September 18, 2009

Mr. Vernon Daub
Deputy Manager
U.S. Department of Energy
Carlsbad Field Office
P.O. Box 3090
Carlsbad, NM 88221

Subject: Contract No. DE-AC30-06EW03005 "Review of the Report: *Proof of Rapid Rainwater Recharge at the WIPP Site*"
PECOS Document #2009-C-0031

Dear Mr. Daub:

PECOS Management Services, Inc. (PECOS) has reviewed the subject report, which was submitted to the U.S. Environmental Protection Agency (EPA) by the "Citizens Against Radioactive Dumping" (CARD) for consideration during the WIPP recertification process. Our review focused on the methodology, basis of arguments, use of supporting information, and overall technical validity of the report. In evaluating the information presented in this report, PECOS personnel also considered the information presented in the 2009 Recertification Application, the results of the hydrogeology peer review convened in 2008, and the previous findings by the EPA on essentially identical concerns raised during the 2004 recertification process. The results of our review are presented in the attached minor action report and are summarized below.

The WIPP conceptual hydrologic model developed by DOE and its contractors is that the Rustler Formation's water bearing units at and near the site are low-conductivity confined beds that would not support significant contaminant transport if the repository is breached. The authors approach has been to focus on the hydrologic conditions of the Culebra dolomite member of the Rustler Formation, and to a lesser degree the Magenta member. The author analyzes data, principally water levels in selected monitoring wells, to try to establish two key points: first that at the WIPP Site itself the Culebra and Magenta are under the direct rapid influence of surface recharge from rains, and second that the Culebra at the WIPP site is a karst formation with subterranean channels and caverns that can result in very high ground water velocities.

The principal method that is used in the analyses presented in the report is to offer pair-wise comparison of maximum monthly changes in monitoring well water level data. However, in many cases, only part of the data is selected for analysis and the other data is ignored with little or no explanation for their exclusion. Further, no statistical analyses are presented. For example, the fact that not all of the water level data in the 70 monitoring wells summarized in Appendix C of the report are considered in the analyses presented in the report gives the appearance that the author has deliberately selected data to support the argument that the Culebra

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formation is unconfined and not included data which refutes that hypothesis, which is not in accord with good science.

PECOS personnel conducted spot checks of the data presented in the tables and appendices in the report and determined that on the selected dates when the argument is made that recharge occurred, numerous other nearby monitoring wells show no water level rises. The checks also reveal other rain events of similar magnitude that were not included in the analysis presented in the report, apparently because they did not result in increases in water levels in the monitoring wells. Therefore, these rainfall events were not included in the arguments presented in the report in support of recharge. It was also noted that, contrary to good scientific reporting, the monitoring wells making up each subset are not identified, thus making it impossible to confirm the calculations.

Inasmuch as one of the principal objectives of the report submitted by CARD was to establish correlations between different hydraulic measurements over time, the analysis method used by the author was entirely inappropriate. By only comparing maximum and minimum monthly values it is impossible to establish trends, to calculate confidence intervals, or to determine if other temporal phenomena such as seasonal fluctuations are occurring. A more accepted procedure would be to use all the monitoring well data and perform a time series or similar analysis.

With respect to the allegation that karstic conditions exist at and near the WIPP site, the report also contains aggressive arguments for the existence of karst terrain extending over the entire area of the WIPP Site and beyond. However, the report does not contain any new evidence of karst conditions and is essentially a re-statement of the arguments about the presence of karst at and around WIPP that were presented previously to EPA during the original certification and 2004 recertification of WIPP. Consequently, we concur with the previous conclusions by DOE and EPA that karst is not an issue at WIPP.

In summary, the subject report presents a weak, incomplete, highly speculative, and scientifically indefensible analysis of the geologic, hydrologic and climate data. More specifically

- The conclusion in the report that the Culebra and Rustler formations in the vicinity of WIPP exhibit evidence of karst formation are not supported by any evidence collected to date, nor by analysis of other highly credible and careful geoscientists.
- The conclusion in the report that ground water in these formations is in direct contact with that in overlying formations is not supported by any evidence or studies.

- The methodology and information presented is insufficient to allow a qualified observer to follow the author's reasoning and thus verify independently the conclusions made.

Given that the report's technical conclusions are not supported by acceptable scientific analysis, the argument presented in the report that the current DOE model is flawed and therefore certification was, and recertification is, invalid is without merit.

Please call me or Christopher Timm at (505) 323-8355 should you have any questions.

