

**2 COMPLIANCE MONITORING**

**2.3 Analysis Plan for Evaluation of the Effects...**

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**SANDIA NATIONAL LABORATORIES  
WASTE ISOLATION PILOT PLANT**

**Analysis Plan for Evaluation of the Effects of Head Changes  
on Calibration of Culebra Transmissivity Fields**

**AP-088**

**Task Number 1.3.5.3.1.2**

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Author:	<u>Original signed by Richard L. Beauheim</u> R.L. Beauheim, 6821 Performance Assessment and Decision Analysis Dept.	<u>12/5/02</u> Date
Technical Review:	<u>Original signed by Mario Chavez for</u> M.G. Wallace, 6851 Total System Performance Assessment Dept.	<u>12/5/02</u> Date
QA Review:	<u>Original signed by Mario Chavez</u> M.J. Chavez, 6820 Carlsbad Programs Group	<u>12/5/02</u> Date
Management Review:	<u>Original signed by M.K. Knowles</u> M.K. Knowles, 6821 Performance Assessment and Decision Analysis Dept.	<u>5 Dec 02</u> Date

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## 1. INTRODUCTION AND OBJECTIVES

This Analysis Plan directs the development of transmissivity (T) fields for the Culebra Dolomite Member of the Rustler Formation at the Waste Isolation Pilot Plant (WIPP) site to evaluate the effects of head changes on T-field calibration. Culebra T fields are used in WIPP Performance Assessment (PA) modeling of groundwater flow and radionuclide transport. The Culebra T fields used for PA modeling for the WIPP Compliance Certification Application (CCA; US DOE, 1996) were calibrated to heads assumed to represent steady-state conditions as well as to transient heads arising from hydraulic testing and shaft activities. Monitoring subsequent to the CCA has shown heads at many wells to be outside the uncertainty ranges for steady-state conditions, raising questions about the validity of the calibration. We hypothesize that while the assumption of Culebra heads being in steady state may have been unwarranted, this would have no effect on the calibration of the T fields. As long as the heads used for calibration were in equilibrium with the boundary conditions on the system and both were reasonably defined in the model, an appropriate representation of the Culebra T fields should have been obtained. Thus, the major objective of this activity is to develop T fields using heads from three different time periods to show whether or not the calibration is significantly affected if the equilibrium state of the overall system changes. The groundwater travel time from above the center of the WIPP disposal panels to the WIPP site boundary (accessible environment) will be used as the metric by which a "significant" change to the T-field calibration is judged. A secondary objective of this activity is to produce Culebra T fields that can be used to evaluate scenarios thought to have the potential to affect observed Culebra water levels, such as leaking boreholes and potash tailings ponds. The T fields developed under this Analysis Plan may be used for Compliance and/or Programmatic Decisions.

An approach will be taken under this Analysis Plan to produce Culebra T fields that are consistent with Sandia's hydrogeological conceptual model of the Culebra. Preliminary regression studies suggest a strong statistical relationship between hypothesized geological controls and values of Culebra transmissivity at WIPP wells. We will extend these results and develop a regression-based approach for predicting Culebra transmissivity based on geologic information and observed Culebra transmissivity data. The T fields generated using the regression-based approach will then be

conditioned to observed heads that were presumably equilibrated with the boundary conditions at the time and also to transient heads.

## 2. APPROACH

The approach to be taken in development of the Culebra T fields involves, first, defining a statistical correlation between Culebra transmissivities measured at individual wells and geologic factors such as thickness of overburden and amount of dissolution of the upper Salado Formation. This correlation will then be used in combination with contour maps of the geologic factors to create 100 equally likely realizations of the Culebra transmissivity distribution ("base" T fields) over the domain of interest. The modeling domain will be similar in extent to that used in the CCA, but will be oriented with its long axis extending from north to south, parallel to the principal flow direction in the Culebra, like the model domain of LaVenue et al. (1990). These base T fields will then be conditioned to Culebra hydraulic heads representing equilibrium conditions at 10-year intervals (e.g., 1980, 1990, and 2000) and the "steady-state" conditions presented in the CCA using a pilot-point method. To determine how much effect the differences in head have on the resulting T fields, cumulative distribution functions (CDFs) of the groundwater travel times from a point above the center of the waste-disposal panels to the WIPP site boundary will be generated for each set of 100 realizations, and the CDFs will be compared to each other. One or more of the sets of T fields conditioned to equilibrated heads will also be conditioned to transient heads arising from activities in the WIPP shafts and hydraulic tests conducted in the Culebra. The CDF of travel times for these transient-calibrated T fields will be compared to a CDF generated of travel times used in the CCA. Finally, the transient-calibrated T fields will be altered to represent the potential effects of future potash mining as was done for the CCA. Again, CDFs of travel times for the mining cases will be compared to the CDFs generated of travel times used in the CCA.

The data that will be needed to accomplish these tasks includes some or all of the following:

- transmissivity values at wells;
- well locations;
- ground surface elevation at wells;

- stratigraphic information;
- equilibrated heads at defined times;
- Culebra fluid density at wells;
- transient pressure data;
- transient flow-rate data; and
- boundaries of potential mining areas.

Each task report that is prepared (see Section 4) will include a description of the verification methods employed for gathering and interpreting the data used.

### 3. SOFTWARE LIST

The following computer codes may be used for different tasks associated with development of Culebra T fields:

- ESRI ArcInfo 8.1 (off-the-shelf software);
- WinGSLib/GSLIB90 (acquired; routines to be qualified under NP 19-1);
- Mathcad 2001i (off-the-shelf software);
- MODFLOW 2000 v. 1.6 (to be qualified under NP 19-1);
- PEST v. 5.5 (to be qualified under NP 19-1); and
- DTRKCDB (to be qualified under NP 19-1).

Off-the-shelf spreadsheet programs, such as Excel 2000, and graphing programs, such as Grapher 3 or SigmaPlot.0, may also be used for data manipulation and plotting. Any pre- or post-processors needed for data manipulation and transfer between codes will also be qualified as part of the analysis package.

### 4. TASKS

Development of Culebra T fields and assessment of their differences with respect to the CCA T fields has been divided into five principal tasks, described below. All tasks will be documented according to NP 9-1 *Analyses* by the task analyst as the analysis progresses. Analysis packages will

be prepared, reviewed, and submitted by the responsible analyst according to Appendices B and C (*Analysis Records* and *Routine Calculation Requirements*, respectively) of NP 9-1 at the completion of each set of related analyses.

### **Task 1            Construction of Geologic Contour Maps**

The first task is to construct maps of the geologic factors affecting transmissivity. These geologic "controls" include the thickness of overburden above the Culebra, the thickness reduction in the upper Salado Formation due to dissolution, and the spatial distribution of halite underlying and overlying the Culebra. These maps will be hand-contoured using the best geologic judgment of the analyst to preserve consistency with known geologic information and Sandia's conceptual hydrogeological model.

The principal analyst for Task 1 will be Dennis Powers. Data sources for this task will include well location and elevation survey information, geophysical well logs, and core logs. Deliverables will be contour maps of the three geologic controls discussed above. The contour maps are expected to be completed by April 1, 2002.

### **Task 2            Estimating Base Transmissivity Fields**

An estimate of the spatial distribution of mean transmissivity is required for generating conditional realizations of Culebra transmissivity. In the past, the transmissivity distribution in the Culebra was determined using a geostatistical approach that incorporated transmissivity data (e.g., variography and kriging) but neglected geologic information. Sandia's current conceptual model for the Culebra relies on geological explanations for the variability of Culebra transmissivity and defines possible geologic controls on Culebra transmissivity (e.g., Beauheim and Holt, 1990; Corbet, 2000). Preliminary studies suggest that Culebra transmissivity values can be accurately estimated ( $R^2 > 0.9$ ) using a linear regression of transmissivity against the thickness of Culebra overburden, the thickness reduction in the upper Salado Formation due to dissolution, and a mode indicator (e.g., high versus low transmissivity). Data on geological controls are much more abundant than hydraulic property data and can be used to provide an improved estimate of the distribution of Culebra transmissivity.

We will develop a geologically based predictor of mean Culebra transmissivity using a standard linear regression approach. We will first formalize a conceptual model for geological controls on Culebra transmissivity. Transmissivity data will then be regressed against our hypothesized controls, and regression results will be verified and validated. The regression will allow the estimation of Culebra transmissivity across the WIPP region. A qualitative mathematical model will also be developed for extending transmissivity predictions to the east of the WIPP site where no Culebra transmissivity data exist.

Maps cannot be created for the transmissivity mode indicator from geologic data alone. The spatial location of Culebra modes will be determined using non-parametric geostatistical methods (e.g., indicator variography, indicator kriging, and conditional indicator simulation). The result will be a series of equiprobable location maps of the mode indicator. Base Culebra transmissivity fields will be developed using the maps of transmissivity controls and the regression parameters.

The principal analyst for Task 2 will be Robert Holt, University of Mississippi. Data inputs for this task will include well location information, inferred transmissivities at wells, values of the geologic controls at the wells, and the maps of geologic controls produced in Task 1. Deliverables will be 100 equally probable realizations of the Culebra mean T field with stochastic variability in the location of the high-T zones. These realizations will not yet be conditioned to heads. The base T fields are expected to be completed by May 15, 2002.

### **Task 3        Conditioning of Base T Fields to Equilibrium Heads**

Four subtasks have been identified under this task:

#### **Subtask 3.1    Analysis of Pilot Point Geometry**

A major development in the field of stochastic inverse modeling that has occurred since T fields were constructed for the CCA is that inverse techniques are now capable of simultaneously determining the optimal T values at a large number of pilot points. In the T fields constructed for the CCA, pilot points were added one at a time and calibrated prior to the addition of the next pilot point. In order to determine the optimal number and placing of pilot points, a known hypothetical test problem, similar to the Culebra, will be constructed and inverse modeling will be done with varying numbers of pilot points located on a grid. Results of this test problem will provide a



defensible basis for the number and location of the pilot points used for the Culebra T fields. A memo documenting the results of this subtask will be completed by July 31, 2002.

### Subtask 3.2 Estimation of Boundary Conditions and Construction of Seed Realizations

Model boundary conditions for each time period for which T fields will be calibrated will be determined by fitting a surface to the freshwater head data available for that time period. Residuals between the fitted surface and the measurements will be used to create a geostatistical estimation of the residuals across the model domain. These residuals will be added to the surface to get the estimates of head at all locations in the model domain. The estimated values of head at the model boundary will provide the specified-head boundary conditions to be used in model calibration. Estimated heads values in the interior of the model domain will be used as the initial head estimates for the groundwater flow model solution. Estimation of boundary conditions will be completed by July 31, 2002.

The base T fields created by Bob Holt in Task 2 do not honor the measured T data at the measurement locations. Prior to the forward or inverse flow modeling, these base transmissivity fields must be conditioned to the measured T data. This conditioning is done by geostatistically simulating a zero mean residual field that is conditional to the residuals at the measurement locations. When this residual field is added to the base T field, it reproduces the true measured T values at the measurement locations and since the mean of the field is zero, it changes the base T-field as little as possible. The combined base T-field and residual field is the seed T field that will be used as input to the stochastic inverse modeling. The seed T fields will be completed by June 30, 2002.

### Subtask 3.3 Forward Modeling

As an initial test of the available data, boundary conditions, and the flow model setup, the seed realizations will be used in a set of forward models. Heads, fluxes, and particle travel times will be retained from these forward models for comparison with the results obtained after the inverse modeling step. This subtask will be completed by July 31, 2002.

#### Subtask 3.4 Steady State Inverse Models

The base realizations created in Task 2 will be used as input to the inverse model using the pilot point method. The number of pilot points and their locations will be based on the results of Subtask 3.1. For this task, the calibration of 100 T fields will be done to three sets of equilibrium-state head measurements approximately recorded in 1980, 1990, and 2000, while a fourth set of T fields will be calibrated to the "steady-state" heads presented in the CCA. Results of this task will include the T fields and heads and fluxes calculated on those T fields as well as data comparing the modeled and observed heads at the observation wells. The flow path and groundwater travel time from a point above the center of the WIPP disposal panels to the WIPP land-withdrawal boundary will also be calculated for each T field. Ensemble average T fields will be prepared for each set of realizations, and difference maps will be prepared showing how the transmissivities differ among the three ensemble average fields. The CDFs of travel times for each set of realizations will be compared statistically to determine the degree to which they differ. The CDFs generated from the calibrated T fields used in the CCA (not modified for the effects of potash mining) will also be compared to the new CDFs. Deliverables for this task will consist of four sets of 100 T fields conditioned to equilibrium-state heads and a memo summarizing the comparison among the sets and the CCA T fields. This task will be completed by October 31, 2002.

The principal analyst for Task 3 will be Sean McKenna, 6115.

#### **Task 4 Conditioning of Base T Fields to Transient Heads**

Assuming that the four sets of T fields developed under Task 3.4 show no significant differences, at least one of the sets (probably the one representing the most recent conditions (year 2000)) will be conditioned to both equilibrated and transient head data. If the four sets of T fields do show significant differences, then at least some of the realizations from each set will be conditioned to both equilibrated and transient head data. Results of this task will include the T fields and heads and fluxes calculated on those T fields as well as data comparing the modeled and observed heads at the observation wells. The flow path and groundwater travel time from a point above the center of the WIPP disposal panels to the WIPP land-withdrawal boundary will also be calculated for each T field. The CDFs generated from the transient-calibrated T fields used in the CCA will also be

compared to the new CDFs. Deliverables for this task will consist of the T fields conditioned to transient heads and a memo summarizing the comparison to the CCA T fields. This task will be completed by January 31, 2003.

The principal analyst for Task 4 will be Sean McKenna, 6115.

#### **Task 5      Evaluation of Mining Scenarios**

For the CCA, the potential effects of future potash mining on flow and transport in the Culebra were evaluated by increasing the transmissivity of the Culebra in the areas that might be affected by mining. For each realization of the calibrated Culebra T fields, the T's within the areas potentially affected by mining were increased by a randomly chosen factor between 1 and 1000. Model boundary conditions were left unchanged during this exercise. Two different scenarios were considered, denoted the partial-mining and full-mining cases. The partial-mining case assumed that all potash was mined from leased areas outside the WIPP land-withdrawal boundary. The full-mining case assumed that all economic-grade ore was also mined from within the WIPP land-withdrawal boundary. For each T-field realization and each case, the flow path and groundwater travel time from a point above the center of the WIPP disposal panels to the WIPP land-withdrawal boundary were calculated.

Full-mining and partial-mining cases will be evaluated in exactly the same manner using the transient-calibrated T fields generated under Task 4 of this Analysis Plan. The flow path and groundwater travel time from a point above the center of the WIPP disposal panels to the WIPP land-withdrawal boundary will be calculated for each modified T field, and CDFs of travel time for the partial-mining and full-mining cases will be generated. The CDFs generated from the mining-altered T fields used in the CCA will be compared to the new CDFs to determine if the new T fields produce results that are significantly different from those presented in the CCA. Deliverables for this task will consist of the T fields modified for partial- and full-mining conditions and a memo summarizing the comparison of travel-time CDFs. This task will be completed by February 28, 2003.

The principal analyst for Task 5 will be Sean McKenna, 6115.

## 5. SPECIAL CONSIDERATIONS

No special considerations have been identified.

## 6. APPLICABLE PROCEDURES

All applicable NWMP quality-assurance procedures will be followed for these analyses. Training of personnel will be done in accordance with the requirements of NP 2-1 *Qualification and Training*. Analyses will be performed and documented in accordance with the requirements of NP 9-1 *Analyses* and NP 20-2 *Scientific Notebooks*. All software used will meet the requirements of NP 19-1 *Software Requirements*. The analyses will be reviewed following NP 6-1 *Document Review Process*. All required records will be submitted to the WIPP Records Center in accordance with NP 17-1 *Records*.

## 7. REFERENCES

Beauheim, R.L., and R.M. Holt. 1990. "Hydrogeology of the WIPP Site," *Geological and Hydrological Studies of Evaporites in the Northern Delaware Basin for the Waste Isolation Pilot Plant (WIPP), New Mexico, GSA Field Trip #14 Guidebook*. Dallas, TX: Dallas Geological Society. 131-179.

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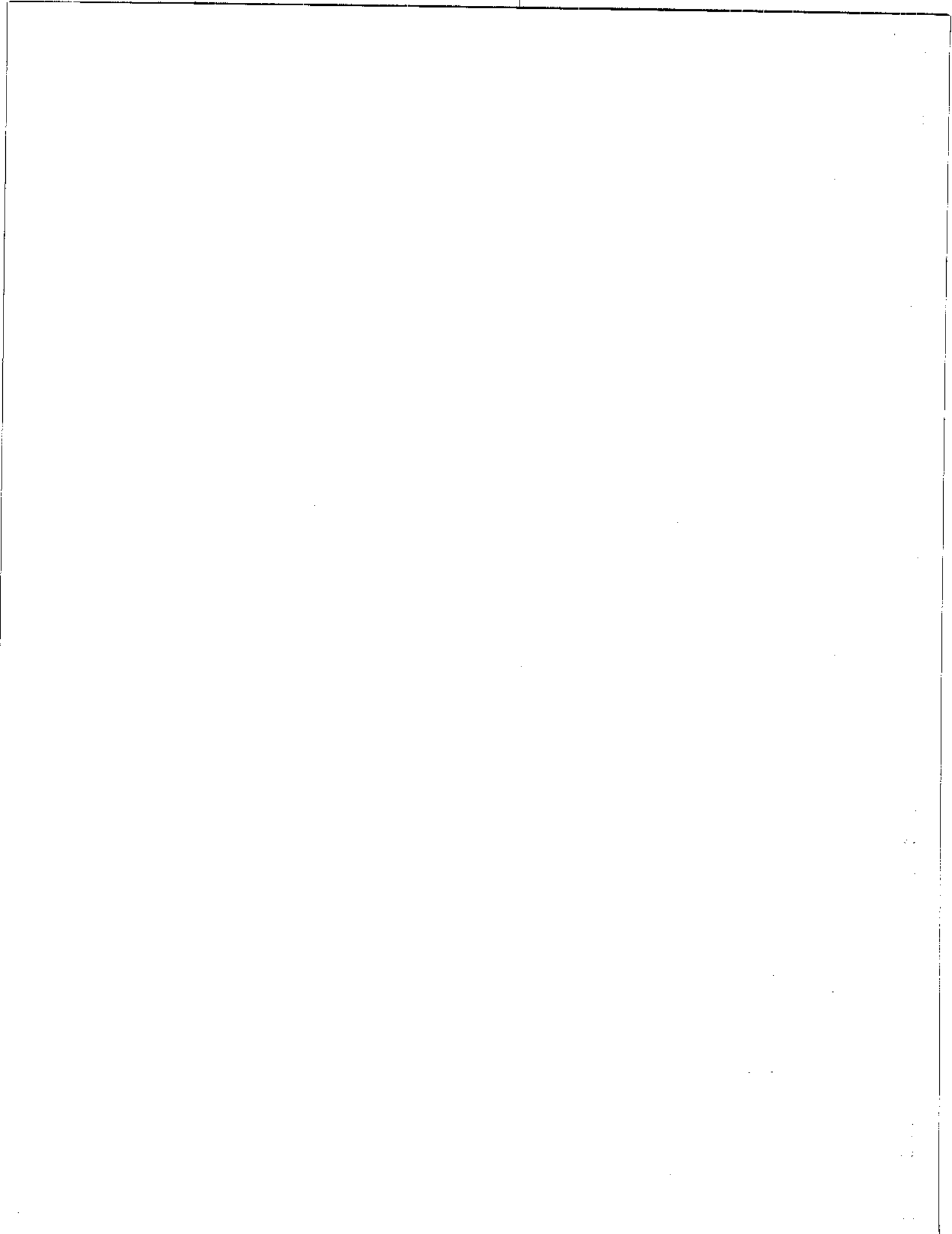
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**2 COMPLIANCE MONITORING**

**2.4 Compliance Monitoring Program: Recompilation...**



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Sandia National Laboratories  
Waste Isolation Pilot Plant (WIPP)

**Compliance Monitoring Program:  
Recompletion and Testing of Wells for Evaluation of  
Monitoring Data from the Magenta Member of the  
Rustler Formation at the WIPP Site.  
Test Plan TP 00-03, Rev. 1**

BOE 1.3.5.3.1.1

Effective Date: \_\_\_\_\_

David A. Chace  
Repository Performance and Certification Depart. 6822  
Sandia National Laboratories  
Carlsbad, NM 88220



## APPROVALS

Author:

\_\_\_\_\_  
D. A. Chace, Date \_\_\_\_\_  
Well Testing Lead  
Repository Performance and Certification Dept. 6822  
Sandia National Laboratories  
Carlsbad, NM 88220

Technical Reviewer:

\_\_\_\_\_  
R. M. Roberts, Date \_\_\_\_\_  
Compliance Monitoring Program  
Repository Performance and Certification Dept. 6822  
Sandia National Laboratories  
Carlsbad, NM 88220

SNL QA:

\_\_\_\_\_  
M. Mitchell, Date \_\_\_\_\_  
Quality Assurance  
Carlsbad Programs Group 6820  
Sandia National Laboratories  
Carlsbad, NM 88220

SNL Management:

\_\_\_\_\_  
M. K. Knowles, Date \_\_\_\_\_  
Manager  
Performance Assessment and Decision Analysis Dept. 6821  
Sandia National Laboratories  
Carlsbad, NM 88220

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## 1 ABBREVIATIONS, ACRONYMS, AND INITIALISMS

A	ampere
APV	access port valve
ASME	American Society of Mechanical Engineers
CAO	(U.S. DOE) Carlsbad Area Office
CBFO	(U.S. DOE) Carlsbad Field Office
CCA	Compliance Certification Application
CMR	Central Monitoring Room
DAS	data-acquisition system
DC	direct current
DOE	(U.S.) Department of Energy
DST	drillstem test
EPA	(U.S.) Environmental Protection Agency
ES&H	environmental safety and health
GET	General Employee Training
gpm	gallons per minute
GWMP	Groundwater Monitoring Program
HA	hazard analysis
I.D.	inside diameter
JHA	job hazard analysis
MA	milliamper
MOC	Management and Operating Contractor
MSDS	Material Safety Data Sheet
NEPA	National Environmental Policy Act
NP	(SNL NWMP) Nuclear Waste Management (QA) Procedure
NWMP	Nuclear Waste Management Program
PHS	primary hazard screening
PI	Principal Investigator
PIP	production-injection packer
psia	pounds per square inch, absolute
psig	pounds per square inch, gauge
QA	quality assurance
QAPD	Quality Assurance Program Document
SNL	Sandia National Laboratories
SP	(SNL NWMP) Activity/Project-Specific Procedure
TOP	(SNL NWMP) Technical Operating Procedure
TP	(SNL) test plan
V	volts
WRES	Washington Regulatory and Environmental Services
WIPP	(U.S. DOE) Waste Isolation Pilot Plant

## 2 REVISION HISTORY

Revision 1 of this test plan (TP) consists of the inclusion of well H-9c in the list of WIPP-Site wells scheduled for recompletion and testing for evaluation of monitoring data from the Magenta Member of the Rustler Formation. Well H-9c was recompleted as a Magenta well in February 2002 in order to extend the information base of the Magenta to the southern boundary of the current model domain. This was done well after the release of Rev. 0 for this TP; therefore, a revision was necessary. Changes to this TP, other than those defined as editorial changes per Sandia National Laboratories' (SNL's) Nuclear Waste Management Program (NWMP) Quality Assurance (QA) Procedure NP 20-1 (Subsection 10.4), shall be reviewed and approved by the same organization that performed the original review and approval. All TP revisions will have at least the same distribution as the original document.



### 3 PURPOSE AND SCOPE

The activities described in this TP constitute one component of a Sandia National Laboratories (SNL) program to evaluate monitoring data collected at the Waste Isolation Pilot Plant (WIPP) Site to demonstrate U.S. EPA (1993, 1996). The overall SNL Compliance Monitoring Program is discussed below, followed by a summary of the specific activities described in this TP and their objectives.

#### 3.1 Purpose of the SNL Compliance Monitoring Program

The WIPP is a U.S. Department of Energy (DOE) facility for the safe disposal of transuranic wastes resulting from the U.S. defense programs. In the WIPP Compliance Certification Application (CCA) (U.S. DOE, 1996), the DOE made commitments to conduct a number of monitoring activities to comply with U.S. EPA (1996) and to ensure that important deviations from the expected long-term performance of the repository are identified at the earliest possible time. Collection and reporting of the data from the WIPP monitoring programs are the responsibility of the WIPP Management and Operating Contractor (MOC), Washington Regulatory and Environmental Services (WRES). SNL, as the Scientific Advisor to the DOE for the WIPP Project, evaluates the monitoring data against performance expectations for the disposal system.

The SNL Compliance Monitoring Program evaluates data collected by WRES under five monitoring programs: the Geotechnical Monitoring Program, the Groundwater Monitoring Program (GWMP), the Delaware Basin Drilling Monitoring Program, the Subsidence Monitoring Program, and the WIPP Waste Information System. This TP supports the SNL Compliance Monitoring Program by providing for evaluation of data collected under the GWMP.

#### 3.2 Purpose and Scope of Recompletion of Wells to the Magenta and Subsequent Data Collection

The WIPP repository is excavated in bedded halite of the Salado Formation, approximately 2150 ft below land surface. At the center of the WIPP Site, the Salado is approximately 2000 ft thick and is overlain by the approximately 310-ft-thick Rustler, the 500-ft-thick Dewey Lake Formation, and approximately 50 ft of surficial deposits ranging from weathered sedimentary rock to Quaternary eolian deposits (Figure 1-1). Groundwater is found principally in three horizons above the Salado: the Culebra Member of the Rustler, the Magenta, and the Dewey Lake Redbeds (over the southern portion of the WIPP Site only).

Appendix GWMP of the CCA (U.S. DOE, 1996) commits the DOE to monitor groundwater levels in the Culebra, the Magenta, and the Dewey Lake. That monitoring is performed by the MOC, and the monitoring data are then evaluated by SNL to determine if any changes from historic and expected conditions have occurred. If changes have occurred, SNL evaluates the potential for those changes to affect the performance of the WIPP disposal system. SNL developed a groundwater flow

model for the Culebra for the CCA; initial calculations were adequate to show that the consequences of a release of radionuclides to the Magenta were less severe than those of a release to the Culebra. In order to facilitate evaluation of Magenta monitoring data, SNL now intends to develop a Magenta groundwater-flow model.

Modeling flow through the Magenta requires a variety of spatially distributed data, including:

- depth and thickness,
- transmissivity,
- storativity,
- hydraulic head, and
- fluid density.

System	Series	Group	Formation	Member	Approximate Thickness* (m ft)		
Quaternary	Recent		Surficial Deposits		3	10	
	Pleistocene		Mescalero Caliche		10	30	
			Gatuña				
Triassic		Dockum	Santa Rosa		3	10	
Permian	Ochoan		Dewey Lake Redbeds		150	500	
			Rustler	Forty-niner		18	60
				Magenta		7	24
				Tamarisk		26	85
				Culebra Dolomite		7	24
				Los Medanos		37	120
			Salado		600	2000	
	Castile		400	1300			
	Guadalupian	Delaware Mountain	Bell Canyon		310	1000	
			Cherry Canyon		335	1100	
			Brushy Canyon		550	1800	

\* At center of WIPP site.

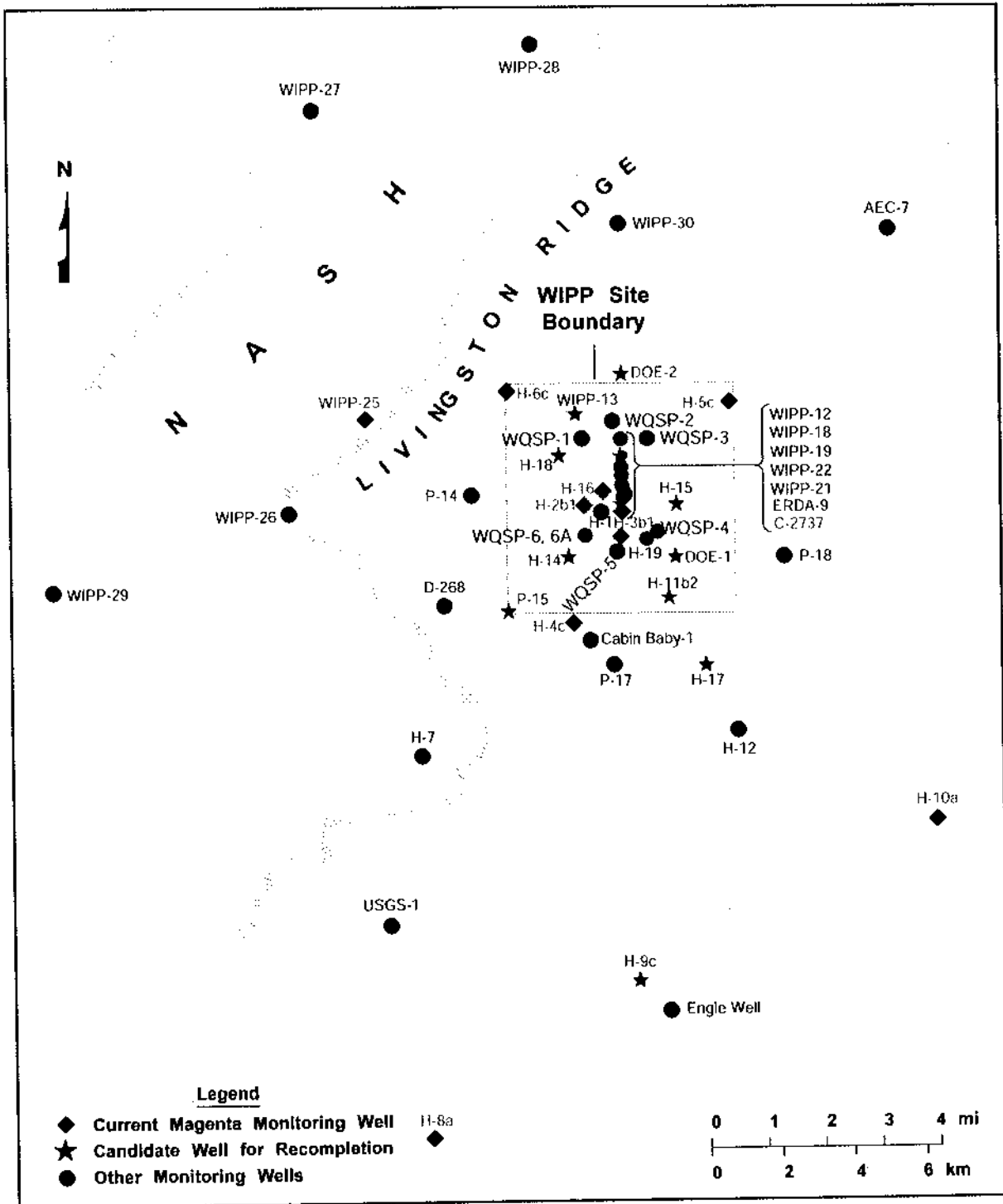
TP-0115-26-4

Figure 1-1. Stratigraphic units at the WIPP Site.

