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BERC/TPR-76/3

NORTH STANLEY POLYMER DEMONSTRATION PROJECT,  
FIRST ANNUAL REPORT

By  
Kewanee Oil Company

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Date Published—October 1976

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**NORTH STANLEY POLYMER DEMONSTRATION PROJECT,  
FIRST ANNUAL REPORT**

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Prepared for the Energy Research  
and Development Administration under  
Contract No. EY-76-C-02-0029.000  
Formerly E(34-1)-0029

Date Published—October 1976 ✓

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NORTH STANLEY POLYMER  
DEMONSTRATION PROJECT

✓  
FIRST ANNUAL REPORT

July 26, 1976

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## SUMMARY

The North Stanley Polymer Demonstration Project is a cooperative venture between Kewanee Oil Company and the United States Energy Research and Development Administration (ERDA). The project is the result of a response by Kewanee to ERDA's Request for Proposals for Secondary Oil Recovery by Controlled Waterflooding. The subsequent negotiations resulted in ERDA Contract Number E(34-1)-0029 which became effective June 26, 1975. Total cost of the project is \$3,884,890 of which Kewanee is paying \$2,734,138 and ERDA is paying \$1,150,752. The project is scheduled to be completed in June 1978.

A discussion of the objectives of the program and detailed description of the test site were included in the 1975 ERDA Symposium on Enhanced Recovery and at the First Annual Tertiary Recovery Conference, October 24, 1975, at Wichita, Kansas, and reported in the proceedings of that conference. For convenient reference, a copy of the paper published in the Tertiary Recovery Conference Proceedings is attached. This report covers the project activities for the first year which ended June 25, 1976.

The objective of the project is to demonstrate the efficiency and economics of recovering tertiary oil from a highly heterogeneous reservoir (which has been successfully waterflooded, but is nearing the economic limit) by injecting a polymer slug of tapered concentrations to improve the sweep efficiency of the reservoir. The project will be a true field test as (1) it encompasses 1,010 productive acres and 72 million barrels of pore volume, (2) it utilizes the current producing and injection wells, and (3) it has a well defined producing history which can be used as a baseline for judging project response.

In preparation for the injection of polymer, a major review of the mechanical condition of all producing and injection wells

prompted a number of remedial workovers. As a preventive measure, all injection wells were equipped with plastic coated tubing, and packers were set approximately 100 feet above the Burbank sand to prevent the possibility of subsequent casing leaks thieving off injected polymer. Where necessary, producing wells were worked over to insure maximum producing capability. The remedial work was done at the start of the project to insure that any production increase resulting from the remedial work was recognized prior to the start of polymer injection.

The necessary surface facility changes were made to allow the injection of fresh water only and to provide for the disposal of 35,000 BPD of produced water. Polymer storage and blending facilities were constructed in such a manner as to allow control of the mixing process with a minimum of supervision and manpower.

In September a one well mini-injection test was conducted which included a fresh water preflush period, injection of 5,000 pounds of Pusher 700 at 1,000 PPM followed by 1,000 pounds of Pusher 1,000 at 100 PPM, and a fresh water afterflush period. The mini test established that there would be no significant well bore problems associated with the injection of the polymer.

The fresh water preflush phase was started on February 23. The purpose of the preflush was threefold:

- (1) To condition the reservoir for the polymer injection
- (2) To allow determination of a stabilized based production curve
- (3) To serve as a tracer in order to identify areas of direct communication between injection and producing wells

The preflush phase identified three producing wells with communication problems that would require action to prevent early breakthrough of polymer.

A study of the reservoir performance including injection profiles, pressure falloff tests, reconstruction of the producing history for each well, core analysis, a computer model study by Dow, and recognition of channeling problems during the fresh water preflush resulted in a change in the polymer slug design. It was decided to change the concentration to 250 PPM for the first six weeks during which time Channel-block\* treatments will be performed on key injection wells. At the end of that period, the concentration will be increased to 600 PPM for three months followed by six more weeks at 250 PPM. The final six months will be 100 PPM as in the original plan. The original plan called for 1,000 PPM the first month, 500 PPM the second month, 250 PPM for months three through six, and 100 PPM the last six months. The reason for the lower concentration initially was to allow correction of the channeling problems before the high concentration injection occurred. The new schedule allows the injection of the same total weight of polymer in the first year while minimizing the risk of losing polymer due to channeling.

Due to problems incurred in obtaining an adequate supply of fresh water, the start of the preflush phase was delayed seven weeks. One week of the slippage was recovered during the preflush phase and polymer injection started six weeks after the original target date. A revised Milestone Chart showing the actual first year's experience and the current schedule of work is shown as Figure 1.

At the end of the first year, the project is essentially on schedule. The preparatory phase has been completed and polymer injection has begun. The next year should give a good indication of the degree of success of the project.

\*Trademark of The Dow Chemical Company

## RESERVOIR ANALYSIS

A comprehensive review of the reservoir performance was conducted in order to determine a final design of the polymer slug and to anticipate reservoir problems before they occurred. The review included a study of the past performance and an analysis of data generated as a result of the project. The study resulted in a change in the polymer slug concentrations and the initiation of Channelblock treatments on selected injection wells, both to correct current reservoir problems and to enhance the anticipated response to the project.

### Review of Producing History

The first step in the analysis was to reconstruct the producing history for the project area during the waterflood. Prior to the polymer project, the North Stanley wells had produced to a single unitized battery which also included wells that were not part of the project area. Consequently, there was no production history for the project area alone. It was necessary to develop a computer program which would accept well tests, battery production and injection rates for all wells in the battery, and generate a history of oil and water production and/or injection for each individual well. The program then regrouped the wells belonging in the North Stanley Project area alone and produced a water-oil ratio versus cumulative production and a cumulative water injection table for the project. This data was later used as input to Dow's model study which will be discussed later. Table 1 is a sample of the printout.

### Permeability Distribution

A study of the permeability distribution and character was made to better understand the complex nature of the flow patterns within the reservoir. It was known from previous performance that

there were two main paths of fluid flow. The high permeability Burbank section provides a northwest-southeast flow path, and the matrix fracture system in the Bartlesville section causes flow generally in an east-west direction. The study included a review of the core analyses, injection profiles in all injection wells, pressure falloff tests in selected injection wells, and the use of fresh water injection as a tracer between wells.

