 95% CI threshold; and the potassium concentration of the primary sample, which was >35% higher than the concentration measured in the duplicate sample. In addition, results from analyses for alkalinity and all cations showed >10% difference between the primary and duplicate samples. The CBE for round 25 was -5.2%, indicating a surplus of anions and/or deficit of cations.

2.3.1.2.3 WQSP-3

Concentrations of sulfate, sodium, calcium, and magnesium were above the upper threshold of their respective 95% CIs for round 24 in both primary and duplicate samples, while concentrations of potassium were below the lower 95% CI threshold for both samples. In addition, results show that that the differences in concentrations for calcium, magnesium, and potassium were >10% between primary and duplicate samples. The CBE was +4.2% for round 24, indicating a surplus of cations and/or a deficit of anions.

For round 25, most concentrations measured in both the primary and duplicate samples were within their respective 95% CIs. Exceptions include: the chloride concentration measured in the duplicate sample, which was significantly higher than its upper 95% CI threshold and >35% higher than the primary; the concentrations of sulfate in both samples, which were slightly higher than the upper 95% CI threshold; and the potassium concentration in the primary sample, which was slightly below its lower 95% CI threshold. The CBE was -2.7% for round 25, indicating a surplus of anions and/or a deficit of cations (Note: the duplicate chloride concentration was not used in the CBE calculation, which improved the CBE).

2.3.1.2.4 WQSP-4

For round 24, concentrations measured of all major ions except alkalinity were either above the upper threshold of their respective 95% CIs, showed a >10% difference between primary and duplicate samples, or both. The concentrations of chloride and sulfate in both samples were significantly above the upper 95% CI thresholds for each ion and the sodium concentration in the primary sample was above its upper 95% CI threshold. All the cation (sodium, calcium, magnesium, and potassium) concentrations showed >10% difference between primary and duplicate samples. The CBE for round 24 was -14.3%, reflecting the anomalously high chloride and sulfate concentrations.

Concentrations of the major ions were within their respective 95% CIs for round 25 except for chloride and sodium, which were slightly higher than their respective upper 95% CI thresholds in both the primary and duplicate samples. Results from analyses for alkalinity showed >10% difference between the primary and duplicate samples. The CBE for round 25 was -0.7%.

2.3.1.2.5 WQSP-5

Concentrations of most of the major ions were within their respective 95% CIs for round 24. The exceptions were the sulfate concentrations for both samples and the sodium concentration in the duplicate sample, which were higher than their respective upper 95% CI thresholds. The CBE for round 24 was -4.4%, indicating a surplus of anions and/or a deficit of cations.

For round 25, most of the major ion concentrations measured in the primary and duplicate samples were within their respective 95% CIs. The sodium concentrations for both samples and the alkalinity concentration in the primary sample were higher than their respective upper 95% CI thresholds. The alkalinity concentration measured in the primary sample was nearly 22% higher than that in the duplicate sample. The CBE for round 25 was +0.7%.

2.3.1.2.6 WQSP-6

For round 24, major ion concentrations at WQSP-6 were within their respective 95% CIs, except for the sulfate concentrations of both the primary and duplicate samples, which were above the 95% CI, and the magnesium concentration in the primary sample, which was just below the 95% CI threshold. The CBE for round 24 was -1.7% indicating a slight surplus of anions or a deficit of cations.

All major ion concentrations were within their respective 95% CIs for round 25, except the chloride concentration in the primary sample, which was below its lower 95% CI threshold. The CBE for round 25 was +5.7%, indicating a surplus of cations or deficit of anions.

2.3.1.2.7 WQSP-6a

All major ion concentrations were within their respective 95% CIs for round 24, except sodium concentrations in both samples, which were below the lower 95% CI threshold. The CBE for round 24 was -6.4%, indicating a surplus of anions or a deficit of cations (e.g., sodium).

For round 25, most major ion concentrations were within their respective 95% CIs. Exceptions include: alkalinity concentrations in both samples that were above their upper 95% CI threshold, and sodium concentrations in both samples and chloride concentration in the primary sample that were below their respective lower 95% CI thresholds. In addition, the reported concentrations of both chloride and sulfate differed by >10% between the primary and duplicate samples. The CBE for round 25 was -3.2%, indicating a surplus of anions or deficit of cations.

2.3.1.3 Assessment of Water Quality Data

2.3.1.3.1 Culebra

Based on review of CBEs calculated for each round for each WQSP-Culebra wells sampled, the analytical results generally show small charge balance errors. Only 3 of the 12 calculated CBEs for the 2 rounds were greater than ±5% and in most cases can be linked to variability between individual analyte results. For example, the WQSP-2 and WQSP-4 CBEs for round 24 were -5.2% and -14.3%, respectively, and in both cases 4 of the 7 analytes had >10% difference between the primary and duplicate sample. The other CBE >5% is more difficult to explain. The CBE in WQSP-6 for round 25 was calculated to be +5.7% (very close to the ±5% limit), with only the chloride concentration in the primary sample outside its 95% CI and no analytes showing a >10% difference between the primary and duplicate sample results. If the low chloride concentration were removed from the CBE calculation, however, the CBE would improve to +4.5%, which suggests that the chloride concentration measured in the primary sample may be in error.

Only one Culebra well has an analyte in exceedance of a TV. The chloride concentration in WQSP-4 has been above the upper 95% CI threshold since round 20 (Figure 2.12), as reported in the 2007 COMPs report (SNL 2008b). Three other analytes can be considered borderline, including: the potassium concentration in WQSP-3, and sodium concentrations in WQSP-4 and WQSP-5, all of which have had 5 of 6 results (2 per round) outside their respective 95% CI over the last 3 rounds (i.e., since round 23).

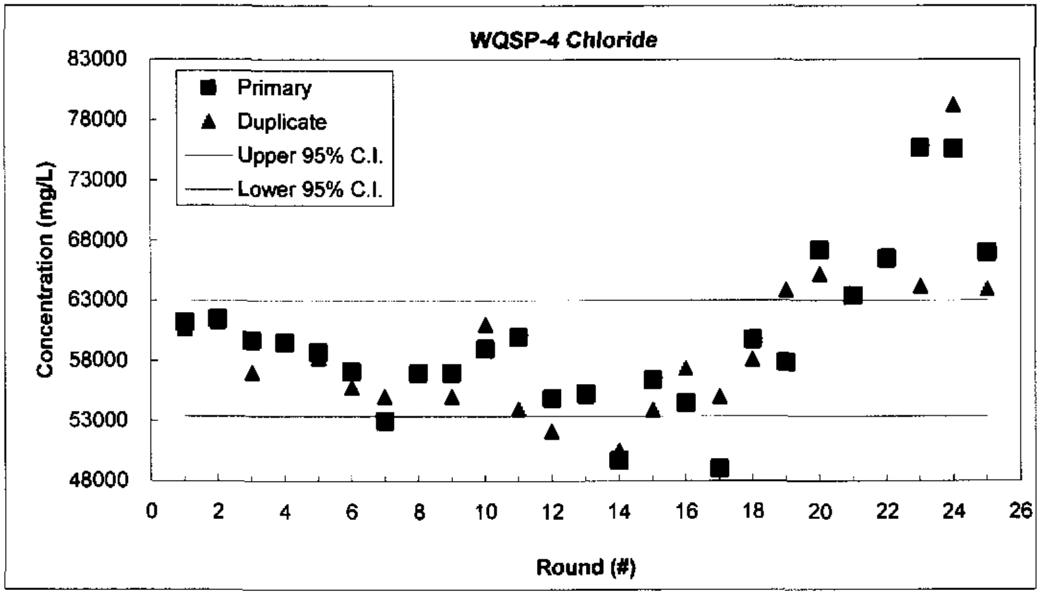


Figure 2.12 Chloride concentrations measured in WQSP-4

Trilinear (or Piper) diagrams provide a better method for determining water chemistry stability, by showing if ion ratios or percentages are changing over time. Trilinear diagrams of Culebra water chemistry (Figure 2.13) over the course of the WQSP (11+ years) show that the groundwater is relatively stable, with results for each well continually plotting within small envelopes.

Full assessment of the Culebra water-chemistry results shows that it is stable and that any variability observed in the data suggesting instability can be attributed to analytical problems. The primary difficulty is that the high TDS of the Culebra waters complicates analyses. Comparison of the WQSP wells with high TDS (Table 2.6) to major ion concentrations for rounds 24 and 25 (Table 2.5) shows that wells with high measured TDS tend to have the most analyte pairs that show >10% difference between primary and duplicate samples. These wells also tend to have more issues with analytes being within their respective 95%CI.

