SANDIA NATIONAL LABORATORIES

WASTE ISOLATION PILOT PLANT (WIPP)

TEST PLAN, TP 01-01

Examining Culebra Water Levels

Task 1.3.5.2.2.2

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Prepared by:

Dennis W. Powers

Consulting Geologist

Sandia National Laboratories

Carlsbad, NM

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1. APPROVAL PAGE

Author	*Original signed by Dennis W. Powers*	*July 24, 2001*
	D.W. Powers, Consulting Geologist	Date
Technical Reviewer:	*Original signed by Mark Crawley*	*7/24/2001*
	Mark Crawley, WTS Environmental Monitoring	Date
Technical Reviewer:	*Original signed by Randall Roberts*	*7/24/01*
	Randall Roberts, SNL Department 6822	Date
SNL QA:	*Original signed by David Guerin*	*7/25/01*
	David Guerin, SNL Department 6820	Date
SNL ES&H:	*Original signed by Diane G. Gibson*	*7-20-2001*
	Diane Gibson, SNL Department 6800	Date
SNL Management:	*Original signed by Francis D. Hansen*	*7/25/01*
	F.D. Hansen, SNL Department 6822	Date

2. Table of Contents

3 REVISION HISTORY

The following text is the original issue of this test plan (TP); no prior revisions exist. Changes to this plan, 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 individuals having the same level of responsibility as those who performed the original review and approval. All TP revisions will have at least the same distribution as the original document.

4 PURPOSE AND SCOPE

4.1 Importance of the Culebra Dolomite Member of the Permian Rustler Formation

The Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, is a mined, underground repository certified by the Environmental Protection Agency (EPA) for the management, storage, and disposal of transuranic (TRU) radioactive wastes generated by US government defense programs. The waste will be emplaced in panels excavated at a depth of around 650 m in the Permian Salado Formation.

The Culebra Dolomite Member of the Rustler Formation is ordinarily the most transmissive fluid-bearing unit above the evaporite beds of the Salado within the land withdrawal area of the WIPP site. As part of the compliance certification application (CCA) to the EPA, the probability of releasing radionuclides to the boundary of the land withdrawal area by transport through the Culebra was calculated for several scenarios, including climate change, leaking boreholes and injection wells, and subsidence due to potash mining. Separate regional-scale models calculated flow directions and velocity through the Culebra using water levels that included rises to, or near, the topographic surface, bounding the expected range of conditions for Culebra fluid levels for those scenarios that do not involve connections to units below the Salado. Possible impacts of scenarios involving connections to units below the Salado were evaluated using “worst-case” calculations with the 2D performance assessment (PA) model. Based on the results of these studies, climate change is the only process assumed to cause future changes in Culebra head gradients in CCA-PA release calculations. These calculations scaled (increased) fluid flow velocities to simulate the effects of hypothesized future changes in head gradients.

The CCA included (Appendix TFIELD) a relatively narrow range of Culebra water level values for test holes. This range represents uncertainty in estimating modern water levels for the undisturbed Culebra (prior to WIPP shaft construction and hydraulic testing). The range was used to condition estimates of the distribution of transmissivity (T) of the Culebra.. Transient water responses to WIPP activities (shaft construction and hydraulic testing) were also used to condition estimates of Culebra T. The distribution of T is uncertain. Consequently, it is treated stochastically in CCA-PA calculations.

In the CCA, it was noted that Culebra water levels were rising in some monitor wells. WIPP construction (especially shafts) and testing activities influenced various wells, particularly during the 1980s. Other wells, especially H-9, were noted to have fluctuations, but the cause was undetermined. Since the CCA was submitted, Culebra fluid levels have changed in a number of WIPP area monitor wells, and many are outside the range used to estimate Culebra T at well locations. Unless there is some error or factor, as yet undetermined, that alters the basic water level information now available, rising Culebra water levels indicate that two relevant questions need to be further investigated:

- What natural or induced conditions contribute to changing water levels?
- What effect, if any, will changing water levels have on estimates of Culebra transmissivity?

This test plan addresses the broader approaches to these questions and detailed means of developing or acquiring new data, and it provides the background for any analysis plans that may be needed to examine data developed as a result of this test plan.

