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MASSIVE HYDRAULIC FRACTURE MAPPING
AND CHARACTERIZATION PROGRAM

FIRST ANNUAL REPORT:
AUGUST 1975 THROUGH JULY 1976

R. P. McCANN, R. G. HAY, AND L. C. BARTEL

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Abstract

The FY'76 major objectives of the Massive Hydraulic Fracture Mapping and Characterization Program were to assess the feasibility of the surface electrical potential and surface seismic systems to provide locational information on hydraulically-created fracture systems. The surface electrical potential system has demonstrated the capability to provide information on fracture azimuthal orientation, asymmetry of fracture, and direction of major fracture wing. Assessment of the surface seismic technique for fracture characterization is not encouraging.

During FY'76, Sandia participated in five MHF experiments for natural gas stimulation. Two of these were conducted by El Paso Natural Gas in the Green River Basin at Pinedale, Wyoming, and three were conducted by AMOCO in the Wattenberg field northeast of Denver, Colorado. Sandia supported all five experiments with the surface electrical potential system and three with surface seismic arrays.

This report describes both fracture characterization techniques, provides an overview of the associated hardware and software development, and presents the results obtained from participation in the field tests.

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Summary

This is the first annual report of the Sandia Laboratories Massive Hydraulic Fracture (MHF) Mapping and Characterization Program funded by the Division of Oil, Gas and Shale Technology of the Energy Research and Development Administration (ERDA). Seismic array correlation studies and surface electrical potential distribution techniques have been selected as the more promising methods to determine the characterization of fractures.¹ This report describes the activities from August 1, 1975 through July 31, 1976, and background information acquired prior to August 1, 1975.

Field data have been obtained during five fracturing tests in two locations. The fracturing was performed by Halliburton Services for El Paso Natural Gas (EPNG) Company in the Green River Basin at Pinedale, Wyoming, and for AMOCO in the Wattenberg field in Colorado.

Two MHF's were performed at Pinedale, Wyoming and were conducted on the same well (Pinedale Unit 5). Data using the surface electrical potential and surface seismic systems were collected for the first fracture in late June and early July of 1975 and for the second fracture in October of 1975. The massive fractures occurred on July 2, 1975 and October 20, 1975. Pinedale Unit 5 is one of 11 wells which have been drilled in the Pinedale anticline and is located approximately 20 miles south and east of Pinedale, Wyoming.

Three MHF's were performed in the Wattenberg field located north and east of Denver, Colorado. Sandia collected data using the surface electrical potential system for the first (Martin Hart "E" No. 1) in November of 1975 and for the second (Salazar, G.U. No. 1) in December of 1975. Data were collected using the surface electrical potential and the surface seismic system for the third (UPRR-22P) in January of 1976. The massive fractures occurred on November 18, 1975, December 16, 1975, and January 27, 1976.

To aid in the interpretation of the surface electrical potential data, a mathematical modeling effort was undertaken. This modeling method utilizes the Green's function integral equation approach where the so-called half-space Green's function is used. The potential difference that exists at the surface between pairs of potential probes placed circumferentially around the well as a function of fracturing conditions are calculated. This calculated potential difference made before the fracture is compared with the calculated potential difference after fracturing and the change in potential gradient for various angles around the well are determined.

Although the mathematical model calculations are for a homogeneous and isotropic earth, the results are believed to describe the azimuthal directions, any asymmetry of the fracture, and the direction of the major portion of the fracture.

Comparison of the model calculations with the field data collected using the surface electrical potential system

indicates for the Pinedale #5 July 2 fracture that the orientation is in a NW-SE direction and is asymmetric with the major wing in the NW direction. The residual conductivity from the July 2 fracture could possibly have effected the measurements of the October 20 fracture; however, it appears the orientation and major wing of the October 20 fracture is the same as that of the July 2 fracture.

Comparison of model calculations with field data collected using the surface electrical potential system in the Wattenberg field indicates asymmetric fractures oriented in the NW-SE direction on all three wells. The major wing of the fracture for the Martin Hart "E" No. 1 and the UPRR-22P appears to be to the NW. The major wing of the fracture for the Salazar, G.U. No. 1 appears to be to the SE.

Because of the many unknown variables encountered when using the surface seismic system, wide-band amplifiers were required in recording the seismic signals. Thus the signal-to-noise ratio of the seismic system output is very poor and its demanding computer codes and long computer runs make the problem complex and time consuming. Whether signals recorded by the surface seismic system that are associated with the fracture are large enough to be useful in fracture characterization has not been conclusively demonstrated.

I. INTRODUCTION

Two methods were used in the attempt to characterize the hydro-fracture, surface potential and seismic. The first method described is the surface potential and the second is the seismic.²

The surface electrical potential method is associated with the science (or art) of electrical prospecting used in the investigation of geological structures. The casing of the well to be fractured is used as the probe for inducing current into the earth. A remote well casing serves as the return current probe. Before fracture, the potential distribution is measured at the surface and on a circumference around the well. Theoretically, the equal potential lines form concentric circles with the well as their center. After fracture, the fracture fluid being conductive causes elliptically-shaped, equal potential lines to form at the surface (Fig. 1). The surface electrical potential measured after the fracture is the resultant of the field from the vertical casing and the horizontal fluid. This causes a predictable distortion of the concentric circles formed by the vertical well casing. Because of the variation in the earth's electrical constants in the vicinity of the well, a reference measurement is made before the fracture. If the potential measurements before and after the fracture are normalized and compared, diagnostic information about the fracture is obtained.

SURFACE POTENTIAL VARIATION MAPPING TECHNIQUE

A. Fracture Well as Current Source

B. Hydraulic Fracture as Current Source

Fig. 1 - Surface Electrical Potential and Potential Gradient Distribution.

The surface electrical potential system was used in all five major fractures.

The seismic hydrofracture characterization program is directed at resolving whether the fracture of a rock formation produces acoustic signals and if produced whether they can be used to characterize the fracture. The actual mechanism of the fracture of nonhomogeneous rock is not well understood nor has it been analytically modeled. The process by which this mechanism might produce acoustic signals is even more obscure. Once generated, such signals would propagate through a largely undefined medium of unknown propagation properties to remote seismometers.

The number of uncertain events required for a detectable seismic signal to reach a given seismic monitor location makes the prediction of signal characteristics extremely difficult. Without knowing the character of the signals to be recorded, it is not possible to optimize the recording system. For this reason, wideband amplifiers have been used in essentially omnidirectional arrays in order to determine empirically the production of acoustic signals.

The known variables in this case are few. They include the time of the fracture operation, the location of the seismic monitor station, the time of some extraneous noise sources, and some measured quantities such as the well pressure and time history of variations in the fracture fluid. Also it is generally assumed that the fracture will lie in a plane perpendicular to the least principle stress of the formation. If

the sources of seismic disturbances during a fracture operation appeared to originate from a vertical plane of a deep fracture, then one could infer the fracture orientation. Because of the many variables in the problem of finding a solution, a considerable effort has gone into writing computer software to convert field recorded seismic array data to source location plots. The computer software takes advantage of this assumed shape character.

The seismic data collection system was included in three of the five major fracture experiments conducted at the Pinedale and the Wattenberg fields. These included both fractures at Pinedale Unit 5 in July and October of 1975 and the fracture at the AMOCO UPRR-22P well in January of 1976. In addition, a second test at the Nevada Test Site (NTS) in July of 1976 was made. This test was similar to the first NTS test made in the spring of 1974.

II. BACKGROUND

A. Nevada Test Site

Several hydrofracture experiments were conducted at the Nevada Test Site by Sandia's nuclear test department and some seismic data were collected during the spring of 1974. The area of the fracture was mined to determine in situ stress and fracture orientation.³ Instrumentation for collecting seismic data was deployed in a tunnel complex which was adjacent to the borehole used for fracturing.

Six pairs of vertical and horizontal seismometers resonant at 14 Hz were spaced at 25 feet intervals on a line perpendicular to and 130 feet distant from the fracture borehole. Seismic data were collected and numerous signals believed to be associated with the fracture were recorded. Data analysis showed that the signals were high in amplitude, high in frequency, and were dissimilar between seismometer stations. A large part of the signal energy was located between 100 Hz and 600 Hz. The mean depth of the fracture zone was 1350 feet. No seismic signals that could be related to the fracture were observed below approximately 800 psi pumping pressure in the fracture zone.

Figures 2 through 5 show typical seismic signals recorded at the NTS test. All signals shown have been band pass filtered from 200 to 500 Hz. Figures 2 and 3 show respectively the vertical and horizontal seismometer output from station 1 located approximately 136 feet from the bottom of the fracture well bore. Figures 4 and 5 show respectively vertical and horizontal signals from station 5 located approximately 157 feet from the bottom of the fracture well bore.

B. San Juan Basin, New Mexico

In the summer of 1974 EPNG conducted a hydraulic fracturing operation in the San Juan Basin of New Mexico. In this gas field hydraulic fracturing is extensively utilized in relatively shallow wells (depths to approximately 3500 ft.) as a means of stimulation. EPNG invited Sandia to participate

ETA3BP NTS HYDRO FRAC-3 1V1T2
TI = 00 37 38.450 + 200 MS. BP = 200 TO 500 HZ.

Fig. 2 - NTS Vertical Seismometer Signal. Station 1 located 136 feet from Fracture Zone.

ETA3BP

NTS

HYDRO FRAC-3 1H1T1

MAY 20, 1974

BP 200 TO 500 HZ.

Fig. 3 - NTS Horizontal Seismometer Signal. Station 1 located 136 feet from Fracture Zone.

ETA3BP NTS HYDRO FRAC-3 SV1T10
TI = 00 37 38.450 + 200 MS. BP = 200 TO 500 HZ.

Fig. 4 - NTS Vertical Seismometer Signal. Station 5 located 157 feet from Fracture Zone.

ETA3BP

NTS

HYDRO FRAC-3 5H1T9

MAY 20, 1974

BP 200 TO 500 HZ.

Fig. 5 - NTS Horizontal Seismometer Signal. Station 5 located 157 feet from Fracture Zone.

in the operation in order to investigate the feasibility of surface electrical potential and seismic instrumentation techniques for characterization of hydraulic fractures. The object of the experiment was to evaluate the instrumentation for subsequent tests. Although no major effort was expended on data analysis, changes in surface potentials were of sufficient magnitude to indicate feasibility in fracture diagnostics. The primary purpose of the seismic techniques was to determine the effect of noise background from the pumping equipment at the well site during fracturing. The noise background due to this equipment was much lower than had been anticipated, indicating that surface seismic may be used in characterization of fractures.

C. Pinedale, Wyoming

In September 1974 EPNG conducted a massive hydraulic fracturing experiment in their Pinedale Unit 7 well in Wyoming. In contrast to the San Juan Basin operation the depth of the Pinedale Unit 7 well extended to approximately 12,000 feet. Again EPNG invited Sandia to participate in the experiment to evaluate the surface electrical potential and seismic techniques when used in deep-well fracturing.

Surface electrical potential data was obtained by measuring the potential gradient induced by a bipolar current pulse. To aid in the interpretation of the data, a simplified mathematical model^{4,5} was employed. Codes were developed for the CDC 6600 computer in order to analyze the data and to evaluate the numerical model. Preliminary data analysis of

several sets of pre- and post-fracture measurements indicated that potential gradient changes did occur. The results showed that additional techniques, such as recording data simultaneously from all radial positions and increasing the data rate, must be developed and sensitivity of the sensors increased to enhance signal-to-noise ratio in order to make surface electrical potential measurements reliable diagnostics.

In order to evaluate the seismic techniques, surface, sub-surface, and deep geophones were employed at several locations. A significant number of signals were recorded that appeared to be associated with the fracturing event. Characteristics of the recorded signals included frequencies which were predominantly in the range of a few hertz, time durations of one to two seconds, and amplitudes at the output of the wide-band logarithmic amplifiers, a factor of three to four above the noise. Because analysis of the seismic data is very complex and time consuming, and the electronics and transducer array used in this exercise were not as well suited to mapping the fracture as that used in later experiments, only selected portions of the data have been studied.

III. SURFACE ELECTRICAL POTENTIAL METHOD

A. Equipment Development

The surface electrical potential data is taken by recording the potential differences between 24 pairs of probes placed circumferentially around the well (Fig. 6). During the conceptual stages of the electrical potential method, the potential data was collected sequentially from pairs of probes.

Fig. 6 - Layout of the Surface Potential Instrumentation.

The September 1974 Pinedale No. 7 fracture experiment indicated that the electrical potential technique may be used to determine the azimuthal orientation of the fracture, although both the instrumentation and the technique used were rudimentary.

Instrumentation was developed for the July 1975 fracture that allowed the electrical potential data to be collected nearly simultaneously. The data from this fracture were recorded on tapes and the tapes were returned to Sandia Laboratories for data reduction and analysis. Equipment associated with the fracture experiment, such as gas and water separating plants, storage tanks, and pipe lines, at the well site can effect the electrical potential measurements. Because the equipment has good electrical contact with the earth and is attached to the wellhead, the potentials measured at the probes are affected and any change in this configuration would also be reflected in the measurements. Examination of the data indicated that equipment changes and the activity around the well site had a great affect on the potential measurements. As a consequence, subsequent experiments utilized an analog-to-digital converter and a mini-computer to record and analyze data in the field. Therefore, any discrepancies in the measurements were detected while the experiment was continuing and corrections made. Also the data transmission rate was greatly increased.

The instrumentation operates as follows: The induced current and the data collection is controlled from the instrumentation van. The mini-computer initiates the entire

sequence of one complete set of data measurements. The potential at each location is transmitted to the van where it is recorded and measured. Figure 7 is a block diagram of the instrumentation located at each stake-pair location. The output for 12 locations are frequency multiplexed onto one coax cable sequentially, and two coax cables carry data from the 24 stake-pair locations into the instrument van. For record-keeping purposes, these are referred to as A-string and B-string. Each location is identified as A1 through A12 and B1 through B12.

The instrumentation van contains 12 subcarrier discriminators, monitoring equipment, power supplies, and a mini-computer. The peripherals for the mini-computer includes an analog multiplexer, an A/D converter, a storage disc, and a teletype terminal. Figure 8 shows a block diagram of this system.

The potential field is created by inducing electrical current flow through the earth. DC current from a series of nickel-cadmium batteries is used. The direction of current flow is reversed during each measurement to eliminate polarization effects. A three-second current pulse is initiated and after a one second delay each data channel is sampled 20 times at 25 millisecond intervals. This is repeated for the reverse current flow. The potential for each position is taken as the difference between the sampled positive pulse and the negative pulse. Because the potential of each location is normalized

Fig. 7 - Stake-Pair Instrumentation.

Fig. 3 - Instrumentation Van Configuration.

with respect to the current used to induce the field, the measurement of the current pulse is consistent with the measurement of the potential pulse. Therefore, the output data is the normalized potential in the form of resistance.

The original current source employed in obtaining the potential measurements made use of high current transistors in circuitry that produced bipolar current pulses. The system had the capability of producing variable pulse amplitude, variable pulse duration, and currents to a maximum of 20 amperes. The sequence was initiated manually by a push-button switch. A serious problem in the system developed when manufacture of the high current transistors was discontinued. Accordingly, the development of another current system was required.

The new system utilizes a silicon controlled rectifier (SCR) for the basic current gate and high power vacuum relays to obtain the bipolar current pulse. Salient features of the system are:

- 1) The entire sequence is initiated and the pulse duration is controlled by the mini-computer.
- 2) Automatic switch over for charging batteries is provided.
- 3) Batteries are sealed lead-acid cells.
- 4) Current capability is 50 amperes.
- 5) Voltage capability is 600 volts.
- 6) Voltage is selectable in steps of 80 volts each to a maximum of 560 volts.

- 7) Because there is a limitation of working into a minimum load of eight ohms, there is a short circuit protection.
- 8) The potential data is collected simultaneously from all 24 stake-pair locations.

Although this system was not available for the Wattenberg experiments, it is now in operation.

B. Theoretical Modeling

Electrical prospecting is a well-known technique that is used in the investigation of geological structures beneath the surface of the earth. The approach taken is to determine the variation of the electrical constants of the earth's crust and to make the proper interpretation of these variations. The variation in resistivity is by far the greatest and the theory used is based entirely upon electrical potential theory.

In the application of potential theory considered here, the fracture well casing serves as a current electrode. The return path for the current is provided by another well casing located some distance from the source. The fracture fluid is made conductive and after fracturing the fluid-filled fracture acts as a horizontal conductor within the fracture zone.

A rigorous analysis of potential distributions resulting from a penetrating electrode has been presented by Muskat.⁶ The formulae developed by Muskat cover both point electrodes at the surface of the earth and penetrating electrodes. Also the formulae are applicable for the potential distribution at

both small distances and large distances from the current source. However, the analysis is overly complicated and for present purposes a simpler analysis can be applied to the hydrofracture problem. Sunde⁷ in his treatment of buried metallic structures used for both power and communication systems describes a simpler analysis. In this analysis, mathematical approximations not affecting the fundamental aspects of the problem are used in order to obtain engineering equations. Two simplifying assumptions made in the development of the equations are that the earth is homogeneous and isotropic and the current flux density along the penetrating electrode is uniform. The equations are believed to be applicable although the assumptions are not strictly valid.

An initial approach treated the well casings and fluid-filled fracture in an infinite homogeneous medium as perfectly conducting line sources. For a nonhomogeneous medium, a resistance ladder network, chosen to represent the well casing, fracture fluid, and the resistivity of the formation, was used to apportion the current densities on the fracture well casing and the fluid-filled fracture. These calculations represent the first attempt to model the electrical potentials encountered in the MHF mapping problem.⁵

A second modeling effort, which utilizes the Green's function integral equation approach where the so-called half-space Green's function is used, was undertaken in order to more readily incorporate variables not included in the first model. Here, the well casing and fracture fluid are assumed

to have a finite resistivity, and the voltage distribution along the well casing and fluid-filled fracture are taken into account. In general this would result in solving an integral equation. However, to illustrate the potentials to expect during fracturing, some simplifying assumptions are made which result in a closed form solution. It is assumed that the well casings and the fluid-filled fracture can be treated as line electrodes with a finite cross-sectional area; the earth is treated as a half-space with a uniform resistivity; and the current leaving or entering the line electrodes per unit length are constant. With these assumptions, the new calculations are similar in some respects to the earlier results.

The use of the Green's function technique for solving partial differential equations in electrostatic problems is quite common.⁸ This technique is used here to solve for the electrical potentials in the MHF mapping problem. A more detailed treatment of the Green's function approach as applied to the MHF mapping problem is given elsewhere.⁹ An outline of this method is as follows:

Consider a volume V bounded by a surface S . Green's second identity given by Van Bladel⁸ is

$$\int_V dv' \left\{ G(\underline{x}, \underline{x}') \nabla'^2 \phi(\underline{x}') - \phi(\underline{x}') \nabla'^2 G(\underline{x}, \underline{x}') \right\} \\ = \int_S dS' \Gamma(\underline{x}, \underline{x}') , \quad (1)$$

where

$$\Gamma(\underline{x}, \underline{x}') = G(\underline{x}, \underline{x}') \frac{\partial \phi(\underline{x}')}{\partial n'} - \phi(\underline{x}') \frac{\partial G(\underline{x}, \underline{x}')}{\partial n'}. \quad (2)$$

Here $G(\underline{x}, \underline{x}')$ is the Green's function, $\phi(\underline{x}')$ is the sought after solution for the potential, $\partial/\partial n'$ is the normal derivative to the surface, and $\underline{x}'$ is on the surface S . The appropriate Green's function to use here is

$$G(\underline{x}, \underline{x}') = \frac{1}{4\pi} \left\{ \frac{1}{[(x-x')^2 + (y-y')^2 + (z-z')^2]^{1/2}} + \frac{1}{[(x-x')^2 + (y-y')^2 + (z+z')^2]^{1/2}} \right\}, \quad (3)$$

where $G(\underline{x}, \underline{x}')$ satisfies the equation

$$\nabla^2 G(\underline{x}, \underline{x}') = -\delta(x-x')\delta(y-y') \{ \delta(z-z') + \delta(z+z') \}, \quad (4)$$

and $\delta(x-x')$, etc., are Dirac delta functions. $G(\underline{x}, \underline{x}')$ has the property that the normal derivative of $G(\underline{x}, \underline{x}')$ in equation (2) will vanish at the surface of the earth.

For a volume which does not contain any charges or currents such that $\nabla^2 \phi = 0$, then from equation (1), $\phi(\underline{x})$ is given by

$$\phi(\underline{x}) = \int_S dS' \Gamma(\underline{x}, \underline{x}') \quad (5)$$

It remains now to solve equation (5) for the potential $\phi(\underline{x})$ with a specified current distribution, $\partial\phi(\underline{x}')/\partial n'$, on S . Since there is a current leakage from the electrodes, the potential distribution on S , $\phi(\underline{x}')$ in equation (2), is

determined by the specified $\partial\phi(\underline{x}')/\partial n'$ as will be shown.

The surface S consists of the surface of the earth ($z' = 0$), the fracture well casing (S_+) along with the associated conducting fracture fluid (S_f), and the current sink well (S_-) as shown in Fig. 9. No current lines flow through the surface of the earth such that $\partial\phi/\partial n' = 0$ at $z' = 0$; also at $z' = 0$, $\partial G/\partial n' = 0$ where $\partial/\partial n' = -\partial/\partial z'$. In addition, $\partial\phi/\partial n'$ and $\partial G/\partial n'$ vanish at ∞ . Thus equation (5) becomes

$$\begin{aligned} \phi(\underline{x}) = & \int_{S_+} dS' \Gamma(\underline{x}, \underline{x}') + \int_{S_-} dS' \Gamma(\underline{x}, \underline{x}') \\ & + \int_{S_f} dS' \Gamma(\underline{x}, \underline{x}') \quad , \end{aligned} \quad (6)$$

where $\Gamma(\underline{x}, \underline{x}')$ is given by equation (2) and the surface is shown in Fig. 9. The normals to the surface are outward normals.

The integral equation, equation (6), is in general difficult to solve. However, to illustrate the potentials for the MHF mapping problem some simplifying assumptions are made. With these assumptions the solution reduces to some simple integrals which can be evaluated in closed form. However, the Green's function technique is general enough to handle more complicated cases which would require solutions to an integral equation.

In this report the following assumptions are made. The resistivity of the earth is assumed to be uniform with a value of ρ . Since the earth is assumed to have a uniform resistivity, it is reasonable to assume that the current leaving or entering

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an electrode per unit area is constant.⁷ The well casings and the fluid-filled fracture are treated as line sources with a finite cross-sectional area and circumference. The current leaving the (+) electrode (+ well casing and conducting fracture fluid) per unit area is taken to be

$$j_+ = I/(S_+ + S_f) \quad (7)$$

while the current entering the (-) electrode (- well casing) per unit area is taken to be

$$j_- = I/S_- \quad (8)$$

where I is the current injected into the (+) electrode. As long as the measurements are made far away from the fracture, the (-) electrode is sufficiently far away from the (+) electrode, and the half-space has a uniform resistivity, the above assumptions are reasonable.

The area integrals in equation (6) are approximated by replacing them by the appropriate line integral times a circumferential factor or area factor. For an electrode, $\partial\phi/\partial n'$ in equation (2) is proportional to the current leaving or entering the electrode per unit area. (Current leaving is positive and current entering is negative.) Thus,

$$\frac{\partial\phi(\underline{x}')}{\partial n'} = \begin{cases} j_+ \rho, & \text{on } S_+ \text{ and } S_f \\ -j_- \rho, & \text{on } S_- \end{cases} \quad (9)$$

To finalize the development, the potential distribution, $\phi(\underline{x}')$ in equation (2), needs to be determined. Briefly, the

potential distributions on the electrodes are determined by the current distribution; a more detailed account is given elsewhere.⁹ The potential distributions on each conductor are given by

$$\phi_+(z) = V_O^+ - (\rho_p j_+ / A_p) \left[(S_+ + S_f) z - \pi a z^2 \right], \text{ on } S_+, ,$$

$$\phi_f(x) = \begin{cases} \phi_+(\ell_+) - (\rho_f j_+ / A_f) \left[S_f' x - (h+t)x^2 \right], & \text{on } S_f, x > 0, \\ \phi_+(\ell_+) + (\rho_f j_+ / A_f) \left[S_f'' x + (h+t)x^2 \right], & \text{on } S_f, x < 0, \end{cases}$$

$$\phi_-(z) = V_O^- + (\rho_p j_- / A_p) \left[S_- z - \pi a z^2 \right], \text{ on } S_-, \quad (10)$$

where the subscript p and f on ρ denote the resistivities for the well casing and fracture fluid, respectively. Here a is the well casing radius and h and t are the fracture height and thickness, respectively. The surface areas S_+ , S_f , and S_- in Fig. 9 are: $S_+ = 2\pi a \ell_+$, $S_f \approx S_f' + S_f'' = 2(h+t)\ell' + 2(h+t)\ell''$, and $S_- = 2\pi a \ell_-$. The cross-sectional area A_p and A_f are given by $A_p = \pi[a^2 - (a-t')^2]$, t' is the well casing thickness, and $A_f = ht$.

Approximating the area integrals by a line integral times the appropriate circumferential factor or area factor, from equations (2), (3), (6-9), and (10) the potential $\phi(x)$ can be determined. It is convenient to express the results in terms of normalized variables where variables are normalized by ℓ_+ , ρ , $I\rho/\ell_+$ for the length, resistivity, and potential, respectively.

The variables in the following equation are the reduced variables where in the previous equations.

$$\begin{aligned}x &\rightarrow x/\ell_+, \text{ etc.}, \\ \rho_i &\rightarrow \rho_i/\rho, \\ \phi &\rightarrow \phi(\ell_+/I\rho).\end{aligned}$$

In terms of the normalized variables the potential $\phi(\underline{x})$ becomes

$$\begin{aligned}\phi(\underline{x}) &= (a/2)\lambda \int_0^1 dz' (g_+ + g_-) |_{x' = x_+, y' = y_+} \\ &- (a^2/2) \int_0^1 dz' \phi_+(z') (g_+^3 + g_-^3) |_{x' = x_+, y' = y_+} \\ &+ \left[(h+t)/2\pi \right] \lambda \int_{-\ell_-}^{\ell_-} dx' (g_+ + g_-) |_{y' = y_+, z' = \ell_+ - h/2} \\ &- (ht/2\pi) \int_{-\ell_-}^{\ell_-} dx' \phi_f(x') (g_+^3 + g_-^3) |_{y' = y_+, z' = \ell_+ - h/2} \\ &- (1/4\pi\ell_-) \int_0^{\ell_-} dz (g_+ + g_-) |_{x' = x_-, y' = y_-} \\ &- (a^2/2) \int_0^{\ell_-} dz' \phi_-(z') [g_+^3 + g_-^3] |_{x' = x_-, y' = y_-}, \quad (11)\end{aligned}$$

where

$$g_{\pm} = \left[(x-x')^2 + (y-y')^2 + (z \mp z')^2 \right]^{-1/2}, \quad (12)$$

and

$$\lambda = \left[2\pi a + 2(h+t)(\ell' + \ell'') \right]^{-1}. \quad (13)$$

The line integrals in equation (11) can be evaluated in closed form or numerically on a computer. For brevity, the closed form of equation (11) will be omitted here.

The potentials V_0^+ and V_0^- in equation (10) are determined self consistently by solving equation (11) for points on the well casing at x_+, y_+ (+ well) and at x_-, y_- (- well) both at $z = 0$. It is noteworthy that for the current injected at any other place than on (+) well casing at $z = 0$, the expressions for the potential distributions on the electrodes, equation (10), will be altered.

The experimental procedure used by Bartel, McCann, and Keck¹⁰ was to compare potential gradients prior to and after the fracturing. To model the experiment, the potential gradient calculated at the surface ($z = 0$) at radii R_1 and R_2 along the same radial is defined by

$$\Delta\phi(\theta) = \phi(R_1, \theta) - \phi(R_2, \theta) \quad (14)$$

where $R_1 < R_2$ as shown in Fig. 9. The comparison of potential gradients before and after the fracturing is

$$V(\theta) = \Delta\phi(\theta)_{\text{after}} - \Delta\phi(\theta)_{\text{before}} \quad (15)$$

A plot for $V(\theta)$ for selected R_1 and R_2 and fracture length $\ell' + \ell''$ are shown in Fig. 10. For the calculations here, the fracture is oriented in the 90° to 270° direction. The various curves in the figure represent the degree of asymmetry of the fracture. For the 0.50 curve, the fracture is symmetric and there are two cycles within the 360° . The 1.00 curve denotes

Fig. 10 - Difference in potential gradient $V(\theta)$ (after fracture minus before fracture) as function of angle around fracture well; fracture is along line from 90° to 270° with major portion in 90° direction for the asymmetrical fractures; R_1 and R_2 are radii at which the potentials are calculated; normalization length is fracture well depth l_+ and normalization potential is $\rho l_+ V(\theta)$ defined by Eq. (15).

the total fracture in the 90° direction. Note that the asymmetric curves (.667, .75, 1.0) show a change in potential gradient to be one cycle for 360°. For an asymmetric fracture, the largest negative value of the cycle occurs in the direction of the major part of the fracture while the smallest negative value of the cycle is in the direction of the minor part. For these conditions, the induced current was injected at the fracture well casing at the surface of the earth. Calculations have been made for the current injected directly into the fracture zone. The results for a downhole current source are similar to those for the current injected at the surface.

C. Data Acquisition and Analysis

1. Pinedale -- Two electrical potential experiments were conducted on the same well (Pinedale Unit 5). One in July of 1975 and the second in October of 1975.

The fracture zone for the July 1975 experiment had an interval of 215 feet beginning at a depth of 10,950 feet and extending to a depth of 11,190 feet. The fracture zone of the October 20, 1975 experiment involved an interval of 667 feet beginning at a depth of 10,120 feet and extending to a depth of 10,787 feet. The thickness of the gas-bearing sandstone in the zones varied from 15 feet to 120 feet and the separating shale layers varied from 7 feet to 200 feet.^{11, 12}

a. July 1975 fracture -- Perforation occurred on June 16, 1975, the breakdown on June 17, 1975, and the massive

fracture on July 2, 1975. Potential data measurements were made for background, breakdown, and the main fracture.

The 24 potential probes were placed circumferentially around the well with an inner probe radius of 1800 feet and an outer probe radius of 2300 feet. Each probe consisted of a copper rod inserted in a saturated solution of copper sulphate. The solution was allowed to seep slowly through the ground to ensure a good electrical contact. Each probe was placed approximately six inches in the ground. This type of probe was chosen in order to minimize polarization effects. Because of poor control on the rate of seepage of the solution, the probe was replaced by a metal stake for subsequent tests.

The current pulse was induced directly into the wellhead (source) at the surface of the earth. The return line (sink) was attached to the well casing of Pinedale Unit 1 located approximately 7500 feet to the southeast.

Pumping for breakdown began at 0908 hours and ended at 1257 hours. A total of 46,000 gallons of fluid were pumped. Pumping for the main fracture began at 0940 hours and continued through 1325 hours. A total of 191,000 gallons of fluid were pumped. The fluid used in this operation contained potassium chloride (KCl) which placed the resistivity of the fluid in the range of .1 to .2 ohm-meter.

The water used in the pumping fluid was obtained from a water well located in the Wagon Wheel well area approximately 3000 feet northwest of Pinedale Unit 5. A metal pipeline, three to four inches in diameter, connected the water well

(approximately 2500 feet deep) and the water tanks at the Pinedale 5 site. In addition, a production unit consisting of gas, condensate, and water separating equipment was constructed and placed at the well site and attached to the wellhead by a conducting pipe. A considerable amount of conducting pipe and two large storage tanks for condensate were associated with this arrangement. Thus current is shunted from the wellhead to all of the various parts of this equipment. Variations in equipment configuration before, during, and after pumping results in perturbations to the potential gradient changes which can completely mask the desired gradient changes required to describe the fracture.

The frequency multiplex signals from both A string and B string were recorded on tape which was returned to Sandia Laboratories for processing. In addition to the potential signal, the induced current for each measurement was monitored and recorded on the tape. The potential measured was normalized by dividing each potential by the induced current. The reduced data was formatted such that it is readily available for use in Sandia Laboratories CDC 6600 computer.

The data for the July 2 fracture are presented in Table I through Table III, Appendix A. The data for breakdown on June 17, 1975 are shown in Table I. The data for background on June 30, 1975 are shown in Table II. Table III shows data which were taken on the day of the main fracture, July 2, 1975.

Examination of the data indicated changes in the equipment configuration at the well site did indeed affect the potential measurements. The data from 255 degrees through 360 degrees had such a deviation from one measurement to the next that they were excluded from the results. It was in this area that changes in equipment configuration had the most influence on the measurements. Also, because of this influence of equipment configuration change, only data taken prior to the main fracture through the completion of pumping was considered. Measurements starting at 0900 hours through 1108 hours were averaged and used as the before-fracture data. Measurements starting at 1118 hours through 1329 hours with the exception of the data point taken at 1239 hours were averaged and used as the after-fracture data. For convenience, a multiplying factor of 100 was used.