The depth and thickness of the Magenta over the WIPP site are well established through the drilling of approximately 100 wells and exploratory boreholes. The other parameters needed for

modeling, however, are not as well established. Transmissivity values are available from only 16 locations in the vicinity of WIPP (ten on the WIPP site); no storativity data are available; hydraulic-head data are available from only 13 wells (six on the WIPP site); fluid-density data are available from only six wells (four on the WIPP site). Thus, the currently available data are inadequate to construct a reliable flow model for the Magenta. The purpose of the activities described in this TP is to recomplate existing wells to the Magenta and then collect the data needed for development of a defensible groundwater flow model of the Magenta in the vicinity of the WIPP site.

Figure 1-2 shows the wells currently existing around the WIPP Site. Wells currently configured to allow monitoring of the Magenta are shown, as well as those that might be recompleted to the Magenta. In all cases, recompletion will involve setting a bridge plug in the well casing between the Culebra and Magenta, and perforating the casing across the Magenta interval. Drillstem and/or slug tests will be performed to obtain transmissivity estimates. The wells will also be pumped to collect samples of the Magenta water for density measurements and major-ion analyses, and possibly to provide additional data for estimation of transmissivity and storativity. Finally, water levels in the wells will be monitored to provide hydraulic-head information. This TP describes plans, procedures, and specifications for the recompletion and data-collection activities to be conducted.



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Figure 1-2. Locations of Magenta and other wells at the WIPP Site.

#### 4 EXPERIMENTAL PROCESS DESCRIPTION

Twelve wells currently completed to the Culebra are under consideration for potential recompletion to the Magenta (Figure 1-2). These wells were selected because they are in locations where Magenta data are currently lacking. For some of the wells, data on hydraulic head are particularly important (e.g., DOE-2, H-11b2, H-15, and P-15). For others, transmissivity data are of primary importance (e.g., H-18, WIPP-18). However, hydraulic-head, transmissivity, and fluid-density data should be collected from all locations.

The recompletions and subsequent data collection are planned to occur in two phases. In the first phase, the six wells considered most important (DOE-2, H-11b2, H-15, H-18, P-15, and WIPP-18) will be recompleted and data collected. We will then evaluate whether the expanded database is adequate for construction of a reliable Magenta model, or if data are needed from some or all of the remaining five wells (DOE-1, ERDA-9, H-9c, H-14, and H-17, and WIPP-13). If additional data are required, the appropriate wells will be recompleted in phase two.

For each well, the sequence of activities will typically be as follows:

1. The well casing will be scraped, if necessary, to remove scale and rust.
2. An inflatable bridge plug will be set in the well casing approximately 20 ft below the Magenta (as determined from available logs) to isolate the open Culebra interval from the well casing above.
3. The water in the casing above the bridge plug will be bailed or swabbed from the well until the water level is approximately 50 ft above the Magenta. This will ensure that the hydraulic gradient will be from the Magenta into the well immediately after perforation, which will prevent Culebra water from entering the Magenta, while leaving enough water in the well to cushion the perforating gun.
4. A natural gamma log will be run in the well to identify the precise depth interval of the Magenta.
5. The well casing will be jet-perforated from 1 ft above to 1 ft below the Magenta, using four shots per foot.
6. A production-injection packer (PIP) will be set in the well casing above the perforations on 2.375-in tubing, with a sliding-sleeve shut-in tool below the PIP controlling communication between the tubing and the Magenta interval. Two slug tests or two drillstem tests (DSTs) will be performed by opening and closing the shut-in valve, as appropriate, and bailing or swabbing the tubing as necessary (see procedures in Subection 6.2.1).

7. A submersible pump will be set just below the perforations and operated at a rate of approximately 1 gpm until water-quality parameters (specific conductance and specific gravity) are stable within  $\pm 5\%$  while two wellbore volumes are pumped. Water-level measurements will be performed at least every 30 min while the pump is on. If the water level in the well gets down to 5 ft above the perforations before the water-quality parameters have stabilized for the desired period, the pump will be shut off overnight while the well recovers. Pumping will resume the next morning and continue, stopping as necessary, until the desired stabilization is achieved. When that occurs, water samples will be collected for laboratory analysis of major ions and the pump will be turned off and removed from the well.

8. The Principal Investigator (PI) will evaluate the data from the pumping exercise to determine if the well can sustain a pumping rate of approximately 1 gpm for a 50-h pumping test. If his determination is that the well cannot support a pumping test, we will proceed to Step 10. If the well can support a pumping test, we will proceed to Step 9.

9. After the well has recovered from the pumping for water-quality samples, a pumping test will be performed in accordance with the procedures given in Subsection 6.2.2.

10. All test equipment will be removed from the well, and the well will be configured for long-term monitoring. This will involve no further work in H-11b2 and WIPP-18. In DOE-2, H-15, H-18, and P-15, a 2.375-in tubing string will be run down and attached to the bridge plug between the Magenta and Culebra, and the bottom plug will be sheared or blown out of the bridge plug, converting it to a PIP. The tubing will then be bailed or swabbed to remove non-Culebra water. In P-15, 0.75-in flush-jointed polyvinyl chloride pipe may be installed alongside the 2.375 in tubing to a depth approximately 50 ft below the Magenta water level to allow easy access of a water-level probe.

This will complete SNL activities in the well. The MOC will begin monthly water-level measurements of the Culebra through the tubing (where present) and the Magenta in the well casing as part of the GWMP. Figures 2-1 through 2-11 show the current configurations of the wells that activities.

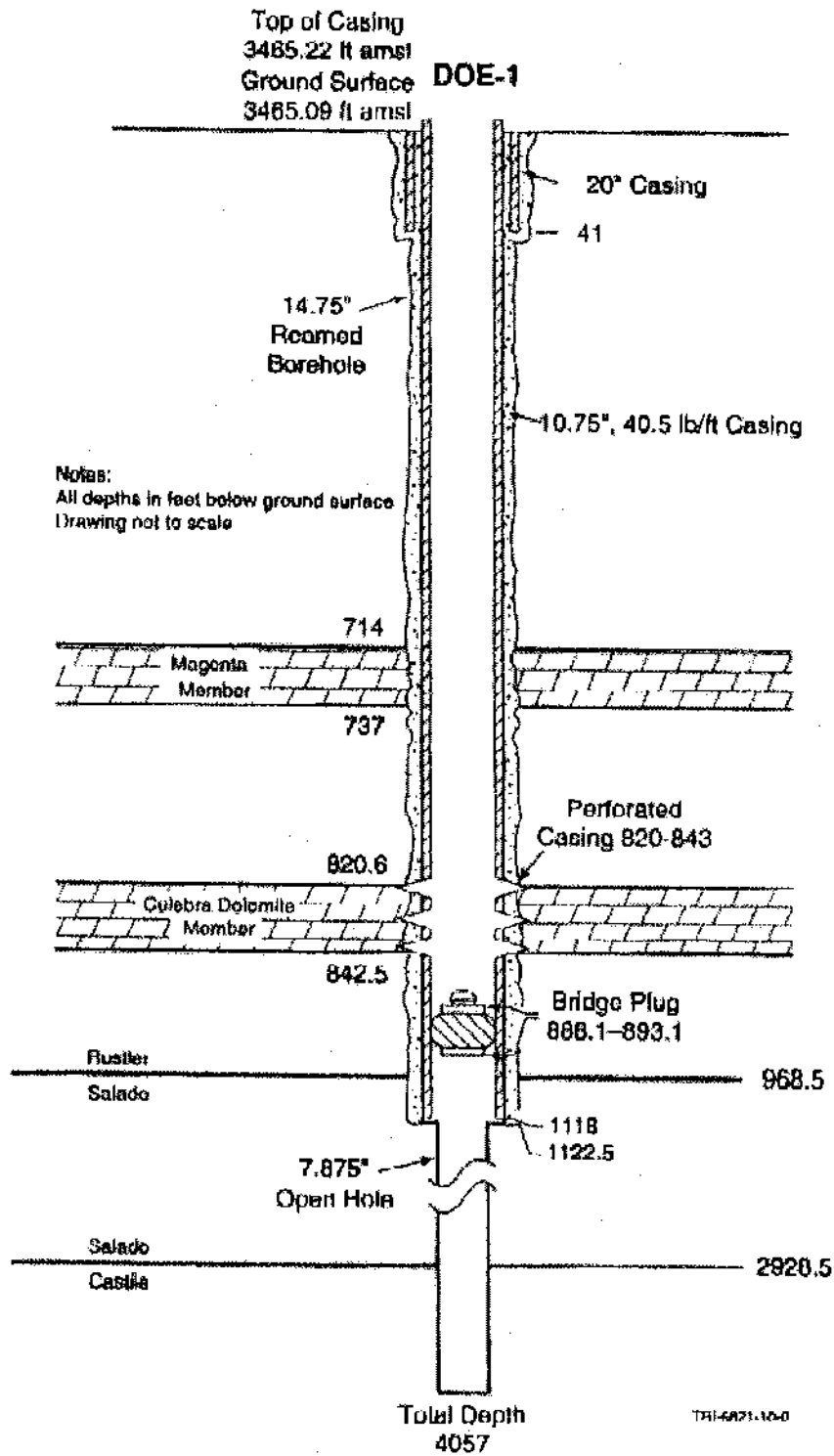


Figure 2-1. Current configuration of Well DOE-1.



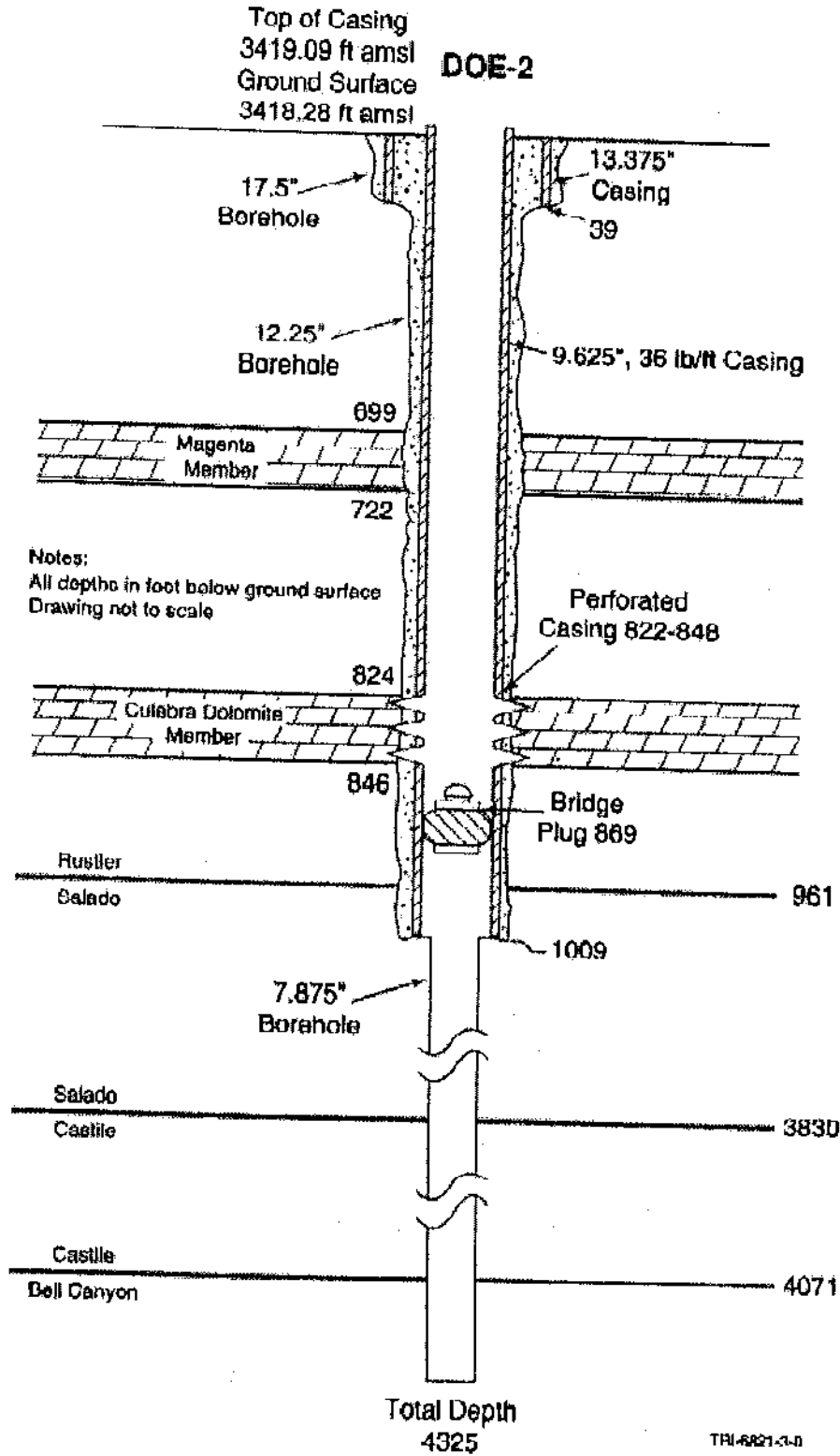


Figure 2-2. Current configuration of Well DOE-2.

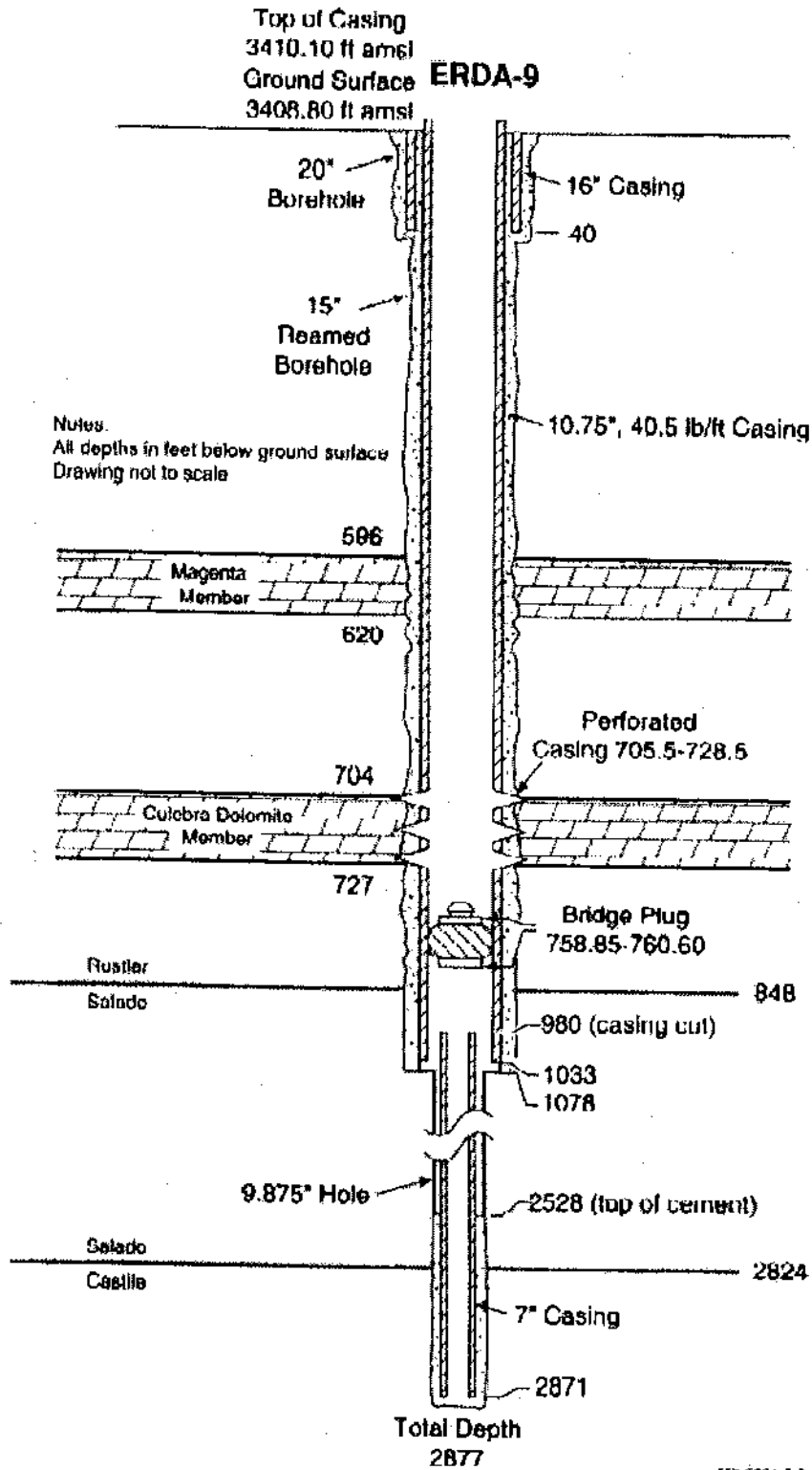


Figure 2-3. Current configuration of Well ERDA-9.

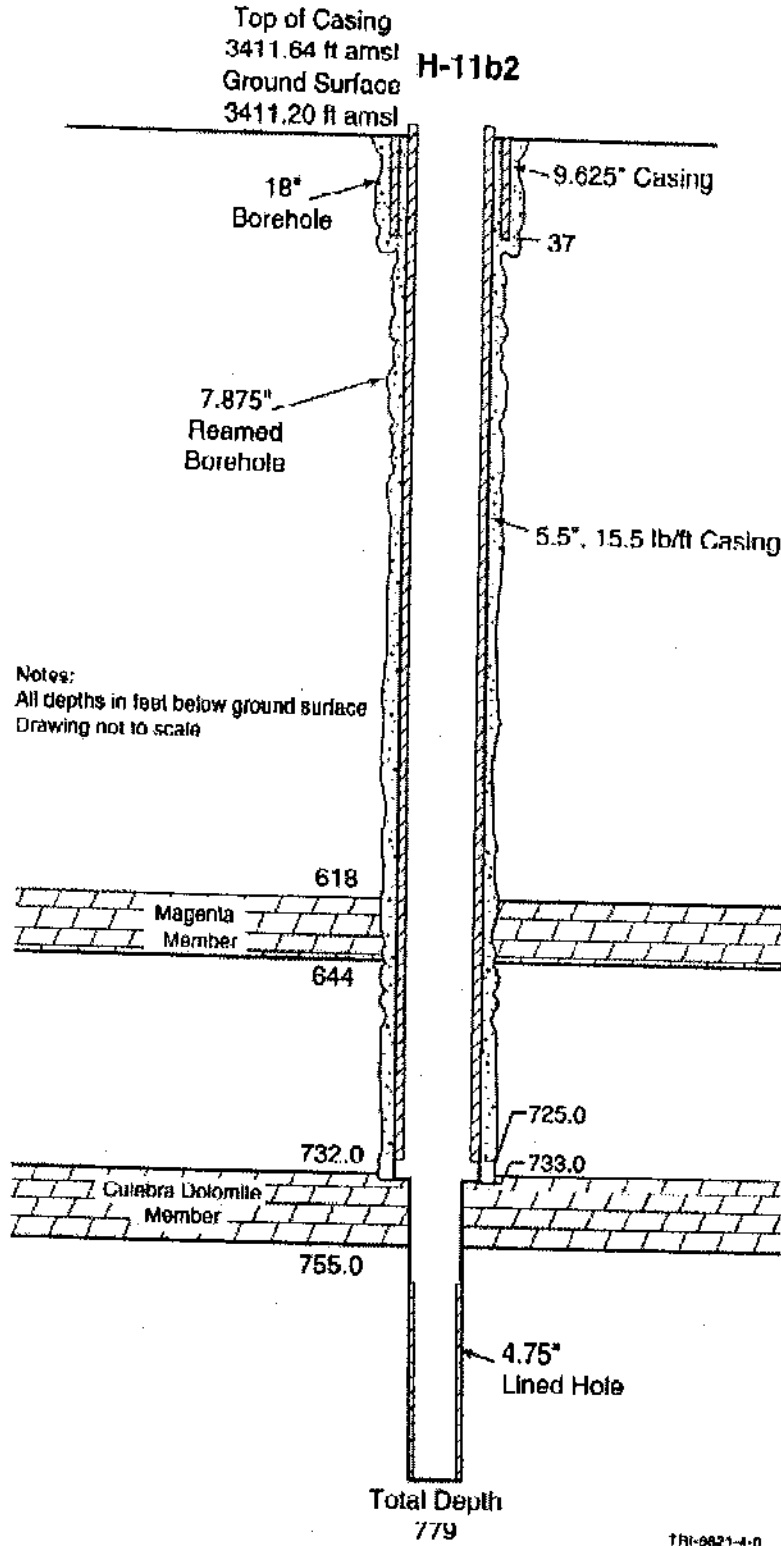


Figure 2-4. Current configuration of Well H-11b2.

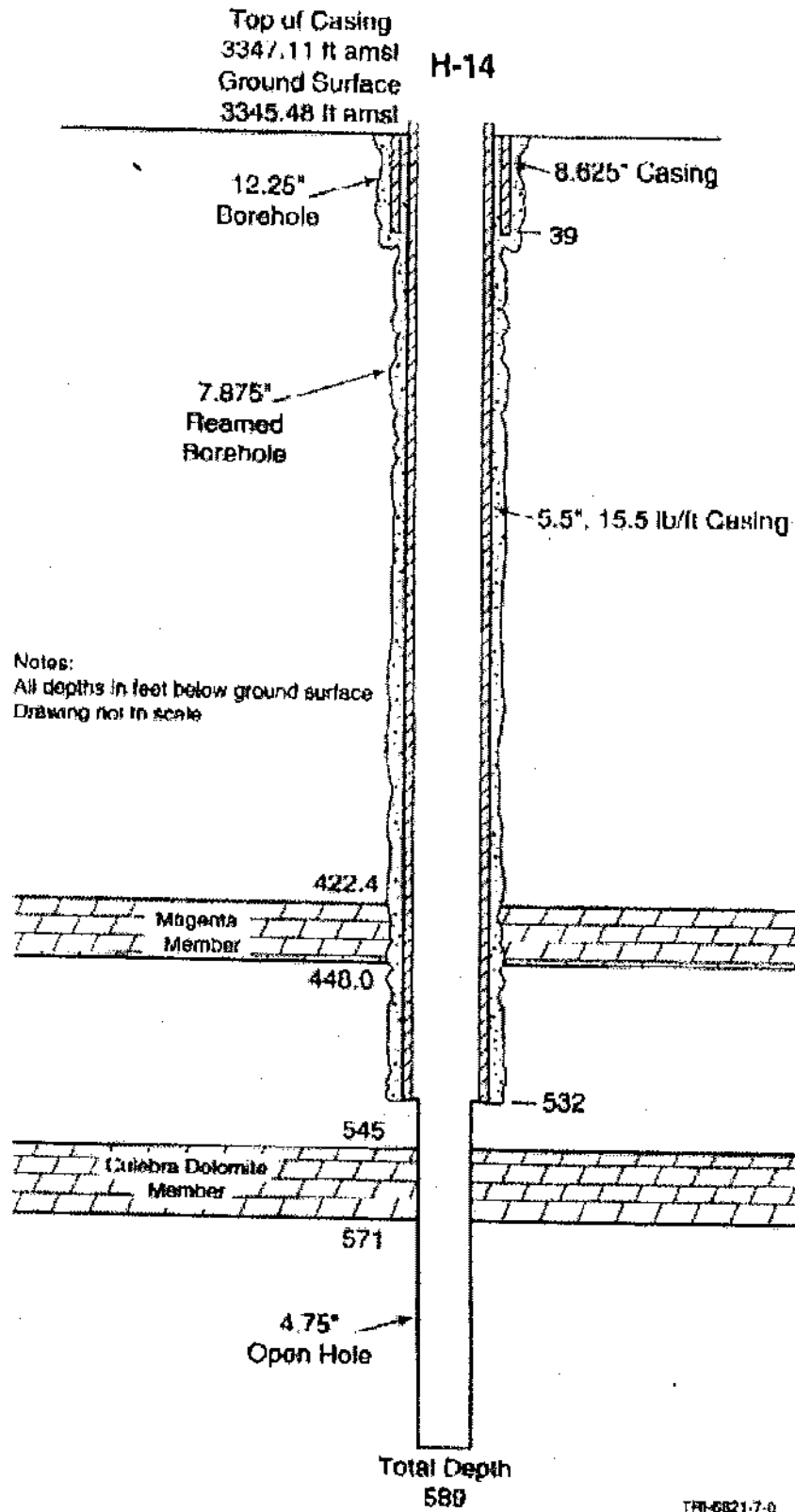


Figure 2-5. Current configuration of Well H-14.

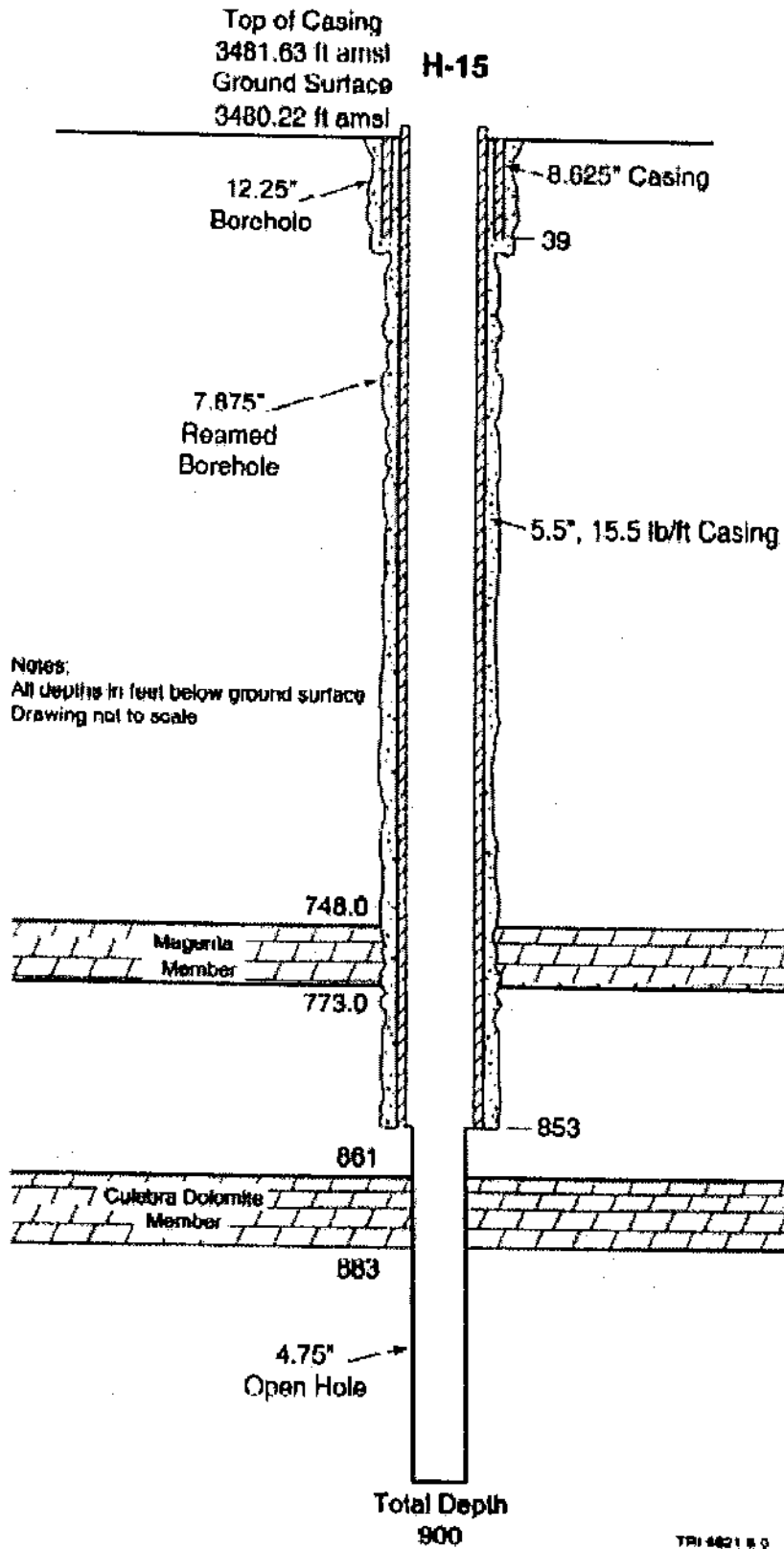


Figure 2-6. Current configuration of Well H-15.