4.2 Overall Strategy of the Test Plan

The test plan provides a framework for examining the water levels of the Culebra through time and across the site area (space) for two basic purposes. The first reason is to increase our understanding of the hydrologic processes that contribute to the water levels (whether those levels differ from ranges included in the CCA or remain within the range) of the Culebra. The second reason is to infer trends in water level changes, or other factors, that help in assessing the effects these changes on estimates of Culebra T values.

The strategy is to focus on developing and testing a set of scenarios or hypotheses about events and processes that seem likely to contribute to the Culebra water level changes. In a variety of ways, various scenarios or hypotheses have already been proposed to explain Culebra water levels. Water level rises in a number of Culebra monitor wells have, at different times, been suggested to be the result of recharge of the Culebra by leakage from hydrocarbon production or water injection wells (e.g., LaVenue, 1991; Silva, 1996). Similarly, long-term natural recharge or short-term recharge through karst, as at Nash Draw, have been suggested as a possible means of raising water levels long-term or short-term. Reducing discharge could have similar effects to increasing recharge. The scenarios or hypotheses that will be developed are not expected to be particularly novel or new with respect to some earlier attempts at examining different possibilities (e.g., LaVenue, 1991). The means of testing scenarios or hypotheses has likely improved, given both a longer data base and generally more powerful analytical techniques.

The studies to carry out this plan are broadly arranged in phases, though there will be considerable overlap in several activities and some feedback:

- Compile information on events or processes that seem likely to explain water levels and their changes, with time and spatial resolution that complements Culebra water level data.

- Refine scenarios and hypotheses about events or processes that may explain Culebra water levels and develop approaches to test these scenarios or hypotheses.
- Develop field evidence related to events (e.g., large rainfall near H-7) or processes that may affect the Culebra potentiometric surface.
- Apply sensitivity analyses to selected data, as appropriate, to determine if the data are useful in hypothesis testing or examining scenarios. An existing Sandia analysis plan will be used if appropriate; a new analysis plan will be developed if necessary.
- Apply analytical or numerical modeling or other means of using water levels and other available information to eliminate or bound scenarios or hypotheses about Culebra water levels. An existing Sandia analysis plan will be used if appropriate; a new analysis plan will be developed if necessary.
- Summarize (report) understanding of process(es) and events affecting the Culebra hydraulic system, as they are manifest in water levels.
- Re-evaluate the effects of changing Culebra water levels on estimates of transmissivity.

The water levels of the Culebra are a complex function of the hydraulic properties of the unit, the short- to long-term natural hydraulic stresses (recharge and discharge), and the various local and short-term hydraulic stresses artificially superimposed on the system by man, including WIPP-related activities. Under this test plan, however, there is no provision for attempting to determine hydraulic properties of the Culebra through tests in the field. Instead, the focus is on understanding the limits of existing data and on compiling complementary information helpful in evaluating scenarios and hypotheses.

This version of the test plan presents an overall program description, with more details for earlier portions of the study and more general approaches for later sections. The initial efforts under the test plan are intended to establish a technical baseline of, and familiarity with, information necessary for developing scenarios and hypotheses. Details for later phases will be provided in revisions of this test plan or in complementary analysis plans, if appropriate.

4.3 Status of Culebra Water Level and Related Data

Culebra water levels are now measured on a monthly basis in 41 monitor wells surrounding for the WIPP in support of determining compliance with 40 CFR 194 and the Hazardous Waste Facility permit (e.g., Jones, 2001). Two other wells (P14 and D268), with significant water level records in which CCA ranges were exceeded, were plugged and abandoned during 1999 because of well problems. For each of the Culebra water levels, an equivalent fresh-water head is calculated, using a fluid density for that location (e.g., Jones, 2001). The water level data from various sources have been collected by several different organizations since 1977 and reported in various formats. Since about 1988, most water level data have been collected by the WIPP

Managing and Operating Contractor (MOC, currently Westinghouse TRU Solutions, LLC). Part of these data have been compiled in a data file to facilitate graphing and other analyses.

Hydraulic properties for the Culebra have been compiled (e.g., Beauheim and Ruskauff, 1998) based on various well tests and observations while tests were conducted at other drillholes and observation wells. These properties will not be directly investigated under this test plan.