The results of the July 2 fracture are shown in Fig. 11. The results indicate a fracture extending to the northwest. However, changes in the equipment configuration could also have influence on the entire set of data.

b. October 1975 fracture -- Most of the potential measurement system remained the same as that for the July test. The changes that were made follows:

- 1) Metal stakes were used as probes in place of the copper sulphate pots.
- 2) A mini-computer was used in the field for receiving and reducing the data.
- 3) The current pulse consisted of one cycle instead of three.

Fig. 11 - Potential Comparison as a Function of Direction for Pinedale 5 Fracture, July 2, 1975.

Breakdown occurred on October 15, 1975, when a total of 22,240 gallons of fluid was pumped. The massive fracture occurred on October 20, 1975, and a total of 460,000 gallons of fluid were pumped with a total of 1.4 million pounds of sand for proppant. The resistivity of the fluid was the same as that used in the July fracture.

As mentioned above, an examination of the July 2, 1975 fracture data indicated changes in the equipment configurations used at the well site affected the potential measurements. Therefore, for the October 20 test more attention was directed to this equipment. An agreement with El Paso Natural Gas was made to preserve the equipment configuration throughout the measurements to ensure integrity of pre-fracture and post-fracture data.

The data for the October 20 fracture are presented in Table I through Table VI, Appendix B. Potential measurements were made on October 14, 15, 16, 18, 20, and 21 of 1975. Breakdown occurred on October 15 and the main fracture on October 20, 1975.

The data was averaged in the same manner as that for the July 2 fracture. For the plot presented here, the data considered was that taken on the day of the main fracture. The before-fracture data started 1030 hours and continued through 1145 hours. The after-fracture data started at 1200 hours and continued through 1430 hours. The October 20 potential comparison data are plotted in Fig. 12, and although the data were

Fig. 12 - Potential Comparison as a Function of Direction for Pinedale 5 Fracture, October 21, 1975.

noisy and the changes were very small the orientation appears to be in a NW-SE direction with the major wing extending to the NW.

The relatively high conductive fluid used in fracturing is pumped with wellhead pressures in excess of 6000 psi. The wall of the fracture zone does absorb some of the fluid. The amount of conductive fluid retained by the sandstone formation after flow back is not exactly known, however, the results of the October fracture may have been influenced by the residual conductivity from the fracture test in July.

2. Wattenberg -- The electrical potential experiments conducted at the Wattenberg field were similar to those performed at Pinedale. The system electronics was very nearly identical. Some improvement was made to the input filter of the isolation amplifier and the communication rate of data into the mini-computer was increased. Although the outer potential probe radius varied, the number and spacing of the probes around the well was the same as that at Pinedale.

The electrical potential experiments were conducted on three wells -- Martin Hart "E" No. 1, Salazar G.U. No. 1, and UPRR-22P. All three wells were open hole and the fracture zone was located at a depth of approximately 8000 feet. All were treated with approximately 300,000 gallons of fluid and 600,000 pounds of proppant. Access to a downhole current probe was provided by AMOCO on all three wells. The Wellex probe provided through AMOCO allowed the current to be induced at the fracture depth. A sinker bar was electrically connected to the center

conductor of a standard wire line which was then connected to the current pulser. Breakdown on all three wells occurred weeks before the main fracture.

a. Martin Hart "E" No. 1, November 18, 1975 fracture --

The massive fracture occurred on November 18, 1975. Potential measurements were made for background and the main fracture.

The electrical potential probes were placed around the wellhead with an inner probe radius of 1800 feet and an outer probe radius of 2800 feet. Although the downhole current probe was available for use, a connection failure at the sinker bar required that the current be induced directly into the wellhead at the surface of the earth. The return line (sink) was attached to another well casing located approximately one mile to the east.

A total of 29,400 gallons of pad fluid were pumped between 0750 hours and 0825 hours. Pumping for the main fracture began at 0830 hours and continued to 1430 hours. A total of 317,000 gallons of fluid were pumped. A mixture of condensate and water (KCl added) was used for the main fracture. The resistivity of the water was in the range of .1 to .2 ohm-meter.

The data for the November 18 fracture are presented in Table I and Table II, Appendix C. Potential measurements were made on November 17 and 18 of 1975. As previously noted the number of measurements made before, during, and after the main fracture was increased to obtain good averages.

The potential comparison data is shown in Fig. 13. Only measurements taken on the day of the main fracture are included in this plot. Approximately 35 data points taken prior to the fracture were averaged and used as the before-fracture measurement. Approximately the same number taken at the end of the fracture were averaged and used as the after-fracture measurement. For convenience, a multiplying factor of 100 was used. The data obtained on the southern side was compromised by a high-tension power line that created excessive noise in the electronics and is, therefore, excluded from the plot.

Data analysis based on the fracture model indicates that an asymmetrical fracture would create electrical potential changes that are basically one cycle around the well. The plot of Fig. 13 suggests that the fracture is asymmetric and that the azimuthal direction is from northwest to southeast with the major extension being oriented to the northwest.

b. Salazar, G.U. No. 1, December 16, 1975 fracture --
The massive fracture occurred on December 16, 1975. Electrical potential measurements were made for the main fracture only.

The electronics system and the placement of the electrical potential probes were the same as that used for the Martin Hart test. However, the current pulse was induced, by means of the downhole probe, directly into the frac zone. The return line (sink) was attached to another wellhead located approximately two miles to the west.

Fig. 13 - Potential Comparison as a Function of Direction for the Wattenberg Martin Hart E No. 1 Fracture, Nov. 18, 1975.

A total of 29,400 gallons of pad fluid were pumped between 0900 hours and 0930 hours. Pumping for the main fracture started at 0935 hours and ended at 1440 hours. A total of 312,000 gallons of fluid were pumped. The fluid mixture was similar to that used for the Martin Hart fracture.

The data for the December 16 fracture are presented in Table I, Appendix D. Electrical potential measurements were made on December 16, 1975.

The data analysis was similar to the Martin Hart analysis and plots of the data are shown in Fig. 14. The Salazar data are the first data obtained with the downhole current probe.

The added resistance to the system due to the downhole current line caused a reduction in the injected current resulting in smaller signals measured at the surface of the earth. Although the effect of the fracture should be more pronounced the signal-to-noise ratio was low.

The data indicates that the fracture is asymmetric and the azimuthal direction is from northwest to southeast with the major portion of the fracture extending to the southeast.

c. UPRR-22P, January 27, 1976 fracture -- The massive fracture occurred on January 27, 1976. Electrical potential measurements were made for background and for the main fracture.

The test configuration and the electronics used was the same as that used for the previous fractures with the exception that the potential probes were placed with the inner probe

Fig. 14 - Potential Comparison as a Function of Direction for the Wattenberg Salazar, G.U. No. 1 Fracture, Dec. 12, 1975.

radius at 1800 feet and the outer probe radius at 4000 feet. The downhole probe was used where the current pulse was induced directly into the frac zone. The return current line was attached at two wells - one located approximately 1.5 miles to the northwest and the second located approximately 1.5 miles to the southeast.

Pumping for the main fracture started at 0840 hours and continued to 1700 hours. The pumping fluid was consistent with the previous two fracture tests where the resistivity of the water was in the range of .1 to .2 ohm-meter.

The data for the UPRR-22P are presented in Table I and Table II, Appendix E. Potential measurements were made on January 26 and 27 of 1976.

As noted in the previous tests, a great number of data points were taken and averaged in a similar manner. A plot of the data is shown in Fig. 15.

The fracture is oriented in a northwest to southeast direction and is also asymmetric with the major extension of the fracture to the northwest.

A location map of the AMOCO Wattenberg field depicting the relative locations of the test wells and the orientation of the fractures is shown in Fig. 16. The arrow drawn through the well location indicates the direction of the major wing of the fracture. Although the map is not exactly to scale the relative distances between well locations are fairly accurate. The distance between the Salazar and Hart locations is approximately six miles.

Fig. 15 - Potential Comparison as a Function of Direction for the Wattenberg UPRR-22P Fracture, January 27, 1976.

Muddy J Gas Sand MHF

310,000 Gallons Fluid

600,000 Pounds Proppant

Hart: Nov. 18, 1975

Salazar: Dec. 12, 1975

UPRR 22: Jan. 28, 1976

AMOCO WATTENBERG FIELD

Fig. 16 - Location Map of the AMOCO Wattenberg Field. Arrow direction indicates the orientation of the fracture and direction of the major wing.

A further analysis of the UPRR-22P data was made in order to determine the progressive growth of the fracture as a function of the quantity of pumping fluid. Figure 17 shows the plot of the fracture fluid volume versus time of day. Five groups of data were chosen and averaged in the same manner as the previous tests. The first group was used as the reference (before-fracture) measurement. Subsequent groups of data are taken in approximately 75,000 gallon increments. A plot of these groups is shown in Fig. 18. A growth away from the southeast quadrant is clearly shown and this represents the major frac length being in the northwest direction. The reversal in the northwest quadrant is not clearly understood, but could be caused by the total length being increased while the degree of asymmetry is changing.

IV. SEISMIC ARRAY METHOD

A. Field Experiments

For the fracture test on Pinedale Unit 7 in the spring of 1974 the seismic data collection system was characterized by wide bandwidths and logarithmic amplifiers which had a relatively large dynamic range. All data were taken with seismometers in cased holes at various depths and distances from the fracture well.

For this experiment the predominant frequencies of signals believed to be fracture related in origin were low, on the order of a few hertz. The noise generated by the pumping operation

Fig. 17 - Fluid Volume vs. Time of Day for the Wattenberg UPRR-22P Fracture, January 27, 1976.

Fig. 18 - Progressive Growth of Fracture as a Function of Direction
for the Wattenberg UPRR-22P Fracture, January 27, 1976.

was not as great as was previously relieved, and it appeared that very little was gained by having the seismometers at several hundred foot depths as opposed to twenty foot depths.

Wellhead pressure was recorded on the assumption that rapid pressure fluctuations would be fiducials for fracture events and indicate times of interest for examining the seismic records. Examination of these data has shown no significant correlation between wellhead pressure fluctuation and the occurrence of seismic events.

1. Pinedale Unit 5 fracture, July 1975 -- For the first massive fracture on El Paso Pinedale Unit 5, the recording hardware for the seismic portion was extensively modified from that of Pinedale Unit 7 in order to take advantage of what was observed in this earlier test. Most of the data were recorded with vertical seismometers which were implanted individually in dry holes approximately ten feet deep. The holes were spaced in an array around the fracture well at various distances from the well. The seismometers used were resonant at 4.5 Hz. The damping factor was 50 percent which produced a sensitivity of approximately 0.4 volts/inch/second.

The signals from the seismometers were fed to a linear, adjustable gain amplifier which had a pass band of approximately .5 Hz to 2300 Hz. The amplifier gains were tailored to the array geometry in that close-in stations, within 3000 feet of the well, were set to saturate (± 2.5 volts at the output) with approximately 40 microvolts rms at the input. Beyond

3000 feet the amplifiers were set to 6 db more gain which creates an input saturation voltage of approximately 20 microvolts rms.

The amplifier output was used to modulate a constant bandwidth voltage controlled oscillator (VCO) with a maximum deviation frequency of ± 2 KHz. The VCO frequencies were multiplexed on coaxial cables and transmitted to a central recording station where they were direct recorded along with time of day and voice annotation. The response of the telemetry system with a modulation index of one was 0 to 2000 Hz.

The array geometry for the July Pinedale Unit 5 experiment is shown in Fig. 19. The seismic stations are shown in boxes with S numbers. The grid lines on the map are section lines.

The data collected during the six-hour breakdown operation of this fracture were the first recorded with linear amplifiers. A large number of stations were used to facilitate calculations of source locations. The results were sufficiently encouraging that this method was adapted as the basis for development and test of reduction routines.

2. Pinedale Unit 5 fracture, October 1975 -- The second massive fracture for Pinedale Unit 5 occurred in October of 1975. Perforations for this fracture were at a mean depth of 10,355 feet and extended over a height of 648 feet. Prior to the operation a packer was set in the well case above the perforations used in the July operation.

The seismic instrumentation was similar to that used in the July experiment with the exception that the surface array was expanded slightly to include three subarrays of three closely spaced vertical elements and the downhole instrumentation in water well No. 2 was expanded to include three hydrophone stations in a vertical array with 2000 foot spacing. The exact locations and amplifier types for the seismic array are listed in Table I. Because the surface cables and the recording van were left in place after the July exercise, emplacement of this instrumentation was readily accomplished.

Seismic data were recorded during several operational events throughout the fracture experiment. The first occurred on October 3, 1975. The well case was perforated and a diagnostic pumping of 37 barrels of fluid took place. Several hours of information were recorded prior to and during the event to test the system and monitor the seismic background. The second major event occurred on October 14, 1975. The formation was initially broken down when a total of 22,240 gallons of fluid were pumped. The final exercise occurred during the main fracture on October 20, 1975. A total volume of 460,000 gallons of fluid were pumped with a total of 1.4 million pounds of proppant.

The reduction of this data has been delayed until more positive results from the July experiment are shown.

3. Wattenberg, UPRR-22P fracture -- The massive fracture experiment on AMOCO's UPRR-22P well was conducted in January of 1976. Eighteen seismic recording stations, one acoustic

Table I
Seismic Array
O-PD #5

Site Number	Location ¹		Transducer/ Type	Amplifier
	E-W	N-S		
1	-900	1700	Geo Space HS-1	Teledyne AS-310
2.1	1400	2100	Geo Space HS-1	Teledyne AS-310
2.2	2027	2410	Geo Space HS-1	Teledyne EA-210A
2.3	1445	2799	Geo Space HS-1	Teledyne EA-210
3	-4440	-2221	Geo Space HS-1	Teledyne AS-310
4	-2000	-1000	Geo Space HS-1	Teledyne EA-210A
5	2707	-4232	Geo Space HS-1	Teledyne AS-310
6.1	-1100	0	Geo Space HS-1	Teledyne AS-310
6.2	-1706	350	Geo Space HS-1	Teledyne EA-310
6.3	-1706	-350	Geo Space HS-1	Teledyne AS-310
7.1	0	-1500	Geo Space HS-1	Teledyne AS-310
7.2	-350	-2106	Geo Space HS-1	Teledyne EA-210
7.3	350	-2106	Geo Space HS-1	Teledyne AS-310
8.1 (H)	1518	-2374	Geo Space HS-1	Sandia T29769
8.2 (H)	1518	-2374	Geo Space HS-1	Sandia T29769
8.3 (V)	1518	-2374	Geo Space HS-1	Sandia T29769
8.4 (V)	1518	-2374	Geo Space HS-10	Sandia T29769
Water Well (H)	-2750	2000	Geo Space HS-1	Sandia T29769
Water Well (H)	-2750	2000	Geo Space HS-1	Sandia T29769
Water Well (V)	-2750	2000	Geo Space HS-1	Sandia T29769

1. Location is in feet with reference to wellhead.

monitor and a downhole pressure gage were used in the test. All the seismometers were located in ten foot holes. Six holes of intermediate distance from the fracture well contained a three-axis array of 4.5 Hz seismometers plus a vertical one with a resonance of 1 Hz. All other stations contained a single vertical seismometer resonant to 4.5 Hz. Figure 20 shows a plain view of the recording array around the UPRR-22P well. The acoustic monitor was co-located with the southernmost seismic station.

Data were continuously recorded from 0830 hours to 2000 hours on the day of the fracture. The pumping operation began at 0840 hours and terminated at 1700 hours with 299,830 gallons total volume pumped.

The downhole current line used for the surface electrical potential experiment required protection from the abrasive action of the fluid and sand during pumping. This was affected by tubing approximately 1.25 inches in diameter that extended from the surface to the depth of the fracture. Thus a static column of liquid existed from the wellhead to the fracture zone. Pressure fluctuations at the top of the tubing should represent the fluctuations at the fracture without flow loss complications. Pressure data recorded at the top of the tubing for a period of six hours were compared with seismic surface monitors. No noticeable correlation was found between pressure fluctuations and the presence of seismic signals.

4. Nevada Test Site - II -- During July of 1976 an attempt was made to duplicate the original NTS experiment.

Fig. 20 - Layout Pattern for the Seismic Monitor Array at Wattenberg Well UPRR-22P.

The intent of the new experiment was to quantify the characteristics of any signals recorded during the fracture operation. The primary seismometer three-axis arrays were grouted in place in 90 foot holes drilled from the tunnel at approximately 5° and 29° below horizontal. Other arrays were located in the tunnel and on the surface. The fracture well was drilled to the depth of the tunnel (1400 ft) at a distance of 280 feet from the tunnel in the direction of the 90 foot holes. Pressure data were recorded in the fracture tube and in the well annulus which was open to the fracture depth. Since there was no flow in the annulus the pressure fluctuations on that gage should represent the downhole fluctuations without flow loss complications. Figures 21 and 22 show the pressure records from the two gages. The differences between the two are due to flow losses, fluid density differences, and periods just prior to pumping when the annulus was open at the upper end.

It may be noted in Fig. 21 that the peak pressure in the fracture tube was approximately 950 psi. This is several hundred psi below the level reached in the previous NTS experiment at the same depth in the same formation. This low pressure is an indication that the fluid was actually inflating an old natural fracture system rather than breaking rock. Examination of corings made prior to the fracture in the well-bore show a large vertical fracture through the well at the fracture depth.

During the operation no significant seismic signals of the type seen in the earlier NTS fracture were recorded. The

FILTY NTS-2 TAPE 7 CHAN 5A 20:51:30.
OUTPUT OF A 0.5 HERTZ DIGITAL LOW-PASS FILTER

Fig. 21 - Nevada Test Site NTS-2 Fracture
Tubing Pressure

FILTY

NTS-2 TAPE 7 CHAN 6A 20:51:30

OUTPUT OF A 0.5 HERTZ DIGITAL LOW-PASS FILTER

Fig. 22 - Nevada Test Site NTS-2 Annulus Pressure.

seismometers were well coupled with an acoustic matching grout at a distance of only 200 feet from the wellbore. Some small signals were recorded by the vertical seismometers at the pump piston rate. These signals were used with the shear wave velocity determined from the core samples to locate the well bottom within the accuracy of the time difference measurement. The time difference of signal arrivals was not observed to change throughout the test indicating the sources were stationary and, therefore, not related to the crack tip.

The seismic records were very clean, the noise levels were low and system sensitivity was high. The records have been carefully examined and the conclusion has been reached that no crack related signals were present. The complication of the natural fracture precludes drawing any generalizations about hydraulic fracturing signals from this experiment. Mineback and examination of the fracture surfaces are currently under way and may shed light on what actually occurred during the operation.

B. Source Location Software -- As has been previously discussed, the direct attempts at finding the actual times of fracture related events by monitoring pressure changes have not proved fruitful. The only remaining known variable which can be utilized is the assumed vertical plane shape of the fracture. This also happens to coincide with the ultimate goal of the program which is to map the orientation and extent of the fracture. To accomplish this mapping, the assumption is made that the fracture does produce seismic

signals and that the sources of these signals are within the fracture. The problem then is to correlate recorded array seismic signals with source coordinate information.

Unfortunately, without knowing which time intervals contain fracture signals, one is left with no alternative but to find locations for all time intervals. Hopefully the locations for some of these intervals will line up in the manner which is assumed correct for a fracture shape and then from those intervals it will be learned what are the characteristics of a fracture signal.

With hours of data being recorded, it was necessary to automate the entire location data reduction process. The only signals which tended to correlate across several seismic stations in the Pinedale Unit 7 experiment were at frequencies in the order of a few Hertz. This is important since the frequencies of interest greatly affect the time required to process the recorded data. Low frequencies allow low sample rates for digitization which, in turn, lowers the number of operations required to perform point-by-point multiplications and summations required to generate correlation functions. Once the observation of analog records had shown that signals of interest were below 10 Hz, it was determined that tunable discriminators and low-pass filters could be used in the data reduction center to play back and digitize the data at four times real time. By filtering the speeded-up data at 40 Hz and sampling at 400 Hz, the digitizer is easily able to produce twelve-bit multiplexed samples for the nine surface

recording stations of the July Pinedale experiment. The effective filter frequency is 10 Hz and the sample rate is 100 Hz which is well above the Nyquist rate*.

The digital tapes thus produced are directly read by the CDC 6600 system which performs the rest of the reduction procedure. Since computation for certain portions of the procedures is directly related to the number of samples of data, the first operation is to request a desired sample rate for the data and decimate if possible. In the case of July Pinedale Unit 5 (J-PD #5) a 50 HZ sample rate would be sufficiently above the Nyquist frequency so a two-to-one decimation is used to reduce the number of samples.

The primary purpose of the routine which does the decimation is to perform cross-correlations on the signature data from various pairs of seismic stations in order to determine time of arrival differences for a signal at the two stations. These differences are later used to calculate seismic hypocenters.

Several pieces of information are required by the routine and are provided prior to any correlation calculation being performed. These are: the length of the time intervals to be correlated -- 10 seconds for J-PD #5, how often to generate the intervals -- every 5 seconds for J-PD #5, the number of

*If a band limited signal is sampled and the samples are to contain complete information of the signal, the rate of sampling must never be less than twice the signal frequency. This minimum sampling rate is the Nyquist rate.

such intervals on the digital tape being processed, the number and coordinates of the seismic monitor stations -- the six best stations as selected by studying the J-PD #5 analog records, the number and pairs of stations to be used in calculating the correlation functions -- all fifteen combinations possible for the six stations of J-PD #5, an estimate of the average velocity of propagation along a straight line path from a fracture hypocenter to any station -- 6,928 ft/sec as estimated shear velocity from velocity sonic logs of the Pinedale Unit 7 well, and the mean depth of the perforations in the fracture well -- 11,062 feet for J-PD #5. Other inputs include a maximum radius of interest -- 20,000 feet, and an identification which tells which file on the digitized tape contains the data of interest.

The first business of the routine is to calculate the maximum shift in time required in each correlation function. As an absolute maximum, this number is determined by the straight line distance between the stations divided by the estimated velocity times the sample period. A more restrictive number is currently being used which is based on the maximum absolute value time difference obtained by assuming 36 equally spaced sources on a circle of the maximum radius of interest at the depth of the perforations.

The first calculation performed in each interval is a numerical integration of each seismic signature. The integral is then subtracted from each data point in order to eliminate any D.C. shift which may have been introduced into the data by the telemetry system.

The correlation functions are then calculated by summing the shifted interproducts. This method is utilized due to the extreme speed of the inter-product routine and because only a fraction of the full cross-correlation function is desired. No obvious significant savings in time is afforded by making use of fast fourier transforms.

Peaks are then located in the correlation functions by fitting a parabola to the maximum sample and its nearest neighbors and finding the peak of this parabola. The correlation function is then zeroed on each side of the maximum value until a zero crossing is encountered. The peak locating routine is then repeated until a maximum of eight peaks are located in descending order from the largest on down.

Finally this routine generates a file containing the information input to it plus, for each time interval by its start time in seconds, the times of peaks for each of the required correlation functions. As was previously stated, a maximum of eight peaks or time differences are possible for each pair of seismic monitor stations.

The location program picks up the file generated by the correlation routine and calculates a seismic hypocenter for each combination of time differences which satisfy some very basic tests for consistency. Several hypocenters are possible for each time interval provided that the following criterion are met. First, at least one time difference must be present for each pair of seismic stations used in correlation calculation,

otherwise, the time interval is dropped and the next interval is selected for consideration.

Next a test is applied which attempts to make sure that the supposed signal for which time differences of arrival are presented was large enough to reach all stations. The basis of the test is that for any three stations only two of the three possible time differences are independent and the third may be obtained by the sum or difference of the other two. The test is that for all combinations of three stations, the third time difference obtained by correlation must agree with the third time difference obtained by summing within a tolerance defined by the geometry of the three stations. If one considers three stations A, B, and C, which each have noise plus some consistent signal then the portion of the signature at A, which correlates with B will be the same as the portion of A which correlates with C. In this case, B and C will correlate and the criterion will be met. If, however, the signal at B is very different from the signal at C, then the portion of A which correlates with B will be different from that portion which correlates with C. For this example, B and C will correlate in a manner unrelated to A and the possibility exists for the criterion not to be met. In general, the test will be met provided that very similar signals are present at two of the three stations. Obviously the closer together any two monitor stations are, the more likely is the possibility that the signals at the two stations will be similar. For this

reason, the acceptance criterion for the test is based on the maximum time difference for the two closest together stations of the three being tested. Maximum time difference is defined as the straight line distance between the two stations divided by the estimated velocity which was input to the correlation routine. The J-PD #5 criterion is 15 percent of the maximum time difference.

For combinations of time differences which pass the previous criterion, a final check is made to make sure that for all pairs no time differences exceed the maximum time difference for that pair. At that time a test is also made for combinations of three stations where only two time differences are obtained by summing the other two and compared with the maximum time difference for the third pair. If the maximum time difference is exceeded, then that combination of time differences is rejected.

Once these tests have been passed, the time differences and the monitor station coordinates are supplied as inputs to a sub-routine whose function is to obtain a least squares solution for a hypocenter via a nonlinear optimization process. The residuals for the optimization are defined as follows:

$$\sqrt{(x-a)^2 + (y-b)^2 + (z-c)^2} - \sqrt{(x-d)^2 + (y-e)^2 + (z-f)^2} - tv = 0$$

where: (x,y,z) = hypocenter coordinates
 (a,b,c) = first monitor station coordinates
 (e,f,g) = second monitor station coordinates
 t = time difference of arrival
 v = average straight line propagation velocity

The problem is set up with four variables: x , y , z and v . Any one combination of variables may be fixed at the initial value. To begin the iteration process x and y are zero, z is the mean perforation depth and v is taken as the estimated value used in the correlation routine. Most of the J-PD #5 analysis has been accomplished with v fixed to its initial value.

In the optimization process, the current value of x , y , z and v are taken as a solution if on a given iteration the change in a variable divided by the variable is less than epsilon for all variables. While values of epsilon, as small as 10^{-5} , have been used, it is felt that this represents changes smaller than the timing errors would create. Through experimentation it has been discovered that very little change in plotted results are obtained for epsilon values.

Once the coordinates and average velocity have been determined, then plots are generated which show the resulting hypocenters in the (x,y) , (x,z) , and (y,z) planes. The plot limits are determined by the maximum radius of interest in x and y and twice the perforation depth in z . In addition to the plots, a permanent file is generated which stores the values of x , y , z and v and the start time in seconds of the interval for which x , y , z and v were calculated. This file allows a more detailed study of the data through the use of specialized processing and plotting routines.

The entire seismic processing then is to collect wideband FM data, filter and digitize the information, correlate and peak detect to obtain time differences, test the time differences

and use optimization to obtain hypocenter coordinates and finally to plot the resulting hypocenters. Block diagrams for the complete system including the computer processing are shown in Fig. 23, 24 and 25.

C. Hypocenter Location Results -- The computerized process just described did not come about in a single step but rather grew in small portions with some encouraging intermediate results. The most important of these was analysis conducted on the Pinedale Unit 7 data. This result was previously reported at the 1975 Annual Meeting of the Society of Petroleum Engineers of AIME.¹ At that time only the location calculation was computerized and the time differences were obtained by hand reading correlation functions. This process greatly limited the amount of data which could be examined. A plot of the locations obtained is shown in Fig. 26. The time intervals which were processed were carefully selected as having some signal which appeared to correlate across the three close-in monitor stations. The location plots to the NE of the well do agree with other mapping techniques which were used at the fracture. Unfortunately, with only three monitor stations, it is impossible to get depth information. However, encouraged by this result, the process was automated and data for the entire Pinedale Unit 7 breakdown was processed. These data are plotted on two plots for approximately the first and second halves of the breakdown operation and are shown in G Fig. 27 and 28. The data which were originally viewed as encouraging with respect to determining fracture orientation

Fig. 23 - Block Diagram of Seismic Measurement and Processing System

Fig. 24 - Block Diagram of Computer Processing for Program TOAD

Fig. 25 - Block Diagram of Program Locate

Fig. 26 - Original hypocenter location data for Pinedale #7 experiment. Concentration to NE is in agreement with other mapping techniques.

Fig. 27 - September 74 Pinedale 7 Seismic Location Data.
First Half of Breakdown Operation.

Fig. 28 - September 74 Pinedale 7 Seismic Location Data. Second Half of Breakdown Operation.

are still present but their effect has been greatly diluted by the addition of much more widely scattered data. Some groupings are present and are apparently due to the station geometry. No clear cut lines through the wellbore are visible indicating that determination of fracture location was not achieved. For these plots the depth was fixed to the mean depth of casing perforations and the velocity was fixed at an average value determined from well sonic logs.

To get away from the monitor station number limitation, attention was next shifted to the July Pinedale Unit 5 breakdown operation. For this experiment, six monitor stations were utilized for location calculations. The location data obtained are shown plotted in Fig. 29 through 34 for the entire breakdown period. Again there appears to be some grouping due to random noise and station geometry. However, no clear cut line through the wellbore was obtained, again indicating that mapping of the fracture was not achieved.

V. CONCLUSIONS

Comparison of model calculations and data acquired in the field tests that were instrumented in the Pinedale, Wyoming and Wattenberg, Colorado areas shown that the surface electrical potential method is a useful technique for MHF mapping and characterization. The comparisons shown that the fracture azimuthal direction, asymmetry of the fracture, and the direction of the major portion of the fracture can be determined.

Fig. 29 - July 75 Pinedale 5 Seismic Location Data.
Breakdown Operation.

Fig. 30 - July 75 Pinedale 5 Seismic Location Data.
Breakdown Operation.

Fig. 31 - July 75 Pinedale 5 Seismic Location Data.
Breakdown Operation.

Fig. 32 - July 75 Pinedale 5 Seismic Location Data.
Breakdown Operation.

Fig. 33 - July 75 Pinedale 5 Seismic Location Data.
Breakdown Operation.

Fig. 34 - July 75 Pinedale 5 Seismic Location Data.
Breakdown Operation.

However, in order to obtain reliable data, several considerations are important. As indicated by the results of the Pinedale tests, surface conditions around the well are significant and must be considered in any test. The inner radius for the voltage probes should be well outside the surface equipment used for the hydrofracture, but small enough to give measurable potential changes. Because in many cases the signal-to-noise ratio is small, it is important to take a great number of potential measurements before, during, and after the fracture to obtain a usable signal. In addition, data taken on the day of the fracture (before, during, and after) seem to give the most reliable results.

The initial objective of the surface seismic mapping task was to assess the feasibility of this technique for fracture characterization. Seismic signals were recorded in the first NTS experiment that were apparently associated with fracture; however, the locations of the seismometers from the fracture zone were at distances of less than 200 feet. The signals were high in frequency (several hundred hertz) and were dissimilar between seismometer stations.

The seismic tests in Pinedale, Wyoming and Wattenberg, Colorado involved seismometer arrays placed at distances greater than 8000 feet from the fracture zone. Because wide-band amplifiers were used in recording the seismic signals, the signal-to-noise ratio is very poor. Although filtering can be employed in the analysis in order to accommodate

parametric variations, computer codes and long computer runs make the problem complex and time consuming. Whether signals propagating from these distances are large enough to be useful in characterizing fractures has not been conclusively demonstrated, but current assessment of the feasibility of the surface seismic technique is pessimistic.