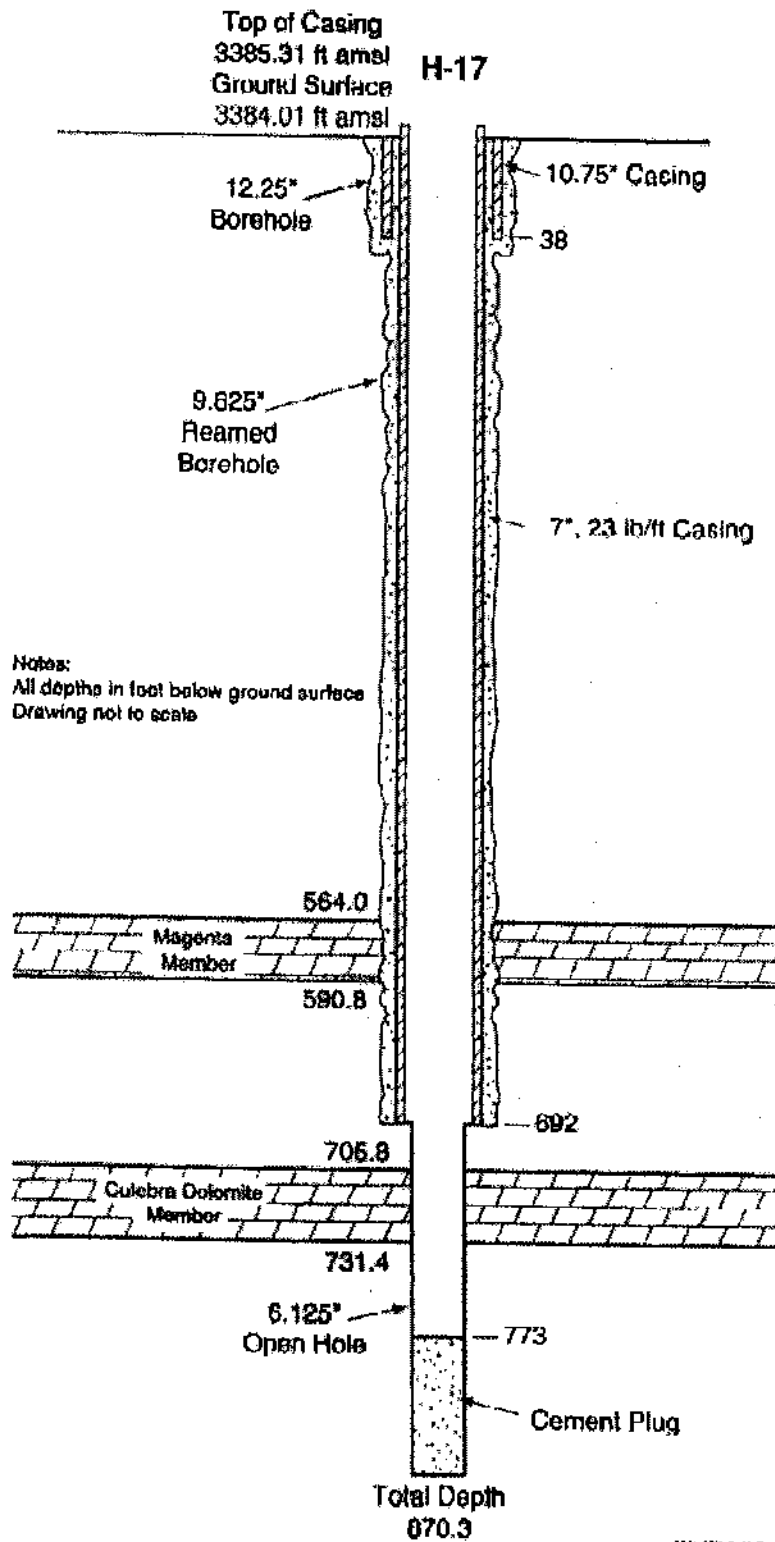


Figure 2-7. Current configuration of Well H-17.

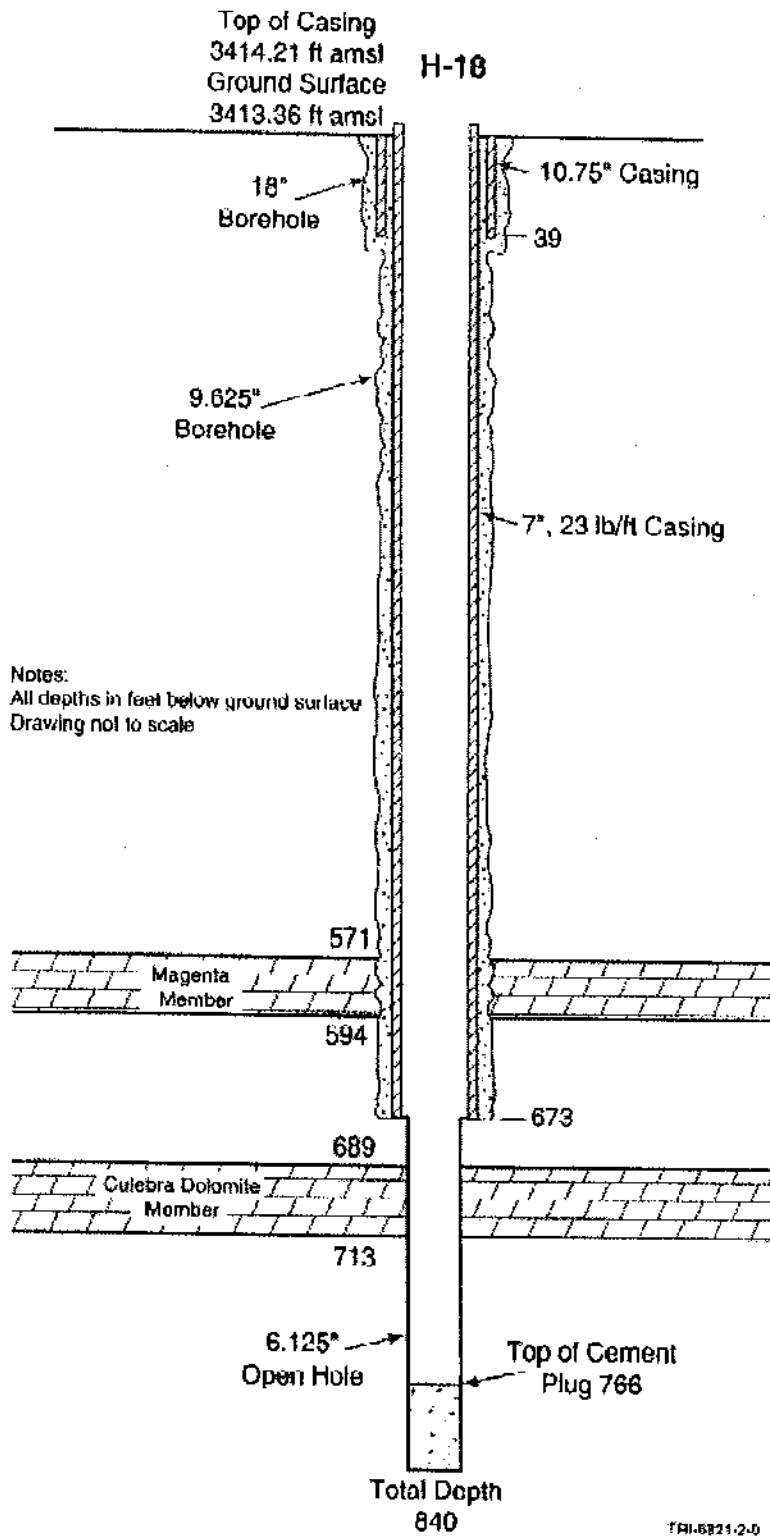


Figure 2-8. Current configuration of Well H-18.

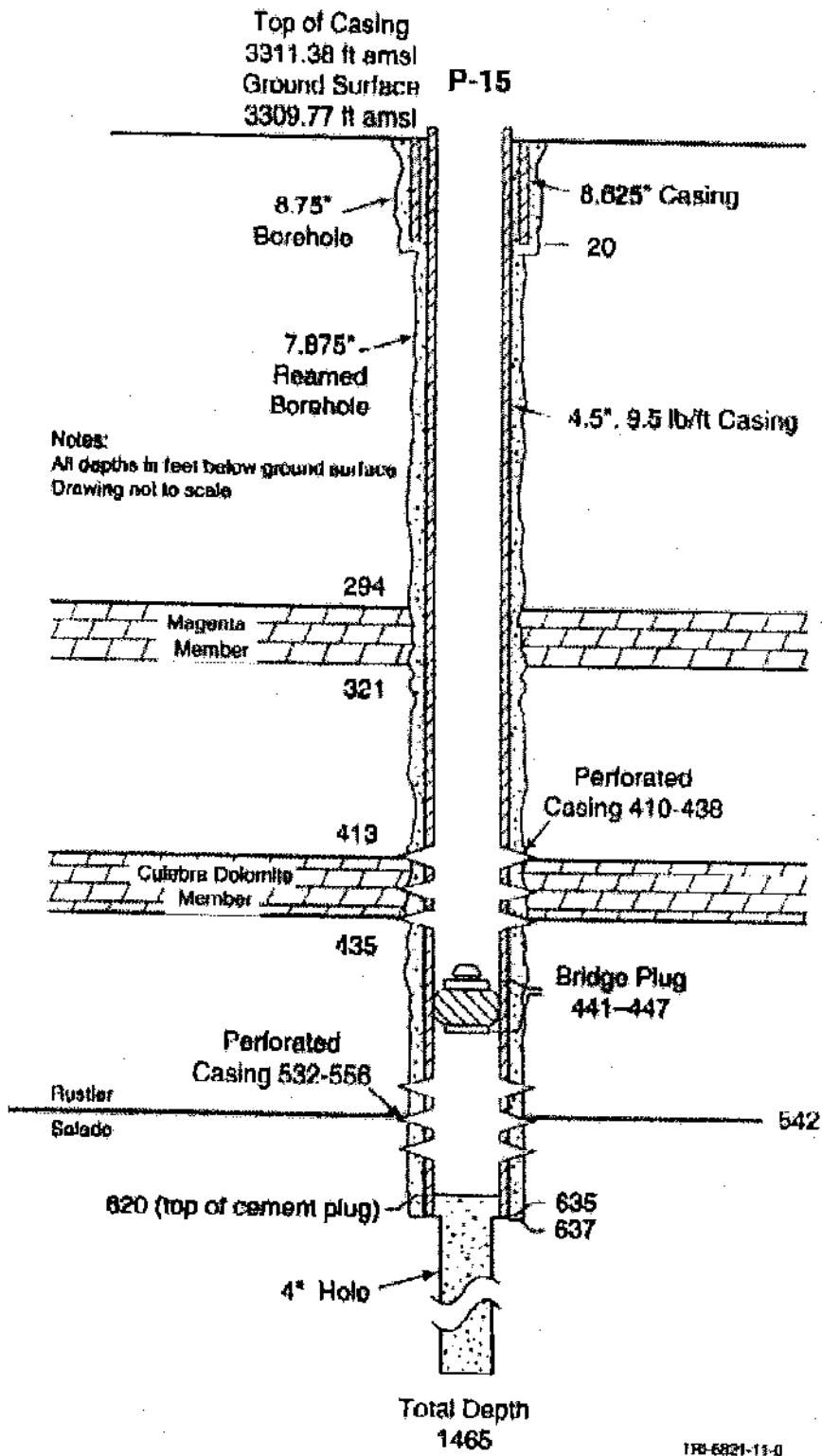


Figure 2-9. Current configuration of Well P-15.



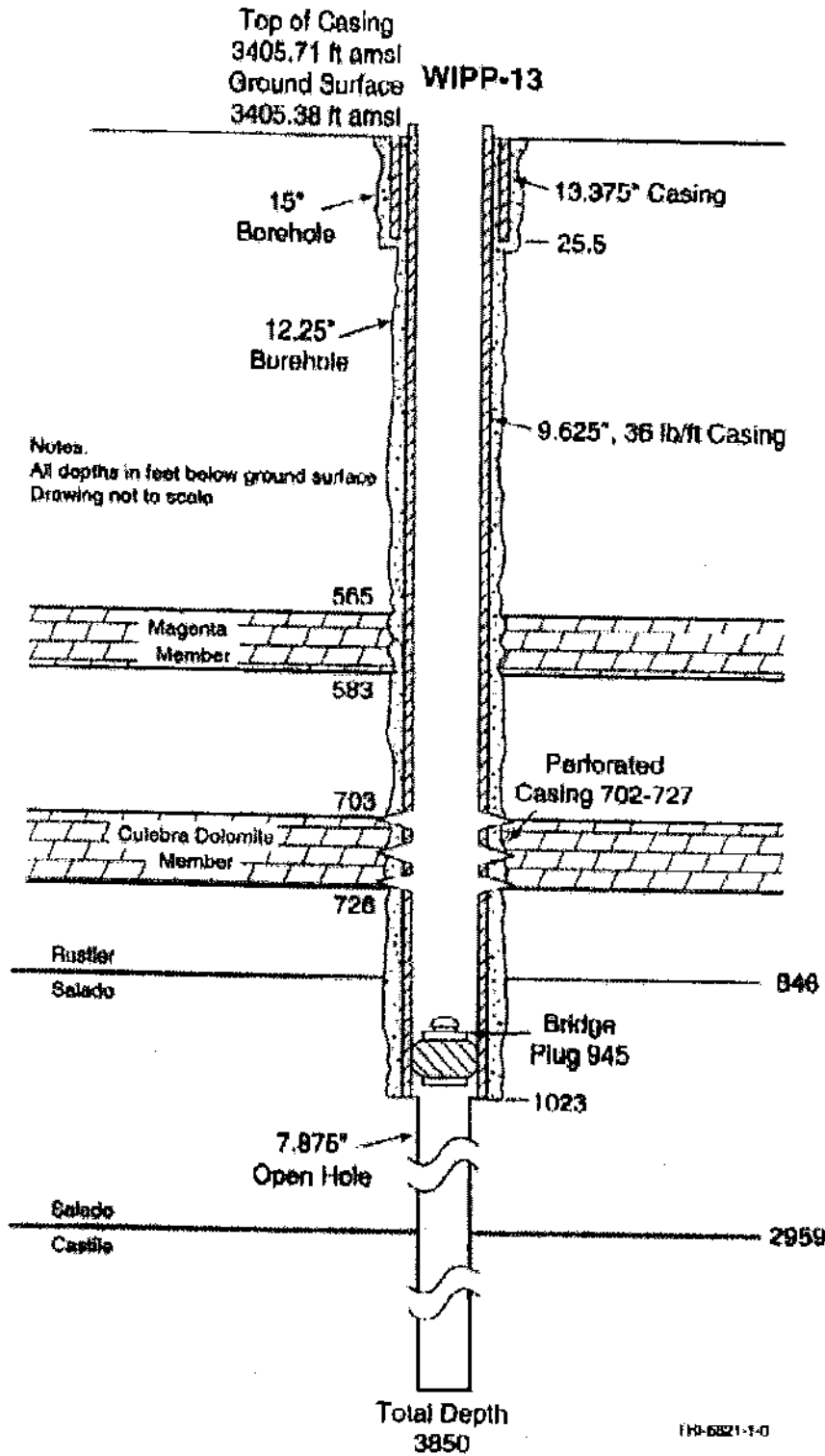


Figure 2-10. Current configuration of Well WIPP-13.

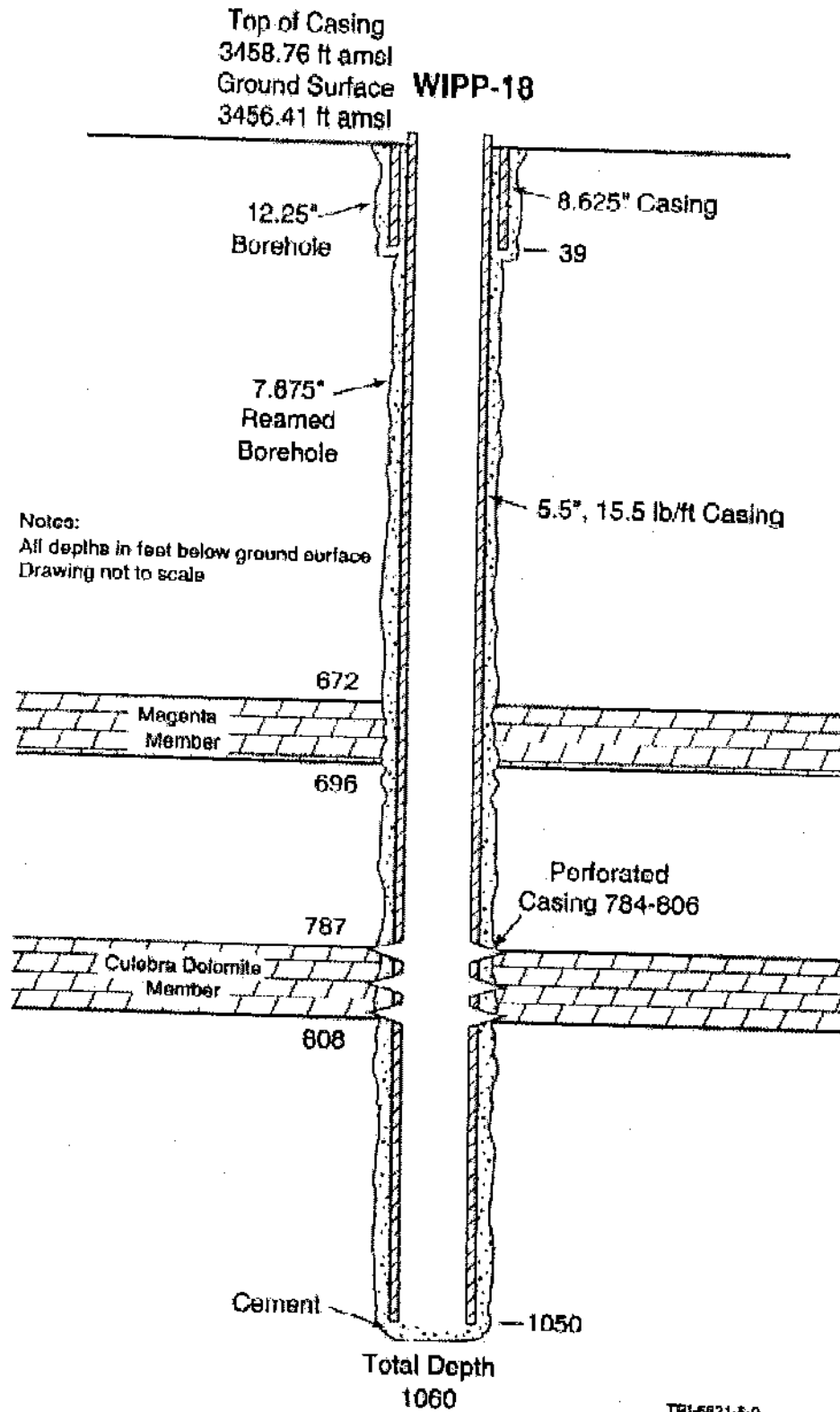


Figure 2-11. Current configuration of Well WIPP-18.

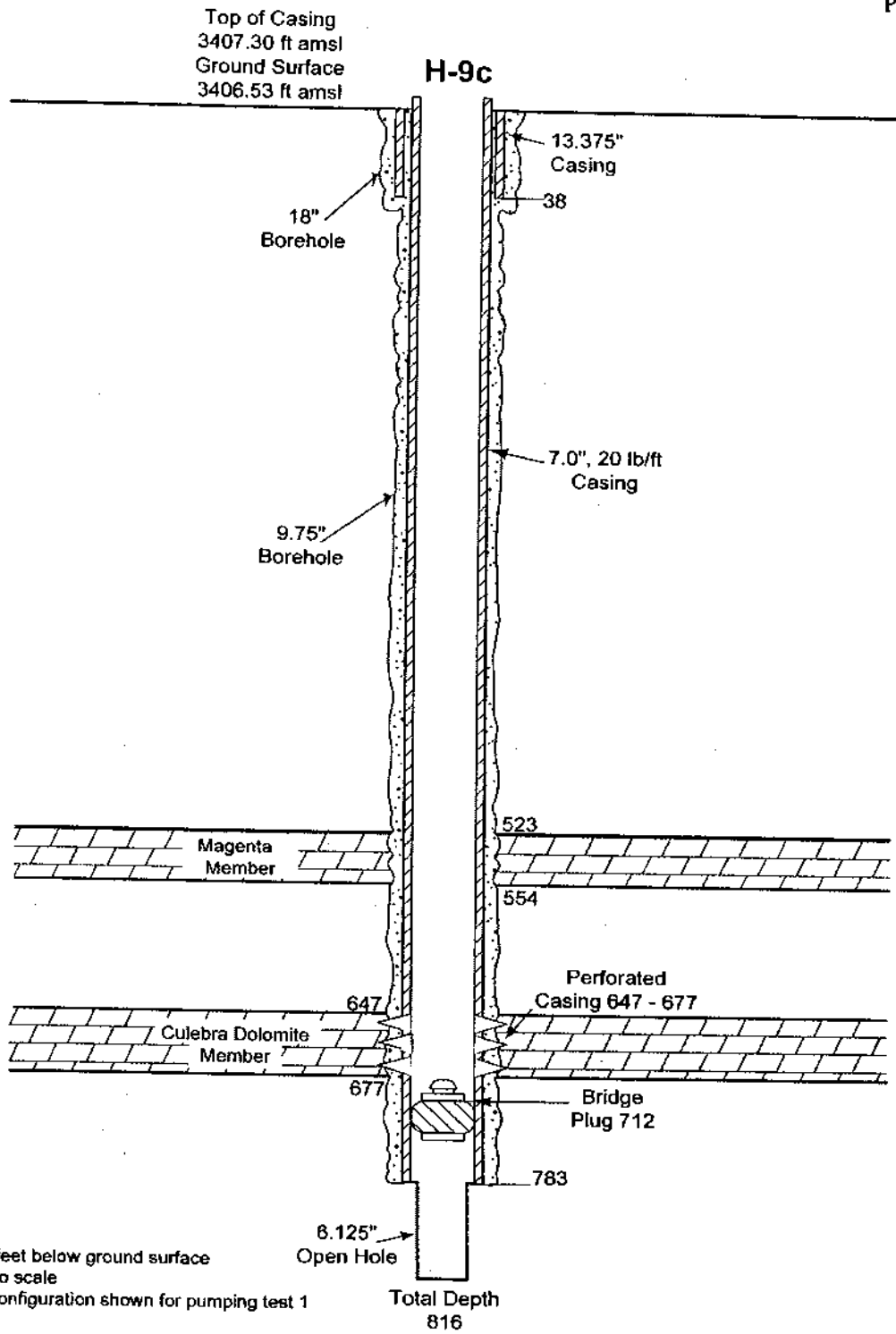
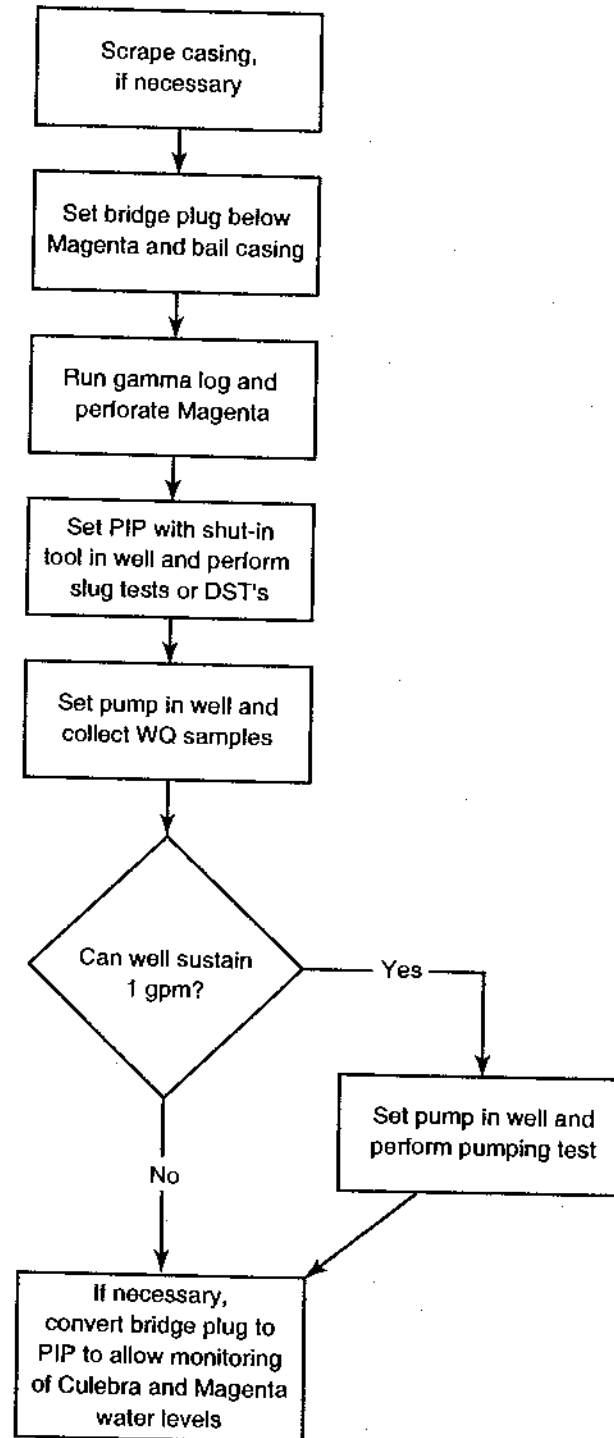


Figure 2-12. Current configuration of Well H-9c.



TRF-6821-13-0

Figure 2-13. Flow chart of the Magenta recompletion and data collection activities.

might potentially be recompleted to the Magenta. Figure 2-12 shows a flow chart of the field activities.

## 5 MEASURING AND TEST EQUIPMENT

Equipment needed for the Magenta recompletion and data-collection activities will consist of equipment at the land surface and downhole equipment to be installed in the wells. Equipment will consist of either "off-the-shelf" items ordered directly from qualified suppliers or standard equipment provided by qualified service companies as required to complete their contracted tasks. No specially designed equipment is anticipated. All equipment used will follow the supplier's operation and calibration recommendations and will be documented as part of the QA records and controlled following NP 12-1 (Subsections 6.1 and 10.4).

### 5.1 Surface Equipment

The Magenta recompletion and data-collection activities will be conducted utilizing some equipment at the land surface and some equipment installed in the wells (i.e., downhole equipment). Equipment will be operated observing relevant SNL and WRES environmental safety and health (ES&H) procedures and protocols. The surface equipment will include water-level sounders, water-quality-measurement instruments, a mechanical flow meter, diesel-powered generators, and storage tanks. A data-acquisition system (DAS) to monitor pressure and flow rate, an electronic flow-control system, and a barometer will be used for any pumping test performed.

#### 5.1.1 Water-Level Sounders

Water levels in the wells will be measured before installing any equipment. Water levels may also be measured in other Magenta monitoring wells within 1 mile of a well undergoing recompletion, pumping, or testing. The water levels will be measured using Solinst electric water-level sounders according to SNL NWNP Technical Operating Procedure (TOP) 512 (Subsection 10.4). All measurements will be documented as part of the QA records. The Solinst meter consists of a graduated plastic tape with two wire leads, a water-level probe at the downhole end of the tape, batteries, and a signal light and buzzer mounted on a surface reel. When the water-level probe enters the water, the electrical conductivity of the water closes the electric circuit on the tape, activating the surface light and buzzer. The water level is read directly, in feet or meters, on the graduated plastic tape, at the observation-well measuring point, which will be clearly marked on the surface casing.

#### 5.1.2 Water-Quality Measurement Instruments

Throughout the pumping phases of this program, the specific conductance, temperature, pH, and specific gravity of the produced water will be measured hourly, or as directed by the PI, following SNL NWNP Activity/Project-Specific Procedure (SP) 13-3 (Subsection 10.4). The same measurements will also be performed on water bailed or swabbed from the wells prior to slug tests or DSTs. With the exception of specific gravity, these data will be considered qualitative in nature and

will not be used for interpretation, but only to indicate relative changes in the quality of the fluid produced. The specific conductance and temperature will be measured with a Yellow Springs Instruments S-C-T meter or equivalent; pH with an Orion pH meter or equivalent; and the specific gravity with a laboratory-grade hydrometer. Measurements will be documented as part of the QA records.

### **5.1.3 Mechanical Flow Meter**

A totalizing mechanical flow meter will be used to measure the cumulative discharge during all pumping periods. The total discharge will be measured with a Carlon (or equivalent) in-line totalizing flow meter. The Carlon flow meter has a 0.675-in orifice, and is a brass-housed synthetic (non-corrosive) turbine flow meter designed for discharge rates of 1 to 20 gpm, with scale divisions of 0.10 gal. The Carlon flow meter is a totalizing flow meter and monitors only the total volume of fluid pumped. If necessary, the data from the totalizing flow meter can be used to calculate the average pumping rate by observing the meter at the beginning and end of a time period. The time and volume data can be used to calculate the average discharge rate for the time period in question. Totalizing-flow-meter data will be documented as part of the QA records. The flow meter will be checked during each pumping activity to verify that it is performing within design specifications by timing the filling of a container of known volume.

### **5.1.4 Diesel-Powered Generators**

Diesel-powered generators are needed to generate electricity for the pump and DAS. Diesel-powered generators will be operated in accordance with the instructions provided by the manufacturer. Operation of diesel generators is not a quality-affecting activity and, therefore, documentation of activities associated with the generators is not mandatory. No diesel fuel will be stored in separate containers at the well sites.

### **5.1.5 Storage Tanks**

All groundwater produced from the wells during these activities will be stored in polyethylene tanks at the well pad until such time as it can be discharged into the H-19 evaporation pond.

