Department of Energy
Office of Civilian Radioactive Waste Management
Yucca Mountain Site Characterization Office
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JAN 30 1997

OVERNIGHT MAIL

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SUBMITTAL OF PARTICIPANTS' MONTHLY STATUS REPORTS

As you have requested, the U.S. Nuclear Regulatory Commission is on distribution to receive a copy of the Yucca Mountain Site Characterization Project participants' monthly status reports on a regular basis. Enclosed is the U. S. Geological Survey Progress Report for December, 1996.

If you have any questions, please contact April V. Gil at (702) 794-5578.

for Stephan J. Brocoum
Assistant Manager for Licensing

AML:AVG-0815

Enclosure: (NOT RECORD MATERIAL)
U.S. Geological Survey Monthly
Status Report for December, 1996

YMP-5

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IN REPLY REFER TO

INFORMATION ONLY

January 17, 1997

Wayne Kozai
Yucca Mountain Site Characterization
Project Office
U. S. Department of Energy
P.O. Box 98608
Las Vegas, Nevada 89193-8608

SUBJECT: Yucca Mountain Project Branch - U.S. Geological Survey (YMPB-USGS) Progress Report, December, 1996

Attached is the USGS progress report in the required format for the month of December, 1996.

If you have any questions or need further information, please call Raye Ritchey Arnold at (303)236-0516, ext. 282.

Sincerely,

Raye Ritchey Arnold

Robert W. Craig
Technical Project Officer
Yucca Mountain Project Branch
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U. S. GEOLOGICAL SURVEY
EXECUTIVE SUMMARY
December, 1996

WBS 1.2.3.1 Coordination and Planning

U. S. Geological Survey - Yucca Mountain Project Branch is currently processing 208 scientific papers authored by USGS authors. Of these, 113 are related to hydrologic studies and 95 to geologic studies. In addition, 52 abstracts are being processed, as well as 17 reports from LBL.

WBS 1.2.3.2 Geology

Geologic Framework

Geologic mapping in the Dune Wash area concentrated on the Dune Wash graben and on the Rainier Mesa Tuff in the Dune Wash and Solitario Canyon areas. The Dune Wash graben is a northwest-trending structure bounded on the east by the down-to-the-west Dune Wash fault and on the west by a down-to-the-east unnamed fault zone. Displacement within the latter is at least 120 m which is equal to or greater than that of the better known Dune Wash fault. The down-to-the-east block-bounding fault zone is about 100 m wide and is made up of tectonically brecciated units of the Topopah Spring Tuff. Portions of this fault zone exhibit higher degrees of oxidation, alteration, and silification relative to other faults in the vicinity. The zone splays to the south into several faults, each splay having down-to-the-east offsets of 30 m or more. The interior of the graben is structurally complex with numerous discontinuous steeply dipping faults; dips of strata in the smaller horst-and-graben fault blocks are dominantly to the east.

The northern end of the Dune Wash graben dies out just south of Abandoned Wash. The deformation within the graben merges with structures typical of hanging wall deformation associated with the Dune Wash fault. This style of hanging wall deformation associated with block-bounding faults is similar to that on the Bow Ridge and Solitario Canyon faults inasmuch as the dips of the strata increase (roll over) toward the faults. The southern end of the Dune Wash graben, which is buried by Quaternary deposits southwest of Busted Butte, seems to terminate against the down-to-the-west Paintbrush Canyon fault.

Mapping of areas containing the Rainier Mesa Tuff in Dune Wash and Solitario Canyon has shown that the angular unconformity between the 12.7 Ma Tiva Canyon Tuff and the 11.45 Ma Rainier Mesa Tuff is relatively minor. Foliations within the Tiva Canyon at Plug Hill (in Solitario Canyon) dip about 12 degrees, similar to the dip of the welding contact in the overlying Rainier Mesa. Earlier mapping by Scott and Bonk in that area showed the contact to be the result of post-Tiva Canyon, pre Rainier Mesa deformation and erosion. The new mapping, however, provides evidence that the contact relations resulted from post-Rainier Mesa faulting (down-to-the-southwest), with the same amount of offset of units within each formation, and that significant erosion did not occur prior to Rainier Mesa time. At the south end of Dune Wash, on the other hand, there is a 5 to 8 degree angular unconformity at the base of the Rainier Mesa, implying that a modest amount of deformation took place that post-dated the eruption of the Tiva Canyon Tuff,

but pre-dated the eruption of the Rainier Mesa Tuff in the southern part of the Dune Wash graben.

Collection of fault and fracture data continued on the south side of Busted Butte as part of the detailed study of the interaction between faulting and fracturing associated with block-bounding faults. To date, fracture data have been collected in portions of the lower vitric section of the Tiva Canyon Tuff, bedded tuffs underlying the Tiva Canyon, and the crystal-rich and upper lithophysal units of the Topopah Spring Tuff from the hanging wall of the major fault cutting Busted Butte. Sketch mapping and preparation of preliminary cross-sections of the major fault have begun, with detailed mapping to commence following receipt of orthophoto base maps. Comparisons of data collected from surface geologic mapping and from full-periphery mapping and detailed line surveys in the ESF to evaluate structural controls of 36-Cl are continuing.

The proposed southern tracer complex at borehole UE-25 WT#17 is designed to test a potentially significant, structurally controlled hydrologic pathway near the margin of the potential repository. Faulting and fracturing in the proposed tracer complex area, however, is much greater than that in the central part of the repository areas as evidenced by the presence of numerous steeply dipping faults. A more representative area for the tracer tests would appear to be on Yucca Crest, which is a much less faulted area that is directly correlative with the setting of the potential repository.

A table showing the revisions and reevaluations of eleven lithostratigraphic contacts from 37 boreholes was completed and submitted (Milestone SPG21M4). Project staff participated in planning meetings for the preparation of sections for the Site Description report. At the meeting in Berkeley (December 17), discussions were held with LBL and other M&O personnel regarding alternative interpretations of regional geophysical data across Yucca Mountain. Some of the differences in interpretations are yet to be resolved, but there was agreement that the "step" in the Paleozoic strata in the vicinity of the Ghost Dance fault is not caused by the fault. The manner in which geophysical data are to be integrated and presented in the Site Description report is under further consideration by all parties involved.

Geologic mapping of the south ramp of the ESF was accomplished as follows: (1) full periphery geologic mapping was completed to station 70+48, (2) detailed line survey at the heading was completed to station 70+53, (3) detailed line survey in Alcove #6 was completed to station 1+27, (4) stereophotography was completed to station 70+49.80, and (5) stereo-photography in Alcove #6 was completed from station 0+30 to 0+88.

Seismotectonic Studies

As part of the probabilistic seismic hazard analysis (PSHA) effort, a report (Milestone SPG28IM4) was completed that summarizes (1) the alternative tectonic and seismicity models that were presented to the Seismic Source Characterization Panel at the November workshop (held in Pahrump, NV), and (2) the issues discussed during the 2½ days of field trips to localities at Yucca Mountain that were conducted at that time. Preparations were made and agendas finalized for the Seismic Source Interpretations workshop to be held January 6-8 and for the

Ground Motion Models and Interpretations workshop to be held January 8-10, both in Salt Lake City.