There is no doubt that various test and construction activities for the WIPP have affected the water levels of the Culebra (e.g., LaVenue et al., 1990). Stevens and Beyeler (1985) used water level changes in H-1, H-2b1, and H-3 as the exploratory (salt) shaft was constructed to estimate diffusivity for the Culebra. As necessary, the dates, duration and magnitude of these activities or events will be further compiled as a means of understanding how the Culebra water levels were affected by them.

There are several types of supplemental data and information that will be incorporated or prepared to support this analysis. More recent fluid density surveys within the drillholes will be important in assessing the degree of water level changes. It will be important to examine the sensitivity of water levels to these data. It will also be helpful to determine whether temporal and spatial changes, if any are indicated, in fluid density are reliable. Various data on non-WIPP drillholes may be compiled to help understand scenarios of artificial influx to the Culebra. Although WTS maintains large data files on drillholes/wells and monitors some non-WIPP drillholes, these files may need to be supplemented. Field study of selected areas of Nash Draw help indicate the likelihood of influx through karst both short- and long-term. Past studies (e.g. Bachman, 1980, 1981, 1985, 1987; Powers, 1999) of the Nash Draw area help focus field work on possible recharge areas in Nash Draw to the Culebra and other units.

4.4 Intended Use of Data

No new water level or hydraulic data will be collected within the scope of this Test Plan. Nevertheless, the results of this study, through evaluation and modeling, may be used in, or affect, three principal areas:

4.4.1 Revision of Features, Events, and Processes (FEPs).

Rising water levels in some monitor wells immediately suggests local inflow, although changes in discharge and other processes are to be considered. If local inflow, whether natural or artificial, is consistent with the data, it may be appropriate to revise the estimates of events or processes to be considered for the WIPP area (US Department of Energy, 1996).

4.4.2 Performance Assessment (PA).

After the Culebra water level data have been reassessed and likely processes established, the effect, if any, on the Culebra T field estimates can be established. After that evaluation, it can be determined whether flow directions and velocities need to be recalculated. If so, it can then be determined whether the probability of release needs to be recalculated for PA. These latter two steps are not covered by this test plan.

4.4.3 Adjust Monitoring Programs

Factors such as time or frequency of water level measurements, methods of measurement, or fluid density can affect water levels. If the water levels are found to be particularly sensitive to these measurements, or other factors, it may be possible to adjust parts of the monitoring program to improve data that help evaluate hypotheses for the water level changes.

5 EXPERIMENTAL PROCESS DESCRIPTION

5.1 Hydrograph Features and Contributing Events

Hydrographs are available showing water levels for the Culebra with time. Some of these hydrographs have been examined and general to specific chronologies of events affecting the water levels have been published (e.g., Beauheim and Ruskauff, 1998). In this initial phase, the hydrographs, chronologies, and available explanations will be compiled. For those hydrographs with limited chronologies and explanations, information will be compiled as is practical to provide comparable detail from test well to test well. References will provide links to published documents, record packages, or other original sources.

5.1.1 Overall Strategy

The overall strategy of this effort is to provide more compact, convenient, and comparable information about the Culebra water levels from different wells over time to facilitate developing hypotheses regarding the water levels. Existing information will be used, although it is expected that a variety of sources will provide the background information and data. Part of this effort will be to compile records and information about various events that might reasonably be expected to affect water levels. WIPP and some commercial drilling records and weather records will likely be compiled as part of this process, although such information may also be called for as a part of hypothesis or scenario examination.

This compilation will continue at some level through parts of successive phases, as information is sought or brought to bear on evaluating hypotheses and scenarios.

5.1.2 Process

The fundamental data are the water levels, measured in particular wells over time, converted to fresh-water equivalent heads using information about fluid density, Culebra midpoint, and an established reference elevation such as top of casing. These data are already available in electronic files and have variously been reported in documents and data packages. It is likely that hydrographs will be scaled alike for direct comparison through time to help determine spatial patterns to water level changes. Large events, such as the construction of the air intake shaft, affected the Culebra water levels in several drillholes (e.g., Stevens and

Beyeler, 1985). A part of this process will be to try to identify the effects of particular events over the area coverd by monitor wells. Another part of the process will be to identify events that are more restricted (e.g., to a single drillhole). Yet another effort will be made to link events in different wells where the chronology may differ somewhat; an example is the difference in response time in wells to salt shaft construction (Stevens and Beyeler, 1985). Tests have shown that widely spaced monitor wells respond differently in time and magnitude to a particular test stress (e.g., Beauheim and Ruskauff, 1998).