### **5.1.6 Data-Acquisition System**

All pumping tests conducted will be controlled and monitored using a computer-controlled DAS. The DAS will send and receive signals to/from the downhole and barometric pressure transmitters and record their responses on the computer's hard disk and on floppy diskettes. The DAS to be used will be PERM or Geomation. The basic PERM system consists of a power-excitation input to access the downhole pressure transmitters and other gauges such as the barometer and flow meter, a digital voltmeter to observe each gauge's output signal, a data-control unit to access each gauge's signal, a programmable voltage standard to verify the signal output from gauge and excitation devices, and a computer to store and process the data. The PERM DAS will collect

and process each gauge's input signal and store the data on hard disk and on floppy disks using SNL's PERM5 version 1.01 data-acquisition software, which has been qualified as software in accordance with SNL NP 19-1 (Subsection 10.4). The PERM5 software requires a computer with a 100-MHz 486 processor (or higher) running DOS 6.20. The Geomation System 2300 field monitoring and control system consists of modules that interface with various instruments by reading and recording voltage, amperage, resistance, and SDI-12 (environmental instrument interface). In addition, the Geomation DAS can provide outputs to flow control valves and other control devices. A computer will be used to provide a user interface and programming capabilities for the Geomation DAS via the Geonet™ Suite of software. The Geomation DAS will collect and process each gauge's input signal and store the data in memory until it can be archived to the computers hard drive. The Geonet™ Suite of software qualifies as "off the shelf software" with no access to the source code. This type of off-the-shelf software does not fall under the QA requirements as per NP 19-1, however the DAS activity must comply with NP 9-1.

### **5.1.7 Electronic Flow-Control System**

Pumping rates during any pumping test will be controlled using an electronic flow-control system consisting of an in-line inductive flow meter, a programmable electronic flow controller, and an electropneumatic valve. The flow-control system will be operated with the DAS and flow rates will be recorded by the DAS. The components of the system are combined in a simple feedback loop. Thus, the flow-rate output from the flow meter will be used as input to the electropneumatic valve allowing stable flow-rate changes to be introduced from the DAS keyboard in less than 30 s. The setpoint can be set manually at the controller or remotely via the DAS. The design control range for flow rate is 0.2 to 2 gpm. Additional checks on the discharge rate may be provided using a calibrated bucket and stopwatch, and a mechanical flow meter.

### **5.1.8 Barometer**

Atmospheric pressure will be monitored during all pumping tests using a Druck PTX 260 series 0-to-17-psia pressure transmitter mounted at the well site. Druck PTX transmitters have a 9 to 30 V (DC) input voltage with a 4-to-20-mA output signal which is converted to a voltage output and monitored by the DAS. The barometric output monitored by the DAS and converted pressure data will be recorded at the same frequency as the downhole pressure data.

## **5.2 Downhole Equipment**

Downhole equipment will be operated from the surface and will consist of bailing and swabbing equipment to remove fluid from the borehole(s), inflatable packers, a sliding-sleeve shut-in tool, memory gauges, a submersible pump, and possibly pressure transmitters. The depths of all equipment installed in a well will be measured and documented relative to a known permanent datum, such as a survey marker established on the hydropad. A secondary datum, such as the top of well casing, may be used as a reference point for depths provided that the elevation of that secondary datum relative to that of the primary datum is known and documented.

### **5.2.1 Bailing and Swabbing Equipment**

Bailing and swabbing equipment will be used to remove fluid from the tubing above the shut-in tool as needed to conduct slug and/or DSTs. The bailing and swabbing equipment will consist of artificial and/or natural rubber tubing wipers (swab cups) or downhole bailers supplied and operated by the pump-truck contractor. If bailing or swabbing is not possible or not effective, the fluid level in the tubing string may be lowered by means of air lifting, whereby a hose or flexible tubing would be used to inject compressed air below the water level in the tubing string at pressures and volumes sufficient to lift the fluid to land surface.

### **5.2.2 Inflatable Packers**

Slug and DSTs will be conducted with a PIP set above the Magenta perforations on 2.375-in tubing. Compressed air or compressed nitrogen will be used to inflate the packers. The packers to be used will have uninflated diameters of 3.5-7 in, depending on the diameter of the casing in each well.

### **5.2.3 Sliding-Sleeve Shut-In Tool**

A Baski Access Port Valve (APV™) will be used to control access to the packer-isolated Magenta zones. An APV is a sliding-sleeve shut-in tool consisting of concentric sections of pipe with circular ports passing through the wall of the pipe. In the open position, the ports on the two sections line up, allowing fluid to pass from the tool string to the well. When one of the sections slides vertically relative to the other, the ports no longer line up (closed position), and the fluid cannot pass from the tool to the well. The Baski APVs are controlled from the surface. Gas or hydraulic pressure is applied to a piston through a 0.25-in control line run alongside the tool string to open or close the sleeve. Separate pistons and control lines are used to open and close the sleeve. No tubing movement or weight change to the tubing above the shut-in tool is required to operate this shut-in tool, thus minimizing tool-induced pressure disturbances in the test zone. APVs will be installed between two 2.375-in pup joints beneath PIPs.

### **5.2.4 TROLL Memory Gauges**

TROLL 4000 and miniTROLL downhole memory gauges will be used as the primary data-acquisition instrument during slug tests and DSTs. Any time a Magenta well is pumped and another Magenta monitoring well is within 1 mile of the pumped well, TROLLs will also be used to monitor the pressure response in the nearby well(s). TROLLs are manufactured by In-Situ, Inc., and consist of a downhole pressure transducer and programmable data logger. They are installed at a known depth below the water surface in a well. The data logger is accessed from land surface by RS-422 or RS-232 cables, allowing the data-acquisition rate to be programmed and accumulate data to be downloaded to any laptop computer using a Windows 95, 98, 2000, or NT operating system and Win-Situ™, version 2.1, software. These battery-operated devices can operate for over 1 year without battery replacement. The use of the TROLL 4000 memory gauges will allow efficient use of manpower and provide useful data at any desired data density over extended time periods.



### **5.2.5 Submersible Pump**

An electric submersible pump with a production capacity of up to 5 gpm will be used for groundwater sampling and possibly pumping tests under open-hole conditions. For pumping tests, the pump will be installed with an in-line check valve so that the pump tubing column can be filled with water at the start of pumping to ensure immediate flow control and regulation, and to ensure that water will not drain back through the pump when the pump is turned off. All wiring of submersible pumps will be performed by a licensed pump installer.

### **5.2.6 Pressure Transmitters**

Druck PTX 161 pressure transmitters will be used to monitor the changes in Magenta pressure during any pumping tests. Two transmitters will be used at all times to ensure continued data collection in the event that one transmitter fails. The transmitters will be strapped to the discharge tubing above the pump. The Druck PTX 161 pressure transmitters have a 0-to-300-psig range of operation. These pressure transmitters will be monitored with the PERMDAS, which will record both the 4- to 20-mA output from the gages and the converted data in the desired pressure units.

## 6 TEST REQUIREMENTS/PROCEDURES

The activities discussed in this TP have been designed so that the data and information collected are of the highest possible value, and are more than adequate to meet specific program objectives.

### 6.1 Test Requirements

The testing elements of the Magenta data-collection activities require specific initial and operational conditions for maximum success. The Magenta pressure must be stabilized (changing less than 0.5 psi/day) before any hydraulic test is initialized. The fluid density in the well must be uniform before testing begins. The pumping rate during a pumping test should ideally be constant within  $\pm 5\%$ , but in any event must be well documented.

The test equipment used for the Magenta data-collection activities has to:

- provide quality data to support test objectives;
- perform according to design specifications; and
- be calibrated, as appropriate, according to standards acceptable under SNL NP 12-1 Subection 10.4).

### 6.2 Test Procedures

Three different types of tests may be performed in the Magenta wells depending on the conditions actually encountered. The following sections list the different tests that may be performed, provide general criteria for their selection, and define the procedures that will govern their performance.

#### 6.2.1 Slug and Drillstem Tests

Slug tests or DSTs will be performed in all recompleted wells. A DST is simply a slug test that is shut in before complete water-level recovery has occurred. The slug portion of a DST is referred to as a flow period and the shut-in portion is referred to as a buildup period. The advantages of a DST relative to a slug test are that it takes less time to complete and provides two data sets that can be analyzed instead of one. The disadvantage of a DST relative to a slug test is that the flow-period data set is less definitive than a full slug data set.

All slug tests and DSTs will be conducted in accordance with the following TP procedures. A PIP will be set on 2.375-in tubing in the well casing above the perforations with a sliding-sleeve shut-in valve immediately below the PIP. The PIP size will be selected so that the casing inside

diameter (I.D.) is not more than twice the uninflated diameter of the PIP. The exact placement of the PIP is not critical, as long as it is within 20 ft of the uppermost perforation and its position is carefully measured. The shut-in valve will be in the open position when the test equipment is installed in the well. Once at the desired depth, the PIP will be inflated (set), after which the shut-in valve will be closed.

A TROLL (Subsection 5.2.4) will be strapped to the tubing at a depth below the stabilized Magenta water surface calculated to provide a pressure of 90-95% of the maximum pressure for that instrument. The pressure sensor of the TROLL will be connected to the Magenta interval using a feed-through line passing through the PIP. The depths of all equipment in the well will be carefully measured and documented in the scientific notebook.

With the shut-in valve closed, the tubing will be bailed or swabbed to remove some of the water above the Magenta and the specific gravity of this water will be measured. The amount of water to be removed will be determined on-site by the PI, based on the following guideline: the water level will be lowered to where it will provide a pressure no less than 5% of the maximum pressure for the TROLL when the shut-in valve is opened. After bailing or swabbing, the water level in the tubing will be measured using a Solinst meter in accordance with TOP 512.

The pressure in the Magenta interval below the PIP will be allowed to stabilize until the rate of change is  $<0.5$  psi/day. At the direction of the PI, the shut-in tool will be opened to initiate a slug test. The PI will evaluate the test data in real time to determine if the test should be continued as a slug test or converted to a DST. Subject to the discretion of the PI, the following guidelines will be used to determine if and when a slug test will be converted to a DST:

- If 50% of the initial slug has dissipated after 3 h, the test will remain a slug test.
- If 50% of the initial slug dissipates between 3 and 24 h, the shut-in valve will be closed and the test will be converted to a DST when 80% of the slug has dissipated.
- If 50% of the initial slug has not dissipated after 24 h, the shut-in valve will be closed and the test will be converted to a DST whenever 50% dissipation occurs.

Slug tests and DST buildup periods will continue until at least 98% pressure recovery has occurred.

For a slug test, the shut-in valve will then be closed and the tubing bailed or swabbed to create a pressure differential approximately half of that created for the first slug test. For a slug test converted to a DST at 80% slug dissipation, the tubing will also be bailed or swabbed to create a pressure differential approximately half of that created for the first test. No bailing or swabbing will be required for a test converted to a DST at 50% slug dissipation. After the pressure disturbance caused by bailing/swabbing has dissipated, the shut-in valve will be opened to begin a second slug test or DST. The second test will be an exact duplicate of the first test, but with half of the initial pressure differential. Testing may be terminated at any time after 98% pressure recovery has occurred.

Data-acquisition rates will be set as fast as possible at the start of each test event (slug/flow or buildup) and will then be systematically decreased throughout the test to provide a reasonably uniform distribution of data with respect to the logarithm of elapsed time.

### **6.2.2 Pumping Tests**

Constant-rate pumping tests will be performed in any Magenta well capable of sustaining a pumping rate of about 1 gpm or more. All pumping tests will be conducted in accordance with the following TP procedures. A submersible pump (Subsection 5.2.5) will be set in the well approximately 5 ft below the Magenta perforations on 2.375-in tubing. A check valve will be installed above the pump to prevent water in the tubing column from draining back down through the pump when the pump is turned off. Two pressure transmitters (Subsection 5.2.6) will be strapped to the tubing approximately 10 ft above the pump. The depths of all equipment in the well will be carefully measured and documented in the scientific notebook.

The pump will be turned on and operated at a constant rate (determined during water-quality sampling) to produce water from the Magenta. A TROLL will be set in any Magenta monitoring well within 1 mile of the pumping well. Real-time analysis of the pressure data from the pumping and monitoring (if any) wells will be used by the PI to establish the time when the pump may be turned off and the time at which recovery monitoring will be terminated. The objective of any pumping test will be to determine the local Magenta transmissivity and, if other monitoring wells are affected, the local storativity. Pumping time may vary from two to as much as ten days depending on the local Magenta transmissivity.

The DAS (Subsection 5.1.6) will be used for any pumping test to record downhole pressure, barometric pressure, and flow rate. Data-acquisition rates will be set as fast as possible at the start of pumping and recovery and will then be systematically decreased to hourly, providing at least 20 readings for each log cycle of elapsed time. Manual totalizing-flow-meter readings and water-quality (temperature, specific conductance, pH, and specific gravity) measurements will be made no less frequently than hourly during pumping. During the recovery period, the water level in the tubing will be measured several times a day to verify that the check valve is not leaking.

### **6.2.3 Modifications to Test Procedures**

Modifications to test procedures may be required during testing activities. These modifications will be conducted at the direction of the PI and will be documented in the scientific notebook as part of the QA records. Such modifications are not deviations and will not be reported as nonconformances that require corrective action.

## 7 DATA-ACQUISITION PLAN

Both manually and electronically collected data will be acquired during the Magenta activities. The following types of data will be recorded:

- electronically collected downhole pressure data;
- electronically and/or manually collected pumping rate and volume data from wells being pumped;
- electronically collected barometric-pressure data;
- manually collected water-level data;
- manually collected water-quality data concerning the temperature, pH, specific gravity, and specific conductance of fluid produced during pumping, bailing, and/or swabbing; and
- manually collected data on equipment and instrument configurations in the wells and at the surface.

### 7.1 Scientific Notebooks

Scientific notebooks will be used in accordance with SNL NP 20-2 (Subsection 10.4) to document all activities and decisions made during the Magenta field activities. Specific information to be included in the scientific notebooks includes:

- a statement of the objectives and description of work to be performed at each well, as well as a reference to this TP;
- a written account of all activities associated with each well;
- documentation of safety briefings;
- a list of all equipment used at each well, including make, model, and operating system (if applicable);
- a description of standards used for on-site instrument calibration and calibration results;
- traceable references to calibration information for instruments and/or gauges calibrated elsewhere;
- a sketch, showing all dimensions, of each downhole equipment configuration;

- tubing tallies and other equipment measurements;
- manually collected water-level measurements;
- manually collected water-quality data concerning the temperature, pH, specific gravity, and specific conductance of fluid produced during pumping, bailing, and/or swabbing;
- entries providing the names, start times, and stop times of all data files created with the DAS software or WinSitu, as well as tables showing the configuration information (pressure transmitter serial number, calibration coefficients, etc.) entered into PERM5 to initiate each data file; and
- discussion of the information and/or observations leading to decisions to initiate, terminate, or modify activities.

All entries in the scientific notebooks will be signed or initialed and dated by the person making the entry. The scientific notebook(s) for each well will be reviewed by an independent, technically qualified individual within 2 weeks of the end of each major field activity (recompletion, pumping, and hydraulic testing) at that well to verify that sufficient detail has been recorded to retrace the activities and confirm the results.

Manually collected water-quality data and water-level measurements may also be recorded on specially prepared forms rather than in the scientific notebooks when that would provide a more efficient means of data collection and tracking. Use of such forms will be noted in the scientific notebooks and these forms will be submitted as QA records.

## **7.2 Electronic Data Acquisition**

TROLL memory gauges (Subsection 5.2.4) will be used for monitoring and testing activities. The PERM or Geomation DAS described in Subsection 5.1.6 will be used if any Magenta pumping tests are performed. If used, the DAS will record downhole pressures, barometric pressure, and pumping rates. Electronic data file-management systems will be documented in the scientific notebooks for these activities. These electronic data files will be submitted as QA records according to NP 17-1 (Subsection 10.4).

## **7.3 Manual Data Acquisition**

Manual data collection will be carried out either using the scientific notebooks or forms designed specifically for each activity or data type. To minimize transcription errors and multiple documentation of the same information, the use of forms specified in the WIPP procedures is not mandatory. The PI will determine the means of documenting manually acquired data and will ensure that all quality-affecting information is documented.

## 7.4 On-Site Data Validation

During the field activities, the PI will evaluate the data as they are acquired. The data will be diagnosed for any tool failure and/or procedure-induced effect that may affect the data quality. The PI will take immediate action (if so required) to make any necessary changes to the equipment configuration or the procedures to assure the data quality is consistent with the objectives of these activities.

The PI will use real-time evaluation of the acquired data during any given activity to assure that the data are usable in a detailed interpretation, the conditions can be maintained over the planned duration of the activity, and that an activity will not be terminated before the minimum objectives can be achieved under the given time constraints. The PI may utilize some or all of the following procedures and analytical tools:

- To assure that the acquired data satisfy program plans, the PI may use the same interpretation techniques during the data-validation process as will be used in later interpretation of these data.
- The PI may use specialized plots to interpret the formation response and to identify the time domain of that response such as the wellbore storage, transition, stabilization, or other response phase.
- The PI may use real-time analysis of the acquired data to determine the time when continuing the activity will provide no further improvement in the interpreted results within the program's time and budget constraints.
- The PI may use real-time analysis to determine whether or not an activity can be terminated earlier than planned, and to develop a revised schedule as appropriate.

If at any time the PI determines that an activity or objective cannot be accomplished due to time constraints, problems concerning the performance of the equipment, or unsuitability of initial conditions, the PI may terminate the activity. The PI will document all real-time evaluation of data in the scientific notebook.

## 8 SAMPLING AND SAMPLE CONTROL

After recompletion to the Magenta, each well will be pumped to allow water samples representative of the Magenta to be collected. As discussed in Section 6, the wells will be pumped until water-quality parameters (electrical conductivity and specific gravity) are stable within  $\pm 5\%$  while two wellbore volumes are pumped. When that occurs, water samples will be collected for laboratory analysis of major ions (calcium, sodium, magnesium, potassium, chloride, sulfate, and alkalinity). Samples will be collected and controlled in accordance with NP 13-1 (Subsection 10.4). The chain of custody for the samples when they are transferred to the WRES mobile analytical laboratory will be established in accordance with SP 13-1.

Water samples will be collected in 1-L acid-washed polyethylene bottles. Each bottle will be rinsed three times with water from the pump discharge line before a sample is collected. Two bottles will be filled in immediate succession. The first bottle will be filled completely. The second bottle will be filled approximately halfway. Approximately 2 mL of nitric acid ( $\text{HNO}_3$  Ultrex II, 70.6 wt %) or equivalent] will be added to this bottle, and then the bottle will be filled to the shoulder. (Note: chemical goggles and protective gloves must be worn while handling nitric acid.) The lid will be screwed on the bottle and the bottle agitated. The pH of the sample will then be checked and, if it is above 2.0 standard units, 1 mL of nitric acid will be added, the sample agitated, and the pH checked again. This procedure will continue until the pH is less than 2.0.

After filling, the lids of all sample bottles will be secured with electrical tape. A label will be affixed to each bottle bearing the information listed below, and the label will be completely covered with clear packing tape. The label will contain the following information, written using an indelible marker:

- project name (WIPP),
- sample number,
- sample location (Magenta),
- well designation,
- collector's name,
- date and time,
- type of sample (groundwater),
- acid wash (yes or no),
- parameter or destination,



- type of preservative ( $\text{HNO}_3$  or none),
- bottle number, and
- method of collection (filtered or unfiltered).

After collection, water samples will be stored in a cooler until they can be delivered to the WRES mobile analytical laboratory, which should occur as soon as practicable.

## 9 TRAINING

All SNL and WIPP-Site contractor personnel must receive WIPP General Employee Training (GET) followed by annual refreshers as part of employment requirements at WIPP. All personnel who will perform quality-affecting activities under this TP must have training in the SNL QA program (Form NP 2-1-1 and have viewed the current QA Refresher video), and must read SNL NPs 12-1, 13-1, and 20-2 and SP 13-1. They must also read the procedures outlined in this TP, the job hazard analysis (JHA), and applicable SPs and TOPs listed in Subsection 10.4, but no additional training in those procedures is required. No other special training requirements are anticipated in addition to the GET and the safety briefings described in Section 11.

## 10 QUALITY ASSURANCE

### 10.1 Hierarchy of Documents

Several types of documents are used to control work performed under this TP. If inconsistencies or conflicts exist among the requirements specified in these documents, the following hierarchy shall apply:

- memoranda or other written instructions used to modify or clarify the requirements of the TP (most recent instructions having precedence over previous instructions);
- this TP,
- NPs (Subsection 10.4),
- SPs,
- TOPs.

SNL QA concurrence will be obtained and/or corrective action reports will be written for modifications to QA procedures implemented for work conducted under this TP.

### 10.2 Quality-Affecting Activities

Activities performed under this TP are quality-affecting with the following exceptions:

- water-quality measurements (except specific gravity; see Subection 5.1.2);
- operation of diesel-powered generators (see Subection 5.1.4);
- assistance provided by the manufacturer/contractor in the installation of tools and equipment;
- support services for tasks that do not involve data collection, such as pump trucks, machining, welding, fishing services, fuel, etc.; and
- water storage and disposal.

Activities that are not quality-affecting are not subject to the requirements of the SNL QA program.

### 10.3 Quality Assurance Program Description

SNL activities are conducted in accordance with the requirements specified in the Carlsbad Field Office (CBFO) Quality Assurance Program Document (QAPD) (U.S. DOE, 2002). The requirements and guidance specified in the QAPD are based on criteria contained in American Society of Mechanical Engineers (ASME) (1989a), ASME (1989), ASME (1989c) and U.S. EPA (1993). The requirements of U.S. DOE (2002) are passed down and implemented through the SNL NWMP QA procedures.

### 10.4 NPs, SPs and TOPs

The following NPs, SPs, and TOPs are applicable to the work described in this TP. Note that the versions listed below may not be the current versions. Always check the SNL NWMP web site ([www.nwmp.sandia.gov/onlinedocuments/](http://www.nwmp.sandia.gov/onlinedocuments/)) to find the current version of these or other NPs, SPs, or TOPs.

- NP 9-1, "Analyses;"
- NP 12-1, "Control of Measuring and Test Equipment;"
- NP 9-1, "Analyses;"
- NP 13-1, "Sample Control;"
- NP 17-1, "Records;"
- NP 19-1, "Software Requirements;"
- NP 20-2, "Scientific Notebooks;"
- SP 13-1, "Chain of Custody;"
- SP 13-3, "Field Water-Quality Measurements;" and
- TOP 512, "Depth-to-Water Measurement Using Solinst Brand Electric Sounder."

Modification to these procedures may be required during field activities. Such modifications are not deviations and will not be reported as nonconformances that require corrective action. However, modifications will be documented by the PI in the scientific notebook as they occur as part of the QA records.

## 10.5 Data Integrity

Care will be taken throughout the performance of the operations for this TP to ensure the integrity of all data collected including documentation on hard copy and data collected on magnetic media. Duplicate copies of all data will be produced no less frequently than monthly and the duplicate copies will be maintained at a location separate from the well site to ensure that data are not lost. Data collected shall not be released unless and until the data are reviewed and approved by the SNL PI.

## 10.6 Records

Records shall be maintained as described in this TP and applicable QA implementing procedures. These records may consist of bound scientific notebooks, loose-leaf pages, forms, printouts, or information stored on electronic media. The PI will ensure that the required records are maintained and are submitted to the SNL NWMP Records Center according to NP 17-1 (Subsection 10.4).

### 10.6.1 Required QA Records

As a minimum, QA records will include:

- scientific notebooks;
- SPs , NPs, and TOPs used;
- calibration records for all controlled equipment;
- equipment-specification sheets or information;
- photographs taken of the equipment and activities, with a log listing the photographs and describing what is seen;
- data files collected by TROLLs and/or the DAS, with a log listing the files and defining their contents;
- all forms containing manually collected data;
- a log of all samples collected;
- copies of all permits obtained; and
- reports (e.g., gamma and perforation logs) provided by contractors.

### **10.6.2 Miscellaneous Non-QA Records**

Additional records that are useful in documenting the history of the activities but are considered non-QA records may be maintained and submitted to the SNL NWMP Records Center. These records include:

- safety briefings,
- as-built diagrams of equipment supplied by contractors,
- pump-truck and other equipment certifications,
- equipment manuals and specifications,
- information related to operation of diesel generators,
- equipment manifests, and
- cost and billing information regarding contracted services.

These records do not support performance assessment or regulatory compliance and, therefore, are not quality-affecting information.

### **10.6.3 Submittal of Records**

Records resulting from work conducted under this TP, including forms and data stored on electronic media, will not be submitted to the SNL QA staff for review and approval in individual pieces. Instead, the records will be assembled into a records package(s), which will be reviewed by the SNL PI before being submitted for QA review.

## 11 HEALTH AND SAFETY

SNL field operations will be conducted on land controlled by WRES, the WIPP Management and Operating Contractor (MOC), and the field operations team assembled for this TP will follow all WRES safety practices and policies. Operational safety for individual field operations will be addressed through an ES&H PHS (SNL2A00137-001) and a Hazard Analysis (HA) developed by SNL. Project-specific WIPP-Site safety procedures and a Job Hazard Analysis (JHA) will be approved through the SNL WTL and WRES safety personnel. All activities will be performed in accordance with the requirements of WP12 FP.01, WP12 IS.01, and WP12 IH.02.

All equipment will be operated in accordance with the appropriate allowable operating pressures and in accordance with the SNL ES&H pressure-safety manual. Pressure ratings for individual parts such as valves and pressure tubing will be either marked by the manufacturer with the maximum allowable operating pressure or such information will be made available in written documentation according to guidelines of the SNL Center 6800 ES&H Coordinator. Additional safety requirements to be observed by field personnel are:

- appropriate use of safety shoes, safety glasses, chemical goggles, hard hats, and protective gloves;
- ensuring adequate fuel is available for all field vehicles, especially those traveling to remote locations;
- proper installation and safety procedures when handling electrical submersible pumps and other electrical equipment;
- proper procedures for operation of diesel-powered generators for on-site electric power;
- proper procedures for inflation of downhole packers;
- familiarity with on- and off-site road conditions and driving regulations;
- familiarity with the locations of First Aid supplies, medical support facilities, and fire extinguishers and other safety equipment;
- familiarity with the location of lists of emergency telephone numbers and persons and offices to notify in the event of emergencies; and
- familiarity with the location of all MSDS information.

All field personnel assigned to the field operations described in this TP will receive a safety briefing before the beginning of field operations at each well site. In addition, the PI or field-site supervisor will conduct daily safety meetings at the beginning of daily operations or at the beginning

of each shift. All personnel receiving safety briefings are required to sign and date the safety-briefing form as part of safety-documentation procedures. All work locations will maintain a mobile communication system. In case of accident, injury, or sudden illness, the WIPP Central Monitoring Room (CMR) will be notified immediately. The CMR will coordinate emergency response activities.



## 12 ROLES AND RESPONSIBILITIES

The work in question will require the drilling of several new wells in the vicinity of the WIPP site. It will also involve reconditioning several existing wells. Throughout this multi-year field program, wells will be tested, water levels monitored, and well water chemistry will be observed. SNL intends to partner with Washington Regulatory and Environmental Services (WRES), the WIPP MOC, and/or its corporate affiliates to ensure integration of program efforts, to see that this work is done in accordance with all applicable technical and regulatory standards, and that data generated are fully qualified under SNL's WIPP quality assurance program for use in assessing the long-term performance of the repository.

### 12.1 SNL Responsibility

SNL responsibilities are:

- Identify which monitoring wells will need to be reconditioned and work with WRES to identify by what means those wells will be made ready for scientific endeavor.
- Identify which wells will need to be hydraulically tested and identify the type(s) of test(s) to be performed.
- Provide water-level and water-chemistry monitoring equipment, when appropriate, for placement in new and/or reconditioned wells.
- Provide all equipment, both downhole and surface-located, necessary to perform hydraulic tests in new/replacement and reconditioned wells.
- Monitor water levels and water chemistry in wells of interest to SNL, or cause levels and chemistry to be monitored.
- In collaboration with WRES (as outlined below), perform all hydraulic tests in wells.
- Analyze and interpret well tests and hydrological monitoring data acquired.

### 12.2 WRES Responsibilities

WRES will assume the following responsibilities in support of the activities discussed in this TP:

- Recondition (or have reconditioned) any existing wells to be tested.

- For wells to be hydraulically tested, provide (or have provided) the requisite capabilities, including (but not limited to) pump-setting trucks or pulling rigs and crews to install hydraulic testing equipment, "kill" trucks to inflate packers (when required), and appropriately licensed, authorized, and experienced electrician(s) to wire and hook up pumps (as needed).
- Provide necessary oversight personnel at well sites to allow SNL to conduct well testing operations on a 24-hour-per-day/7-day-per-week basis, as needed. In turn, SNL will provide to WRES as much advance notice as possible of the need for specific operations outside normal day-time work hours.
- Dispose of any waste water or other waste materials generated during well testing and well reconditioning operations in accordance with all applicable environmental and regulatory standards (including chemical analysis of produced waste water, as appropriate).
- Facilitate compliance with the applicable WIPP Site environment, health, safety, and security requirements as they relate to program activities.
- Participate in water-level and water-chemistry monitoring and data gathering to the degree that SNL and WRES jointly determine is needed.

### **12.1 Responsibility for Permitting and Licensing**

WRES is responsible for ensuring that WIPP-site activities are conducted in accordance with applicable federal, state, and local regulatory requirements. WRES is responsible for all permitting and licensing requirements associated with drilling, coring, logging, reconditioning, testing, and waste disposal necessary to complete the activities outlined within this TP. SNL will abide by all of the permitting and licensing rules and regulatory requirements as indicated by WRES. SNL is responsible for ensuring that all contracted experimental work performed by SNL contractors at the WIPP site meets all applicable federal, state, and local regulatory requirements.