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APPENDIX A

TABLE I

PINEDALE UNIT 5 HYDROFRACTURE 1

BREAKDOWN-JUNE, 17, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
6:19	1.581	.871	1.711	1.699	1.716	1.867	1.878	2.119	2.108	1.995	2.105	2.023
6:29	1.574	.868	1.705	1.695	1.713	1.863	1.874	2.116	2.091	1.991	2.101	2.018
6:39	1.592	.877	1.726	1.715	1.730	1.880	1.893	2.136	2.101	2.013	2.125	2.043
6:49	1.584	.872	1.711	1.699	1.714	1.862	1.874	2.114	2.086	1.989	2.100	2.016
6:59	1.596	.879	1.731	1.719	1.736	1.888	1.902	2.146	2.106	2.019	2.131	2.047
7:0	1.598	.876	1.734	1.723	1.740	1.894	1.909	2.153	2.113	2.025	2.139	2.054
7:18	1.507	.892	1.734	1.720	1.735	1.888	1.900	2.143	2.105	2.017	2.132	2.047
7:19	1.612	.884	1.739	1.725	1.740	1.892	1.902	2.146	2.107	2.019	2.134	2.049
7:23	1.618	.887	1.748	1.734	1.751	1.905	1.916	2.160	2.120	2.033	2.148	2.063
7:39	1.595	.875	1.720	1.708	1.730	1.884	1.897	2.128	2.101	2.006	2.118	2.033
7:49	1.609	.882	1.736	1.723	1.748	1.902	1.902	2.144	2.114	2.018	2.135	2.049
7:58	1.599	.876	1.724	1.711	1.737	1.888	1.884	2.124	2.098	2.000	2.112	2.026
8:19	1.527	.891	1.760	1.749	1.774	1.930	1.933	2.178	2.152	2.052	2.159	2.021
8:19	1.510	.879	1.720	1.712	1.736	1.899	1.888	2.128	2.102	2.008	2.122	2.036
8:28	1.603	.879	1.734	1.721	1.751	1.906	1.906	2.148	2.125	2.027	2.144	2.058
8:34	1.700	.914	1.778	1.748	1.767	1.923	1.912	2.152	2.118	2.036	2.152	2.066
8:48	1.634	.890	1.748	1.730	1.757	1.912	1.905	2.147	2.112	2.026	2.142	2.056
9:0	1.624	.887	1.746	1.731	1.758	1.912	1.907	2.149	2.113	2.030	2.144	2.058
9:18	1.729	.918	1.766	1.723	1.735	1.889	1.873	2.107	2.078	1.999	2.116	2.031
9:19	1.602	.876	1.731	1.718	1.748	1.903	1.901	2.143	2.106	2.024	2.142	2.054
9:29	1.597	.874	1.722	1.707	1.737	1.891	1.885	2.124	2.089	2.006	2.120	2.035
9:34	1.642	.895	1.755	1.736	1.764	1.916	1.914	2.157	2.121	2.037	2.155	2.066
9:49	1.624	.887	1.745	1.730	1.763	1.914	1.910	2.153	2.116	2.033	2.150	2.063
9:58	1.617	.894	1.746	1.733	1.765	1.913	1.910	2.153	2.115	2.029	2.146	2.059
10:18	1.609	.878	1.734	1.723	1.755	1.904	1.900	2.142	2.105	2.020	2.135	2.048
10:18	1.663	.899	1.757	1.737	1.782	1.934	1.903	2.143	2.108	2.025	2.142	2.055
10:29	1.528	.884	1.732	1.713	1.741	1.890	1.885	2.127	2.092	2.011	2.124	2.039
10:38	1.622	.890	1.725	1.706	1.735	1.896	1.880	2.119	2.086	2.005	2.118	2.034
10:49	1.654	.900	1.770	1.754	1.785	1.940	1.933	2.178	2.140	2.056	2.175	2.088
10:58	1.597	.873	1.726	1.716	1.766	1.919	1.897	2.137	2.100	2.016	2.133	2.046
11:18	1.621	.891	1.758	1.746	1.784	1.940	1.933	2.177	2.137	2.053	2.173	2.084
11:19	1.612	.879	1.729	1.714	1.750	1.901	1.891	2.130	2.094	2.013	2.130	2.041
11:29	1.645	.895	1.754	1.734	1.773	1.927	1.910	2.150	2.114	2.031	2.150	2.060
11:39	1.612	.882	1.747	1.737	1.741	1.937	1.927	2.169	2.132	2.049	2.167	2.078
11:49	1.610	.880	1.737	1.724	1.762	1.910	1.900	2.138	2.100	2.017	2.131	2.043
11:58	2.107	1.169	2.078	2.066	2.117	2.193	2.104	2.118	2.244	2.262	2.206	2.215
12:19	1.654	.897	1.760	1.739	1.773	1.925	1.909	2.146	2.109	2.026	2.141	2.052
12:19	1.508	.875	1.723	1.707	1.744	1.900	1.892	2.132	2.101	2.021	2.135	2.049
12:28	1.704	.914	1.773	1.740	1.772	1.929	1.904	2.142	2.111	2.029	2.149	2.060
12:39	1.710	.917	1.781	1.748	1.780	1.935	1.910	2.147	2.115	2.031	2.153	2.062
12:48	1.625	.888	1.755	1.743	1.783	1.939	1.930	2.173	2.138	2.055	2.178	2.088
12:58	1.629	.890	1.755	1.741	1.783	1.937	1.921	2.160	2.121	2.036	2.156	2.065
13:13	1.694	.907	1.759	1.725	1.759	1.916	1.888	2.122	2.092	2.010	2.128	2.037
13:19	1.605	.880	1.742	1.731	1.773	1.925	1.916	2.157	2.118	2.032	2.148	2.059
13:28	1.598	.876	1.733	1.722	1.767	1.921	1.905	2.145	2.110	2.023	2.135	2.048
13:39	1.613	.882	1.748	1.739	1.788	1.944	1.926	2.167	2.129	2.043	2.162	2.072
13:48	1.615	.882	1.740	1.726	1.764	1.909	1.898	2.124	2.081	1.991	2.102	2.014
14:10	1.597	.875	1.730	1.720	1.766	1.920	1.904	2.144	2.106	2.022	2.136	2.047
14:18	1.590	.879	1.719	1.708	1.752	1.906	1.889	2.127	2.091	2.008	2.123	2.034
14:18	1.626	.884	1.748	1.736	1.779	1.935	1.919	2.159	2.124	2.039	2.160	2.071
14:20	1.603	.874	1.731	1.722	1.768	1.926	1.912	2.153	2.119	2.043	2.156	2.066

TABLE I (Continued)

PINEDALE UNIT 5 HYDROFRACTURE 1

BREAKDOWN-JUNE, 17, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
6: 9	2.011	1.874	1.819	1.734	1.570	1.635	1.612	1.640	1.694	1.782	1.533	1.499
6:19	2.003	1.866	1.809	1.723	1.560	1.623	1.592	1.629	1.684	1.772	1.525	1.490
6:29	2.032	1.898	1.842	1.758	1.590	1.653	1.628	1.656	1.707	1.792	1.543	1.507
6:39	2.003	1.867	1.812	1.728	1.566	1.631	1.606	1.639	1.695	1.783	1.535	1.500
6:49	2.033	1.897	1.840	1.756	1.589	1.653	1.626	1.653	1.706	1.793	1.544	1.511
7: 0	2.038	1.902	1.844	1.760	1.592	1.656	1.625	1.655	1.707	1.794	1.545	1.513
7: 8	2.035	1.898	1.843	1.759	1.594	1.659	1.637	1.683	1.764	1.920	1.596	1.534
7:13	2.037	1.901	1.844	1.762	1.596	1.663	1.636	1.687	1.769	1.926	1.600	1.538
7:28	2.052	1.917	1.861	1.780	1.610	1.678	1.654	1.697	1.777	1.932	1.606	1.545
7:39	2.018	1.881	1.825	1.741	1.576	1.642	1.621	1.678	1.751	1.909	1.584	1.523
7:49	2.035	1.899	1.843	1.761	1.594	1.660	1.638	1.694	1.767	1.925	1.597	1.536
7:58	2.012	1.875	1.820	1.738	1.575	1.641	1.622	1.679	1.751	1.895	1.585	1.525
8: 9	2.067	1.934	1.876	1.797	1.624	1.691	1.664	1.710	1.777	1.912	1.604	1.549
8:19	2.022	1.887	1.833	1.751	1.587	1.656	1.638	1.702	1.782	1.983	1.613	1.543
8:28	2.043	1.908	1.852	1.768	1.599	1.665	1.640	1.693	1.763	1.918	1.591	1.531
8:38	2.056	1.926	1.873	1.799	1.637	1.723	1.723	1.839	1.982	2.521	1.811	1.663
8:48	2.044	1.911	1.855	1.775	1.609	1.680	1.665	1.734	1.825	2.083	1.651	1.571
9: 0	2.045	1.912	1.856	1.776	1.608	1.676	1.657	1.716	1.794	1.982	1.620	1.554
9: 8	Start Pump	2.020	1.891	1.844	1.770	1.620	1.718	1.742	1.904	2.100	2.483	1.934
9:19		2.039	1.905	1.847	1.766	1.597	1.661	1.636	1.693	1.765	1.924	1.592
9:29		2.019	1.836	1.830	1.749	1.584	1.650	1.632	1.688	1.762	1.923	1.589
9:38		2.054	1.923	1.865	1.795	1.626	1.688	1.673	1.910	1.839	2.110	1.663
9:49		2.048	1.916	1.857	1.785	1.616	1.675	1.655	1.813	1.799	1.999	1.623
9:58		2.043	1.912	1.852	1.782	1.611	1.669	1.647	1.790	1.766	1.896	1.591
10: 8		2.033	1.900	1.841	1.769	1.599	1.657	1.633	1.782	1.761	1.897	1.585
10:18		2.040	1.910	1.853	1.785	1.620	1.689	1.685	1.876	1.898	2.302	1.723
10:29	Stop Pump - 37,550 gal.	2.025	1.893	1.835	1.764	1.599	1.663	1.652	1.829	1.834	2.137	1.660
10:33		2.020	1.887	1.832	1.752	1.589	1.659	1.646	1.726	1.825	2.118	1.653
10:49		2.073	1.942	1.884	1.808	1.636	1.706	1.688	1.753	1.844	2.095	1.666
10:58		2.027	1.893	1.834	1.753	1.586	1.647	1.623	1.670	1.726	1.839	1.559
11: 8		2.063	1.931	1.870	1.790	1.618	1.679	1.651	1.690	1.737	1.833	1.568
11:19		2.021	1.890	1.831	1.752	1.587	1.652	1.632	1.693	1.759	1.951	1.593
11:29		2.041	1.910	1.851	1.772	1.607	1.677	1.664	1.737	1.822	2.126	1.656
11:39		2.058	1.925	1.863	1.781	1.608	1.669	1.635	1.681	1.730	1.825	1.558
11:49		2.023	1.891	1.831	1.751	1.586	1.649	1.628	1.574	1.725	1.827	1.559
11:58		2.228	1.970	2.082	1.942	1.786	1.842	1.788	1.962	1.990	2.344	1.950
12: 9		2.034	1.905	1.846	1.771	1.607	1.679	1.664	1.736	1.814	2.080	1.649
12:19		2.031	1.898	1.837	1.754	1.588	1.653	1.630	1.693	1.759	1.968	1.592
12:28	Start Pump	2.044	1.917	1.860	1.789	1.628	1.713	1.712	1.833	1.965	2.559	1.801
12:39		2.044	1.917	1.860	1.788	1.630	1.713	1.717	1.836	1.971	2.564	1.806
12:48		2.069	1.937	1.875	1.797	1.623	1.686	1.661	1.711	1.778	1.926	1.600
12:58	Stop Pump - 8,530 gal.	2.044	1.912	1.851	1.774	1.604	1.670	1.647	1.700	1.762	1.915	1.595
13: 9		2.018	1.891	1.834	1.761	1.605	1.691	1.699	1.822	1.959	2.535	1.800
13:19	Total Volume - 46,080 gal.	2.035	1.904	1.841	1.762	1.592	1.652	1.626	1.667	1.715	1.794	1.547
13:28		2.029	1.897	1.835	1.756	1.587	1.647	1.624	1.661	1.710	1.784	1.541
13:39		2.052	1.922	1.859	1.780	1.608	1.669	1.639	1.678	1.723	1.798	1.554
13:48		1.993	1.862	1.803	1.725	1.567	1.633	1.615	1.661	1.716	1.794	1.555
14: 0		2.026	1.895	1.833	1.753	1.584	1.645	1.619	1.659	1.705	1.779	1.539
14: 8		2.012	1.880	1.819	1.738	1.572	1.633	1.613	1.654	1.705	1.791	1.539
14:19		2.054	1.925	1.864	1.786	1.617	1.680	1.658	1.711	1.787	1.933	1.604
14:20		2.045	1.912	1.849	1.767	1.596	1.657	1.632	1.682	1.754	1.879	1.574

TABLE II

PINEDALE UNIT 5 HYDROFRACTURE 1

BACKGROUND-JUNE, 30, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
7:0	1.653	.965	1.761	1.742	1.716	1.844	1.928	2.099	2.174	2.116	2.269	2.123
7:13	1.645	.959	1.755	1.738	1.713	1.843	1.930	2.108	2.177	2.121	2.275	2.127
7:29	1.647	.956	1.748	1.729	1.704	1.833	1.917	2.098	2.164	2.109	2.262	2.115
7:44	1.652	.960	1.764	1.744	1.717	1.851	1.937	2.122	2.185	2.128	2.285	2.133
8:0	1.648	.957	1.750	1.727	1.699	1.832	1.915	2.099	2.159	2.108	2.262	2.112
8:14	1.661	.960	1.756	1.732	1.703	1.835	1.919	2.105	2.162	2.113	2.268	2.117
8:29	1.686	.979	1.795	1.759	1.729	1.863	1.949	2.138	2.193	2.142	2.301	2.149
8:44	1.650	.965	1.765	1.744	1.718	1.854	1.942	2.132	2.185	2.137	2.294	2.141
9:0	1.673	.976	1.783	1.757	1.730	1.865	1.951	2.145	2.196	2.149	2.310	2.154
9:13	1.667	.972	1.778	1.754	1.726	1.862	1.949	2.143	2.191	2.144	2.303	2.146
9:28	1.682	.978	1.784	1.757	1.729	1.864	1.950	2.145	2.192	2.149	2.307	2.151
9:43	1.696	.987	1.803	1.774	1.746	1.881	1.968	2.167	2.210	2.166	2.330	2.172
10:0	1.693	.937	1.793	1.762	1.733	1.868	1.953	2.152	2.194	2.149	2.311	2.154
10:13	1.697	.938	1.792	1.760	1.733	1.865	1.950	2.148	2.187	2.143	2.307	2.148
10:29	2.548	1.527	2.278	2.368	2.493	2.465	2.359	2.313	2.358	2.579	2.380	2.486
10:44	1.693	.946	1.802	1.771	1.746	1.889	1.967	2.169	2.204	2.162	2.323	2.162
11:0	1.684	.967	1.784	1.752	1.728	1.858	1.944	2.146	2.177	2.139	2.297	2.138
11:13	1.719	.992	1.819	1.784	1.756	1.892	1.980	2.189	2.221	2.187	2.348	2.186
11:28	1.694	.981	1.797	1.763	1.737	1.869	1.957	2.166	2.196	2.164	2.320	2.159
11:44	1.724	1.000	1.824	1.794	1.766	1.901	1.992	2.204	2.232	2.197	2.360	2.198
11:58	1.702	.988	1.802	1.768	1.736	1.872	1.961	2.173	2.199	2.165	2.325	2.165
12:14	1.731	1.002	1.831	1.794	1.763	1.899	1.990	2.205	2.228	2.192	2.359	2.198
12:28	1.728	1.000	1.825	1.789	1.757	1.891	1.983	2.198	2.221	2.184	2.350	2.189
12:43	1.698	.931	1.810	1.776	1.749	1.883	1.976	2.193	2.214	2.175	2.340	2.178
12:58	1.711	.978	1.825	1.793	1.764	1.894	1.987	2.206	2.220	2.185	2.350	2.188
13:13	2.249	1.349	2.148	2.127	2.256	2.280	2.251	2.300	2.386	2.489	2.437	2.441
13:28	1.679	.980	1.795	1.762	1.737	1.868	1.961	2.180	2.196	2.156	2.321	2.159
13:43	1.693	.989	1.812	1.782	1.757	1.890	1.986	2.208	2.223	2.185	2.352	2.191
13:58	1.732	1.010	1.846	1.812	1.774	1.904	2.015	2.242	2.258	2.217	2.389	2.229
14:14	1.713	.998	1.827	1.793	1.765	1.895	1.995	2.218	2.232	2.187	2.353	2.196
14:28	1.715	.999	1.825	1.791	1.758	1.886	1.991	2.216	2.229	2.188	2.353	2.195
14:43	1.705	.995	1.816	1.782	1.749	1.878	1.993	2.208	2.220	2.183	2.347	2.190
14:58	1.712	.995	1.817	1.781	1.748	1.874	1.978	2.202	2.213	2.175	2.339	2.182
15:13	1.761	1.030	1.893	1.862	1.835	1.905	2.005	2.232	2.242	2.201	2.370	2.298
15:28	1.719	1.001	1.828	1.794	1.768	1.896	1.991	2.218	2.228	2.188	2.357	2.197
15:44	1.723	1.005	1.832	1.799	1.774	1.903	1.999	2.227	2.234	2.195	2.366	2.204
15:58	1.713	.997	1.823	1.790	1.766	1.898	1.995	2.222	2.228	2.190	2.360	2.197
16:14	1.711	.997	1.824	1.791	1.770	1.903	2.001	2.230	2.237	2.199	2.368	2.204
16:28	1.311	.738	1.592	1.579	1.419	1.646	1.823	2.174	2.060	1.994	2.334	2.025
16:43	1.708	.994	1.813	1.778	1.756	1.884	1.978	2.206	2.210	2.178	2.336	2.174

TABLE II (Continued)

PINEDALE UNIT 5 HYDROFRACTURE 1

BACKGROUND-JUNE, 30, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
7:0	2.086	1.950	1.894	1.766	1.632	1.687	1.654	1.694	1.783	1.939	1.583	1.570
7:13	2.088	1.953	1.892	1.767	1.631	1.684	1.647	1.677	1.747	1.858	1.550	1.553
7:29	2.075	1.939	1.882	1.756	1.622	1.676	1.648	1.685	1.768	1.919	1.569	1.559
7:44	2.092	1.957	1.897	1.773	1.637	1.690	1.651	1.686	1.758	1.892	1.562	1.562
8:0	2.073	1.935	1.878	1.752	1.621	1.678	1.655	1.705	1.813	2.034	1.607	1.577
8:14	2.078	1.941	1.882	1.761	1.629	1.687	1.665	1.713	1.826	2.040	1.613	1.582
8:29	2.108	1.972	1.914	1.794	1.659	1.717	1.688	1.736	1.842	2.055	1.629	1.604
8:44	2.099	1.959	1.900	1.778	1.640	1.690	1.655	1.685	1.771	1.853	1.554	1.558
9:0	2.114	1.974	1.916	1.797	1.660	1.714	1.682	1.724	1.832	1.936	1.608	1.589
9:13	2.103	1.962	1.903	1.784	1.648	1.700	1.666	1.697	1.777	1.882	1.567	1.571
9:29	2.109	1.967	1.910	1.792	1.658	1.713	1.682	1.734	1.852	2.045	1.627	1.600
9:43	2.130	1.989	1.931	1.815	1.679	1.735	1.705	1.754	1.875	2.079	1.646	1.617
10:0	2.115	1.973	1.917	1.802	1.668	1.726	1.696	1.752	1.878	2.098	1.648	1.615
10:13	2.106	1.964	1.907	1.793	1.661	1.719	1.695	1.753	1.885	2.129	1.656	1.619
10:29	2.405	2.133	2.225	2.059	2.061	2.066	1.968	2.187	2.239	2.661	2.201	2.306
10:44	2.117	1.973	1.913	1.799	1.664	1.721	1.690	1.739	1.853	2.056	1.633	1.611
11:0	2.092	1.947	1.889	1.775	1.643	1.701	1.676	1.724	1.835	2.042	1.621	1.600
11:13	2.142	1.999	1.940	1.828	1.692	1.750	1.719	1.769	1.884	2.127	1.662	1.636
11:28	2.113	1.970	1.910	1.798	1.664	1.720	1.698	1.732	1.833	2.030	1.620	1.605
11:44	2.153	2.010	1.950	1.840	1.701	1.757	1.725	1.771	1.895	2.109	1.662	1.638
11:58	2.120	1.975	1.916	1.804	1.669	1.726	1.696	1.747	1.869	2.077	1.642	1.618
12:14	2.153	2.010	1.949	1.841	1.703	1.761	1.734	1.786	1.924	2.171	1.686	1.650
12:29	2.144	2.002	1.942	1.832	1.696	1.754	1.729	1.780	1.919	2.161	1.682	1.645
12:43	2.132	1.939	1.925	1.814	1.677	1.730	1.695	1.734	1.840	1.986	1.617	1.605
12:58	2.142	1.999	1.935	1.824	1.685	1.736	1.711	1.739	1.847	1.955	1.620	1.611
13:13	2.315	2.120	2.126	1.981	1.938	1.953	1.867	1.984	2.004	2.116	1.914	1.998
13:29	2.111	1.969	1.904	1.794	1.657	1.709	1.675	1.703	1.789	1.881	1.576	1.553
13:43	2.144	2.000	1.933	1.822	1.681	1.734	1.694	1.719	1.803	1.886	1.585	1.565
13:58	2.184	2.043	1.976	1.868	1.723	1.778	1.740	1.772	1.890	2.015	1.649	1.608
14:14	2.151	2.009	1.943	1.833	1.694	1.748	1.712	1.754	1.876	2.017	1.637	1.595
14:28	2.149	2.009	1.943	1.834	1.695	1.751	1.718	1.757	1.880	2.024	1.641	1.597
14:43	2.144	2.004	1.937	1.828	1.689	1.746	1.711	1.752	1.874	2.020	1.636	1.590
14:58	2.137	1.997	1.929	1.821	1.684	1.741	1.711	1.754	1.880	2.039	1.644	1.596
15:13	2.162	2.021	1.950	1.841	1.698	1.821	1.771	1.786	1.874	1.941	1.640	1.624
15:28	2.154	2.014	1.945	1.836	1.696	1.752	1.717	1.758	1.880	2.018	1.642	1.600
15:44	2.159	2.021	1.951	1.843	1.702	1.756	1.721	1.761	1.877	2.020	1.641	1.602
15:58	2.149	2.012	1.941	1.834	1.693	1.747	1.715	1.743	1.840	1.969	1.617	1.587
16:14	2.158	2.019	1.948	1.839	1.697	1.745	1.709	1.730	1.809	1.910	1.595	1.578
16:28	2.021	1.984	1.855	1.774	1.557	1.644	1.650	1.593	1.756	1.857	1.408	1.290
16:43	2.127	1.989	1.920	1.811	1.675	1.731	1.702	1.734	1.831	1.978	1.615	1.584

TABLE III

PINEDALE UNIT 5 HYDROFRACTURE 1

FRACTURE-JULY, 2, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
7:39	1.544	.958	1.729	1.708	1.759	1.916	.656	2.128	2.122	2.046	2.159	2.059
7:49	1.548	.959	1.729	1.708	1.761	1.920	.656	2.128	2.122	2.048	2.163	2.062
8:0	1.644	.957	1.725	1.701	1.751	1.909	.653	2.117	2.111	2.039	2.154	2.051
8:9	1.667	.969	1.746	1.722	1.772	1.930	.660	2.141	2.135	2.064	2.182	2.078
8:18	1.672	.973	1.754	1.729	1.779	1.940	.661	2.151	2.145	2.070	2.189	2.085
8:29	1.675	.971	1.747	1.720	1.771	1.932	.656	2.138	2.135	2.065	2.184	2.080
8:39	1.701	.985	1.768	1.739	1.788	1.949	.660	2.155	2.151	2.080	2.203	2.098
8:48	1.720	.997	1.789	1.759	1.812	1.974	.666	2.184	2.180	2.110	2.237	2.128
9:0	1.751	1.012	1.816	1.783	1.836	2.000	.672	2.211	2.206	2.136	2.255	2.155
9:9	1.733	1.003	1.797	1.761	1.795	1.950	.662	2.186	2.183	2.116	2.242	2.133
9:19	1.730	.999	1.791	1.754	1.788	1.944	.659	2.178	2.175	2.106	2.234	2.124
9:20	1.738	1.004	1.804	1.768	1.803	1.958	.664	2.195	2.191	2.124	2.251	2.140
9:28	1.770	1.014	1.805	1.753	1.790	1.947	.657	2.173	2.173	2.106	2.234	2.123
9:38 Start Pumping	1.776	1.018	1.811	1.763	1.794	1.950	.663	2.175	2.174	2.107	2.237	2.125
9:49	1.776	1.018	1.813	1.766	1.798	1.959	.668	2.183	2.183	2.120	2.247	2.134
9:58	1.793	1.029	1.834	1.787	1.819	1.981	.676	2.208	2.208	2.144	2.273	2.159
10:9	1.770	1.017	1.814	1.769	1.803	1.962	.671	2.187	2.188	2.125	2.253	2.139
10:18	1.762	1.013	1.815	1.771	1.810	1.970	.674	2.193	2.191	2.129	2.257	2.142
10:28	1.787	1.031	1.844	1.802	1.840	2.001	.686	2.230	2.228	2.165	2.296	2.181
10:38 50,000 gal.	1.744	1.011	1.815	1.777	1.817	1.975	.681	2.202	2.199	2.137	2.267	2.153
10:48	1.732	1.006	1.813	1.779	1.824	1.987	.687	2.215	2.212	2.146	2.280	2.163
10:58	1.703	.994	1.799	1.769	1.818	1.978	.688	2.205	2.202	2.140	2.268	2.151
11:8	1.715	1.003	1.811	1.782	1.832	1.993	.699	2.222	2.215	2.155	2.287	2.170
11:19 80,000 gal.	1.705	.996	1.801	1.771	1.820	1.979	.700	2.208	2.204	2.141	2.273	2.156
11:28	1.726	1.008	1.822	1.791	1.842	2.001	.713	2.229	2.225	2.162	2.298	2.181
11:39	1.776	1.032	1.860	1.824	1.869	2.027	.726	2.255	2.250	2.188	2.326	2.210
11:48	1.771	1.030	1.857	1.821	1.871	2.029	.731	2.255	2.250	2.186	2.327	2.209
11:58 110,000 gal.	1.752	1.025	1.844	1.811	1.864	2.021	.733	2.245	2.239	2.176	2.314	2.196
12:9	1.783	1.037	1.858	1.819	1.871	2.031	.738	2.247	2.242	2.178	2.318	2.200
12:10	1.790	1.038	1.859	1.819	1.871	2.030	.739	2.247	2.243	2.182	2.320	2.204
12:19	1.771	1.029	1.845	1.806	1.860	2.019	.738	2.233	2.229	2.169	2.303	2.188
12:28 140,000 gal.	1.718	1.010	1.834	1.800	1.872	2.032	.748	2.254	2.246	2.183	2.320	2.203
12:39	2.408	1.461	2.316	2.193	2.435	2.610	1.195	2.692	2.522	2.579	2.474	2.525
12:49	1.712	1.007	1.830	1.805	1.874	2.032	.754	2.248	2.238	2.177	2.313	2.195
12:58	1.727	1.014	1.842	1.810	1.887	2.046	.764	2.267	2.256	2.197	2.332	2.214
13:9 170,000 gal.	1.716	1.010	1.833	1.800	1.877	2.032	.762	2.250	2.239	2.176	2.312	2.195
13:19	1.724	1.011	1.834	1.808	1.878	2.036	.766	2.254	2.244	2.185	2.319	2.202
13:29 Stop Pumping	1.726	1.015	1.835	1.810	1.880	2.037	.769	2.254	2.243	2.185	2.320	2.202
13:39	1.721	1.006	1.830	1.803	1.863	1.980	.725	2.192	2.182	2.123	2.253	2.135
13:49 Total Volume = 191,000 gal.	1.824	1.027	1.903	1.862	1.924	2.191	.829	2.418	2.409	2.345	2.492	2.365
14:0	1.752	1.020	1.866	1.843	1.906	2.124	.807	2.354	2.342	2.282	2.424	2.301
14:11	1.761	1.020	1.874	1.846	1.914	2.146	.820	2.377	2.366	2.303	2.443	2.320
14:19	1.713	1.004	1.817	1.793	1.857	2.023	.772	2.239	2.229	2.171	2.306	2.189
14:29	1.732	1.015	1.837	1.811	1.873	2.039	.781	2.257	2.245	2.186	2.321	2.203
14:39	1.717	1.004	1.818	1.792	1.852	2.016	.762	2.226	2.214	2.152	2.279	2.158
14:49	1.709	1.003	1.821	1.799	1.877	2.050	.766	2.240	2.227	2.164	2.296	2.174
15:0	1.621	.955	1.737	1.722	1.812	1.986	.742	2.172	2.162	2.106	2.224	2.133
15:9	1.713	1.008	1.824	1.803	1.883	2.055	.768	2.246	2.235	2.173	2.306	2.189
15:19	1.746	1.021	1.842	1.817	1.892	2.062	.774	2.252	2.243	2.181	2.316	2.198
15:29	1.729	1.017	1.847	1.826	1.906	2.081	.781	2.273	2.260	2.201	2.338	2.216
15:39	1.733	1.020	1.854	1.832	1.916	2.091	.784	2.284	2.272	2.212	2.348	2.226

TABLE III (Continued)

PINEDALE UNIT 5 HYDROFRACTURE 1

FRACTURE-JULY 2, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
7:39	2.040	1.921	1.023	1.741	1.603	1.662	1.640	1.698	1.760	2.043	1.594	1.541
7:49	2.046	1.925	1.825	1.740	1.604	1.671	1.638	1.701	1.764	2.053	1.596	1.537
8:00	2.037	1.917	1.823	1.733	1.599	1.666	1.639	1.700	1.768	2.063	1.597	1.535
8:09	2.065	1.946	1.854	1.761	1.626	1.693	1.671	1.737	1.826	2.161	1.642	1.563
8:18	2.070	1.952	1.861	1.771	1.631	1.697	1.668	1.730	1.802	2.116	1.626	1.561
8:29	2.066	1.948	1.859	1.765	1.628	1.696	1.673	1.749	1.846	2.226	1.662	1.572
8:39	2.087	1.970	1.882	1.790	1.652	1.722	1.707	1.792	1.921	2.356	1.718	1.509
8:48	2.116	1.997	1.908	1.810	1.671	1.742	1.720	1.809	1.922	2.352	1.725	1.623
9:00	2.143	2.025	1.937	1.838	1.698	1.770	1.751	1.841	1.971	2.433	1.763	1.652
9:09	2.121	2.003	1.915	1.819	1.678	1.750	1.730	1.823	1.941	2.403	1.743	1.637
9:19	2.110	1.991	1.904	1.805	1.667	1.741	1.722	1.813	1.924	2.398	1.733	1.632
9:20	2.125	2.008	1.919	1.819	1.681	1.754	1.731	1.818	1.921	2.378	1.732	1.636
9:28	2.110	1.994	1.908	1.809	1.679	1.762	1.750	1.873	2.009	2.689	1.825	1.688
9:38	2.112	1.995	1.911	1.814	1.682	1.766	1.760	1.884	2.029	2.733	1.842	1.598
9:49	2.119	2.003	1.916	1.826	1.591	1.768	1.760	1.879	2.018	2.707	1.831	1.594
9:58	2.145	2.032	1.942	1.855	1.715	1.793	1.780	1.901	2.045	2.733	1.852	1.710
10:09	2.123	2.009	1.920	1.833	1.693	1.768	1.753	1.871	2.006	2.647	1.817	1.636
10:18	2.125	2.010	1.921	1.831	1.692	1.764	1.741	1.853	1.975	2.552	1.788	1.570
10:28	2.166	2.054	1.962	1.874	1.730	1.802	1.781	1.887	2.025	2.594	1.819	1.695
10:39	2.137	2.021	1.930	1.839	1.696	1.763	1.742	1.836	1.966	2.425	1.759	1.652
10:48	2.144	2.027	1.936	1.839	1.693	1.758	1.731	1.801	1.895	2.252	1.697	1.621
10:58	2.131	2.011	1.921	1.831	1.677	1.736	1.696	1.755	1.825	2.056	1.631	1.581
11:08	2.150	2.032	1.939	1.840	1.695	1.753	1.719	1.774	1.856	2.102	1.653	1.598
11:18	2.138	2.019	1.928	1.826	1.682	1.742	1.705	1.762	1.846	2.064	1.641	1.586
11:28	2.165	2.046	1.955	1.857	1.708	1.768	1.735	1.797	1.906	2.152	1.684	1.613
11:38	2.198	2.090	1.989	1.889	1.742	1.806	1.777	1.857	1.987	2.340	1.761	1.668
11:48	2.195	2.077	1.986	1.886	1.741	1.806	1.776	1.857	1.990	2.350	1.763	1.668
11:58	2.180	2.059	1.967	1.867	1.718	1.780	1.744	1.813	1.910	2.202	1.704	1.637
12:09	2.185	2.067	1.976	1.878	1.734	1.804	1.777	1.870	2.004	2.450	1.788	1.635
12:10	2.190	2.072	1.980	1.881	1.738	1.807	1.782	1.881	2.030	2.506	1.807	1.694
12:19	2.171	2.052	1.961	1.861	1.718	1.787	1.754	1.846	1.961	2.395	1.757	1.668
12:28	2.182	2.064	1.968	1.869	1.715	1.769	1.724	1.762	1.824	1.946	1.617	1.586
12:39	2.446	2.209	2.297	2.093	2.039	2.056	1.954	2.102	2.086	2.260	2.029	2.126
12:49	2.177	2.055	1.960	1.853	1.706	1.759	1.712	1.750	1.812	1.900	1.605	1.580
12:58	2.194	2.075	1.979	1.872	1.724	1.777	1.732	1.762	1.818	1.909	1.611	1.589
13:09	2.173	2.054	1.959	1.853	1.708	1.762	1.722	1.754	1.812	1.910	1.608	1.585
13:19	2.182	2.064	1.969	1.864	1.717	1.770	1.728	1.763	1.827	1.945	1.618	1.591
13:29	2.182	2.063	1.968	1.864	1.716	1.769	1.728	1.769	1.842	1.966	1.630	1.596
13:39	2.112	1.994	1.901	1.799	1.655	1.764	1.725	1.764	1.835	1.975	1.625	1.591
13:49	2.344	2.218	2.119	2.011	1.858	1.825	1.797	1.897	2.032	2.516	1.815	1.716
14:00	2.278	2.160	2.061	1.955	1.799	1.815	1.768	1.809	1.887	2.037	1.662	1.623
14:11	2.297	2.176	2.077	1.971	1.815	1.812	1.766	1.810	1.889	2.051	1.667	1.628
14:19	2.166	2.048	1.954	1.851	1.702	1.758	1.719	1.762	1.839	1.997	1.628	1.586
14:29	2.182	2.065	1.971	1.868	1.721	1.776	1.736	1.779	1.856	2.013	1.642	1.603
14:39	2.129	2.013	1.922	1.826	1.681	1.740	1.705	1.752	1.832	1.994	1.627	1.589
14:49	2.147	2.028	1.935	1.834	1.685	1.740	1.702	1.735	1.799	1.891	1.595	1.574
15:00	2.070	1.948	1.851	1.742	1.598	1.646	1.605	1.639	1.701	1.814	1.514	1.491
15:09	2.168	2.049	1.956	1.860	1.702	1.755	1.714	1.749	1.810	1.918	1.506	1.531
15:19	2.178	2.060	1.968	1.874	1.716	1.778	1.745	1.795	1.876	2.082	1.668	1.622
15:29	2.195	2.077	1.983	1.883	1.727	1.779	1.733	1.766	1.824	1.920	1.617	1.595
15:39	2.204	2.086	1.990	1.893	1.733	1.783	1.736	1.763	1.815	1.901	1.610	1.596