### Injection Profiles

As the injection profiles surveys were run, it became apparent that there was not a single general pattern to injection well behavior. Instead, the well's performance fell into groupings depending on completion type and formation behavior. Figure 2 shows the profile types and groupings. Figure 3 shows the location and profile type for each injection well and demonstrates the lack of a specific areal pattern in the injection well behavior. Figures 4 through 8 are samples of the analyses done on each well. The base drawing includes the wellbore configuration, the permeability distribution from core analysis, and a Gamma Ray tracing from an earlier well log. The injectivity per foot and the Gamma Ray run during the injection profile survey were then superimposed on the base. The combination plots allow us to determine both where the fluid was leaving the wellbore during the profile survey and where the fluid has left the wellbore throughout the life of the well.

Figure 4 is a plot for Big Eagle 9 WI. The injection profile shows that acid stimulation in January 1976 probably opened the upper set of perforations since all the current injection is leaving the well through that zone. The comparison of the Gamma Ray logs clearly indicates the bulk of the cumulative injection has gone out the lower perforations as shown by the crosshatched area. Figure 5, the plot for Art 8 WI, shows a similar situation. The current injection is through a section from 2912-20. The

Gamma Ray comparison indicates there has been significant cumulative injection in that zone. However, there has also been cumulative injection through the lower set of perforations although the injection profile indicates no current injection into the lower zone. Figure 6 (Fanny 5 WI) is representative of many of the injection wells. The nature of the profile is different than was expected. There are open perforations across the high permeability upper section of the sand (see the permeability profile), but all of the injection is leaving the well through the lower set of perforations. In addition, the Gamma Ray comparison indicates this has been happening throughout the well's life. Although there is some Gamma Ray deflection from 2930-32, it is quite small in comparison to the reaction in the lower section. Figure 7 (Hiram 17 WI) is a new well that was drilled to the top of the sand, casing was set, the producing section was cored, and the well was completed open hole. Again, all of the injection is occurring through vertical fractures in the low permeability section, while sand with permeability exceeding 1,000 md is taking no water at all. Figure 8 is a plot for Gale 14 and is typical of several of the old producing wells that were converted to injection. The well is an old open hole that was shot with nitroglycerine upon completion. All the injection is going into the upper half of the sand.

The injection profiles, combined with pressure falloff surveys which had negative skin factors (see Figure 21 for location of pressure falloff tests), indicated the fracture system was controlling the fluid flow in the immediate vicinity of many of the injection wells. Only in the old shot holes was there significant injection directly into the higher permeability zones.

#### Influence of High Permeability Upper Section

The next area studied was the effect of the high permeability section. Looking at the flow profiles alone, there was no correlation between completion type or location and injection

rate. However, there does appear to be a definite correlation between injection rate and the presence or absence of the high permeability section in the well. The correlation appears to be independent of completion type, i.e. it does not matter through what section of the sand the water leaves the wellbore. Table 2 summarizes injection rates for wells in each group. It is apparent that the wells with the high permeability sand generally take more than 2,000 BPD while those without it accept less than 2,000 BPD. In Group I there are two anomalous wells, Art 8 and Hiram 12. Both have had numerous mechanical problems which may be the cause of the low rates. In Group II, only Big Eagle 11 is anomalous. It has been established using fresh water injection as a tracer that a direct channel exists between Big Eagle 11 and Big Eagle 3, which allows the higher injection rate. The correlation between injection rate and the presence of the high permeability sand is interpreted as indicating the water is eventually utilizing the Upper Burbank section as the principal flow path. It is speculated that in the cases where it leaves the wellbore through vertical fractures in the lower sand section, the water eventually migrates upward to the high permeability sands and travels through that section to the producing wells. The lack of tracer in the nonperforated section of the wellbore indicates the migration to the upper sand is not occurring directly at the wellbore and that at least some of the lower section is probably being swept. We were unable to arrive at a method to quantitatively estimate at what point the migration might be occurring.

### Fresh Water Injection

The reservoir performance was further studied by observing the appearance of fresh water at producing wells during the preflush period. The specific gravity and total dissolved solids of the produced water were measured at each well prior to the start of fresh water injection and at least once per week thereafter. Figure 9 shows the results of the fresh water injection. The wells that have experienced major breakthrough are designated

by triangles and those with suspected minor breakthrough are outlined with squares. The number of days from the start of fresh water injection, until breakthrough was indicated at the well, is shown for each well. Those wells showing 124 days have not experienced identifiable dilution of the produced water. The record of specific gravity and total dissolved solids for each well is included in the appendix. The suspected minor breakthrough comes from subtle changes in the slope of the curves. It may or may not be occurring. However, the times noted will be used to make a close check of the wells for polymer breakthrough.

The three wells experiencing major fresh water influx are Big Eagle 3, Hiram 15, and Gale 13. The well with the worst communication problem is Big Eagle 3. The offending injector has been identified as Big Eagle 11 WI. Figure 12 is a graph showing the specific gravity and total dissolved solids for the three wells since the start of fresh water injection. Big Eagle 11 was shut in on May 27, and the produced water samples showed an immediate increase in specific gravity and TDS. When it was opened on June 10, the specific gravity and TDS again started dropping. Big Eagle 11 WI is now shut in, and it will not be used for injection. It is felt that the effect on Big Eagle 3's oil production will be minimal although the water production should drop.

The offending injection wells for Hiram 15 and Gale 13 have not been positively identified. However, the most probable wells are receiving Channelblock treatments, and it is anticipated this will alleviate the problem. If the polymer breaks through early in high concentrations, it will be necessary to positively identify the offending wells and either take remedial steps or shut the wells in during the period of 600 PPM injection.

## Reservoir Modeling

Using the waterflood production history and the relative permeability curves generated from the Hiram 17 WI core analyses, Dow Chemical made a computer simulation of the performance to be expected from polymer injection. Dow's program is basically a multi-layered Buckley-Leverett model (without crossflow) that can accommodate multiple fluid slugs. It is two dimensional in scope and cannot simulate the effects of pressure interference between any irregular array of wells.