### 13 REFERENCES

- ASME. 1989a. *Quality Assurance Program Requirements for Nuclear Facilities*. ASME NQA-1-1989 Edition. New York, NY: American Society of Mechanical Engineers.
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- ASME. 1989c. *Quality Assurance Program Requirements for the Collection of Scientific and Technical Information for Site Characterization of High Level Nuclear Waste Repositories*. ASME NQA-3-1989 Edition. New York, NY: American Society of Mechanical Engineers.
- U.S. DOE. 1996. *Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant*. DOE/CAO-1996-2184. Carlsbad, NM: U.S. Department of Energy Carlsbad Area Office.
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- U.S. EPA. 1996. "40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance With the 40 CFR Part 191 Disposal Regulations: Final Rule," *Federal Register*. Vol. 61, no. 28, 5224-5245.

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**2 COMPLIANCE MONITORING**

**2.5 Geohydrological Conceptual Model...**



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**SANDIA NATIONAL LABORATORIES  
WASTE ISOLATION PILOT PLANT (WIPP)**

**TEST PLAN, TP 02-05**

**Geohydrological Conceptual Model for the Dewey Lake Formation  
in the Vicinity of the Waste Isolation Pilot Plant (WIPP)**

WBS: 1.3.5.3.1.2

Effective Date: \_\_\_\_\_

Prepared by:  
Dennis W. Powers  
*Consulting Geologist*  
140 Hemley Road  
Anthony, TX 79821

WIPP:1.3.5.3.1.2:DC:QA:DPRP1:FF:TP02-05, Rev. 0

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## APPROVALS

Author: \_\_\_\_\_  
Dennis W. Powers  
Consulting Geologist  
Date \_\_\_\_\_

Technical Reviewer: \_\_\_\_\_  
R.L. Beauheim, 6821  
Performance Assessment and Decision Analysis Dept.  
Date \_\_\_\_\_

Technical Reviewer: \_\_\_\_\_  
W.A. Stensrud  
Geotechnical Engineering  
(Washington TRU Solutions)  
Date \_\_\_\_\_

SNL QA: \_\_\_\_\_  
Marty Mitchell, 6820  
Carlsbad Programs Group  
Date \_\_\_\_\_

SNL Management: \_\_\_\_\_  
M. Kathryn Knowles, 6821  
Performance Assessment and Decision Analysis  
Dept.  
Date \_\_\_\_\_

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## REVISION HISTORY

This is the original edition of this Test Plan (TP); no prior revisions exist. The purpose and content of any future changes and/or revisions will be documented and appear in this section of revised editions. Changes to this TP, other than those defined as editorial changes per Nuclear Waste Management Program (NWMP) quality assurance (QA) procedure NP 20-1 *Test Plans*, shall be reviewed and approved by the same organization that performed the original review and approval. All TP revisions will have at least the same distribution as the original document.

## DEFINITIONS OF ACRONYMS

aka	also known as
Carlsbad Field Office	CBFO (US Department of Energy)
ES&H	environmental safety and health
FEPs	features, events and processes
NWMP	nuclear waste management program
PA	performance assessment
QA	quality assurance
QAPD	Quality Assurance Program Document
SEM	scanning electron microscope
SNL	Sandia National Laboratories
T	transmissivity
TP	Test Plan
WIPP	Waste Isolation Pilot Plant
WQSP	Water Quality Sampling Program
WTS	Westinghouse TRU Solutions
XRD	x-ray diffraction

## 1.0 PURPOSE AND SCOPE

This Test Plan (TP) describes laboratory activities to be conducted for Sandia National Laboratories (SNL) in support of developing a conceptual geohydrologic model of the Dewey Lake Formation in the general vicinity of the Waste Isolation Pilot Plant (WIPP). The geohydrology of the Dewey Lake is of interest across organizational boundaries because of local natural saturated zones in the Dewey Lake as well as shallow zones that have been recharged recently since WIPP was constructed. The TP therefore describes a broad range of activities and interests, but the responsibility for many activities will fall to Westinghouse TRU Solutions (WTS); this TP is not a statement of the work to be undertaken by WTS. If necessary, further activities by SNL will be developed in revisions to this plan or under analysis plans.

### 1.1 Importance of the Dewey Lake Formation

The Dewey Lake Formation (aka Redbeds) (Figure 1) is a thick sequence of fine-grained reddish-brown clastic sediments overlying the Rustler Formation. Although the Dewey Lake is considered unsaturated over most of the WIPP Site, water has been encountered in some drillholes in the southern

part of the site (e.g., Jones, 1978; Mercer, 1983; Beauheim and Ruskauff, 1998). The single test of a natural saturated zone in the Dewey Lake, at drillhole WQSP 6A (see Figure 2 for drillhole locations), provides an estimate of transmissivity (T) of  $3.9 \times 10^{-4} \text{ m}^2/\text{s}$  (Beauheim and Ruskauff, 1998, p. 193), a value approximately five times larger than the largest value of T for the Culebra Dolomite Member of the Rustler Formation within the WIPP boundaries.

ERATHEM	SYSTEM	Series	Group	Formation	Members
CENOZOIC	QUATERNARY	Holocene	Dockum	Dune sand/Berino	
		Pleistocene		Mescalero caliche	
	NEOGENE	Miocene	Gatuña		
MESOZOIC	TRIASSIC			Santa Rosa	
		Ochoan		Dewey Lake	
PALEOZOIC	PERMIAN			Rustler	Forty-niner Magenta Dolomite Tamarisk Culebra Dolomite Los Medanos

Figure 1 –  
Simplified stratigraphy of  
the WIPP site.

Dewey Lake hydraulic properties affect several processes: a) vertical recharge to underlying units such as the Culebra Dolomite, b) how water and solutes move in saturated zones, and c) the fate of groundwater created recently in the vicinity of WIPP surface facilities (Intera, 1997). The results of further examination of Dewey Lake geohydrology may be evaluated for 1) effects on features, events, and processes (FEPs), 2) performance assessment (PA), and 3) monitoring programs. Study of the Dewey Lake contributes to a fundamental understanding of the geohydrologic setting near WIPP, which is a requirement for continued certification by the Environmental Protection Agency (EPA).

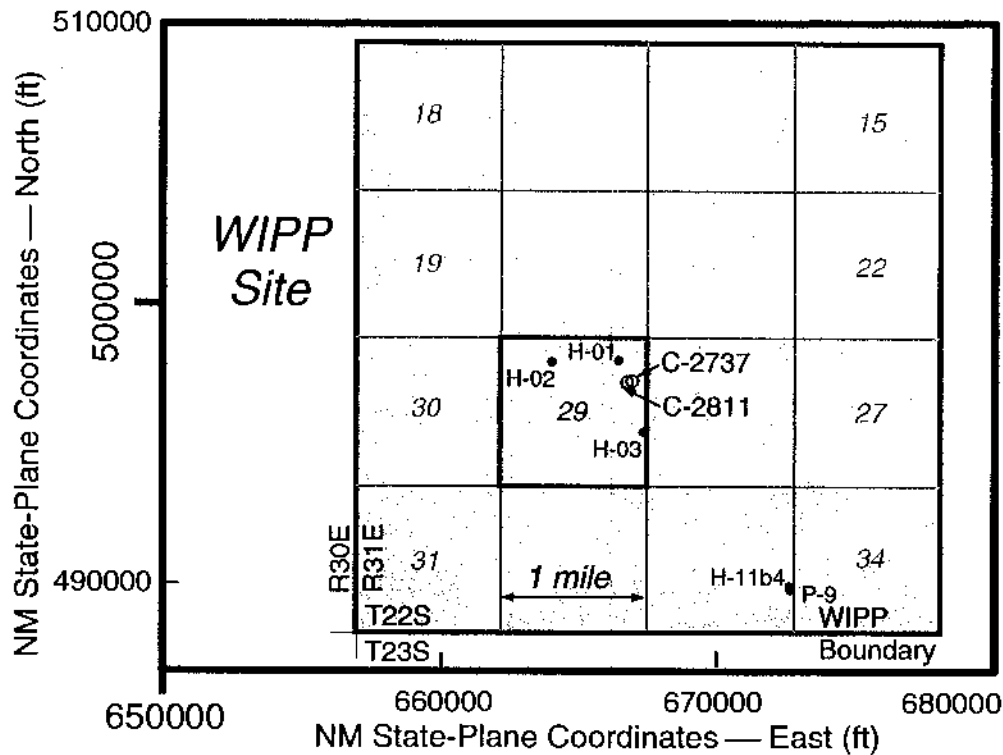


Figure 2 – WIPP site and location of drillholes referred to in TP.

### 1.2 Strategy of the Test Plan

The laboratory tests described in this TP are the responsibility of SNL. The tests are designed to supplement existing information about the way in which matrix and natural mineral cements in the Dewey Lake control infiltration and cementation. Based on previous work that has not yet been fully described, Powers (2002) related changes in natural cements in the upper Dewey Lake at drillhole C-2737 to changes on downhole resistivity logs (Figure 3). Above 202 ft depth, the C-2737 core is more porous, has carbonate cement, and has a lower resistivity. Below 202 ft., the core is less porous, is dominated by sulfate cement, and the resistivity sharply increases. Resistivity indicates some combination of factors of porosity and resistivity of the liquid in the pores, whether saturated or not. At drillhole H-11b4, resistivity increases sharply (Figure 4) just below the zone where natural groundwater was reported in drillhole P-9 (Jones, 1978), located on the same drilling pad as H-11b4. The resistivity change in drillhole H-11b4 occurs at a stratigraphically different position from the change in resistivity in C-2737. The laboratory investigations focus on identifying matrix and cement changes in

cores from different drillholes to establish more firmly the correlation with resistivity logs or other logs (e.g., acoustic velocity or density). The cement change and geophysical log responses are expected to be a significant key to understanding the current geohydrological architecture of the Dewey Lake and estimating the effects of this geohydrological architecture on the broader hydrological processes important to the WIPP Site.

### 1.3 Background Information and Status of Dewey Lake Geohydrology

Geological studies of the Dewey Lake<sup>1</sup> have been relatively limited. Miller (1955a,b, 1957, 1966) conducted a detailed petrographic study of the formation. In support of Project Gnome, Vine (1963) described the general characteristics of the unit in Nash Draw and Gard (1968) described the geology of the Dewey Lake as exposed in the Gnome shaft. Nicholson and Clebsch (1961) and Hendrickson and Jones (1952) reported only gross characteristics and distribution of the formation. The principal characteristics of the formation as described in such reports are reddish-brown color, fine grain sizes (mostly < fine sand), bedded to laminar, and marked by greenish-gray reduction spots. Quartz and feldspars are the main minerals; clay, calcite, and gypsum are the main rock cements. Some coarser sandstones were noted as having well-rounded, frosted quartz grains (e.g., Miller, 1966). Schiel (1988, 1994) developed a depositional model based on describing outcrops; she also inferred broader stratigraphic relationships from geophysical log information.

The Dewey Lake has not been a focus of geologic study for the WIPP. Various summaries based on the extant literature were included in reports (e.g., Powers et al., 1978; Mercer, 1983). The stratigraphic and basic lithology reported by Jones (1978) in support of investigations of potash resources at the WIPP, along with included geophysical logs, are the most concentrated source of geologic data for the Dewey Lake during early work at the WIPP. Basic data reports for various drillholes at the WIPP include geophysical logs and lithologic descriptions, but there is little analysis of the formation.

Holt and Powers (1990a,b) described the Dewey Lake in detail from exposures inside the large-diameter air intake shaft at WIPP. They inferred that the lower part of the Dewey Lake was similar in some respects to saline mud-flat facies within the underlying Rustler Formation. The rest of the Dewey Lake was interpreted as fluvial in origin, similar to the interpretation of Schiel (1988).

Hydrologic data about the Dewey Lake in the vicinity of the WIPP are scarce, consisting of a) one test for which a value of T was obtained, and b) several occurrences of water or moist zones noted during drilling. Some stock or ranch wells have been completed in the Dewey Lake. As noted earlier, the estimated value of T at the location of monitoring well WQSP 6A is  $3.9 \times 10^{-4} \text{ m}^2/\text{s}$  (Beauheim and Ruskauff, 1998, p. 193). This value is approximately five times larger than the largest value of T for the Culebra Dolomite Member of the Rustler Formation within the WIPP boundaries. Cooper and Glanzman (1971) summarized basic data from the area about water in formations above evaporites.

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<sup>1</sup> In reports before about 1963, the rocks now considered the Dewey Lake Formation in southeastern New Mexico were commonly called "Pierce Canyon redbeds" (e.g., Miller, 1955a). Outcrops of reddish sedimentary rocks in Pierce Canyon, however, belong to the Gatuña Formation, which is much later in age (Miocene-Pleistocene) than the Dewey Lake. The name "Pierce Canyon" has been abandoned for this reason, and the name Dewey Lake has been extended into this area (see Schiel, 1988, for further discussion).



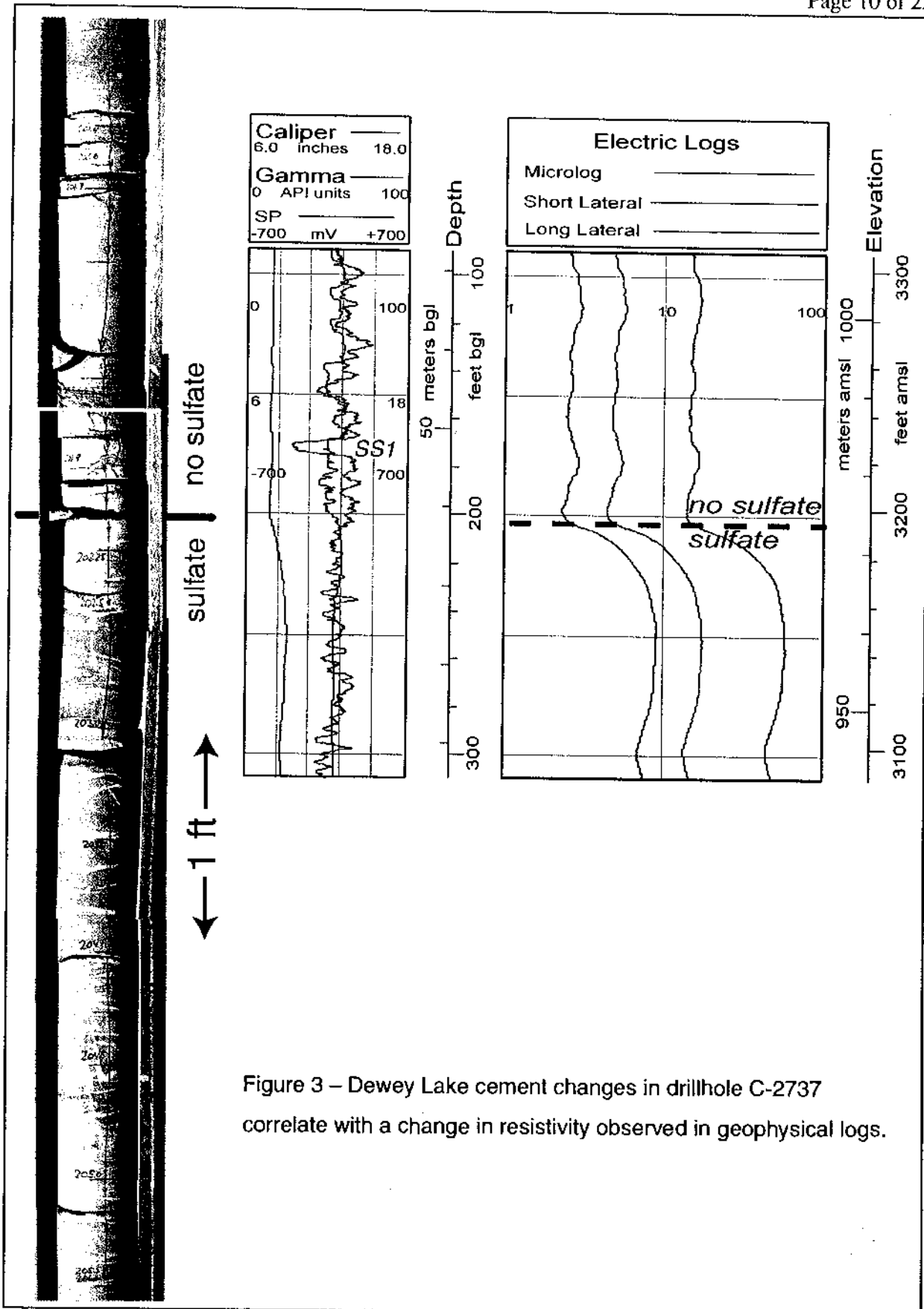


Figure 3 – Dewey Lake cement changes in drillhole C-2737 correlate with a change in resistivity observed in geophysical logs.

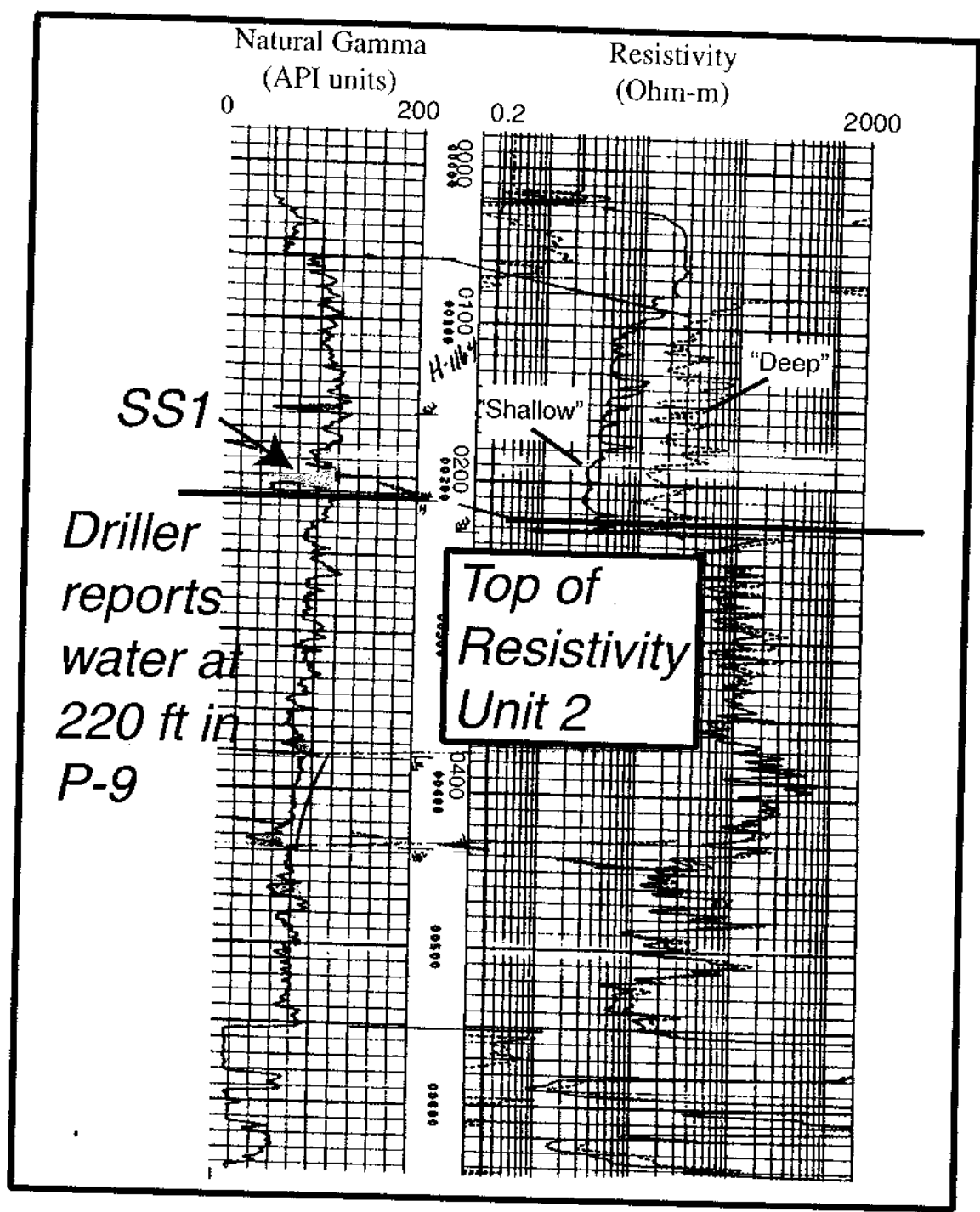


Figure 4 – Water encountered while drilling P-9 occurs just above the change in resistivity in nearby H-11b4. The natural gamma log (left side) shows a sandstone bed (SS1) that was deposited over a wide area at the WIPP.

Powers (1997) summarized the geologic data obtained during an investigation of shallow water under the facilities at WIPP. The saturated zone, created since construction investigations for the WIPP, is the basal Santa Rosa Formation overlying the Dewey Lake. Holt and Powers (1990a,h) recorded a change in natural cements from sulfate (below) to carbonate (above) in the upper Dewey Lake while mapping in the air intake shaft. Powers (1997) reviewed drilling records for the WIPP area and known encounters of natural Dewey Lake waters. Powers (1997) suggested that natural waters in the Dewey Lake accumulated on this surface at the change in cements. It was proposed that this surface is irregular and is lower stratigraphically in the Dewey Lake from the center of the site to the south and west. At the site center, however, the upper surface of the Dewey Lake has, at least temporarily, retarded downward infiltration of the modern water (Powers, 1997).

In work in progress, Powers has followed up this preliminary version of a geohydrological conceptual model for the Dewey Lake. Drillhole B-25, located near WIPP shafts, obtained cores and a good suite of geophysical logs. It is near the air intake shaft, and it has been possible to establish a clear correspondence between natural cement changes and formation resistivity (Figure 5), which is related to the porosity and pore fluids of the formation. The set of drillholes with comparable resistivity logs through the Dewey Lake is relatively small, and all known logs in the area come from the WIPP project. The logs illustrate that the stratigraphic position of the resistivity change (and by inference change in hydraulic properties) differs most across the southwestern part of the WIPP Site, and that specific encounters of natural waters in the Dewey Lake during drilling can be correlated with this change in resistivity properties. Drillhole C-2737 (Figure 3) shows the correspondence again between natural cements and formation resistivity (Powers, 2002).

Water encountered while drilling the upper Dewey Lake at C-2737 and C-2811, adjacent to C-2737, is at a depth of less than 20 m below the ground surface. Given the general drilling history of this area, this water is believed to be an extension of the shallow water under the WIPP facilities. The zone may have become saturated within the last few years. The current stratigraphic position of this water is well above the change in cements, but it is below very thin (< 2 m thick) Santa Rosa sandstones at this location. Multiple hardened zones were noted in the upper Dewey Lake at C-2737 (Powers, 2002) and in twelve piezometer holes drilled within and adjacent to the secure area of the WIPP (Powers, 1997), and these hardened zones may indicate thin beds that impede vertical infiltration. Abandoned stock wells in section 15, T22S, R31E in the northeastern part of the WIPP Site noted by Cooper and Glanzman (1971) produced from the lower Santa Rosa.

For the moment, the preliminary conceptual model of Dewey Lake geohydrology can be summarized as follows. The Dewey Lake is apparently unsaturated over most of the WIPP Site. South and west of the center of the WIPP Site, several drillholes have encountered natural saturated zones within the Dewey Lake, and there are a few Dewey Lake wells off the WIPP Site used mainly for stock watering. Near the site center, cores and shaft mapping reveal a boundary between natural carbonate and sulfate cements in the Dewey Lake about 50-55 m below the ground surface. Resistivity logs correlate with this cement change and show that formation porosity drops significantly across this boundary from carbonate cements (above) to sulfate cements (below). Resistivity logs and drilling records indicate this boundary trends downward stratigraphically to the south and west of the site center, and it occurs near the base of the Dewey Lake in the southwestern corner of the WIPP Site. Natural waters in the Dewey Lake southwest of the WIPP Site center are found at this boundary. A

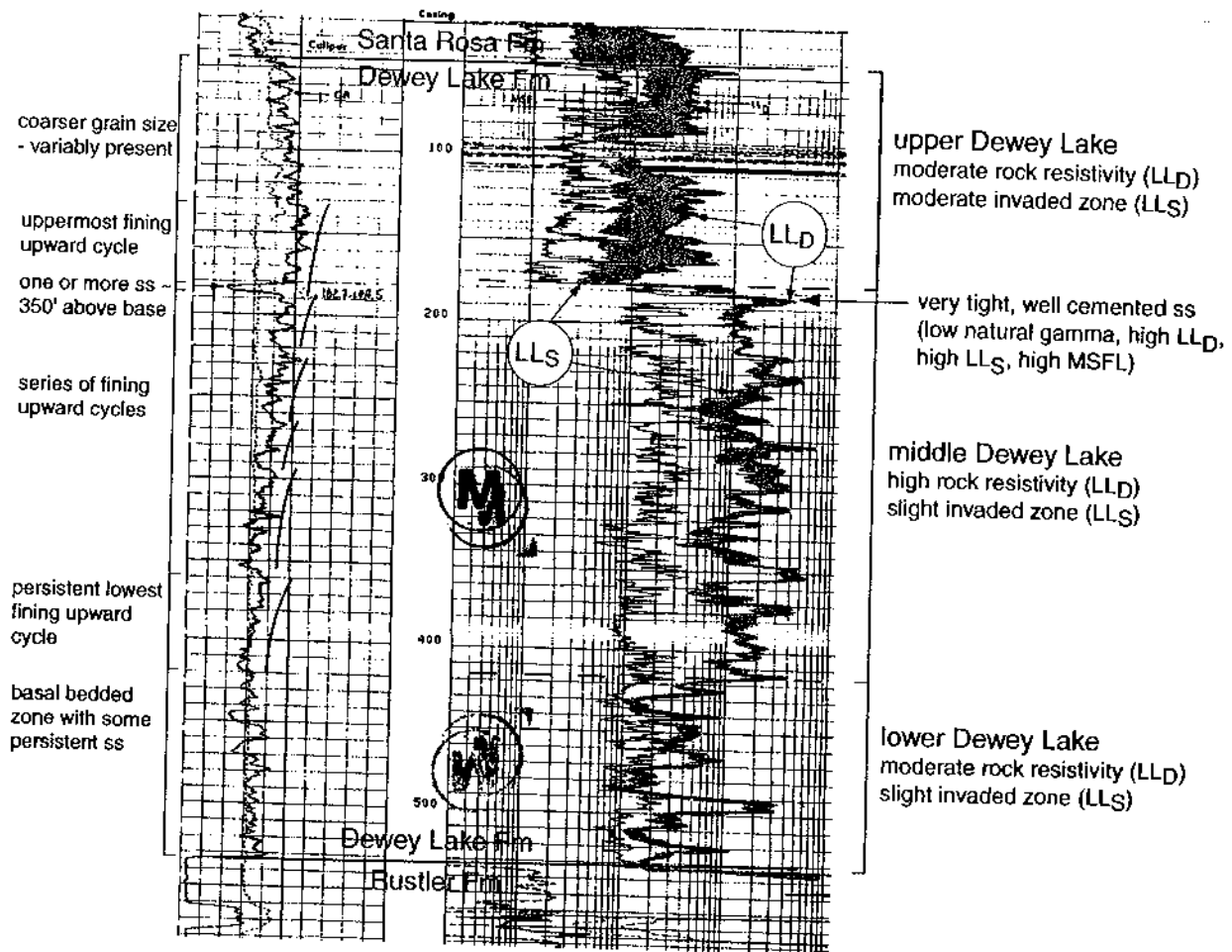


Figure 5 – Natural gamma (left) and resistivity (right) log for drillhole B-25, which is located near the center of the WIPP site. Natural gamma reveals three basic depositional subdivisions: a basal bedded zone (bbz), a general fining upward system comprising several smaller (~10 m thick) fining upward cycles, and an upper sequence that coarsens upward. The resistivity logs show a basal mixed resistivity unit corresponding to the bbz. The middle resistivity zone shows higher resistivity. The transition upward to lower resistivity corresponds to the change from sulfate cements (below) to carbonate cements (above) and higher porosity.

saturated zone in the uppermost Dewey Lake and basal Santa Rosa, with water of highly variable salinity, has developed at the center of the site since early investigations of the WIPP. Drillholes for engineering studies show this zone was not saturated before construction of the WIPP surface facilities. Thin hard zones in the upper Dewey Lake encountered in this area during drilling may be impeding deeper infiltration at the same time that short vertical to subvertical open fractures enhance infiltration.

There are several areas likely to yield further insight into a geohydrologic conceptual model for the Dewey Lake. The relationship between natural cements in cores and resistivity logs can be established more securely through studies of additional cores (the immediate objective of this Test Plan). It is possible that the cement boundary can be correlated with other log types (e.g., density or acoustic velocity) and that the boundary can be mapped over a larger area, and more thoroughly, than is possible with resistivity logs. Outcrops of the Dewey Lake along the margins of Nash Draw to the west and northwest of the WIPP Site will be examined, and several samples will be studied to relate previous outcrop studies (e.g., Miller, 1955a; Schiel, 1988) to laboratory work planned under this TP. Knowledge of hydraulic properties of the Dewey Lake may be improved with additional sample tests, tests in holes monitoring modern water, and tests of cores and any saturated zones in new drillholes. The degree of saturation of the Dewey Lake is not established, and core from a new hole should be appropriately tested. Additional geochemical and isotopic studies of Dewey Lake waters and rocks should also yield insights into the development of the current hydrologic system. Existing surface resistivity data may provide indications of the area with pre-existing saturated zones, and they may also provide help in designing new geophysical surveys to detect saturated zones in the Dewey Lake. Hydrologic modeling may be used to sharpen the geohydrologic conceptual model.

#### **1.4 Intended Use of Data**

Data obtained from laboratory studies of Dewey Lake sample mineralogy will be used to extend correlation of geophysical logs with rock properties over a larger area at the WIPP. Up to now, sample studies have been limited to drillhole B-25 as representative of Dewey Lake geology near the center of the WIPP Site. Basic descriptions of cores and cuttings from other drillholes, as well as existing geophysical logs, will be used to help guide sampling. These data will help confirm or be used to revise the geohydrologic conceptual model as it now exists.