Table 2.13 Average measured TDS in WQSP wells

Well ID	Average TDS (mg/L)
WQSP-1	65,000
WQSP-2	65,000
WQSP-3	210,000
WQSP-4	115,000
WQSP-5	35,000
WQSP-6	15,000

Though it was reported in the 2007 COMPs report (SNL 2008b) that it appeared that improvements in data quality were observed between rounds 22 and 23 (with indicators of analytical problems being the most notable), it appears that this was a short-lived improvement.

From round 27 onward, a different laboratory (Hall Environmental Analysis Laboratory Inc. (HEAL) of Albuquerque, New Mexico) will be analyzing the WQSP samples and the SA will evaluate the consistency of results provided by HEAL in subsequent years.

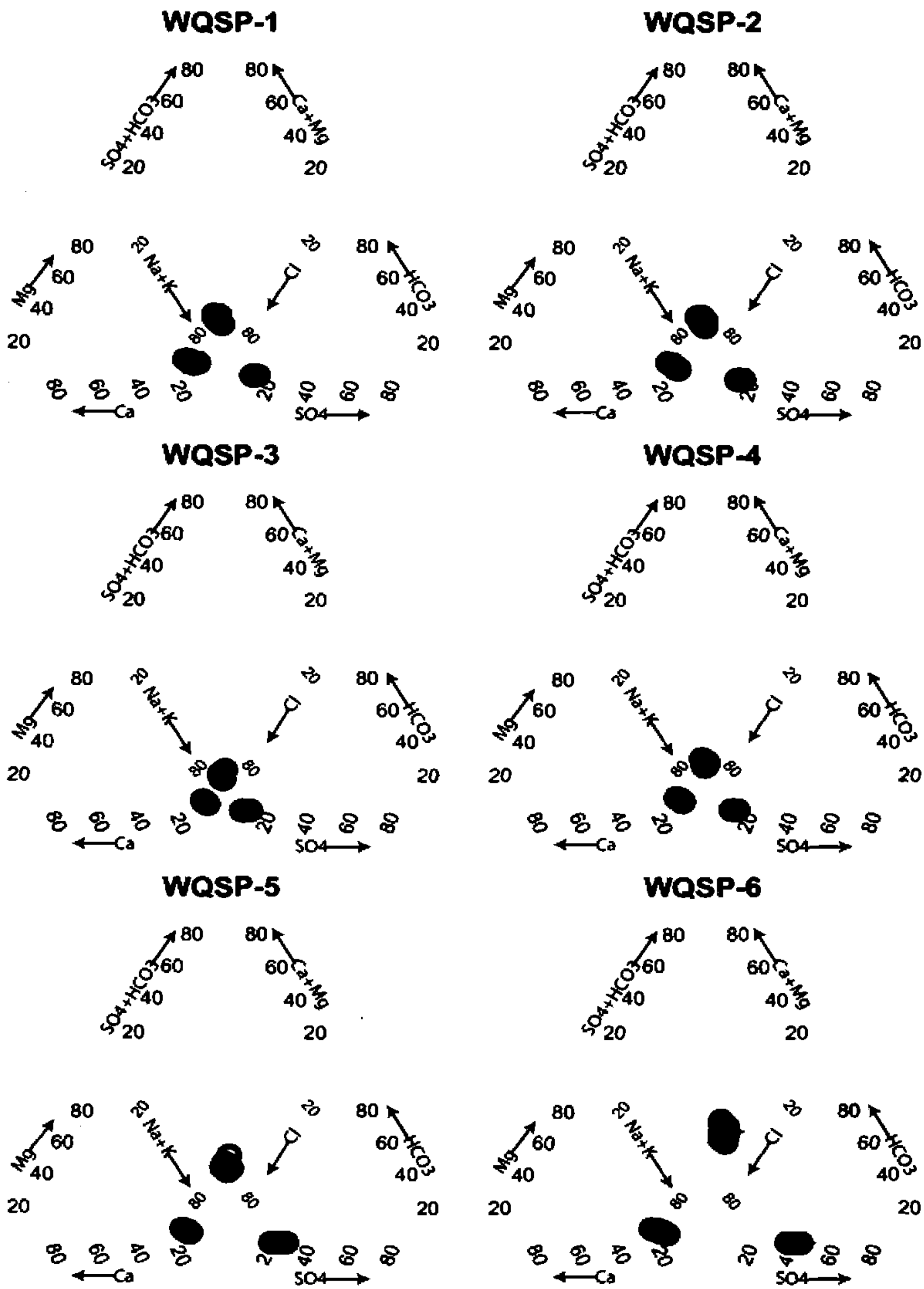


Figure 2.13 Trilinear diagrams of data collected from WQSP-1 through WQSP-6. The plots show both historical data (gray areas) and results from rounds 24 (blue star) and 25 (red star).

2.3.1.3.2 Dewey Lake

Interpretation of the long-term data and the trilinear diagram (Figure 2.14), suggest that water chemistry in WQSP-6a is changing. Both sodium and chloride show declines in concentration with each sampling event (Figure 2.15), while other ion concentrations remain relatively stable. This suggests that the Dewey Lake, at least at WQSP-6a, is freshening slightly.

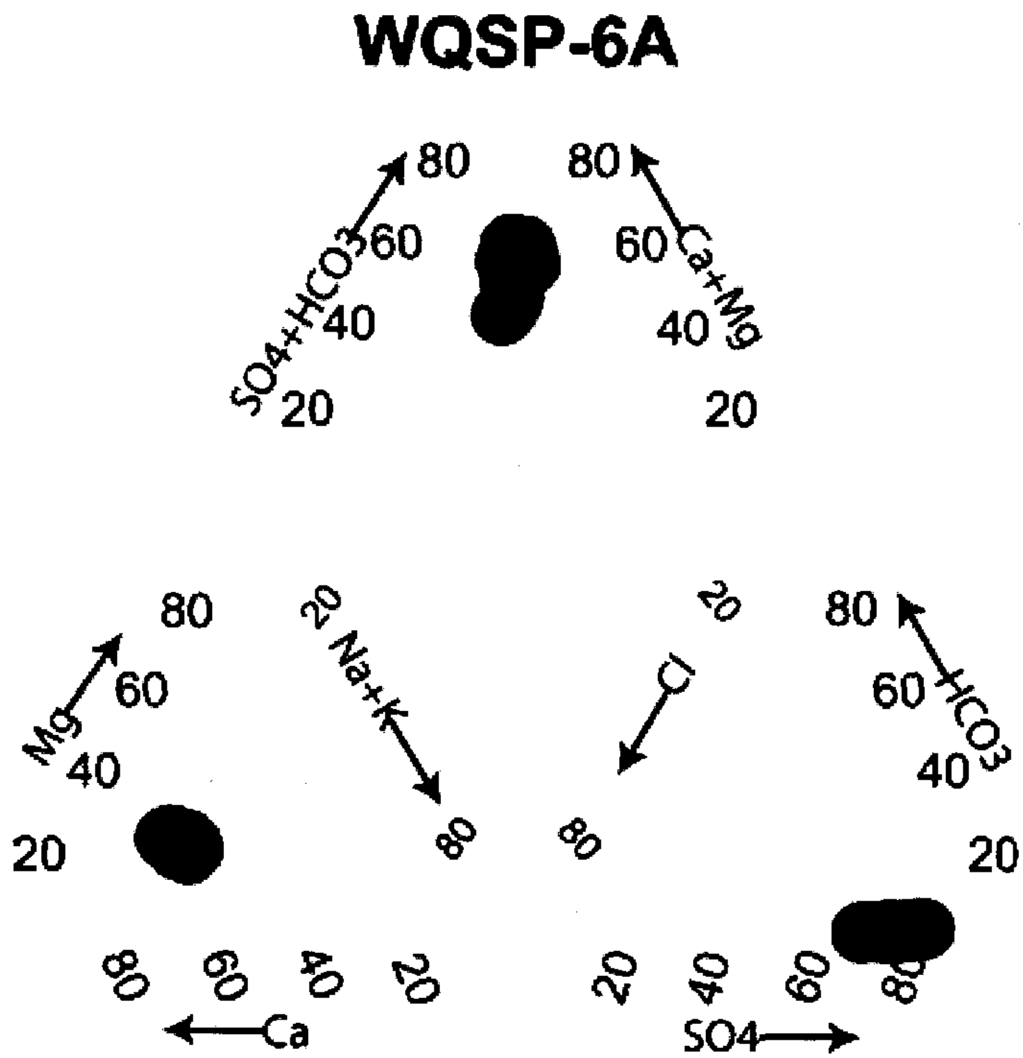
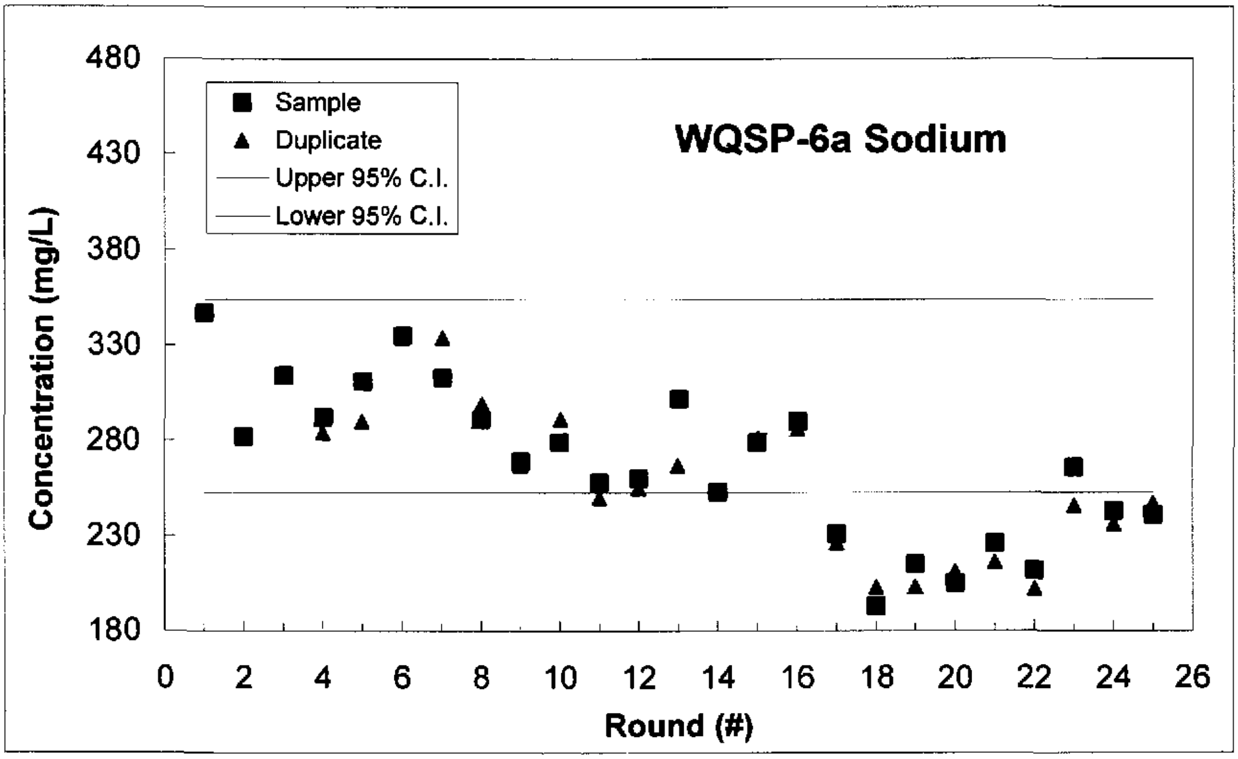


