INTERIM REPORT ON RESULTS OF INSTRUMENTATION AND MONITORING OF UE-25 ONC#1 AND USW NRG-4 BOREHOLES, YUCCA MOUNTAIN, NEVADA

Nye County Nuclear Waste Repository
Project Office
Nye County, Nevada

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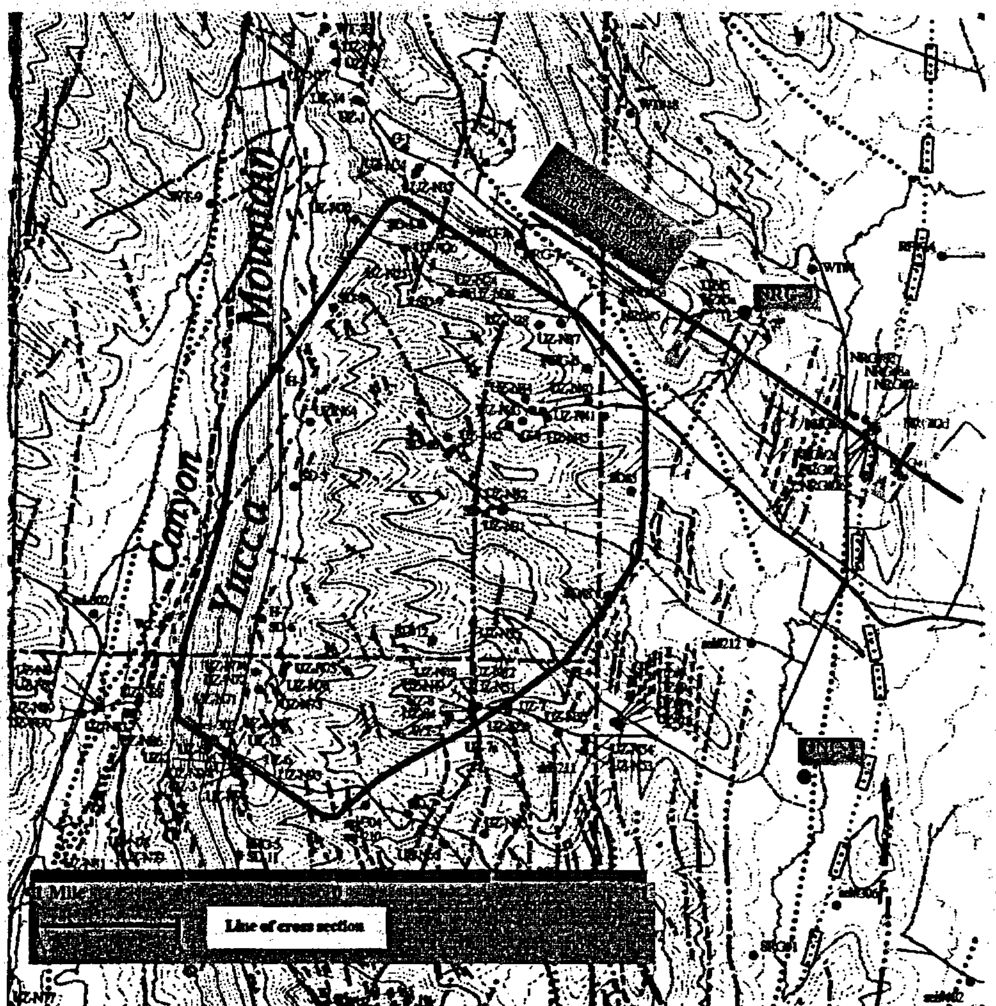

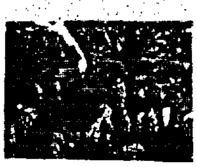

Prepared by:
Multimedia Environmental Technology, Inc.
Newport Beach, California

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INTRODUCTION

Nuclear Waste Policy Act of 1982, as amended, (NWPA) designates Yucca Mountain in Nye County, Nevada, as the preferred site for the nation's first high-level radioactive waste repository. U.S. Department of Energy (DOE) plans to evaluate the geotechnical suitability of this site by and through the process of scientific site characterization and socioeconomic impacts evaluation related to the siting, construction and operation of a high-level nuclear waste repository. NWPA empowers Nye County as an affected unit of local government to oversight the activities performed by DOE at the Yucca Mountain Site (YMS).

This report is a preliminary interim report that summarizes the results of monitoring two boreholes that were instrumented by Nye County. This report presents results of observations and a limited interpretations of the results. It is solely for the purpose of discussion and timely distribution of the information obtained since March 1995. Further evaluations of these results may provide alternative interpretations. Therefore, these results and interpretations should not be viewed as the position of Nye County on this particular issue.

BACKGROUND AND PURPOSE

Yucca Mountain (Figure 1) lies in and west of the southwestern part of the Nevada Test Site (NTS). The NTS is in Nye County, Nevada, about 105 km northwest of the city of Las Vegas. The hydrogeologic setting of the site is summarized in Montazer and Wilson (1984).

The purpose of installation of instruments in UE-25 ONC#1 and USW NRG-4 boreholes is to evaluate the long-term pneumatic conditions in these boreholes in response to fluctuations in atmospheric conditions and in response to other disturbances as a result of site characterization activities. In this regard, Nye County has several concerns, some of which are as follows:

1. Can the pneumatic properties of the rocks be characterized?

2. Can the pneumatic potential be defined adequately?

3. Does the site characterization activities, such as the tunneling as part of the ESF, cause irreversible disturbances that could have potential adverse effects?

4. Are there pertinent information that should be collected before the repository block is disturbed by such activities?

The first concern relates to the application of the available technologies to characterization of fractured and porous tuffaceous formations. The scale effect in application of such technologies is of question. It is uncertain whether the results of tests conducted in boreholes can be extrapolated to larger volumes of rocks. Monitoring barometric fluctuations provides means of estimating large-scale pneumatic conductivity of the formations. However, each is in a directions that is dictated by the orientation of the borehole in which such tests are performed.

The second concern is whether the dynamic pneumatic fluctuations encountered in fractured formations at the site would allow determination of long-term pneumatic potentials which are required to establish initial conditions for the pre-waste emplacement state of the repository.

The third concern is multifaceted and is not only related to pneumatic conditions. It is obvious that tunneling in unsaturated rocks creates a sink and/or source condition for which could cause invasion of the formation by atmospheric air and removal of the in-situ humid air from the rock. The result is an obvious disturbance. What is not commonly obvious is that the introduction of the atmospheric air into the fractured formations of concern also introduces the environmental tracers such as ^{14}C, ^{3}H, and possibly ^{36}Cl which are the primary tracers that can be used to decipher the hydrogeologic history of the fractured formations at depth. Introduction of the atmospheric air and the modern tracers associated with it will result not only in modification of the gas chemistry but also modification of the pore- and fracture-water chemistry through equilibration processes. Once the volume of influence around the tunnel is affected and the chemistry of the rock is changed, any hydrochemical or pneumochemical information obtained after the impact by the tunnel would be questionable and potentially useless in determination of the travel time and long-term infiltration rates. Much faster travel times and larger infiltration rates may have to be assumed to account for such uncertainties. It is Nye Counties understanding that adequate pre-excavation characterization of the hydrochemistry of the formations is not performed. The results of the present study demonstrates that the potential for air invasion of the formations is greater than previously thought.

The fourth concern is basically alluded to in the above paragraph. Further investigations will be necessary to evaluate and determine the need for pre-excavation characterization requirements.

INSTRUMENTATION OF BOREHOLES

UE-25 ONC#1 is situated southeast of the repository block and is in the path of the future South Ramp of the ESF tunnel. USW NRG-4 is located northeast of the repository block (Figure 1) and is situated about 1100 m from the North Ramp (NR) portal of the ESF tunnel.

Instrumentation of the USW NRG-4 borehole was completed in March 3, 1995. at YMS. UE-25 ONC#1 instrumentation was completed in April. Both boreholes were instrumented using Westbay multiprobe packer system. The boreholes were drilled and instrumented to:

1. To monitor the long-term variation of pressure and temperature.

2. To use the packed off intervals and perform vacuum and/or injection pneumatic testing to evaluate the horizontal and probably vertical pneumatic conductivity of the hydrogeologic units packed off by the Westbay Instruments.

3. Sample the packed off intervals for environmental isotopes to evaluate the residence time of the gases in the hydrogeologic formations.