Sincerely,

Jerry V. Fox

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Project Director

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Review of the Report, "Proof of Rapid Rainwater Recharge at the WIPP Site"

August 2009

Purpose and Scope: The Department of Energy (DOE) has issued its second *Compliance Recertification Application (CRA-2)* for the Waste Isolation Pilot Plant (WIPP). In response, a concerned citizens group, Citizens Against Radioactive Dumping (CARD), engaged the services of Dr. Richard Phillips to assist in protesting this recertification. Among other things, the group produced a report entitled "Proof of Rapid Rainwater Recharge at the WIPP Site" (the Proof Report), which challenges the hydrogeologic basis used to support long-term safety issues at the WIPP. The scope of this minor action report includes a technical review of the Proof Report, along with evaluations of relative analyses and reports prepared by DOE and its contractor, Sandia National Laboratories (SNL).

The purpose of this task is to assess the methodology, basis of arguments, use of supporting information, and overall technical validity of the Proof Report. PECOS will also evaluate the impact, if any, the Proof Report might have on the evaluation of the *CRA-2*.

Background: The WIPP is a repository for defense-related transuranic (TRU) waste. It is located approximately 25 miles east of Carlsbad, New Mexico in a four-mile-square area set aside for this purpose by the Land Withdrawal Act (LWA) as amended in 1997. The WIPP operates under the regulatory authority of the LWA and the state of New Mexico Hazardous Waste Facility Permit and in compliance with Code of Federal Regulation (CFR) 40CFR 191 and 40CFR 194 as certified by the Environmental Protection Agency (EPA).

The WIPP repository, 2150 feet below land surface, is embedded in the roughly 2,000-foot-thick Salado Formation. The salt beds of the Salado are effectively impermeable to groundwater. Overlying the Salado stratigraphically is the 300-foot-thick Rustler Formation, which is about 1,200 feet above the level of the repository and is permeable enough to allow modest groundwater flow—generally from north-northeast to south-southwest—particularly in two of its members: the Culebra dolomite and to a lesser extent, the Magenta dolomite.

The general hydrologic character of the salt beds of the Rustler Formation is location-dependent. Two to four miles west of the WIPP site, beyond the escarpment known as Livingston Ridge, is the wide lowland area called Nash Draw. Here the Rustler Formation is at relatively shallow depths below local land surface. In Nash Draw, water levels in Culebra monitoring wells are now known to be influenced by local rainfall events, as confirmed in *CRA-2, Appendix HYDRO*. This influence is a result of karst solution features, common in this broad Nash Draw area, which allow infiltration into low-permeability

anhydrites, mudstones, and halites that overlay the Culebra dolomite. Resultant increases in water levels in the overlying strata quickly effect increased pressure in groundwater in the Culebra.

In the vicinity of the WIPP site, east of Livingston Ridge, the top of the Rustler Formation is roughly 500 feet below land surface and is mainly overlain by low-permeability mudstones of the Dewey Lake Formation. Here, detailed water-level monitoring has shown that groundwater in the Culebra and Magenta dolomites of the Rustler is hydraulically separated by confining layers, resulting in groundwater that is under artesian conditions in both dolomites. In addition, data from nearly 20 monitoring wells in this area exhibit no correlation between rainfall events and water level rises.

From the earliest studies of the WIPP site, most geologic and hydrologic attention has been focused on the strata of the Rustler and the Culebra hydrogeology. The Culebra and Magenta strata apparently have been tested by more monitoring wells than any other strata in the study area. Project technical personnel have aggressively pursued hydrologic investigation of these and other strata, including those areas that are only slightly permeable. Tests and analyses have included but have not been limited to detailed water-level monitoring and construction of over 80 boreholes for extensive characterization and testing of aquifers in the WIPP site area and for an area covering more than 100 square milessurrounding the site. Based on these studies, the WIPP conceptual hydrologic model that DOE and its contractors developed in the 1990's establishes the fact that the Rustler Formation's water-bearing units at and near the site are low-conductivity confined beds that would not support contaminant transport if the repository were to be breached. EPA has accepted this conceptual model, which has been used as the basis for groundwater flow and transport modeling in initial and subsequent performance assessments of the WIPP that predicted the long-term (10,000 years) performance of its repository. Nevertheless, due to stakeholder concerns (such as those raised in the Phillips Proof Report), the DOE has continued its investigation of the Culebra hydrology—as shown by additional information provided in the *CRA-2 Appendix, HYDRO*—on new wells, monitoring updates, and basin modeling and groundwater chemistry in the Culebra.