Figure 2. 14 Trilinear diagram of data collected from WQSP-6a. The plot shows both historical data (gray areas) and results from rounds 24 (blue star) and 25 (red star).



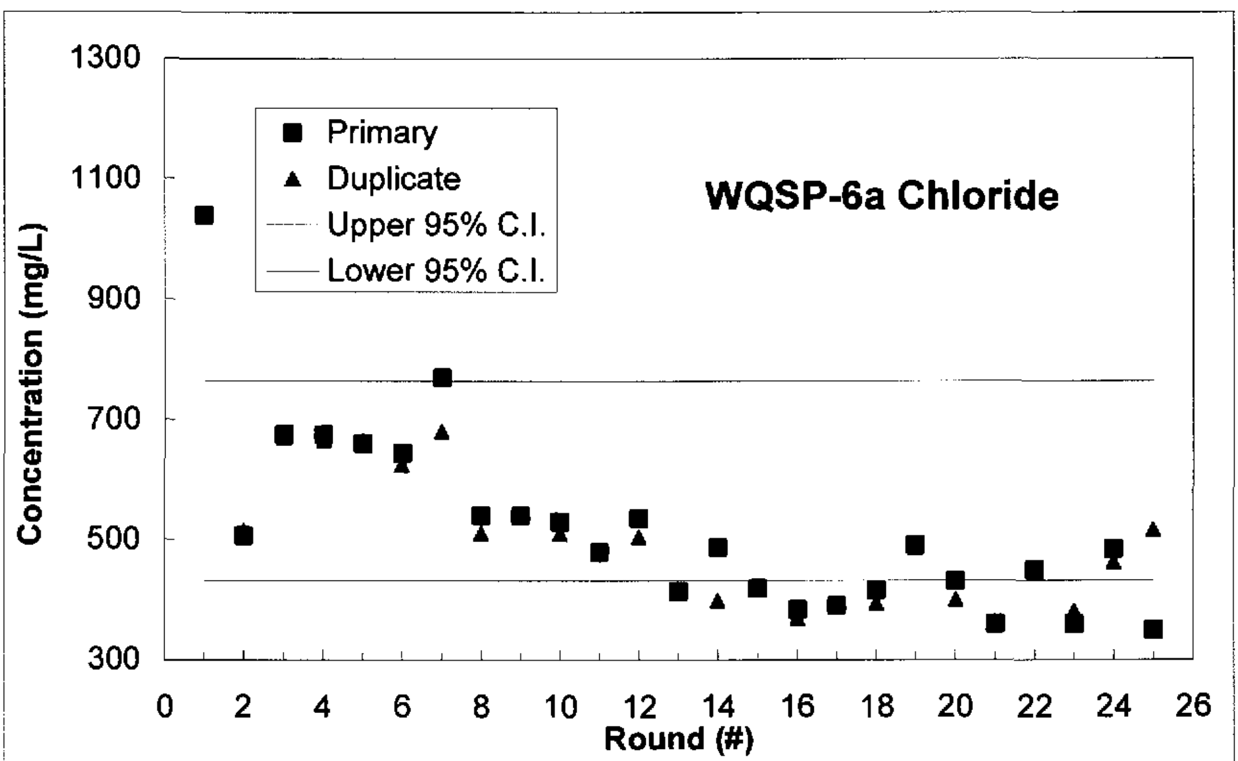


Figure 2. 15 Sodium and chloride concentrations measured in WQSP-6a through time.

Table 2.14 Change in Groundwater Composition - 2008:

Trigger Value Derivation

COMP Title:	Groundwater Composition
COMP Units:	mg/L

Related Monitoring Data

Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Groundwater Monitoring	Composition	Semi-annual chemical analysis	RCRA Background Water Quality Baseline

COMP Derivation Procedure – Data acquired in two rounds, March-May (round 24) and September-November (round 25) 2007

Annually evaluate SER data and compare to previous years and baseline information

Related Performance and Compliance Elements

Element Title	Type & ID	Derivation Procedure	Compliance Baseline	Impact of Change
Groundwater conceptual model, 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 flow, transport, and solubility and redox assumptions.

Monitoring Data Trigger Values

Monitoring Parameter ID	Trigger Value	Basis
Change in Culebra groundwater composition	Both duplicate analyses for any major ion falling outside the 95% confidence interval (see Table 2.6) for three consecutive sampling periods	The 95% confidence interval for a particular analyte defines the range of concentrations that 19 out of 20 analyses, on average, should fall within. Therefore, TVs should not be set so that a single analysis falling outside the 95% confidence interval is significant. In addition, analysis of solutes in the concentrated brines of the Culebra is not a routine procedure, and occasional analytical errors are to be expected, particularly when a new laboratory is contracted to perform the analyses (SNL 2002b).

2.3.2 Changes in Groundwater Flow (Water Level)

Assessment of the COMP "Changes in Groundwater Flow" involves TVs derived from the steady-state freshwater heads estimated for Culebra flow modeling in the CRA-2004 (DOE 2004). The Culebra transmissivity (T) fields that were used to simulate the transport of radionuclides through the Culebra were considered calibrated when, among other things, the modeled heads at 32 wells (24 of which remain) fell within the ranges of uncertainty estimated for steady-state freshwater heads at those wells. If monitoring shows that heads at these wells are outside the ranges used for T-field calibration (hereafter called the "CRA-2004 range"), the cause(s) and ramifications of the deviations must be investigated.

The Dewey Lake, Magenta, and Bell Canyon are not currently monitored as COMPs and do not have TVs. The water-level measurements in these units do, however, provide information used in the development of the conceptual model of overall site hydrology.