Schematic completion diagrams for these boreholes are presented in Figure 2. The lithology penetrated by these boreholes will be discussed in the following sections. It should be noted that the two bottom-most probes in ONC#1 are situated below the water table and are monitoring the piezometric potential..

RESULTS OF CONTINUOUS MONITORING

Data obtained from these two boreholes are entered into a data base which has automatically built-in correction factor for both temperature and pressure and ability to convert pressure and temperature data into pneumatic pressure potential values. The temperature is important in determination of the pneumatic potential. Temperature fluctuations influence the air density which is one of the factors determining the pneumatic potential.

MONITORING UE-25 ONC#1

TEMPERATURE DATA

Temperature variation with time for almost three months are shown in Figure 3 for ONC#1 borehole. Temperatures reported for all downhole instruments are fairly stable with occasional deviations from the norm. Atmospheric probe records wide ranges of temperature fluctuations as is typical of a desert environment.

The temperature variations are averaged over a months period and are plotted in Figure 4 for ONC#1. This temperature profile is believed to be representative of the geothermal gradient in the vicinity of this borehole. An anomaly is observed in temperature profile consistently in all three monthly averages. This temperature anomaly coincide with the fault zone. In Probe 5, which is adjacent to the fault zone, the temperature is measured to be consistently about 0.5 °C higher than Probe 6 which is situated in the upthrown side of the fault and about 10 m below Port 5. There are several potential interpretation for this anomaly. The most plausible hydrologic explanation is that the water table is about 30 m below this probe. The fault zone is conductive to air and water vapor and facilitates convection in the fault from the water table. The adjacent rock pneumatic conductivity is smaller; therefore, convective heat transfer is less dominant in the adjacent rock blocks as opposed to that of the fault zone. Along the fault zone, the convective heat transfer dominates the conductive heat transfer.

Further investigations will be necessary to demonstrate the plausibility of the above interpretation for this anomaly or formulate alternative interpretations.

PRESSURE DATA

Pressure fluctuations with time for ONC#1 are shown in Figure 5. The first few days of data are generated during calibration of the instruments downhole. From April 11, 1995 and on, the pressure responses are consistent and show relative changes that are synchronous. Probe 4 has deviated by about 3.5 kilo Pascal (0.5 psi). The reason for this deviation is currently under investigation.

MONITORING NRG-4 BOREHOLE

TEMPERATURE DATA

Results of temperature monitoring and average monthly temperature gradients are shown in Figures 6 and 7 for NRG-4, respectively. The data seem to be normal and consistent with other information available from the site. Comparison of the temperature fluctuation between Probe-0 (atmospheric probe) in NRG-4 and ONC#1 indicates very consistent temperature pattern between the two sites despite the difference in elevation (about 40 m).

PRESSURE DATA

Pressure fluctuations in NRG-4 probes are shown in Figure 8. Comparison of Probe-0 (atmospheric probe) responses at NRG-4 with that of Probe-0 responses at ONC#1 indicate that there is a very consistent weather pattern between the two boreholes and the fluctuations of pressure from these probes may be extrapolated to other parts of the Yucca Mountain with corrections for elevation differences.

ANALYSIS OF DATA

In order to evaluate the pneumatic relation between the probes in each borehole at different depth, a series of computer simulations were performed using A-TOUGH. Documentation of A-TOUGH and its history of development are provided in Appendix-I.

At first one dimensional and simple simulations were setup to understand the relations and obtain an estimate of the pneumatic conductivity of the formations. Pneumatic conductivity is related to the intrinsic permeability of the formation but varies with the density and viscosity of the air which are dependent on pressure and temperature. Permeability values calculated from air flow measurements are sometimes substantially different from those calculated from water measurements. Montazer (1982) provides detailed description of the reasons why such a discrepancy exists, especially in unsaturated fractured rocks. The two primary reasons are klinkenberg effect or the slip phenomenon and the turbulence effects, The klinkenberg effects are enhanced in the unsaturated formations due to existence of water film around the grains and on the fracture walls.

AIR PERMEABILITY CALIBRATION

ONE DIMENSIONAL SIMULATIONS

SIMULATION OF ONC#1 PRESSURE DATA

A one-dimensional simulation was setup consisting of 14 nodes (Figure 11). This simulation was a first try and it is realized that the mesh is coarse. Mesh and dimensional sensitivity analysis are currently underway.

Results of the one-dimensional analysis for ONC#1 are presented in Figure 9. The calibration comparison results are shown in Figure 10. Permeability values calibrated for this borehole compare very well with those in NRG-4 for Tiva

Canyon Welded Unit. Ptn unit consists of the nonwelded tuffs of Tiva Canyon, Pah Canyon, and Topopah Spring Members of the Paintbrush Tuff Formation. In ONC#1, Probes 1 and 2 are located above and below the Ptn Unit at a vertical distance that includes 25 m of Tiva Canyon Welded Unit, 15 m of Ptn, and 40 m of Topopah Spring Member. Therefore, the responses in these two probes include the combined effect of all three units. The presence of Ptn is not sensed by the instrumentation. Since packers and ports are already setup above and below the Ptn Unit, the pressure transducers can be installed immediately above and below the Ptn to obtain a better resolution for Ptn permeability. This activity is currently planned to be conducted in the future.

The permeability values calibrated for this borehole only show those of Tiva and Topopah Springs Welded Units and are comparable with those calibrated to in the NRG-4 column (see below). The difference is that ONC#1 column reveals some relatively thin units within Topopah Spring Welded Unit that have permeability values at least one order of magnitude smaller than the rest of the unit. Of course, these layers (top11 and top02 in Figure 9) would be too deep in NRG-4 column which are not instrumented.

Although Calico Hills Nonwelded Unit and Prow Pass Unit are instrumented in this borehole, atmospheric fluctuations could not be reproduced even with assignment of large permeability values. This is because these units probably are connected to the atmosphere through other paths than a vertical one in this particular location. Also the lower boundary conditions influence the permeability results in the deeper section of the column.

SIMULATION OF NRG-4 PRESSURE DATA

A one-dimensional simulation was setup consisting of 11 nodes (Figure 11). This simulation was a first try and it is realized that the mesh is course. Mesh and dimensional sensitive analysis are currently underway. This figure also shows the lithology penetrated by this borehole. The calculated equivalent intrinsic permeability values are shown adjacent to each rock unit. The nodes were selected to correspond to the probes in the borehole so that the model could be calibrated against the actual measurements. It should be noted that in A-TOUGH atmospheric node permeability values are not averaged with the adjacent rock nodes. Therefore, the calibrated permeability values are those of the rock units and not a harmonic average of the atmosphere and the adjacent rock. Also no upstream weighting is done when atmospheric elements are involved regardless of the choice of the upstream weighting factor. However, the permeability of the rock units are harmonically averaged and the selected upstream weighting factor is used for the non-atmospheric elements just as the original TOUGH code (see Appendix I for references to the models).

Figure 12 shows the result of the calibration of the model. The pressure for the probes as simulated with A-TOUGH and measured in the instrument package are shown. Although all simulated pressure result are fairly well calibrated to the measured pressures, it should be noted that the deeper probes (Probes 5, 6, and 7) do not show adequate fluctuations in this period to provide accurate calibration of the model. Therefore, permeability values calculated for nodes Topo3, to 5 are not very reliable. In addition, the lower boundary is uncertain in this case. The pressure data for the lower probes can be calibrated by either changing the permeability of the units or the volume of the lowest unit (Topo5).

One-dimensional simulation assumes that flow (which basically is induced by compression and decompression of the air column in the one-dimensional model) is either up or down during pressure fluctuations. No lateral flow is allowed. Depending on the heterogeneity of the surficial material and variation in lateral geologic conditions, this assumption may or may not be valid as will be discussed in the two-dimensional case.

TWO-DIMENSIONAL SIMULATIONS FOR NRG-4

As was noted above, there are many restrictions that are imposed when simulating barometric effects in a one dimensional fashion. There are many constraints that are artificially imposed in a one-dimensional simulation that could bias the results in a complex and heterogeneous medium such as Yucca Mountain unsaturated zone. For these reasons, a quasi three dimensional case was setup to evaluate various effects. The mesh is referred to as quasi-three-dimensional because it consists of a two-dimensional cross-sectional mesh representing the cross section shown in Figure 13 and a row of tunnel nodes that is connected to this cross section. The tunnel nodes are connected to the appropriate rock formations they penetrated through the third permeability and an appropriate area that is calculated based on the tunnel interface with the rock. The effect of the tunnel lining and excavation effects are all built into the permeability values in the third direction (perpendicular to the plane of the cross section). The cross sectional node configuration is shown in Figure 14.