APPENDIX B

TABLE I

PINEDALE UNIT 5 HYDROFRACTURE 2

BACKGROUND-OCTOBER, 14, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
9:45	3.181	-0.051	3.347	3.184	2.122	4.659	3.836	4.264	4.028	3.904	4.176	-0.060
10:10	3.190	3.620	3.311	3.180	2.174	4.603	3.873	4.284	4.015	3.851	4.175	4.193
10:30	3.161	3.477	3.336	3.209	2.157	4.617	3.856	4.246	4.028	3.865	4.130	4.222
10:50	3.171	3.484	3.324	3.235	2.155	4.567	3.792	4.254	4.048	3.836	4.188	4.261
11:13	3.266	3.501	3.357	3.296	2.209	4.749	3.892	4.272	4.025	3.830	4.141	4.218
11:30	3.235	3.497	3.349	3.254	2.144	4.630	3.823	4.288	4.055	3.902	4.206	4.238

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
9:45	4.201	3.833	3.607	3.295	3.196	3.508	3.208	3.387	3.535	4.318	3.300	3.017
10:10	4.168	3.938	3.622	3.297	3.175	3.404	3.138	3.391	3.514	4.303	3.287	3.014
10:30	4.159	3.748	3.558	3.295	3.158	3.365	3.127	3.430	3.529	4.387	3.300	3.046
10:50	4.168	3.875	3.567	3.279	3.170	3.367	3.133	3.443	3.519	4.271	3.271	3.087
11:13	4.167	3.830	3.610	3.294	3.200	3.393	3.250	3.537	3.694	4.668	3.454	3.128
11:30	4.184	3.848	3.605	3.286	3.191	3.375	3.278	3.580	3.743	4.927	3.505	3.155

TABLE II

PINEDALE UNIT 5 HYDROFRACTURE 2

BREAKDOWN-OCTOBER, 15, 1975

TIME		0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
14:10	11:50 Start Pumping	3.192	3.431	3.360	3.027	2.028	4.713	3.867	4.340	4.094	.281	4.301	4.293
14:30		3.185	3.488	3.371	3.252	2.069	4.636	3.879	4.341	4.095	3.963	4.272	4.298
14:45		3.158	3.431	3.378	3.231	2.060	4.682	3.897	4.346	4.107	3.959	4.308	4.312
15:00		3.151	3.477	3.347	3.238	2.074	4.668	3.891	4.347	4.075	3.943	4.283	4.296
15:15		3.191	3.526	3.358	3.259	2.037	4.627	3.893	4.344	4.092	3.945	4.299	4.304
15:30		3.199	3.495	3.370	3.280	2.251	4.731	3.920	4.356	4.103	3.949	4.260	4.307
15:45	Stop Pumping - 22,240 gal.	3.132	3.437	3.349	3.263	2.095	4.618	3.862	4.315	4.077	3.902	4.235	4.240
16:00	Total Volume - 22,240 gal.	3.151	3.477	3.358	3.247	2.082	4.642	3.896	4.342	4.081	3.913	4.276	4.280
16:15		3.185	3.449	3.351	3.282	2.050	4.628	3.911	4.235	4.068	3.877	4.216	4.206
16:30		3.102	3.426	3.311	3.237	2.064	4.598	3.844	4.267	4.040	3.844	4.176	4.189
16:45		3.113	3.416	3.320	3.191	2.116	4.517	3.838	4.290	4.065	3.856	4.185	4.189
17:00		3.114	3.413	3.302	3.235	2.072	4.590	3.850	4.278	4.040	3.855	4.137	4.153

TIME		180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
14:10	11:50 Start Pumping	4.251	3.384	3.676	3.322	3.228	3.530	3.271	3.366	3.453	3.972	3.178	3.013
14:30		4.242	3.940	3.662	3.333	3.238	3.434	3.251	3.426	3.472	3.995	3.208	3.020
14:45		4.244	3.906	3.687	3.332	3.232	3.403	3.211	3.345	3.385	3.701	3.117	2.974
15:00		4.235	4.011	3.655	3.332	3.215	3.381	3.207	3.346	3.373	3.728	3.123	2.964
15:15		4.227	3.874	3.654	3.335	3.227	3.370	3.217	3.338	3.417	3.756	3.166	2.989
15:30		4.255	3.927	3.687	3.327	3.235	3.367	3.218	3.364	3.408	3.789	3.152	3.002
15:45	Stop Pumping - 22,240 gal.	4.198	3.829	3.630	3.307	3.203	3.321	3.157	3.315	3.368	3.739	3.116	2.962
16:00	Total Volume - 22,240 gal.	4.225	3.828	3.645	3.312	3.225	3.348	3.206	3.350	3.379	3.720	3.117	2.970
16:15		4.164	3.941	3.560	3.232	3.142	3.365	3.228	3.340	3.390	3.723	3.106	2.988
16:30		4.108	3.776	3.532	3.211	3.114	3.253	3.045	3.269	3.332	3.638	3.068	2.924
16:45		4.108	3.812	3.536	3.225	3.126	3.258	3.117	3.256	3.330	3.705	3.086	2.943
17:00		4.112	3.794	3.541	3.210	3.109	3.253	3.151	3.235	3.323	3.669	3.069	2.921

TABLE III

PINEDALE UNIT 5 HYDROFRACTURE 2

POST BREAKDOWN-OCTOBER, 16, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
11:15	3.149	3.456	3.350	3.247	1.929	4.467	3.893	4.316	4.134	3.948	4.174	4.321
11:30	3.136	3.490	3.358	3.236	1.909	4.517	3.881	4.351	4.157	4.012	4.386	4.333
11:45	3.140	3.483	3.374	3.201	1.888	4.514	3.901	4.355	4.187	4.014	4.445	4.378
12:00	3.154	3.479	3.400	3.274	1.938	4.507	3.914	4.368	4.160	4.021	4.425	4.336
12:15	3.168	3.501	3.404	3.313	1.911	4.469	3.868	4.322	4.127	4.012	4.296	4.358
12:30	3.120	3.451	3.352	3.243	1.918	4.502	3.911	4.333	4.135	4.014	4.412	4.357
12:45	3.210	3.532	3.421	3.337	1.938	4.498	3.935	4.395	4.194	4.072	4.342	4.447
13:00	3.170	3.510	3.399	3.326	1.969	4.513	3.925	4.387	4.206	4.059	4.465	4.381
13:15	3.148	3.484	3.389	3.266	1.924	4.523	3.927	4.380	4.188	4.029	4.440	4.357
13:30	3.176	3.494	3.387	3.278	1.952	4.523	3.911	4.359	4.155	4.025	4.405	4.351
13:45	3.161	3.470	3.395	3.290	1.942	4.496	3.908	4.351	4.145	4.010	4.375	4.314
14:00	3.175	3.501	3.434	3.402	1.967	4.532	3.911	4.350	4.141	4.004	4.424	4.342
14:15	3.150	3.502	3.382	3.338	1.973	4.516	3.942	4.407	4.214	4.078	4.522	4.414

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
11:15	4.182	3.858	3.614	3.293	3.197	3.539	3.173	3.264	3.376	3.623	3.084	2.933
11:30	4.211	3.903	3.616	3.275	3.199	3.418	3.190	3.260	3.381	3.626	3.091	2.967
11:45	4.247	4.053	3.644	3.307	3.215	3.396	3.188	3.280	3.383	3.626	3.095	2.961
12:00	4.216	3.912	3.625	3.205	3.210	3.358	3.173	3.291	3.368	3.633	3.079	2.962
12:15	4.271	3.925	3.661	3.416	3.257	3.341	3.183	3.266	3.408	3.642	3.107	2.974
12:30	4.233	3.910	3.653	3.333	3.233	3.348	3.215	3.251	3.366	3.585	3.037	2.921
12:45	4.243	3.962	3.662	3.328	3.227	3.351	3.246	3.340	3.459	3.683	3.151	3.018
13:00	4.288	3.883	3.668	3.328	3.229	3.330	3.213	3.272	3.394	3.638	3.100	2.969
13:15	4.242	3.868	3.617	3.315	3.213	3.350	3.194	3.311	3.397	3.630	3.083	2.961
13:30	4.239	3.859	3.626	3.317	3.229	3.328	3.194	3.301	3.392	3.634	3.100	2.972
13:45	4.227	3.870	3.634	3.338	3.240	3.358	3.218	3.272	3.404	3.642	3.098	2.966
14:00	4.215	4.027	3.627	3.304	3.222	3.317	3.189	3.268	3.391	3.634	3.096	2.971
14:15	4.266	3.976	3.668	3.339	3.231	3.326	3.190	3.260	3.383	3.620	3.096	2.960

TABLE IV

PINEDALE UNIT 5 HYDROFRACTURE 2

PRE FRACTURE-OCTOBER, 18, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
11:0	3.073	3.426	3.267	3.195	3.631	4.385	3.776	4.230	4.043	3.947	4.375	4.239
11:5	3.083	3.404	3.298	3.178	3.687	4.380	3.772	4.229	4.024	3.910	4.327	4.229
11:15	3.158	3.469	3.367	3.243	3.674	4.429	3.764	4.235	4.041	3.920	4.299	4.246
11:30	3.076	3.428	3.289	3.217	3.647	4.431	3.787	4.252	4.063	3.928	4.367	4.251
11:45	3.094	3.403	3.303	3.208	3.634	4.413	3.788	4.233	4.059	3.935	4.288	4.254
12:0	3.096	3.419	3.337	3.222	3.652	4.415	3.783	4.224	4.028	3.928	4.296	4.243
12:15	3.014	3.393	3.340	3.223	3.661	4.430	3.734	4.228	4.045	3.950	4.113	4.267
12:30	3.126	3.414	3.365	3.208	3.636	4.440	3.794	4.235	4.059	3.940	4.345	4.260
12:45	3.096	3.411	3.340	3.225	3.650	4.404	3.785	4.226	4.052	3.935	4.364	4.255
13:0	3.103	3.404	3.305	3.221	3.654	4.428	3.792	4.241	4.077	3.957	4.338	4.308
13:15	3.131	3.448	3.300	3.233	3.656	4.447	3.819	4.259	4.081	3.977	4.360	4.286
13:30	3.070	3.405	3.268	3.230	3.639	4.478	3.796	4.243	4.059	3.990	4.396	4.260
13:45	3.113	3.437	3.384	3.227	3.642	4.422	3.801	4.244	4.060	3.936	4.380	4.271
14:0	3.136	3.434	3.294	3.244	3.660	4.411	3.804	4.222	4.042	3.948	4.331	4.255
14:15	3.108	3.421	3.389	3.225	3.645	4.423	3.834	4.230	4.061	3.958	4.338	4.236
14:30	3.087	3.434	3.298	3.230	3.639	4.406	3.788	4.230	4.025	3.938	4.297	4.231
14:45	3.100	3.398	3.316	3.216	3.669	4.437	3.790	4.246	4.046	3.945	4.256	4.292
15:0	3.109	3.439	3.342	3.223	3.652	4.426	3.802	4.236	4.065	3.974	4.410	4.267
15:15	3.111	3.421	3.339	3.247	3.672	4.429	3.797	4.238	4.058	3.924	4.347	4.234
15:30	3.098	3.408	3.333	3.229	3.653	4.404	3.797	4.242	4.071	3.965	4.381	4.266
15:45	3.107	3.480	3.203	3.226	3.653	4.354	3.816	4.242	4.046	3.967	4.346	4.258
16:0	3.186	3.451	3.358	3.238	3.658	4.382	3.797	4.230	4.040	3.922	4.353	4.243

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
11:0	4.106	3.735	3.544	3.224	3.158	3.325	3.109	3.218	3.313	3.572	3.032	2.896
11:5	4.125	3.848	3.537	3.223	3.164	3.320	3.111	3.248	3.322	3.608	3.045	2.891
11:15	4.114	3.777	3.525	3.222	3.159	3.324	3.112	3.273	3.375	3.704	3.124	2.965
11:30	4.132	3.818	3.551	3.243	3.171	3.313	3.116	3.239	3.343	3.608	3.045	2.895
11:45	4.123	3.791	3.546	3.232	3.161	3.353	3.160	3.318	3.361	3.645	3.071	2.915
12:0	4.108	3.848	3.547	3.242	3.161	3.323	3.131	3.273	3.367	3.643	3.061	2.899
12:15	4.135	3.756	3.551	3.261	3.187	3.314	3.140	3.257	3.355	3.614	3.046	2.902
12:30	4.164	3.817	3.554	3.254	3.174	3.319	3.162	3.224	3.349	3.627	3.052	2.906
12:45	4.106	3.733	3.560	3.252	3.193	3.310	3.144	3.298	3.365	3.621	3.055	2.923
13:0	4.144	3.902	3.575	3.266	3.193	3.322	3.151	3.275	3.400	3.630	3.065	2.907
13:15	4.197	3.784	3.561	3.257	3.187	3.327	3.132	3.171	3.411	3.643	3.098	2.932
13:30	4.143	4.014	3.572	3.264	3.189	3.312	3.165	3.279	3.371	3.630	3.065	2.905
13:45	4.104	3.730	3.558	3.251	3.200	3.328	3.160	3.294	3.383	3.733	3.073	2.929
14:0	4.086	3.782	3.554	3.254	3.193	3.328	3.143	3.300	3.410	3.662	3.103	2.943
14:15	4.133	3.805	3.533	3.234	3.165	3.295	3.119	3.266	3.368	3.604	3.091	2.923
14:30	4.088	3.876	3.531	3.230	3.171	3.284	3.130	3.245	3.362	3.618	3.091	2.914
14:45	4.091	3.870	3.534	3.238	3.153	3.281	3.117	3.372	3.350	3.601	3.054	2.904
15:0	4.143	3.831	3.554	3.238	3.174	3.289	3.144	3.219	3.374	3.623	3.077	2.922
15:15	4.165	3.844	3.543	3.259	3.176	3.304	3.147	3.228	3.371	3.634	3.079	2.924
15:30	4.121	3.828	3.544	3.260	3.171	3.296	3.085	3.252	3.369	3.623	3.059	2.912
15:45	4.195	3.841	3.539	3.246	3.183	3.301	3.100	3.223	3.367	3.620	3.075	2.931
16:0	4.116	3.862	3.566	3.266	3.203	3.342	3.155	3.294	3.331	3.701	3.097	2.966

TABLE V

PINEDALE UNIT 3 HYDROFRACTURE 2

FRACTURE-OCTOBER, 20, 1975

TIME		0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
10:20	Start Pumping - 10:04	3.120	3.434	3.330	3.238	2.825	4.572	3.774	4.203	4.002	3.860	4.075	4.218
10:30		3.115	3.422	3.305	3.229	3.817	4.617	3.796	4.238	4.040	3.876	4.079	4.264
10:45		3.126	3.447	3.330	3.254	3.780	4.594	3.808	4.273	4.043	3.889	4.176	4.261
11:00	90,000 gal.	3.118	3.437	3.325	3.251	3.890	4.582	3.801	4.232	4.048	3.888	4.244	4.278
11:15		3.127	3.436	3.297	3.247	3.789	4.663	3.854	4.271	4.074	3.937	4.214	4.312
11:30		3.133	3.457	3.329	3.273	3.847	4.637	3.946	4.292	4.101	3.933	4.388	4.291
11:45	140,000 gal.	3.138	3.449	3.366	3.266	3.840	4.655	3.854	4.291	4.105	3.950	4.277	4.318
12:00		3.147	3.487	3.325	3.278	3.809	4.644	3.853	4.283	4.089	3.949	4.273	4.303
12:20		3.137	3.455	3.315	3.282	3.870	4.623	3.841	4.292	4.070	3.929	4.246	4.291
12:40	235,000 gal.	3.141	3.463	3.374	3.284	3.913	4.679	3.861	4.313	4.093	3.961	4.328	4.346
13:10		3.150	3.457	3.299	3.280	3.848	4.663	3.866	4.300	4.107	3.953	4.316	4.322
13:45	336,000 gal.	3.164	3.476	3.357	3.298	3.856	4.690	3.871	4.324	4.099	3.968	4.300	4.332
14:10		3.179	3.487	3.420	3.292	3.830	4.680	3.878	4.313	4.100	3.968	4.277	4.339
14:30	410,000 gal.	3.133	3.435	3.293	3.300	3.886	4.659	3.854	4.289	4.097	3.956	4.294	4.290
14:50	Stop Pumping - 15:10	3.120	3.426	3.370	3.286	3.819	4.625	3.855	4.291	4.071	3.933	4.295	4.260
16:20	Total Volume - 458,640 gal.	3.117	3.441	3.386	3.240	3.844	4.651	3.856	4.278	4.057	3.905	4.216	4.257
16:40		3.109	3.423	3.337	3.230	3.645	4.394	3.847	4.256	4.065	3.951	4.354	4.336
17:00		3.090	3.405	3.457	3.217	3.644	4.392	3.808	4.243	4.055	4.006	4.353	4.266
17:20		3.093	3.407	3.369	3.212	3.615	4.378	3.804	4.218	4.028	3.910	4.245	4.262

TIME		180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
10:20	Start Pumping - 10:04	4.174	3.843	3.590	3.264	3.217	3.344	3.190	3.363	3.313	3.679	3.092	2.931
10:30		4.169	3.932	3.612	3.293	3.231	3.347	3.159	3.336	3.323	3.731	3.091	2.944
10:45		4.202	3.944	3.615	3.293	3.230	3.356	3.198	3.355	3.397	3.891	3.121	2.959
11:00	90,000 gal.	4.181	3.917	3.612	3.306	3.224	3.353	3.204	3.362	3.372	3.879	3.135	2.951
11:15		4.242	3.952	3.667	3.340	3.267	3.379	3.185	3.315	3.327	3.640	3.060	2.929
11:30		4.239	3.900	3.672	3.349	3.273	3.393	3.191	3.353	3.347	3.649	3.087	2.938
11:45	140,000 gal.	4.261	3.947	3.661	3.349	3.270	3.370	3.212	3.329	3.335	3.649	3.073	2.940
12:00		4.236	3.905	3.669	3.360	3.277	3.388	3.202	3.326	3.333	3.628	3.080	2.943
12:20		4.245	3.943	3.665	3.354	3.292	3.389	3.230	3.357	3.354	3.667	3.089	2.957
12:40	235,000 gal.	4.242	3.907	3.679	3.370	3.284	3.401	3.255	3.361	3.357	3.655	3.076	2.941
13:10		4.241	3.964	3.687	3.377	3.291	3.389	3.220	3.335	3.339	3.726	3.091	2.949
13:45	336,000 gal.	4.268	3.954	3.696	3.398	3.309	3.410	3.252	3.372	3.365	3.622	3.107	2.972
14:10		4.281	4.006	3.694	3.377	3.236	3.405	3.294	3.380	3.393	3.642	3.114	2.977
14:30	410,000 gal.	4.205	3.943	3.643	3.339	3.264	3.352	3.204	3.298	3.348	3.569	3.048	2.923
14:50	Stop Pumping - 15:10	4.176	3.911	3.639	3.308	3.233	3.346	3.225	3.274	3.385	3.593	3.091	2.941
16:20	Total Volume - 458,640 gal.	4.120	3.888	3.590	3.283	3.200	3.311	3.075	3.280	3.371	3.632	3.087	2.935
16:40		4.212	3.855	3.612	3.293	3.248	3.293	3.104	3.285	3.384	3.614	3.066	2.931
17:00		4.115	3.873	3.545	3.232	3.163	3.260	3.089	3.221	3.356	3.596	3.047	2.907
17:20		4.087	3.884	3.531	3.223	3.175	3.260	3.146	3.222	3.353	3.553	3.048	2.900

TABLE VI

PINEDALE UNIT 5 HYDROFRACTURE 2

POST FRACTURE-OCTOBER, 21, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
10:10	3.087	3.404	3.297	3.186	3.628	4.398	3.789	4.235	4.045	3.949	4.341	4.244
10:30	3.065	3.409	3.269	3.196	3.685	4.424	3.777	4.225	4.034	3.928	4.329	4.215
10:45	3.115	3.422	3.313	3.206	3.593	4.443	3.756	4.206	4.038	3.922	4.305	4.248
11:0	3.094	3.415	3.344	3.211	3.637	4.416	3.792	4.249	4.010	3.946	4.282	4.241
11:4	3.083	3.399	3.405	3.218	3.699	4.427	3.783	4.234	4.065	3.938	4.224	4.248
11:15	3.116	3.426	3.327	3.198	3.656	4.433	3.793	4.207	4.013	3.942	4.424	4.267
11:30	3.122	3.435	3.302	3.255	3.656	4.458	3.798	4.238	4.076	3.964	4.331	4.268
11:41	3.124	3.437	3.344	3.236	3.673	4.454	3.795	4.232	4.029	3.935	4.323	4.252
12:0	3.121	3.440	3.361	3.227	3.661	4.432	3.791	4.246	4.009	3.948	4.297	4.286
12:15	3.123	3.427	3.333	3.242	3.632	4.450	3.799	4.262	4.036	3.968	4.363	4.263
12:30	3.149	3.420	3.216	3.244	3.684	4.448	3.819	4.263	4.059	3.947	4.344	4.288
12:45	3.117	3.442	3.344	3.244	3.675	4.500	3.830	4.280	4.081	3.968	4.378	4.283
13:0	3.146	3.454	3.360	3.278	3.709	4.460	3.833	4.289	4.088	3.988	4.366	4.291
13:17	3.141	3.440	3.349	3.274	3.698	4.426	3.829	4.290	4.085	3.992	4.211	4.280
13:30	3.140	3.435	3.223	3.301	3.682	4.473	3.816	4.268	4.063	3.933	4.476	4.341
13:45	3.178	3.472	3.370	3.294	3.690	4.385	3.848	4.287	4.105	4.038	4.454	4.325

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
10:10	4.120	3.885	3.517	3.211	3.144	3.281	3.159	3.268	3.415	3.738	3.116	2.919
10:30	4.102	3.810	3.504	3.197	3.164	3.279	3.101	3.243	3.399	3.735	3.100	2.910
10:45	4.086	3.839	3.522	3.222	3.185	3.280	3.151	3.276	3.460	3.837	3.156	2.940
11:0	4.118	3.759	3.536	3.217	3.178	3.277	3.091	3.255	3.420	3.753	3.115	2.906
11:4	4.106	3.823	3.532	3.229	3.180	3.265	3.140	3.269	3.408	3.756	3.090	2.906
11:15	4.105	3.832	3.528	3.232	3.195	3.295	3.143	3.281	3.450	3.794	3.129	2.941
11:30	4.104	3.883	3.523	3.225	3.170	3.277	3.133	3.287	3.476	3.850	3.154	2.950
11:41	4.110	3.892	3.535	3.226	3.190	3.288	3.148	3.292	3.470	3.862	3.155	2.949
12:0	4.159	3.885	3.536	3.241	3.195	3.290	3.167	3.305	3.476	3.845	3.151	2.953
12:15	4.132	3.772	3.544	3.241	3.197	3.294	3.138	3.310	3.466	3.785	3.147	2.953
12:30	4.129	3.833	3.564	3.264	3.205	3.300	3.164	3.321	3.448	3.751	3.141	2.940
12:45	4.133	4.001	3.550	3.257	3.213	3.308	3.227	3.300	3.477	3.770	3.145	2.952
13:0	4.160	3.830	3.570	3.276	3.226	3.320	3.180	3.320	3.451	3.750	3.150	2.950
13:17	4.165	3.818	3.565	3.254	3.221	3.321	3.174	3.280	3.450	3.746	3.129	2.952
13:30	4.189	3.941	3.589	3.291	3.256	3.322	3.163	3.286	3.483	3.777	3.138	2.981
13:45	4.162	3.860	3.606	3.292	3.241	3.321	3.195	3.334	3.524	3.844	3.210	3.021

APPENDIX C

TABLE 1

WATTENBERG - MARTIN MARY HYDROFRACTURE

BACKGROUND-NOVEMBER 17, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
16:20	1.9397	2.2956	2.1695	2.4884	2.9222	3.1371	3.2100	2.8897	2.5693	2.2672	1.9457	1.9464
16:23	2.0244	2.3183	2.1597	2.4901	2.9352	3.1341	3.2416	2.8750	2.5684	2.3224	2.1917	2.0050
16:24	1.9796	2.3058	2.1743	2.4913	2.9363	3.1376	3.2418	2.8803	2.5825	2.2698	1.9986	2.0189
16:27	1.9302	2.3075	2.1542	2.4941	2.9285	3.1369	3.2603	2.8782	2.6004	2.2515	2.2166	1.9985
16:31	1.9937	2.3101	2.1587	2.4788	2.9338	3.1353	3.2562	2.8828	2.5666	2.2804	2.1932	2.1682
16:33	2.0013	2.3091	2.1454	2.4712	2.9270	3.1389	3.2632	2.8803	2.5400	2.2872	2.2011	1.9529
16:35	2.0027	2.3051	2.1432	2.4796	2.9286	3.1351	3.2596	2.8925	2.5875	2.3152	2.1611	1.9981
17:17	2.0146	2.3225	2.1756	2.4891	2.9374	3.1432	3.2675	2.7752	2.5801	2.3100	2.2276	2.0571
16:40	2.0049	2.3137	2.2147	2.4923	2.9317	3.1316	3.2556	2.8847	2.5174	2.2824	1.8879	2.0034
16:42	2.0280	2.3078	2.1602	2.4842	2.9326	3.1405	3.2623	2.8875	2.6321	2.3388	2.1555	2.0416
16:55	2.0168	2.3288	2.1393	2.4725	2.9242	3.1345	3.2579	2.7773	2.6016	2.3755	2.3426	2.0567
17:20	2.0178	2.3182	2.1860	2.4852	2.9345	3.1397	3.2575	2.7751	2.5658	2.2967	2.0733	2.0280
17:53	2.0054	2.3357	2.2205	2.4898	2.9393	3.1462	3.2631	2.9323	2.5727	2.2663	2.1476	1.9813
17:43	2.0225	2.3434	2.1931	2.4888	2.9351	3.1456	3.2668	2.9368	2.5808	2.3665	2.0953	1.9481
17:59	2.0199	2.3136	2.1518	2.4896	2.9352	3.1461	3.2647	2.9304	2.5814	2.4144	2.2168	1.9456
17:58	2.0058	2.3366	2.1647	2.4869	2.9367	3.1457	3.2657	2.9367	2.5811	2.3027	2.2882	2.0801
18:00	1.9988	2.3136	2.1842	2.5052	2.9533	3.1483	3.2678	2.9349	2.5723	2.1279	2.0533	2.0728
18:02	1.9897	2.3263	2.1228	2.4706	2.9293	3.1387	3.2620	2.9321	2.6116	2.4496	2.4092	2.0866
18:05	2.0073	2.3037	2.2026	2.5003	2.9547	3.1464	3.2655	2.9338	2.5607	2.3143	2.2076	2.1475
18:08	2.0220	2.3189	2.1493	2.4775	2.9263	3.1457	3.2665	2.9342	2.6106	2.2508	2.1055	1.9818
18:09	1.9341	2.2961	2.2873	2.5104	2.9481	3.1434	3.2637	2.9290	2.5103	2.2366	1.9488	2.0355
17:48	2.0281	2.3358	2.1866	2.4897	2.9330	3.1422	3.2668	2.9281	2.5738	2.3026	2.2425	2.0260
17:43	2.0031	2.3195	2.1824	2.4793	2.9348	3.1426	3.2636	2.9359	2.5737	2.3600	2.1473	2.0909
17:45	1.9916	2.3116	2.1756	2.4891	2.9402	3.1434	3.2657	2.9341	2.5304	2.3858	2.1707	2.0217
17:47	2.0041	2.3272	2.1631	2.4814	2.9342	3.1468	3.2113	2.9394	2.5963	2.2761	2.1635	2.0848

TABLE 1 (continued)

WATTENBERG - MARTIN HART HYDROFRACTURE

BACKGROUND-NOVEMBER 17, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
16:23	2.0950	1.9709	1.9181	1.7960	2.0704	2.0330	1.9769	1.9303	1.8765	1.9104	1.9461	1.9877
16:23	2.0395	1.9589	1.9584	1.8072	2.0632	2.0487	1.9802	1.9360	1.8698	1.8924	1.9524	1.9941
16:24	2.1528	2.1261	2.0936	1.8866	2.0843	2.1004	1.9689	2.0411	1.9027	1.8737	1.9377	1.9812
16:27	1.9420	1.9378	2.0061	1.8014	2.0994	2.0937	1.9798	1.9566	1.8392	1.8585	1.9425	1.9818
16:31	2.1920	2.0470	2.0225	1.8212	2.0679	2.1137	1.9804	2.0597	1.8769	1.9109	1.9423	1.9821
16:33	2.0527	1.9094	1.9352	1.7716	2.0838	2.0900	1.9805	2.0157	1.8933	1.8901	1.9429	1.9864
16:35	2.0634	2.1195	1.9388	1.8251	2.0721	2.0933	1.9658	2.0309	1.9127	1.8890	1.9436	1.9818
17:17	2.0295	2.0422	1.9796	1.8057	2.0793	2.0321	1.9709	2.0120	1.8777	1.8856	1.9451	1.9846
16:40	1.9405	1.8922	2.0598	1.8340	2.0849	2.0946	1.9785	1.9674	1.8599	1.8925	1.9433	1.9866
16:42	2.0150	2.1520	2.0734	1.7892	2.0709	2.0962	1.9763	2.0233	1.9280	1.8850	1.9472	1.9879
16:55	2.0776	2.0534	2.0352	1.7403	2.0868	2.0945	1.9723	2.0117	1.8928	1.9047	1.9429	1.9789
17:20	2.1150	2.0074	1.9933	1.8140	2.0890	2.0869	1.9703	2.0106	1.8974	1.8915	1.9450	1.9834
17:53	2.0482	2.0164	2.0412	1.8306	2.0646	2.0914	1.9784	2.0155	1.9284	1.8801	1.9486	1.9876
17:49	2.0137	2.0083	2.0525	1.8401	2.0939	2.0951	1.9759	2.0131	1.9109	1.8845	1.9466	1.9890
17:55	2.1552	2.0805	2.0642	1.8167	2.0933	2.0976	1.9777	2.0128	1.9216	1.8900	1.9448	1.9822
17:58	2.0482	2.0295	2.1255	1.8797	2.0787	2.0943	1.9766	2.0102	1.9184	1.8938	1.9453	1.9835
18:00	2.1586	2.1821	2.1138	1.8839	2.0694	2.0950	1.9853	2.0131	1.9132	1.8773	1.9465	1.9855
18:02	2.3492	2.2445	2.0279	1.7590	2.0766	2.0963	1.9719	2.0146	1.9225	1.8710	1.9447	1.9866
18:05	2.1621	2.2812	1.8976	1.7810	2.0739	2.0913	1.9739	2.0116	1.9109	1.8907	1.9432	1.9833
18:08	2.0602	1.9598	2.0298	1.8503	2.0962	2.0953	1.9775	2.0143	1.9279	1.8796	1.9470	1.9849
18:09	1.9461	1.9229	2.1079	1.8767	2.1050	2.0943	1.9802	2.0107	1.9197	1.8733	1.9413	1.9805
17:48	2.0078	2.0280	1.9592	1.8091	2.0932	2.0967	1.9754	2.0132	1.8955	1.8769	1.9471	1.9957
17:43	1.9823	2.0083	2.0336	1.8456	2.0817	2.0946	1.9770	2.0158	1.9363	1.8965	1.9474	1.9846
17:45	2.1679	2.0823	2.0054	1.8100	2.0809	2.0952	1.9765	2.0171	1.9282	1.8943	1.9478	1.9679
17:47	2.0955	2.0641	1.9463	1.8252	2.0778	2.0921	1.9733	2.0113	1.9137	1.8851	1.9430	1.9875