2.3.2.1 Water Level Monitoring Program (WLMP)

The Water Level Monitoring Program (WLMP) collects two types of data:

1) fluid pressure exerted by the water column at the midpoint of the unit (Culebra); and
2) the water level, to determine the height of the water column in the well above the midpoint of the unit.

Using the known ground-surface elevation at a given well, these data are used to calculate fluid density and freshwater head (FWH), which is the elevation of the column of freshwater (density = 1.0 g/cm^3) that would exert the same pressure at the midpoint of the Culebra as that exerted by the column of fluid actually in the well. Wells in which water level and/or fluid pressure measurements were made in 2007 are shown in Figure 2.16.

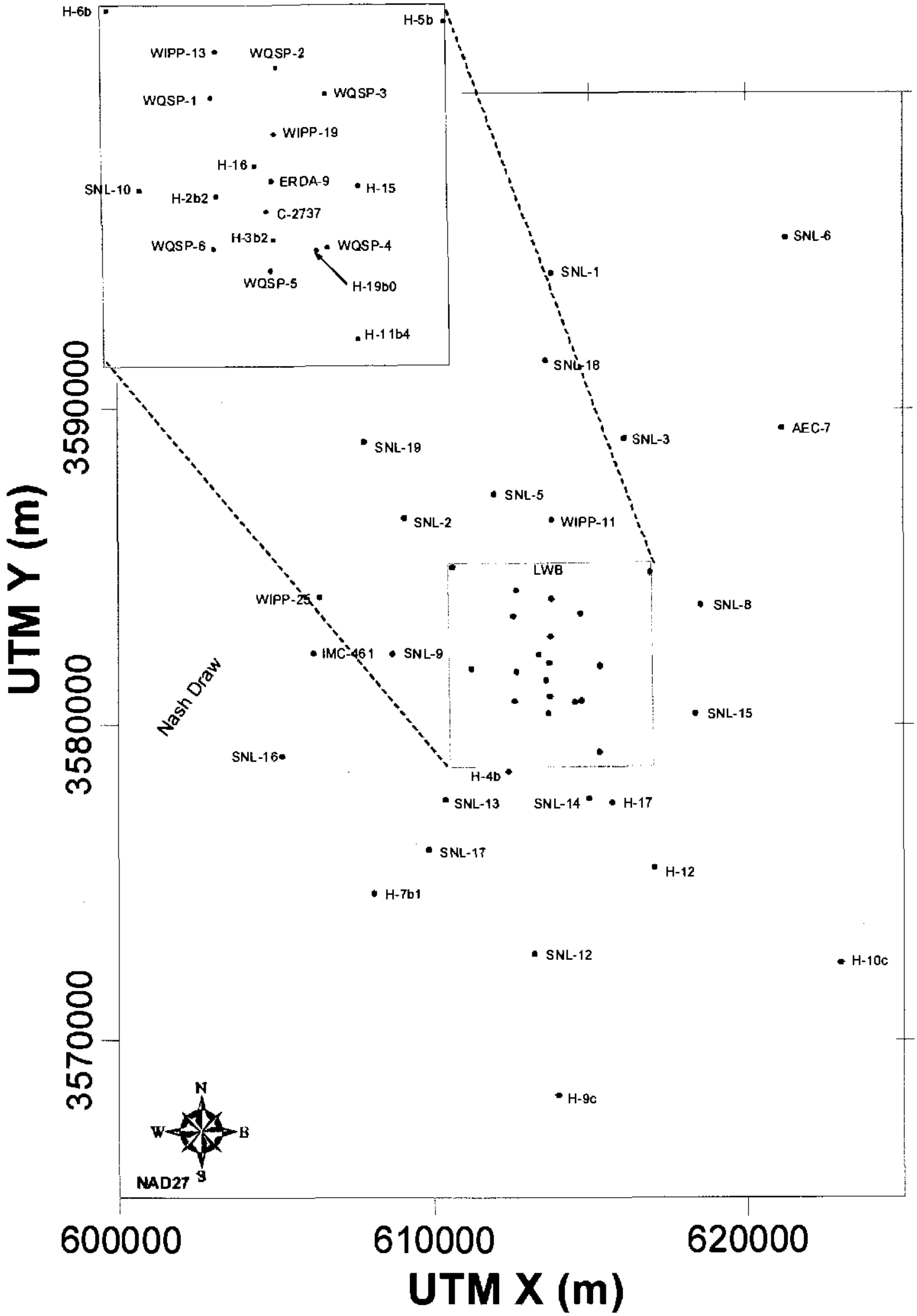


Figure 2.16 Map of the WIPP area showing well locations discussed in this section.

2.3.2.1.1 Fluid Density Survey

Since 2000, the MOC has conducted an annual program of pressure-density (PD) surveys in monitoring wells. In addition to the data collected via the PD survey, specific gravity (SG) is measured on samples collected from the seven WQSP wells (SG is the ratio of the density of the water being measured to that of freshwater and is unitless). Due to equipment problems encountered by the MOC, the SA was asked to make the 2007 PD measurements in all Culebra wells, with the exception of the six WQSP wells. This amounted to 44 PD measurements (DOE 2008c) including the 6 redundant wells on the H-19 hydropad, which are not discussed in this document. Six PD values were the result of first-time measurements, while the others updated previous measurements. The MOC measured SG in WQSP-1 through 6 completed to the Culebra (DOE 2008c), with the average SG value of both rounds being reported here. Measurements of PD or SG were not made in any of the fifteen Magenta wells because there was no regulatory or modeling need for such data.

2.3.2.1.2 Water-Level Monitoring

In 2007, the MOC made monthly or quarterly water-level measurements in 63 wells (includes 5 dual-completion Culebra-Magenta wells). Of these, 50 are completed to the Culebra Member of the Rustler Formation, 15 to the Magenta Member of the Rustler Formation, 2 to the Bell Canyon Formation, and 1 to the Dewey Lake Formation. Measurements were taken monthly in 44 Culebra wells and quarterly in the 6 redundant Culebra wells on the H-19 hydropad. Limited measurements (noted in Tables 2.8 and 2.9) were made in some wells due to SA well testing activities, maintenance issues, and/or the well being plugged and abandoned during 2007.

2.3.2.2 Results and Assessment of Culebra Data

Assessment of Culebra data involves the interpretation of fluid density and water-level data. Both are indicators of the flow regime, in that if density or water-level change significantly, it may reflect a change in flow direction and/or velocity. The SA has determined that if water-level changes by > ±2.0 ft and/or density changes by > ±0.010 g/cm^3, the change(s) will be noted and investigated.

2.3.2.2.1 Results and Assessment of Culebra Fluid Density Data

Results from the 2007 PD and SG measurements are compared with previous results (SNL 2008b) in Table 2.7. Of the 38 resurveyed Culebra wells, 12 experienced a change in fluid density of ≥±0.01 g/cm^3 from previous measurements. Of these, 10 showed a change ≤±0.02 g/cm^3, while 2 wells, H-3b2 and SNL-8, showed larger changes of +0.033 and +0.052 g/cm^3, respectively.

Though nearly one-third of the Culebra wells evaluated in 2007 show changes ≥±0.01 g/cm^3 in fluid density from 2006 to 2007, most of the changes may result from the use of two similar, yet different methods to calculate the fluid densities of each well. The MOC method employed prior to 2007 used a pressure transducer connected to a non-graduated cable that was lowered into a well for a short period of time (~15 minutes). The depth of the transducer installation was determined using a mechanical depth counter that was accurate only to within a few feet, and only one depth to water (DTW) measurement was taken in conjunction with a pressure reading. This method is susceptible to error in two significant ways: uncertainty as to the exact depth of the transducer and the lack of repeated DTW measurements (i.e., only a single measurement versus multiple). The SA method used for 2007 addressed these issues. The SA used pressure transducers installed on a measured, graduated cable for at least 4 days (in most cases the transducers were year-round installations) and multiple DTW measurements were taken (except at WIPP-25, which was only measured once) in conjunction with pressure readings.

The relatively large change in fluid density observed in SNL-8 is a result of SA testing conducted between July 2 and August 2, 2008. Over this time, a series of pumping events were conducted after which a noticeable change in fluid density was observed. The reason for the initially lower fluid density in SNL-8 was likely due to incomplete post-drilling development of the well after it was completed in mid 2005. The SA believes that the current density (1.103 g/cm^3) is reflective of the Culebra in the area around SNL-8. The smaller fluid-density change observed at H-3b2 is believed to be related to measurement error during the 2006 PD Survey. The 2007 PD value was calculated at 1.042 g/cm^3, which is close to the historical specific gravity value of 1.037 reported after pumping the well for 62 days in 1985 (Intera Technologies, 1986).