This mesh is also coarse and is the first try at evaluating the conceptual problems of concern. The quasi three-dimensional setup is made for computational efficiency and timeliness reasons. Further refinements will be made to assess the representatives of this setup. For these simulations the fault zones are not active and only represent a discontinuity in the nodes. There is no permeability barrier effect simulated with these faults at this time.

In a two-dimensional simulation, as depicted here, the degree of freedom is increased by two as compared with the one-dimensional case. The ratio of constraints (the nodes for which pressure measurements exists) to the unknowns is much smaller than that of a one-dimensional case. In other words, if only 11 permeability values were to be estimated for the one-dimensional case, there are 191 permeability values (the number of nodes) that has to be estimated for the two-dimensional case. In addition, in the one-dimensional case, only the vertical permeability influences the results. In the quasi three-dimensional case permeability in all three directions must be considered. Furthermore, the boundary conditions of the simulated area create an additional degree of freedom for which data will need to be available before a unique solution to the problem can be obtained. Therefore, simplifications had to be made.

In this first attempt, it was assumed that each of the layers depicted have the same anisotropic permeability. For example, all Ptn nodes have the same vertical and horizontal permeability values. This is not realistic since the permeability of Ptn varies spatially not only because of geologic differences in the unit, but also because of the variations in water content of the unit. In all these simulations water content of all units was kept constant. A geothermal gradient was imposed on the nodes and the temperature was allowed to be changed in response to the atmosphere. However, the atmospheric temperature was kept at an average in these simulations. Future simulations will consider atmospheric fluctuation of temperature. The fractured units (Topopah Spring and Tiva Canyon Welded Units) were treated as equivalent porous media.

The tunnel elements were treated as atmospheric elements; however, only the portal element (on the east side of the cross section) was connected to the atmosphere. All other tunnel elements responded to the atmospheric fluctuations via this connection.

SIMULATION SETUPS

Although 100 different setups were tried, three are shown and discussed here as follows:

1. Calibration of the model with the April barometric data set without the tunnel effect.

2. Verification of the calibration with the June barometric data set without the tunnel.

3. Simulation of the tunnel effects for the June barometric data set.

The reason for simulation of the tunnel with the June data set is that the tunnel penetrated the Ptn unit between June 16 and June 20. The effect of which is clearly recorded in the June data set for NRG-4 (Figure 8).

RESULTS OF SIMULATIONS WITH 2-D MODEL

CASE 1 - CALIBRATION WITH APRIL DATA SET

In this case a static initial condition was assumed and the simulation was performed by allowing atmospheric fluctuations to occur in the second atmospheric layer which passes the NRG-4 elevation. Other atmospheric layers above and below this layer were allowed to equiblirate with this layer through their connections. The results at the end of the simulations are shown in Figure 15 and the atmospheric fluctuations imposed are shown in Figure 16 along with the observed values and the anisotropic permeability values. It should be noted that in Figure 15 the velocity arrows are scaled to show the atmospheric velocities. Velocities in the formation are too small and are shown by black dots. In the cases that follow subsequently, the velocity arrows are scaled to show only the velocity of air in the formations and the atmospheric velocities are not shown.

In this case, the permeability of the tunnel has no consequence since the tunnel elements have the same properties as the rocks and are free to communicate with the formations.

Pressure fluctuations down to the Ptn Unit are fairly well matched; however, the permeability values are two to three orders of magnitude smaller than those predicted by the one dimensional case.

Permeability values are compared with those reported for USW UZ-1 and UE-25a#4 (Montazer et. al., 1987, see Appendix II for a copy of the paper). Montazer et. al. reported permeability of $2x10^{-14}$ to $2x10^{-12}$ m^2 for Ptn Unit in these boreholes which are located to the Southeast of NRG-4. Values calculated by the one-dimensional model in this report is $3.5x10^{-12}m^2$ which falls within the range reported by these authors. The value of permeability calculated using the two-dimensional case is $3.0x10^{-15}$ $3.0x10^{-14}$ m^2 which is much smaller than either of the above cases.

The values calibrated for the Tiva Canyon by the two-dimensional case is $1x10^{-12}$ m^2 which is two orders of magnitude smaller than that calculated by the one dimensional case but corresponds to the range reported by Montazer et. al. (1987). The discrepancy between the one- and two-dimensional case is currently under investigation, although preliminary review does not indicate any error in the input files. One of the reasons for such discrepancies could be the dimensionality and the grid spacing of the simulated region. In the two-dimensional case lateral influences are significant and the air advects (moves) laterally asynchronous with the atmosphere. That is rocks across from a fault zone may be reflecting the barometric fluctuations that may be days apart. One side responding to a high pressure front whereas the other side responding to a lower pressure front.

In the simulations presented here, the bottom of the model region is set to be impermeable, simulating the water table which is practically impermeable to air. The sides of the model are also set to no flow (or impermeable) conditions. This boundary may not be justified because the sides of the model at deeper zones may be communicating with interior of the mountain which does not see as much fluctuations, especially to the west where the unsaturated zone is significantly thicker. As may be seen in the results presented in Figure 16, the permeability values of the Topopah Springs Welded Unit had to be set to $1x10^{-16}$ m^2 to reduce the influence of the barometric fluctuations from getting to the deeper zones. Simulations are currently underway to evaluate whether this condition can be simulated by connecting the western portion of the modeled region to larger volumes.

In any case, these preliminary simulations conceptually simulate the effect of the tunnel and the following discussion of the simulations is solely for the purpose of demonstrating the influence of the tunnel in the shallower zones. Therefore, the permeability of the deeper zones do not affect the conclusions reached with respect to the effect of the tunnel.

CASE 2 - CALIBRATION WITH JUNE DATA SET (BEFORE TUNNEL)

In this set of simulations the calibrated input file for April was used and the June barometric conditions were imposed on the second atmospheric layer. The results of pressure distribution at the end of the simulation and the predicted pressure responses in the nodes corresponding to the NRG-4 probes are presented in Figures 17 and 18. As can be seen in Figure 18, probes 1 to 4 are simulated fairly closely until June 18. After this time, fluctuation in pressure in all probes was increased and the peaks and troughs are synchronous with the atmospheric peaks and troughs. Before this time, the trough in Probe 3 is lagged by about 12 hours and that for Probe 4 is lagged by about 18 hours behind the atmospheric trough that occurred at about 18:00 hour of June 15 (see Probe 0). If one looks at the atmospheric peak that occurred at 10:00 on June 19, it is evident that the lags in responses in both Probes 3 and 4 are less than 2 hours. This pattern is repeated from this point in time and on.

It should be noted that the pressure distribution shown in Figure 17 is almost identical to that of Figure 15. In case of Figure 17, which shows the simulated pressures at the end of June 21, relatively large upward fluxes are noticed. These fluxes are due to the decompression that followed the June 20 compression. However, it is also evident that lateral flux in all directions is in progress as a result of the compression and decompression histories.

The tunnel began penetrating The Ptn Unit on about June 5. By June 15, it had advanced to about 2/3 of the thickness of the Ptn Unit. It finally broke through this unit on about June 18.

CASE 3 - CALIBRATION WITH JUNE DATA SET (AFTER TUNNEL)

For this case, the conditions simulated at 0:00 hour on June 16 were used as initial conditions for simulation of the tunnel effects. Results are presented in Figures 19, 20, and 21. Figure 19 is the pressure distribution and flow velocities. It is immediately evident that the pressure distribution is much different in this case than those of the previous cases. On the eastern part of the cross section, the 89100 pa pressure contour line that was at 1100 m elevation is now at 1000 m elevation. The velocity vectors are also downward below the tunnel line. The western portion of the model is almost the same. It should be noted that because the scale of the velocity vectors are reduced in this figure the relatively large arrows that are shown in Figure 17 on the west side are not shown in this figure. These effects are basically the results of the pressure fluctuations in the tunnel elements, some of which are plotted in Figure 21 for comparison purposes. The node named Tun 4 in this figure is immediately to the west of the NRG-4 column and is inactive. All other tunnel elements are on the east side of this column and are all active. The reason for slight pressure differences among the tunnel nodes is their elevation differences.

In Figure 20 it is noticeable that although the pressure trends in all probes above probe 5 are simulated, the perturbations in the probe pressures are not matched. Another simulation was conducted by reducing the connections among the tunnel nodes. The results of this simulation are shown in Figure 22. The pressures in Probe 3 are almost exactly matched. The pressure distribution is similar to that shown in Figure 19 and therefore is not repeated.