Although the laboratory data obtained under this TP are not expected to be used directly in PA, the geohydrologic conceptual model for the Dewey Lake may be used for revising FEPs and it may affect assumptions about recharge used in PA.

## 2.0 EXPERIMENTAL PROCESS DESCRIPTION

The principal activity under this TP is to obtain laboratory data about the mineralogy and diagenesis of Dewey Lake sedimentary rocks that can be used to interpret the architecture of apparent hydraulic conductivity of the formation. The experimental process develops the details of the laboratory work. A later section shows how the information fits with other possible activities regarding Dewey Lake hydraulic properties, although those activities may be conducted under other test plans or by different organizations.

### 2.1 Planning, Overall Strategy and Process

For the most part, the laboratory work will be compiled into a record that shows the composite results of the mineral, texture, and porosity observations for each sample, arranged to reflect depth and stratigraphic occurrence. The history of diagenesis, to understand the development of porosity, will be interpreted using basic relationships among mineral cements or other secondary accumulations of minerals. The basic chemistry of these minerals (e.g., silicate, sulfate, carbonate) will be used to help understand the history of the fluid phases in the rock diagenesis.

After the basic laboratory data are interpreted, the information can be compared to other features, such as the resistivity or density logs for the drillholes. If the basic relationships already observed in a few drillholes hold, the geophysical logs can be used to extend inferences about the basic lithology and geohydrology of the unit.

#### 2.1.1 Important Variables to be Measured and Controlled

The important variables for this study are the presence, relationships, and locations (i.e., depth in a particular drillhole) of natural mineral cements and matrix minerals. From previous study, these minerals are mainly carbonate and sulfate cements and clay as matrix material. Using X-ray diffraction and petrography, the presence and relative abundance of mineral phases can be established for different samples. Petrography and SEM (scanning electron microscope) can be used to establish diagenetic relationships among minerals. These are mainly qualitative observations with semi-quantitative or relative proportions being established.

#### 2.1.2 Coordination with Organizations Providing Inputs or Using Results

Additional core samples may be requested from WTS to extend the data or to refine ideas of the location and extent of mineral cements in the Dewey Lake. Requests will be processed through normal WTS procedures.

Summary results will be distributed by a SAND document or similarly reviewed report to Sandia organizations responsible for PA, WTS organizations with responsibilities for geological and hydrological studies, and to cognizant managers at CBFO.

### 2.1.3 Procedures to be Used or Developed

No special procedures need to be developed and approved for this study. Sampling, sample handling and preparation, and sample study for the Dewey Lake are normal geological practices.

Three main analytical tools will be used to provide data on the Dewey Lake samples: petrographic microscope, X-ray diffraction (XRD), and scanning electron microscope (SEM). The binocular microscope may be used for grain and fabric identification on some samples. The petrographic microscope will be used to identify mineralogy and rock fabric, estimate porosity, and understand diagenetic sequences using standard or polished thin sections. In addition to recorded observations about the individual sample, digital or film records (photomicrography) will be made of selected samples or portions of thin sections. Each such film or digital record will be catalogued on a photograph log. XRD will be used on powdered samples of bulk rock to identify minerals, and it may also be used on physical or chemical concentrations of minerals to identify them. Minerals will commonly be identified by comparing sample patterns with standard patterns; more specialized methods may be applied, such as the method of Bodine and Fernald (1973) for clay mineral concentration and identification. SEM methods provide high-magnification images of mineral and pore textures. These may be noted by recording general observations, and selected images may be saved digitally or as a print record for further use. In addition, the concentrations of selected elements (e.g., potassium or calcium) can be mapped over an image area to help identify mineral phases and their distributions. Selected images may be retained as printed or digital records for basic data and use in illustrating features. The SEM also has the capability of providing a spot analysis (an area a few microns in diameter) for a number of elements. These spot analyses can help identify the locations of minerals reported through XRD or below the level of detection for XRD.

Sample blocks will be sized for standard thin sections or will be marked to indicate the area for the thin section block. Samples will be impregnated with epoxy containing a blue fluorescing dye. The dye color helps to identify porosity during normal petrographic work; an ultraviolet light causes the dye to fluoresce, and this can be helpful in using computer software to estimate the porosity. A number of thin sections will be polished for SEM work. The sample must be coated before SEM analysis, and established laboratory procedures will govern the process. XRD analysis will require a small subsample be ground in a non-reactive mortar. More detailed XRD analysis of clays may require some concentration and analysis after various treatments such as heating or expanding the clay lattice with a chemical such as ethylene glycol. Established procedures, such as those in Millot (1970) or Bodine and Fernald (1973), will be used to prepare samples. Any other sample preparation will be documented and the method referenced.

### 2.1.4 Identification of Prerequisites or Special Controls

The drilling records and previous work on existing WIPP drillholes will be used to compile a listing of useful core intervals of the Dewey Lake and compare them with available natural gamma and resistivity logs. From this list, cores from several drillholes will be designated for sampling to provide evidence of cements and matrix representing differing resistivity zones across the WIPP Site and beyond, if possible. In addition, some samples will be selected to represent some of the sedimentary zones within the Dewey Lake having stratigraphic continuity across the area. An example would be the sandstone unit found in drillhole B-25 at a depth of about 57 m (~ 185 ft) (Figure 5). A preliminary estimate is that between 100 and 200 small samples will be taken for possible analysis. More samples will be acquired

than are likely to be analyzed; given the current core inventory, it is more practical to select possible alternative or ancillary samples at the beginning than it is to make additional sampling expeditions. Where practical, samples will be quarter or half cores to preserve samples of the interval in the core inventory.

After core samples have been described and re-examined as appropriate in the laboratory (possibly using a binocular microscope), a table will be developed showing the analyses to be conducted on each sample. At this point, a number of samples may not be designated for initial sampling but they will be reserve samples that will be available to extend or narrow the stratigraphic coverage or to provide supplemental samples if there are unusual results requiring verification. If additional samples are analyzed, the table will be revised, and the table number or footnotes will indicate the revisions.

#### 2.1.5 Known Sources of Error and Uncertainty

Mineral abundances estimated by XRD in polymineralic samples is semi-quantitative or relative; some minerals have overlapping diffraction peaks, and diffraction peak intensity depends on abundance and mineral structure.

Core sample depth may vary from depths recorded on geophysical logs. Larger errors or uncertainty have been reported in basic data reports for drillboles.

#### 2.1.6 Compatibility of Data Processing with Conceptual or Mathematical Models

The data to be obtained on types and distribution of mineral cements and matrix minerals are compatible with developing a basic geohydrological conceptual model of the Dewey Lake incorporating a variety of data, including geophysical logs.

#### 2.1.7 Documents to be Maintained as QA Records

A scientific notebook, electronic files and printouts supporting the notebook or summary report, and a report including relevant tables, charts, or figures of data will be prepared, submitted, reviewed, and archived.

### 2.2 Sample Control

#### 2.2.1 Sample Labeling or Identification

Core or rock samples will be collected and controlled in accordance with SNL NP 13-1 *Sample Control*. The chain of custody for the samples when they are moved to the point of analysis (mainly SNL-Carlsbad) will be established in accordance with SNL SP 13-1 *Chain of Custody*. SNL SP 13-2 *Core Sample Logging and Management* applies to a limited degree to the existing core inventory managed by WTS; some basic sample controls are repeated here. Each will be uniquely marked, catalogued, and described as they are identified. Where practical, an arrow will be marked on the core pointing in the uphole direction. Each sample will be put in its own plastic bag for ease of identification and handling. Each bag will be marked to represent uniquely the sample. Identifying information on or



in the bag will include: project name (SNL Dewey Lake Geohydrology; sample number (abbreviated well name-depth in feet; e.g., B25-186.4); well designation; sample location (core depth in ft); collector's name; and date of collection. Outcrop samples taken for comparison with core samples will be similarly marked, with location information as appropriate. Sample identification and description should be adequate for another investigator to relocate the sampling point.

#### 2.2.2 Sample Handling or Nonconforming Requirements

The samples require no special disposal or handling.

#### 2.2.3 Sample Storage and Environmental Controls

The main sources of samples for this study are cores currently held in storage facilities by WTS. There may be some supplemental sampling of outcrops in the field. These samples will have a varying history of drilling and storage (or exposure) periods and conditions. They are acceptable for this project as long as the source (e.g., drillhole and depth) can be determined. The natural cements within these rocks develop and change over geological time in response to pressure, temperature, and the volume and solute concentrations of water as it moves through the sediment or rock. During storage at WIPP, cores experience varying degrees of diurnal and seasonal changes in temperature. Air flow and changes in relative humidity are moderated by the storage facility, boxes, and sleeving. Pressure changes are insignificant while in storage. The silicate, carbonate, and sulfate minerals that are part of matrix materials and natural cements of most interest in determining natural cements in the Dewey Lake are considered stable to metastable for most local surface conditions.

For this study, drilling, recovery, and storage conditions are insignificant compared to geological processes.

#### 2.2.4 Sample Disposal

Large remains of samples can be returned to the source.

### 2.3 Data Quality Control

#### 2.3.1 Measuring and Test Equipment

Standard measuring and test equipment for purposes of calibrating pressure measurements or similar quantitative variable are not used for this study. Equipment such as the XRD and SEM are maintained to provide data for a variety of studies. As described in section 2.3.4, common minerals such as quartz provide internal controls on the consistency and accuracy of the equipment for this study.

#### 2.3.2 Data Acquisition System

Data acquisition systems are built-in to equipment such as the X-ray diffraction and SEM units and are not maintained separately.

### 2.3.3 Methods for Justification, Evaluation, Approval, and Documentation of Deviations from Test Standards or Use of Specially Prepared Test Procedures

There are no typical test standards (e.g., sampling rate to obtain a level of statistical confidence) applied to this study except those built-in to the operation of XRD and SEM. No special test procedures are being developed; references to test procedures (e.g. Bodine and Fernald, 1973) will be included in notes if the tests are applied.

### 2.3.4 Controls or Reference Samples Used

Dewey Lake samples include well-known minerals (e.g., quartz) with standard responses to analyses such as X-ray diffraction. The mineral quartz is not an object of this study, and it serves as an internal control on such procedures. If significant uncertainty develops over such a procedure, a standard material can be obtained as an external reference.

### 2.3.5 Control and Characterization of Test Media

There are no test media identified for this study.

## 2.4 Data Identification and Use

### 2.4.1 Methods of Recording Data

Electronic records, photographs, or written records must be clearly identified with the investigation, investigator's name, date, description of record content, scales, or other necessary information to understand the record and associate it correctly with the study and individual sample. A scientific notebook is appropriate for recording information and data (NP 20-2, *Scientific Notebooks*) but is not required.

Observations or data collected for a sample must refer to the sample identification and must also record the conditions under which the observations were made or data collected. The criterion for this is that an auditor or independent investigator can associate the observation or datum with the correct interval within a core or outcrop and can associate proper scales and other conditions for the observation or datum.

### 2.4.2 Data Transfer and Reduction Controls

Selections or copies of data obtained during this investigation will be transferred, as needed, by memo or letter with attachments in appropriate formats. A copy of the memo will be sent for archiving; data will not be archived unless they differ from data prepared for a record package.

### 2.4.3 Control of Erroneous or Inadequate Data

If erroneous data are generated during this study, records will be examined to determine which are erroneous or inadequate. Scientific notebook entries regarding the erroneous or inadequate data will be

annotated, initialed, and dated to indicate clearly which data are erroneous or inadequate. If these data have not entered an analysis phase, they may be discarded and the annotation should so indicate. If the data have been included in an analysis, those who are know to have received, used, and archived the erroneous or inadequate data will be informed in writing of the erroneous or inadequate data, and any records package including the data will include such information.

#### 2.4.4 Data Conversion Controls

Data obtained during standard laboratory investigations (e.g., X-ray diffraction) are converted into useful information, such as relative peak height and diffracting angle, during operation of the equipment and attendant computers. Malfunctions of such conversion are determined by inspection; an example would be the lack of a diagnostic peak for a mineral such as quartz that is known to be present in the samples.

Other data, such as depth of a core sample from a particular drillhole, may be converted from English (e.g., feet) to metric (e.g., meters) for presentation or publication. These conversions are carried out using standard hand calculators or commercial spreadsheets such as Excel. The conversion standard commonly used is  $1 \text{ ft} = 0.3048 \text{ m}$ , and spreadsheet equations can be checked.

### **3.0 BROAD FRAMEWORK FOR ESTABLISHING AND EXTENDING A GEOHYDROLOGIC CONCEPTUAL MODEL OF DEWEY LAKE**

A broad framework for Dewey Lake studies is helpful for understanding how different project efforts can contribute to establishing and extending a geohydrology conceptual model for the Dewey Lake. As stated earlier, this framework is not intended to replace or override other SNL efforts or other organization's efforts to understand or investigate aspects of the Dewey Lake geology or hydrology. It provides a general framework for developing the conceptual model, and it places the study of sample mineralogy and natural cementation in that framework (Section 3.2).

#### **3.1 Interpret Architecture of Apparent Hydraulic Properties**

There is only one reported test yielding a value for transmissivity of the Dewey Lake (Beauheim and Ruskau, 1998), and therefore there is no direct basis for establishing the architecture of hydraulic properties for the Dewey Lake. There is, however, information on formation resistivities from holes drilled for the WIPP, and these resistivities can be used to establish porosity zonation, a general three-dimensional framework or architecture for that zonation, and an estimate of the relative hydraulic properties of the zones.

The initial work for this part has been done, and the resistivity logs show vertical zonation (Figure 5) and evidence of areal variation. It is likely that this work will be completed outside of this test plan, under the direction of WTS. This work should be incorporated in a Dewey Lake geohydrological conceptual model as developed by WTS or SNL.

As new wells are drilled in the vicinity of the WIPP for groundwater monitoring, some will have geophysical logs that can be used to extend the resistivity zonation, and by proxy the hydraulic architecture of the Dewey Lake and related units. Saturated zones in the Dewey Lake encountered in these wells may be tested, providing more direct evidence of the hydraulic properties and some degree of correlation of measured formation resistivity to hydraulic properties.

Anthropogenic or recent groundwater at shallow depths in the vicinity of WIPP facilities will be further investigated by WTS. Although most of the groundwater has been found in the basal Santa Rosa, recent drilling at C-2737 and C-2811 shows the groundwater in the upper Dewey Lake south of the site facilities (Powers, 2002). Past testing of the saturated zone under the facility area provides some hydraulic properties of the Santa Rosa, which can be compared to the resistivity logs of this formation. Additional testing of this saturated zone, especially in the upper Dewey Lake, will contribute to our knowledge of Dewey Lake (and Santa Rosa) hydraulic architecture.

#### **3.2 Relate Hydraulic Architecture to Geological Factors**

This part of developing a geohydrologic conceptual model for the Dewey Lake is the focus of this TP. Likely factors affecting hydraulic properties and their distribution in the Dewey Lake include depositional bedding, matrix minerals and distribution, and natural cements in the porosity. Work to date (Powers, 1997, 2002) suggests that a major change in formation resistivity is related to the change in natural cement from sulfate (below) to carbonate (above). The resistivity zonation of much of the

formation is also closely related to depositional units as well. The program of study covered in this TP will help to define the spatial relationships of cements, matrix, and other lithological factors across the WIPP Site and immediate surroundings.

The information about the lithological factors will be directly related through the log information (Section 3.1) to the resistivity structure, and, by inference, to the hydraulic architecture. Maps and cross-sections will be created to illustrate the spatial relationships. [These graphic illustrations may be produced as part of the work identified under other sections.]

### **3.3 Relate Known Occurrences of Water in the Dewey Lake to Apparent Hydraulic Conductivity and Geological Factors**

Beauheim and Ruskauff (1998) and Powers (1997) summarized known occurrences of water in the Dewey Lake in the vicinity of the WIPP Site. The geophysical logs of H-11b4, for example, indicate that a significant change in resistivity (Figure 4) occurs at the depth where water was encountered in nearby drillhole P-9 (Jones, 1978).

Maps of the elevations of resistivity changes or lithologic factors may be used to interpolate the elevation of groundwater encounters in drillholes without resistivity logs. As noted in Section 3.1, future drilling and testing programs can provide data for confirming or refining these relationships.

WTS is considering a program to explore the distribution of anthropogenic or recent groundwater near the center of the WIPP Site, and this program may contribute significantly to the broader understanding of Dewey Lake (and Santa Rosa) geohydrology. Surface-based geophysical techniques may be found useful in delineating shallow to deeper zones of saturation prior to drilling and testing. In addition, some samples may be tested to determine the degree of saturation of shallow units; this could contribute to our understanding of how saturated zones develop.

### **3.4 Develop and Test a Conceptual Model of Dewey Lake Geohydrology**

The laboratory work covered by this TP can be coupled with resistivity zones and known groundwater occurrences to develop a conceptual model of Dewey Lake geohydrology. Preliminary work suggests that natural groundwater occurs above the contact between sulfate cements (below) and carbonate cements (above). Saturated zones created in the basal Santa Rosa and uppermost Dewey Lake near the center of the WIPP Site since WIPP construction began, however, are still above this cement change, and a different explanation is necessary. It isn't known yet whether the upper Dewey Lake will retard infiltration to the cement change for a short period or for a time approaching 10,000 years.

Two general kinds of tests of a conceptual model can be applied. Future wells for monitoring groundwater will be drilled into or through the Dewey Lake, and the record of cores, geophysical logs, or saturated zones will provide a direct test. The second kind of test may be to consider the effects of hydraulic zonation predicted by the conceptual model on models of infiltration and recharge of units at the WIPP. These effects can be compared to previous models considering the Dewey Lake to be a homogenous hydraulic unit.

## 4.0 QUALITY ASSURANCE

The data developed through laboratory studies undertaken for this TP are not to be used directly in setting parameters for performance assessment or for re-evaluating FEPs. The data will be useful in developing and refining a geohydrologic conceptual model of the Dewey Lake Formation, and that geohydrologic conceptual model will be useful in evaluating the existing understanding of the hydrologic system at WIPP. The principal elements of QA that will apply to this activity therefore reflect the need for traceability of samples and results to sample, and accurate record-keeping.

## 5.0 TRAINING

Investigations under this test plan may affect the SNL WIPP Performance Assessment calculations. Therefore, all activities performed under this test plan will be performed under quality assurance (QA) procedures which are consistent with the requirements specified in the Carlsbad Field Office (CBFO) Quality Assurance Program Document (QAPD). All personnel associated with this test plan will be qualified in accordance with all applicable QA requirements prior to performing any quality-affecting work.

The qualifications of Sandia participants will be documented on Nuclear Waste Management Program (NP) Form NP 2-1-1, *Qualification and Training Form* as per NP 2-1, *Qualification and Training*. The existence of these forms will be verified in the WIPP Records Center. Sandia participants receive QA program and NP training via Annual Refresher QA Training, either by attendance at training seminars or by viewing a training video. Training for Sandia participants will also be verified.

Non-Sandia participants under contract to Sandia will follow the same training and qualification processes as Sandia participants.

## 6.0 HEALTH AND SAFETY

The work described in this Test Plan is principally undertaken within the laboratory area of SNL-Carlsbad, and ES&H training associated with such laboratory work will be provided. General Employee Training is required for unescorted on-site visits at WIPP, and general fieldwork requires normal precautions.

Activities, such as core examination and selection, conducted in areas controlled by WTS will follow applicable safety practices and policies.

## 7.0 PERMITTING/LICENSING

Not applicable.

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**2 COMPLIANCE MONITORING**

**2.6 Testing of Wells at the W/PP Site**



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Sandia National Laboratories  
Waste Isolation Pilot Plant (WIPP)

## **Testing of Wells at the WIPP Site, Test Plan TP 03-01, Rev. 0**

BOE 1.3.5.3.1.1

Effective Date: \_\_\_\_\_

David A. Chace  
Repository Performance and Certification Depart. 6822  
Sandia National Laboratories  
Carlsbad, NM 88220

## APPROVALS

Author:

\_\_\_\_\_  
D. A. Chace  
Well Testing Lead  
Repository Performance and  
Certification Dept. 6822  
Sandia National Laboratories  
Carlsbad, NM 88220

\_\_\_\_\_  
Date

Technical Reviewer:

\_\_\_\_\_  
R. L. Beauheim, 6822  
Performance Assessment and  
Decision Analysis Dept. 6821  
Sandia National Laboratories  
Carlsbad, NM 88220

\_\_\_\_\_  
Date

SNL QA:

\_\_\_\_\_  
M. J. Mitchell  
Quality Assurance  
Carlsbad Programs Group 6820  
Sandia National Laboratories  
Carlsbad, NM 88220

\_\_\_\_\_  
Date

SNL Management:

\_\_\_\_\_  
F. D. Hansen, 6822  
Repository Performance and Certification Dept. 6822  
Sandia National Laboratories  
Carlsbad, NM 88220

\_\_\_\_\_  
Date

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## 1 ABBREVIATIONS, ACRONYMS, AND INITIALISMS

A	ampere
APV	access port valve
CBFO	(U.S. DOE) Carlsbad Field Office
CMR	Central Monitoring Room
DAS	data-acquisition system
DC	direct current
DOE	(U.S.) Department of Energy
DST	drill-stem test
EPA	(U.S.) Environmental Protection Agency
ES&H	environmental safety and health
FY	fiscal year
gal	gallons
GET	General Employee Training
gpm	gallons per minute
GWMP	Groundwater Monitoring Program
HA	hazard analysis
I.D.	inside diameter
JHA	job hazard analysis
mA	milliamp
NMOSE	New Mexico Office of the State Engineer
n	flow dimension
NP	(SNL NWMP) Nuclear Waste Management (QA) Procedure
NWMP	Nuclear Waste Management Program
PHS	primary hazard screening
PI	Principal Investigator
PIP	production injection packer
psia	pounds per square inch absolute
psig	pounds per square inch gauge
QA	quality assurance
QAPD	Quality Assurance Program Document
S	storativity
SNL	Sandia National Laboratories
SP	(SNL NWMP) Activity/Project-Specific Procedure
T	transmissivity
TOP	(SNL NWMP) Technical Operating Procedure
TP	(SNL) test plan
WRES	Washington Regulatory and Environmental Services
WIPP	(U.S. DOE) Waste Isolation Pilot Plant
WTL	(SNL) Well Testing Lead

## 2 REVISION HISTORY

This is the original edition of this test plan (TP); no prior versions exist. The purpose and content of any future changes and/or revisions will be documented and appear in this section of revised editions. Changes to this TP, other than those defined as editorial changes per Nuclear Waste Management Program (NWMP) quality assurance (QA) procedure NP 20-1 (Subsection 4.6.4), shall be reviewed and approved by the same organization that performed the original review and approval. All TP revisions will have at least the same distribution as the original document.

### 3 PURPOSE AND SCOPE

The Waste Isolation Pilot Plant (WIPP) is a U.S. Department of Energy (DOE) facility designed for the safe disposal of transuranic wastes resulting from U.S. defense programs. In order to demonstrate compliance with U.S. EPA (1993) and U.S. EPA (1996), models of groundwater flow around the WIPP are needed. These models must:

- demonstrate that an understanding of the hydrologic system within which WIPP exists,
- identify the flowpaths that radionuclides released from the WIPP repository through inadvertent human intrusion would most likely take, and
- simulate groundwater flow and radionuclide transport along the important flowpaths in the event that human intrusion of the repository occurs.

Development of these models requires data from wells completed to all units within the hydrologic system. Some of the data for modeling come from tests (including sampling) performed in these wells. These data include:

- hydraulic parameters, e.g., flow dimension ( $n$ ), storativity ( $S$ ), and transmissivity ( $T$ ), inferred from well tests used to define parameter distributions within the models;
- transient head responses from observation wells during long-term pumping tests that can be used during model calibration to infer hydraulic properties in areas where no wells may exist;
- direct measurements of the rates and directions of groundwater flow through wells that can be used in model verification;
- fluid specific gravities (or densities) used in calculation of hydraulic head gradients; and
- water-quality analyses that may be useful in inferring flow directions and fluid sources.

This TP describes the methods that will be used to obtain the data needed for hydrologic modeling at the WIPP.

#### 4 EXPERIMENTAL PROCESS RATIONALE AND DESCRIPTION

The wells to be tested include both existing wells and new wells to be drilled in FY 2003 and later years. New wells are expected to be completed to the Culebra Member and the Magenta Member (both of these are members of the Rustler Formation), and to the Dewey Lake Fm. and the Santa Rosa Fm. (Figure 4-1). The existing wells to be tested are C-2737, WIPP-25, and WIPP-26 (Figure 4-2). These three wells are all completed to both the Culebra and Magenta (the Magenta is unsaturated at WIPP-26). Both the Culebra and Magenta need to be tested in C-2737, but only the Culebra needs to be tested in WIPP-25 and WIPP-26. All new wells will be completed in single horizons.

Well C-2737 was drilled and completed in 2001 as a replacement for H-1 and has never been tested. Although testing of the Culebra was performed in WIPP-25 and WIPP-26 in 1980 (Lambert and Robinson, 1984), no documentation of that testing is available. Hence, the Culebra needs to be retested in those wells to provide data that can be used in modeling. Current configurations of these wells are shown in Figures 4-3 through 4-5.

Twelve new Culebra wells (Figure 4-2) have been proposed to provide data needed for modeling and to resolve questions about observed water-level fluctuations. At least four of these wells are planned to be drilled in FY 2003 to investigate leakage from a potash tailings pile 7 miles to the north of the WIPP Site and to determine if dissolution of the upper Salado Fm. has occurred and affected the Culebra in specific areas. Preliminary designations of these wells are Sandia National Laboratories-1 (SNL-1, near the tailings pile), SNL-2, SNL-3, and SNL-9. These designations will be replaced with C-#### designations reflecting the permit numbers assigned by the New Mexico Office of the State Engineer (NMOSE) once those permits have been obtained. Although not discussed in this TP, Magenta and/or Dewey-Lake wells may also be installed at some of these locations. Additional wells may also be drilled in future years to supplement the existing monitoring well network, or to replace existing monitoring wells that have deteriorated so badly that they must be plugged and abandoned. Testing will be required in all new wells.

System	Series	Group	Formation	Member	Approximate Thickness* ( m ft )		
Quaternary	Recent		Surficial Deposits		3	10	
	Pleistocene		Mescalero Caliche		10	30	
			Gatuña				
Triassic		Dockum	Santa Rosa		3	10	
Permian	Ochoan		Dewey Lake Redbeds		150	500	
			Rustler	Forty-niner		18	60
				Magenta		7	24
				Tamarisk		26	85
				Culebra Dolomite		7	24
				Los Medanos		37	120
	Salado		600	2000			
	Castile		400	1300			
	Guadalupian	Delaware Mountain	Bell Canyon		310	1000	
			Cherry Canyon		335	1100	
			Brushy Canyon		550	1800	

\* At center of WPP site.