TABLE II

WATTENBERG - MARTIN HART HYDROFRACTURE

FRACTURE-NOVEMBER 18, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
5:31	2.0048	2.3345	2.2682	2.5111	2.9382	3.1533	3.2640	2.9285	2.5122	2.1488	1.8677	1.9348
5:35	1.9824	2.3382	2.1931	2.4663	2.8954	3.1595	3.2685	2.9346	2.5653	2.3803	2.0862	2.0479
5:40	2.0394	2.3215	2.1690	2.4685	2.9152	3.1487	3.2635	2.9351	2.5737	2.3213	2.2564	2.1546
5:45	1.9838	2.3328	2.1713	2.4887	2.9378	3.1433	3.2598	2.9219	2.5629	2.3506	2.1813	2.0692
5:50	1.9848	2.3315	2.1483	2.4737	2.9147	3.1496	3.2662	2.9329	2.6016	2.3423	2.0245	1.9519
5:55	1.9890	2.3460	2.1943	2.4771	2.9333	3.1565	3.2704	2.9378	2.5938	2.2872	2.1784	2.0136
6:00	1.9931	2.3446	2.1976	2.4894	2.9345	3.1565	3.2697	2.9315	2.5761	2.3793	2.1434	1.9486
6:05	1.9983	2.3245	2.1826	2.4901	2.9350	3.1439	3.2646	2.9255	2.5334	2.4810	2.0148	2.0256
6:10	1.9926	2.3366	2.1907	2.4844	2.9390	3.1492	3.2668	2.9318	2.5762	2.1923	2.1364	2.0831
6:15	1.9803	2.3255	2.1555	2.4507	2.9292	3.1521	3.2729	2.9379	2.5775	2.3425	2.1368	2.1875
6:20	1.9951	2.3225	2.1739	2.4811	2.9435	3.1524	3.2707	2.9339	2.6045	2.3798	2.2952	2.0853
6:25	2.0226	2.3817	2.1805	2.5008	2.9606	3.1769	3.2885	2.9520	2.5977	2.3157	2.1140	1.7796
6:30	2.0779	2.3749	2.1731	2.5394	2.9646	3.1815	3.2990	2.9640	2.6178	2.3163	2.2841	2.0836
6:35	2.1129	2.3574	2.1923	2.5086	2.9559	3.1763	3.2931	2.9548	2.6250	2.3036	2.2300	2.0327
6:40	2.0388	2.3606	2.2198	2.5221	2.9565	3.1665	3.2853	2.9461	2.5517	2.3115	1.9666	1.9893
6:45	1.9979	2.3123	2.1633	2.4828	2.9333	3.1471	3.2657	2.9292	2.5699	2.4105	2.3283	2.1063
6:50	2.0137	2.3317	2.1616	2.4917	2.9287	3.1511	3.2677	2.9313	2.5687	2.2948	2.0609	2.0124
6:55	1.9886	2.3179	2.1779	2.4923	2.9420	3.1537	3.2699	2.9330	2.5764	2.3720	2.1281	2.0411
7:00	2.0006	2.3330	2.1608	2.4646	2.9260	3.1495	3.2692	2.9310	2.5903	2.2009	2.0760	2.0837
7:10	2.0331	2.3278	2.1646	2.4896	2.9381	3.1503	3.2689	2.9288	2.5915	2.2238	2.1736	2.0917
7:15	2.0071	2.3278	2.1692	2.4846	2.9358	3.1495	3.2699	2.9454	2.6040	2.2504	1.9528	2.0314
7:20	2.0224	2.3216	2.1569	2.4935	2.9333	3.1484	3.2672	2.9307	2.5860	2.4648	2.1746	1.9969
7:25	2.0419	2.3052	2.1789	2.4815	2.9351	3.1527	3.2683	2.9257	2.5746	2.3679	2.0846	2.1080
7:30	1.9947	2.3056	2.1705	2.4648	2.9326	3.1455	3.2642	2.9273	2.5571	2.3000	2.2887	2.0374
7:35	1.9790	2.3137	2.1751	2.4789	2.9334	3.1483	3.2690	2.9338	2.5609	2.3719	2.1731	2.0814
7:45	2.0039	2.3206	2.2018	2.5049	2.9390	3.1516	3.2656	2.9220	2.5525	2.4187	2.3949	2.0672
7:50	2.0029	2.3271	2.3074	2.0088	1.9863	1.9422	1.8779	1.9451	2.0199	1.9722	2.0850	2.0800
7:55 Start pumping	1.9927	2.3139	2.1934	2.4780	2.9299	3.1442	3.2460	2.9247	2.5812	2.2882	2.0980	1.9701
8:00	2.0020	2.3130	2.1503	2.4723	2.9226	3.1386	3.1999	2.9266	2.5767	2.2306	2.1137	2.0772
8:05	1.9749	2.2952	2.1869	2.4730	2.9185	3.1269	3.2122	2.8987	2.5319	2.2997	2.1723	1.9825
8:10	1.9774	2.3077	2.1994	2.4766	2.9169	3.1269	3.2219	2.9243	2.5627	2.2129	2.2149	1.9835
8:15	1.9809	2.3115	2.1695	2.4730	2.9163	3.1300	3.2207	2.9159	2.5592	2.2700	2.1170	2.0187
8:20	1.9967	2.3035	2.1463	2.4636	2.9236	3.1286	3.1182	2.7675	2.5580	2.3025	1.9690	2.0050
8:30	2.0170	2.3174	2.1180	2.4924	2.9326	3.1453	3.2362	2.8597	2.5743	2.2939	2.1306	1.9987
8:40	1.9995	2.3156	2.0581	2.4726	2.9263	3.1389	3.2429	2.8713	2.5730	2.2441	2.1108	2.0445
8:45	2.0045	2.3202	2.2111	2.4783	2.9354	3.1470	3.2422	2.8576	2.5329	2.4492	2.0905	2.0184
8:50	2.0095	2.3344	2.1744	2.4755	2.9207	3.1379	3.2366	2.8644	2.6043	2.2325	2.0943	1.8671
8:55 54,600 gal.	2.0091	2.3346	2.2056	2.4819	2.9290	3.1412	3.2394	2.8598	2.5544	2.3518	2.1471	2.0331
9:00	2.0116	2.3269	2.1427	2.4855	2.9252	3.1431	3.2430	2.8690	2.6065	2.1967	2.1917	2.0666
9:05	1.9809	2.3159	2.1972	2.4737	2.9349	3.1431	3.2428	2.8644	2.5633	2.2725	1.9764	1.9968
9:10	2.0148	2.3207	2.2036	2.4766	2.9374	3.1471	3.2436	2.8689	2.5676	2.1802	2.1471	2.1268
9:15	1.9986	2.3189	2.1432	2.4851	2.9248	3.1435	3.2408	2.8683	2.6025	2.1790	2.1189	1.9874
9:20	1.9876	2.3130	2.1942	2.4737	2.9284	3.1434	3.2393	2.8574	2.5733	2.3553	2.1043	1.9332

TABLE II (continued)

WATTENBERG - MARTIN HART HYDROFRACTURE

FRACTURE-NOVEMBER 18, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
9:25	2.0212	2.3310	2.2142	2.4537	2.9349	3.1437	3.2468	2.8565	2.5497	2.5557	2.1600	2.0653
9:30	2.0102	2.3322	2.1791	2.4812	2.9267	3.1436	3.2453	2.8749	2.6220	2.0818	1.9012	2.0427
9:40	2.0023	2.3185	2.1746	2.4980	2.9337	3.1432	3.2391	2.8539	2.5807	2.2884	2.0609	1.9883
9:45	2.0098	2.3211	2.1713	2.4574	2.9282	3.1382	3.2392	2.8591	2.5748	2.3315	2.0055	2.0705
9:50	2.0035	2.3297	2.2322	2.4943	2.9387	3.1414	3.2318	2.8443	2.5475	2.2151	2.2374	1.9587
9:55	96,600 gal.	2.0139	2.3298	2.2485	2.4792	2.9450	3.1364	3.2408	2.3543	2.5543	2.2122	1.6826
10:00		2.0435	2.3316	2.1680	2.5025	2.9264	3.1453	3.2429	2.9697	2.6033	2.1433	2.3737
10:05		2.0227	2.3254	2.1676	2.4996	2.9310	3.1408	3.2432	2.3640	2.5831	2.3268	2.7357
10:15		1.9960	2.3224	2.1412	2.4540	2.9156	3.1366	3.2374	2.3533	2.5933	2.0312	2.1644
10:20		2.0194	2.3342	2.1535	2.4816	2.9206	3.1380	3.2391	2.8560	2.4904	2.3565	2.1402
10:25		2.0182	2.3318	2.2051	2.4659	2.9364	3.1376	3.2375	2.8591	2.5680	2.1324	2.3284
10:30		2.0013	2.3195	2.2019	2.4895	2.9314	3.1375	3.2392	2.3588	2.5642	2.2133	2.1589
10:35		2.0057	2.3203	2.1224	2.4732	2.9246	3.1376	3.2435	2.8713	2.6324	2.1908	2.3325
10:40		2.0115	2.3305	2.1948	2.4707	2.9240	3.1351	3.2375	2.8628	2.5641	2.1525	1.9222
10:45		2.0036	2.3327	2.2049	2.4787	2.9278	3.1364	3.2363	2.8562	2.5421	2.1455	2.1873
10:50		1.9980	2.3273	2.2336	2.4974	2.9453	3.1384	3.2436	2.8679	2.5285	2.2190	2.1762
10:55		1.9689	2.2837	2.1575	2.4725	2.9391	3.1343	3.2342	2.8552	2.5702	2.1684	2.2564
11:00	153,300 gal.	2.0273	2.3348	2.2110	2.4815	2.9247	3.1397	3.2324	2.8539	2.5657	2.0923	2.3188
11:05		1.9743	2.3305	2.2097	2.4843	2.9112	3.1249	3.2261	2.8560	2.5531	2.0095	2.0979
11:40		2.0111	2.3438	2.1497	2.4914	2.9334	3.1337	3.2481	2.8747	2.5968	1.8791	2.0876
11:45		1.9988	2.3216	2.2241	2.4769	2.9416	3.1350	3.2395	2.8621	2.5042	1.8592	2.0969
11:50		2.0313	2.3412	2.1507	2.5017	2.9281	3.1370	3.2391	2.8593	2.5791	2.2873	1.9212
11:55		2.0252	2.3470	2.1798	2.4739	2.9278	3.1365	3.2411	2.9641	2.5823	2.3462	2.1355
12:00		2.0174	2.3219	2.2061	2.4863	2.9377	3.1350	3.2369	2.9469	2.5556	2.5230	2.1523
12:05	200,000 gal.	2.0127	2.3317	2.2123	2.4739	2.9289	3.1390	3.2424	2.4711	2.6016	2.4011	2.3182
12:10		2.0015	2.3305	2.1847	2.5111	2.9442	3.1430	3.2460	2.3686	2.5900	2.3215	2.2845
12:15		2.0337	2.3344	2.1492	2.4764	2.9215	3.1380	3.2419	2.8640	2.6028	2.4180	2.1634
12:23		1.9916	2.2984	2.1619	2.4750	2.9213	3.1356	3.2373	2.8572	2.5674	2.4639	2.1511
12:30		2.0148	2.3333	2.1889	2.4763	2.9327	3.1392	3.2395	2.8551	2.5643	2.3377	1.8279
12:35		1.9980	2.2881	2.2070	2.4676	2.9236	3.1310	3.2334	2.8515	2.5258	2.4136	1.7533
12:40		2.0038	2.3407	2.1638	2.4768	2.9227	3.1352	3.2388	2.8635	2.5791	2.4735	2.2854
12:45		2.0035	2.3224	2.1756	2.4897	2.9383	3.1407	3.2442	2.8542	2.5725	2.4651	2.0607
13:00		2.0219	2.3196	2.1374	2.4862	2.9310	3.1331	3.2397	2.8520	2.6180	2.3767	2.3612
13:05	252,000 gal.	2.0002	2.3455	2.1953	2.4898	2.9390	3.1381	3.2412	2.8520	2.5477	2.3435	2.3669
13:10		2.0150	2.3225	2.1353	2.4687	2.9235	3.1356	3.2386	2.8596	2.5830	2.2915	2.2418
13:18		1.9998	2.2988	2.2844	2.4889	2.9283	3.1374	3.2379	2.8547	2.5455	2.2961	2.0560
13:25		2.0158	2.3173	2.2541	2.5250	2.9519	3.1471	3.2521	2.8770	2.5540	2.2908	2.0999
13:30		2.0262	2.2802	2.2055	2.4780	2.9289	3.1380	3.2422	2.8641	2.5670	2.3668	2.1961
13:38		2.4728	2.1096	2.1976	2.5145	2.9377	3.1455	3.2508	2.8733	2.5668	2.4037	2.0822
13:45		2.0194	2.3234	2.2311	2.4858	2.9317	3.1335	3.2373	2.8523	2.5116	2.3627	2.0288
13:55		2.0001	2.3525	2.1518	2.4854	2.9172	3.1324	3.2361	2.8572	2.5371	2.5466	2.2996
14:05	305,000 gal.	2.0084	2.2995	2.1638	2.4793	2.9239	3.1322	3.2380	2.8590	2.5797	2.4624	2.0457
14:10		2.0103	2.3124	2.2078	2.4732	2.9304	3.1423	3.2450	2.8669	2.5772	2.4712	2.0862

TABLE II (continued)

MATTENBERG - MARTIN HART HYDROFRACTURE

FRACTURE-NOVEMBER 18, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
14:15	2.0104	2.3140	2.1552	2.4898	2.9384	3.1327	3.2370	2.8590	2.6074	2.3533	2.3673	1.9952
14:20	2.0192	2.3079	2.1339	2.4587	2.9172	3.1288	3.2282	2.8477	2.5659	2.4190	1.9758	1.9610
14:25	1.9817	2.2865	2.2538	2.4785	2.9290	3.1264	3.2230	2.8416	2.4973	2.3947	2.2850	2.0203
14:30	2.0040	2.3206	2.1776	2.4669	2.9257	3.1364	3.2445	2.8719	2.5452	2.3795	2.2041	2.3125
14:35	1.9853	2.2806	2.1333	2.4512	2.9192	3.1256	3.2331	2.8530	2.5791	2.3585	1.9929	2.2422
14:40 Stop pumping	1.9694	2.2932	2.1530	2.4642	2.9211	3.1274	3.2315	2.8568	2.5382	2.3130	1.7795	2.0588
14:45	1.9848	2.2809	2.1838	2.4606	2.9297	3.1276	3.2339	2.8539	2.5651	2.2938	2.1079	2.1991
14:50 Total Volume - 317,000 gal.	1.9736	2.3055	2.1829	2.4557	2.9369	3.1150	3.2214	2.8375	2.5750	2.3043	2.2122	1.9020
14:55	1.9623	2.2761	2.1537	2.4556	2.9116	3.1147	3.2173	2.8306	2.5536	2.3275	2.4348	2.3414
15:00	1.9974	2.2771	2.1736	2.4555	2.9117	3.1179	3.2231	2.8424	2.5476	2.4277	2.3341	2.0695
15:05	1.9810	2.2825	2.1615	2.4862	2.9146	3.1199	3.2248	2.8532	2.5611	2.3564	1.9995	1.9043
15:10	1.9758	2.3440	2.1662	2.4496	2.9170	3.1254	3.2258	2.8482	2.5737	2.3804	2.0127	1.9404
15:15	1.9681	2.3233	2.2033	2.4702	2.9188	3.1204	3.2274	2.8488	2.5493	2.3221	1.8174	2.0371
15:20	1.9958	2.2882	2.1403	2.4424	2.9014	3.1174	3.2278	2.8477	2.5719	2.3802	1.8246	1.9676
15:30	1.9772	2.2616	2.1115	2.4432	2.9075	3.1187	3.2242	2.8443	2.5393	2.5143	1.7750	1.7901
15:40	1.9852	2.3084	2.1628	2.4492	2.9183	3.1241	3.2229	2.8471	2.5205	2.3699	1.9645	1.9003
15:44	1.9845	2.3054	2.1832	2.4721	2.9119	3.1242	3.2300	2.8619	2.5652	2.4738	2.3903	1.9340
15:46	1.9889	2.2959	2.1632	2.4663	2.9078	3.1217	3.2279	2.8493	2.5675	2.3320	2.1057	1.8650
15:48	1.9878	2.2962	2.1423	2.4581	2.9085	3.1190	3.2261	2.8517	2.5694	2.4066	2.2248	2.0063
15:51	1.9607	2.2952	2.1728	2.4666	2.9198	3.1298	3.2287	2.8581	2.5517	2.2434	2.5270	2.0605
16:15	2.0157	2.2984	2.1724	2.4865	2.9268	3.1314	3.2273	2.8391	2.5369	2.5146	2.2723	1.7757
15:56	1.9832	2.2984	2.1314	2.4760	2.9103	3.1175	3.2216	2.8360	2.5348	2.5540	1.9205	2.1305
15:58	1.9702	2.2841	2.1595	2.4582	2.9079	3.1202	3.2224	2.8443	2.5590	2.3356	1.6403	2.0031
16:00	1.9965	2.3029	2.1673	2.4572	2.9115	3.1206	3.2254	2.8511	2.5501	2.4021	2.2261	1.9870
16:05	1.9442	2.3112	2.1574	2.4732	2.9084	3.1241	3.2247	2.8455	2.5456	2.4589	1.9599	2.1271
16:08	2.0011	2.3116	2.1488	2.4489	2.9095	3.1228	3.2251	2.8432	2.5782	2.3451	2.1660	2.1943
16:10	1.9344	2.2809	2.1950	2.4650	2.9167	3.1250	3.2320	2.8589	2.5641	2.2521	2.2083	1.9908
16:12	1.9840	2.2724	2.1477	2.4587	2.9115	3.1280	3.2295	2.8558	2.5588	2.4037	2.4649	2.1301
16:15	1.9885	2.2848	2.1542	2.4656	2.9179	3.1172	3.2206	2.8412	2.5602	2.3874	2.1070	2.0110
16:20	1.9745	2.3019	2.1771	2.4757	2.9119	3.1233	3.2299	2.8536	2.5600	2.3786	1.9355	1.9674
16:22	1.9589	2.3044	2.1438	2.4837	2.9186	3.1274	3.2298	2.8488	2.5536	2.4216	2.3562	2.0712
16:24	2.0096	2.3189	2.1635	2.4886	2.9214	3.1262	3.2280	2.8524	2.5751	2.3927	2.1218	2.0547
16:27	2.0112	2.3071	2.1936	2.4753	2.9164	3.1246	3.2274	2.8521	2.5571	2.3465	2.4827	2.0300
16:29	1.9871	2.2837	2.1736	2.4697	2.9241	3.1258	3.2266	2.8439	2.5519	2.4309	2.1755	2.0336
16:32	1.9801	2.3251	2.1877	2.4523	2.9150	3.1202	3.2221	2.8378	2.5620	2.3590	1.6993	2.0298
16:34	1.9809	2.2882	2.1742	2.4503	2.9146	3.1245	3.2276	2.8550	2.5333	2.3313	2.1348	2.1524
16:36	1.9830	2.2900	2.1678	2.4486	2.9093	3.1216	3.2278	2.8462	2.5883	2.2007	1.9816	2.0441
16:37	1.9705	2.2937	2.1586	2.5028	2.9218	3.1297	3.2302	2.8527	2.5404	2.4761	2.1275	1.9080
16:40	1.9659	2.2850	2.1759	2.4497	2.9168	3.1231	3.2265	2.8667	2.5784	2.5771	2.0893	2.0918

TABLE II (continue)

WATTENBERG - MARTIN HART HYDROFRACTURE

FRACTURE-NOVEMBER 18, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
5:31	1.7782	1.9056	2.0622	1.8420	2.0956	2.0900	1.9698	2.0038	1.9066	1.8902	1.9406	1.9794
5:35	2.2168	2.1414	2.0589	1.8331	2.0786	2.0812	1.9703	2.0054	1.9171	1.8775	1.9489	1.9833
5:40	2.1611	2.2358	1.9282	1.8451	2.1065	2.0958	1.9725	2.0045	1.9178	1.8736	1.9457	1.9864
5:45	2.1829	2.1788	2.0325	1.8059	2.0822	2.0833	1.9688	2.0045	1.9121	1.8648	1.9456	1.9757
5:50	1.9586	1.8774	1.9019	1.8347	2.0899	2.0377	1.9596	2.0044	1.9115	1.8570	1.9416	1.9846
5:55	1.9049	2.0355	2.0330	1.8576	2.0756	2.0859	1.9674	2.0038	1.9217	1.8859	1.9396	1.9623
6:00	1.9732	1.9009	2.0523	1.8652	2.0637	2.0896	1.9698	2.0065	1.9132	1.9375	1.9438	1.9754
6:05	2.0225	1.9257	1.9625	1.8233	2.0858	2.0827	1.9675	2.0049	1.9160	1.8633	1.9455	1.9790
6:10	1.9984	2.1101	1.9977	1.8845	2.0571	2.0783	1.9698	2.0030	1.9253	1.8782	1.9467	1.9893
6:15	2.4068	2.1137	2.0730	1.8599	2.0716	2.0884	1.9684	2.0044	1.9148	1.8651	1.9385	1.9647
6:20	2.1700	2.1339	2.0055	1.8020	2.1321	2.0300	1.9702	2.0063	1.9055	1.8548	1.9447	1.9776
6:25	2.0194	1.9438	2.0405	1.8319	2.1065	2.1514	2.0311	2.0703	1.9804	1.9351	1.9971	2.0161
6:30	2.3471	2.1941	1.9659	1.7695	2.1277	2.1528	2.0418	2.0801	1.9926	1.9415	2.0108	2.0407
6:35	2.1523	2.0726	2.0757	1.7853	2.1633	2.1416	2.0215	2.0605	1.9685	1.9404	1.9964	2.0363
6:40	1.9882	1.9329	2.0035	1.8432	2.1055	2.1242	2.0154	2.0548	1.9619	1.9176	1.9876	2.0206
6:45	2.3160	2.2958	2.0430	1.8179	2.0798	2.0942	1.9714	1.9919	1.9221	1.8986	1.9509	1.9976
6:50	2.0619	2.0447	2.0276	1.8112	2.0737	2.0805	1.9667	2.0045	1.9485	1.8910	1.9483	1.9851
6:55	2.1506	2.1023	2.0039	1.8281	2.0864	2.0853	1.9756	1.9985	1.9165	1.8926	1.9458	1.9770
7:00	2.1970	2.0992	2.0183	1.7818	2.0738	2.0824	1.9679	2.0345	1.9338	1.8556	1.9347	1.9536
7:05	1.9496	2.1104	2.0023	1.7945	2.0815	2.0860	1.9714	1.9902	1.9041	1.8795	1.9465	1.9992
7:10	2.0206	2.0702	2.0415	1.7798	2.0707	2.0903	1.9685	2.0392	1.9274	1.9159	1.9641	2.0199
7:15	2.0515	1.9940	1.9688	1.7997	2.0763	2.0805	1.9687	1.9920	1.9098	1.8858	1.9452	1.9803
7:20	2.2344	2.0894	2.0056	1.7657	2.0820	2.0949	1.9721	2.0367	1.9303	1.8460	1.9379	1.9911
7:25	2.1000	1.9797	1.9304	1.7878	2.0651	2.0875	1.9677	1.9932	1.9089	1.8604	1.9481	1.9930
7:30	2.0826	2.0315	2.0373	1.7990	2.0734	2.0773	1.9671	1.9985	1.9065	1.8579	1.9481	1.9774
7:35	1.9785	2.0996	2.0143	1.8007	2.0773	2.0946	1.9788	2.0049	1.9252	1.8692	1.9489	1.9856
7:40	1.7840	2.0001	2.0240	1.8161	2.0760	2.0924	1.9737	1.9933	1.8976	1.8722	1.9410	1.9754
7:45	2.0496	2.0205	1.9535	1.7918	2.0787	2.0871	1.9622	2.0624	1.9493	1.8736	1.9383	1.9720
8:00	2.0120	2.1178	1.9580	1.7965	2.0755	2.0991	1.9772	1.9390	1.8785	1.8089	1.9324	1.9846
8:05	1.8542	1.9892	1.9055	1.8015	2.0548	2.0751	1.9611	2.0177	1.9112	1.8515	1.9188	1.9534
8:10	1.6989	2.1143	1.9020	1.8085	2.0485	2.0598	1.9444	1.9819	1.8920	1.8787	1.9290	1.9629
8:15	1.8073	2.0456	1.9971	1.7635	2.0551	2.0755	1.9632	2.0038	1.9166	1.8621	1.9377	1.9717
8:20	2.1304	2.0954	1.9482	1.7795	2.0655	2.0623	1.9490	1.9952	1.8597	1.8525	1.9217	1.9600
8:30	2.0624	2.0742	2.0034	1.8250	2.0858	2.0947	1.9725	1.9201	1.8425	1.9009	1.9463	1.9831
8:40	2.1063	2.1362	2.0313	1.8207	2.0898	2.0948	1.9779	1.9903	1.8652	1.8819	1.9375	1.9741
8:45	2.2052	2.0949	2.0313	1.7892	2.0797	2.0907	1.9733	1.9965	1.8743	1.9116	1.9452	1.9813
8:50	2.0355	1.9639	1.9337	1.7153	2.0754	2.0895	1.9809	2.0119	1.8997	1.9036	1.9576	1.9933
8:55	2.0749	2.0586	2.0384	1.8387	2.0828	2.0814	1.9599	2.0569	1.9317	1.9287	1.9515	1.9838
9:00	2.0937	2.0651	1.9062	1.7966	2.0827	2.1056	1.9808	2.0536	1.8911	1.8768	1.9500	2.0063
9:05	2.1255	2.1255	2.0773	1.8554	2.0822	2.0951	1.9810	2.0052	1.8821	1.8521	1.9484	1.9899
9:10	2.2369	2.1038	2.0143	1.8099	2.1034	2.1066	1.9826	1.9774	1.8719	1.8833	1.9490	1.9872
9:15	2.1394	2.1582	1.9792	1.7714	2.0775	2.0905	1.9727	2.0168	1.8805	1.8619	1.9503	1.9804
9:20	2.0916	2.0348	1.9429	1.8297	2.0892	2.1089	1.9878	2.0300	1.8896	1.8466	1.9379	1.9702

Start pumping

54,600 gal.

TABLE II (continued)

WATTENBERG - MARTIN HART HYDROFRACTURE

FRACTURE-NOVEMBER 18, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
9:25	1.7840	2.1054	1.9788	1.8245	2.0913	2.1012	1.9855	2.0351	1.9012	1.9010	1.9494	1.9940
9:30	1.8931	2.1273	2.2130	1.9797	2.0914	2.1051	1.9853	2.0141	1.9016	1.8669	1.9522	1.9879
9:40	2.0272	2.3999	1.9739	1.6978	2.0829	2.1030	1.9823	1.9977	1.8336	1.8673	1.9492	1.9892
9:45	1.8708	2.0830	2.0741	1.8775	2.0893	2.1033	1.9784	1.9985	1.8710	1.8539	1.9476	1.9834
9:50	1.7077	1.7826	2.0785	1.8107	2.0801	2.0926	1.9826	2.0470	1.9035	1.9122	1.9553	1.9810
9:55	96,600 gal.	2.1993	2.3355	2.0050	1.9553	2.0907	1.9863	2.0380	1.8952	1.8868	1.9560	1.9899
10:00		2.0697	1.8652	1.8729	1.7002	2.0875	1.9766	2.0305	1.8998	1.8821	1.9477	1.9905
10:05		2.1043	1.8487	1.9871	1.7261	2.1396	1.9803	2.0290	1.8895	1.8593	1.9503	1.9778
10:15		2.0302	2.3014	2.0354	1.8331	2.0907	1.9752	1.9914	1.8688	1.8746	1.9473	1.9978
10:20		1.8818	2.0842	2.0402	1.8607	2.1132	1.9064	1.9923	1.8701	1.8992	1.9526	1.9910
10:25		2.0541	2.0537	2.1237	1.8936	2.0957	1.9806	2.0314	1.8873	1.8788	1.9546	1.9925
10:30		1.6540	2.0125	.7353	1.9338	2.0796	1.9804	2.0021	1.8682	1.8710	1.9513	1.9833
10:35		1.7885	2.1002	2.0584	1.7844	2.0858	1.9815	2.0233	1.8809	1.9019	1.9488	1.9873
10:40		1.5373	2.0263	2.0480	1.8043	2.0896	1.9819	2.0263	1.8939	1.8630	1.9513	1.9843
10:45		1.8997	1.9715	2.0824	1.8466	2.0970	1.9853	1.9392	1.8415	1.8425	1.9475	1.9857
10:50		1.8280	2.1822	2.0856	1.8733	2.0786	1.9762	2.0117	1.8713	1.8761	1.9463	1.9829
10:55		1.8517	2.1703	2.0641	1.9046	2.0759	1.9578	2.0077	1.8701	1.8654	1.9312	1.9689
11:00	153,300 gal.	1.6596	1.8388	1.8439	1.7477	2.0577	1.9743	2.0510	1.9007	1.8949	1.9554	1.9943
11:05		1.8023	1.7802	2.1530	1.8739	2.0923	1.9877	2.1009	1.9423	1.8795	1.9564	1.9868
11:10		1.7043	1.2452	2.0404	1.7288	2.0758	1.9757	2.0607	1.9053	1.8751	1.9412	1.9759
11:15		1.6996	2.3885	2.0418	1.7739	2.0888	1.9849	2.0373	1.8913	1.8704	1.9489	1.9865
11:20		2.6593	2.3136	2.0094	1.5994	2.3833	2.0669	1.9888	1.8716	1.8483	1.9451	1.9881
11:25		2.0052	1.3448	2.0639	1.8090	2.0809	1.9931	2.0443	1.8955	1.8762	1.9483	1.9820
12:00		2.2812	2.2001	2.2394	1.7459	2.0854	1.9959	2.0334	1.8893	1.8646	1.9554	1.9898
12:05	200,000 gal.	2.2534	2.1205	2.1398	1.7371	2.0915	1.9605	2.0383	1.8912	1.8780	1.9518	1.9905
12:10		2.2380	2.3775	2.1888	1.7769	2.0888	2.0069	1.9968	1.8734	1.9121	1.9535	1.9933
12:15		2.1432	2.0661	2.0202	1.6891	2.0618	2.0047	2.0122	1.8867	1.8793	1.9497	1.9923
12:23		2.1103	2.3496	2.1212	1.7397	2.0907	1.9769	1.9685	1.8929	1.8787	1.9525	1.9939
12:30		2.2603	2.1855	2.2128	1.7421	2.0885	1.9991	2.0270	1.8780	1.8877	1.9348	1.9818
12:35		2.2308	1.9138	1.9080	1.6897	2.0750	1.9950	1.9613	1.8446	1.8827	1.9458	1.9869
12:40		1.9202	1.9842	2.0263	1.7834	2.0375	2.0409	1.9761	1.8587	1.8883	1.9528	1.9763
12:45		1.9515	2.1820	2.1232	1.8571	2.0921	2.0358	1.9689	1.8631	1.8666	1.9537	1.9922
13:00		2.2077	2.0503	1.8701	1.8395	2.0770	1.9787	2.0116	1.8824	1.9130	1.9589	2.0026
13:05	252,000 gal.	2.0061	1.9137	1.9089	1.8565	2.1547	2.0477	2.0050	1.8857	1.8799	1.9509	1.9857
13:10		1.9838	2.3307	2.0559	1.7858	2.0858	2.0381	2.0148	1.8915	1.8482	1.9489	1.9834
13:18		2.0722	2.0253	2.0538	1.8259	2.0988	2.0342	2.0297	1.9081	1.8414	1.9524	1.9919
13:25		2.0777	1.7916	1.9953	1.8298	2.0835	2.0370	2.0110	1.8775	1.8828	1.9468	1.9841
13:30		1.9585	2.2902	2.1192	1.8549	2.1102	2.0423	1.9874	1.8587	1.8643	1.9554	2.0034
13:38		2.1760	1.7357	2.0753	2.2022	2.0425	2.3380	2.6381	2.8727	3.2455	3.1442	2.9326
13:45		2.2042	1.9535	2.0798	1.8055	2.0877	2.0345	2.0241	1.8883	1.8826	1.9559	1.9787
13:55		2.1779	2.3345	1.9274	1.8977	2.0825	2.0275	1.9977	1.8597	1.8985	1.9492	1.9855
14:05	305,000 gal.	1.7484	1.9964	2.1184	1.7541	2.0612	2.0238	1.9967	1.8486	1.8201	1.9342	1.9775
14:10		2.2301	2.1642	1.9647	1.8297	2.0787	2.0263	1.9990	1.8738	1.8960	1.9481	1.9910

TABLE II (continued)