In addition, broader patterns of the hydrographs in time and space will be examined as a possible basis for trends in water level changes to revise the general concept of the Culebra indicated in the CCARecords and other information about drillholes, monitor wells, weather, and other events or processes will generally be compiled by paying particular attention to timing, spatial relationships, and magnitude. An example would be to provide a best estimate of the amount of rainfall at a location in Nash Draw at a particular time by comparing records at Carlsbad, the WIPP site, and other available local sources.

This effort may, at times, require coordination or consultation with the Sandia records center, hydrologists at Sandia, and personnel from Environmental Monitoring (of the MOC) who are currently providing water level measurements and monitoring and other data. Some records are expected to come from non-project sources. Examples are drilling records for a specific non-WIPP drillhole from a company or the NM Oil conservation Division and meteorological records at the Carlsbad airport or potash mines.

5.2 Scenario and Hypothesis Development

In this phase, a variety of scenarios or hypotheses will be developed for further testing as valid explanations of the water levels of the Culebra and the processes that contribute. Some highly improbable ideas may be included as a means of being more rigorous. Others may be included even though data exist that seriously limit or eliminate their significance. The purpose is to be thorough and to indicate that such ideas haven't been overlooked.

5.2.1 Overall Strategy

Three general classes of scenarios and hypothesis are expected to cover processes that contribute to water level measurements in the Culebra: observational "errors", effects of natural recharge and discharge, and effects of artificial (human-induced) inflow and outflow. For the most part, the ideas examined here will not be new; that is, informally at least, most of these will have been discussed or offered as partial or complete explanations of the observed changes in Culebra hydrographs. Nevertheless, they may not have been more formally developed (along with ways to test and, if possible, reject or limit them as explanations for specific hydrograph features or explanations for overall patterns), and there hasn't been a broad and recent compilation. The hydrograph and event information, along with more formal and informal ideas, will provide the general inspiration for developing a set of scenarios and hypotheses.

It likely will be easiest to explain rather abrupt changes or spikes in hydrographs. Broader patterns of rises may be much more difficult, and here it's important to note that a successful explanation should also account for the water levels that change very little at some monitoring wells.

5.2.2 Process

General classes of scenarios and hypotheses are inductively arrived at here through broad background understanding that 1) water levels in many Culebra monitoring wells are changing with time and 2) some of them now are out of the ranges used to estimate Culebra transmissivity. Observational "errors" and possible sources of inflow and outflow seem likely classes of "processes" to explain the water levels. A more detailed set of hypotheses will be derived mainly from specific hydrograph features or patterns. To the degree possible, a hypothesis will be related to a specific hydrograph feature or pattern. Where necessary, subhypotheses will be developed to facilitate testing. At the lowest level of hypothesis, data or other observations appropriate to testing will be identified, although it is possible that such data or observations will not currently be available.

To produce consistency and broad coverage, a set of hypotheses and tests will be circulated internally within the project for comment at an intermediate stage.

5.3 Field and Drillhole Evidence for Events and Processes

This will be a specific effort to obtain evidence to support or contradict scenarios or hypotheses of events and processes that have some likelihood of affecting Culebra water levels. The most likely natural event and process are specific recharge of the Culebra in Nash Draw by a rainfall through karst. The most likely artificial event and process are specific inflow by a malfunctioning well; casing or cement failures of WIPP wells, along with commercial injection and production wells, will be considered.

5.3.1 Overall Strategy

There is no evidence within the land withdrawal area of karst (e.g., Lappin, 1988) or of surface features focusing direct and short-term natural recharge of the Culebra from rainfall. The more likely target is the area of Nash Draw, where karst is evident (Bachman, 1981, 1985) and the Culebra is generally relatively shallow or crops out. The strategy will be to try to eliminate unlikely areas and focus on more likely areas for specific study.