Figure 4-1. Stratigraphic units at the WIPP Site

TP-03-01-004

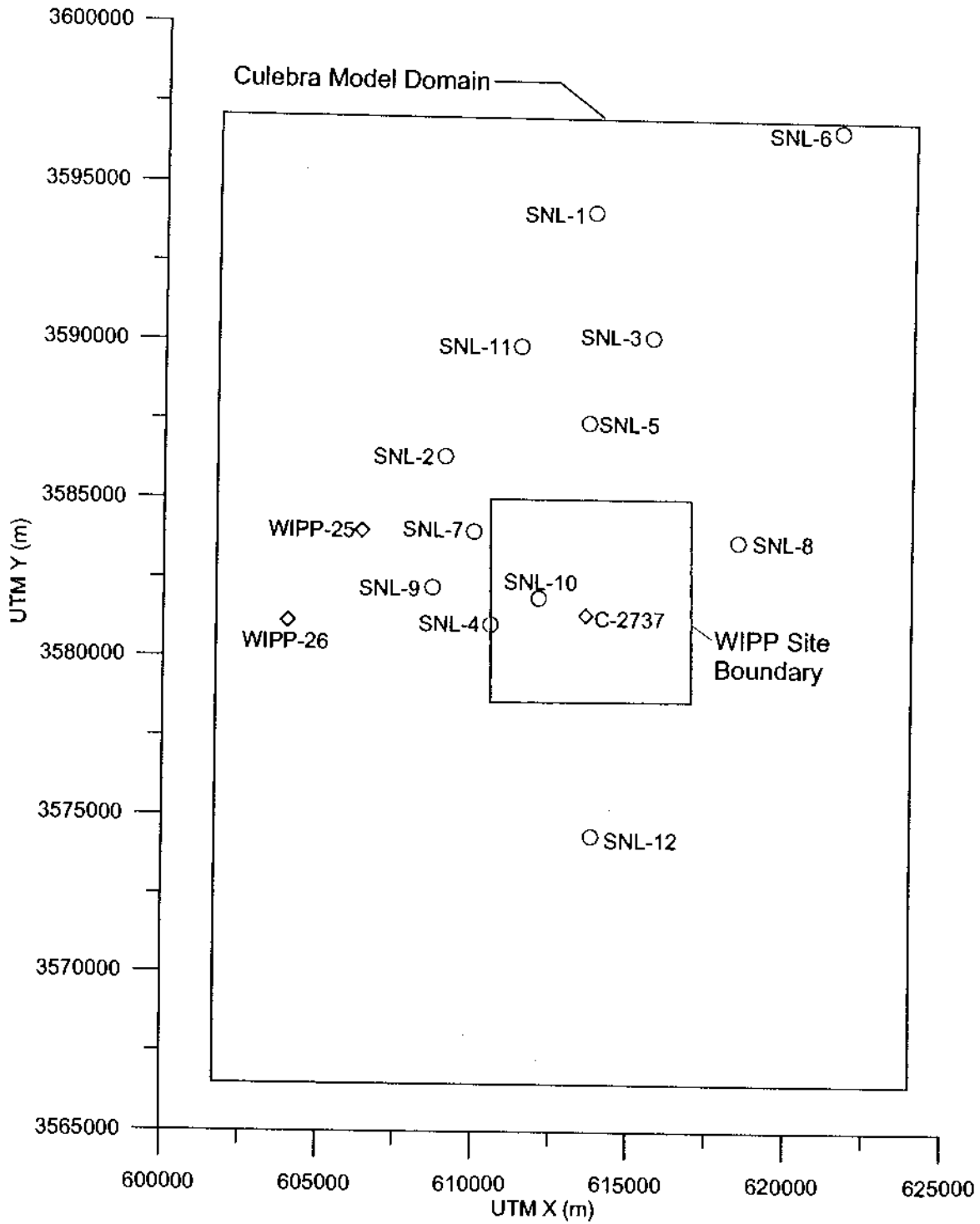
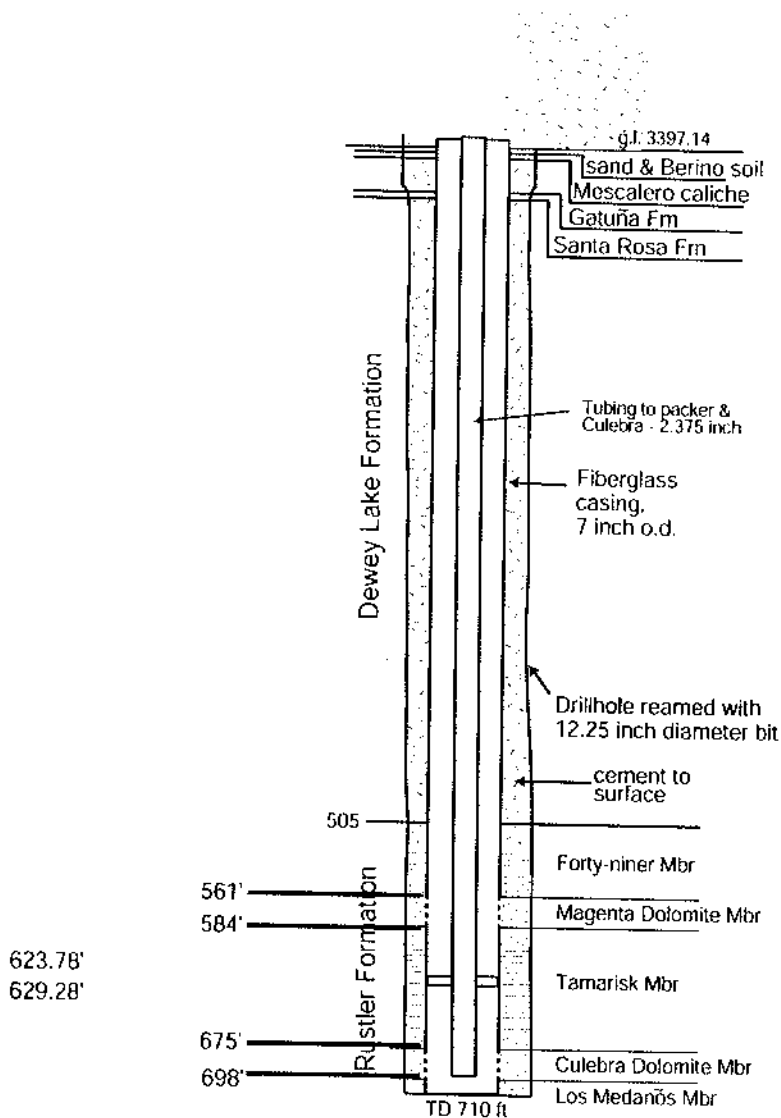


Figure 4-2. Locations of wells to be tested

# C-2737 As-built Diagram

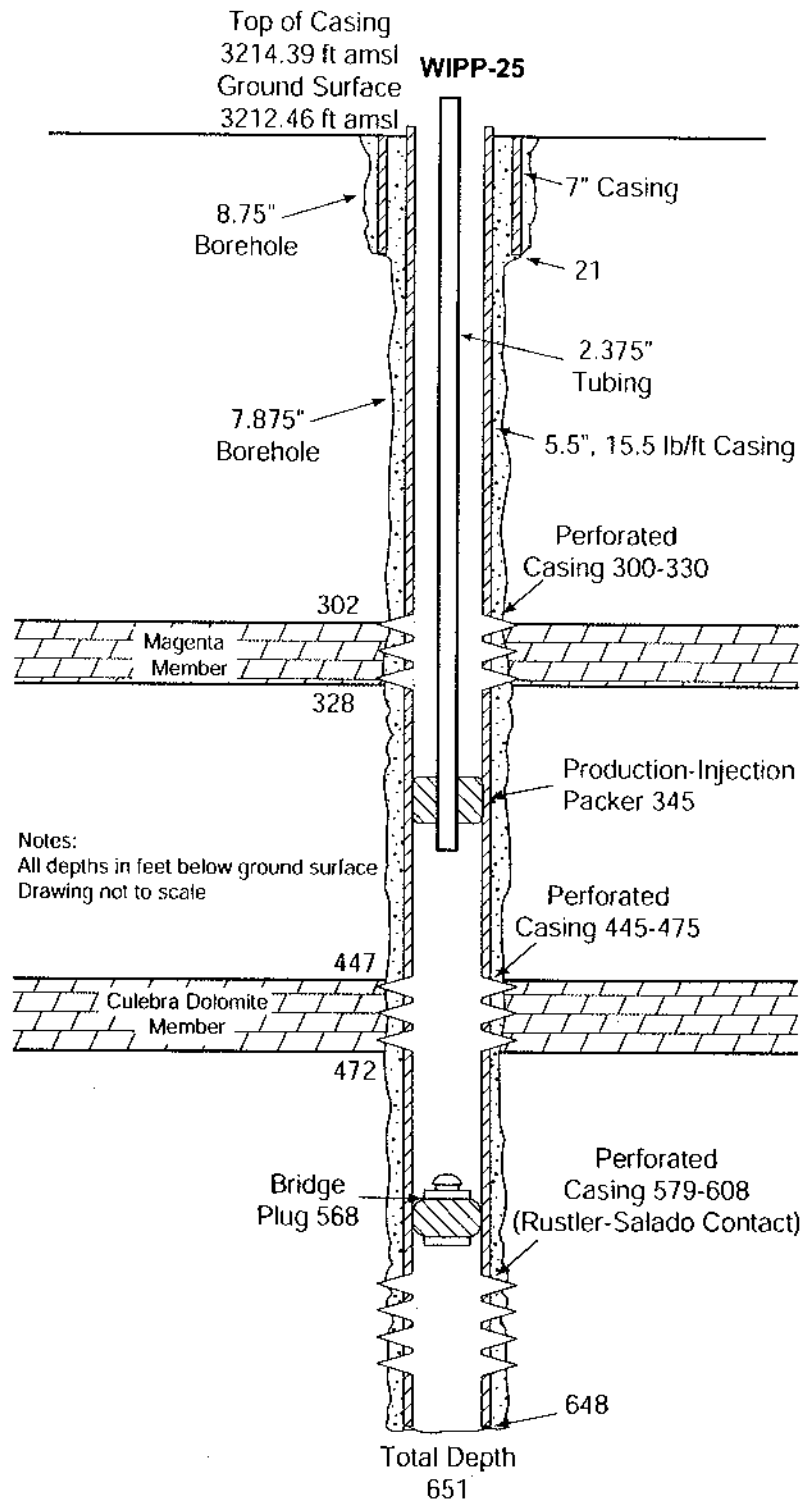
## General Stratigraphy and Configuration



### Completions and Monitoring Configuration (10/1/01)

Figure 4-3. C-2737 well configuration.





TRI-6115-530-0

Figure 4-4. WIPP-25 well configuration.

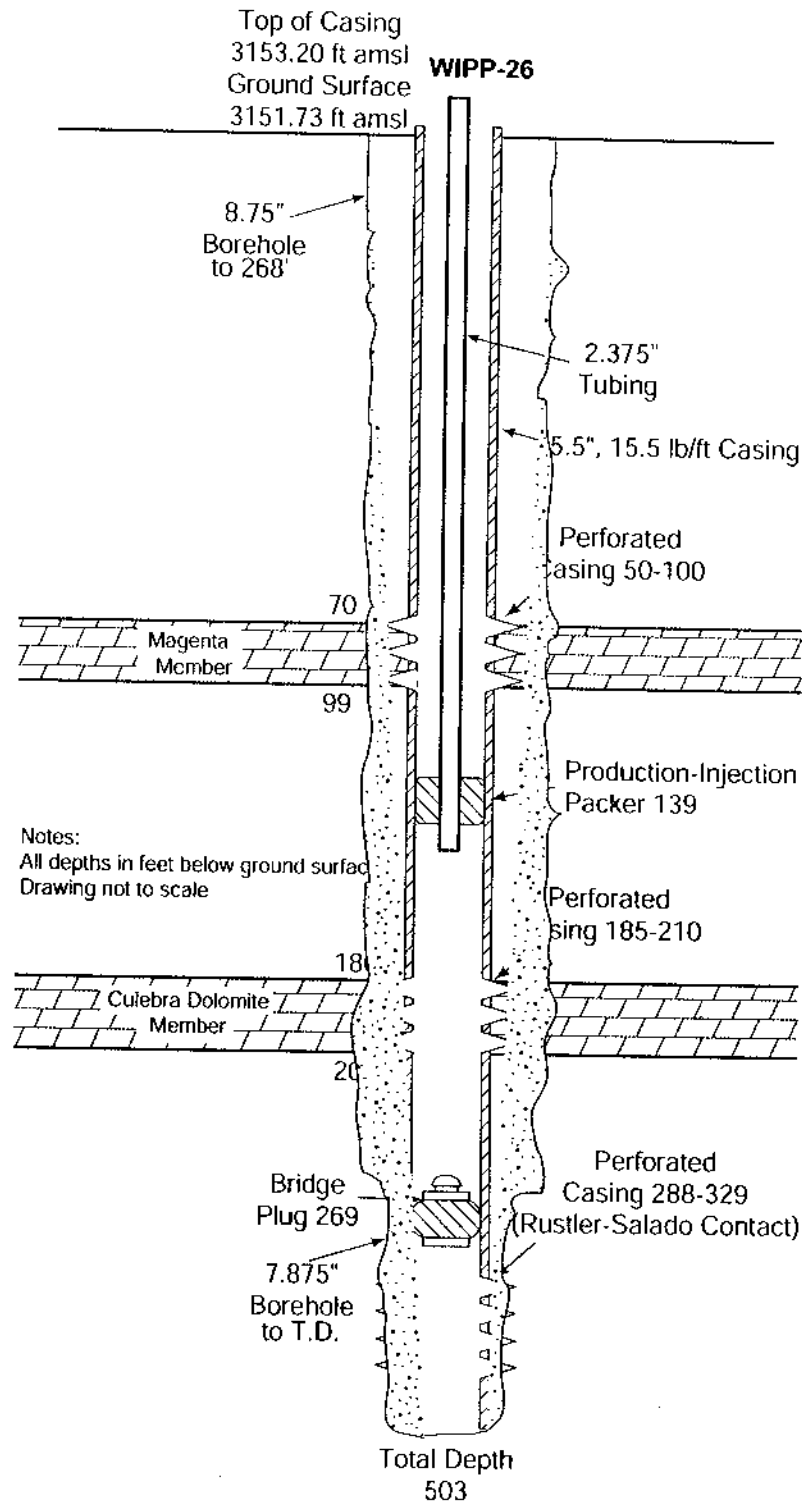


Figure 4-5. WIPP-26 well configuration

One or more wells will also be drilled in FY 2003 to allow evaluation and testing of a shallow perched zone at the base of the Santa Rosa. The first well will be south to southwest of the WIPP surface facilities, but no specific location has yet been established.

#### 4.1 Testing Activities

In a new well, the following activities will occur:

1. The SNL Well Testing Lead (WTL) will evaluate the data from the well-development pumping performed by Washington Regulatory and Environmental Services (WRES) in order to design a hydraulic test(s) to meet the objectives for both the location and interval being tested. When the WTL has determined the type and duration of the hydraulic test(s) that will be run in an individual well, an appropriate test tool will be installed in the well. The type and configuration of test tools will vary from well to well based on the following:

- the type of test to be performed, e.g., slug or drill-stem test (DST), single-well pumping test, multipad pumping test;
- the objectives of the hydraulic testing (formation(s) or parameters of interest); and
- the well configuration (single-interval completion or dual-interval completion).

Due to the inherent variability in test-tool configurations that will be necessary to complete the hydraulic testing successfully, no standard configuration is provided in this TP. Each test-tool configuration will be documented in the scientific notebook and will be submitted as part of the final records package. The placement of the test tool within the borehole will be determined by the WTL. After the well has recovered from the well-development pumping, an appropriate hydraulic test(s) will be performed in accordance with the procedures given in Subsection 4.2.

2. Regardless of the type of hydraulic test(s) conducted, the WTL will evaluate all of the data collected on a real-time basis in order to ensure that the objectives of the test are being met prior to the termination of the test as well as to ensure that the tests are conducted with the maximum efficiency possible. The reader is referred to Subsections 4.2.1, 4.2.2, and 4.2.3 for additional information regarding the real-time data analysis associated with the various types of hydraulic tests.

3. All test equipment will be removed from the well, and the well will be configured for long-term monitoring.

This will complete SNL activities in the well. WRES will incorporate the wells into the long-term monitoring well network and begin monthly water-level measurements of the various water-bearing intervals as part of the GWMP.

## 4.2 Measuring and Test Equipment

Equipment needed for the hydraulic testing and data-collection activities will consist of equipment at the land surface and downhole equipment to be installed in the wells. Equipment will consist of either "off-the-shelf" items ordered directly from qualified suppliers or standard equipment provided by qualified service companies as required to complete their contracted tasks. No specially designed equipment is anticipated. All equipment used will follow the supplier's operation and calibration specifications and will be documented as part of the QA records and controlled following NP 12-1 (Subsection 4.6.4).

### 4.2.1 Surface Equipment

The surface equipment will include water-level sounders, water-quality measurement instruments, a mechanical flow meter, diesel-powered generators, and storage tanks. A data-acquisition system (DAS) to monitor pressure and flow rate and an electronic flow-control system will be used for any pumping test performed. A barometer will be used to measure atmospheric pressure at a given location before, during, and after any hydraulic test is performed as determined by the WTL. Equipment will be operated observing relevant SNL and WTS environmental safety and health (ES&H) procedures and protocols.

#### 4.2.1.1 WATER-LEVEL SOUNDERS

Water levels in the wells will be measured before installing any equipment. Water levels may also be measured in other monitoring wells as designated in this TP or by the WTL. The water levels will be measured using Solinst electric water-level sounders according to SNL NWMP Technical Operating Procedure (TOP) 512 (Subsection 4.6.4). All measurements will be documented as part of the QA records. The Solinst meter consists of a graduated plastic tape with two wire leads, a water-level probe at the downhole end of the tape, batteries, and a signal light and buzzer mounted on a surface reel. When the water-level probe enters the water, the electrical conductivity of the water closes the electric circuit on the tape, activating the surface light and buzzer. The water level is read directly, in feet or meters, on the graduated plastic tape, at the observation-well measuring point, which will be clearly marked on the surface casing.

#### 4.2.1.2 WATER-QUALITY MEASUREMENTS

Throughout the pumping phases of this program, the specific conductance, temperature, pH, and specific gravity of the produced water will be measured hourly, or as directed by the WTL, following SNL NWMP Activity/Project-Specific Procedure (SP) 13-3 (Subsection 4.6.4). The same measurements will also be performed on water bailed and/or swabbed from the wells prior to slug tests or DSTs. With the exception of specific gravity, these data will be considered qualitative in nature and will not be used for interpretation, but only to indicate relative changes in the quality of the fluid produced. The specific conductance and temperature will be measured with a Yellow

Springs Instruments S-C-T meter (or equivalent); pH with an Orion pH meter (or equivalent); and the specific gravity with a laboratory-grade hydrometer. Measurements will be documented as part of the QA records.

#### 4.2.1.3 MECHANICAL FLOW METER

A totalizing mechanical flow meter will be used to measure the cumulative discharge during all pumping periods. The total discharge will be measured with a Carlon (or equivalent) in-line totalizing flow meter. The Carlon flow meter has a 1-in orifice, and is a brass-housed synthetic (noncorrosive) turbine flow meter designed for discharge rates of 1 to 20 gpm, with scale divisions of 0.1 gal. The Carlon flow meter is a totalizing flow meter and monitors only the total volume of fluid pumped. If necessary, the data from the totalizing flow meter can be used to calculate the average pumping rate by observing the meter at the beginning and end of a time period. The time-and-volume data can be used to calculate the average discharge rate for the time period in question. Totalizing-flow-meter data will be documented as part of the QA records. The flow meter will be checked during each pumping activity to verify that it is performing within design specifications by timing the filling of a container of known volume.

#### 4.2.1.4 DIESEL-POWERED GENERATORS

Diesel-powered generators are needed to generate electricity for the pump and DAS. Diesel-powered generators will be operated in accordance with the instructions provided by the manufacturer. Operation of diesel generators is not a quality-affecting activity and, therefore, documentation of activities associated with the generators is not mandatory. No diesel fuel will be stored in separate containers at the well sites.

#### 4.2.1.5 STORAGE TANKS

All groundwater produced from the wells during these activities will be stored in polyethylene tanks or steel frac-tanks at the well pad until such time that WRES disposes of the produced water by whatever means is appropriate.

#### 4.2.1.6 DATA-ACQUISITION SYSTEM

All pumping tests conducted will be controlled and monitored using a computer-controlled DAS. The DAS will send and receive signals to and from the downhole pressure transmitters and record their responses on the computer's hard disk and on floppy diskettes. The DAS to be used will be PERM or Geomation.

The basic PERM system consists of a power-excitation input to access the downhole pressure transmitters and other gauges such as the flow meter, a digital voltmeter to observe the gauges' output signals, a data-control unit to access each gauge's signal, a programmable voltage standard to

verify the signal output from gauge and excitation devices, and a computer to store and process the data. The PERM DAS will collect and process the gauges' input signals and store the data on hard disk and on floppy disks using SNL's PERM5, version 1.01, data-acquisition software, which has been qualified as software in accordance with NP 19-1 (Subsection 4.6.4). The PERM5 software requires a computer with a 100-MHz 486 processor (or higher) running DOS.

The Geomation System 2300 field monitoring and control system consists of modules that interface with various instruments by reading and recording amperage, resistance, and voltage (SDI-12 environmental instrument interface). In addition, the Geomation DAS can provide outputs to flow-control valves and other control devices. A computer will be used to provide a user interface and programming capabilities for the Geomation DAS via the Geonet Suite of software. The Geomation DAS will collect and process the gauges' input signals and store the data in memory until it can be archived to the computer's hard drive. The Geonet Suite of software qualifies as off-the-shelf software with no access to the source code. This type of off-the-shelf software does not fall under the QA requirements as per NP 19-1, however the DAS activity must comply with NP 9-1.

#### 4.2.1.7 ELECTRONIC FLOW-CONTROL SYSTEM

Pumping rates during any pumping test will be controlled using an electronic flow-control system consisting of an in-line inductive flow meter, a programmable electronic flow controller, and a control valve or a variable-speed pump. The flow-control system will be operated with the DAS and flow rates will be recorded by the DAS. The components of the system are combined in a simple feedback loop. Thus, the flow-rate output from the flow meter will be used as input to the control valve or variable speed pump allowing stable flow-rate changes to be introduced from the DAS keyboard in less than 30 s. The set point can be set manually at the controller or remotely via the DAS. The design control range for flow rate is 0.2-5 gpm. Additional checks on the discharge rate may be provided using a calibrated bucket and stopwatch, and a mechanical flow meter.

#### 4.2.1.8 BAROMETER

Barometric pressure will be monitored during all hydraulic tests using a 30-psia TROLL installed at the well site or a Druck PTX 260 series 0 to 17-psia pressure transmitter mounted at the well site. Druck PTX transmitters have a 9-30-V-DC input voltage with a 4-20-mA output signal, which is converted to a voltage output and monitored by the DAS. The barometric output monitored by the DAS and converted barometric pressure data will be recorded at the same frequency as the downhole pressure data. The operation of the 30-psia TROLL is similar to that described in Subsection 4.2.2.4 for standard TROLL pressure gages. Because the barometric pressure will be recorded by a stand-alone gage, the barometric output will not be recorded at the same rate as the DAS records other information. Some form of interpolation will be required to determine the barometric efficiency of the various wells as well as to make barometric pressure corrections to the pressure responses measured under open-hole conditions (if necessary).

## 4.2.2 Downhole Equipment

Downhole equipment will be operated from the surface and will consist of bailing and swabbing equipment to remove fluid from the borehole(s), inflatable packers, a sliding-sleeve shut-in tool, memory gauges, a submersible pump, and possibly pressure transmitters. The depths of all equipment installed in a well will be measured and documented relative to a known permanent datum, such as a survey marker established on the hydropad. A secondary datum, such as the top of the well casing, may be used as a reference point for depths provided that the elevation of the secondary datum relative to that of the primary datum is known and documented.

SNL will provide technical direction and assistance, as needed, to WRES or its contractors in installing all downhole equipment.

### 4.2.2.1 BAILING AND SWABBING EQUIPMENT

Bailing and swabbing equipment will be used to remove fluid from the tubing above the shut-in tool (Subsection 3.2.3) as needed to conduct slug and/or (DST (Subsection 4.2.1). The bailing and swabbing equipment will consist of artificial and/or natural rubber tubing wipers (swab cups) or downhole bailers supplied and operated by the pump-truck contractor. If bailing or swabbing is not possible or ineffective, the fluid level in the tubing string may be lowered by means of air lifting, whereby a hose or flexible tubing is used to inject compressed air below the water level in the tubing string at pressures and volumes sufficient to lift the fluid to land surface.

### 4.2.2.2 INFLATABLE PACKERS

Slug and drillstem testing (Subsection 4.2.1) will be conducted with a production-injection packer (PIP) set above the perforations or screen associated with the formation of interest on 2.375-in tubing. Compressed nitrogen or compressed air will be used to inflate the packers. The packers to be used will have uninflated diameters of 3.75-6.25 in, depending on the diameter of the casing in each well.

In addition, pumping tests (Subsection 4.2.2) conducted in wells that have dual completions such as C-2737 and WIPP-25 will require the use of PIPs to reconfigure the wellbore in such a way as to allow the pressure to be monitored in multiple formations simultaneously within the same borehole. Figures 2-3 and 2-4 show the current configurations of wells C-2737 and WIPP-25, respectively.

### 4.2.2.3 SLIDING-SLEEVE SHUT-IN TOOL

A Baski Access Port Valve (APV™) will be used to control access to the packer-isolated zones in the wells in which slug tests or DSTs are performed. An APV is a sliding-sleeve shut-in tool consisting of concentric sections of pipe with circular ports passing through the wall of the pipe. In

the open position, the ports on the two sections line up, allowing fluid to pass from the tool string to the well. When one of the sections slides vertically relative to the other, the ports no longer line up (closed position), and the fluid cannot pass from the tool to the well. The Baski APVs are controlled from the surface. Gas or hydraulic pressure is applied to a piston through a control line run alongside the tool string to open or close the sleeve. Separate pistons and control lines are used to open and close the sleeve. No tubing movement or weight change to the tubing above the shut-in tool is required to operate this shut-in tool, thus minimizing tool-induced pressure disturbances in the test zone. APVs will be installed between two 2.375-in pup joints beneath PIPs.

#### 4.2.2.4 TROLL MEMORY GAUGES

TROLL 4000 and miniTROLL downhole memory gauges will be used as the primary data-acquisition instrument during slug tests or DSTs (Subsection 4.2.1). Any time that a well is pumped and another well, not on the active hydropad, is monitored, TROLLs will also be used to monitor the pressure response in the nearby well(s). TROLLs are manufactured by In-Situ, Inc., and consist of a downhole pressure transducer and programmable data logger. They are installed at a known depth below the water surface in a well. The data logger is accessed from land surface by RS-422 or RS-232 cables, allowing the data-acquisition rate to be programmed and accumulated data to be downloaded to any laptop computer using a Windows 95, 98, 2000, or NT operating system and the most current version of the Win-Situ software. These battery-operated devices can operate for over a year without battery replacement. The use of the TROLL memory gauges will allow efficient use of manpower and provide useful data at any desired data density over extended time periods.

#### 4.2.2.5 SUBMERSIBLE PUMP

In most cases, an electric submersible pump with a production capacity of up to 5 gpm will be used for groundwater sampling and possibly pumping tests (Subsection 4.2.2) under open-hole conditions. It is anticipated that a larger-capacity pump, on the order of 80 gpm, may be required for one or more multipad tests (Subsection 4.2.3). For pumping tests, the pump will be installed with an in-line check valve so that the pump tubing column can be filled with water at the start of pumping to ensure immediate flow control and regulation, and to ensure that water will not drain back through the pump when the pump is turned off. All wiring of submersible pumps will be performed by a licensed pump installer.

#### 4.2.2.6 PRESSURE TRANSMITTERS

Druck PTX 161 pressure transmitters (or equivalent) will be used to monitor the changes in pressure in all wells monitored on the active hydropad during any pumping tests (Subsections 4.2.2 and 4.2.3). Two transmitters will be used at all times in each well, or for each formation as necessary, to ensure continued data collection in the event that one transmitter fails. The transmitters will be strapped to the discharge tubing above the pump. The Druck PTX 161 pressure transmitters (or equivalent) have a 0 to 300-psig range of operation. These pressure transmitters will be



monitored with the PERM or Geomation DAS (Subsection 3.1.6), which will record both the 4- to 20-mA output from the gages and the converted data in the desired pressure units.

### **4.3 Test Requirements and Procedures**

The activities discussed in this TP have been designed so that the data collected are of the highest possible value, and are more than adequate to meet specific program objectives.

#### **4.3.1 Test Requirements**

The testing elements of the data-collection activities require specific initial and operational conditions for maximum success. Pressures in the formation of interest at the well to be tested, other wells being monitored that are completed to the formation of interest, and other formations being monitored for pressure response associated with the test must be stabilized (changing <0.5 psi/day) before any hydraulic test is initialized. The fluid density in the well being tested must be uniform before testing begins. The pumping rate during a pumping test should ideally be constant within approximately 5%, but in any event must be well documented.

The test equipment used for the data-collection activities has to:

- provide quality data to support test objectives;
- perform according to design specifications; and
- be calibrated, as appropriate, according to standards acceptable under SNL NP 12-1 (Subsection 4.6.4).

#### **4.3.2 Test Procedures**

Five different types of hydraulic tests may be performed depending on the conditions actually encountered. The following subsections list the different hydraulic tests that may be performed, provide general criteria for their selection, and define the procedures that will govern their performance.

##### **4.3.2.1 SLUG AND DSTs**

Slug tests or DSTs will be performed in any wells incapable of sustaining a pumping rate of at least 1 gpm, which will likely include most Magenta wells and a few Culebra wells. Slug tests or DSTs may also be performed in some of the new Culebra, Dewey-Lake, and Santa-Rosa wells initially in order to get a preliminary idea of the hydraulic characteristics of the formation at that location. Future testing in these wells will be designed based upon the preliminary hydraulic data.

A DST is simply a slug test that is shut-in before complete water-level recovery has occurred. The slug portion of a DST is referred to as a flow period and the shut-in portion is referred to as a buildup period. The advantages of a DST relative to a slug test are that it takes less time to complete and provides two data sets that can be analyzed instead of one. The disadvantage of a DST relative to a slug test is that the flow-period data set is less definitive than a full slug data set.

All slug tests and DSTs will be conducted in accordance with the following TP procedures. A PIP (Subsection 4.2.2.2) will be set on 2.375-in tubing in the well casing above the perforations or screen with a sliding-sleeve shut-in valve (Subsection 4.2.2.3) immediately below the PIP. The PIP size will be selected so that the casing inside diameter (I.D.) is not more than twice the uninflated diameter of the PIP. The exact placement of the PIP is not critical, as long as it is within 20 ft of the uppermost perforation (slot) and its position is carefully measured. The shut-in valve will be in the open position when the test equipment is installed in the well. Once at the desired depth, the PIP will be inflated (set). After allowing the formation that is to be tested to re-equilibrate, the shut-in valve will be closed.

A TROLL (Subsection 4.2.2.4) will be strapped to the tubing at a depth below the stabilized formation water surface calculated to provide a pressure of 90–95% of the maximum pressure for that instrument. The pressure sensor of the TROLL will be connected to the formation of interest using a feed-through line passing through the PIP or other configuration as deemed appropriate. Barometric pressure will be recorded during all slug tests using a 30-psia TROLL. The depths of all equipment in the well will be carefully measured and documented in the scientific notebook.

With the shut-in valve closed, the tubing will be bailed and/or swabbed to remove some of the water above the formation of interest and the specific gravity of this water will be measured. The removal of water from the tubing (effectively under-pressuring the formation) is referred to as a slug-withdrawal test. The amount of water to be removed will be determined on-site by the WTL, based on the following guideline: the water level will be lowered to provide a pressure no less than 5% of the maximum pressure for the TROLL when the shut-in valve is opened. After bailing and/or swabbing, the water level in the tubing will be measured using a Solinst meter (Subsection 4.2.1.1) in accordance with TOP 512 (Subsection 4.6.4). It should be noted that this type of test can also be accomplished by adding water to the tubing (effectively over-pressuring the formation) rather than removing water from the tubing. This is referred to as a slug-injection test and may be performed as part of this TP if the circumstances are deemed appropriate by the WTL.

The pressure in the formation of interest below the PIP will be allowed to stabilize until the rate of change is  $<0.5$  psi/day. At the direction of the WTL, the shut-in tool will be opened to initiate a slug test. The WTL will evaluate the test data in real time to determine if the test should be continued as a slug test or converted to a DST. Subject to the discretion of the WTL, the following guidelines will be used to determine if and when a slug test will be converted to a DST:

- If 50% of the initial slug has dissipated after 3 h, the test will remain a slug test.