PSHA staff met with DOE engineers and Geomatrix personnel in Oakland, CA, to discuss the kinds of data, hazard assessments, and hazard curves that will be made available to the DOE seismic design team. Most of the discussion focused on fault displacement values for the potential repository block and the engineering significance of these values. Project personnel also participated in meetings to discuss the preparation of sections for the Site Description report.

WBS 1.2.3.3 HYDROLOGY

Regional Hydrology

Work continued on the analysis and interpretation of regional precipitation data.

Closing calibrations of the tipping-bucket rain gages were completed. Sites for the locations of 17 precipitation gages were identified. Eleven sites were instrumented and brought on line.

Formatting the meteorological data for FY96 for the two weather stations active during that time was completed. Work began on compilation of the data package, with technical review expected to begin by late January.

Project staff has completed computing and checking daily discharges for the three recording streamgage sites on Fortymile Wash. A technical reviewer has not yet been selected.

During the month of December, routine maintenance was performed on the three recording streamflow gages located along Fortymile Wash. Project staff awaited potential precipitation during the month as several storm systems tracked through southern Nevada. Runoff was not observed nor reported during the reporting period for the three gages.

In preparation of data intended for initial regional-flow model simulations, maps of past discharge areas obtained from the USGS Climate Team were examined and digitized. Staff began creation of MODFLOWP input arrays (IBND, STRT) from the digital maps.

Possible future recharge and recharge areas were discussed, and a scenario for an initial simulation has been formulated.

Staff began preparations for work with the regional model with examination of MODFLOWP documentation and review of the regional-modeling report.

In unscheduled work, the regional-flow modeling team worked on revisions to the regional potentiometric-surface map report, in preparation for re-submittal for approval. Revisions were also prepared for the regional modeling report in support of publication. Review was performed on the scientific notebook documenting work done on the regional flow model. Additional revisions were made to plates and figures for other approved reports related to the regional flow modeling effort.

Unsaturated-Zone Hydrology

In work on infiltration processes, comparison continued of results of simulated precipitation obtained from the Global Climate Model to the results obtained using historical data from the regional precipitation gage network. A geostatistical approach was used to develop maps of the ratio of 21-ka paleoclimate average annual precipitation (corresponding to the full glacial-maximum climate) and double-CO_2 average annual precipitation (corresponding to the greenhouse climate) to current-climate average annual precipitation. The ratio maps were then combined with the co-kriged map of average annual precipitation developed for the Death Valley Basin to obtain detailed maps of the two potential future climate scenarios. The detailed maps provide results which are representative of the orographic effect on precipitation in the Death Valley Basin. The two maps were applied using the modified Maxey-Eakin models of recharge to obtain detailed maps of potential future average annual recharge for the Death Valley Basin.

Work continued on developing an improved version of the bucket sub-model using a cascading bucket approach which would allow for improved modeling of the root zone. Two versions of the cascading-bucket model were completed and tested; the first version does not allow for unsaturated flow to occur at water contents less than field capacity (the simple cascading-bucket model), while the second version allows for unsaturated flow to occur at water contents above a residual value which is less than field capacity (the redistributing cascading-bucket model). Preliminary results were completed and presented for expert elicitation. Work on calibrating the dynamic root-zone sub-model of the cascading-bucket models was continued. Work also continued on improving the Richards equation sub-model.

Several additional figures were prepared for inclusion in the Main Drift Hydrology report. Work on the text of this report was initiated, but only a limited amount of time was available to work on this report during the reporting period because of holidays and personnel end-of-year leaves.

Compilation of borehole monitoring data (pneumatic-pressure, temperature, and water-potential data) was finalized in completion of Level 4 **Milestone SPH22GM4** [Monitoring data April to September 1996 to RPC], reported in a memo to the TPO, and submitted to the RPC.

In analysis of borehole monitoring data, pneumatic data from instrument station "B" located in the basal vitrophyre of the Topopah Spring Tuff in SD-12 indicate the presence of diurnal and synoptic signals in the pressure record. These signals have been present in the pressure record from this station since this borehole was first instrumented in November 1995 but have only recently been recognized. These signals appear to be superimposed on a seasonal pressure signal that is severely lagged and damped with respect to the surface barometric pressure signal. The phase of the synoptic and diurnal signals that are present in this record, however, is coincident with the phase of the surface synoptic and diurnal signals. These signals also lead the synoptic and diurnal pressure signals that are present in all of the overlying Topopah Spring stations. A preliminary analysis of these data suggest that the superimposed signals may be the result of atmospheric loading and/or Earth-tide effects. An analysis of the pressure record from station "C" located at the base of the lower non-lithophysal subunit of the Topopah Spring Tuff also indicates

the presence of a synoptic signal component (with zero phase-lag) superimposed on a larger-amplitude signal derived from barometric pumping. The presence of this zero phase-lag signal accounts for the higher amplitude and the earlier arrival of the composite pressure signal that has been observed at the base of the Topopah Spring Tuff when compared to the pressure records of all overlying Topopah Spring stations in SD-12. These observations will be addressed in the Main Drift Hydrogeology report.

In matrix-property studies, analyses have continued on unsaturated conductivity measurements for two core samples to improve the fit of predictive equations. Efforts to improve the high-saturation portion of moisture-retention data encountered several problems in methodology using pressure plates. Other methods are currently being tried for collection of the wet-end moisture-retention data. It needs to be determined if the accuracy and resolution of the data in this region of the moisture-retention curves result in moisture-retention parameters that cause significant changes in the predicted unsaturated conductivities. The rotor on the centrifuge is currently not operational and is being evaluated by the manufacturer.

Data collected from Ghost Dance fault Alcove #6 borehole 1-A were evaluated, and some of the samples are being resaturated to remeasure core volume. Samples from borehole 1 in Alcove #6 were received. The collection of systematic samples from the main drift was completed, and bulk properties were determined on all 70 samples. Extensive variability in porosity and particle density in certain regions will be compared with data collected from surveys that were conducted to determine the frequency of occurrence of calcite deposits along the main drift. It will be determined if there are correlations of properties with mineralization, or if there may have been a systematic sampling bias.

In unsaturated-zone borehole instrumentation and monitoring, borehole data from NRG-7a, UZ#4, UZ#5, UZ-7a, and SD-12 were transferred to Denver, converted to engineering units, and archived to optical disk on a routine basis throughout the month. Daily EKES files were checked for any shelter activity. Sensor readings were checked daily as well for unusual occurrences, and any statistical outliers were flagged as such. No field or lab standards required calibration during this reporting period. Three pressure transducers were calibrated for the ESF air-permeability testing program.

Several trips were made to field sites. Two trips to NRG-7a were made to retrieve data manually, and three trips were made to remedy generator failures. Seven trips were made to UZ-7a. One trip was made to retrieve data manually. The other six trips to UZ-7a were made to change out the generator and to fix generator-related problems.

Seven trips were made to SD-12. One trip was made to retrieve data manually and to restart data collection because of a failure of the phone line to the site. Two trips were made to reset the computer clock. Two trips were made to perform a backup on the computer system, and two additional trips were made to modify the sensor monitoring configuration.