The SA method of fluid density measurement is a marked improvement over the old method because it eliminates multiple sources of error by more accurately determining the depth of the transducer in conjunction with repeated long-term DTW and pressure-head measurements. The SA believes that a more consistent picture of fluid density will emerge from the continued use of the new technique.

Table 2.15 Summary of Culebra fluid densities collected during the 2007 PD survey.

Well	Date	Unit	2007 Density (g/cm³)	2006 Density (g/cm³)	Method
AEC-7	12/10/07	Culebra	1.211*	1.211*	PD
C-2737	12/11/07	Culebra	**1.010**	1.027	PD
ERDA-9[a]	12/11/07	Culebra	1.047	N/A	PD
H-2b2	12/11/07	Culebra	**1.014**	1.000	PD
H-3b2	12/11/07	Culebra	**1.042**	1.009	PD
H-4b	12/11/07	Culebra	1.015	1.021	PD
H-5b	12/10/07	Culebra	1.091	1.099	PD
H-6b	12/07/07	Culebra	1.034	1.043	PD
H-7b1	12/10/07	Culebra	1.002	1.006	PD
H-9c	12/10/07	Culebra	1.001	1.007	PD
H-10c	12/10/07	Culebra	1.008	1.005	PD
H-11b4	12/11/07	Culebra	1.070	1.071	PD
H-12	12/10/07	Culebra	**1.097**	1.108	PD
H-15[a]	12/11/07	Culebra	1.053	N/A	PD
H-17	12/11/07	Culebra	1.133	1.134	PD
H-19b0	12/11/07	Culebra	1.068	1.071	PD
IMC-461	12/07/07	Culebra	**1.005**	1.017	PD
SNL-1	12/07/07	Culebra	1.033	1.027	PD
SNL-2	12/07/07	Culebra	1.012	1.017	PD
SNL-3	12/07/07	Culebra	1.023	1.028	PD
SNL-5	12/07/07	Culebra	1.010	1.010	PD
SNL-6[a]	12/10/07	Culebra	1.246	N/A	PD
SNL-8	12/10/07	Culebra	**1.103**	1.051	PD
SNL-9	12/07/07	Culebra	1.024	1.024	PD
SNL-10	12/11/07	Culebra	1.011	1.004	PD
SNL-12	12/10/07	Culebra	1.005	1.006	PD
SNL-13	12/10/07	Culebra	**1.027**	1.008	PD
SNL-14	12/11/07	Culebra	**1.048**	1.038	PD
SNL-15	12/10/07	Culebra	1.228	1.221	PD
SNL-16	12/10/07	Culebra	**1.010**	1.000	PD
SNL-17A[a]	12/10/07	Culebra	1.006	N/A	PD
SNL-18[a]	12/07/07	Culebra	1.028	N/A	PD
SNL-19[a]	12/07/07	Culebra	1.003	N/A	PD
WIPP-11	12/07/07	Culebra	1.038	1.039	PD
WIPP-13	12/11/07	Culebra	1.053	1.041	PD
WIPP-19	12/11/07	Culebra	**1.044**	1.055	PD
WIPP-25[b]	12/19/07	Culebra	1.011	1.013	PD
WIPP-30	09/17/07	Culebra	1.000	1.007	PD
WQSP-1	05/23/07 & 11/28/07	Culebra	1.040	1.048	SG
WQSP-2	05/16/07 & 11/07/07	Culebra	**1.035**	1.047	SG
WQSP-3	05/02/07 & 10/31/07	Culebra	**1.135**	1.145	SG
WQSP-4	04/18/07 & 10/10/07	Culebra	1.070	1.074	SG
WQSP-5	04/04/07 & 10/03/07	Culebra	1.018	1.025	SG
WQSP-6	03/21/07 & 09/26/07	Culebra	1.008	1.014	SG

* The fluid density in AEC-7 is not reflective of the Culebra (see SNL 2006, 2007)

[a] First time PD or SG measurements on new or existing wells as of 2007.

[b] PD is based on a single data point collected by SNL.

N/A = not available or not measured

PD = Pressure Density and SG = Specific Gravity

Bold = Changes in fluid density ≥ ±0.010 g/cm³ from previous measurements.

2.3.2.2.2 Results and Assessment of Culebra Water-Level Data

A comparison of Culebra water levels, in feet above mean sea level (ft amsl), from December 2006 to December 2007 is presented in Table 2.8. Water-level changes in the 43 Culebra wells ranged from -32.40 ft to +78.35 ft, with 11 of the wells experiencing water-level changes of ≥ ±2.0 ft (Note: the redundant wells on the H-19 hydropad are excluded from this assessment). Due to SA well testing activities conducted at WIPP-25, the MOC was unable to make a DTW measurement in 2007. However, the SA collected a DTW when the well was recompleted and a transducer installed in the Culebra in December 2007.

Table 2. 16 Summary of 2007 Culebra water-level changes and freshwater heads.

Well I.D.	12/06 W.L. (ft amsl)*	12/07 W.L. (ft amsl)	2007 Change (ft)	12/07 FWH (ft amsl)	CRA-2004 FWH Range (ft amsl)	Outside CRA-2004 Range?
AEC-7	3234.35	3201.95	**-32.40**	3239.22	3057.1-3066.2	Y
C-2737	3012.58	3018.69	**6.11**	3021.78	N/A	N/A
ERDA-9	3011.83	3013.32	1.49	3028.38	3001.8-3012.3	Y
H-2b2	3045.02	3046.53	1.51	3050.47	3036.8-3043.4	Y
H-3b2	3001.12	3002.49	1.37	3013.37	3004.2-3013.9	N
H-4b	3003.62	3004.71	1.09	3006.63	3000.2-3007.3	N
H-5b	3038.40	3039.59	1.19	3083.43	3065.5-3077.9	Y
H-6b	3059.84	3060.84	1.00	3074.32	3059.9-3070.0	Y
H-7b1	2999.92	3000.30	0.38	3000.48	2996.4-3001.0	N
H-9c	2990.87	2996.32	**5.55**	2997.58	2987.7-2993.8	Y
H-10c	3025.00	3024.13	-0.87	3030.53	N/A	N/A
H-11b4	2986.56	2988.25	1.69	3008.28	2998.6-3008.5	N
H-12	2969.89	2970.31	1.42	3001.92	2993.3-3008.4	N
H-15	3005.29[a]	2997.94	**-7.35**	3018.55	3012.5-3023.4	N
H-17	2965.78	2967.18	1.40	3008.22	2999.8-3006.6	Y
H-19b0	2992.15	2993.40	1.35	3015.41	3005.5-3012.4	Y
IMC-461	3047.73	3047.46	-0.27	3048.00	N/A	N/A
SNL-1	3082.98	3084.72	1.74	3089.90	N/A	N/A
SNL-2	3074.86	3075.46	0.60	3077.69	N/A	N/A
SNL-3	3074.36	3076.46	**2.10**	3084.57	N/A	N/A
SNL-5	3075.81	3077.46	1.65	3081.27	N/A	N/A
SNL-6[#]	2691.34[b]	2769.69	**78.35**	2883.11	N/A	N/A
SNL-8	3029.52	3014.34	**-15.18**	3038.29	N/A	N/A
SNL-9	3052.60	3053.20	0.60	3058.84	N/A	N/A
SNL-10	3050.95[c]	3054.28	**3.33**	3054.47	N/A	N/A
SNL-12	3000.96	3002.68	1.72	3003.61	N/A	N/A
SNL-13	3008.52	3009.63	1.09	3016.00	N/A	N/A
SNL-14	2992.39[d]	2992.42	0.03	3006.51	N/A	N/A
SNL-15	2823.51	2816.48	**-17.03**	2874.96	N/A	N/A
SNL-16	3011.52	3011.11	-0.41	3011.95	N/A	N/A
SNL-17A	3006.94	3007.35	0.41	3007.46	N/A	N/A
SNL-18	3076.38	3077.76	1.38	3081.55	N/A	N/A
SNL-19	3075.72	3076.52	0.80	3077.98	N/A	N/A
WIPP-11	3066.81	3068.75	1.94	3087.68	N/A	N/A
WIPP-13	3063.60	3064.89	1.29	3083.39	3069.1-3078.4	Y
WIPP-19	3045.79	3047.74	1.95	3070.67	3054.3-3065.5	Y
WIPP-25	N/A[e]	3066.53[f]	N/A	3069.67	3055.2-3064.9	Y
WIPP-30	3080.90	3083.43[g]	**2.52**	3089.85	3069.1-3078.4	Y
WQSP-1	3062.17	3063.69	1.52	3080.88	3067.0-3072.4	Y
WQSP-2	3067.35	3068.82	1.47	3089.46	3077.2-3083.0	Y
WQSP-3	3017.40	3018.84	1.44	3077.03	3067.4-3073.6	Y
WQSP-4	2988.65	2990.91	**2.26**	3016.31	3007.8-3012.4	Y
WQSP-5	3005.19	3006.44	1.25	3013.46	3006.3-3012.2	Y
WQSP-6	3020.69	3021.56	0.87	3025.12	3016.2-3020.7	Y

* Adjusted to resurveyed well elevations based on November 2006 survey (DOE 2007b)

[#] SNL-6 was not reported in the 2007 SER (DOE 2008c), data are summarized from the WRES monthly water-level reports (Hillesheim 2008)

All measurements made in December, except as noted

[a] Water-level elevation on 1/16/07, first MOC measurement after reconfiguration to dual-completion Culebra-Magenta well on 10/26/06.