WATTENBERG - MARTIN HART HYDROFRACTURE

FRACTURE-NOVEMBER 18, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
14:15	2.0572	2.1228	1.8395	1.8404	2.0793	2.0767	2.0332	2.0380	1.8768	1.9103	1.9459	1.9763
14:20	2.0992	2.2643	2.1058	1.8074	2.0882	2.0644	2.0263	2.0173	1.8962	1.8354	1.9212	1.9554
14:25	1.8423	1.8085	1.9754	1.8267	2.0735	2.0525	2.0191	2.0252	1.8757	1.8414	1.8941	2.0241
14:30	2.1754	2.1958	2.0325	1.8181	2.0873	2.0564	2.0204	2.0036	1.8636	1.8446	1.9259	1.9564
14:35	2.5073	2.4454	1.9468	1.7828	2.0639	2.0520	2.0139	1.9941	1.8511	1.8430	1.9287	1.9697
14:40	2.1468	2.1322	2.1363	1.8733	2.0560	2.0555	2.0180	1.9858	1.8480	1.9051	1.9313	1.9670
14:45	2.3334	2.1960	2.0511	1.8428	2.0550	2.0384	2.0053	2.0029	1.8687	1.8497	1.9233	1.9397
14:50	1.9976	2.2332	1.8366	1.7691	2.0489	2.0334	1.9940	2.0068	1.8743	1.8702	1.9087	1.9397
14:55	2.1200	1.8471	1.9420	1.9277	2.0429	2.0372	1.9933	2.0296	1.8771	1.9296	1.9116	1.9651
15:00	1.9227	1.9044	1.9515	1.7542	2.0439	2.0343	2.0043	1.9289	1.8133	1.8225	1.9172	1.9558
15:05	2.0512	1.8883	1.9670	1.8271	2.0504	2.0396	2.0019	1.9865	1.8435	1.8231	1.9174	1.9601
15:10	2.0895	2.2504	2.0454	1.8616	2.0609	2.0413	2.0068	1.9879	1.8451	1.8348	1.9104	1.9417
15:15	2.1394	2.0625	2.0213	1.8445	2.0597	2.0313	1.9356	1.9948	1.8627	1.8212	1.9144	1.9470
15:20	1.5780	2.0657	1.9565	1.8067	2.0553	2.0387	2.0061	1.9703	1.8491	1.8434	1.9211	1.9673
15:38	1.6940	1.9354	1.9850	1.8252	2.0499	2.0370	1.9988	2.0249	1.8861	1.8849	1.9244	1.9760
15:40	1.9930	2.0358	1.8889	1.7645	2.0514	2.0399	1.9934	1.9733	1.8332	1.8381	1.9117	1.9489
15:44	1.9410	1.5984	1.9418	1.8544	2.0598	2.0390	2.0008	1.9767	1.8568	1.8283	1.9111	1.9442
15:46	2.0079	2.0095	1.9715	1.8509	2.0564	2.0435	2.0013	2.0043	1.8633	1.8284	1.9152	1.9606
15:48	1.8541	1.8334	2.0491	1.8416	2.0509	2.0305	2.0003	1.9979	1.8985	1.8633	1.9188	1.9614
15:51	1.8743	1.7526	2.1180	1.8488	2.0572	2.0442	2.0074	1.9417	1.8259	1.8341	1.9132	1.9346
16:15	2.0641	1.9343	1.9481	1.7575	2.0513	2.0364	2.0053	1.9750	1.8402	1.8511	1.9231	1.9678
16:56	2.0323	1.9839	1.9782	1.8428	2.0478	2.0352	1.9991	1.9827	1.8656	1.8236	1.9092	1.9445
16:58	2.3316	2.3072	1.9873	1.8831	2.0622	2.0343	1.9192	2.0175	1.8723	1.8440	1.9118	1.9577
16:00	2.0972	1.9741	1.8939	1.8083	2.0660	2.0466	2.0033	1.9982	1.8606	1.8783	1.9228	1.9631
16:05	2.0597	2.0924	1.9310	1.8513	2.0495	2.0369	2.0055	1.9898	1.8509	1.8484	1.9056	1.9402
16:08	2.2581	2.1256	2.0303	1.8255	2.0556	2.0342	1.9390	2.0174	1.8920	1.8591	1.9149	1.9673
16:10	1.9378	1.9812	1.9379	1.7912	2.0576	2.0306	1.9399	2.0137	1.8677	1.8360	1.9173	1.9547
16:12	2.0500	1.9175	2.0576	1.9096	2.0654	2.0445	2.0029	1.9791	1.8507	1.8460	1.9205	1.9565
16:15	2.0467	2.0125	1.8982	1.7367	2.0511	2.0447	2.0062	1.9623	1.8350	1.8252	1.9129	1.9594
16:20	2.1199	2.0937	2.0006	1.8456	2.0583	2.0352	2.0079	1.8934	1.7873	1.8433	1.9113	1.9560
16:22	2.0579	1.8621	2.1605	1.9446	2.0526	2.0331	1.9996	2.0060	1.8451	1.8262	1.9138	1.9354
16:24	1.9907	2.0074	1.9434	1.8600	2.0651	2.0413	2.0047	1.9665	1.8395	1.8618	1.9149	1.9666
16:27	1.8720	1.7953	1.9691	1.7663	2.0567	2.0355	2.0085	1.9150	1.8105	1.8556	1.9192	1.9581
16:29	1.9056	1.8170	2.0892	1.7923	2.0569	2.0325	1.9973	2.0013	1.8722	1.8287	1.9129	1.9519
16:32	2.1229	2.3153	2.0263	1.8646	2.0517	2.0355	2.0092	1.9630	1.8343	1.8753	1.9149	1.9401
16:34	2.4201	2.1587	2.1153	1.9197	2.0501	2.0399	2.0017	1.9741	1.8368	1.8409	1.9246	1.9598
16:36	2.0085	2.1945	2.0704	1.7554	2.0545	2.0389	2.0048	1.9766	1.8425	1.7909	1.9163	1.9629
16:37	2.1344	2.0559	1.9466	1.7853	2.0519	2.0327	1.9987	1.9806	1.8512	1.8609	1.9099	1.9561
16:40	2.2240	2.1084	2.0431	1.9200	2.0475	2.0395	2.0003	2.0145	1.8527	1.8539	1.9150	1.9499

APPENDIX D

TABLE I

MATTENBERG - SALAZAR HYDROFRACTURE

FRACTURE-DECEMBER 16, 1975

TIME		15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	
7:15		.1735	-.0025	.0939	-.0059	-.0174	-.0722	-.1083	-.1451	-.2140	.0706	-.0419	-.0528
7:21		-.1065	.0021	-.0005	-.1239	-.0686	-.1034	-.1166	-.1261	-.1154	.0298	-.0052	.0153
7:23		-.1662	.0024	-.0254	-.1002	-.3717	-.3268	-.2534	-.1605	-.0525	.0381	.1312	.1553
7:25		-.0814	-.0025	-.1301	-.1130	-.1326	-.1536	-.1560	-.1465	-.1558	.1751	.0059	.0108
7:40		.0103	.0035	-.1574	-.2001	-.2481	-.2471	-.1933	-.1470	-.1163	.1137	.0788	.0918
8:44		-.0105	-.0095	-.3380	-.1995	-.1673	-.1659	-.1566	-.1224	-.0406	.0114	.0275	.0728
8:46		-.0489	.0023	.0034	-.2171	-.1718	-.1542	-.1388	-.0973	-.0547	.0146	.0500	.1051
9:00		.4085	.0035	.2080	.0861	-.1817	-.2391	-.2704	-.2980	-.3213	.1512	-.0393	-.0547
9:05		.2744	.0027	.1726	.0447	-.1442	-.1573	-.1519	-.1412	-.1299	.0325	.0645	.0466
9:10		.1584	-.0004	.1329	-.0562	.0901	.0034	-.0702	-.1581	-.2176	.0556	-.0951	-.1273
9:15		.0483	-.0028	-.1808	-.1001	.0463	-.0895	-.1893	-.3029	-.3219	-.2887	-.1785	-.1257
9:23		.2567	-.0018	.0917	.0684	-.0354	-.0790	-.0854	-.0882	-.0642	.0892	-.0381	.0118
9:25		.2533	.0026	.1142	.0448	-.2929	-.2588	-.1916	-.1219	-.0717	.0380	.0812	.1519
9:30	Start pumping	-.5780	.0018	-.5758	-.6094	-.3793	-.2936	-.1960	-.0704	-.0458	.4127	.1905	.1679
9:35		.3794	.0019	.4174	.1180	-.0853	-.1368	-.1544	-.1681	-.1409	-.0112	-.0290	.0015
9:40		.0155	-.0027	-.0099	-.1989	-.1149	-.1350	-.1441	-.1558	-.1275	-.0680	-.0418	.0014
9:45		.6127	-.0028	.4173	.3224	-.3362	-.3392	-.3195	-.2765	-.2514	.0206	-.0022	.0452
9:50		.0972	-.0005	.1098	-.1308	.0024	-.0284	-.0370	-.0523	-.0676	.2697	.0978	.1173
9:55		.1851	.0023	.0049	-.0688	-.1624	-.1981	-.1968	-.2400	-.2626	.2516	-.0151	-.0279
10:00	61,000 gal.	.0190	-.0033	-.1154	-.1270	-.1489	-.1405	-.1302	-.1163	-.1167	.0082	-.0428	.0968
10:05		.1336	.0005	-.0307	-.0731	-.1704	-.1896	-.1965	-.1910	-.1435	.0229	-.0271	-.0042
10:10		.0338	-.0020	-.1390	-.1860	-.1746	-.1998	-.1985	-.1894	-.1853	.1165	-.0698	.0131
10:15		.1350	-.0018	.0543	-.0218	-.2107	-.1379	-.1780	-.1409	-.1504	.0714	.0193	.0327
10:20		.0541	-.0023	-.0609	-.1210	-.3299	-.3253	-.2824	-.2273	-.3140	.0372	.0233	.0809
10:25		.1102	.0051	-.1528	-.1150	-.1444	-.2232	-.2400	-.2362	-.1432	.1203	-.1670	.2089
10:30		.0537	.0008	-.0659	-.1345	-.2150	-.2192	-.2031	-.1832	-.0559	-.0343	.1084	.0324
10:35		-.0020	-.0013	-.0572	-.1640	-.0745	-.1672	-.1392	-.2182	-.1720	-.0794	-.0749	-.0389
10:40		.0086	-.0016	-.1257	-.1714	-.1759	-.2146	-.2263	-.2287	-.1539	-.0808	-.0191	.0208
10:45		.0858	-.0001	-.1140	-.1526	-.2477	-.2452	-.2304	-.2101	-.3031	.1205	.0244	.0167
10:50		.0250	.0050	-.2003	-.2192	-.1931	-.2183	-.2263	-.2105	-.1733	.0602	-.0657	.0412
10:55		.0280	0.0000	-.0317	-.1619	-.1816	-.1883	-.1841	-.1779	-.1598	-.0638	-.0455	.0188
11:00	116,000 gal.	.0671	-.0013	.0331	-.1129	-.2077	-.2270	-.2170	-.2166	-.1945	.0824	-.0414	-.0199
11:05		.0395	-.0048	-.0192	-.0988	-.2916	-.2253	-.2206	-.2131	-.4235	.0213	-.0317	.0026
11:10		.0402	.0013	-.0849	-.1605	-.1599	-.2337	-.2213	-.2388	-.2000	.1244	-.0842	-.0750
11:15		-.0046	-.0006	-.0188	-.1602	-.2137	-.2350	-.2207	-.2026	-.1800	.0548	.3427	.0133
11:20		.1400	.0007	.0959	-.0956	-.1840	-.2084	-.1992	-.1665	-.1575	.0858	-.0392	-.0348
11:25		.0521	-.0017	-.1139	-.1832	-.2110	-.2325	-.2403	-.2403	-.2340	.0020	-.0868	-.0407
11:30		.0580	.0053	-.1228	-.1708	-.1892	-.1785	-.1715	-.1680	-.1181	-.3242	0.0000	.0156
11:55		.2148	.0018	.0533	-.0239	-.2564	-.2524	-.2398	-.2167	-.1573	-.1130	.0185	.0368
12:00	172,000 gal.	.0074	.0066	-.1118	-.1955	-.0558	-.1075	-.1431	-.1858	-.2255	.0077	0.0000	-.0740
12:05		-.0952	-.0017	-.2028	-.2306	-.2885	-.2623	-.2442	-.2034	-.1240	-.0219	-.0954	.0574
12:10		.2065	-.0038	.0829	.0045	-.2465	-.2479	-.2309	-.2063	-.1522	-.1187	-.0094	.0354
12:20		.1604	.0056	.0105	-.0628	-.0105	-.0850	-.1134	-.1463	-.1847	.0586	.3990	-.0750
12:30		-.0897	-.0005	-.1981	-.2082	-.2218	-.1807	-.1925	-.1576	.1935	-.0180	.1424	.0258
12:35		-.0494	-.0023	-.2231	-.2151	-.0670	-.1316	-.1699	-.2060	-.2330	.0811	.0043	-.1154

TABLE I (continued)

HATTENBERG - SALAZAR HYDROFRACTURE

FRACTURE-DECEMBER 16, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
7:15	-.0879	.0028	.1217	.2365	.6660	.7510	.7744	.7730	.5675	.4855	.2501	.3047
7:21	.0933	.1110	.1746	.2655	.6972	.7709	.7990	.7998	.5565	.4829	.2442	.2260
7:23	.3115	.2472	.3668	.5238	.6604	.7587	.7963	.7961	.5770	.5178	.2478	.2650
7:25	.0010	.1071	.2078	.3133	.7558	.8272	.8359	.8196	.5736	.4636	.2599	.1951
7:40	.1376	.2021	.2990	.4400	.8666	.8821	.8512	.8122	.5436	.4443	.1800	.1255
8:44	.1804	.1795	.2363	.3401	.6777	.7584	.7395	.7076	.4711	.3895	.1278	.0779
8:46	.2394	.1869	.2639	.3600	.6726	.7519	.7518	.6458	.4554	.3583	.1734	.1172
9:00	-.1293	.0003	.2453	.3646	.6052	.7404	.8445	.8655	.6959	.6667	.3840	.5269
9:05	.1127	.1483	.2329	.3536	.5749	.7207	.7732	.7918	.6130	.5681	.3343	.4022
9:10	-.1905	-.0448	.0554	.1496	.6567	.7772	.8090	.7827	.5688	.4957	.2525	.2833
9:15	.1430	.1387	.0587	.1470	.6582	.7391	.7433	.7170	.4888	.4040	.1756	.1303
9:23	.0084	.1398	.1923	.3099	.5234	.6765	.7455	.7586	.5702	.5581	.3248	.3758
9:25	.2740	.2091	.3452	.4628	.5734	.7344	.7936	.8179	.6253	.6015	.3141	.3717
9:30	-.0598	.2525	.4115	.5678	1.1231	1.0343	.8590	.6780	.3050	-.0061	-.1795	-.4245
9:35	.0977	.1256	.1889	.3000	.4807	.6705	.7465	.7876	.6321	.5993	.4144	.5427
9:40	.0461	.1147	.1553	.2526	.6677	.7614	.7657	.7490	.5091	.4241	.1914	.1847
9:45	.1247	.1045	.2047	.3853	.2370	.4950	.6749	.7541	.6788	.7437	.4875	.7030
9:50	.1094	.1720	.2244	.2679	.5989	.6337	.7048	.6869	.4973	.4225	.2423	.2514
9:55	-.0439	.0559	.1963	.3092	.5819	.7286	.7776	.7876	.5921	.5231	.2640	.3078
10:00	.0899	.1233	.1782	.2642	.5250	.6370	.6505	.6135	.4208	.3372	.1427	.1102
10:05	.0253	.0916	.1714	.2732	.5706	.6949	.7224	.7227	.5222	.4565	.2142	.2371
10:10	.0531	.1272	.1982	.3096	.6296	.7358	.7318	.7166	.4948	.3956	.1608	.1300
10:15	.0401	.1247	.2110	.3162	.4911	.6299	.6693	.6079	.4859	.4352	.2274	.2525
10:20	.1897	.1239	.2778	.3873	.6122	.6942	.7084	.6850	.4823	.3930	.1725	.1683
10:25	.0105	.0840	.1734	.2755	.5732	.6923	.7110	.7195	.5296	.4351	.1758	.1627
10:30	.1445	.1739	.2075	.2954	.5470	.6311	.7403	.7194	.4975	.4355	.2502	.1777
10:35	.0089	.1745	.1260	.2204	.5903	.6926	.6936	.6784	.4470	.3640	.1682	.1531
10:40	-.0492	.3057	.1589	.2048	.6020	.7094	.7075	.6912	.4515	.3634	.1436	.1323
10:45	-.0006	.0937	.2119	.3294	.6044	.7140	.7406	.7247	.5176	.4019	.1770	.1751
10:50	.1149	.1245	.1866	.1423	.6813	.7841	.7954	.7654	.5345	.4411	.1778	.1235
10:55	.1225	.1440	.1777	.2658	.5796	.6898	.7139	.7047	.4742	.4090	.2698	.1729
11:00	.0279	.0750	.1754	.2876	.5474	.7292	.6761	.6915	.4890	.4028	.2042	.2070
11:05	.0467	.1022	.1912	.3413	.6316	.6945	.7018	.6808	.4890	.3954	.1910	.1714
11:10	-.1652	.0064	.1414	.2564	.5827	.6875	.6828	.6878	.4681	.3812	.1550	.1522
11:15	.0040	.1157	.1934	.3024	.6033	.7099	.6848	.5589	.4328	.3428	.1367	.1063
11:20	-.0200	.0716	.1835	.2970	.5283	.6595	.7317	.7173	.5412	.4731	.2722	.2920
11:25	.0000	.0855	.1517	.2704	.6095	.7195	.7280	.7025	.4895	.4091	.1710	.1637
11:30	.0822	.1311	.1662	.2705	.5859	.6981	.7168	.7008	.5013	.4203	.1825	.1485
11:55	.2102	.1585	.2512	.2990	.5235	.6819	.7249	.7366	.5541	.5115	.2676	.3214
12:00	-.0841	.0033	.0918	.1855	.6341	.7218	.6519	.7111	.5021	.3910	.1753	.1204
12:05	.2101	.1770	.2393	.3438	.6095	.6983	.6808	.6111	.3990	.2724	.0722	.0007
12:10	.1223	.1963	.2157	.3143	.4815	.6177	.6417	.7019	.5240	.4823	.2665	.3142
12:20	-.1002	-.0151	.0925	.1743	.5357	.6640	.7494	.7270	.5337	.4817	.2314	.2633
12:30	.1268	.1336	.1824	.2655	.6597	.7214	.6288	.6507	.4046	.2889	.3818	.0047
12:35	-.1521	-.0250	.0971	.2689	.7374	.7369	.6909	.6778	.4425	.3247	.1003	.0444

TABLE I (continued)

WATTENBERG - SALAZAR HYDROFRACTURE

FRACTURE-DECEMBER 16, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
12:45	-.0501	.0010	-.0911	-.0866	.0263	-.1314	-.2600	-.4030	-.4326	-.3266	.0024	-.2131
12:50	-.2640	-.0016	-.4667	-.4101	-.0882	-.1591	-.1886	-.2367	-.3108	.2761	.0017	-.1466
12:55	.0617	.0025	-.1328	-.1902	-.0927	-.1515	-.1589	-.1723	-.1567	-.0263	.0008	-.0193
13:00	.0434	.0001	-.1245	-.1760	-.1535	-.1924	-.2132	-.2313	-.2622	.0379	-.0058	-.0347
13:05	.3076	-.0017	.1800	.0549	-.3094	-.3032	-.2939	-.2783	-.2514	.0842	.0017	-.0747
13:10	.1276	.0044	.0239	-.0017	-.1277	-.1879	-.2392	-.2889	-.3333	.0357	-.0034	-.1272
13:15	.0360	-.0010	-.0629	-.1449	-.1896	-.1875	-.1650	-.1320	-.0579	-.2592	.0010	.1731
13:20	.1559	-.0037	-.0539	-.0926	-.1431	-.1687	-.2193	-.2565	-.2545	-.0777	-.0510	-.0723
13:25	.2726	.0054	.0069	.0277	-.1466	-.1665	-.1876	-.2039	-.2071	-.0278	-.0153	-.0235
13:30	.2239	.0074	.0690	-.0342	-.3073	-.2347	-.1891	-.1320	-.0717	.1215	.0783	.0683
13:35	.1403	.0024	.0135	-.0480	-.2364	-.2395	-.2208	-.1945	-.1185	-.0684	-.0332	.0433
13:40	-.1703	.0023	-.3038	-.3298	-.1292	-.1289	-.1317	-.1290	-.2019	.1654	.0169	.0365
13:45	.0769	.0084	-.0189	.0005	-.1549	-.1632	-.1602	-.1527	-.2022	.0967	-.0100	-.0068
13:50	-.4000	0.0000	-.0071	-.0066	-.3211	-.3801	-.3394	-.2967	-.2244	.0334	.0550	.0800
14:00	.5422	-.0032	.2841	.2248	-.1804	-.1669	-.1361	-.0916	-.0110	.0588	.0420	.1521
14:05	.0666	-.0004	-.1147	-.1743	-.2265	-.2376	-.2267	-.1975	-.1971	.0602	-.0320	-.0426
14:10	.3536	.0015	.1195	.0175	-.3438	-.2595	-.1758	-.0624	-.1431	.4251	.0966	.1311
14:15	.0314	.0011	-.1763	-.1950	-.1911	-.1916	-.1674	.0192	-.0985	-.0325	.0111	.0718
14:20	.3105	-.0011	.1017	-.0021	.1270	.0056	-.0746	-.1737	-.2574	.0995	-.1291	-.1662
14:25	.0555	.0004	-.0412	-.0437	-.2509	-.2358	-.2493	-.2513	-.2426	.1548	-.0495	-.0763
14:30	.1352	.0005	.0327	-.0480	-.2524	-.3179	-.3627	-.3874	-.3484	-.1611	-.1622	-.0403
14:35	.2172	-.0007	.0488	-.0158	-.2175	-.2316	-.2104	-.1963	-.1390	.1306	-.1588	-.0175
14:40	.1545	-.0013	-.0170	-.0542	-.1507	-.1925	-.2159	-.2440	-.1468	-.0073	-.2080	-.0937
14:45	.0448	.0034	-.2310	-.2166	-.0447	-.1187	-.0975	-.0874	-.0654	.2236	.0465	.1415
14:50	.0464	-.0001	-.1458	-.1402	-.1724	-.1835	-.2030	-.1939	-.1441	.1159	-.2192	.0432
14:55	.0568	.0005	-.1091	-.0684	-.1391	-.1768	-.1968	-.1991	-.2309	-.0739	-.0409	.0020
15:00	.0836	.0005	-.1137	-.0889	-.1253	-.1409	-.1536	-.1626	-.1285	-.0845	.1282	.1474
15:05	.2522	.0004	.0900	.0281	-.0370	-.0845	-.1172	-.1456	-.1644	-.0512	-.1616	-.0567
15:10	.2387	.1849	.0630	.0082	-.0591	-.1295	-.0712	-.0381	-.0240	-.0932	.1591	.0008
15:15	.1929	.0963	.0405	-.0072	-.0730	-.1681	-.0792	-.0797	-.1141	.1125	-.1634	.1406
15:20	.1907	.0016	-.0045	-.0406	-.0785	-.0925	-.0817	-.0668	.0636	-.2076	.0011	.0623
15:25	.1298	.0555	-.0376	-.0957	-.0260	-.0667	-.0972	-.0932	-.0595	.0673	-.0637	-.0197
15:30	.1224	.0779	-.0979	-.0677	-.1180	-.1455	-.1341	-.1333	-.2030	.1771	.0496	-.4438
15:35	.1353	-.0739	-.0643	-.1525	-.2265	-.1781	-.1316	-.0518	-.0992	.2619	.1169	-.0204
15:40	.1500	.0159	.0414	.0653	-.0154	-.0611	-.0967	-.1390	-.1345	-.0505	-.0729	0.0000
15:45	.1136	-.0125	-.0780	-.0892	-.2434	-.2633	-.2363	-.1775	-.1375	.0550	-.0512	-.1256
15:50	.0871	.0606	.0402	-.0386	-.1451	-.1805	-.1508	-.1301	-.0930	.0303	.0141	.0271
15:55	.1396	.0170	.0170	-.0629	.0915	-.0898	-.1313	-.1603	-.0301	-.0117	.0219	-.0156
16:00	.2015	.0916	-.0010	.0159	-.0693	-.0877	-.0994	-.0910	-.0876	.0581	-.0954	.1287
16:05	.1753	.0140	.0478	.0243	-.0779	-.0946	-.1085	-.1040	-.1256	.1538	.0194	.0149
16:10	.0902	.0113	-.0546	-.0936	-.0892	-.1078	-.1139	-.1169	-.1260	.0802	-.0217	-.9864
16:15	.1515	.0820	.0089	-.0845	-.0926	-.0975	-.0853	-.0628	-.0426	.1390	.0523	-.0239
16:20	.1185	-.0047	.0040	-.0616	-.0526	-.0663	-.0739	-.0695	-.2672	.2309	-.0495	-.0137
16:25	.2876	.2128	.1784	.0664	-.0834	-.1615	-.1137	-.0976	-.1969	.1379	.0683	.5896
16:30	.1828	.0835	-.0356	-.1163	-.0343	-.0191	.0043	.0406	.1179	.0969	.0451	-.0677

TABLE I (continued)

MATTEMBERG - SALAZAR HYDROFRACTURE												
FRACTURE-DECEMBER 16, 1975												
TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
12:45	.0258	-.0207	-.0277	.0535	.5496	.5835	.6044	.5151	.3204	.2203	.0710	.0207
12:50	-.3455	-.0994	.1069	.2843	.8920	.8867	.7595	.7113	.4144	.2309	.0096	-.1329
12:55	.0247	.0737	.1503	.2437	.7240	.7517	.8100	.7298	.5171	.4130	.1892	.1752
13:00	231,000 gal.	.0095	.0556	.1417	.2548	.6074	.7500	.7656	.7294	.5180	.4186	.1885
13:05		.0074	.1159	.2523	.3575	.4481	.6160	.7440	.7255	.5720	.5620	.3194
13:10		-.1124	-.1157	.0925	.2093	.4663	.6181	.6387	.6613	.4887	.4311	.2171
13:15		.2301	.3206	.2311	.2917	.5701	.7095	.7058	.7077	.4959	.4140	.1977
13:20		.0240	-.0150	.1959	.2532	.5741	.7518	.7760	.7922	.5812	.5055	.2368
13:25		.0740	.0820	.1402	.2406	.4235	.5915	.6347	.6893	.5316	.5194	.2730
13:30		.0017	.1496	.2398	.3481	1.6901	.6733	.7289	.7409	.5639	.5317	.2887
13:35		.1740	.1468	.2035	.3076	.5376	.6587	.6741	.7098	.4989	.4619	.1940
13:40		-.0795	.0901	.1446	.2693	.7946	.8316	.8365	.7162	.4575	.3653	-.0360
13:45		-.0109	.0913	.1638	.2441	.6005	.7959	.8294	.6187	.5774	.5034	.2335
13:50		.0502	.1832	.2820	.3911	1.0798	.9432	.8554	.7140	.3692	.1758	-.0773
14:00		.0903	.1453	.2250	.3068	.3641	.5500	.7112	.7810	.6631	.7140	.4473
14:05	282,000 gal.	.0601	.1202	.2102	.3020	.6013	.8141	.8432	.8169	.5870	.4949	.2222
14:10		-.0480	.1786	.3436	.4635	.4703	.6575	.7484	.8072	.6508	.6445	.0835
14:15		.1936	.1979	.2138	.3442	-.0059	.7351	.7546	.7077	.4899	.4014	.1758
14:20		-.2037	-.0898	-.0233	.0585	.6877	.7173	.7925	.8327	.6604	.6515	.3687
14:25		-.1478	.3484	.1713	.3018	.5515	.6091	.6082	.5608	.4163	.3398	.1453
14:30		.1337	.1003	.1731	.2931	.4796	.6043	.6560	.5307	.4502	.4068	.1951
14:35		-.1054	.0594	.1986	.3205	0.0000	.7832	.8080	.8123	.6065	.5299	.2807
14:40		-.1190	.0169	.1426	.2526	.5450	.6435	.6683	.6901	.5092	.4376	.2208
14:45	Stop pumping	.1653	.1654	.2774	.3333	.7053	.7279	.7186	.6607	.4493	.2998	.0940
14:50		.1534	.1512	.2285	.3351	.4187	.7071	.5892	.6918	.4828	.3680	.1675
14:55	Total Volume-312,000 gal.	.1236	.1105	.1676	.2968	.7764	.7258	.7215	.6932	.4764	.3772	.1221
15:00		.2593	.2150	.1990	.3159	.9612	.9139	.8522	.8343	.5800	.4563	.2026
15:05		.1108	.1135	.1850	.2999	.7659	.8655	.9427	.9223	.6981	.6448	.3519
15:10		.3558	.2754	.2715	.3227	.6848	.8151	.8044	.8920	.6469	.5763	.3015
15:15		.0736	-.0581	.2232	.3696	.6637	.8220	.9156	.8283	.5985	.5037	.2619
15:20		.5015	.3154	.2724	.3892	.6105	.7935	.8945	.8087	.5863	.5174	.2683
15:25		.0789	.1208	.2210	.3378	.8278	.8469	.8057	.8086	.5820	.4893	.2353
15:30		.0405	.1259	.3061	.3927	.7230	.8031	.8291	.7865	.5644	.4798	.2186
15:35		.1361	.1332	.3394	.4748	.5759	.8095	.8768	.8414	.6132	.5156	.2408
15:40		.1152	.0950	.1793	.2876	.8354	.7445	.7427	.7460	.5409	.4687	.2391
15:45		.1985	.2534	.3363	.4776	.8976	.8231	.8226	.7973	.5651	.4893	.2182
15:50		.1178	.2255	.2632	.4028	.6332	.8020	.8146	.7994	.5536	.4808	.2206
15:55		.1743	.3698	.2530	.3566	.7889	.8114	.8228	.8114	.5355	.5146	.2392
16:00		.0616	.1414	.2242	.3472	.6521	.8123	.8413	.8256	.6144	.5477	.2714
16:05		-.0124	.1155	.2179	.3547	.6476	.7870	.7965	.7945	.5835	.5085	.2705
16:10		.1029	.1920	.2382	.2898	.7403	.8605	.8125	.7809	.5444	.4489	.2148
16:15		.1111	.1017	.2527	.3694	.5783	.8127	.8339	.8067	.5883	.5087	.2563
16:20		-.3582	-.0015	.1934	.3405	.9383	.8236	.8304	.8057	.5738	.4827	.2330
16:25		-.1835	.0198	.2248	.3522	.6512	.7772	.8350	.8515	.6514	.5986	.3421
16:30		.2251	.2205	.2972	.3663	.4091	.8208	.8200	.8113	.6310	.5375	.4659

APPENDIX E

TABLE I

WATTENBERG - UPRR22 HYDROFRACTURE

BACKGROUND-JANUARY 26, 1976

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
11:51	.8393	.3726	-.3030	-.0886	-.2196	-.3640	-.3634	-.4437	-.5255	-.4819	-.4309	-.4748
11:53	.8506	.3353	.0249	-.1524	-.2764	-.3753	-.4499	-.4678	-.5297	-.4731	-.5103	-.4466
11:55	.8560	.3576	.0597	-.0769	-.1973	-.3170	-.3645	-.4167	-.4942	-.4553	-.4926	-.4673
11:57	.9136	.4588	.0618	-.1334	-.2743	-.4130	-.4439	-.4870	-.5512	-.4893	-.5196	-.4710
11:59	.8333	.3473	.0352	-.1479	-.2842	-.3758	-.4476	-.4853	-.5531	-.4480	-.5043	-.4763
12:03	-.0966	-.0798	-.0707	.0392	.1625	.4513	.9162	1.5829	2.6863	2.4160	1.9847	1.1255
12:05	-.6028	-.5278	-.3280	-.1291	.1670	.5974	1.2148	1.9901	2.5906	2.9599	2.5868	1.7015
12:07	-.5041	-.4010	-.2637	-.1065	.1633	.5289	1.1406	1.9171	2.4831	2.8405	2.4583	1.5774
12:08	-.4060	-.3032	-.1420	-.0966	.1518	.5324	1.1006	1.8508	2.4257	2.7861	2.4227	1.5208
12:10	-.4296	-.3687	-.2528	-.0604	.2249	.5541	1.0616	1.7816	2.3182	2.6547	2.2432	1.3656
12:22	-1.3811	-.8151	-.3520	.0133	.3976	.8482	1.5015	2.2597	2.9403	3.2481	2.8689	1.9749
12:24	-1.3953	-.8459	-.3775	.0184	.3885	.8733	1.4723	2.2537	2.8323	3.1928	2.8344	1.9245
12:26	-1.3569	-.7407	-.3459	.0104	.3835	.8757	1.5310	2.3313	2.9778	3.2909	2.9061	2.0115
12:28	-1.3371	-.7726	-.3126	-.0294	.3532	.8350	1.4806	2.2812	2.9379	3.2598	2.8533	2.0018
12:29	-1.3959	-.8266	-.3806	-.0259	.3374	.8202	1.4442	2.2386	2.8860	3.2077	2.8389	1.9515
13:00	.1992	-.0127	-.1456	-.1171	-.0735	-.0411	.3093	.6695	.9199	1.1285	.9135	.5111
13:05	.3061	.0980	-.0370	-.1043	-.0476	-.0828	.2977	.6507	.8953	1.1028	.9294	.4821
13:10	.2763	.0753	-.0054	-.0985	-.0486	-.0815	.3087	.6505	.8883	1.0891	.8692	.4564
13:15	.2050	-.0002	-.0852	-.0963	-.0579	-.0597	.2519	.5919	.8240	1.0296	.8291	.4175
13:20	.2660	.0346	-.1002	-.0793	-.0688	-.0763	.2865	.6246	.8586	1.0570	.8393	.4255
13:25	.1439	-.0475	-.1197	-.1082	-.0683	-.0620	.3012	.6222	.8994	1.1040	.9001	.4873
13:30	.2157	.0138	-.0444	-.1016	-.0565	-.0585	.2843	.6269	.8714	1.0779	.8654	.4538
13:35	.2260	.0074	-.0844	-.0796	-.0113	-.1133	.3640	.7164	.9714	1.1709	.9614	.5410
13:40	.0772	-.1195	-.1714	-.0791	-.0441	-.1312	.3311	.6397	.8752	1.0741	.8683	.4417
13:45	.2094	.0138	-.0565	-.0685	-.0306	-.0940	.3163	.6548	.8921	1.0862	.9180	.4506
13:50	.1727	-.0200	-.1104	-.0852	-.0424	-.0734	.3249	.6665	.9094	1.1087	.9032	.4714
13:55	.2550	.0486	-.0500	-.1266	-.0445	-.1535	.3800	.7558	1.0170	1.2218	1.0266	.5994
14:00	.2035	-.0128	-.1050	-.0786	-.0579	-.0839	.2890	.6280	.8573	1.0569	.8568	.4236