SUMMARY AND CONCLUSIONS

Results of monitoring pressure and temperature data for the three months of April through June 1995 are presented for boreholes UE 25-ONC#1 and USW NRG-4 that were instrumented in late March and early April of 1995. Simulations were performed using one-dimensional and two-dimensional mesh setups and compared. The two dimensional simulations were performed both without and with the tunnel. Substantial differences in the results of permeability calculations are noted between one-dimensional and two-dimensional simulations. The effect of the tunnel is clearly demonstrated both in the data from the NRG-4 borehole and simulation results. It is concluded that the effect of the tunnel can be as far as 100 m away from the tunnel in the short time of the simulations (about 10 days). Continued presence of the tunnel can influence larger radii. Because of the heterogeneity of the formations involved, the direction of the flow of air is variable and can be in any direction. Therefore, the pressure radius of influence can also depict the radius of influence for the introduction of the modern environmental tracers into the repository block. Introduction of the environmental tracers in to the repository block will render any future geochemical sampling of both pore water and fracture gases useless and biased. Travel times and infiltrations calculated based on the samples collected from these affected areas are expected to be much shorter than the natural pre-excavation infiltration and travel times. It is strongly recommended that the areas that are not affected by the tunnel as yet be sampled for geochemical characterization as soon as possible before the tunnel reaches to within 500 m of these sites.

Also it is important to continuously monitor the pressure, temperature, and humidity in the tunnel. This information can be used in future simulations to calculate the permeability of the material penetrated and will serve as a relatively inexpensive cross-hole testing. The simulations presented in this report suffer from inadequate number and distribution of the constraints. If more data on these parameters are collected in the tunnel on a regular basis, the permeability picture can be much more clear in future simulations.

Also it is important to investigate the effect of the mesh size on the calculations. It appears that the mesh size and the dimensionallity could substantially affect the results of the simulations.

REFERENCES

Montazer, P., and W.E. Wilson, 1984, Conceptual hydrologic model of flow in the unsaturated zone, Yucca Mountain, Nevada, U.S. Geological Survey, Water Resources Investigation Report 84-4345.

Montazer, P., 1982, Permeability of unsaturated fractured metamorphic rocks near an underground opening: Golden, Colorado School of Mines, Ph.D. Thesis, 630 p.

Figure 1 - Map of Yucca Mountain showing the location of UE-25 ONC-1 and USW NRG-4 boreholes.

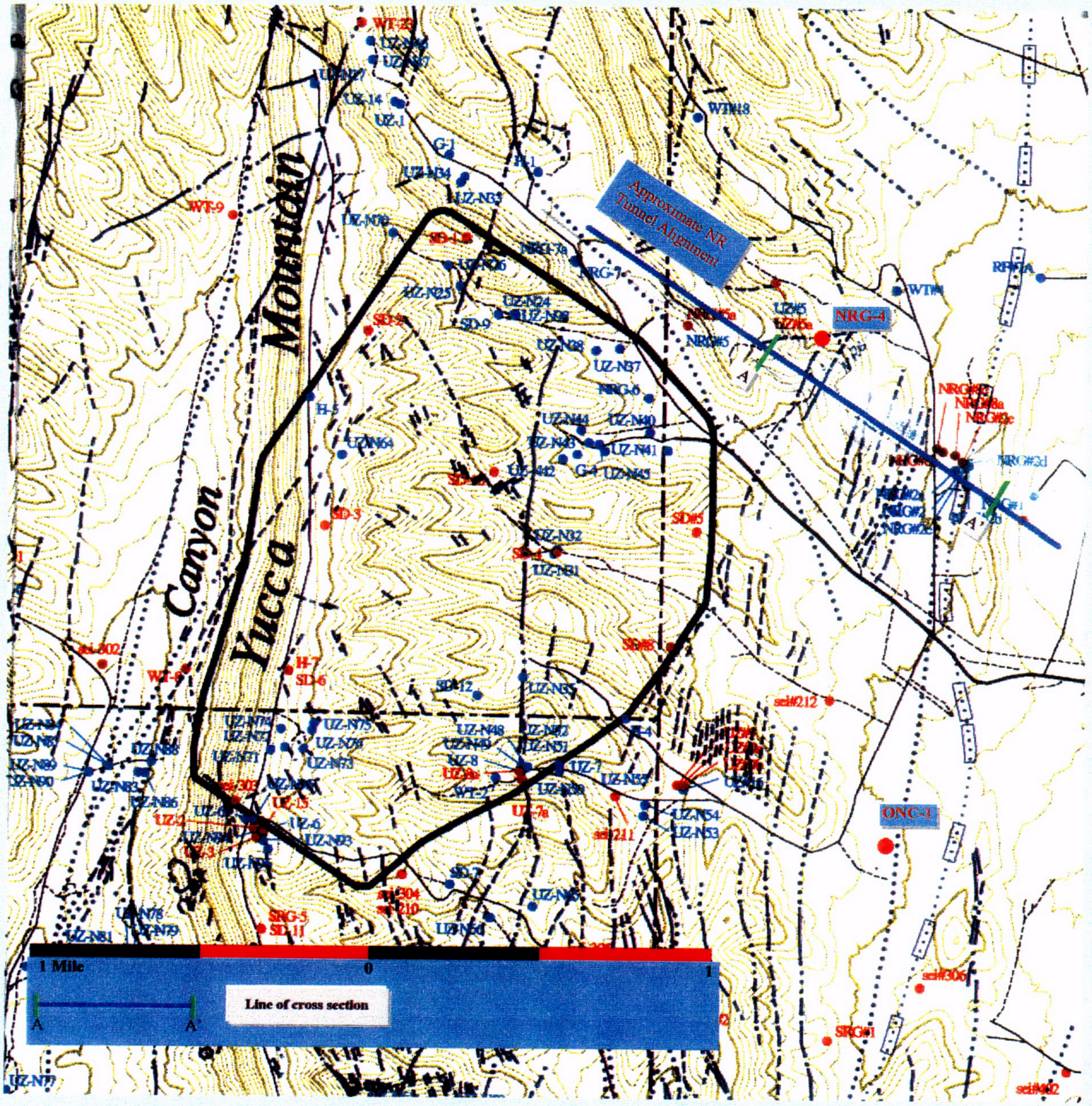

Figure 2 - Schematic profile of instrumentation setup in UE-25 ONC# 1 and USW NRG-4