[b] Water-level elevation on 3/13/07, first-time measurement by WRES.

[c] Water-level elevation on 4/12/07 after pump was removed.

[d] Water-level elevation on 11/14/07, pump installed 9/18/06 and removed 11/09/07.

[e] Well was configured to test Magenta between 02/09/06 and 12/19/07.

[f] Measurement taken by the SA after reconfiguration back to dual-completion Culebra-Magenta on 12/19/07.

[g] Water-level measurement taken 9/17/07, after which well was obstructed and scheduled for P&A.

N/A = not applicable (data from well not used in CRA-2004 T-field calibration) or data unavailable

Bold = changes in water level ≥ ±2.0 ft

Most of the water-level changes greater than 2 ft are related to human activities such as hydrologic testing, well maintenance, and water-quality sampling. For example, changes in water level at wells C-2737, H-15, SNL-8 (discussed above), SNL-10, and SNL-15 are due to SA well testing activities. WIPP-30 was a dual-completion well with a production-injection packer (PIP) installed to separate the Culebra and Magenta. In August 2007, the PIP failed. The SA attempted to replace the PIP in September, but it became irretrievably lodged and the well was scheduled for plugging and abandonment (sometime in early 2008).

As discussed in the 2006 COMPs report (SNL 2008b), water level in AEC-7 is being influenced by the leakage of pressurized brine from a lower unit(s). During much of 2007, water level in AEC-7 continued its steady rise until November when it began to inexplicably decline. It is not known what caused this reversal in water level, but it was probably caused by something that reduced the amount of brine-water leakage from the lower unit(s). In early 2008, AEC-7 is scheduled for plug-back activities (~80 ft of grout will be added to seal the bottom of the well and it will then be re-perforated over the Culebra interval) in an attempt to shut off the leakage of the brine water.

The approximately 5.5 ft rise in water level observed in H-9c is due to recovery from a large-scale drawdown event observed in many wells in the southern portion of the monitoring network, but most notably at H-9c (SNL 2008b). In the 2006 COMPs report (SNL 2008b), the SA speculated that the drawdown was the result of a long duration (i.e., 2-3 months) pumping event at Engle well, which is located approximately 2 km southeast of H-9c (Engle well is completed to the Culebra and is pumped to fill stock tanks for watering of livestock). Though the SA was unable to confirm the source of the drawdown event, pumping at Engle well is the most plausible explanation.

Three wells, SNL-3, WQSP-4, and SNL-6, showed changes in water level that cannot be explained by human activities. Water-level changes observed in SNL-3 (+2.1 ft) and WQSP-4 (+2.26 ft) were only slightly more than the overall water level rise observed in the Culebra across the WIPP area. The largest increase in water level, 78.35 ft, was observed in SNL-6, located northeast of the WIPP site (Figure 2.16). SNL-6 is situated in an area of the Culebra with very low transmissivity and continues to recover from post-drilling development. The SA has conducted an analysis on both SNL-6 and SNL-15 which indicates that the water levels in the two wells will not reach equilibrium (i.e., stabilize) for quite some time (on the order of 10^2 yr); therefore, significant water-level increases are expected on an annual basis in both wells into the foreseeable future.

Overall, Culebra water levels showed a slight, uniform rise across the entire WIPP vicinity, with the exception of small declines observed at IMC-461 (-0.27 ft) and SNL-16 (-0.41 ft), which are located in close proximity to each other on the edge of Nash Draw (~8 km west of the WIPP site; Figure 2.16). In general, water-level rise in the Culebra was steady through 2007 with wells in the far northern portion of the WIPP area showing a small decrease during the last two months of the year (Figure 2.17). Short-lived, minor fluctuations observed in some wells were due primarily to SA testing, sampling, and maintenance activities.

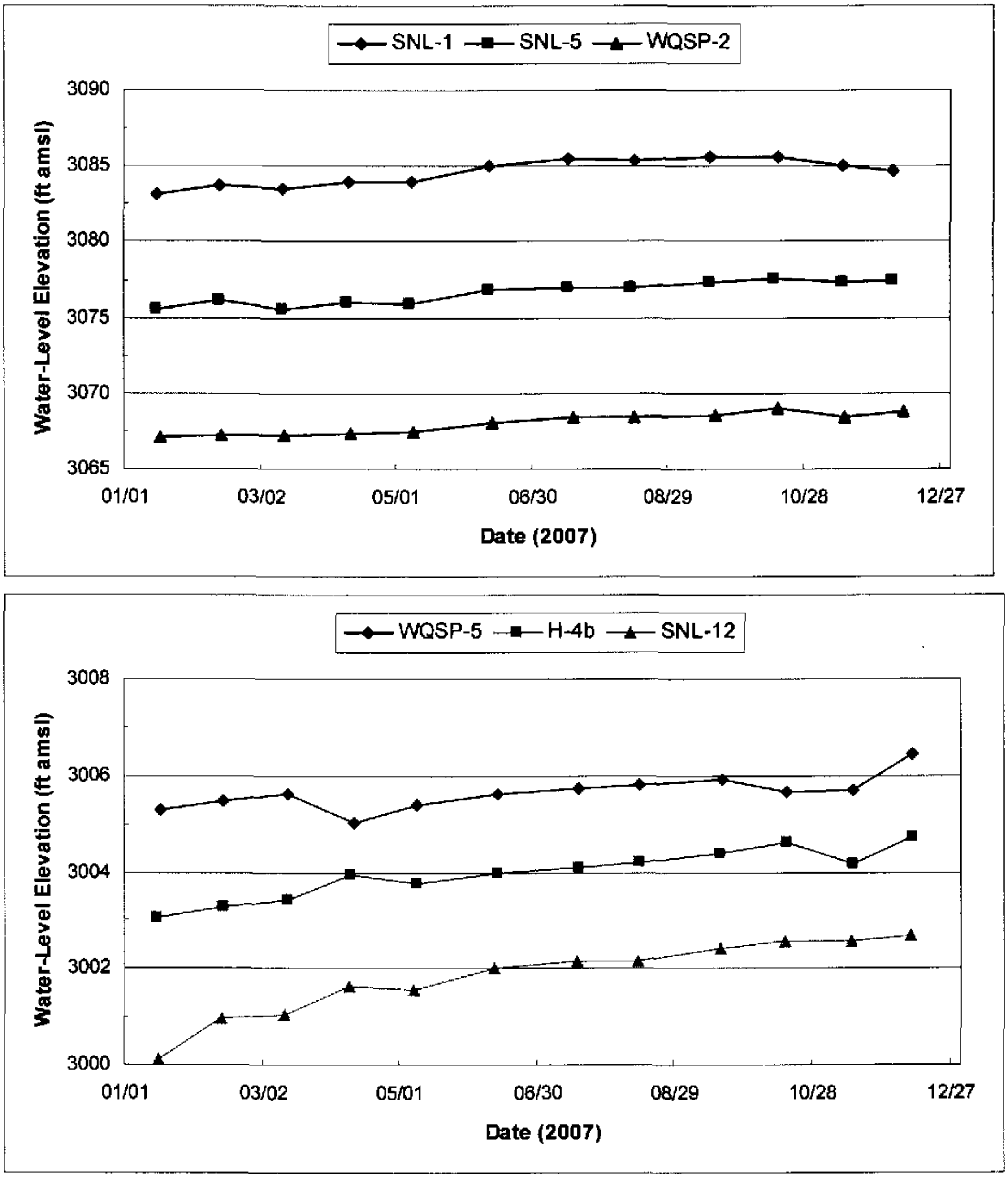


Figure 2.17 2007 water-level trends observed in various wells completed to the Culebra. See Figure 2.16 for well locations.