The reservoir model indicated an incremental recovery due to polymer flooding of 920,000 barrels. Due to the limitations of the model, it was not possible to match the entire flood performance. However, a good match for the last five years was achieved and Dow felt it was a good basis for projecting the benefit of polymer injection. The model runs indicated that the early polymer flood response would be heightened by the use of a programmed slug rather than a constant concentration slug. The model did not consider any benefit from the application of Channelblock to the injection wells. The limitations on the effect of areal variations and crossflow between layers made it inadvisable to attempt to design the specific slug concentrations based on the model studies alone. However, it is felt that the model studies do confirm the desirability of proceeding with the polymer injection. A complete discussion of the model study along with specific results is included in the appendix.

## Overall Reservoir Performance

Since the computer model was not capable of allowing for the effects of crossflow and the profiles strongly indicated crossflow is a factor in this reservoir, a qualitative look at the current overall producing trends in the reservoir was necessary. Figure 10 is a map showing the current oil producing rate in BPD

for each well. All production in excess of 20 BPD was contoured to highlight the areas of maximum production. The water-oil ratio performance was also reviewed. It was apparent that oil producing rate was only minimally affected by water-oil ratio. Figure 11 is a map showing the total fluid producing rate for each well. The general shape and location of the high total fluid rates is very similar to that of the oil producing rate, thus indicating that total fluid production is the controlling factor in determining oil producing rate.

### Need for Channelblock Treatments

The conclusion drawn from the review of reservoir performance and injection well behavior is that the fluid flow behavior is so complex that it cannot be characterized simply. However, because several of the producing wells have seen fresh water breakthrough and several of the injection wells appear to have excessive injection rates, it was decided to perform Channelblock treatments on six injection wells. The wells to be treated are Art 7, Brenner 9, Fanny 5, Gale 14, Hiram 10, and Hiram 17.

The Channelblock treatments should result in altering the injection profile in each well as well as redistributing the injection between wells. The Channelblock treatments being used are a soft gel designed for deep penetration. Although it is not clear what the exact path of the injection water is now, it is reasonable to expect that altering that path should improve the sweep efficiency of the reservoir and result in additional oil being produced.

### Current Project Status

Due to the need for Channelblock treatments and the fresh water breakthrough in a few of the injection wells, it was decided to delay the period of high polymer concentration until the

reservoir problems to be encountered could be better defined. For the first six weeks of injection the concentration will be held at 250 PPM. During that time the Channelblock treatments will be performed on the six high rate injection wells and the producing wells will be monitored for indications of polymer breakthrough. If excessive polymer production is experienced, two options are open: (1) additional Channelblock treatments can be performed or (2) the producing well can be shut in for the three month period of high concentration injection.

The peak injection concentration will be cut back from 30 days each of 1,000 PPM and 500 PPM to 90 days of 600 PPM. The lower concentration will reduce the likelihood of significant quantities of polymer being channeled from injection well to production well before it is discovered. The new injection schedule is outlined in Figure 1.

Figure 13 is a production data graph showing the actual waterflood history and the computer model history. It is likely that the model is greatly optimistic in its projection of response time and maximum producing rate although the total incremental production is reasonable. Figure 14 shows the response predicted at the start of the project, the prediction made by the computer model for the polymer injection program based on the recent work, and a curve representing the current estimate of future performance. The adjusted curve takes into account the delay in response and failure to reach the maximum producing rate experienced under waterflooding. The incremental production from the polymer is essentially the same.

## MINI-INJECTION TEST

### Purpose

In September, 1975, a one well injection feasibility test was conducted. The primary objective of the test was to make sure that injection of the polymer at the proposed concentrations could be realized without significant decreases in injection rate and without excessive polymer degradation. There were several secondary objectives of the test. They were as follows:

1. Check polymer compatibility with the oxygen scavenger and the proposed biocide.
2. Determine oxygen scavenger requirements.
3. Determine if the injection characteristics of the well are changed by the polymer.
4. Check for severe fresh water and/or polymer breakthrough in the surrounding wells.

### Well Selection

The well selected for the test was Roach 19 WI. Although the well was outside the project area, it was considered representative of the injection wells within the project and had the advantage of being located close to the fresh water system at the Forbes Battery. By not waiting until fresh water was available at the Gale Plant in the project area, it was possible to conduct the mini test several months ahead of schedule. This would allow additional time to solve any problems which might be recognized as a result of the test. Figure 15 shows the location of Roach 19 WI in relation to the test area. It is in the quarter section adjacent to the south boundary of the project area. The sand character and injection rate of Roach 19 WI fell in the middle range of all injection wells in the project area.

## Equipment

The configuration of the equipment used in the mini test is shown in Figure 16. The equipment included a two inch steel line from the Ark-Burbank fresh water source at the Forbes Battery to the well, chemical pumps to inject oxygen scavenger and biocide, a blending unit supplied by Dow, a triplex pump, a meter, and pressure gauges.

The blending unit supplied by Dow is one generally used for mixing chemical for Channelblock treatments. It is a self contained skid mounted unit. The unit takes a portion of the injection water, blends it with the polymer to form a slurry, and injects the slurry back into the main injection line where final mixing and dilution to the desired concentration takes place. If retention time in the line is adequate, the polymer becomes a true solution by the time it is injected into the well.

## Test Sequence

The test was designed to be a small scale reproduction of the actual polymer injection process. The first step was to preflush with fresh water until the well stabilized at 2,300 BPD. An injection profile survey was run to establish a baseline prior to polymer injection. The profile revealed that the majority of the water was leaving the bottom three feet of the well. In order to prevent excessive shear of the polymer, 33 feet of additional interval was perforated and acidized. After stabilizing the injection rate at 2,300 BPD again, another injection profile survey was run.

Five thousand pounds of Dow Pusher 700 (P-700) polymer were injected at a concentration of 1,000 parts per million. At 2,300 barrels of water per day, 786 pounds of polymer were injected per day. At the conclusion of the P-700, another injection profile was run. The next step was the injection of

1,000 pounds of Dow Pusher 1,000 polymer at a concentration of 100 parts per million. The test was concluded by following the polymer with fresh water for two months.