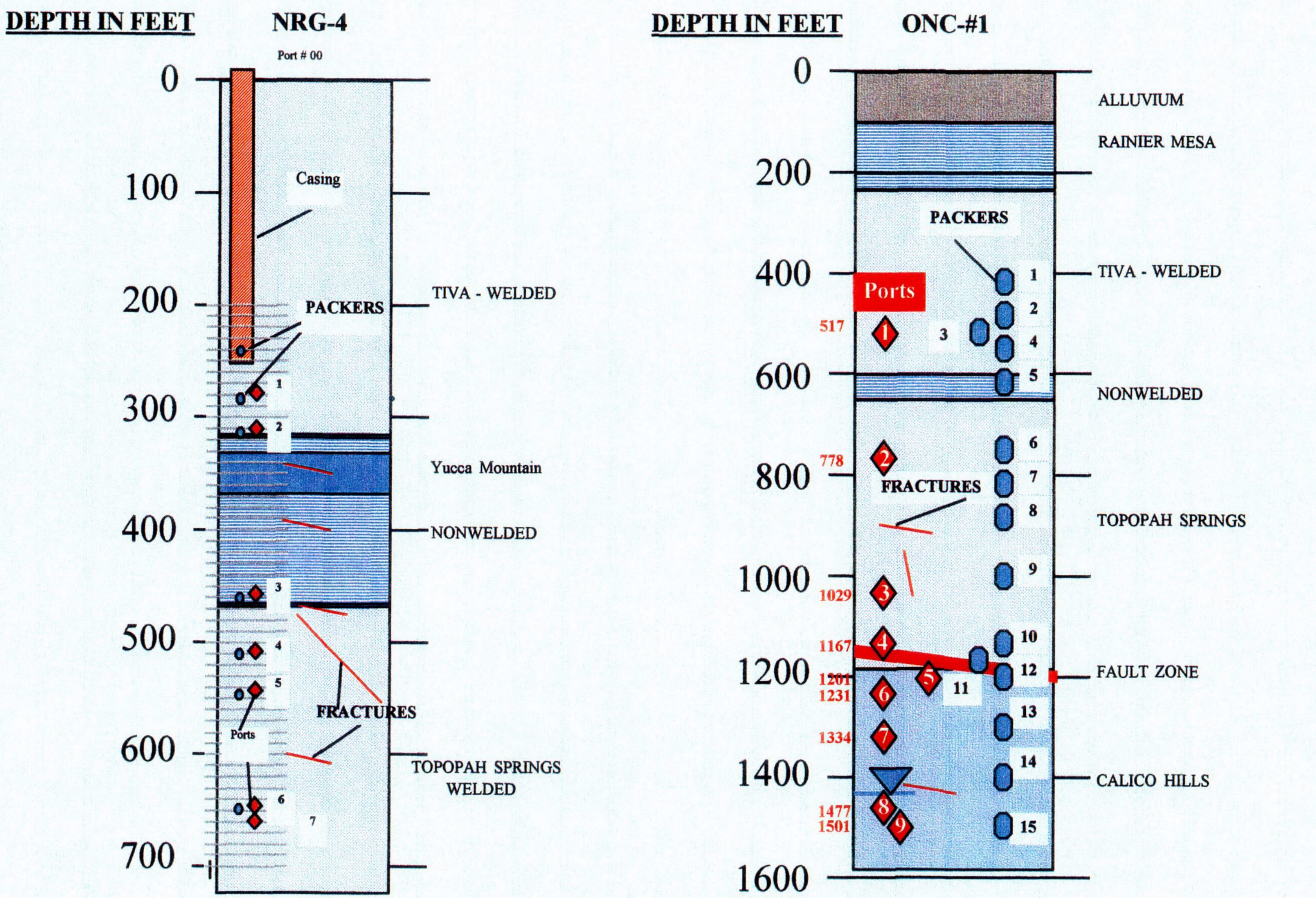

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Figure 3 - Temperature variation in UE-25 ONC-1 (4/7/95 - 5/7/95)

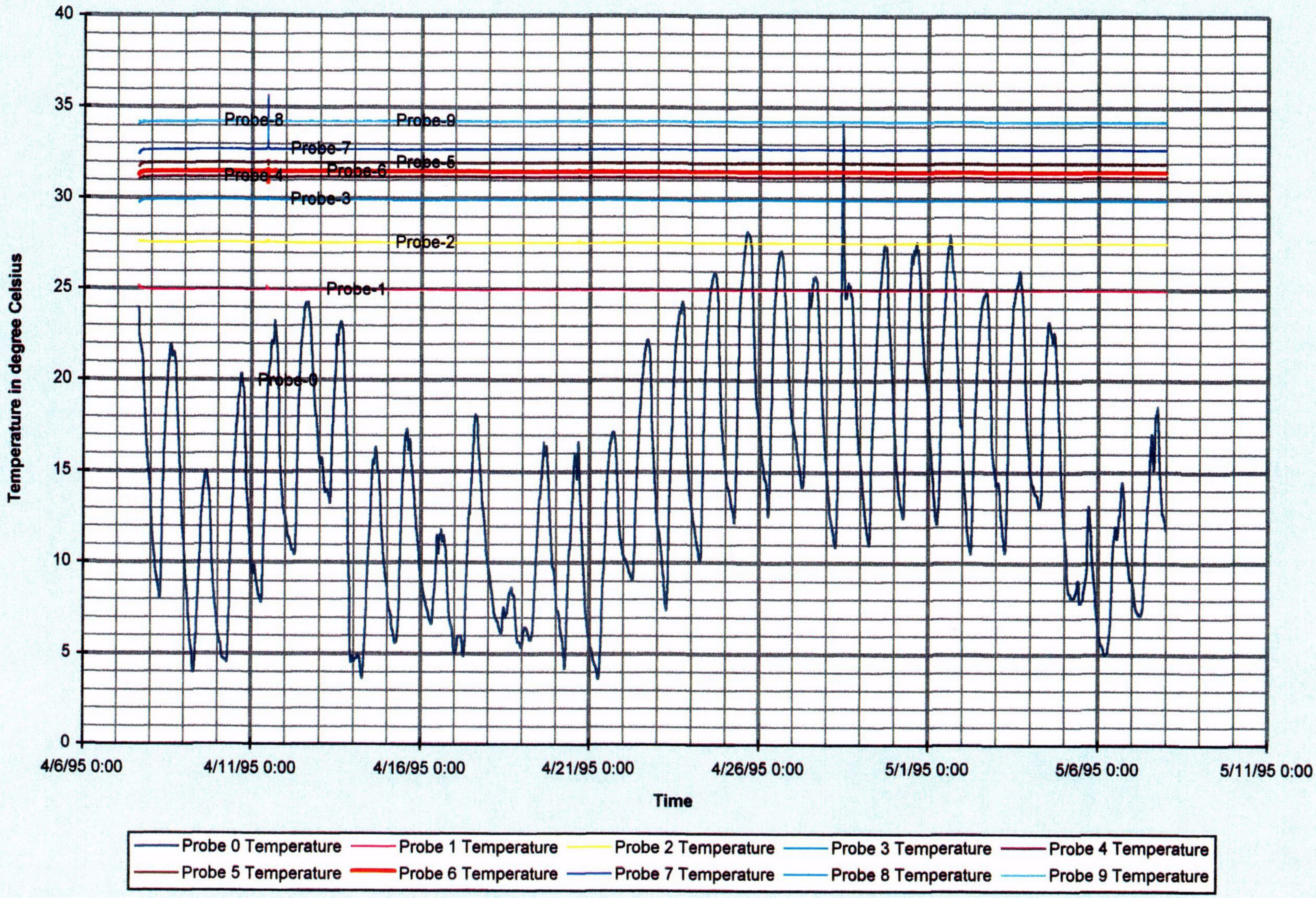


Figure 3 (cont.) - Temperature variation in UE-25 ONC-1 (5/8/95 - 6/8/95)