Seven trips were made to UZ#4 and UZ#5 to investigate a major malfunction of the data collection system at this site. Beginning on November 21 (during a major storm), spurious

readings from all psychrometers and three pressure transducers in these two boreholes were recorded. Source of the spurious psychrometer readings has been traced to several burned-out nanovolt relay cards in the data acquisition system. Source of the spurious pressure transducer readings has not yet been located. A major generator failure, somehow associated with the storm event of November 21, 1996, is believed to be responsible for the system malfunctions that have been observed. A major rewiring of the data collection system will be needed to fix the system. This is anticipated for January 1997.

Air-permeability studies continued in the Ghost Dance fault alcoves. After deepening of the Ghost Dance fault alcove, a second geothermal log was run in the North Ghost Dance fault (NGDF) borehole. Following successful geothermal logging, a SEAMIST liner was installed in the geothermal borehole, and gas samples were collected from sample points in and around the Ghost Dance Fault. The SEAMIST was then connected to a pressure transducer, and pneumatic monitoring begun. The pneumatic monitoring will be conducted into early January 1996 to insure that the monitoring period includes at least two low-pressure periods.

Results of the second geothermal borehole log show that the early temperature decrease over the Ghost Dance fault no longer exists. This indicates that the original temperature drop may have been due to evaporative cooling during drilling and not due to fluid movement in the fault.

Collection of temperature and relative humidity data continued at four sites in the ESF. Wind speed data are currently being collected at two locations (near Alcoves 3 and 4). Barometric pressure, temperature, and relative humidity are being collected in Alcove 4. Collection of data from four heat dissipation probes in Alcove 3 continued.

A project designed to preserve the in-situ water content of selected sites in the tunnel continued. Plastic sheets (1.5 x 1.5 m) are being attached to the tunnel wall (below the spring line) using nails and silicon sealer. These selected locations may be sites of future sampling and/or instrumentation locations. To date, approximately 21 pieces of plastic have been installed. As the TBM advances, additional plastic will be installed.

Sets of tensiometer and heat dissipation probes continued to monitor the dry-out of the tunnel wall. To date, a total of eight tensiometers and eight heat dissipation probes have been installed at two locations. Based on the results of this test, additional tensiometer and heat dissipation probes will be installed at selected locations in the south ramp.

Seventy-one rock samples were collected along the main drift of the tunnel. Rock samples were collected from stations 29+00 to 57+00. The samples were collected every 40 meters and are being used to determine variation in particle density, porosity, bulk density, and permeability within the proposed repository horizon. The samples have been processed, and the data are being assembled for a data package.

Standard data formats have been developed for the various types of data being collected. The data, calibration records, and field notes are being assembled into a data package for submittal.

The data package "Chemical and Isotopic Composition of Pore Water and Pore Gas, 1994-96, From Boreholes UZ-1, UZ-14, UZ #16, NRG-6, NRG-7/7A, SD-7, SD-9, SD-12, and the ESF" was submitted to the RPC.

The draft milestone report on UZ hydrochemistry (*Interpretations of chemical and isotopic composition data and geochemical modeling (NETPATH) in the unsaturated zone, Yucca Mountain, Nevada*) was completed. The report received two technical reviews from USGS isotope-studies staff. Comments were resolved after revisions, and the report went to the QA office and the Reports Unit for additional reviews.

Data from water collection by compression and distillation during December was recorded in the water-collection database. In addition, water samples analyzed for tritium during December were recorded in the tritium database.

In work related to the SD-12 borehole, sixteen storage cylinders were leak-tested and heat evacuated to remove residual CO_2 gas. The cylinders will be used to store CO_2 gas samples degassed from molecular collection cylinders.

Analytical efforts continued in study of aqueous ions, stable isotopes, tritium and carbon systems. Forty-four core samples (from SD-9, SD-7, and NRG-7/7A boreholes) were distilled. The extracted pore water will be analyzed for tritium and stable isotopes. Ten UZ water samples (four from SD-7 and six from SD-12) were prepared for tritium analysis and counted for tritium concentrations. The data have been reduced.

Results of stable isotope compositions for 34 pore waters from NRG-7a and SD-7, -9, and -12 boreholes were received. The data were entered into the computer and plotted.

A gas sample, collected by extracting dissolved CO_2 from pore water in NRG-7/7A core samples using the newly designed and constructed CO_2 distillation rack, was prepared and shipped to Beta Analytical for ^{14}C analysis.

Development of conceptual and numerical models of flow in UZ fractured rock was completed with a letter to the TPO [Level **4 Milestone SPH21AM4:** Fracture network flow model of the Topopah Spring Welded Unit in the ESF] describing development of this fracture-flow model

In unscheduled work, staff attended the NRC/DOE/UA Appendix 7 Meeting in Phoenix and Tucson, Arizona. The meeting included a tour of the hydrologic studies site at Apache Leap and presentations of work being conducted there, as well as a tour of the Radiocarbon Laboratory at the University of Arizona. Staff also attended the Workshop on Yucca Mountain Total System Performance Assessment-Viability Assessment-Abstraction Testing, held at Sandia National Lab December 11 and 12. Staff also prepared and presented results of preliminary fracture modeling for the Topopah Spring Tuff at the TSPA-VA workshop.

Saturated Zone Hydrology

Preparation of a memorandum intended to describe the planned USGS purely-convergent tracer test in C-hole wells continued in December. However, because this tracer test has not yet taken place, this memo will focus largely on the processing of data obtained at the C-hole complex from July 1 to December 31, 1996. Iodide data produced by LANL for UE-25 c#3 samples are being analyzed by the USGS to derive antecedent iodide concentration curves and injected concentrations and to predict results from the upcoming purely-convergent tracer test. The USGS is attempting to obtain the tracer concentration data resulting from the LANL partial-recirculation reactive test for analysis.

On December 16, 1996, the State of Nevada issued a letter approving the injection of the requested amounts of Pyridone and 2, 6 DFBA.

Due to an accident that occurred in the ESF, the DOE conducted a Readiness Review and determined that Job Package 95-08, which governs the work at the C-hole complex, should be upgraded to include a Job Safety Analysis. The current plan calls for all safety controls to be in place and approved by the DOE by January 3, 1997, and for the purely-convergent tracer test with near-simultaneous injections of Pyridone into UE-25 c#1 and 2,6 DFBA into UE-25 c#2 to be initiated during the week of January 6.

A variety of efforts in support of water-level measurements continued during the period. The network includes 31 zones in 24 wells to be measured manually. All hourly measurements of wells for the ground-water network were discontinued during September 1996 due to budget constraints. However, in support of the aquifer testing conducted at well USW G-2 and at the C-hole complex, selected wells are being monitored hourly with transducers and 21X data loggers. This monitoring will continue until aquifer testing at these two sites is complete.

For the month of December 1996, 32 manual measurements were completed. Six zones in five wells were monitored hourly with transducer measurements. Well USW G-2 has been monitored since January 1996 in support of hydraulic testing of the well. This test was completed on December 17. Well UE-25 p#1 is being measured hourly in support of C-hole testing. Measurements continued at wells UE-25 WT#3, UE-25 WT#14, and USW H-4 (upper and lower intervals).