Basing its depiction of the Culebra hydrogeology on the decades of groundwater monitoring performed at and around the WIPP, DOE concludes that in the vicinity of Nash Draw, when water levels in the Culebra and Magenta rise as a result of local recharge, the hydrostatic pressures propagate eastward along the bedding in each member. Hydraulic continuity in the strata thereby causes pressures to increase progressively eastward toward the WIPP in the more deeply buried beds, including the Culebra, which are under confined-aquifer pressure. Thus, after a time lag that is a function of distance, water levels in monitor holes here also are driven upwards. (*Figure HYDRO-17, CRA-2 Appendix HYDRO* shows the lag time eastward from the recharge area in Nash Draw before confined water levels in the Culebra adjust to the recharge miles to the west.) The physical explanation is that pressure associated with rising water levels at one locale in a hydraulically integrated aquifer will spread laterally in a manner analogous to a

pressure increase in a pipe system that becomes distributed throughout the system; this of course requires no actual water flow through the system. The pressure increase is evidenced by the increase in the water levels in the monitoring wells.

These well-documented conditions invite the conclusion that there can be no direct recharge from rainfall on the surface in this general area, a hypothesis also supported by geochemical data discussed in the *CRA-2 Appendix HYDRO*, which shows a very high content (>3000 mg/l) of dissolved solids present in the water that ultimately reaches the Culebra. These data suggest long residence times in the overlying strata before the water physically reaches the Culebra, which is indicative of a confined aquifer as opposed to local recharge caused by precipitation. Note also that the WIPP monitoring data show groundwater flow directions individually in the Culebra and Magenta to be southward and westward, respectively.

It is also important to note that in contrast to the regional hydrologic conditions described above, the localized hydrology immediately around the WIPP repository itself was initially and clearly affected by facility construction. As shown in *Figure 1* of the Proof Report submitted by CARD, groundwater drainage into the repository's vertical shafts, for example, created a temporary cone of depression more than 75 feet deep in the Culebra. This feature in the ensuing two decades has mostly disappeared as a result of groundwater recharge from north of the WIPP site rather than from seepage into the ground from precipitation events on and near the WIPP.

The central thesis of the Proof Report is that any evidence of rainwater recharge to the Culebra and Magenta dolomite beds of the Rustler Formation would confirm that the conceptual groundwater model, which treated these beds as confined aquifers, is wrong. Furthermore, as presented in the document, any evidence that karstic characteristics in the Nash Draw area west of the WIPP site actually extend eastward through the WIPP site would significantly support conclusions that recharge is occurring at the site. The sole focus of the arguments presented in the Proof Report seems to be to prove that the conceptual understanding of groundwater behavior at the site is fundamentally flawed, which directly compromises the integrity of the repository. Based on this conclusion, the Proof Report demands that the entire WIPP Project be terminated.

The author of the Proof Report has focused on the hydrologic conditions of the Culebra dolomite member of the Rustler Formation, and to a lesser degree the Magenta member. His approach analyzes data—principally water levels in monitoring wells—in an attempt to establish two key points: first, that at the WIPP site itself, the Culebra and Magenta are under the direct rapid influence of surface recharge from rains; and second, the Culebra is also a karst formation at the WIPP site, complete with subterranean channels and caverns that can result in very high groundwater velocities.
The Proof Report, however, contains no statistical analyses to defend these theories. The author's principal analysis method is pair-wise comparison of maximum monthly changes in monitoring well

water-level data. In many cases, only selected data are chosen for analysis and the remaining data ignored, with little or no explanation for their exclusion. An egregious example of how problematic this method of analysis can be for the reader is illustrated in *Table 1*, "Recharge Events at the WIPP Site," (found on page five). This table, which conveys information central to the argument that water level increases result from local rainfall recharge, compares monthly water level rises in selected monitoring wells. Water level rises are attributed to 30 selected rainfall events that occurred over periods varying from one to nine weeks. The rain events were chosen from records of either the weather station at the WIPP site or from a weather station at Carlsbad Airport 25 miles west of the site. For each of these selected rainfall events, *Table 1* shows the following:

1. The number of monitoring wells with a water level rise in the month of the rain (out of a total of about 70 wells listed in *Appendix C* of the report, the source for these data);
2. The average of the values for all rises in each subset of wells that exhibit rise; and
3. The average of the water level changes in the subsets wells in the month preceding and the month following the rain.