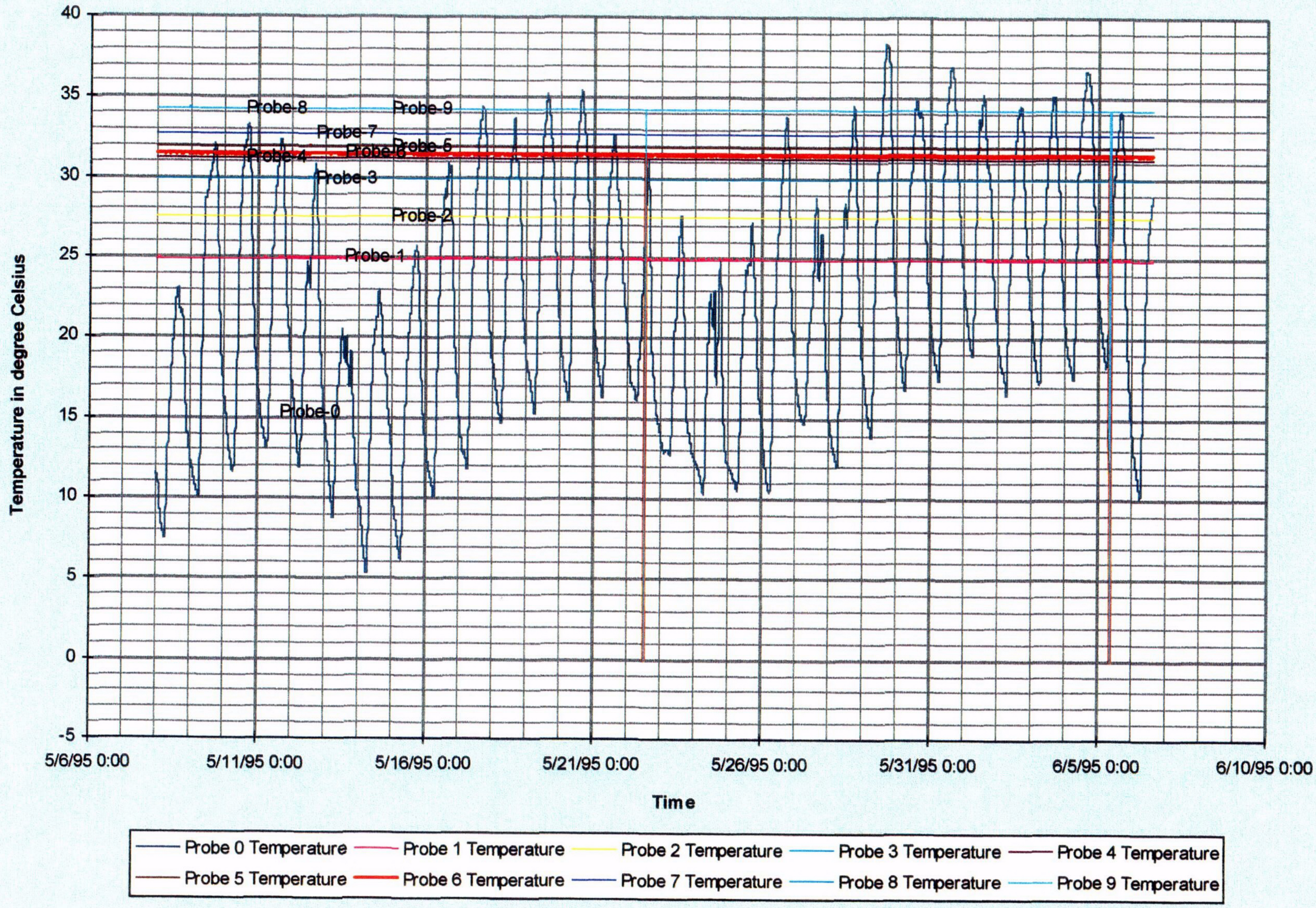


Figure 3 (cont.) - Temperature variation in UE-25 ONC-1 (6/9/95 - 6/22/95)

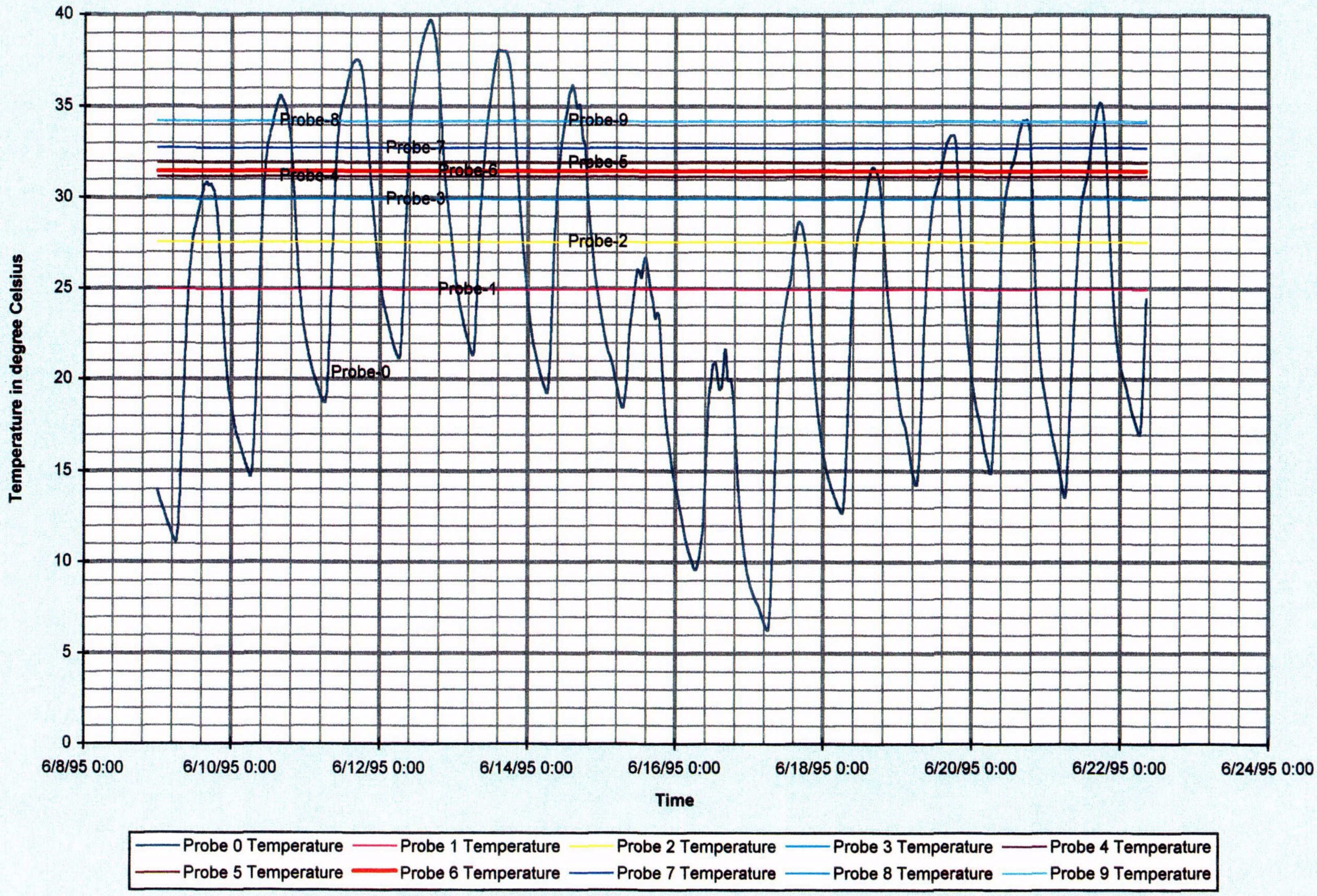
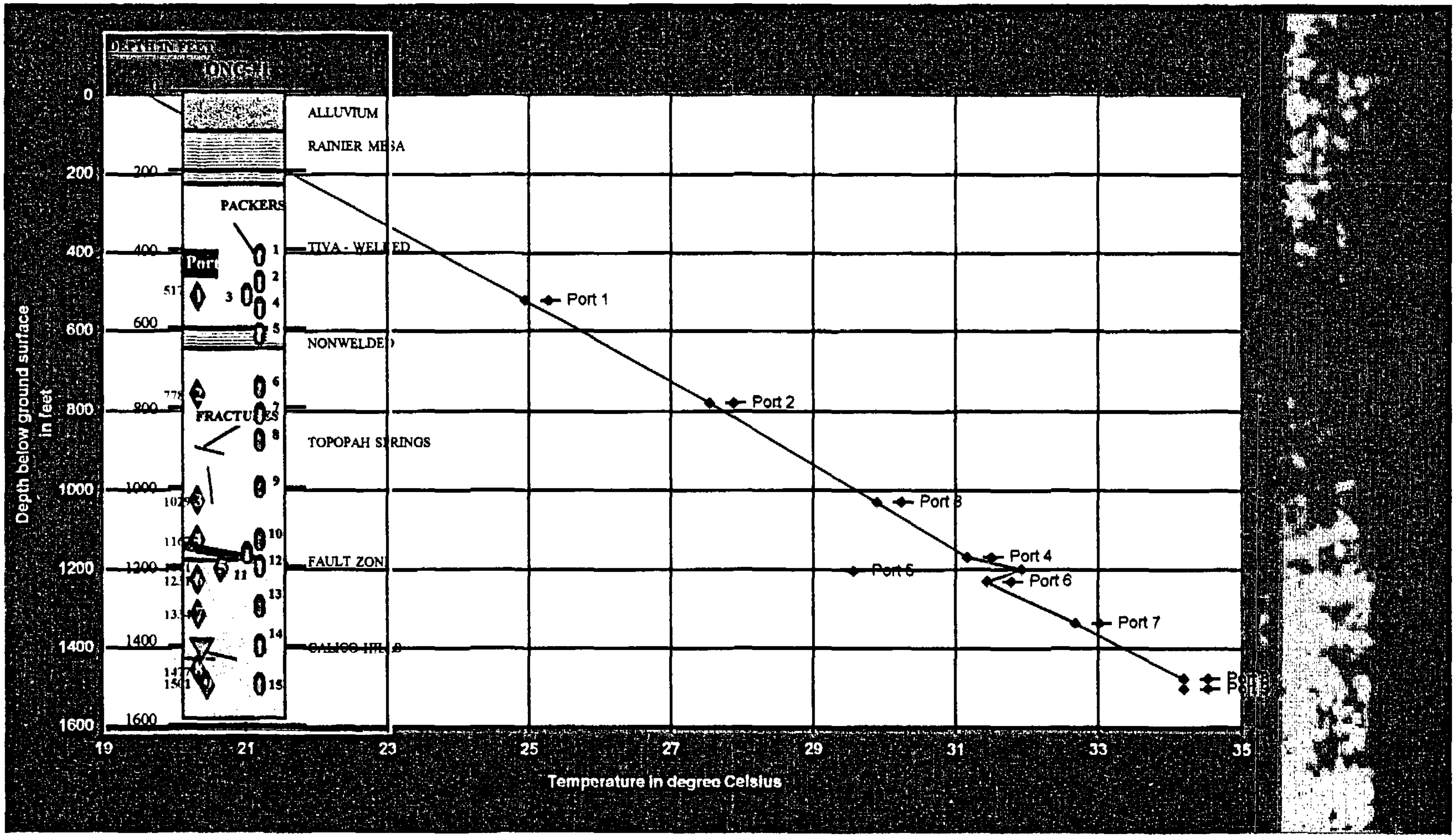