## Results

The conclusions reached from the test were as follows:

1. There will be no appreciable problems involved in injecting polymer at the desired concentrations and rates.
2. There will be no problem in maintaining polymer quality, and the degree of shear will be less than previously anticipated.
3. At the proposed concentrations, the biocide will not degrade the polymer.
4. The sodium hydrosulphite is an acceptable oxygen scavenger. The recommended concentration is 2.5 PPM.
5. A small increase of injection pressure from 190 psi to 205 psi was noted during the P-700 injection @ 1,000 PPM. However, the rate remained constant at 2,300 BPD.
6. A relatively small amount of polymer injection did succeed in altering the injection profile.
7. There was no significant fresh water breakthrough at the offset producing wells.

Polymer degradation caused by the injection process was checked during the test. Fluid samples were swabbed from various depths at the end of the P-700 injection. The samples collected from the tubing showed no decrease in screen factor. The samples received by swabbing the fluid back from the formation through the perforations (i.e. the fluid had left the wellbore through perforations and was swabbed back into the wellbore again through the perforations) showed a 21% loss in screen factor. The samples were sent to Dow Chemical's laboratory for further

testing. The lab tests indicated that the screen factor degradation was caused by the dilution of the polymer by formation brine rather than by mechanical shearing. Table 3 summarizes the results of the laboratory test.

Table 4 summarizes the results of polymer quality tests in the presence of oxygen scavenger and biocide at varying polymer concentrations. The only degradation occurred when the oxygen scavenger was not used. A concentration of 2.5 PPM sodium hydrosulphite was adequate to eliminate oxygen from the system.

A test was conducted to determine the degree of shearing occurring as the solution passed through an orifice. At a rate of 2,375 BPD and various concentrations there was no loss in quality through the 1.5 inch orifice. Consequently, wellhead injection rates will be monitored with orifice readings throughout the project.

Figures 17 and 18 compare the injection profiles run before and after the injection of P-700 polymer. Prior to the polymer, 80% of the water was going out the bottom foot of perforations and channeling below. Following the polymer, the channeling below the perforations had stopped, 74% of the polymer was leaving the bottom two feet, and eleven feet of interval was taking water that had not been open before. This was considered very encouraging as the mini test involved less than 10% of the total polymer the average well would receive during the project.

Pressure falloff tests were conducted before and after the P-700 injection. Analysis of the tests indicated a reduction in the formation permeability following polymer injections.

Figure 19 shows the produced water analyses for the wells offsetting Roach 19 WI. There was no significant dilution noted after the injection of 220,000 barrels of fresh water. Consequently, widespread channeling problems between injectors and producers is not anticipated.

## WELL PREPARATION

### Injection Well

Prior to the start of the fresh water preflush, a thorough check of the mechanical condition of all the injection wells was made. Each well was checked for casing leaks and the necessary repairs were made. Plastic lined tubing was run on a packer in all the injection wells in order to minimize future corrosion problems and to ensure that all injection went into the Burbank-Bartlesville zone. During cleanout operations of Pappin 11 WI and Hiram 5 WI, parted casing was discovered, and the wells were plugged and abandoned. Hiram 17 WI was drilled as a replacement for Hiram 5 WI. The well was drilled to the top of the Burbank, casing was set, the Burbank-Bartlesville section was cored, and the well was completed as an open hole injector. Figure 20 shows the location of the injection wells and the type work done on each one.

During the fresh water preflush period, injection profile surveys were run in each well. (Refer to Figures 2 and 3 and Appendix.) Pressure falloff tests were also run in selected wells as shown on Figure 21. As a result of this work, six wells are to be Channelblocked and three wells are to have perforations added. The location of the wells and the type work to be performed are shown on Figure 22.

### Producing Wells

The condition of the producing wells was checked, but due to the cost of pulling and reconditioning downhole centrifugal pumps, only a few with suspected problems were actually pulled. Two high volume wells were pulled and checked for casing leaks. No remedial work was necessary, and they were returned to production. A new producing well, Skelly-Barber #10, was drilled to improve the well pattern.

## Salt Water Disposal Wells

Since the polymer requires fresh water as a carrying fluid, it was necessary to develop capacity to dispose of 35,000 BPD of produced water. One new salt water disposal well, Skelly-Barber SWD #1, was drilled and completed in the Arbuckle formation. The well was completed open hole from 3,417 to 4,488 feet. The casing was 8-5/8" with 5-1/2" plastic lined casing used as the injection string. The 5-1/2" was set at 3,112 feet on a Baker Model G fully coated hookwall packer. After a 10,000 gallon multistage acid treatment, the well is disposing of 21,000 BWPD. Forbes SWD #1 was reactivated and reconditioned with a 20,000 gallon 15% HCL treatment and the running of a 5-1/2" plastic lined injection string. It is currently disposing 14,000 BPD of produced water.

## EQUIPMENT PREPARATION AND DESIGN

### Salt Water Disposal System

In addition to the wells discussed in the previous section, a cement lined 8-5/8" line was laid to Skelly-Barber SWD 1 and a 7" cement coated line was laid from the Skelly-Barber SWD 1 to the Forbes SWD 1 (see Figure 23). The water is moved with two Deming 6x4x9 centrifugal pumps. Each pump has a capacity of 35,000 BPD and is capable of handling the entire volume of water in case the other pump is down for repairs.

### Fresh Water Supply System

The fresh water supply system utilized an existing 8" line from the Forbes Plant to the Gale Plant. A BJ 4x6x12½ SM centrifugal pump with a 150 HP motor serves as a booster pump and a Peerless 5 ABX 10.5 centrifugal pump with a 100 HP motor is available as an auxiliary backup unit. It was necessary to lay a 5" line from the Forbes battery paralleling the fresh water supply line to supply produced water to the Roach lease line injection wells which serve as a buffer on the south end of the project. In addition, a 4" fresh water line was laid from the Gale Plant to serve the Pappin-Gale lease line injection wells. Once the fresh water reaches the Gale Plant, oxygen scavenger, Virchem D-OX, is added to the entire fresh water volume. The fresh water system is also shown in Figure 23.

### Fresh Water/Polymer Injection System

Figures 23 and 24 show the fresh water injection/polymer injection system. The fresh water arrives at the Gale Plant at the rate of 35,000 BPD. Approximately 3,000 BPD is diverted through the polymer blending system and re-enters the injection

stream downstream from the turbine pumps. The remaining 32,000 BPD bypasses the polymer blending system and goes through two stages of turbine pumps. These are the same pumps that were used for produced water injection prior to the polymer project.