The following water-level measurements were made: UE-25 WT#3 on December 2; UE-25 WT#14 and UE-25 p#1 on December 3; USW H-4 (upper and lower intervals) on December 4; UE-25 WT#4, UE-25 WT#6, UE-25 WT#16, and UE-25 WT#13 on December 9; UE-25 WT#15, USW WT-2, UE-25 b#1 (upper interval) and USW H-1 (tubes 1, 2, 3, and 4) on December 10; USW WT-1, USW H-3 (upper and lower intervals) and USW H-5 (upper and lower intervals) on December 11; USW VH-1, USW WT-7, USW WT-10, USW WT-11, and USW H-6 (upper and lower intervals) on December 12; USW UZ-14, J-11, J-12, and J-13 on December 16; and USW G-2 on December 17.

Several items of equipment were calibrated. Transducer SN 621313 was calibrated in well UE-25 WT#3 on December 2; transducer SN 592473 in well UE-25 WT#14 and transducer SN 670689

in well UE-25 p#1 were calibrated on December 3; and transducer SN 592474 in USW H-4 (upper interval) and transducer SN 621287 in the lower interval were calibrated on December 4. New Paroscientific transducers SN 59296 and 65021 were received during November 1996. Factory calibration of each transducer was reviewed and accepted during December 1996. A field calibration check of Paroscientific transducer SN 6241, which was installed at well USW G-2, was completed on December 17. Transducer SN 6241 and Setra barometer SN 588128 was removed from well USW G-2 on December 17. The single-well aquifer test of USW G-2 was completed, and all data collection equipment was removed from the well on December 17.

Data were downloaded from 21X recorders at wells USW G-2, H-4 (upper and lower zones), UE-25 WT #3, UE-25 WT #14, and UE-25 p#1.

A report entitled *Water levels in the Yucca Mountain area, Nevada, 1995* received Team Chief approval and was submitted to the Reports Unit for preparation for colleague review on December 17.

A report entitled *Analysis of water-level data in the Yucca Mountain area, Nevada, 1985-95* with Director's approval as USGS-WRIR-96-4526 has undergone correction and final editing, with text and tables submitted to the Colorado District Publications Unit for manuscript preparation..

Graves, Robert P., Tucci, Patrick, and O'Brien, Grady M., *Analysis of water-level data in the Yucca Mountain area, Nevada, 1985-95*, U.S. Geological Survey Water-Resources Investigations Report 96-4526, *in press*.

A report describing water-level monitoring in 28 wells in the Yucca Mountain vicinity during 1994 was received from the printers. Water-level altitudes in the Tertiary volcanic rocks ranged from 728 to 1,034 m above sea level, and the mean level in the Paleozoic carbonate test was about 753 m above sea level. These levels average 0.01 m lower than the 1993 levels.

Graves, Robert P., Tucci, Patrick, and Goemaat, Robert L., 1996, *Water levels in the Yucca Mountain area, Nevada, 1994*, U.S. Geological Survey Open-File Report 95-757, 101 p.

Work continued on preparation of potentiometric-surface maps that will be used for geohydrologic framework model calibration and for the synthesis report. Analysis also continued of water-level fluctuations to estimate hydraulic properties of the saturated zone rock units. Input was requested from several individuals throughout the Project, concerning hydraulic characteristics of faults in the vicinity of Yucca Mountain.

The finite-difference grid for the MODFLOWP model was revised, following discussions with several individuals. Work began on obtaining flux information from the calibrated regional flow model for use in the MODFLOWP model.

Staff continued to refine the grid-spacing of the framework model to 250 meters. The model was regridded and visually inspected.

Work continued with LANL personnel to solve problems in generation of the finite-element mesh to be used with the FEHMN flow model. The source of the problem in the GEOMESH software appears to have been found, and a simple test mesh was generated. Checking of that mesh continued, while LANL generates a new mesh for the site model.

It is anticipated that the milestones [SPH24FM4: updated geohydrologic framework model submitted for review; and SPH24BM3: saturated-zone flow model] will be met. Concerns still exist, however, as to how well-calibrated the flow model will be by the time the milestone is due. There will be results on which to report and use for PA, but additional refinement to the flow model will probably be required. Weekly reports are being submitted, in order to provide all concerned with up-to-date status information. A meeting is planned for January 16, in Denver, to update all concerned with progress and plans for the flow modeling and to discuss any concerns that people may have.

Staff continued to revise early drafts of sections of the site saturated-zone synthesis report. The annotated outline is essentially complete. Because it is unsure at this time as to which flow model (FEHMN or MODFLOWP) will be documented in the report, however, those parts of the report remain open.

In work on the sensitivity analysis of the saturated-zone flow model, efforts continued into investigation of perched water occurrence at well USW G-2, and staff worked on a report documenting hydraulic testing at G-2. Discussions considered use of different flow models (FEHMN and MODFLOWP) to investigate alternate conceptual models of the site hydrology.

Efforts continued on planning a workshop (in conjunction with SNL staff) that will address critical issues on SZ flow modeling and the transfer of information obtained in process modeling for use by PA modelers. An interim meeting to update interested parties on the status of the site flow models is planned for mid-January.

In unscheduled work related to these efforts, staff prepared and submitted software QA documents for MODPATH (particle-tracking) software for technical review. Revisions were made to a report documenting aquifer tests at three wells in 1995, and the report was submitted for preparation of camera-ready copy. Work also continued on documenting results of hydraulic testing at well USW G-2 during 1995. Additional staff was shifted to the modeling unit to provide computer, technical and GIS support, freeing up staff time for efforts on the site flow model.

WBS 1.2.3.6 Climatology and Paleohydrology

Staff continued collection and compilation of diatom data from Owens Lake, California, to establish a regional climate history for the past 500 ky. In addition, staff continued assembling hydrologic and climatic data for the Owens Lake region to develop analog models for determining precipitation and temperature changes over the past 400 ky.

Galley proof examination was completed of a paper to be published in Quaternary Science Reviews entitled *A diatom record of climate and hydrology for the past 200 ky from Owens Lake, California*.

Staff initiated extraction of ostracodes from prepared sediment residues for inclusion in the baseline dataset. Preparation continued of diatom samples from Owens Lake cores and from analog sites. Sample preparation has been impeded by partial shutdown of the lab in preparation for move to new quarters.

Climatology staff spent a week collecting various samples within areas down the flow gradient from Yucca Mountain to evaluate the degree and nature of past discharge and flow within that ground water system

Approximately 100 ostracode samples for isotopic analyses were prepared and submitted for analysis.

In planning for the climatic synthesis report, staff from the USGS, the Desert Research Institute, NOAA, DOE, and Dames & Moore (Las Vegas) conducted a climate roundtable on December 18 and 19 in Denver. The purpose of the meeting was to discuss the methods used by the participants to reconstruct past climate from proxy datasets and to discuss the potential strengths and weaknesses of those methods. Plans were made for output of climate parameters for the Yucca Mountain region for various late Pleistocene intervals.

Staff (J.P. Bradbury) prepared a manuscript discussing the application of fossil diatom assemblages from cores to interpret long-term paleoenvironmental records. The manuscript will be a chapter in a book entitled *Application of Diatom Studies to Environmental Research* to be published by Cambridge University Press.