Figure 4- Average temperature profile for the three months of monitoring in UE-25 ONC-1



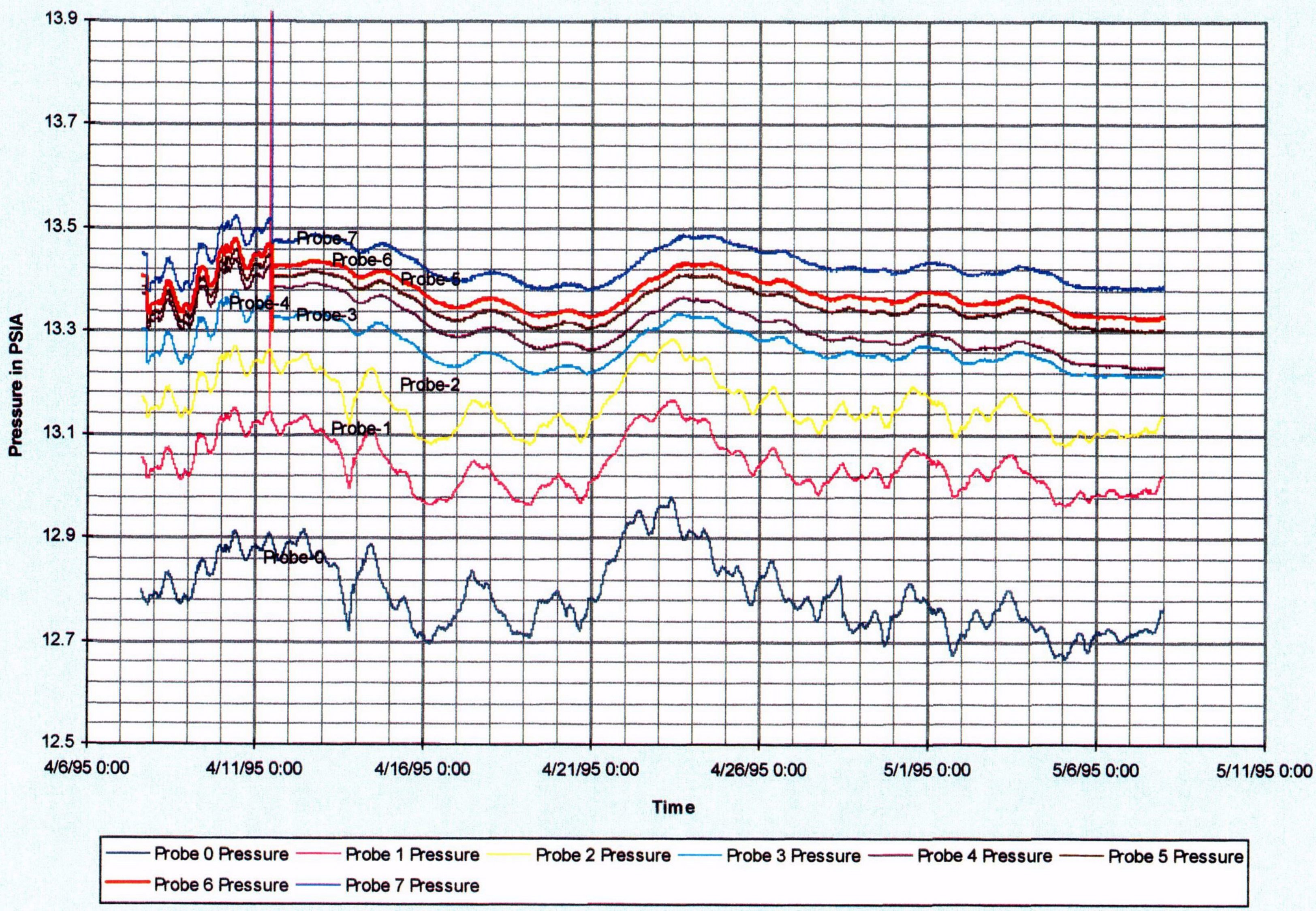


Figure 5- Fluctuation of pressure with time in UE-25 ONC-1. (4/7/95 to 5/7/95)

Figure 5 (cont.)- Fluctuation of pressure with time in UE-25 ONC-1. (5/8/95 to 6/8/95)