### Polymer Blending System

Figure 25 shows the polymer storage and feeding system. The polymer is stored in bulk form in a 100,000 pound capacity storage bin. It is fed by gravity to two horizontal feed screws which deliver the polymer at the desired rates to the blending tanks. The 3,000 BPD of fresh water entering the system has an over balance of oxygen scavenger. The feed water is split with 1,200 BPD going to each blender and 600 BPD bypassing the blenders. The blenders mix a slurry of polymer and water which, when recombined with the total water stream, will yield the correct concentration. Any air introduced in the blending is neutralized by the excess oxygen scavenger. The polymer slurry recombines with the 600 BPD that bypassed the blenders, passes through a gas separator and desurger, and enters the duplex pump which raises the pressure of the slurry high enough to enter the injection line downstream from the turbine pumps. The duplex pump is required because turbine pumps would shear the polymer if the fluid streams were recombined upstream of the turbines. The final dilution and dissolving of the polymer to the desired concentration occurs as the fluids move through the injection lines to the wells. The system has been designed to allow fifteen minute retention time needed for the polymer to become fully dissolved.

## INITIATION OF INJECTION

### Injection Rate and Pressure Response

The polymer injection was kicked off on June 15, 1976. The first day was spent testing the blending system and no attempt was made to achieve a fixed concentration. Injection started the 16th at 200 PPM and continued for five days at which time it was increased to 250 PPM. The 250 PPM injection will continue through August 2. The polymer mixing equipment has functioned well, with a minimum of problems.

As soon as the polymer injection started, the system pressure dropped from 275 psi to 175 psi as a result of the friction reducing property of the polymer inside the pipe. Figure 26 shows the recent rate and pressure performance for the project. The system pressure has slowly risen back to 200 psi as the polymer began to affect the injection wells. The field wide injection rate has stayed essentially constant at 35,000 BPD.

### Application of Channelblock

The first Channelblock treatment was started on June 24 on Hiram 17 WI. The 250 PPM polymer solution from the plant is mixed with a crosslinker at the well employing a chemical pump. The initial concentration was to be four quarts of "C" per day tapered down to one quart per day after approximately one week. A Channelblock treatment was started on Gale 14 WI on June 26.

It was originally thought that the fresh water was too low in divalent ion concentration to allow the crosslinker to react. It appeared that it would be necessary to mix some of the produced water in with the Ark-Burbank in order to get a satisfactory reaction. The produced water has significant barium

concentration, and scaling problems were anticipated if the mixing had been necessary. However, experimental mixtures indicated that the soft gel desired in these treatments, in order to get deep penetration from the wellbore, could be achieved with the Ark-Burbank water. Early indications are that the Channelblock treatments are going to be successful. Total volume per well of the treatments will exceed 25,000 barrels of polymer solution.

### Polymer Quality

Screen factor tests were run at all injection wells to determine both quality and consistency throughout the system. The screen factors at all the wells, except Gale 10, were either 16.2 or 16.3. The Gale 10 screen factor was 15.0. Gale 10 is the well nearest the plant and the reason for the lower screen factor at Gale 10 appears to be incomplete dissolving of the polymer at that point. The additional retention time occurring by the time the polymer solution reaches the sand face in the wellbore should increase the screen factor. The values are acceptable for a 250 PPM polymer concentration.

## DATA GATHERING REQUIREMENTS

Kewanee plans to collect the following data during the polymer injection phase of the project.

### Producing Wells

1. At least one well test will be taken each month.
2. Water samples will be tested for polymer with a clay flocculation test every two weeks. The wells where fresh water dilution was suspected will have extra checks based on the time the apparent water breakthrough was noted.
3. After a positive qualitative test for polymer has been noted for a well, samples will be sent every two weeks to Dow for a quantitative lab analysis of polymer concentration.
4. Chlorides and specific gravity of the water from each producing well will be checked in the field once per week for the first two months. After that, they will be checked semi-monthly.
5. A laboratory analysis of specific gravity and total dissolved solids will be made on one sample per month for each producing well. A complete analysis will be run every six months.

### Injection Wells

1. The injection rate and pressure will be recorded for each well two to three times per month.
2. The plant pressure and total injection rate will be recorded daily.
3. Fresh water supply will be checked monthly for bacteria presence.

4. Polymer quality screen factor tests will be taken for key wells throughout the system each week.
5. The pumper will check the oxygen content at the plant discharge several times per day during the polymer injection period.

#### FUTURE PLANS

Plans for the coming year are outlined on the Milestone Chart (Figure 1).