There are no industry water injection or hydrocarbon production wells within the land withdrawal area . Only production wells proximal to WIPP monitor wells with unexplained transient water level changes are likely to be checked further for evidence of casing or cement problems. The injection wells in the WIPP vicinity need to be clearly identified. Specific production wells may be studied in more detail if analytical or numerical models suggest that a source of fluid is more localized around some wells and is not likely to be natural.

5.3.2 Process

There will be a general effort to compile rainfall records for the period since about 1975 compatible with the frequency of water level measurements. More detailed chronology, location, and magnitude estimates are likely to be developed to use in testing or examining scenarios and hypotheses about short-term water level changes.

Because of the large number of industry wells in the area of concern, the search for information about possible sources of fluids will be directed by common sense (e.g., proximity) and possibly by modeling to estimate how large an area would be affected by a range of hypothetical inflows at a specific location.

5.4 Sensitivity Analyses

5.4.1 Overall Strategy

Some factors, such as fluid density, that contribute to the water levels may need to be examined in more detail to better understand how measuring the factor and applying it affect water levels and the subsequent assessment of Culebra fluid flow direction and velocity. The strategy is to try to isolate these factors and, if possible, account for their effects on water levels before testing various scenarios or hypotheses.

5.4.2 Process

During the review and development of scenarios or hypotheses, an initial list of factors that might be usefully tested for sensitivity to measurement "errors" or other variations will be developed. Some priorities will be established as well as means of testing. This process will take place during scenario and hypothesis development. Sensitivity analysis carried out under an appropriate analysis plan is likely to modify hypothesis and scenario testing.

5.5 Scenario and Hypothesis Testing

Scenario and hypothesis testing will generally follow from the initial definition of test data or observations and scenario and hypothesis development (section 4.2 bullet list). Analysis of data will be covered under AP-070 (analysis Plan for Non-Salado Hydraulic-Test Interpretation) where it applies. Interpret/2, GTFM, nSIGHTS, and some commercial software are usable under this Analysis Plan for Culebra data management and interpretion. A new Analysis Plan may be written or AP-070 may be revised if needed to cover analyses supporting this test plan.

5.5.1 Overall Strategy

Where specific data are appropriate, analytical or numerical methods will be applied to test a hypothesis. At this stage, no new field data will be required, although hypothesis testing is expected to indicate areas where new data might help resolve whether an hypothesis is appropriate.

Observations about drillholes, wells, and possible sources of natural inflow are expected to help limit hypotheses or form the basis for an analytical model. These observations may not be suitable for analytical modeling, but they may help frame the analytical model to test a hypothesis.

5.5.2 Process

Analytical or numerical modeling will be conducted according to an analysis plan, to be developed or by revising an existing analysis plan.

5.6 Summary of Findings

A document will be prepared, either for a data package or SAND report, in which the findings from this work are summarized. Elements of this document include:

- A statement of the problem
- Recap of the approach in the Test Plan
- Summary of important hydrograph features, with illustrations
- Summary of the significant hypotheses and tests of hypotheses
- Discussion of relative significance of processes affecting Culebra water levels
- Limitations of the data and analysis
- Conclusions
- Appendix materials, such as hydrographs, full listing of hypotheses, details of specific analyses.

5.7 Culebra Water Level Ranges

The findings of the study are expected to provide the basis for deciding whether Culebra water levels for individual well locations alter estimates of Culebra transmissivities. If the Culebra transmissivity field is estimated again on the basis of such data, the water level or other information used to estimate the T field will be compiled as part of the WIPP technical baseline. The test plan will be revised as necessary to provide for this effort.

6 DATA IDENTIFICATION AND USE

No new test data are to be developed under this test plan. Sources of data used in any analysis will be identified. There will be additional observations in the field about areas that have some potential for recharge or inflow of fluid to the Culebra, but this work is not expected to provide direct data to analytical models. If

such a case develops, an analysis plan will be developed or an appropriate existing analysis plan will be used for guidance.

7 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 Description (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.

8 HEALTH AND SAFETY

The work described in this Test Plan is principally undertaken within the normal place of work in an office setting and should require no special ES&H training. General Employee Training is required for on-site visits, and general fieldwork requires normal precautions.

9 PERMITTING/LICENSING

Not applicable.

10 REFERENCES

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