Staff spent three days in the Yucca Mountain vicinity examining discharge deposits and collecting samples for isotopic, geochronologic and paleontologic analyses. Several stratigraphic sections 5 to 6 meters in thickness were collected from deposits in the Amargosa River Valley at the distal portion of the Fortymile Wash fan (informally, Stateline deposits). In all cases, the sections consisted of fine-grained sediments (fine sand through clay) with variable amounts of authigenic carbonate or silica cement. In no case were the sections interrupted by intercalated beds of alluvium in spite of the proximity of two major fluvial systems. This is particularly noteworthy in the case where about 6 meters of greenish-brown silts were augered through in an area of Amargosa River bottomland. Previous radiocarbon, uranium-series disequilibrium and thermoluminescence analyses of the upper portion of these same deposits yield ages of 11 to 9 ka. A field-based conclusion from these observations is that the discharge deposits formed an extensive area adequately elevated above the adjacent valley-bottom and constructionally robust enough to preclude frequent or even rare fluviation by either of the two drainage systems throughout the late Pleistocene. The lateral extent of these deposits is comparable to those at Ash Meadows and suggests that a similarly extensive system of discharge existed in the past. Samples from the sections taken in this area will be analyzed to investigate the possibility that the two ground-water systems (Amargosa/Oasis and Fortymile Wash) may have both provided recharge

sources that varied in intensity as climate shifted throughout the Pleistocene.

Additional samples were collected from discharge sites along Highway 95 and in Crater Flat to help refine the timing and sources of discharge in various areas. The distribution of sparse *Distichlis* (salt grass) at one of the sites (Crater Flat deposit) was mapped on air photos and was found to be restricted to the eastern end of the main badlands area despite identical lithologic units exposed at the surface to the west. Within this range, *Distichlis* occurs both in swales as well as mound-tops. The cause for this distribution is unclear; however, it does not support the hypothesis of a shallow, wide-spread aquitard and perched water zone that can explain both the wide extent of the fine-grained deposits and the restricted distribution of salt grass.

A total of 42 samples plus 57 subsamples were collected, described, and logged into the HD sample tracking system, and five new thermoluminescence samples were logged into the TL sample tracking system. The line survey of secondary mineral occurrence database was updated by including new data collected on the December field trip, and staff also logged the ESF samples collected in December into the HD sample tracking system.

Thirteen subsamples of outermost opal and calcite from nine secondary mineral occurrences in the ESF between stations 51 and 63 were prepared, and chemical separation of U and Th for all of these samples was also completed. Isotopic measurements on all subsamples were completed. Of the data that have been reduced, ages range from 50 to over 300 ka with several calcites yielding undefined ages due to excess ^{230}Th. Calculated initial $^{234}U/^{238}U$ activity ratios range from 6 to 8 for subsamples with ages less than 100 ka, compared to values less than 2.5 for samples with ages greater than 200 ka.

Two days were spent by staff in the ESF collecting samples and documenting the occurrences of secondary minerals. Eight samples of fracture and cavity coatings were collected between station locations 69+42 and 66+88. One sample was collected at station 64+12, but completion of sampling activities between Stations 64+00 and 67+00 will await the next sampling trip. The North Ghost Dance Alcove was also examined for secondary mineral occurrences, and one sample was collected at 117.5 m. In addition to sampling, the distributions and descriptions of mineral occurrences were documented over 30-m intervals between ESF stations 69+00 and 64+00, and between 48+00 and 34+00.

Work continued on a manuscript devoted to the description of the continuous deposition model described in the FY96 administrative report. First drafts of all figures and tables were completed.

Eight subsamples of outermost opal samples from the ESF were prepared for U-Pb analyses. Subsamples were submitted to Y. Amelin on contract at the Jack Satterly Geochronology Lab, Royal Ontario Museum. Samples were submitted to test the applicability of U-Pb dating of the youngest, ^{234}U-enriched opals by techniques typically reserved for more ancient materials.

Y. Amelin (Jack Satterly Geochronology Lab, Royal Ontario Museum) transmitted results of U-Pb isotopic analyses of 32 opal residues, four leachates, three calcites and two secular-equilibrium standards. Reduction of data and graphical representation of results continued, including investigation of methods of solving U-Pb equations that incorporate initial $^{234}U/^{238}U$ disequilibrium and evolution with time. Preliminary results for young opals are generally consistent with previously obtained uranium-series disequilibrium results with ages between 100 and 500 ka and

initial $^{234}U/^{238}U$ activity ratios between 4 and 10. The young ages obtained for these materials using this technique are a remarkable testament to the technical capability of the analyst and the uniqueness of the materials themselves. Preliminary results for the stratigraphically older materials generally confirm that deposition was initiated during the Tertiary and indicate that average rates of deposition may have been more or less constant over the last 10 Ma. These results do not support the hypothesis that deposition reflects a more-recent phenomenon related to the arid climate typical of the Quaternary period (last 2 million years).

Staff drafted responses to an M&O memo concerning assumptions of unsaturated zone fluxes and a change in the strategy of waste isolation within the repository block. These responses were sent to the USGS-TPO where they were incorporated with comments from other YMPB staff as an official response.

Preliminary investigation continued into running radium isotopic analyses by mass spectrometry. A NIST ^{226}Ra standard was gravimetrically diluted and will be used to calibrate the ^{228}Ra spike. A working standard of the two solutions was prepared, and several test runs were made on the mass spectrometer. The $^{226}Ra/^{230}Th$ geochronometer is being developed to provide further constraints on the younger end of the age spectrum for opal (less than 10 ka) and to test for unsupported ^{226}Ra in calcite as an indication of the youthfulness of outermost layers.

Preliminary evaluation was completed of strontium-isotope analyses obtained from soluble salts leached out of 30 USW SD-7 core samples. Strontium-isotope ratios ($^{87}Sr/^{86}Sr$) in the Tiva Canyon Tuff (TCw thermo-mechanical unit) increase slightly but systematically with depth from values characteristic of surface waters and carbonate coatings on bedrock surfaces (ratio about 0.7117). Isotope ratios increase dramatically through the Paintbrush nonwelded unit (PTn) and then generally stabilize downward through the Topopah Spring Tuff (TSw) at values closer to those of surficial calcretes in alluvium (about 0.7124). Strontium-isotope ratios deep in the TSw reach values as high as 0.7127, perhaps reflecting additional rock-water interaction. This trend could be explained by two isotopically distinct input waters--one recharging directly onto the ridge crests through bedrock (TCw) and the other recharging through valley-floor alluvium into the PTn, followed by mixing of these end-members and deep percolation of the mixture to produce the observed ratios in the TSw. Two samples from the Calico Hills formation suggest a reversal of the depth-wise increase of $^{87}Sr/^{86}Sr$ and perhaps indicate yet another source of water. These studies provide important constraints, through mass balance relations, on large-scale infiltration and percolation processes.

The strontium isotopic databases were updated to take advantage of relational capabilities and to make data entry easier. There is now less duplication of data, and standard data are handled automatically.

In unscheduled work, staff finalized 12 thermoluminescence analyses on samples associated with geomorphic evolution of the Fortymile Wash drainage system, as well as surface deposits from northern Crater Flat, Rock Valley and Frenchman Flat. Staff participated in the TSPA-VA unsaturated zone workshop at Sandia on December 11 and 12, including a short presentation of data from secondary mineral and pore-water studies pertinent to modeling of the UZ flux. In addition, staff attended the Geology-PISA meeting at LBL on December 17. The meeting was dominated by discussion of site geophysics and the 3-D model of the site area.