2.3.2.2.3 Assessment of 2007 Freshwater Head Data

A comparison of December 2007 FWH to the CRA-2004 ranges for the 24 remaining wells used in the generation of the CRA-2004 T fields is also presented in Table 2.8. FWH for each well was calculated using fluid densities reported in the 2007 SER (DOE 2008c). FWH values in 18 of the 24 wells used in this assessment are now outside the upper limit of the CRA-2004 ranges, and in most cases this is independent of any density uncertainties, as no physically reasonable density (i.e., 1.0 to 1.25 g/cm^3) would result in calculated FWH within each well's respective CRA-2004 range. The next CRA (2009) will use updated FWH values.

2.3.2.2.4 Summary of Culebra Data

Assessment of Culebra water-level and density data collected during 2007 shows that observed increases in Culebra FWH were relatively uniform across the WIPP area, which would result in little change in groundwater flow direction or velocity.

Various scenarios have been proposed to explain the observed rise in Culebra water levels, including leaky boreholes (Beauheim 2003) and precipitation recharge to the Culebra through Nash Draw (Hillesheim et al. 2006; 2007). Two large rainfall events that occurred in August and September 2006 have been linked to increases in Culebra water level (Hillesheim et al. 2006; SNL 2006) and a similar increase in Culebra water level was observed after a large rainfall event in September 2004 (Hillesheim et al. 2006; SNL 2005). In all three cases, increases in Culebra head propagated away from Nash Draw over periods of days to months. Additional studies are underway to improve our understanding of how hydrologic processes and events in Nash Draw affect Culebra water levels at the WIPP site.

2.3.2.3 Assessment of Data from Other Units

Assessment of water-level changes from other hydrologic units present in the WIPP vicinity (Table 2.9) is important for refining the conceptual model of overall site hydrology. Water-level measurements for the Magenta Member of the Rustler Formation provide information about confinement of and connectivity to the underlying Culebra Member. Water-level changes in the Magenta ranged from -2.12 to 5.28 ft, with 5 wells experiencing water-level changes of ≥ ±2.0 ft. In general, water levels in the Magenta rose during 2007, continuing the long-term trend. In addition, it appears that water levels in wells H-2b1, H-14, and H-18 continue to recover from reconfiguration activities conducted in 2005 (SNL 2007; Salness 2006). At WIPP-25 and H-15, the PIPs were reset after hydrologic testing was completed. Both PIPs were reset late in 2007 and the reduced water levels observed in each well are related to the early stage of water-level recovery. It is expected that water levels in both wells will return to past levels.

Table 2. 17 Summary of 2007 water-level changes in units other than the Culebra.

Well I.D.	12/06 W.L. (ft AMSL)	12/07 W.L. (ft AMSL)	2007 Change (ft)
Magenta Wells			
C-2737	3144.18	3145.85	1.67
-2b1	3140.84	3142.99	**2.15**
H-3b1	3146.65	3146.91	0.26
H-4c	3146.44	3146.66	0.22
H-6c	3068.47	3069.63	1.16
H-8a	3027.21	3027.28	0.07
H-9c	3136.23	3136.88	0.65
H-10a	3223.63	3223.28	-0.35
H-11b2	3138.45	3139.41	0.96
H-14	3133.80	3138.39	**4.59**
H-15	3125.58[a]	3123.46	**-2.12**
H-18	3141.61	3146.89	**5.28**
WIPP-18	3149.36	3149.69	0.33
WIPP-25	N/A[b]	2991.36[c]	**N/A**
WIPP-30	3122.96	3124.07[d]	1.11
Dewey Lake Wells			
WQSP-6a	3196.91	3196.97	0.06
Bell Canyon Wells			
CB-1	2729.96	2731.95	1.99
DOE-2	2689.23	2694.29	**5.06**

All measurements made in December, except as noted

[a] January 2007, no measurement due to SA testing activities (well reconfigured to dual-completion on 02/13/07)

[b] No MOC measurements made during 2007 due to SA testing activities, which began 02/09/06

[c] Based on SA measurement on 12/19/07, after well was reconfigured back to dual-completion.

[d] September 2007, well became obstructed on 12/13/07 and was scheduled for plugging and abandonment

N/A = not available

Bold = changes in water level ≥ ±2.0 ft

The water level was stable in WQSP-6a, the Dewey Lake well (Table 2.9). The 2 wells completed to the Bell Canyon showed continued water-level rises, with a ≥2.0 ft increase observed in DOE-2 during 2007 (Table 2.9). The water level in DOE-2 appears to be continuing to recovering from reconfiguration activities conducted in June 2004. The water level measured in December 2007 in DOE-2 was ~340 ft lower than the last measurement made in March 1986, before the well was temporarily recompleted to the Culebra.

2.3.2.4 Re-assessment of 2006 Freshwater Head Data

Due to an oversight by the SA, the FWH data for CY 2006 reported in the 2007 COMPs report (SNL 2008b) were inadvertently compared to TVs derived from the Compliance Certification Application (DOE 1996) rather than from the CRA-2004. To address this issue, the SA has recast 2006 Culebra FWH values with the newer TVs from the CRA-2004. Table 2.10 shows a comparison of December 2006 FWH to the CRA-2004 ranges for the 27 remaining wells used in the generation of the CRA-2004 T fields. FWH for each well was calculated using fluid densities reported in the 2006 SER (DOE 2007b). FWH values in 16 of the 27 wells used in this assessment are now outside the upper limit of the CRA-2004 ranges regardless of any density uncertainties, as no physically reasonable density (i.e., 1.0 to 1.25 g/cm^3) would result in calculated FWH within each well's respective CRA-2004 range. Culebra FWH values outside of the respective CRA-2004 ranges will not affect WIPP's compliance with EPA regulations. The latest data from the groundwater program will be accounted for as part of the second recertification such that their impacts on compliance with EPA disposal regulations will be demonstrated. After the EPA's recertification of WIPP, a revised baseline will be established that will become the basis for future groundwater data comparison. New data ranges will be established and the trigger value report will be updated to account for the evolution of the compliance baseline.

Table 2.18 Summary of 2006 Culebra water-level changes and freshwater heads.

Well I.D.	12/05 W.L. (ft AMSL)	12/06 W.L. (ft amsl)	2005 Change (ft)	12/06 FWH (ft AMSL)	CRA-2004 FWH Range (ft AMSL)	Outside CRA-2004 Range?
AEC-7	3161.97	3234.65	**72.68**	3274.83	3057.1-3066.2	Y
C-2737	3008.23	3012.30	**4.07**	3015.32	N/A	N/A
DOE-1	2989.01	2995.97[a]	**6.96**	3031.85	3001.8-3012.3	Y
ERDA-9	3008.84	3012.44	**3.60**	3033.82	3018.6-3028.6	Y
H-2b2	3042.23	3044.97	**2.74**	3048.89	3036.8-3043.4	Y
H-3b2	2996.87	3001.12	**4.25**	3011.95	3004.2-3013.9	N
H-4b	3002.80	3003.39	0.59	3005.29	3000.2-3007.3	N
H-5b	3036.26	3037.67	1.41	3081.31	3065.5-3077.9	Y
H-6b	3058.28	3060.40	**2.12**	3073.86	3059.9-3070.0	Y
H-7b1	3001.00	3000.37	-0.63	3000.55	2996.4-3001.0	N
H-9c	2996.80	2991.13	**-5.67**	2992.36	2987.7-2993.8*	N
H-10c	3033.51	3025.24	**-8.27**	3031.65	N/A	N/A
H-11b4	2984.45	2986.66	**2.21**	3006.58	2998.6-3008.5	N
H-12	2968.54	2969.75	1.21	3001.31	2993.3-3008.4	N
H-15	2986.58	2989.38[b]	-	3026.22	3012.5-3023.4	Y
H-17	2963.21	2965.85	**2.64**	3006.71	2999.8-3006.6	Y
H-19b0	2988.04	2992.20	**4.16**	3014.13	3005.5-3012.4	Y
IMC-461	3051.83	3053.60	1.77	3054.16	N/A	N/A
P-17	2988.21	2990.67[c]	**2.46**	3006.22	2998.6-3006.7	N
SNL-1	3078.02	3082.95	**4.93**	3088.11	N/A	N/A
SNL-2	3073.61	3074.83	1.22	3077.05	N/A	N/A
SNL-3	3070.74	3074.35	**3.61**	3086.64	N/A	N/A
SNL-5	3074.40	3077.71	**3.31**	3081.52	N/A	N/A
SNL-6	No water-level measurements due to >1000 ft between top of casing and water column					
SNL-8	3029.20	3029.58	0.38	3054.38	N/A	N/A
SNL-9	3051.02	3052.59	1.57	3058.22	N/A	N/A
SNL-10	-	3054.84[d]	-	3055.13	N/A	N/A
SNL-12	3001.52	3000.94	-0.58	3001.86	N/A	N/A
SNL-13	3007.16	3008.55	1.39	3014.86	N/A	N/A
SNL-14	2990.84	2992.18[e]	1.34	3010.16	N/A	N/A
SNL-15	2788.58	2824.81	**36.23**	2885.21	N/A	N/A
SNL-16	-	3011.55	-	3012.76	N/A	N/A
SNL-17A	-	3006.94	-	3007.05	N/A	N/A
SNL-18	-	3075.14	-	3078.89	N/A	N/A
SNL-19	-	3075.73	-	3077.18	N/A	N/A
WIPP-11	3066.25	3069.56	**3.31**	3088.52	N/A	N/A
WIPP-13	3060.66	3063.60	**2.94**	3082.14	3062.7-3073.6	Y
WIPP-19	3042.56	3045.96	**3.40**	3068.63	3054.3-3065.5	Y
WIPP-25	3068.40	3068.84[f]	-	3075.79	3055-2-3064.9	Y
WIPP-26	3025.45	3024.14[g]	-1.31	3025.47	3020.0-3024.3	Y
WIPP-27	Plugged and abandoned 08/06, no water-level measurements due to inaccessibility					
WIPP-30	3079.02	3080.90	1.88	3088.29	3069.1-3078.4	Y
WQSP-1	3058.76	3062.10	**3.34**	3076.34	3067.0-3072.4	Y
WQSP-2	3063.93	3067.34	**3.41**	3084.46	3077.2-3083.0	N
WQSP-3	3014.56	3017.53	**2.97**	3073.11	3067.4-3073.6	N
WQSP-4	2985.47	2988.54	**3.07**	3008.56	3007.8-3012.4	N
WQSP-5	3000.70	3005.17	**4.47**	3010.86	3006.3-3012.2	N
WQSP-6	3017.91	3020.64	**2.71**	3023.17	3016.2-3020.7	N