TABLE 1

## PRODUCING HISTORY OF NORTH STANLEY WATERFLOOD

KEWANEE OIL COMPANY  
PRODUCTION SUMMARY BY MONTH

YEAR	MONTH	OIL PRODUCTION	WATER PRODUCTION	INJECTION	OIL ACCUMULATION	WATER ACCUMULATION	INJECTION ACCUMULATION	WOR
1959	AUGUST	1,310.0	38	5,686	1,310.0	38	5,686	0.03
1959	SEPTEMBER	1,052.8	60	116,292	2,362.8	98	121,978	0.06
1959	OCTOBER	481.9	101	139,657	2,844.7	199	261,635	0.21
1959	NOVEMBER	1,256.6	283	147,753	4,101.3	482	409,388	0.23
1959	DECEMBER	1,036.6	0	179,273	5,137.9	482	588,661	0.00
1960	JANUARY	871.1	93	254,804	6,009.0	575	843,465	0.11
1960	FEBRUARY	1,191.3	3,079	257,006	7,200.3	3,654	1,100,471	2.58
1960	MARCH	1,294.0	1,287	305,738	8,494.3	4,941	1,406,209	0.99
1960	APRIL	1,044.8	60	480,981	9,539.1	5,001	1,887,190	0.06
1960	MAY	1,068.6	201	543,903	10,607.7	5,202	2,431,093	0.19
1960	JUNE	3,533.0	3,106	484,616	14,140.7	8,308	2,915,709	0.88
1960	JULY	3,479.2	9,635	576,340	17,619.9	17,943	3,492,049	2.77
1960	AUGUST	2,716.7	7,116	558,002	20,336.6	25,059	4,050,051	2.62
1960	SEPTEMBER	2,865.0	7,519	473,391	23,201.6	32,578	4,523,442	2.62
1960	OCTOBER	3,338.6	9,078	564,606	26,540.2	41,656	5,088,048	2.72
1960	NOVEMBER	2,330.6	9,171	544,557	28,870.8	50,827	5,632,605	3.94
1960	DECEMBER	3,170.2	14,834	507,576	32,041.0	65,661	6,140,181	4.68
1961	JANUARY	3,577.1	19,219	271,981	35,618.1	84,880	6,412,162	5.37
1961	FEBRUARY	2,233.3	10,649	60,174	37,851.4	95,529	6,472,336	4.77
1961	MARCH	2,341.0	14,632	66,916	40,192.4	110,161	6,539,252	6.25
1961	APRIL	1,936.0	12,347	98,594	42,128.4	122,508	6,637,846	6.38
1961	MAY	1,749.0	9,646	109,345	43,877.4	132,154	6,747,191	5.52
1961	JUNE	1,980.4	16,716	353,064	45,857.8	148,870	7,100,255	8.44
1961	JULY	2,554.2	15,368	652,613	48,412.0	164,238	7,752,868	6.02
1961	AUGUST	4,261.5	45,841	656,259	52,673.5	210,079	8,409,127	10.76
1961	SEPTEMBER	5,122.4	46,374	625,653	57,795.9	256,453	9,034,780	9.05
1961	OCTOBER	5,507.1	84,452	639,446	63,303.0	340,905	9,674,226	15.34
1961	NOVEMBER	6,307.0	83,350	650,600	69,610.0	424,255	10,324,826	13.22
1961	DECEMBER	8,546.6	109,025	679,655	78,156.6	533,280	11,004,481	12.76
1962	JANUARY	12,130.2	151,458	684,607	90,286.8	684,738	11,689,088	12.49
1962	FEBRUARY	10,721.5	149,852	647,284	101,008.3	834,590	12,336,372	13.98
1962	MARCH	12,752.3	144,935	732,477	113,760.6	979,525	13,068,849	11.37
1962	APRIL	13,402.0	138,432	756,993	127,162.6	1,117,957	13,825,842	10.33
1962	MAY	15,344.4	267,363	743,753	142,507.0	1,385,320	14,569,595	17.42
1962	JUNE	18,627.5	222,161	699,818	161,134.5	1,607,481	15,269,413	11.93
1962	JULY	20,991.6	273,829	596,976	182,126.1	1,881,306	15,866,389	13.04
1962	AUGUST	20,555.0	359,633	526,730	202,681.1	2,240,939	16,393,119	17.50
1962	SEPTEMBER	17,094.5	596,649	655,530	219,775.6	2,837,588	17,048,649	34.90
1962	OCTOBER	18,853.0	466,378	534,435	238,628.6	3,303,966	17,583,084	24.74
1962	NOVEMBER	20,638.1	285,817	489,548	259,266.7	3,589,783	18,072,632	13.85

TABLE 2

## INJECTION WELL GROUPING

GROUP I - Wells with 10 feet or more of high permeability  
Upper Burbank sand

<u>Well Number</u>	<u>Injection Rate, BPD</u>
Art 7	2378
Art 8	1284
Fanny 5	3334
Gale 11	2541
Gale 14	3622
Hiram 10	3290
Hiram 12	746
Hiram 17	3375
Pappin 12	2193
Pappin 13	3220

GROUP II - Wells with less than 10 feet of high permeability  
Upper Burbank sand

<u>Well Number</u>	<u>Injection Rate, BPD</u>
Big Eagle 9	205
Big Eagle 11	2723
Brenner 7	625
Brenner 9	1590
Brenner 12	138
Fanny 4	1099
Gale 10	906
Hiram 11	1497
Pappin 14	589

TABLE 3

POLYMER DILUTION OF FLUID  
SWABBED DURING  
POLYMER DEGRADATION TEST

<u>Event</u>	<u>R<sub>s</sub> Screen Factor Equivalent (Field Test)</u>	<u>Polymer Concentration (Lab Values)</u>	<u>Chloride Content</u>
Sample caught @ surface	25.3	977 PPM	356 mg/l
*Sample caught after swabbing 5 bbls	25.3	1,066 PPM	356 mg/l
Sample caught after swabbing 15 bbls	25.3	1,066 PPM	356 mg/l
**Sample caught after swabbing 28 bbls	18.4	933 PPM	747 mg/l
Sample caught after swabbing 33 bbls	21.8	755 PPM	853 mg/l
Sample caught after swabbing 37 bbls	20.0	600 PPM	853 mg/l

FLUID: Fresh Water - 1,000 PPM P-700 Polymer - 2.5 PPM Oxygen  
Scavenger - 10 PPM Biocide

TUBING VOLUME: 15.7 bbls

VOL TO PERFORATIONS: 19.6 bbls

\*R<sub>s</sub> value on under laboratory condition @ 1,000 PPM is 27.