WBS 1.2.3.9 Special Studies

The principal investigator and six others from the USGS attended a meeting with DOE and the M&O on December 17 to finalize outlines of PISA chapter 2.3 (Geological Systems) and to hear presentations on the geophysical and 3-D model inputs to the final chapter.

Final outlines of subsections on site stratigraphy, site structure, regional geology, and seismicity were submitted to the M&O. Final input for the tectonics and surficial process sub-chapters is in progress.

The principal investigator and three others from the USGS met on December 16 with the M&O, staff from LBNL, Tom Brocher, from the USGS Geologic Division, and George Thompson, from Stanford University, to discuss the disparity in interpretations of the geophysical data about the configuration of the Paleozoic-Tertiary contact. The hypothesized connection between the Ghost Dance fault and an apparent offset in the basement has been clarified. Other geophysical data suggest that the offset may arise from another unnamed structure in the Paleozoic section which coincidentally crosses the seismic profile beneath the approximate location of the Ghost Dance fault. Disagreement remains as to the amount of relief in the pre-volcanic basement.

The first phase of preparing the detailed content outline for PISA Chapter 2.4 (Hydrology) was completed. In accordance with summary account planning, the outline will be updated to reflect actual content when the initial draft input to the chapter is received from all authors, planned for August 1997. A meeting was held in Denver on December 3 between DOE, M&O/SPO, and USGS representatives to discuss progress in preparing the content outline, USGS staff assignments, and possible changes to the content guidelines contained in Appendix A of the PISA Management Plan.

The detailed content outline for PISA Chapter 2.4 (Hydrology) was submitted by memorandum to the USGS TPO on December 13, completing Level 4 **Milestone SPH391M4** [Memo to TPO: Detailed Content Outline].

Preparation of the Hydrology chapter of the PISA report was initiated on schedule. However, there remain many still-unresolved issues regarding the availability of needed staff during the time interval scheduled for this task.

The USGS Technical Lead for the Site Characterization Progress Report (SCPR) received from the M&O and resolved several comments on Appendix A of SCPR #15 made by DOE-YMSCPO staff. Appendix A consists of Investigation-level summaries of the differences between the SCP published in 1988 and the current characterization program. The most controversial and difficult to resolve comment involved the Project decision not to drill the three additional geologic holes called for by the SCP. These holes would have provided stratigraphic and structural information that would have reduced uncertainty regarding two important site features: the Tertiary-Paleozoic contact under Yucca Mountain, and the large hydraulic gradient. Originally, the USGS wanted to use the Appendix A narrative to highlight the differences in the two competing models of the Tertiary-Paleozoic contact based on interpretation of seismic-reflection data. The matter was resolved when the USGS agreed to drop discussion of the two interpretations as long as the

critical connection between the geologic holes and the two site features was retained.

The USGS Technical Lead for the SCPR prepared a presentation on the content of SCPR #15 Appendix A for USGS studies. The presentation consists of 31 overheads with bullets addressing various SCP investigations and studies in the Geohydrology, Rock Characteristics, Climate, and Tectonics Programs. The presentation will be given at the January USGS Planning/Progress meeting.

In unscheduled work, the USGS Technical Lead for the SCPR submitted comments to the USGS TPO on E. Taylor's (M&O) proposed "new performance concept" for a repository at Yucca Mountain. Taylor's concept emphasizes various engineering measures to be implemented in repository design, construction, and operation to overcome perceived shortcomings in and uncertainties about the natural-barrier system. In addition, the USGS Technical Lead for the SCPR began revising the text for the North Ramp UZ Hydrogeology report in response to the technical edit performed by the Colorado District Publications Management Unit. Major revisions that must be made to allow publication as a USGS Water Resources Investigations Report include 1) elimination of the hierarchial numbering system for report sections, figures, and tables; 2) conversion of all English units to metric units; and 3) adoption of specific terminology and word usage that are more consistent with USGS report style. The editorial review was detailed and comprehensive and will be very useful for finalizing the report text for publication.

WBS 1.2.13.4.7 Water Resources Monitoring

Ground-water levels were measured at 29 sites, and discharge was measured at one flowing well. In work at site MV-1, staff coordinated USGS water-level measurements within the pump-discharge column, measured the altitude of the new measuring point, and measured water level in that well. Staff coordinated concurrent steel- and electric-tape measurements with USGS-ESIP personnel planned for January. Ground-water data collected during November were checked and filed. Continuing water-level measurements in the pump-discharge column at site MV-1 will be considered following a review of water-level data for the site.

In support of the FY97 Environmental Program, staff met with National Park Service (NPS) personnel to discuss potential methods for improved water-use monitoring in the Amargosa Desert and analyses of NPS data from Devils Hole. Preparation of electronic data files for 1995 data was completed, and the files were forwarded to USGS-YMPB for submittal to the YMP Technical Data Base. Checking of the NWIS database for consistency with previously stored and reported data following a merge of USGS-NV District and USGS-ESIP databases continued during the reporting period.

USGS Level 3 Milestone Report

October 1, 1996 - December 31, 1996

Sorted by Baseline Date

Deliverable	Due Date	Expected Date	Completed Date	Comments
LETTER REPORT	11/1/96	10/30/96	10/30/96	
Milestone Number: SSH13BM3				

USGS Level 4 Milestone Report

October 1, 1996 - December 31, 1996

Sorted by Baseline Date

Deliverable	Due Date	Expected Date	Completed Date	Comments
Memo to TPO: SS Hazards Methodologies Wrkshop **Milestone Number:** SPG28FM4	10/25/96	10/24/96	10/24/96	
Memo to TPO: Jan-Jun96 Perio Wtr Lvl Data to RPC **Milestone Number:** SPH21CM4	10/31/96	10/30/96	10/30/96	
Memo to TPO: SS Hazards Method. Wrkshop Summary **Milestone Number:** SPG28GM4	11/15/96	11/14/96	11/14/96	
Memo toTPO: Seis. Src. Mdls & Proponents Wrkshop **Milestone Number:** SPG28HM4	11/27/96	11/26/96	11/26/96	
Memo to TPO: Comp Frac Data Coll:Cal. Hills,Prow **Milestone Number:** SPG34M4	11/27/96	11/27/96	11/27/96	
Memo to TPO: Comp Re-Eval Priority Strat Contact **Milestone Number:** SPG21M4	12/13/96	12/13/96	12/13/96	
Memo to TPO: Detailed Content Outline **Milestone Number:** SPH391M4	12/13/96	12/13/96	12/13/96	
Memo to TPO: SS Modls & Propnents Wrkshop Summry **Milestone Number:** SPG28IM4	12/19/96	12/19/96	12/19/96	
Report: Mod Flow In UZ Frac Ntwk TS W-U in ESF **Milestone Number:** SPH21AM4	12/31/96	12/19/96	12/19/96	
Memo to TPO: Monitoring Data Apr-Sep 1996 to RPC **Milestone Number:** SPH22GM4	12/31/96	12/23/96	12/23/96	

Inc. Dollars in Thousands

Yucca Mtn. Site Char. Project-Planning & Control System
PACS Participant Work Station (PPWS)
WBS Status Sheet (WBS02)

WBS No. - 1.2

WBS Title - Yucca Mountain Project

Parent WBS No. - 1.0

Parent WBS Title - Mined Geologic Disposal System

Element ID - 12

Statement of Work:

See the current WBS Dictionary

Cost/Schedule Performance

		Current Period					FY1997 Cumulative to Date					FY1997 at Completion		
Id	Description	BCWS	BCWP	ACWP	SV	CV	BCWS	BCWP	ACWP	SV	CV	BAC	EAC	VAC
1.2.3	Site Investigations	695	887	882	192	5	2640	2727	2485	87	242	11387	11475	-88
1.2.5	Regulatory	15	15	31	0	-16	94	94	71	0	23	504	502	2
1.2.8	Environment, Safety, and H	52	52	39	0	13	151	151	115	0	36	612	604	8
1.2.9	Project Management	29	29	46	0	-17	151	151	134	0	17	664	657	7
1.2.12	Information Management	7	7	5	0	2	20	20	12	0	8	80	76	4
1.2.15	Support Services	141	141	140	0	1	428	428	417	0	11	1722	1721	1
Total		939	1131	1143	192	-12	3484	3571	3234	87	337	14969	15035	-66

Resource Distributions by Element of Cost

Fiscal Year 1997

Budgeted Cost of Work Scheduled

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
LBRHRS	19540	19599	16166	21314	21406	20134	22011	22047	22404	22270	21538	20362	248791
LABOR	885	899	632	882	877	903	904	904	910	908	889	856	10449
SUBS	139	143	87	148	145	145	140	150	153	149	148	136	1683
TRAVEL	25	43	34	45	43	47	35	37	38	36	35	31	449
PM&E	7	6	7	5	9	6	7	6	9	7	5	4	78
OTHER	197	201	179	206	285	184	178	182	176	179	170	173	2310
Total BCWS	1253	1292	939	1286	1359	1285	1264	1279	1286	1279	1247	1200	14969

Actual Cost of Work Performed

LBRHRS	19283	18578	18523	0	0	0	0	0	0	0	0	0	56384
LABOR	771	712	732	0	0	0	0	0	0	0	0	0	2215
SUBS	127	139	117	0	0	0	0	0	0	0	0	0	383
TRAVEL	11	24	61	0	0	0	0	0	0	0	0	0	96
PM&E	43	16	88	0	0	0	0	0	0	0	0	0	147
OTHER	119	129	145	0	0	0	0	0	0	0	0	0	393
Total ACWP	1071	1020	1143	0	0	0	0	0	0	0	0	0	3234

Inc. Dollars in Thousands

WBS No. - 1.2 -Yucca Mountain Project

Resource Distributions by Element of Cost

Fiscal Year 1997
Estimate to Complete

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
LBRHRS	0	0	0	21321	21413	20151	22011	22047	22471	22336	21605	20362	193717
LABOR	0	0	0	901	878	968	937	902	915	914	909	876	8200
SUBS	0	0	0	141	144	147	145	149	154	149	149	135	1313
TRAVEL	0	0	0	48	44	47	36	37	38	36	37	31	354
PM&E	0	0	0	5	8	6	9	6	9	7	2	1	53
OTHER	0	0	0	227	266	182	179	183	223	199	191	231	1881
Total ETC	0	0	0	1322	1340	1350	1306	1277	1339	1305	1288	1274	11801

Resource Distributions

Fiscal Year 1997	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
BCWS	1253	1292	939	1286	1359	1285	1264	1279	1286	1279	1247	1200	14969
BCWP	1195	1245	1131	0	0	0	0	0	0	0	0	0	3571
ACWP	1071	1020	1143	0	0	0	0	0	0	0	0	0	3234
ETC	0	0	0	1322	1340	1350	1306	1277	1339	1305	1288	1274	11801

Fiscal Year Distribution

	Prior	FY1997	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	Future	At Complete
BCWS	15914	14969	9432	980	0	0	0	0	0	0	0	0	41295
BCWP	15609	3571	0	0	0	0	0	0	0	0	0	0	
ACWP	15908	3234	0	0	0	0	0	0	0	0	0	0	
ETC	0	11801	9432	980	0	0	0	0	0	0	0	0	41355

YMP PLANNING AND CONTROL SYSTEM (PACS)

Participant U.S. Geological Survey
Date Prepared 01/17/97 15:31

MONTHLY COST/FTE REPORT

Fiscal Month/Year DECEMBER 1996

	CURRENT MONTH END						FISCAL YEAR		
WBS ELEMENT	ACTUAL COSTS	PARTICIPANT HOURS	SUBCON HOURS	PURCHASE COMMITMENTS	SUBCON COMMITMENTS	ACCRUED COSTS	APPROVED BUDGET	APPROVED FUNDS	CUMMULATIVE COSTS
1.2.3	875	15103	2464	0	1115	32	11387	4176	2478
1.2.5	31	408	352	0	232	0	504	200	70
1.2.8	39	611	0	0	0	0	612	400	115
1.2.9	45	880	176	0	67	4	664	300	134
1.2.12	5	176	0	0	0	7	80	20	12
1.2.15	138	1345	352	0	85	25	1722	700	411
TOTALS	1133	18523	3344	0	1499	68	14969	5796	3220