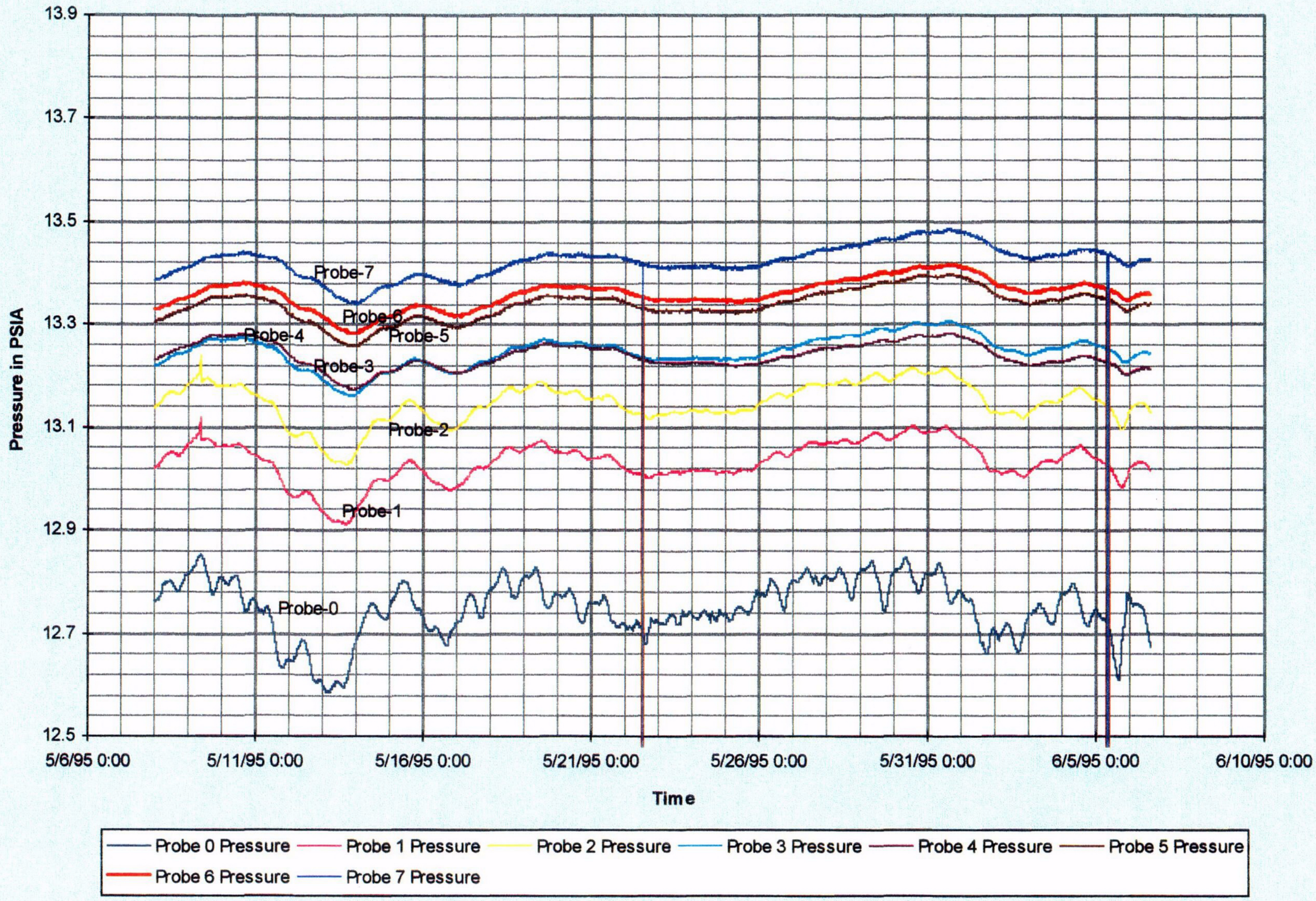
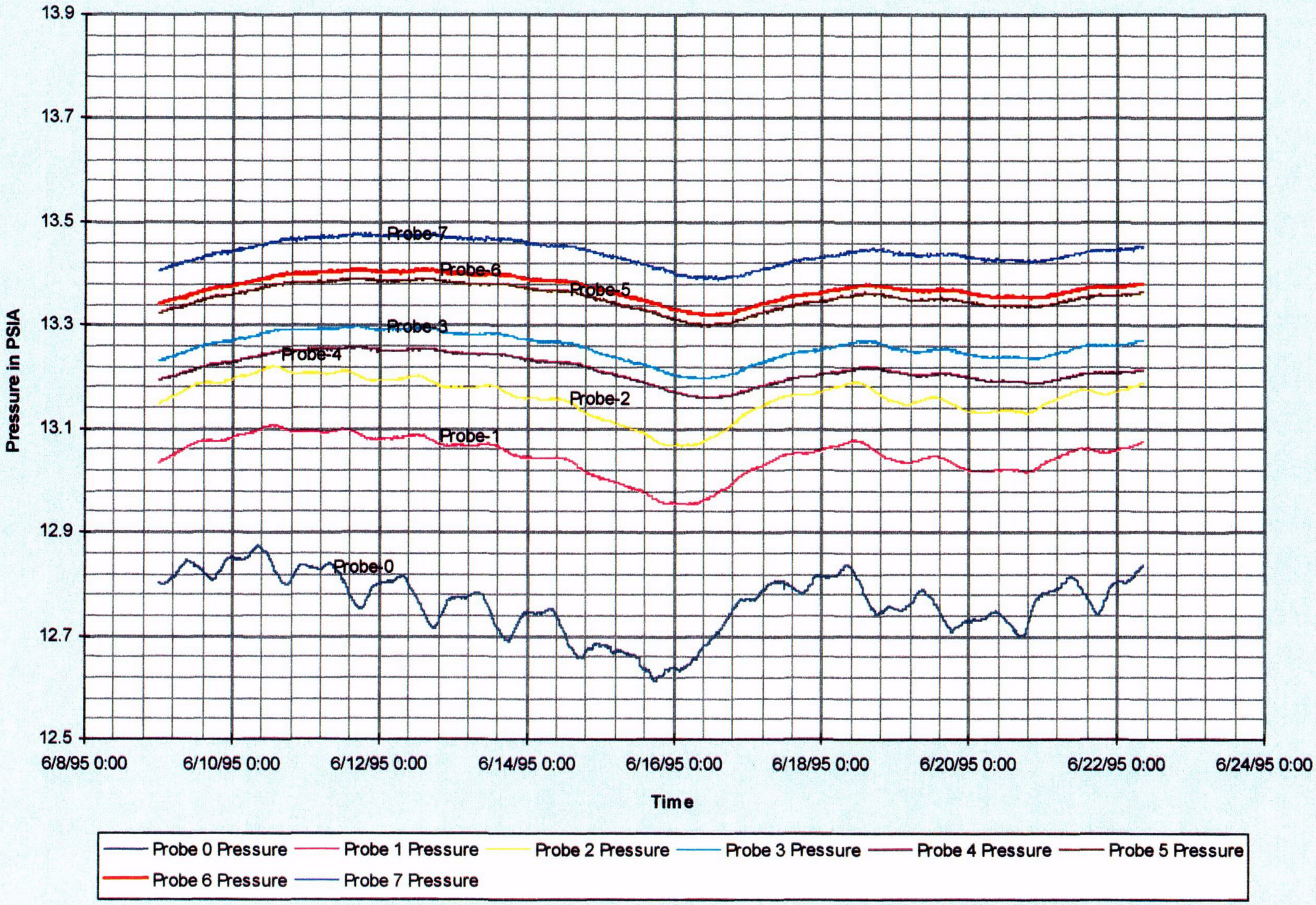


Figure 5 (cont.)- Fluctuation of pressure with time in UE-25 ONC-1. (6/9/95 to 6/22/95)



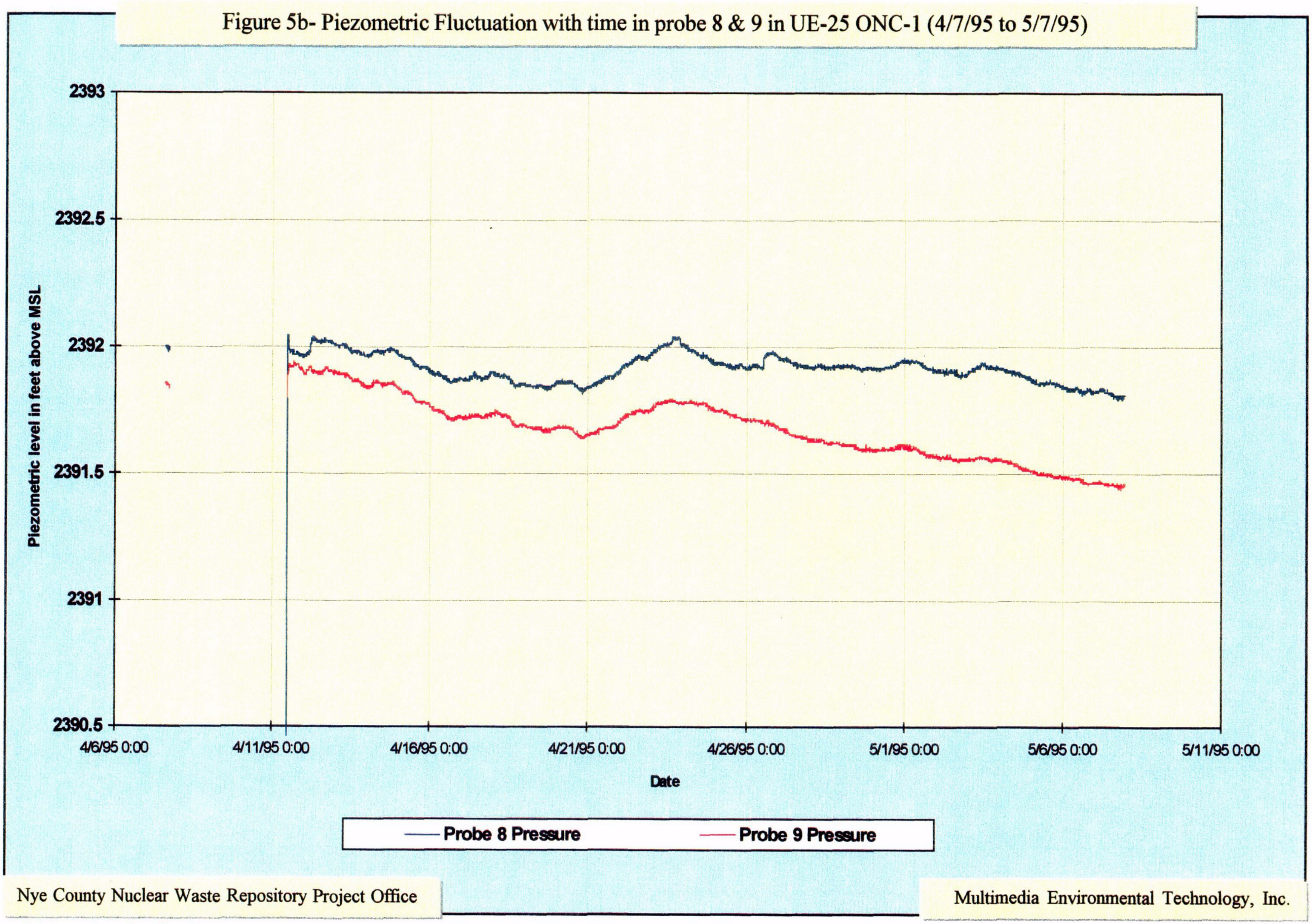


Figure 5b- Piezometric Fluctuation with time in probe 8 & 9 in UE-25 ONC-1 (4/7/95 to 5/7/95)
2393
2392.5
2392
2391.5
2391
2390.5
Piezometric level in feet above MSL
4/6/95 0:00
4/11/95 0:00
4/16/95 0:00
4/21/95 0:00
4/26/95 0:00
5/1/95 0:00
5/6/95 0:00
5/11/95 0:00
Date
Probe 8 Pressure
Probe 9 Pressure