TABLE I (continued)

WATTENBERG - UPRR22 HYDROFRACTURE

BACKGROUND-JANUARY 26, 1976

TIME	0°	15°	30°	45°	65°	75°	90°	105°	120°	135°	150°	165°
14:05	.2036	.0076	-.0844	-.1023	-.0814	.1070	.3215	.6769	.9198	1.1220	.9191	.4988
14:10	.2353	.0283	-.0732	-.1174	-.0776	.1123	.3383	.7071	.9545	1.1592	.9923	.5378
14:15	.2162	.0107	-.0794	-.1325	-.0869	.0752	.3484	.7169	.9797	1.1913	.9949	.5753
14:20	.2244	.0371	-.0145	-.0791	-.0632	.0714	.3207	.6623	.9037	1.1001	.9048	.4661
14:25	.2881	.1078	.0032	-.1356	-.0641	.0764	.3399	.7077	.9659	1.1730	.9761	.5552
14:30	.0566	-.1247	-.1725	-.1464	-.0569	.1205	.4089	.7934	1.0593	1.2778	1.1000	.6577
14:35	.2581	.0567	-.0330	-.1142	-.0310	.0392	.2734	.6206	.8697	1.0748	.8625	.4645
14:40	.2440	.0326	-.0866	-.0932	-.0711	.0589	.3015	.6475	.8913	1.0918	.8843	.4699
14:45	.2452	.0184	-.1021	-.0924	-.0337	.0532	.3438	.6978	.9436	1.1403	.9407	.5100
14:50	.2227	-.0077	-.1038	-.1235	-.0744	.0810	.2875	.6452	.8983	1.1068	.9341	.5065
14:55	.2209	.0187	-.0784	-.1245	-.0487	.0892	.3310	.6944	.9498	1.1623	.9696	.5459
15:00	.2455	.0362	-.0470	-.1030	-.0608	.0762	.3047	.6586	.9036	1.1051	.8973	.4832
15:05	.2805	.0691	-.0259	-.1540	-.0890	-.0670	.2659	.6249	.8794	1.0904	.8936	.4874
15:10	.2640	.0500	-.0614	-.0870	-.0497	.0703	.3245	.6712	.9119	1.1062	.9081	.4779
15:15	.1416	-.0651	-.1333	-.1422	-.0671	.0448	.3314	.7073	.9679	1.1763	.9782	.5573
15:20	.2039	.0005	-.0714	-.1065	-.0703	.0344	.3002	.6450	.8913	1.0934	.8925	.4702
15:25	.1617	-.0482	-.1014	-.1359	-.0664	.0599	.3371	.7031	.9619	1.1714	.9674	.5582
15:30	.2144	.0249	-.1231	-.1001	-.0438	.0316	.0796	.6864	.9351	1.1394	.4507	.5131
15:35	.2374	.0142	-.1105	-.0860	-.0515	.0713	.3014	.6417	.8801	1.0820	.8683	.4577
15:40	.2149	.0092	-.0632	-.1386	-.0837	.0502	.2943	.6513	.9083	1.1179	.9348	.5077
15:50	.1700	.0277	-.1082	-.1142	-.0525	.1005	.3282	.6811	.9372	1.1437	.9385	.5171
15:55	.2410	.0387	-.0612	-.1026	-.0511	.0924	.3253	.6797	.9279	1.1345	.9158	.5056
16:00	.2220	.0133	-.0683	-.1353	-.0533	.0670	.3340	.6848	.9412	1.1498	.9213	.5259
16:05	.2351	.0299	-.0518	-.0874	-.0393	.1102	.3383	.6944	.9426	1.1491	.9519	.5343
16:10	.1881	-.0202	-.1077	-.1101	-.0584	.0716	.3268	.6930	.9290	1.1307	.9369	.5117
16:15	.2052	-.0032	-.1233	-.1227	-.0698	.0563	.3175	.6760	.9250	1.1341	.9308	.5076
16:20	.2045	-.0052	-.0910	-.1113	-.0636	.0283	.3177	.6735	.9202	1.1268	.9690	.5015

TABLE I (continued)

WATTENBERG - UPRR22 HYDROFRACTURE

BACKGROUND-JANUARY 26, 1975

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
11:51	-.4458	-.3931	.3541	-.1816	.0502	.4076	.9027	1.6937	2.5087	2.8995	2.1898	1.5285
11:53	-.4039	-.3462	-.3168	-.0819	.1318	.4673	1.0549	1.8220	2.6851	3.0650	2.4067	1.5557
11:55	-.4491	-.4050	-.2448	-.1199	.1095	.4834	1.0122	1.7847	2.6278	3.3138	2.3959	1.5553
11:57	-.4343	-.3654	-.2086	-.0517	.1894	.5573	1.1554	1.9383	2.9659	3.3262	2.5195	1.6295
11:58	-.4985	-.3774	-.1741	-.1521	.0742	.4519	.9437	1.7220	2.5131	2.9054	2.3482	1.5238
12:03	.4477	.0279	-.1975	-.3520	-.3688	-.3775	-.3286	-.3105	-.3314	-.2944	-.1814	-.1245
12:05	.9631	.4686	.0686	-.0291	-.2105	-.3865	-.4487	-.5106	-.4983	-.5715	-.6131	-.6557
12:07	.8608	.3754	-.0030	-.1538	-.2758	-.4273	-.4675	-.5134	-.4917	-.5425	-.5696	-.5470
12:08	.8079	.3383	.0049	-.2482	-.3882	-.4872	-.5224	-.5518	-.5185	-.5417	-.5844	-.4678
12:10	.6478	.2005	-.0631	-.2692	-.3147	-.3958	-.4448	-.4858	-.5626	-.5745	-.4936	-.4679
12:22	1.2364	.7151	.1917	.0040	-.3762	-.8768	-1.4949	-2.2984	-3.1172	-3.5533	-2.9633	-2.1261
12:24	1.1932	.5789	.1900	.0361	-.3382	-.8451	-1.4654	-2.2822	-3.1630	-3.5961	-2.9649	-2.1378
12:26	1.2656	.7370	.2252	-.0162	-.3714	-.8763	-1.4862	-2.2957	-3.1589	-3.5832	-2.9445	-2.3977
12:28	1.2689	.7522	.2342	-.0373	-.3936	-.8778	-1.4805	-2.2889	-3.1623	-3.5771	-2.9154	-2.0765
12:29	1.2236	.7202	.2274	.0366	-.3766	-.8661	-1.4909	-2.3096	-3.1763	-3.6103	-2.9792	-2.1346
13:00	.1768	-.0211	-.1394	-.1276	-.0795	.0593	.3033	.6569	1.0532	1.2214	.9292	.5212
13:05	.1477	-.0466	-.1187	-.2453	-.1331	.0351	.2978	.6610	1.0912	1.2914	1.3110	.6375
13:10	.1226	-.0778	-.1244	-.2394	-.1791	-.0253	.2413	.6084	1.0118	1.2103	.9640	.5837
13:15	.0914	-.0883	-.1409	-.1764	-.1179	.0177	.2594	.6142	.9952	1.1844	.9266	.5278
13:20	.0889	-.1040	-.2360	-.1385	-.0533	.1171	.3575	.7383	1.1754	1.3524	1.0191	.6006
13:25	.1528	-.0437	-.1232	-.1554	-.1181	-.0122	.2279	.5667	.9453	1.1115	.8417	.4490
13:30	.1305	-.0594	-.1318	-.1725	-.1121	.0215	.2623	.6268	1.0656	1.2416	.9386	.5283
13:35	.1971	-.0045	-.0753	-.0746	.0504	.1317	.3778	.7741	1.3292	1.4668	1.3148	.5661
13:40	.1101	-.0839	-.1644	-.1815	-.0722	.0304	.2384	.5577	.9057	1.0582	.8022	.3843
13:45	.1056	-.0927	-.1642	-.1962	-.1255	.0098	.2547	.6155	1.0513	1.2294	.9299	.5290
13:50	.1335	-.0692	-.1481	-.1562	-.1101	.0075	.2494	.6060	1.0254	1.1979	.8924	.4902
13:55	.2486	.0323	-.0587	-.2136	-.1440	.0128	.2633	.6224	1.0293	1.2203	.9608	.5691
14:00	.0846	-.1020	-.1705	-.1323	-.0652	.0693	.3137	.6786	1.1128	1.2812	.9592	.5319

TABLE I (continued)

WATTENBERG - UPRR22 HYDROFRACTURE

BACKGROUND - JANUARY 26, 1976

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
14:05	.1594	-.0396	-.0995	-.1898	-.1321	.0034	.2511	.5963	.9876	1.1709	.9139	.5176
14:10	.1917	-.0126	-.0914	-.1659	-.1020	.0415	.2906	.6669	1.1243	1.2963	.9660	.5588
14:15	.2330	.0255	-.0577	-.1766	-.1144	.0119	.2659	.6247	1.0381	1.2180	.9375	.5290
14:20	.1316	-.0606	-.1306	-.2195	-.1597	-.0221	.2237	.5868	1.0228	1.2152	.9322	.5352
14:25	.2128	.0031	-.0923	-.2825	-.2089	-.0612	.2067	.5850	1.0181	1.2250	.9562	.5963
14:30	.2985	.0705	-.0679	-.1157	-.0981	-.0119	.1935	.5142	.9010	1.0517	.7646	.3590
14:35	.1394	-.0470	-.1169	-.2352	-.1662	-.0122	.2479	.6086	.9880	1.1923	.9662	.5771
14:40	.1359	-.0510	-.1242	-.1763	-.1029	.0522	.3121	.6691	1.0549	1.2359	.9728	.5737
14:45	.1637	-.0434	-.1072	-.1488	-.0653	.0831	.3474	.7054	1.0812	1.2628	.9933	.5799
14:50	.1728	-.0157	-.1331	-.1354	-.0729	.0650	.3160	.6749	1.0751	1.2698	.9865	.5528
14:55	.2165	.0114	-.0859	-.1970	-.1431	.0884	.2567	.6108	.9845	1.1790	.9303	.5377
15:00	.1478	-.0514	-.1043	-.1649	-.0958	.0569	.3118	.6917	1.1539	1.3305	.9925	.5717
15:05	.1612	-.0303	-.1155	-.1936	-.1127	.0415	.3127	.6864	1.1287	1.3222	1.0319	.6121
15:10	.1391	-.0620	-.1231	-.1794	-.1093	.0419	.3162	.6770	1.0748	1.2624	.9938	.5855
15:15	.2232	.0152	-.1690	-.1175	-.0697	.0411	.2708	.6166	1.0294	1.1907	.8787	.4569
15:20	.1364	-.0607	-.1158	-.1671	-.1065	.0277	.2738	.6278	1.0476	1.2242	.9376	.5205
15:25	.2177	.0124	-.0938	-.1760	-.1292	-.0202	.2224	.5536	.9257	1.1017	.8585	.4573
15:30	.1698	-.0332	-.0950	-.2251	-.1621	-.0252	.2124	.5656	.9260	1.1191	.8778	.5207
15:35	.1235	-.0723	-.1352	-.1651	-.0833	.0538	.3165	.6780	1.0550	1.2375	.9687	.5582
15:40	.1747	-.0212	-.0885	-.1717	-.1101	.0227	.2759	.6354	1.0387	1.2208	.9456	.5346
15:50	.1752	-.0316	-.1328	-.2410	-.1932	-.0352	.2029	.4966	.6770	.8906	.8368	.4774
15:55	.1581	-.0400	-.1268	-.2635	-.1327	.0092	.2666	.6299	1.0288	1.2157	.9503	.5557
16:00	.1855	-.0152	-.0527	-.1644	-.0989	.0356	.2855	.6541	1.1057	1.2851	.9576	.5416
16:05	.2019	.0107	-.0383	-.1757	-.1623	.0300	.2889	.6551	1.0865	1.2725	.9685	.5577
16:10	.1740	-.0302	-.1045	-.1671	-.1156	.0157	.2618	.5990	.9680	1.1502	.9032	.4973
16:15	.1659	-.0385	-.1236	-.2072	-.1468	-.0674	.2433	.5860	.9226	1.1251	.9174	.5148
16:20	.4929	.3070	-.1000	-.1779	-.1052	.0293	.2755	.6241	1.0283	1.2043	.9309	.5183

TABLE II

WATTEYBERG - UPRR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1976

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	
7:00	.2206	.0153	-.0090	-.1121	-.0611	.0715	.3221	.6749	.9223	1.1283	.9358	.5101	
7:03	.2518	.0379	-.0591	-.0735	-.0529	.0761	.3104	.6543	.8851	1.0856	.8879	.5101	
7:05	.2423	.0425	-.0499	-.0805	-.0372	.0895	.3455	.6989	.9473	1.1525	.9644	.5101	
7:10	.2172	.0057	-.0310	-.1211	-.0644	.0680	.3137	.6641	.9072	1.1124	.9194	.5101	
7:15	.2460	.0317	-.0598	-.0658	-.0376	.0300	.3319	.6794	.9186	1.1153	.9230	.5101	
7:20	.2109	.0056	-.0349	-.0992	-.0458	.0792	.3180	.6660	.9050	1.1065	.9150	.5101	
7:25	.1849	-.0157	-.0930	-.1237	-.0811	.0596	.3066	.6577	.9064	1.1118	.9236	.5620	
7:30	.2083	.0071	-.0919	-.1198	-.1019	.0537	.2959	.6448	.8915	1.0983	.9112	.5102	
7:35	.2048	-.0057	-.1106	-.1123	-.0548	.0815	.3300	.6826	.9271	1.1282	.9371	.5215	
7:45	.2199	.0216	-.0802	-.0851	-.0303	.0919	.3248	.6614	.9010	1.0967	.8959	.4712	
7:48	.2191	.0098	-.0885	-.1311	-.0776	.0628	.3117	.6631	.9160	1.1233	.9270	.5215	
7:50	.2346	.0234	-.0559	-.1673	-.1097	.0415	.3004	.6705	.9326	1.1485	.9744	.5669	
7:55	.1859	.0254	-.1073	-.1503	-.0990	.0674	.3029	.6598	.9118	1.1210	.9333	.5145	
8:00	.2245	.0186	-.0612	-.1060	-.0528	.0732	.3231	.6645	.9099	1.1094	.9265	.5008	
8:05	.2146	.0084	-.0949	-.1191	-.0786	.0550	.3089	.6646	.9198	1.1217	.9377	.5218	
8:10	.2280	.0172	-.0673	-.1005	-.0582	.0715	.3076	.6473	.8884	1.0885	.8940	.4756	
8:15	.1761	-.0281	-.1065	-.1304	-.0713	.0599	.3238	.6771	.9339	1.1394	.9568	.5354	
8:20	.2645	.0532	-.0758	-.1274	-.0676	.0568	.3028	.6510	.9023	1.1054	.9149	.5028	
8:25	.2093	-.0097	-.0923	-.1099	-.0632	.0700	.3121	.6554	.8995	1.0988	.9150	.4904	
8:30	.2327	.0173	-.0740	-.1203	-.0628	.0605	.3205	.6660	.9137	1.1173	.9281	.5097	
8:35	.2801	.0719	-.0375	-.1397	-.0822	.0546	.3104	.6528	.9069	1.1103	.9189	.4915	
8:40	Start pumping	.2228	.0175	-.0712	-.1097	-.0712	.0774	.3226	.6679	.9135	1.1160	.9278	.5063
8:45		.1805	-.0224	-.1028	-.1095	-.0485	.0748	.3230	.6644	.9099	1.1050	.9190	.4906
8:50		.2130	.0160	-.0773	-.0922	-.0377	.0336	.3427	.6931	.9406	1.1402	.9529	.5247
8:55		.2169	.0070	-.0806	-.1055	-.0619	.0818	.3313	.6799	.9275	1.1270	.9453	.5182
9:00		.1975	-.0040	-.0929	-.0739	-.0384	.0985	.3401	.6801	.9197	1.1102	.9202	.4933
9:05		.2040	.0001	-.0888	-.1081	-.0740	.0773	.3291	.6753	.9275	1.1248	.9374	.5101
9:10		.2146	.0053	-.0812	-.1038	-.0730	.0830	.3314	.6782	.9299	1.1315	.9423	.5195
9:13		.2146	.0062	-.0773	-.1359	-.0760	.0705	.3296	.6866	.9446	1.1495	.9738	.5505
9:16		.1734	-.0213	-.1014	-.0800	-.0350	.0371	.3347	.6761	.9172	1.1106	.9180	.4871
9:19		.2073	.0054	-.0600	-.0745	-.0492	.1039	.3424	.6815	.9207	1.1093	.9141	.4840
9:22		.2532	.0450	-.0486	-.1136	-.0836	.0514	.2987	.6410	.8925	1.0919	.9070	.4827
9:25		.2177	.0164	-.0654	-.1313	-.1017	.0634	.3183	.6712	.9258	1.1276	.9413	.5176
9:28		.1818	-.0220	-.0987	-.0839	-.0641	.0875	.3311	.6686	.9114	1.1025	.9081	.4751
9:30		.2279	.0058	-.0776	-.1306	-.0725	.0590	.3241	.6796	.9326	1.1327	.9494	.5212
9:33		.2431	.0386	-.0515	-.1141	-.0693	.0756	.3330	.6841	.9353	1.1392	.9535	.5204
9:36		.1797	-.0203	-.0981	-.1161	-.0635	.0734	.3315	.6846	.9382	1.1395	.9573	.5302
9:39	55,000 gal.	.2105	.0045	-.0740	-.1204	-.0782	.0691	.3226	.6722	.9258	1.1273	.9433	.5177
9:42		.2086	-.0009	-.0793	-.1052	-.0526	.0829	.3305	.6791	.9300	1.1317	.9428	.5181
9:45		.1737	-.0339	-.0986	-.1373	-.0686	.0708	.3353	.6980	.9525	1.1566	.9718	.5426

TABLE II (continued)

WATTENBERG - UPRR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1976

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
9:48	.2112	.0113	-.0659	-.1533	-.0916	.0560	.3143	.6773	.9383	1.1433	.9685	.5476
9:51	.2025	-.0045	-.0926	-.0932	-.0368	.0959	.3441	.6898	.9321	1.1323	.9384	.5093
9:54	.1991	-.0062	-.0804	-.1248	-.0632	.0572	.3289	.6827	.9350	1.1404	.9551	.5294
9:57	.2375	.0329	-.0499	-.1086	-.0849	.0885	.3375	.6870	.9429	1.1412	.9559	.5269
10:00	.1659	-.0432	-.1152	-.0911	-.0463	.0797	.3218	.6614	.9034	1.1015	.9090	.4687
10:03	.2180	.0126	-.0705	-.1082	-.0620	.0740	.3279	.6757	.9273	1.1270	.9465	.5112
10:06	.2075	.0043	-.0752	-.1210	-.0693	.0684	.3245	.6625	.9348	1.1409	.9588	.5283
10:09	.1844	-.0055	-.0907	-.0949	-.0539	.0725	.3261	.6675	.9162	1.1151	.9254	.4918
10:12	.1947	-.0054	-.0840	-.1019	-.0535	.0708	.3174	.6601	.9033	1.1004	.9145	.4830
10:15	.2247	.0171	-.0614	-.1090	-.0619	.0663	.3114	.6548	.9054	1.1036	.9156	.4869
10:18	.1971	-.0119	-.0800	-.1185	-.0655	.0814	.3204	.6733	.9209	1.1219	.9342	.5095
10:21	.1962	-.0073	-.0742	-.1309	-.0715	.0710	.3241	.6792	.9354	1.1339	.9532	.5282
10:24	.2078	.0057	-.0751	-.1222	-.0696	.0580	.3209	.6735	.9242	1.1282	.9425	.5128
10:27	.1980	-.0120	-.0843	-.1135	-.0605	.0789	.3301	.6821	.9331	1.1331	.9494	.5160
10:30	.1751	-.0347	-.1010	-.0897	-.0639	.0818	.3286	.6735	.9141	1.1134	.9175	.4842
10:33	.1761	-.0128	-.0633	-.0912	-.0487	.0737	.3202	.6635	.9054	1.1013	.9119	.4783
10:36	.1807	-.0157	-.0636	-.1270	-.0642	.0701	.3274	.6781	.9235	1.1334	.9474	.5175
10:39 103,000 gal.	.1998	-.0147	-.0852	-.1169	-.0638	.0696	.3211	.6777	.9245	1.1168	.9575	.5137
10:42	.1949	-.0058	-.0844	-.1128	-.0631	.0666	.3270	.6761	.9270	1.1295	.9401	.5154
10:45	.1947	-.0126	-.0865	-.1373	-.0757	.0694	.3344	.6924	.9533	1.1556	.9651	.5501
10:48	.2092	.0003	-.0747	-.1223	-.0664	.0649	.3256	.6745	.9373	1.1372	.9570	.5252
10:51	.2082	.0029	-.0654	-.1258	-.0677	.0762	.3359	.6961	.9466	1.1514	.9730	.5414
10:54	.2189	.0124	-.0557	-.1259	-.0559	.0746	.3314	.6869	.9461	1.1455	.9670	.5345
10:57	.1953	-.0033	-.0785	-.1168	-.0667	.0733	.3292	.6867	.9383	1.1335	.9524	.5223
11:00	.1955	-.0098	-.0753	-.1104	-.0562	.0700	.3437	.6950	.9534	1.1520	.9648	.5366
11:03	.2041	.0058	-.0689	-.1165	-.0723	.0816	.3336	.6928	.9445	1.1480	.9582	.5289
11:06	.2090	.0035	-.0571	-.1179	-.0660	.0829	.3274	.6764	.9320	1.1381	.9454	.5148
11:09	.2224	.0213	-.0528	-.1053	-.0491	.0870	.3410	.6906	.9337	1.1398	.9515	.5175
11:12	.1828	-.0150	-.0636	-.1225	-.0490	.0717	.3289	.6788	.9360	1.1395	.9554	.5305
11:15	.2102	.0049	-.0631	-.1036	-.0562	.0930	.3439	.6915	.9501	1.1519	.9761	.5303
11:18	.1889	-.0082	-.0840	-.1242	-.0707	.0684	.3255	.6800	.9305	1.1420	.9714	.5274
11:21	.1918	-.0034	-.0807	-.1143	-.0592	.0739	.3302	.6970	.9335	1.1387	.9525	.5240
11:24	.2080	.0124	-.0520	-.1056	-.0550	.0814	.3318	.6864	.9366	1.1328	.9551	.5121
11:27	.2174	.0081	-.0744	-.1188	-.0601	.0723	.3401	.7004	.9545	1.1626	.9699	.5449
11:30	.2155	.0054	-.0559	-.1123	-.0657	.0801	.3366	.6779	.9381	1.1356	.9439	.5228
11:33	.2444	.0527	-.0338	-.0983	-.0490	.0958	.3305	.6759	.9217	1.1225	.9465	.4962
11:36	.2332	.0150	-.0525	-.1159	-.0552	.0761	.3153	.6633	.9183	1.1136	.9298	.4996
11:39 148,000 gal.	.1650	-.0277	-.0943	-.0936	-.0339	.0721	.3272	.6656	.9168	1.1127	.9150	.4823
11:42	.2120	.0145	-.0581	-.1570	-.0806	.0720	.3431	.7116	.9849	1.1881	2.1563	.42738
11:54	.2354	.0336	-.0347	-.1099	-.0517	.0653	.3241	.6753	.9272	1.1268	.9395	.5133

TABLE II (continued)

WATTENBERG - UPRR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1976

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	160°
11:57	.2153	.0071	-.0635	-.1473	-.0997	.0691	.3396	.7032	.9677	1.1789	.9938	.5735
12:03	.1981	-.0430	-.0306	-.1099	-.0488	.0852	.3403	.6949	.9463	1.1537	.9734	.5330
12:08	.2184	.0128	-.0437	-.1026	-.0716	.1052	.3418	.6909	.9460	1.1450	.9582	.5153
12:10	.1899	-.0103	-.0559	-.0959	-.0498	.1257	.3241	.6726	.9223	1.1152	.9125	.4938
12:15	.1857	-.0194	-.0738	-.1188	-.0632	.0607	.3437	.7024	.9555	1.1560	.9631	.5337
12:18	.1943	-.0157	-.1134	-.1110	-.0559	.0950	.3490	.7050	.9656	1.1617	.9686	.5411
12:21	.2247	.0192	-.0333	-.0723	-.0377	.0885	.3282	.6712	.9088	1.0988	.9218	.4603
12:24	.2259	.0159	-.0445	-.1024	-.0463	.1258	.3582	.7056	.9672	1.1595	.9682	.5325
12:27	.1952	-.0084	-.0689	-.1111	-.0591	.0579	.3333	.6791	.9397	1.1340	.9577	.5161
12:30	.2170	.0082	-.0587	-.1130	-.0556	.0889	.3408	.6931	.9538	1.1548	.9626	.5264
12:33	.1854	-.0029	-.0318	-.1093	-.0549	.0842	.3493	.6910	.9573	1.1567	1.0104	.5363
12:36	.1985	-.0102	-.0637	-.1151	-.0574	.1238	.3434	.7028	.9555	1.1534	.9571	.5331
12:39	.2152	.0150	-.0568	-.1071	-.0710	.0747	.3434	.6958	.9517	1.1518	.9719	.5297
12:42	.2027	-.0010	-.0435	-.0998	-.0527	.1398	.3426	.7002	.9514	1.1491	.9516	.5260
12:45	.2149	.0103	-.0438	-.1058	-.0734	.1394	.3391	.6917	.9450	1.1441	.9387	.5200
12:48	.2060	-.0012	-.0534	-.1206	-.0512	.0458	.3343	.6903	.9456	1.1480	.9366	.5222
12:51	.1941	-.0382	-.0550	-.1085	-.0507	.1040	.3412	.6957	.9528	1.1513	.9960	.5285
12:54	.2168	.0138	-.0451	-.1195	-.0553	.1254	.3312	.6920	.9439	1.1457	.9577	.5284
12:57	.4051	.6547	.0833	-.1089	-.0549	.0965	.3518	.6999	.9675	1.1700	.9824	.5466
13:00	.2254	.0222	-.0455	-.0959	-.0405	.0694	.3516	.7009	.9543	1.1495	.9585	.5191
13:05	.1995	-.0015	-.0315	-.1029	-.0419	.1140	.3471	.7017	.9570	1.1580	.9455	.5374
13:08	.2045	.0033	-.0482	-.1119	-.0564	.0960	.3362	.6813	.9442	1.1472	.9624	.5205
13:15	.2248	.0173	-.0377	-.1029	-.0308	.0982	.3456	.7098	.9609	1.1593	.9835	.5288
13:18	.2197	.0177	-.0299	-.0966	-.0729	.0851	.3398	.6905	.9444	1.1454	.9209	.5228
13:21	.2227	.0178	-.0454	-.1007	-.0395	.0956	.3602	.7142	.9717	1.1737	.9691	.5443
13:24	.1944	-.0050	-.0443	-.1105	-.0612	.0884	.3393	.6976	.9541	1.1572	.9538	.5313
13:30	.2175	.0083	-.0682	-.1168	-.0482	.0916	.3533	.7191	.9718	1.1735	.9925	.5514
13:33	.1678	-.0232	-.0473	-.1159	-.0664	.0487	.3233	.6708	.9304	1.1401	.9583	.5151
13:36	.2385	.0291	-.0128	-.1035	-.0554	.0784	.3329	.6823	.9386	1.1382	.9270	.5137
13:39	.2137	.0017	-.0498	-.1137	-.0574	.0809	.3485	.6990	.9078	1.1069	.9769	.5407
13:42	.2161	.0054	-.0553	-.1154	-.0639	.0688	.3387	.6899	.9508	1.1552	.9617	.5278
13:45	.2197	.0076	-.0266	-.1152	-.0615	.0584	.3318	.6940	.9417	1.1407	.9446	.5126
13:51	.2140	.0077	-.0516	-.0909	-.0422	.0876	.3386	.6871	.9339	1.1300	.9416	.4964
13:54	.2151	-.0059	-.0255	-.1254	-.0686	.0882	.3311	.6901	.9458	1.1524	.9657	.5266
14:00	.2048	.0050	-.0530	-.1118	-.0600	.0775	.3386	.6948	.9550	1.1570	.9634	.5299
14:03	.1944	-.0059	-.0620	-.1117	-.0435	.0645	.3384	.6943	.9527	1.1562	.9560	.5255
14:06	.2094	.0043	-.0349	-.1135	-.0630	.0725	.3310	.6785	.9414	1.1437	.9556	.5136
14:09	.1912	-.0101	-.0544	-.1123	-.0551	.0879	.3346	.6935	.9524	1.1515	.9468	.5232
14:15	.2013	-.0053	-.0479	-.1223	-.0751	.0684	.3268	.6846	.9407	1.1454	.9463	.5153
14:18	.2351	.0408	-.0240	-.1069	-.0585	.0728	.3272	.6887	.9348	1.1351	.9428	.5059

TABLE II (continued)