- If 50% of the initial slug dissipates between 3 and 24 h, the shut-in valve will be closed and the test will be converted to a DST when 80% of the slug has dissipated.
- If 50% of the initial slug has not dissipated after 24 h, the shut-in valve will be closed and the test will be converted to a DST whenever 50% dissipation occurs.

Slug tests and DST buildup periods will continue until at least 98% pressure recovery has occurred. For a slug test, the shut-in valve will then be closed and the tubing bailed and/or swabbed to create a pressure differential approximately half of that created for the first slug test. For a slug test converted to a DST at 80% slug dissipation, the tubing will also be bailed and/or swabbed to create a pressure differential approximately half of that created for the first test. No bailing and/or swabbing will be required for a test converted to a DST at 50% slug dissipation. After the pressure disturbance caused by bailing and/or swabbing has dissipated, the shut-in valve will be opened to begin a second slug test or DST. The second test will be an exact duplicate of the first test, but with half of the initial pressure differential. Testing may be terminated at any time after 98% pressure recovery has occurred.

Data-acquisition rates will be set as fast as possible at the start of each test event (slug/flow or buildup) and will then be systematically decreased throughout the test to provide a reasonably uniform distribution of data with respect to the logarithm of elapsed time. If the WTL deems it appropriate to employ the use of a DAS (Subsection 4.2.1.6) to monitor slug-testing activities, all pertinent information will be documented in the scientific notebook.

During slug and DST testing activities, pressure-response data will be evaluated on a real-time basis by the WTL in order to determine that the objectives of the test are being met and that the test proceeds in the most efficient and effective manner. Standard straight-line and diagnostic derivative techniques described in Horne (1995) and Peres (1989) will be employed to assess both the progress of the test and to determine the flow regime of the system being tested.

#### 4.3.2.2 SINGLE-WELL PUMPING TESTS

Constant-rate pumping tests will be performed in any wells capable of sustaining a pumping rate of approximately 1 gpm or more. All single-well pumping tests will be conducted in accordance with the following TP procedures. A submersible pump (Subsection 4.2.2.5) will be set in the well approximately 5 ft below the perforations or screen for the formation of interest on 2.375-in tubing. A check valve will be installed above the pump to prevent water in the tubing column from draining back down through the pump when the pump is turned off. Two pressure transmitters (Subsection 4.2.2.6) will be strapped to the tubing approximately 10 ft above the pump. The depths of all equipment in the well will be measured to the nearest 0.01 ft and documented in the scientific notebook.

In some cases, when one of the objectives of the hydraulic testing is to assess the hydraulic connection of the formation being tested with water-bearing formations above and/or below, PIPs

(Subsection 4.2.2.2) will have to be installed in order to isolate the various water-bearing formations and additional pressure transmitters will have to be installed in the pumping well in order to monitor the various other water-bearing formations of interest associated with the particular test being conducted. Again, these decisions and associated configurations will be made on a case-by-case basis based upon prior information of the hydraulic system at that location. It is anticipated that the WIPP-25 hydraulic test will be of this nature. The rationale for all testing decisions and all testing configurations will be documented in the scientific notebook associated with the respective wells.

Prior to the initiation of the pumping test, the pump will be turned on briefly in order to perform several checks of the system. These include:

- ensuring that the submersible pump is operating properly;
- filling the 2.375-in tubing string with fluid to ensure that:
  - the check valve above the pump is holding,
  - there is fluid filling the surface discharge lines to ensure that both the mechanical and the electronic flow meters will register flow rates immediately upon initiation of the formal pumping test; and
- ensuring that all of the electronic equipment both at the surface and downhole is operating properly.

When all of these checks and any others that the WTL deems necessary have been made, the pumping will be terminated and the system will be allowed to equilibrate fully prior to the initiation of the formal pumping test.

After it has been established that the formation of interest has re-equilibrated from the pre-test pumping, the pump will be turned on and operated at a constant rate (determined during water-quality sampling and/or well-development activities) to produce water from the formation of interest. Although the primary purpose of these tests is to obtain estimates of  $n$  or  $T$  for the pumping well, any nearby wells that may respond to the test will be monitored as well. The wells to be monitored during any pumping test will be determined by the WTL on a case-by-case basis based upon prior knowledge of the hydraulic system at that location. Monitoring of these wells will be performed using TROLLs (Subsection 4.2.2.4). In some cases, a qualitative assessment of any hydraulic connection between the formation being tested and water-bearing formations above and/or below the formation being tested will be made. Should a hydraulic connection between water-bearing formations be identified, the design and duration of the test may be modified in real-time in order to maximize the information obtained or additional testing may be scheduled at that location with modified test objectives. Pumping time may vary from 2–10 days depending on the local  $T$  of the formation of interest and/or the observed pressure response(s). Real-time analysis of the pressure data from the pumping and monitoring (if any) wells will be used by the WTL to establish the time

when the pump may be turned off and the time at which recovery monitoring will be terminated. Recovery monitoring will typically continue for a period at least twice as long as the pumping duration.

The DAS (Subsection 4.2.1.6) will be used for any pumping test to record downhole pressure and flow rate in the pumping well and any other wells located on the same hydropad. Data-acquisition rates will be set as fast as possible at the start of pumping and recovery and will then be systematically decreased to hourly, providing at least 20 readings for each log cycle of elapsed time. Barometric pressure may be collected through the use of a 30-psia TROLL instead of through the use of a DAS using the equipment described in Subsection 4.2.1.8. Manual totalizing-flow-meter (Subsection 4.2.1.3) readings and water-quality (temperature, specific conductance, pH, and specific gravity) measurements (Subsection 4.2.1.2) will be made no less frequently than hourly during pumping. During the recovery period, the water level in the tubing will be measured several times per day to verify that the check valve is not leaking.

During single-well testing activities, pressure-response data will be evaluated on a real-time basis by the WTL in order to determine that the objectives of the test are being met and that the test proceeds in the most efficient and effective manner. Standard straight-line and diagnostic derivative techniques as described in Horne (1995) will be employed to assess both the progress of the test and to determine the flow regime of the system being tested.

In some cases, when one of the objectives of the hydraulic testing is to assess the hydraulic connection of the formation being tested with water bearing formations above and/or below, PIPs (Subsection 4.2.2.2) will be installed in order to isolate the various water bearing formations and additional pressure transmitters will have to be installed in the pumping well in order to monitor the various other water-bearing formations of interest associated with the particular test being conducted. Again, these decisions and associated configurations will be made on a case-by-case basis based upon prior information of the hydraulic system at that location. The rationale for all testing decisions and all testing configurations will be documented in the scientific notebook associated with the respective wells.

#### 4.3.2.3 MULTIPAD-PUMPING TESTS

Constant-rate, multipad-pumping tests are performed to obtain transient head response data from observation wells spread over an area of several square miles. They differ from the single-well pumping tests described in Subsection 4.3.2.2 primarily in terms of duration. Multipad pumping tests typically last from one to several months to allow distant observation wells time to respond.

All multipad pumping tests will be conducted in accordance with the following TP procedures. A submersible pump (Subsection 4.2.2.5) will be set in the well approximately 5 ft below the perforations or screen for the formation of interest on 2.375-in tubing. A check valve will be installed above the pump to prevent water in the tubing column from draining back down through the pump when the pump is turned off. Two pressure transmitters (Subsection 4.2.2.6) will be

strapped to the tubing approximately 10 ft above the perforations. The depths of all equipment in the well will be carefully measured and documented in the scientific notebook.

Prior to the initiation of the pumping test, the pump will be turned on briefly in order to perform several checks of the system. These include:

- ensuring that the submersible pump is operating properly;
- filling the 2.375-in tubing string with fluid to ensure that:
  - the check valve above the pump is holding,
  - there is fluid filling the surface discharge lines to ensure that both the mechanical and the electronic flow meters will register flow rates immediately upon initiation of the formal pumping test; and
- ensuring that all of the electronic equipment both at the surface and downhole is operating properly.

When all of these checks and any others that the WTL deems necessary have been made, the pumping will be terminated and the system will be allowed to fully equilibrate prior to the initiation of the formal pumping test.

After it has been established that the formation of interest has re-equilibrated-in the pumping well and observation wells-from the pretest pumping, the pump will be turned on and operated at a constant rate (determined during water-quality sampling and/or well-development activities) to produce water from the formation of interest. TROLLs (Subsection 4.2.2.4) will be set in any monitoring wells that may show a pressure response during the pumping test. Monitoring wells for each multipad test will be determined by the WTL on a case-by-case basis. Real-time analysis of the pressure data from the pumping and monitoring wells will be used by the WTL to establish the time when the pump may be turned off and the time at which recovery monitoring will be terminated. The objectives of any of the multipad pumping tests will be to determine the flow geometry and the local S and T of the formation being tested. In addition, the multipad pumping tests will provide transient pressure response data at locations in the vicinity of the WIPP Site against which the Culebra flow model can be calibrated. Also, in some cases, a qualitative assessment of any hydraulic connection between the formation being tested and water-bearing formations above and/or below the formation being tested will be made. Should a hydraulic connection between water-bearing formations be identified, the design and/or duration of the test may be modified in real time in order to maximize the information obtained, or additional testing may be scheduled at that location with modified test objectives. Pumping time may vary from 1-3 months depending on the observed pressure response(s).

The DAS (Subsection 4.2.1.6) will be used for any pumping test to record downhole pressure

and flow rate in the pumping well and any other wells located on the same hydropad. Data-acquisition rates will be set as fast as possible at the start of pumping and recovery and will then be systematically decreased to hourly, providing at least 20 readings for each log cycle of elapsed time. Barometric pressure may be collected through the use of a 30-psia TROLL or through the DAS using the equipment described in Subsection 4.2.1.8. Manual totalizing-flow-meter (Subsection 4.2.1.3) readings and water-quality (temperature, specific conductance, pH, and specific gravity) measurements (Subsection 4.2.1.2) will be made no less frequently than hourly during pumping. During the recovery period, the water level in the tubing will be measured several times a day to verify that the check valve is not leaking.

During multipad testing activities, pressure-response data will be evaluated on a real-time basis by the WTL in order to determine that the objectives of the test are being met and that the test proceeds in the most efficient and effective manner. Standard straight-line and diagnostic derivative techniques described in Horne (1995) will be employed to assess both the progress of the test and to determine the flow regime of the system being tested.

#### 4.3.2.4 SCANNING COLLOIDAL BORESCOPE

Direct measurement of the direction of groundwater flow is needed in a number of wells to verify that models are accurately simulating flow. Therefore, the screened intervals of both Culebra and Magenta wells will be logged in wells selected by the SNL PI using the scanning colloidal borescope. The scanning colloidal borescope images colloidal-size particles moving with the water through the wellbore, and tracks their motion to determine the direction and velocity of groundwater flow at that location. It differs from the colloidal borescope described in Beauheim (2000) in that it has a variable focal length that allows scanning over a 0.5-m thickness for each placement of the tool, instead of a fixed focal length. Thus, the scanning colloidal borescope allows all flowing zones to be identified and characterized. All scanning colloidal borescope activities will be conducted under the direction of the SNL PI. This service will follow QA grading procedure SP 1-1 and procurement procedure NP 4-1 (Subsection 4.6.4). Upon completion, the contractor conducting the scanning colloidal borescope activities will provide all results in both paper and digital format as well as all applicable supporting documentation and records for equipment used. This equipment will be supplied in a calibrated condition by the contractor.

#### 4.3.2.5 MODIFICATIONS TO TEST PROCEDURES

Modifications to test procedures may be required during testing activities. These modifications will be conducted at the direction of the WTL and will be documented in the scientific notebook as part of the QA records as well as any supporting records and reports. Such modifications are anticipated as normal operational procedures and will not be reported as nonconformances that require corrective action.

#### 4.4 Data-Acquisition Plan

Both manually and electronically collected data will be acquired during the hydraulic testing activities. The following types of data will be recorded:

- electronically collected downhole pressure data;
- electronically and/or manually collected pumping rate and volume data from wells being pumped;
- electronically collected barometric-pressure data;
- manually collected water-level data;
- manually collected water-quality data concerning the temperature, pH, specific gravity, and specific conductance of fluid produced during pumping, bailing and/or swabbing; and
- manually collected data on equipment and instrument configurations in the wells and at the surface.

##### 4.4.1 Scientific Notebooks

Scientific notebooks will be used in accordance with NP 20-2 to document all activities and decisions made during the hydraulic-testing activities. Specific information to be recorded in the scientific notebooks includes:

- a statement of the objectives and description of work to be performed at each well, as well as a reference to this TP;
- a written account of all activities associated with each well;
- documentation of safety briefings;
- a list of all equipment used at each well, including make, model, and operating system (if applicable);
- a description of standards used for on-site instrument calibration and calibration results;
- traceable references to calibration information for instruments and/or gauges calibrated elsewhere;
- a sketch, showing all dimensions, of each downhole equipment configuration;



- tubing tallies and other equipment measurements;
- manually collected water-level measurements;
- manually collected water-quality data concerning the specific conductance, specific gravity, pH, and temperature of fluid produced during pumping, bailing and/or swabbing;
- entries providing the names, starting times, and completion times of all data files created with the DAS software or WinSitu, as well as tables showing the configuration information (pressure transmitter serial number, calibration coefficients, etc.) entered into PERM5 to initiate each data file; and
- discussion of the information and/or observations leading to decisions to initiate, terminate, or modify activities.

All entries in the scientific notebooks will be signed or initialed and dated by the person making the entry. The scientific notebook(s) for each well will be reviewed by an independent, technically qualified individual within 2 weeks of the end of each major field activity (pumping associated with water quality sampling, hydraulic testing, and logging with scanning colloidal borescope) at that well to verify that sufficient detail has been recorded to retrace the activities and confirm the results.

Manually collected water-quality data and water-level measurements may also be recorded on specially prepared forms rather than in the scientific notebooks when that would provide a more efficient means of data collection and tracking. Use of such forms will be noted in the scientific notebooks and these forms will be submitted as QA records.

#### **4.4.2 Electronic Data Acquisition**

TROLL memory gauges (Subsection 4.2.2.4) will be used for monitoring and testing activities. The PERM or Geomatics DAS described in Subsection 4.2.1.6 will be used at locations where pumping tests are performed. If used, the DAS will record downhole pressures in all wells located on the hydropad being tested, and pumping rates. Electronic data file-management systems will be documented in the scientific notebooks for these activities. These electronic data files will be submitted as QA records according to NP 17-1 (Subsection 4.6.4).

#### **4.4.3 Manual Data Acquisition**

Manual data collection will be carried out using either scientific notebooks or forms designed specifically for each activity or data type. To minimize transcription errors and multiple documentation of the same information, the use of forms specified in the WIPP procedures is not mandatory. The WTL will determine the means of documenting manually acquired data and will

ensure that all quality-affecting information is documented.

#### 4.4.4 On-Site Data Validation

During the field activities, the WTL will evaluate the data as they are acquired. The data will be diagnosed for any tool failure and/or procedure-induced effect that may affect the data quality. The WTL will take immediate action (if required) to make any necessary changes to the equipment configuration or the procedures to assure the data quality is consistent with the objectives of these activities. Data associated with these testing activities provided by entities other than SNL will be checked for accuracy and adequacy by the WTL and documented in the scientific notebook as such. Any deficiencies will be noted. This on-site real-time data evaluation will follow NP 9-1 (Subsection 4.6.4) as a method of determining if the data are acceptable and will be documented in the scientific notebook.

The WTL will use real-time evaluation of the acquired data during any given activity to assure that the data are usable in a detailed interpretation, the conditions can be maintained over the planned duration of the activity, and that an activity will not be terminated before the minimum objectives can be achieved under the given time constraints. The WTL may utilize some or all of the following procedures and analytical tools:

- To assure that the acquired data satisfy program plans, the WTL may use the same interpretation techniques during the data-validation process as will be used in later interpretation of these data.
- The WTL may use specialized plots to interpret the formation response and to identify the time domain of that response, such as the wellbore storage, transition, stabilization, or other response phase.
- The WTL may use real-time analysis of the acquired data to determine the time when continuing the activity will provide no further improvement in the interpreted results within the program's time and budget constraints.
- The WTL may use real-time analysis to determine whether an activity can be terminated earlier than planned, and to develop a revised schedule as appropriate.

If at any time the WTL determines that an activity objective cannot be accomplished due to time constraints, problems concerning the performance of the equipment, or unsuitability of initial conditions, the WTL may terminate the activity. The WTL will document all real-time evaluation of data in the scientific notebook.

#### 4.5 Sampling and Sample Control

All new wells and wells to be tested will be pumped to allow water samples representative of the completion formation to be collected. As discussed in Section 4, the wells will be pumped until water-quality parameters (electrical conductivity and specific gravity) are stable within approximately 5% while two wellbore volumes are pumped. When that occurs, water samples will be collected for laboratory analysis of major ions (Na, Mg, SO<sub>4</sub>, Cl, K, Ca, sulfate, and alkalinity). Water-quality sampling will be performed in all wells to provide baseline information and allow inferences to be made regarding the origins and flow paths of the groundwater. Water samples will be collected at the end of well-development activities for those wells at which pumping tests do not appear to be feasible, or for replacement wells where hydraulic testing is not necessary. During the pumping tests at the remainder of the wells, water-quality parameters, as mentioned above, will be collected no less frequently than every hour to assess their stability. Prior to turning off the pump, samples will be collected for laboratory analysis of major-ion concentrations, also listed above. Age dating may also be performed on Dewey-Lake water samples. Samples will be collected and controlled in accordance with SNL NP 13-1 (Subsection 4.6.4). The chain of custody for the samples when they are transferred to the SNL analytical laboratory will be established in accordance with SP 13-1.

Water samples will be collected in 1-L acid-washed polyethylene bottles. Each bottle will be rinsed three times with water from the pump discharge line before a sample is collected. Two bottles will be filled in immediate succession. The first bottle will be filled completely. The second bottle will be filled approximately halfway. Approximately 2 mL of HNO<sub>3</sub> (nitric acid) Ultrex II (70.6 wt %) or equivalent) will be added to this bottle, and then the bottle will be filled to the shoulder. (Note: chemical goggles and protective gloves must be worn while handling HNO<sub>3</sub>.) The lid will be screwed on and the bottle agitated. The pH of the sample will then be checked and, if it is above 2.0 standard units, 1 mL of HNO<sub>3</sub> will be added, the sample agitated, and the pH checked again. This procedure will continue until the pH is less than 2.0.

After filling, the lids of all sample bottles will be secured with electrical tape. A label will be affixed to each bottle bearing the information listed below, and the label will be completely covered with clear packing tape. The label will contain the following information, written using an indelible marker:

- project name (WIPP),
- sample number,
- sample location (e.g., Magenta),
- well designation,
- collector's name,

- date and time,
- type of sample (groundwater),
- acid wash (yes or no),
- parameter or destination,
- type of preservative (HNO<sub>3</sub> or none),
- bottle number, and
- method of collection (filtered or unfiltered).

After collection, water samples will be stored in a cooler until they can be delivered to the SNL analytical laboratory, which should occur as soon as practicable.

## **4.6 Quality Assurance**

### **4.6.1 Hierarchy of Documents**

Several types of documents will be used to control work performed under this TP. If inconsistencies or conflicts exist among the requirements specified in these documents, the following hierarchy (in decreasing order of authority) shall apply:

- memoranda or other written instructions used to modify or clarify the requirements of the TP (most recent instructions having precedence over previous instructions),
- this TP,
- NPs (Subsection 4.6.4), and
- SPs and TOPs.

SNL QA concurrence will be obtained and/or corrective action reports will be written for modifications to QA procedures implemented for work conducted under this TP.

### **4.6.2 Quality-Affecting Activities**

Activities performed under this TP are quality-affecting with the following exceptions:

- water-quality measurements, except specific gravity (see Subsection 3.1.2);
- operation of diesel-powered generators (see Subsection 3.1.4);
- assistance provided by the manufacturer/contractor in the installation of tools and equipment;
- support services for tasks that do not involve data collection, such as pump trucks, machining, welding, fishing services, fuel, etc.; and
- water storage and disposal.

Activities that are not quality-affecting are not subject to the requirements of the SNL QA program.

#### **4.6.3 Quality Assurance Program Description**

SNL activities are conducted in accordance with the requirements specified in the Quality Assurance Program Document (QAPD) (U.S. DOE, 2002a), or subsequent revisions of this document. The requirements and guidance specified in the QAPD are based on criteria contained in American Society of Mechanical Engineers (ASME) (1989a), ASME (1989b), ASME (1989c), or U.S. EPA (1993). The requirements of U.S. DOE (2002a) are passed down and implemented through the SNL NWMP QA procedures.

#### **4.6.4 NPs, SPs and TOPs**

The following NPs, SPs, and TOPs are applicable to the work described in this TP. Note that the versions listed below may not be the current versions. Always check the SNL NWMP web site ([www.nwmp.sandia.gov/onlinedocuments/](http://www.nwmp.sandia.gov/onlinedocuments/)) to find the current version of these or other NPs, SPs, or TOPs.

- NP 2-1, "Qualification and Training;"
- NP 4-1, "Procurement;"
- NP 9-1, "Analyses;"
- NP 12-1, "Control of Measuring and Test Equipment;"
- NP 13-1, "Sample Control;"
- NP 17-1, "Records;"

- NP 19-1, "Software Requirements;"
- NP 20-1, "Test Plans;"
- NP 20-2, "Scientific Notebooks;"
- SP 1-1, "QA Grading;"
- SP 5-1, "Engineering Drawings;"
- SP 13-1, "Chain of Custody;"
- SP 13-3, "Field Water-Quality Measurements;" and
- TOP 512, "Depth-to-Water Measurement Using Solinst Brand Electric Sounder."

Existing procedures implemented in the field cannot be expected to anticipate every possible event affecting the tests. Therefore, the WTL is tasked with implementing appropriate measures during the conduct of the tests. These technical decisions will be documented in the scientific notebook.

#### **4.6.5 Data Integrity**

Care will be taken throughout the performance of the operations for this TP to ensure the integrity of all data collected including documentation on hard copy and data collected on magnetic media. Duplicate copies of all data will be produced no less frequently than monthly and the duplicate copies will be maintained at a location separate from the well site to ensure that data are not lost. Data collected shall not be released unless and until the data are reviewed and approved by the WTL.

#### **4.6.6 Records**

Records shall be maintained as described in this TP and applicable QA implementing procedures. These records may consist of bound scientific notebooks, loose-leaf pages, forms, printouts, or information stored on electronic media. The WTL will ensure that the required records are maintained and are submitted to the SNL NWMP Records Center according to NP 17-1 (Subsection 4.6.4).

##### **4.6.6.1 REQUIRED QA RECORDS**

As a minimum, QA records will include:

- scientific notebooks;
- NPs, SPs, and TOPs used;
- calibration records for all controlled equipment;
- equipment-specification sheets or information;
- photographs taken of the equipment and activities, with a log listing the photographs and describing what is seen;
- data files collected by TROLLs and/or the DAS, with a log listing the files and defining their contents;
- all forms containing manually collected data;
- a log of all samples collected;
- copies of all permits obtained; and
- reports (e.g., gamma and perforation logs) provided by contractors.

#### 4.6.6.2 MISCELLANEOUS NON-QA RECORDS

Additional records that are useful in documenting the history of the activities but are considered non-QA records may be maintained and submitted to the SNL NWMP Records Center. These records include:

- safety briefings,
- as-built diagrams of equipment supplied by contractors,
- pump-truck and other equipment certifications,
- equipment manuals and specifications,
- information related to operation of diesel generators,
- equipment manifests, and
- cost and billing information regarding contracted services.

These records do not support performance assessment or regulatory compliance and, therefore, are not quality-affecting information.

#### 4.6.6.3 SUBMITTAL OF RECORDS

Records resulting from work conducted under this TP, including forms and data stored on electronic media, will not be submitted to the SNL QA staff for review and approval individually. Instead, the records will be assembled into a records package or packages, which will be reviewed by the WTL before being submitted for QA review.



## 5 TRAINING

All SNL and WIPP-Site contractor personnel are required to take and pass WIPP General Employee Training (GET) followed by annual refreshers to work at the WIPP Site. All personnel who will perform quality-affecting activities under this TP must have training in the SNL QA program (Form NP 2-1-1), must view the current QA refresher video, and must read SNL NP 12-1, NP 13-1, NP 20-2, and SP 13-1 (Subsection 4.6.4). They must also read the procedures outlined in this TP, the Primary Hazard Screening (PHS), and all applicable NPs, SPs and TOPs listed in Subsection 4.6.4, but no additional training in those procedures is required. No other special training requirements are anticipated in addition to the GET and the safety briefings described in Section 6.

## 6 HEALTH AND SAFETY

SNL field operations will be conducted on land controlled by WRES and the field operations team assembled for this TP will follow all WRES safety practices and policies. Operational safety for individual field operations will be addressed through an ES&H PHS (SNL2A00137-001) and a Hazard Analysis (HA) developed by SNL. Project-specific WIPP-Site safety procedures and a Job Hazard Analysis (JHA) will be approved through the WTL and WRES safety personnel. All activities will be performed in accordance with the requirements of WP12 FP.01, WP12 IS.01, and WP12 IH.02.

All equipment will be operated in accordance with the appropriate allowable operating pressures and in accordance with the SNL ES&H pressure-safety manual. Pressure ratings for individual parts such as valves and pressure tubing will be either marked by the manufacturer with the maximum allowable operating pressure or such information will be made available in written documentation according to guidelines of the SNL Center 6800 ES&H Coordinator.

Additional and specific safety concerns and requirements to be observed by field personnel will be addressed and documented in the daily safety briefing conducted prior to any field activities. Some of these issues include:

- appropriate use of safety shoes, safety glasses, chemical goggles, hard hats, and protective gloves;
- ensuring adequate fuel is available for all field vehicles, especially those traveling to remote locations;
- proper installation and safety procedures when handling electrical submersible pumps and other electrical equipment;
- proper procedures for operation of diesel-powered generators for on-site electric power;
- proper procedures for inflation of downhole packers;
- familiarity with on- and off-site road conditions and driving regulations;
- familiarity with the locations of first-aid supplies, medical support facilities, and fire extinguishers and other safety equipment;
- familiarity with the location of lists of emergency telephone numbers and persons and offices to notify in the event of emergencies; and

- familiarity with the location of Material Safety Data Sheets.

All field personnel assigned to the field operations described in this TP will receive a safety briefing before the beginning of field operations at each well site. In addition, the WTL or field-site supervisor will conduct daily safety briefings at the beginning of daily operations or at the beginning of each shift. All personnel receiving safety briefings are required to sign and date the safety-briefing form as part of safety-documentation procedures. All work locations will maintain a mobile communication system. In case of accident, injury, or sudden illness, the WIPP Central Monitoring Room (CMR) will be notified immediately. The CMR will coordinate emergency response activities.

## **7 PERMITTING AND LICENSING**

Permitting and licensing requirements are discussed in Subsection 8.3.

## 8 ROLES AND RESPONSIBILITIES

The work described in this TP will require the drilling of several new wells in the vicinity of the WIPP Site. It will also involve reconditioning several existing wells. Throughout this multiyear field program, wells will be tested, water levels monitored, and well water chemistry will be observed. SNL intends to collaborate with WRES and/or its corporate affiliates to ensure integration of program efforts, to see that this work is done in accordance with all applicable technical and regulatory standards, and that data generated are fully qualified under SNL's WIPP QA program for use in assessing the long-term performance of the repository.

### 8.1 SNL Responsibilities

SNL's responsibilities are:

- Identify which monitoring wells will need to be reconditioned and work with WRES to identify by what means those wells will be made ready for scientific endeavor.
- Identify which wells will need to be hydraulically tested and identify the type(s) of test(s) to be performed.
- Provide water-level and water-chemistry monitoring equipment, when appropriate, for placement in new (replacement) and/or reconditioned wells.
- Provide all equipment, both downhole and surface, necessary to perform hydraulic tests in new and reconditioned wells.
- Monitor water levels and water chemistry in wells of interest to SNL, or have levels and chemistry monitored.
- Perform all hydraulic tests in wells in collaboration with WRES (Subsection 8.2).
- Analyze and interpret well tests and hydrological monitoring data acquired.

### 8.2 WRES Responsibilities

TP: WRES will assume the following responsibilities in support of the activities discussed in this

- Recondition (or have reconditioned) any existing wells to be tested.

- For wells to be hydraulically tested, provide (or have provided) the requisite capabilities, including (but not limited to) pump-setting trucks or pulling rigs and crews to install hydraulic testing equipment, "kill" trucks to inflate packers (when required), and appropriately licensed, authorized, and experienced electrician(s) to wire and hook up pumps (as needed).
- Provide necessary oversight personnel at well sites to allow SNL to conduct well-testing operations on a 24-h/day, 7-day/week basis, as needed. In turn, SNL will provide to WRES as much advance notice as possible of the need for specific operations outside normal daytime work hours.
- Dispose of any waste water or other waste materials generated during well testing and well reconditioning operations in accordance with all applicable environmental and regulatory standards (including chemical analysis of produced waste water, as appropriate).
- Facilitate compliance with the applicable WIPP Site environment, health, safety, and security requirements as they relate to program activities.
- Participate in water-level and water-chemistry monitoring and data gathering to the degree that SNL and WRES jointly determine is needed.

### **8.3 Responsibility for Permitting and Licensing**

WRES is responsible for ensuring that WIPP-Site activities are conducted in accordance with applicable federal, state, and local regulatory requirements. WRES is responsible for all permitting and licensing requirements associated with drilling, coring, logging, reconditioning, testing, and waste disposal necessary to complete the activities outlined within this test plan. SNL will abide by all of the permitting and licensing rules and regulatory requirements as indicated by WRES. SNL is responsible for ensuring that all contracted experimental work performed by SNL contractors at the WIPP Site meets all applicable federal, state, and local regulatory requirements.

## 9 REFERENCES

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