U.S. GEOLOGICAL SURVEY
ESTIMATED COSTS FOR 10/1/96 - 12/31/96

		OCT EST	NOV EST	DEC EST	JAN EST	FEB EST	MAR EST	APR EST	MAY EST	JUN EST	JUL EST	AUG EST	SEP EST	TOTAL
OG311FA1	Scientific Programs Management & Integra	15.7	16.6	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.3
1.2.3.1.1		15.7	16.6	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.3
OG312FA1	Nevada Operations/Earth Science Investig	55.0	57.4	62.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	175.3
1.2.3.1.2		55.0	57.4	62.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	175.3
*1.2.3.1		70.7	74.0	74.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	219.6
OG32211FB1	Review & Revision of Lithostratigraphy B	14.1	13.4	50.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.8
1.2.3.2.2.1.1		14.1	13.4	50.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.8
OG32212FB2	Complete Site Area Geologic Map	36.9	24.9	34.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.0
OG32212FB3	Fracture Studies	6.3	16.8	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.0
OG32212FB4	Geologic Mapping of the Exploratory Stud	119.7	139.2	106.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365.2
1.2.3.2.2.1.2		162.9	180.9	155.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	499.2
OG3252FB1	Evalute Tectonic Scenarios for PA	10.6	4.1	-4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6
1.2.3.2.5.2		10.6	4.1	-4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6
OG32836FB1	Conduct Probabilistic Seismic Hazards An	88.3	62.1	54.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	204.7
1.2.3.2.8.3.6		88.3	62.1	54.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	204.7
*1.2.3.2		275.9	260.5	255.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	792.3
OG33111FB4	Collection of Site Meteor. Data for Hydr	7.8	8.8	12.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.8
1.2.3.3.1.1.1		7.8	8.8	12.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.8
OG33112FB1	Collection of Site Streamflow Data	5.6	5.1	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0
OG33112FB2	Collection of Site Streamflow Data	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3.3.1.1.2		5.6	5.1	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0
OG33114FB3	Regional Saturated Zone Synthesis Report	7.6	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2
1.2.3.3.1.1.4		7.6	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2
OG33121FB1	Infiltration Processes	21.5	16.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.5
1.2.3.3.1.2.1		21.5	16.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.5
OG33123FB4	Integrated Analysis & Interpretation	14.5	5.4	14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.4
OG33123FB5	Matrix Properties of Hydrologic Units	14.1	12.0	16.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.3
OG33123FBA	Unsaturated Zone Borehole Instrumentatio	31.9	36.3	32.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.8
OG33123FB8	Unsaturated Zone Borehole Instrumentatio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG33123FBC	Integrated Analysis & Interpretation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG33123FBD	Matrix Properties of Hydrologic Units	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3.3.1.2.3		60.5	53.7	63.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	177.5
OG33124E96	Air-K and Hydrochemisty Test - North Ram	5.5	3.1	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0
OG33124FB7	Air Permeability & Hydrochem Testing ESF	46.1	40.6	40.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	127.6
OG33124FB8	Percolation Flux across Repository Horiz	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG33124FBA	Moisture Monitorning in the ESF	2.4	2.4	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3
OG33124FBB	Air-Permeability & Hydrochem Testing ESF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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0G33124FBD Moisture Monitoring in the ESF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3.3.1.2.4	54.0	46.1	48.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	148.9
0G33127FBA UZ Hydrochemistry	23.0	27.1	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.1
0G33127FBB UZ Hydrochemistry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3.3.1.2.7	23.0	27.1	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.1
0G33128FBD Fluid Flow in Unsaturated Zone Fractured	7.6	5.3	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8
1.2.3.3.1.2.8	7.6	5.3	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8
0G33129FBG Site Unsaturated Zone Flow Model	7.8	6.4	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.5
0G33129FBK Support UZ Model Expert Elicitation	0.0	21.2	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.
1.2.3.3.1.2.9	7.8	27.6	15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.5
0G33131FBA C-Well Complex Hydraulic & Conservative	46.5	42.2	46.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	135.3
0G33131FBB C-Well Complex Hydraulic & Tracer Test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0G33131FBC Water-Level Monitoring	20.7	17.8	20.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.0
0G33131FBD Water-Level Monitoring	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3.3.1.3.1	67.2	60.0	67.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	194.3
0G33133FB3 Site Saturated Zone Flow Model	16.5	25.9	21.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.2
0G33133FB4 Site Saturated Zone Synthesis Report	1.3	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
0G33133FB5 Conduct VA SZ Flow Model Sensitivity An	4.0	2.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6
0G33133FB6 Confirm SZ Hydrologic Flow Models	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3.3.1.3.3	21.8	27.9	26.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.6
*1.2.3.3	284.4	285.2	282.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	852.2
0G3521FA1 Tracer Gas Support	5.7	5.1	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8
1.2.3.5.2.1	5.7	5.1	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8
*1.2.3.5	5.7	5.1	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8
0G36212FB1 Confirmatory Aquatic Investigations	0.0	2.1	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.
1.2.3.6.2.1.2	0.0	2.1	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0
0G36215FB2 Paleoclimate/Paleoenvironmental Synthesi	40.1	38.6	31.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.4
1.2.3.6.2.1.5	40.1	38.6	31.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.4
0G36221FB1 Evaluation of Paleo Ground-Water Dischar	17.4	15.4	27.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.7
0G36221FB2 Geo. Fract. Fill Mater, ESF & Est Past W	57.0	39.2	87.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	183.8
0G36221FB3 Syn.Dist.&Anal Geochron. Age Dets Potent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3.6.2.2.1	74.4	54.6	115.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	244.5
*1.2.3.6	114.5	95.3	154.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	363.9
0G39BFA1D Support Systems Engineering Reports & St	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0G39BFA1F Data & Del Mgt., QA Compl, Oversite Sup,	14.6	13.0	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.9
0G39BFB1 Support Development of PISA Ch 2.3 (Geol	30.1	29.7	43.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.7
0G39BFB1C Provide Support to LA Plan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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0G39BFB1E	Provide Input to SC Progress Report 16	9.9	11.0	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.8
0G39BFB2	Develop PISA Chapter 2.4 (Hydrology)	11.6	12.5	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.1
0G39BFB2E	Provide Input to SC Progress Report 17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0G39BFB4	Dev Climate/Meteorologic Sys Desc (PISA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3.9.11		66.2	66.2	101.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	233.5
*1.2.3.9		66.2	66.2	101.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	233.5
**1.2.3		817.4	786.3	874.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2478.3
0G535FA1	Provide FY97 Technical Data Base Input	21.3	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.3
1.2.5.3.5		21.3	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.3
*1.2.5.3		21.3	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.3
0G541FA2	Viability Assessment Scenarios Developme	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.5.4.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0G544FA1	UZ Flow Model Abstractions for VA	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5
0G544FA2	SZ Flow Model Abstractions for VA	0.0	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1
1.2.5.4.4		0.0	0.0	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6
*1.2.5.4		0.0	0.0	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6
**1.2.5		21.3	18.0	30.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	69.9
0G825FA1	Federal Occupation Safety & Health	8.8	7.1	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.9
1.2.8.2.5		8.8	7.1	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.9
*1.2.8.2		8.8	7.1	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.9
0G845FA1	Radiation Protection	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
1.2.8.4.5		0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
0G847FA1	Water Resources Envir Impact Stmt Suppor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0G847FA2	Rad Water Quality Sample Collection	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0G847FB1	Water Resources	30.4	29.6	30.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.3
1.2.8.4.7		30.4	29.6	30.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.3
*1.2.8.4		30.4	29.6	30.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.4
**1.2.8		39.2	36.7	39.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	115.3
0G912FA1	Participant Technical Project Office	25.0	23.2	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.5
1.2.9.1.2		25.0	23.2	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.5
*1.2.9.1		25.0	23.2	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.5
0G922FA1	Participant Project Control - USGS	21.4	18.6	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.1
1.2.9.2.2		21.4	18.6	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.1
*1.2.9.2		21.4	18.6	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.1
**1.2.9		46.4	41.8	45.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	133.6
0GC522FA1	Satellite Records Operations	3.8	3.5	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0
1.2.12.5.2.2		3.8	3.5	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0

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*1.2.12.5		3.8	3.5	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0
**1.2.12		3.8	3.5	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0
OGF23FA1	Support/Personnel Services	32.4	28.7	35.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.5
OGF23FA2	Facilities Management - Space	61.7	61.7	61.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	185.1
OGF23FA3	Facilities Management - Computers/Phones	16.7	16.7	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.1
OGF23FA4	Facilities Management - Other	12.5	12.5	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5
OGF23FA5	Procurement/Property Management - USGS	10.2	11.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2
1.2.15.2.3		133.5	130.6	134.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	398
*1.2.15.2		133.5	130.6	134.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	398
OGF3FA1	USGS Training Support	4.5	4.2	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4
1.2.15.3		4.5	4.2	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4
*1.2.15.3		4.5	4.2	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4
**1.2.15		138.0	134.8	138.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	410.8
1.2 OPERATING		1066.1	1021.1	1132.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3219.9
CAPITAL EQUIPMENT		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRAND TOTAL		1066.1	1021.1	1132.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3219.9
FTEs														
FEDERAL		112.7	108.9	108.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CONTRACT		17.0	17.8	19.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
TOTAL		129.7	126.7	127.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

* Fourth level WBS roll-up
** Third level WBS roll-up