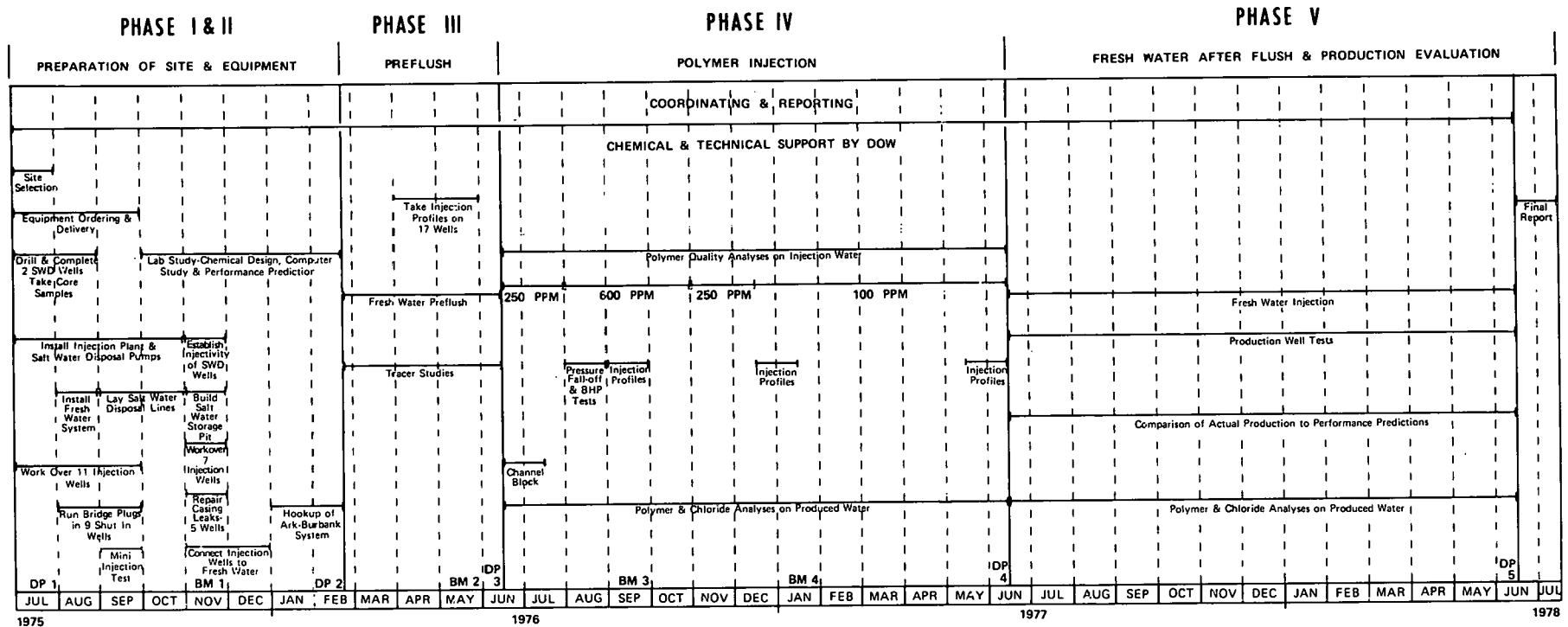
\*\*Swabbing problems during this pull damaged the polymer and reduced the R<sub>s</sub> value.

TABLE 4

## CHEMICAL COMPATIBILITY TEST

Fluid	$R_s$ Screen Factor Equivalent
Oxygen Scavenger 2.5 PPM	
Biocide 10.0 PPM	
Fresh Water - $O_2$ Scavenger - Biocide - 1000 PPM P-700	25.3
Fresh Water - $O_2$ Scavenger - 1000 PPM P-700	25.3
Fresh Water - 1000 PPM P-700	23.7
Fresh Water - Biocide - 1000 PPM P-700	23.7
Fresh Water - Biocide - $O_2$ Scavenger - 1000 PPM P-700	25.3
Fresh Water - $O_2$ Scavenger - Biocide - 800 PPM P-700	21.6
Fresh Water - $O_2$ Scavenger - 800 PPM P-700	21.6
Fresh Water - 800 PPM P-700	19.2
Fresh Water - Biocide - 800 PPM P-700	19.2
Fresh Water - Biocide - $O_2$ Scavenger - 800 PPM P-700	21.6
Fresh Water - $O_2$ Scavenger - Biocide - 600 PPM P-700	19.4
Fresh Water - $O_2$ Scavenger - 600 PPM P-700	19.4
Fresh Water - 600 PPM P-700	17.0
Fresh Water - Biocide - 600 PPM P-700	17.0
Fresh Water - Biocide - $O_2$ Scavenger - 600 PPM P-700	19.4

FIGURE 1  
**MILESTONE CHART**  
**POLYMER INJECTION PROJECT**  
**Controlled Water Flooding**



DECISION POINT 1. IS THE TEST SITE ADEQUATE ?  
 DECISION POINT 2. IS THE TEST SITE READY FOR FRESH WATER INJECTION ?  
 DECISION POINT 3. IS THE TEST SITE READY FOR POLYMER INJECTION ?  
 DECISION POINT 4. IS THE POLYMER INJECTION COMPLETE ?  
 DECISION POINT 5. IS ADDITIONAL EVALUATION DATA NEEDED ?

BENCH MARK 1. ATTAINMENT OF ADEQUATE PRODUCED WATER DISPOSAL CAPACITY  
 BENCH MARK 2. COMPLETION OF INJECTION PROFILE SURVEYS DURING FRESH WATER INJECTION  
 BENCH MARK 3. COMPLETION OF TWO MONTHS OF POLYMER INJECTION  
 BENCH MARK 4. COMPLETION OF INJECTION PROFILE SURVEYS AFTER 1/3 OF POLYMER SLUG HAS BEEN INJECTED