The fact that not all of the water-level data in the 70 wells summarized in *Appendix C* are considered in *Table 1* suggests that the author has selected data to illustrate his point to the reader, yet has failed to include data that could disprove his hypothesis. The number of wells singled out each month varies from six to 28. The Proof Report indicates that there is extensive special variation in the wells selected for each water rise event ("Sometimes they are spread throughout the region; sometimes they cluster at the WIPP site," page four); but offers no explanation as to why all wells in the data set are not used.

In addition, spot checks of tables and appendices in the Proof Report reveal that on selected dates when an argument is made that recharge occurred, there was no rise in water levels in numerous other nearby monitoring wells. Spot checks also reveal other rain events of similar magnitude that were not included in *Table 1* of the Proof Report. Apparently, these rainfall events did not result in increases in water levels in the monitoring wells and were therefore, not included in arguments presented in support of recharge. It is also noted that, contrary to good scientific reporting, the specific monitoring wells comprising each subset are not identified, thus making it impossible to confirm the calculations.

Information used to generate the Proof Report (as presented in *Appendix A*) includes 32 years of rainfall data from the Carlsbad Airport (approximately 25 miles from the WIPP site) and 22 years of WIPP site data. According to this data, there is limited correlation between rainfalls at these weather stations, and the rain events themselves are highly variable. Based on visual inspection of this data, roughly half of the data points confirm rain at one location but not at the other. This is not surprising, since rainfall in southeast New Mexico is typically associated with storms that affect only a few square miles and consists of precipitation that varies from traces to inches across the path of the storm. This point introduces a factor of uncertainty that does not appear to be accounted for in the analyses presented in the Proof

Report, where the author's premise is based on the fact that because he uses both of the above-noted weather stations, he presents a "fuller picture of the frequency of rainfall affecting the Nash Draw." However, the author states on page four of the Proof Report that, "Not every one of these recharge events can be correlated with the rainstorms recorded at the weather stations . . ." This discrepancy, coupled with the cause and effect the author's arguments attempt to demonstrate, implies that rain did occur nearby, despite the fact no mention of such occurrence is offered.

Inasmuch as one of the principal objectives of the Proof Report submitted by CARD is to establish correlations among different hydraulic measurements over time, the analysis method used by the author was entirely inappropriate. In comparing only maximum and minimum monthly values, it is impossible to establish trends, to calculate confidence intervals, or to determine if other temporal phenomena such as seasonal fluctuations are occurring. A more accepted procedure would be to use all of the monitoring well data and perform a time series or similar analysis.

The Proof Report also contains aggressive arguments for the existence of karst terrain extending over the entire area of the WIPP site and beyond. The premise is that the WIPP is in the middle of a large geographical area with substantial known karst formations, including Nash Draw, which is the conventional and well-documented area of karst terrain near the WIPP site. Admittedly, the regional land surface for great distances in nearly every direction around WIPP is arid, barren, and has subdued relief that has been created on, and hence is affected by, the underlying formations and their erodability. But karst is that terrain which, owing to the presence of soluble strata in the subsurface, has been degraded by dissolution of substantial volumes of rock by groundwater at relatively shallow depth, which typically creates subterranean void spaces, channels, sinkholes, and other features. While these are common at Nash Draw, few other investigators at the WIPP report having observed signs of serious subsurface dissolution east of Livingston Ridge or anything other than small and local signs of minor dissolution of the strata.

SNL has completed a detailed study and produced a careful and credible report entitled, "Assessment of the Potential for Karst in the Rustler Formation at the WIPP Site" (SAND2005-7303, January 2006), which responded to earlier general and specific claims found in the Proof Report regarding widespread karst terrain. SNL's report concluded that karst is limited to the area of Nash Draw, stating that "Most of the evidence that has been offered for the presence of karst in the subsurface [at the WIPP Site] has been used out of context, and the different pieces are not mutually supporting."

Additionally, the EPA conducted a very thorough review of the potential for the existence of karst in the area of the WIPP, as reported in its March 2006 document, "Technical Support Document for Section 194.14/15, Evaluation of Karst At The WIPP Site." The EPA found that "the evidence for the lack of pervasive karst at WIPP is even stronger today than at the time of EPA's 1998 certification decision."