WATTENBERG - UPRR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1976

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
14121	.2109	.0174	-.0334	-.1365	-.0855	.0263	.3165	.6729	.9351	1.1406	.9300	.5156
14124	.2003	-.0039	-.0563	-.1180	-.0631	.0851	.3447	.7069	.9675	1.1666	.9706	.5404
14127	.2060	-.0059	-.0532	-.1011	-.0505	.0968	.3555	.7175	.9753	1.1852	1.0043	.5536
14130	.2188	.0034	-.0458	-.0781	-.0349	.1144	.3577	.7162	.9701	1.1728	.9875	.5430
14133	.1865	-.0154	-.0530	-.1135	-.0615	.0652	.3383	.7010	.9588	1.1652	.9689	.5354
14136	.1773	-.0220	-.0503	-.1232	-.0632	.0811	.3517	.7244	.9779	1.1839	.9812	.5554
14139	.1719	-.0332	-.0748	-.1391	-.0831	.0713	.3238	.6914	.9479	1.1575	.9733	.5319
14142	.1848	-.0110	-.0634	-.1259	-.0661	.0885	.3436	.7122	.9748	1.1849	.9955	.5532
14145	.2280	.0192	-.0351	-.1066	-.0669	.0556	.3138	.6710	.9228	1.1291	.9257	.4972
14148	.2225	.0154	-.0232	-.1222	-.0676	.0577	.3297	.6943	.9467	1.1528	.9544	.5243
14151	.2289	.0200	-.0418	-.1194	-.0623	.0849	.3330	.6912	.9453	1.1507	.9519	.5243
14154	.1373	-.0065	-.0558	-.1112	-.0600	.0396	.3432	.6995	.9557	1.1625	.9661	.5333
14157	.2115	.0078	-.0471	-.1073	-.0558	.1089	.3338	.6969	.9462	1.1465	.9459	.5169
15100	.2187	.0134	-.0363	-.1181	-.0628	.1008	.3350	.6855	.9479	1.1546	.9523	.5309
15106	.1765	-.0181	-.0564	-.1282	-.0784	.0428	.3216	.6848	.9387	1.1463	.9515	.5264
15109	.1891	-.0098	-.0626	-.1266	-.0817	.0640	.3259	.6863	.9423	1.1511	.9617	.5198
15112	.2139	.0050	-.0531	-.1164	-.0654	.0703	.3299	.6836	.9402	1.1517	.9739	.5235
15115	.2700	.0454	-.0234	-.1251	-.0703	.0716	.3277	.6894	.9485	1.1552	.9354	.5342
15118	.2425	.0023	-.0422	-.1082	-.0745	.0337	.3411	.6991	.9542	1.1602	.9563	.5285
15121	.2373	.0245	-.0124	-.1170	-.0695	.0791	.3349	.6931	.9545	1.1612	.9781	.5327
15124	.2651	.0507	-.0036	-.1178	-.0585	.0968	.3387	.6918	.9549	1.1584	.9782	.5250
15127	.1933	.0019	-.0508	-.1243	-.0653	.0830	.3397	.7025	.9509	1.1615	.9662	.5344
15130	.1336	-.0558	-.0870	-.1453	-.0860	.0424	.3161	.6811	.9398	1.1512	.9470	.5191
15133	.2192	.0160	-.0349	-.1216	-.0665	.0674	.3347	.6940	.9553	1.1643	.9695	.5351
15136	.2017	.0024	-.1404	-.1231	-.0735	.0702	.3272	.6963	.9407	1.1532	.9566	.5304
15139	.2502	.0441	-.0155	-.1146	-.0715	.0517	.3371	.6863	.9397	1.1152	.9031	.4879
15142	.1848	-.0122	-.0613	-.1329	-.0868	.0381	.3031	.6680	.9209	1.1283	.9369	.5085
15145	.2200	.0034	-.0451	-.1205	-.0653	.0784	.3214	.6822	.9340	1.1368	.9424	.5029
15148	.2094	-.0038	-.0545	-.1072	-.0565	.0533	.3314	.6963	.9432	1.1496	.9342	.5123
15151	.1661	-.0401	-.0738	-.1162	-.0600	.0843	.3295	.6893	.9414	1.1438	.9671	.5158
15154	.2242	.0125	-.0264	-.1095	-.0560	.0759	.3325	.6852	.9438	1.1501	.9586	.5161
15157	.2133	.0073	-.0409	-.1074	-.0538	.0939	.3536	.7161	.9725	1.1801	.9930	.5468
16100	.2033	-.0053	-.0562	-.1256	-.0687	.0547	.3168	.6738	.9315	1.1415	.9421	.5166
16103	.1987	-.0335	-.0542	-.1134	-.0653	.0694	.3319	.6853	.9451	1.1489	.9349	.5174
16106	.2029	-.0023	-.0559	-.1169	-.0671	.0888	.3224	.6774	.9355	1.1410	.9397	.5131
16109	.2064	-.0003	-.0552	-.1214	-.0741	.0728	.3148	.6716	.9256	1.1289	.9417	.5010
16112	.2153	.0179	-.0210	-.1155	-.0598	.0927	.3394	.6997	.9557	1.1631	.9693	.5233
16115	.2250	.0085	-.0629	-.1089	-.0614	.0724	.3415	.7032	.9624	1.1691	.9866	.5392
16118	.1982	-.0084	-.0649	-.1318	-.0711	.0674	.3385	.7056	.9690	1.1780	.9826	.5583
16121	.1997	-.0105	-.0683	-.1265	-.0619	.0754	.3439	.7083	.9727	1.1842	.9948	.5501

TABLE II (continued)

WATTENBERG - UPRR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1975

TIME	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
16:24	.2213	.3122	-.0452	-.1344	-.0681	.0752	.3412	.7099	.9674	1.1720	.9877	.5456
16:27	.2089	.0001	-.0430	-.1219	-.0602	.0782	.3458	.7132	.9714	1.1815	.9834	.5504
16:30	.2038	-.0312	-.0643	-.1208	-.0662	.0753	.3272	.6916	.9473	1.1530	.9452	.5223
16:33	.2702	.0001	.0335	-.0983	-.0439	.0865	.3575	.7193	.9813	1.1803	1.0266	.5573
16:42	.2406	.3357	-.0212	-.1127	-.0579	.0827	.3398	.6999	.9553	1.1626	.9447	.5324
16:45 Start flush	.2444	.0300	-.0276	-.1020	-.0487	.1018	.3562	.7148	.9758	1.1823	.9843	.5509
16:48	.2618	.0530	-.0126	-.0941	-.0406	.0317	.3587	.7154	.9771	1.1848	.9753	.5603
16:51 Finish	.2050	-.0323	-.0561	-.1138	-.0580	.0799	.3367	.6948	.9575	1.1567	.9666	.5346
16:54	.2549	.0425	-.0255	-.1061	-.0551	.0982	.3453	.7049	.9623	1.1696	.9737	.5477
16:57 Total Volume-297,000 gal.	.2221	.3183	-.0472	-.1042	-.0501	.0737	.3442	.7050	.9607	1.1652	.9931	.5344
17:00	.2431	.0299	-.0211	-.0917	-.0411	.0847	.3554	.7148	.9683	1.1724	.9708	.5400
17:03	.2500	.3489	-.0145	-.1015	-.0483	.0841	.3422	.6927	.9534	1.1654	.9690	.5408
17:09	.2580	.0428	-.0239	-.1110	-.0545	.0731	.3359	.6993	.9544	1.1631	.9859	.5421
17:12	.2436	.0406	-.0419	-.1054	-.0433	.0881	.3471	.7298	.9699	1.1825	.9751	.5624
17:15	.2145	.0089	-.0649	-.1127	-.0526	.0825	.3556	.7176	.9846	1.1946	.9885	.5766
17:19	.2489	.3426	-.0412	-.0858	-.0309	.0934	.3410	.7002	.9521	1.1582	.9502	.5333
17:21	.2104	.0140	-.0479	-.0924	-.0386	.1054	.3461	.6984	.9584	1.1626	.9473	.5383
17:23	.2344	.0250	-.0177	-.0875	-.0608	.1335	.3518	.7148	.9650	1.1661	.9680	.5410
17:25	.2254	.0150	-.0489	-.0883	-.0320	.1041	.3493	.7116	.9637	1.1646	.9703	.5348
17:26	.1600	-.0314	-.0854	-.0861	-.0358	.1154	.3500	.7108	.9654	1.1616	.9623	.5344
17:28	.2415	.0304	-.0724	-.0666	-.0274	.1130	.3576	.7222	.9703	1.1751	.9905	.5504
17:30	.1977	-.0057	-.0684	-.1044	-.0479	.0967	.3434	.7101	.9655	1.1709	.9665	.5448
17:31	.2353	.0213	-.0528	-.1205	-.0699	.0665	.3176	.6835	.9417	1.1448	.9260	.5178
17:33	.2401	.0218	-.0485	-.1033	-.0612	.0760	.3259	.6908	.9377	1.1468	.9369	.5195
17:34	.1524	-.0444	-.1070	-.1191	-.0747	.0600	.3098	.6599	.9145	1.1193	.8994	.4814

TABLE II (continued)

HATTENBERG - UPRR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1975

TIME	180°	195°	210°	225	240°	255°	270°	285°	300°	315°	330°	345°	
7:00	.1819	-.0199	-.1124	-.1546	-.0932	.0455	.3054	.6610	1.0841	1.2604	.9806	.5423	
7:03	.1303	-.1614	-.1484	-.1884	-.1139	.0267	.2915	.5575	1.0839	1.2696	.9931	.5714	
7:05	.2056	.0018	-.1011	-.2083	-.1399	.0028	.2596	.5279	1.0676	1.2538	.9745	.5607	
7:10	.1729	-.1236	-.1161	-.1729	-.1059	.0314	.2838	.5381	1.0542	1.2369	.9628	.5368	
7:15	.1689	-.0279	-.1199	-.1173	-.0341	.0831	.3528	.7564	1.3135	1.4711	1.3472	.5823	
7:20	.1672	-.0283	-.1194	-.2103	-.1467	-.0019	.2472	.5824	.9080	1.1040	.9193	.5206	
7:25	.1780	-.0205	-.1177	-.2356	-.1876	-.0339	.2030	.5176	.7671	.9767	.8678	.4882	
7:30	.1668	-.0271	-.1170	-.1726	-.1020	.0341	.2815	.6375	1.0481	1.2262	.9571	.5318	
7:35	.1762	-.0210	-.1192	-.1620	-.0960	.0355	.2860	.6406	1.0538	1.2294	.9481	.5231	
7:45	.1350	-.0650	-.1577	-.1924	-.1278	.0162	.2708	.6344	1.0423	1.2291	.9632	.5464	
7:48	.1880	-.0105	-.1048	-.1695	-.1048	.0209	.2837	.6443	1.0763	1.2507	.9605	.5359	
7:50	.2301	.0414	-.0529	-.1889	-.1177	.0174	.2850	.6518	1.0734	1.2013	.9895	.5611	
7:55	.1793	-.0237	-.1288	-.1651	-.1015	.0291	.2710	.6100	.9856	1.1639	.9217	.4994	
8:00	.1656	-.0298	-.1161	-.1458	-.0074	.0513	.3150	.6928	1.1800	1.3458	.9919	.5529	
8:05	.1910	-.0051	-.1005	-.1889	-.1214	.0247	.2699	.6245	1.0089	1.1909	.9464	.5329	
8:10	.1410	-.0537	-.1319	-.1258	-.0500	.0376	.3394	.7234	1.2290	1.3881	1.0130	.5614	
8:15	.2021	.0007	-.0982	-.1434	-.0821	.0397	.2820	.6403	1.0641	1.2343	.9326	.4993	
8:20	.1725	-.0229	-.1253	-.1898	-.1074	.0399	.3044	.6801	1.1198	1.3052	1.0247	.5938	
8:25	.1601	-.0373	-.1283	-.1743	-.1073	.0283	.2762	.6340	1.0412	1.2189	.9584	.5277	
8:30	.1733	-.0256	-.1157	-.1093	-.0976	.0381	.2899	.6633	1.1183	1.2910	.9904	.5495	
8:35	.1503	-.0603	-.1677	-.2184	-.1335	.0107	.2799	.6613	1.0844	1.2762	1.0232	.5993	
8:40	Start pumping	.1067	-.0293	-.1138	-.1776	-.0987	.0345	.2819	.6480	1.0823	1.2610	.9792	.5449
8:45		.1581	-.0405	-.1281	-.1598	-.1004	.0323	.2685	.6155	.9942	1.1674	.9254	.4988
8:50		.1906	-.1126	-.1132	-.1427	-.0789	.0495	.2921	.6551	1.0800	1.2525	.9692	.5367
8:55		.1874	-.0116	-.1047	-.1509	-.0834	.0480	.2919	.6554	1.0836	1.2557	.9702	.5367
9:00		.1507	-.0472	-.1335	-.1478	-.0860	.0431	.2772	.6377	1.0425	1.2161	.9448	.5203
9:05		.1784	-.0216	-.1142	-.1617	-.0850	.0374	.2766	.6392	1.0507	1.2246	.9571	.5261
9:10		.1835	-.0158	-.1036	-.1605	-.0929	.0402	.2813	.6391	1.0529	1.2286	.9578	.5316
9:13		.2204	.0225	-.0749	-.1570	-.0829	.0498	.2938	.6614	1.0915	1.2640	.9756	.5418
9:16		.1513	-.0500	-.1359	-.1752	-.1164	.0204	.2530	.5960	.9531	1.1297	.9106	.4958
9:19		.1467	-.0618	-.1483	-.1929	-.1391	.0026	.2429	.6157	1.0248	1.2135	.9114	.4451
9:22		.1538	-.0399	-.1215	-.2238	-.1477	.0090	.2586	.6209	1.0025	1.1969	.9780	.5695
9:25		.1817	-.0213	-.1225	-.1586	-.0995	.0384	.2831	.6527	1.0861	1.2625	.9853	.5453
9:28		.1387	-.0520	-.1478	-.1622	-.1035	.0385	.2674	.6249	1.0128	1.1895	.9323	.5019
9:30		.1855	-.0154	-.1084	-.1748	-.1008	.0326	.2765	.6392	1.0561	1.2280	.9656	.5341
9:33		.1899	-.0119	-.1010	-.1906	-.1176	.0261	.2763	.6479	1.0743	1.2563	.9845	.5619
9:36		.1955	-.0052	-.1007	-.1734	-.1086	.0289	.2530	.6001	.9788	1.1522	.9136	.4961
9:39	55,000 gal.	.1821	-.0218	-.1105	-.1789	-.1128	.0217	.2641	.6285	1.0451	1.2209	.9512	.5277
9:42		.1864	-.0125	-.0896	-.1614	-.0930	.0344	.2815	.6476	1.0852	1.2542	.9569	.5257
9:45		.2032	.0023	-.0992	-.1510	-.0832	.0274	.2766	.6360	1.0561	1.2238	.9343	.4958

TABLE II (continued)

WATTENBERG - UPR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1976

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
9:48	.2161	.0216	-.0806	-.1998	-.1352	.0045	.2422	.5982	.9797	1.1623	.9337	.5276
9:51	.1668	-.0344	-.1289	-.1333	-.0673	.0474	.3012	.6772	1.1431	1.3064	.9737	.5312
9:54	.1900	-.0082	-.0933	-.1749	-.1102	.0323	.2625	.6222	1.0150	1.1924	.9318	.5165
9:57	.1881	-.0154	-.1098	-.1788	-.1026	.0350	.2813	.6529	1.1002	1.2775	.9848	.5574
10:00	.1413	-.0593	-.1435	-.1159	-.0548	.0664	.2917	.6637	1.1405	1.2956	.9459	.4885
10:03	.1801	-.0191	-.1139	-.1843	-.1130	.0223	.2645	.6292	1.0374	1.2323	.9545	.5351
10:06	.1841	-.0050	-.1028	-.1735	-.1166	.0234	.2550	.6265	1.0280	1.2033	.9430	.5242
10:09	.1592	-.0420	-.1265	-.1902	-.1205	.0134	.2479	.5972	.9798	1.1599	.9248	.5108
10:12	.1485	-.0521	-.1341	-.1759	-.1057	.0225	.2598	.6214	1.0422	1.2170	.9378	.5176
10:15	.1520	-.0398	-.1253	-.1880	-.1177	.0211	.2661	.6293	1.0371	1.2167	.9582	.5423
10:18	.1734	-.0358	-.1138	-.1651	-.0994	.0357	.2649	.6267	1.0268	1.2031	.9361	.5126
10:21	.1902	-.0247	-.1017	-.1603	-.0938	.0368	.2738	.6337	1.0447	1.2176	.9442	.5201
10:24	.1775	-.0237	-.1088	-.1865	-.1162	.0203	.2619	.6215	1.0206	1.2007	.9491	.5307
10:27	.1801	-.0205	-.1130	-.1719	-.1054	.0279	.2699	.6322	1.0355	1.2103	.9426	.5163
10:30	.1451	-.0617	-.1354	-.1495	-.0901	.0323	.2619	.6247	1.0268	1.1943	.9159	.4930
10:33	.1405	-.0537	-.1391	-.1502	-.0877	.0364	.2762	.6375	1.0342	1.2254	.9435	.5151
10:36	.1795	-.0224	-.1107	-.1697	-.1052	.0237	.2571	.6139	1.0198	1.1934	.9230	.5035
10:39	.1769	-.0275	-.1098	-.1525	-.0892	.0366	.2753	.6347	1.0341	1.2283	.9423	.5164
10:42	.1792	-.0236	-.1100	-.1599	-.0971	.0374	.2674	.6332	1.0503	1.2226	.9429	.5158
10:45	.2114	-.0359	-.0956	-.1643	-.1032	.0353	.2672	.6353	1.0546	1.2239	.9369	.5134
10:48	.1895	-.0181	-.0949	-.1888	-.1154	.0237	.2588	.6183	1.0068	1.1872	.9424	.5261
10:51	.1996	-.0052	-.0985	-.1661	-.0951	.0312	.2707	.6369	1.0661	1.2381	.9502	.5249
10:54	.1847	-.0151	-.1019	-.1895	-.1247	.0174	.2609	.6210	1.0135	1.1975	.9483	.5275
10:57	.1825	-.0325	-.1185	-.1730	-.1009	.0316	.2701	.6335	1.0490	1.2238	.9445	.5215
11:00	.2019	.0053	-.0920	-.1718	-.1058	.0206	.2575	.6158	1.0151	1.1926	.9280	.5105
11:03	.1916	-.0041	-.1008	-.1778	-.1085	.0266	.2584	.6253	1.0332	1.2165	.9429	.5301
11:06	.1769	-.0118	-.1434	-.2079	-.1070	.0221	.2610	.6254	1.0270	1.2066	.9358	.5254
11:09	.1790	-.0258	-.1253	-.1913	-.1310	.0148	.2514	.6212	1.0167	1.2019	.9495	.5469
11:12	.1919	-.0058	-.0994	-.1641	-.1036	.0273	.2647	.6220	1.0313	1.2040	.9304	.5079
11:15	.1891	-.0040	-.1058	-.1745	-.0937	.0254	.2683	.6391	1.0821	1.2542	.9545	.5292
11:18	.1916	-.0123	-.1003	-.2108	-.1493	-.0054	.2273	.5682	.8900	1.0825	.8918	.5103
11:21	.1842	-.0080	-.1073	-.1766	-.1041	.0247	.2620	.6235	1.0311	1.2034	.9310	.5316
11:24	.1773	-.0246	-.1109	-.1745	-.1082	.0210	.2621	.6266	1.0412	1.2176	.9437	.5315
11:27	.2071	.0093	-.0966	-.1503	-.0788	.0585	.2947	.6764	1.1323	1.3142	.9791	.5467
11:30	.1847	-.0453	-.1013	-.1646	-.0958	.0319	.2655	.6290	1.0320	1.2096	.9386	.5228
11:33	.1547	-.0750	-.1299	-.2110	-.1252	.0150	.2563	.6336	1.0554	1.2407	.9714	.5642
11:36	.1692	-.0234	-.1071	-.1885	-.1239	.0155	.2524	.6273	1.0342	1.2146	.9469	.5410
11:39	.1441	-.0615	-.1403	-.1568	-.0989	.0243	.2515	.6678	.9889	1.1664	.9088	.4888
11:42	1.8554	.5312	4.4527	-.1790	-.1149	.0156	.2524	.6170	1.0138	1.1962	.9384	.5285
11:54	.0002	-.0061	-.0934	-.1953	-.1168	.6322	.2766	.6494	1.0614	1.2432	.9014	.5713

TABLE II (continued)

MATTEBERG - UPR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1976

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
11:57	0.0000	.0399	-.0316	-.1802	-.1100	.0341	.2854	.6312	1.0089	1.1919	1.0563	.5375
12:03	-.0001	.0114	-.0032	-.1541	-.1037	.0135	.2387	.5943	.9923	1.1606	.8885	.4697
12:08	-.0006	-.1966	-.1039	-.1781	-.1032	.0265	.2682	.6413	1.0724	1.2490	.9591	.5363
12:10	.1487	-.0227	-.1155	-.1589	-.0908	.0377	.2683	.6341	1.0671	1.2317	.9336	.5094
12:15	.1998	-.0074	-.0917	-.1297	-.0696	.0507	.2891	.6651	1.1106	1.2808	.9536	.5267
12:18	.2034	-.0163	-.0843	-.1505	-.0872	.0425	.2728	.6322	1.0343	1.2083	.9332	.5125
12:21	.1316	-.1037	-.1385	-.1813	-.1163	.0223	.2602	.6372	1.0622	1.2419	.9552	.5374
12:24	.1920	-.1775	-.1091	-.1877	-.1153	.0201	.2603	.6271	1.0357	1.2142	.9517	.5371
12:27	.1777	.0012	-.0908	-.1736	-.1107	.0216	.2445	.6136	1.0124	1.1861	.9232	.5080
12:30	.1874	-.0171	-.0932	-.1559	-.0818	.0511	.2801	.6623	1.1210	1.2876	.9656	.5296
12:33	.1963	-.0058	-.0823	-.2069	-.1514	-.0070	.2249	.5663	.8819	1.0728	.8896	.4911
12:36	.1963	-.0017	-.0843	-.1853	-.1273	.0059	.2381	.5854	.9453	1.1280	.9084	.5040
12:39	.1952	.0039	-.0771	-.1730	-.1060	.0317	.2625	.6357	1.0409	1.2223	.9543	.5370
12:42 190,000 gal.	.1095	-.0152	-.0948	-.1588	-.0995	.0365	.2663	.6376	1.0504	1.2287	.9439	.5205
12:45	.1792	-.0394	-.1031	-.1627	-.0917	.0373	.2710	.6448	1.0797	1.2533	.9562	.5327
12:48	.1754	-.0197	-.0924	-.1754	-.1075	.0250	.2580	.6278	1.0261	1.2029	.9369	.5157
12:51	.1896	-.0102	-.0884	-.1753	-.1185	.0162	.2454	.6001	.9673	1.1514	.9181	.5079
12:54	.1840	-.0324	-.0897	-.1710	-.1053	.0331	.2600	.6294	1.0178	1.2003	.9436	.5312
12:57	.2105	.0038	-.0668	.5641	2.2244	.1311	.4126	.7167	1.1898	1.1887	2.2830	2.5356
13:00	.1803	.0001	-.0890	-.2203	-.1090	.0243	.2585	.6356	1.0552	1.2403	.9542	.5359
13:03	.1903	-.0036	-.0785	-.1811	-.1093	.0173	.2512	.6161	1.0147	1.1944	.9309	.5088
13:09	.1791	-.0394	-.0924	-.1757	-.1110	.0254	.2537	.6178	.9901	1.1712	.9263	.5182
13:15	.1892	-.0058	-.0875	-.1744	-.1032	.0323	.2651	.6330	1.0419	1.2291	.9562	.5387
13:18	.1792	-.0321	-.0909	-.1863	-.1238	.0137	.2460	.6125	1.0085	1.1960	.9418	.5309
13:21	.2021	.6126	-.0745	-.1026	-.0801	.0524	.2431	.6650	1.1070	1.2779	.9747	.5420
13:24	.1952	.0004	-.0935	-.1615	-.1035	.0236	.2584	.6255	1.0460	1.2223	.9399	.5119
13:30	.2099	.0129	-.0579	-.1795	-.1145	.0223	.2527	.6216	1.0227	1.2063	.9336	.5267
13:33	.1013	-.0188	-.0724	-.1546	-.0931	.0277	.2574	.6162	1.0281	1.1967	.9147	.4866
13:36	.1742	-.0440	-.0735	-.1853	-.1170	.0274	.2677	.6392	1.0425	1.2302	.9711	.5497
13:39 235,000 gal.	.2022	.0021	-.0635	-.1654	-.0981	.0341	.2647	.6373	1.0578	1.2287	.9454	.5237
13:42	.1867	-.0227	-.0801	-.1692	-.1009	.0278	.2594	.6369	1.0527	1.2343	.9486	.5202
13:45	.1731	-.0417	-.1897	-.1568	-.0878	.0431	.2871	.6610	1.1176	1.2964	.9661	.5358
13:51	.1576	-.0502	-.0743	-.2453	-.1071	.0271	.2625	.6377	1.0635	1.2407	.9502	.5282
13:54	.1814	-.1222	-.0222	-.1777	-.1044	.0246	.2542	.6234	1.0344	1.2150	.9395	.5125
14:00	.1857	-.0113	-.0940	-.1807	-.1122	.0236	.2535	.6226	1.0143	1.1980	.9359	.5221
14:03	.1815	-.1237	-.0858	-.1853	-.1199	.0105	.2459	.6073	.9891	1.1715	.9186	.5026
14:06	.1736	-.0316	-.0944	-.1795	-.1037	.0286	.2674	.6429	1.0755	1.2543	.9564	.5306
14:09	.1848	.0084	-.0855	-.2173	-.1514	-.0121	.2228	.5551	.8560	1.0523	.8895	.4934
14:15	.1758	-.0300	-.0893	-.1645	-.0921	.0393	.2713	.6477	1.0853	1.2539	.9446	.5201
14:18	.1891	-.0519	-.0904	-.2175	-.1352	.0028	.2465	.6245	1.0485	1.2416	.9662	.5512

TABLE II (continued)

MATTEMBERG - UPRR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1976

TIME	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
14:21	.1676	-.0332	-.1035	-.1708	-.0952	.0349	.2714	.6593	1.1271	1.3616	.9671	.5392
14:24	.1957	-.0248	-.0684	-.1824	-.1095	.0284	.2619	.6251	1.0211	1.2019	.9370	.5181
14:27	.2114	.0036	-.0538	-.1669	-.0955	.0360	.2726	.6375	1.0559	1.2334	.9457	.5198
14:30	.1956	-.0710	-.0760	-.1910	-.1172	.0180	.2489	.6193	1.0145	1.2010	.9368	.5237
14:33	.1939	-.0238	-.0573	-.1876	-.1221	.0070	.2290	.5935	.9702	1.1559	.9083	.4926
14:36	.2070	.0048	-.0795	-.2167	-.1545	-.0189	.2116	.5438	.8636	1.0562	.8765	.4829
14:39	.1905	.0074	-.0827	-.1564	-.0901	.0346	.2605	.6164	1.0105	1.1898	.9175	.4903
14:42	.2114	-.0049	-.0888	-.1734	-.1098	.0211	.2542	.6157	1.0084	1.1881	.9242	.5052
14:45	.1618	-.0226	-.1031	-.2000	-.1227	.0120	.2509	.6205	1.0343	1.2205	.9478	.5326
14:48	.1855	-.0133	-.0868	-.1844	-.1083	.0326	.2696	.6419	1.0566	1.2400	.9645	.5421
14:51	.1849	-.0127	-.0838	-.1836	-.0849	.0557	.3092	.7127	1.2193	1.3858	1.0011	.5593
14:54	.1936	-.0032	-.0710	-.1755	-.1013	.0270	.2589	.6249	1.0279	1.2080	.9339	.5103
14:57	.1777	-.1286	-.1010	-.1788	-.1043	.0326	.2711	.6378	1.0552	1.2353	.9597	.5347
15:00	.1932	-.0197	-.0589	-.1866	-.1129	.0285	.2669	.6415	1.0560	1.2362	.9567	.5383
15:03	.1872	-.0353	-.0579	-.1848	-.1137	.0232	.2576	.6083	.9851	1.1695	.9262	.5007
15:09	.1791	-.0035	-.0747	-.1830	-.1284	.0365	.2379	.5916	.9705	1.1561	.9097	.5004
15:12	.1832	-.0096	-.0624	-.1800	-.1074	.0218	.2579	.6391	1.0629	1.2428	.9476	.5279
15:15	.1937	-.0112	-.0732	-.0516	.0345	.1450	.4011	.8564	1.5613	1.6888	1.1012	.6060
15:18	.1876	-.0138	-.0866	-.1638	-.0993	.0340	.2705	.6514	1.1086	1.2813	.9541	.5230
15:21	.1913	-.0203	-.0804	-.1669	-.0844	.0505	.2979	.5878	1.1666	1.3494	1.0055	.5616
15:24	.1836	-.0398	-.0344	-.0864	.0202	.1357	.3963	.8461	1.5420	1.6689	1.0326	.6008
15:27	.1870	-.0241	-.0865	-.1756	-.1061	.0234	.2667	.6290	1.0308	1.2119	.9420	.5222
15:30	.1704	-.0450	-.1497	-.2777	-.2358	-.0833	.1293	.3958	.4939	.7136	.7632	.4190
15:33	.1910	-.0356	-.0733	-.1560	-.0814	.0498	.2874	.6733	1.1282	1.3034	.9743	.5442
15:36	.1874	-.0040	-.0699	-.1683	-.0993	.0316	.2712	.6439	1.0984	1.2679	.9491	.5208
15:39	.1524	-.0511	-.1059	-.1888	-.1107	.0306	.2816	.6643	1.1223	1.3032	.9882	.5677
15:42	.1746	-.0511	-.0777	-.2125	-.1500	-.0040	.2323	.5603	.8909	1.0928	.9089	.4961
15:45	.1597	-.0408	-.0680	-.1812	-.1124	.0273	.2655	.6401	1.0500	1.2354	.9572	.5325
15:48	.1711	-.0354	-.0971	-.1205	-.0443	.0744	.3151	.7196	1.2420	1.4033	.9980	.5373
15:51	.1758	-.0540	-.0824	-.1448	-.0850	.0386	.2688	.6110	.9913	1.1385	.8782	.4735
15:54	.1755	-.0418	-.0883	-.1626	-.0888	.0436	.2898	.6744	1.1334	1.3150	.9857	.5412
15:57	.2035	-.0030	-.0763	-.1795	-.1058	.0296	.2712	.6445	1.0603	1.2429	.9567	.5335
16:00	.1750	-.0235	-.0897	-.1848	-.1168	.0178	.2524	.6184	1.0112	1.1939	.9310	.5124
16:03	.1701	-.0379	-.0898	-.1805	-.1165	.0167	.2558	.6266	1.0376	1.2192	.9396	.5154
16:06	.1701	-.0359	-.0824	-.1869	-.1119	.0205	.2565	.6197	1.0212	1.2059	.9391	.5148
16:09	.1611	-.0517	-.0956	-.1728	-.1021	.0312	.2593	.6381	1.0490	1.2293	.9444	.5227
16:12	.1794	-.0435	-.1057	-.1940	-.1221	.0137	.2550	.6259	1.0402	1.2287	.9523	.5326
16:15	.1902	-.0033	-.0742	-.1939	-.1190	.0205	.2504	.6246	1.0019	1.1940	.9431	.5344
16:18	.2144	.0224	-.0620	-.1433	-.0773	.0524	.2894	.6693	1.1117	1.2813	.9588	.5227
16:21	.2030	.0203	-.0710	-.1100	-.0316	.0879	.3278	.7383	1.2762	1.4365	1.0099	.5356

TABLE II (continued)

HATTENBERG - UPRR22 HYDROFRACTURE

FRACTURE-JANUARY 27, 1976

TIME	130°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
16:24	.2009	-.0197	-.0772	-.1799	-.1082	.0299	.2681	.6416	1.0486	1.2371	.9644	.5385
16:27	.2068	-.0126	-.0725	-.2261	-.1537	-.0047	.2335	.5994	.9503	1.1559	.9388	.5276
16:30	.1771	-.0391	-.0966	-.1890	-.1218	.0158	.2565	.6089	.9838	1.1599	.9147	.5165
16:33	.2158	-.0004	-.0661	-.0797	.0059	.1238	.3800	.8123	1.4345	1.3844	1.0845	.6164
16:42	.1864	-.0553	-.0935	-.1621	-.0936	.0466	.2336	.6576	1.0556	1.2425	.9727	.5583
16:45 Start flush	.2082	-.0065	-.0830	-.1618	-.0905	.0442	.2829	.6588	1.0744	1.2687	.9892	.5615
16:48	.2198	-.0307	-.0622	-.1552	-.0691	.0662	.3114	.7118	1.1954	1.3856	1.0358	.5904
16:51 Finish	.1923	-.0299	-.0920	-.2051	-.1442	-.0023	.2261	.5556	.8363	1.0327	.8920	.5084
16:54	.2080	.0135	-.0809	-.1359	-.0522	.0795	.3264	.7324	1.2319	1.4103	1.0350	.5914
16:57 Total Volume-297,000 gal.	.1900	-.0407	-.0962	-.2020	-.1361	.0106	.2497	.5864	.8900	1.0953	.9204	.5231
17:00	.2030	.0031	-.0747	-.1385	-.0639	.0655	.3061	.6456	1.1499	1.3191	.9855	.5571
17:03	.1960	-.0106	-.0910	-.1200	-.0473	.0802	.3315	.7464	1.2648	1.4380	1.0440	.5946
17:09	.2020	0.0000	-.0413	-.1330	-.0635	.0694	.3300	.7136	1.1842	1.3750	1.0232	.5820
17:12	.2200	.0198	-.0703	-.1413	-.0784	.0579	.3134	.6787	1.1105	1.2864	.9734	.5660
17:15	.2313	.0359	-.0332	-.1340	-.0764	.0935	.2984	.6466	1.0484	1.2255	.9391	.5285
17:19	.1967	.0210	-.0636	-.1478	-.0621	.0579	.3085	.6647	1.0626	1.2483	.9718	.5681
17:21	.1943	-.0050	-.0706	-.2124	-.1529	-.0104	.2335	.5468	.8075	1.0153	.8787	.5159
17:23	.2000	-.0042	-.0937	-.1831	-.1160	.0268	.2475	.6254	.9813	1.1716	.9345	.5444
17:25	.1926	-.0156	-.1180	-.1572	-.0936	.0423	.2927	.6465	1.0450	1.2358	.9647	.5462
17:26	.1959	-.0122	-.1015	-.2452	-.2088	-.0607	.1671	.4422	.5849	.8067	.7942	.4476
17:28	.2180	.0135	-.0438	-.1499	-.0744	.0568	.3029	.6844	1.1442	1.3322	.9943	.5680
17:30	.2047	.0113	-.0945	-.0905	-.1175	.0173	.2639	.6039	.9577	1.1577	.9295	.5188
17:31	.1707	-.0184	-.1301	-.1150	-.0361	.0893	.3430	.7482	1.2940	1.4531	1.0147	.5684
17:33	.1795	-.0255	-.1135	-.1283	-.0450	.0732	.3334	.7356	1.3159	1.4661	1.0057	.5564
17:34	.1450	-.0583	-.0887	-.2629	-.1443	-.0131	.2261	.5560	.9140	0.3000	0.0000	0.0000

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