All measurements made in December, except as noted

[a] Last water-level measurement taken 08/16/06, well plugged and abandoned 09/06
[b] Water-level elevation on 03/07/06, prior to reconfiguration for Magenta testing by SA
[c] Last water-level measurement taken 07/10/06, well plugged and abandoned 08/06
[d] Water-level elevation taken 10/10/0, first measurement taken 9/14/06, well completed 08/06
[e] Water-level measurement taken 09/11/06, prior to installation of a pump for age-dating sampling.
[f] Water-level measurement taken 01/16/06, prior to reconfiguration for Magenta testing by SA
[g] Last water-level measurement taken 08/15/06, well plugged and abandoned 10/06

N/A = not applicable; data from well not used in CRA-2004 T-field calibration or data unavailable
Bold = changes in water level ≥ ±2.0 ft

Table 2.19 Changes in Groundwater Flow - 2008:

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; annual pressure-density surveys.	Indirect	
COMP Derivation Procedure - Data acquired between December 2006 and December of 2008				
Annual assessment from SER data.				
Related PA Elements				
Element Title	**Type & ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Culebra water levels	T-fields – groundwater conceptual models	Compare groundwater monitoring data with compliance baseline	Water level ranges used in latest compliance baseline calculation	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	CRA-2004 range; see Table 2.8	Annual comparisons with ranges of undisturbed steady-state freshwater heads used to calibrate Culebra T fields for CRA.		

2.4 Waste Activity

The reporting period for the waste activity COMP started at first waste receipt and ended on June 30, 2008. A comparison of the tracked actinides and the total repository inventory used in the PABC-2004 is detailed in Table 2.20. No other activity-related assessment has been made at this time.

There are no TVs for CH activity, only RH. The TV for RH is the regulatory limit of 5.1 million Curies decayed to the year 2033, the reference date used by the project to represent site closure. This is the first reporting period for RH waste. The total non-decayed curies of RH waste for the period ending June 30, 2008 is 7.412×10^2 Curies, well below the TV. A detailed waste inventory assessment has been provided in the CRA-2004 (DOE 2004). As such the assumptions relating to waste emplacement were accounted for in the latest PA calculations. No assessment of the waste emplacement records is necessary for this year's COMPs assessment. There are no recognized reportable issues associated with this COMP. No changes to the monitoring program are recommended at this time.

Table 2.20 Comparison of tracked radionuclide inventory to the PABC-2004 Inventory in Curies

Radionuclide (CCA Table 4-10)	Non-Decayed Total Activity as of June 30, 2007	Non-Decayed CH Activity as of June 30, 2008	Non-Decayed RH Activity as of June 30, 2008	Non-Decayed Total Activity as of June 30, 2008	PABC-2004 Total Activity at Closure (2033)[1]
^{241}Am	1.83×10^5	1.876×10^5	1.694×10^1	1.876×10^5	5.17×10^5
^{137}Cs	9.66×10^1	1.466	3.799×10^2	3.813×10^2	2.07×10^5
^{238}Pu	9.98×10^4	1.607×10^5	9.631	1.608×10^5	1.13×10^6
^{239}Pu	2.65×10^5	2.744×10^5	3.492×10^1	2.744×10^5	5.82×10^5
^{240}Pu	6.42×10^4	6.665×10^4	1.837×10^1	6.667×10^4	9.54×10^4
^{242}Pu	9.66	1.041×10^1	5.791×10^{-3}	1.041×10^1	12.70
^{90}Sr	7.37×10^1	3.259	2.812×10^2	2.846×10^2	1.76×10^5
^{233}U	2.66	3.194	6.421×10^{-2}	3.258	1.23×10^3
^{234}U	1.69×10^1	2.693×10^1	1.129×10^{-1}	2.704×10^1	3.44×10^2
^{238}U	1.05×10^1	1.063×10^1	6.709×10^{-4}	1.063×10^1	2.17×10^2
Total	**6.12×10^5**	**6.894×10^5**	**7.412×10^2**	**6.901×10^5**	**2.71×10^6**

[1] From Leigh et al. 2005a

Table 2.21 Waste Activity - 2008:

Trigger Value Derivation			
COMP Title:	Waste Activity		
COMP Units:	Curies		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
WWIS, BIR	Radionuclide activity per container and volume	Curies per container. Container volume.	TRU Waste Inventory for the 2004 Compliance Recertification Application Performance Assessment Baseline Calculation (Leigh et al. 2005a)
COMP Derivation Procedure - Reporting Period July 1, 2007 to June 30, 2008			
Total curie content of emplaced CH-TRU and RH-TRU waste. *[Total radionuclide inventories reported by WWIS]*			
Year 2008 COMP Assessment Value			
A comparison of emplaced and PA waste parameters is found in Table 2.19.			

Element Title	**Parameter Type & ID or Model Description**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Radionuclide inventories	Parameter	Product of waste stream content and volume scaled up to the Land Withdrawal Act limits. (U.S. Congress 1992)	Table 14 in Leigh et al. 2005a.	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 6-30 of the CRA-2004 (DOE 2004)	Cuttings are a significant contributor to releases. 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.	NA	Spallings are a significant contributor to releases. 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 curies of emplaced RH-TRU waste	5.1 million curies (non-decayed)	LWA emplacement limit reached. Administrative controls address these limits.

3 COMPs Assessment Conclusion

The operational period monitoring program designed to meet the Assurance Requirements of 40 CFR §191.14 and the terms of WIPP certification was initiated in 1999. This monitoring program is useful to further validate the assumptions and conceptual models that were used to predict WIPP performance and identify conditions that could potentially cause radioactive release above the limits established in 40 CFR §191.13. Since releases above these limits cannot occur during the operational period of WIPP, the monitoring program looks at other potential performance indicators of the disposal system and compares these data to PA performance expectations. Specifically, 10 monitoring parameters are assessed and compared to PA expectations and assumptions. The CRA-2004 (DOE 2004) and later the PABC-2004 (Leigh et al. 2005b) contain the results of updated PAs presented to EPA. The PABC-2004 was used in EPA's certification decision and became the new compliance baseline PA. The results of this year's COMP assessment using the PABC-2004 as the baseline are documented in this report and conclude that there are no COMPs data or results that indicate a reportable event or condition adverse to predicted performance. In instances where TVs have been exceeded, further investigations or activities will be pursued as described. The operational period monitoring program will continue to seek to identify conditions that could indicate deviations from the expected disposal system performance.

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