The Proof Report nevertheless uses a theory involving karst conditions located in the vicinity of the WIPP from which to cite influences and characteristics in an effort to demonstrate that groundwater flow in this area varies from that presented by DOE. For example, the *CRA-2, Appendix HYDRO* concludes that Culebra groundwater gradient is southward, and that this groundwater ultimately discharges to the Pecos River farther downstream. The Proof Report argues, by contrast, that Culebra water does not flow southward from the WIPP site; rather, it flows west to southwest, according to the report. That is, Culebra groundwater flows generally across the gradient, discharging to and evaporating from Laguna Grande de la Sal, the shallow, closed-basin surface lake in Nash Draw. The preferential westerly permeability in the Culebra that would be necessary to actualize this theory has not been recorded independently, nor has it ever been suggested by any other investigator.

As discussed above, the *CRA-2, Appendix HYDRO* presents data and analyses demonstrating the pressure-confined character of the Culebra in and east of the WIPP site results in water-level rises rather than karstic conditions around the WIPP site. This conclusion is based on basic hydraulic principles, namely that a confined system's ability to propagate pressure changes through confined aquifers will cause water levels to rise in distant wells. Many such concepts and their applicability to the situations in question were convincingly summarized by Dr. Beauheim, SNL, in a June 30, 2009, presentation during an EPA stakeholders meeting. However, based on the content of the Proof Report and the dialogue between its author and Dr. Beauheim at the EPA stakeholders meeting, it appears the author of the Proof Report does not understand nor is willing to recognize or directly address the principles, concepts, data, and/or analyses that led to the interpretations contained therein.

PECOS notes that the author's recent writings continue to follow a traditional line of arguments directed at the WIPP. He, sometimes with coauthors, has produced numerous documents, all devoted to the same proposition: Permitting of the WIPP site was based on a fundamentally flawed conceptual groundwater model of the Rustler Formation. Therefore, his argument consistently purports that the WIPP Project is not technically supportable, and that it must be terminated. This review considered only two of his earlier reports, both prepared in 1997: "Rainwater Recharge at the WIPP Site" and "Potential Flow Paths from the WIPP Site to the Accessible Environment," coauthored with David T. Snow. Arguments contained in these reports are in essence, interchangeable with Dr. Phillips' main arguments presented in the 2009 Proof Report, central focus of this review. In the Proof Report, as in previous documents prepared by the author, his fundamental argument seems to be that the original hydrogeologic model in the Performance Assessment (PA) was flawed because it lacked inclusion of a karst attribute in the immediate vicinity of the WIPP, at the Culebra. As stated earlier, investigations conducted by SNL and EPA have proven this argument invalid.

While the Proof Report does not directly address the argument that continued operation of the WIPP will present future hazards to human health, the author verbally advanced that argument at the EPA stakeholders meeting in June. The hydrogeologic connection to human health hazards is evaluated in the PA, which models the impact of a hypothetical penetration of a WIPP waste chamber on groundwater. In this distant-future model, an exploration hole is drilled through and presumably beyond the Castile. In this scenario, high-pressure water penetrated in the Castile rises up the same or subsequent drill hole and passes through the waste chamber on the way either to land surface or to the Culebra for distribution to the accessible environment. This possibility has been included in every PA prepared for WIPP certification and recertification using very conservative assumptions for time-of-travel for any brine releases in the Culebra. Each of these analyses was compliant with the radiation release standards established for the WIPP. It is critical to note in this evaluation that the hazard level that could ultimately and possibly result from this type of scenario, as presented in the PA, seems entirely independent of cause from the original and continued claim by the author that the original groundwater conceptual model was incorrect.

Conclusions: In summary, the Proof Report presents a weak, incomplete, highly speculative, and scientifically indefensible analysis of the geologic, hydrologic, and climate data. More specifically:

- The conclusion that the Culebra and Rustler formations in the vicinity of the WIPP exhibit have evidence of karst formation is not supported by any evidence collected to date nor by analysis of any other credible geoscientists.
- The conclusion that groundwater in these formations is in direct contact with that in overlying formations is not supported by any evidence or studies.
- As documented, methodology and information are insufficient and therefore, obstruct a qualified reader's attempt to follow the author's reasoning; this in turn, impedes the reader's ability to independently verify the author's conclusions.

Therefore, arguments presented in the Proof Report to the effect that the conceptual model of groundwater hydrology at the WIPP site is flawed are neither valid nor relevant to the evaluation of the *CRA-2*.

Recommendation: This issue should be considered closed unless the author or others present additional new information that warrants another evaluation.

Report prepared by:

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