FIGURE 2

NORTH STANLEY INJECTION PROFILE PATTERNS

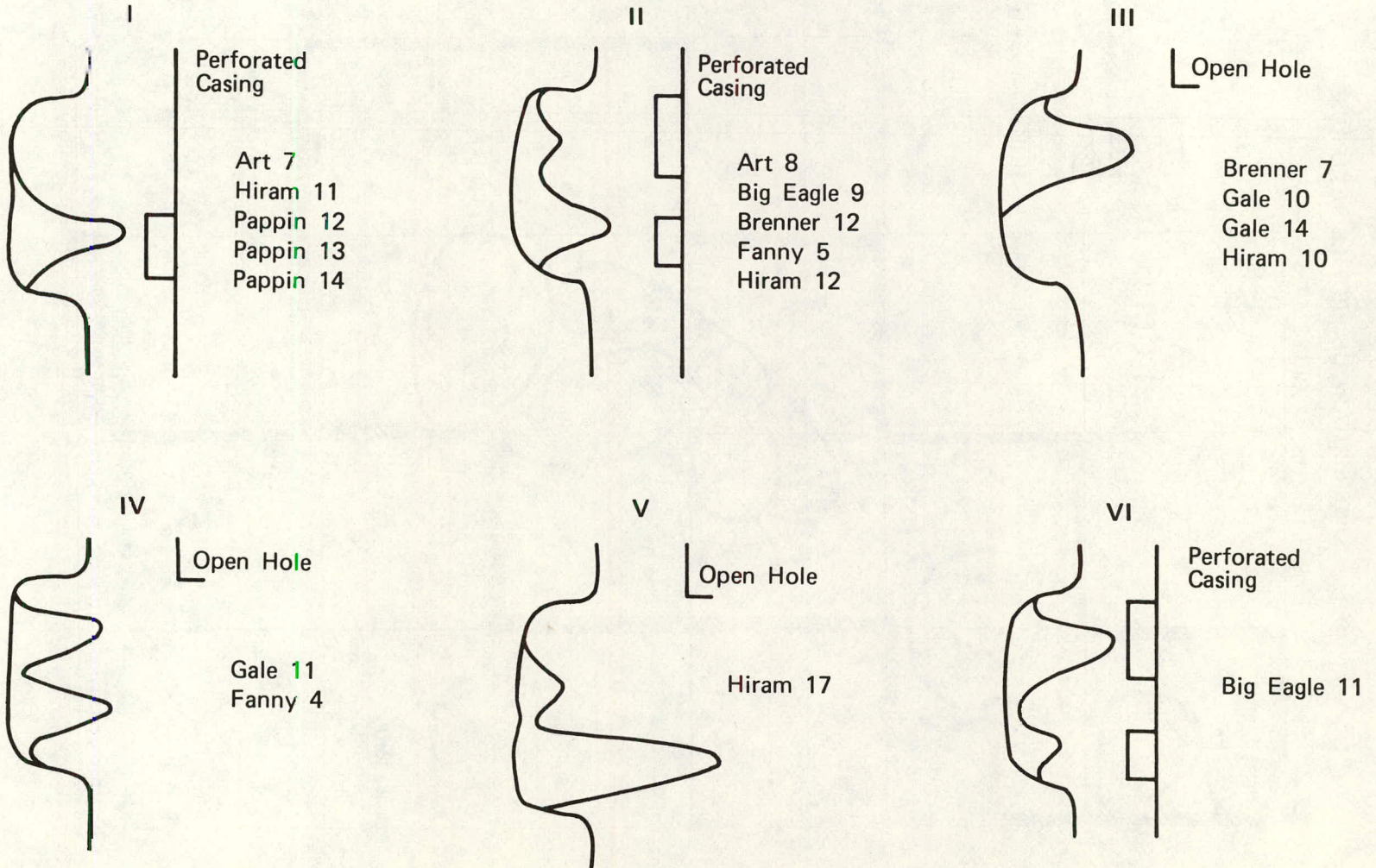
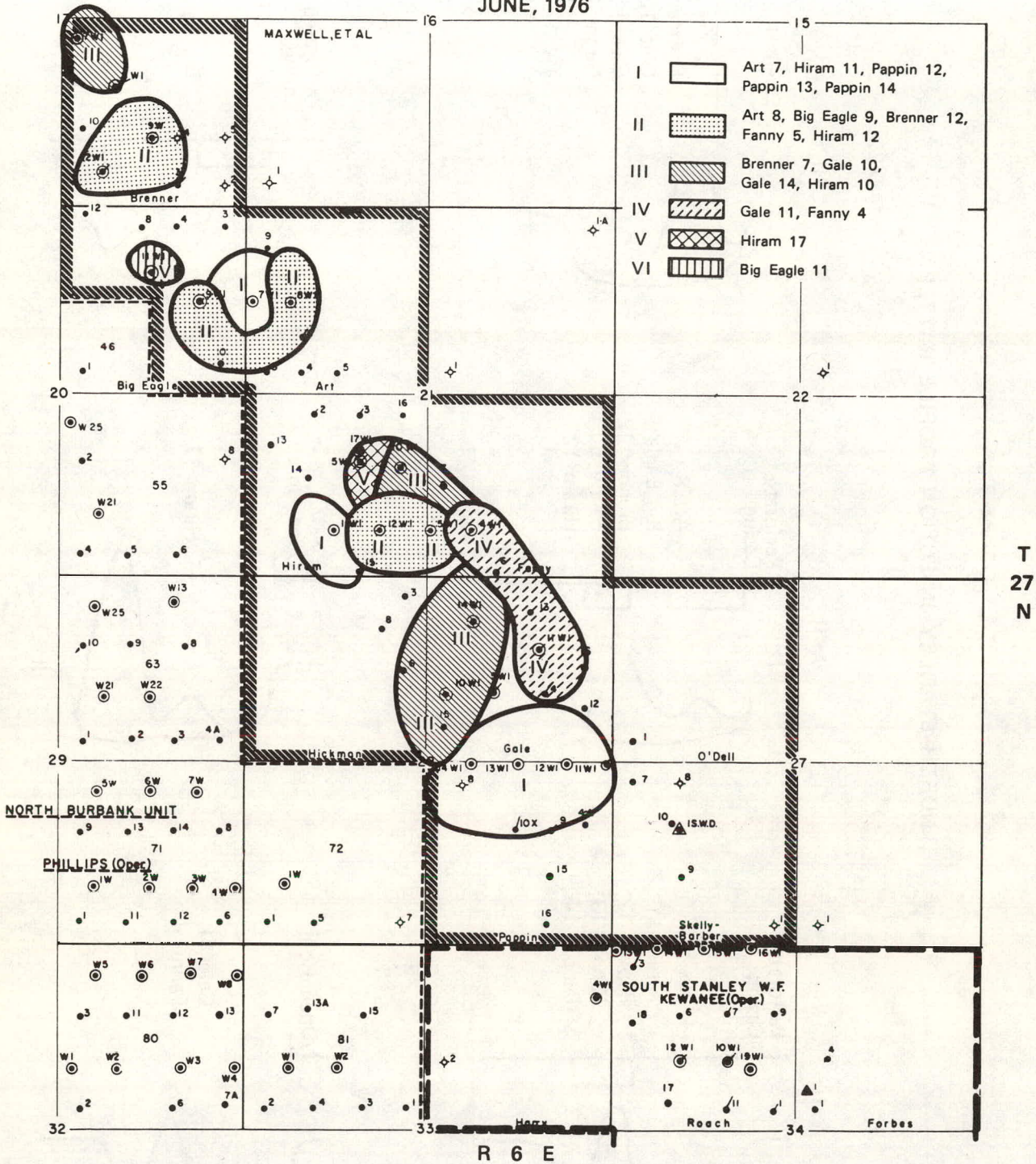


FIGURE 3

DISTRIBUTION OF PROFILE PATTERNS

JUNE, 1976



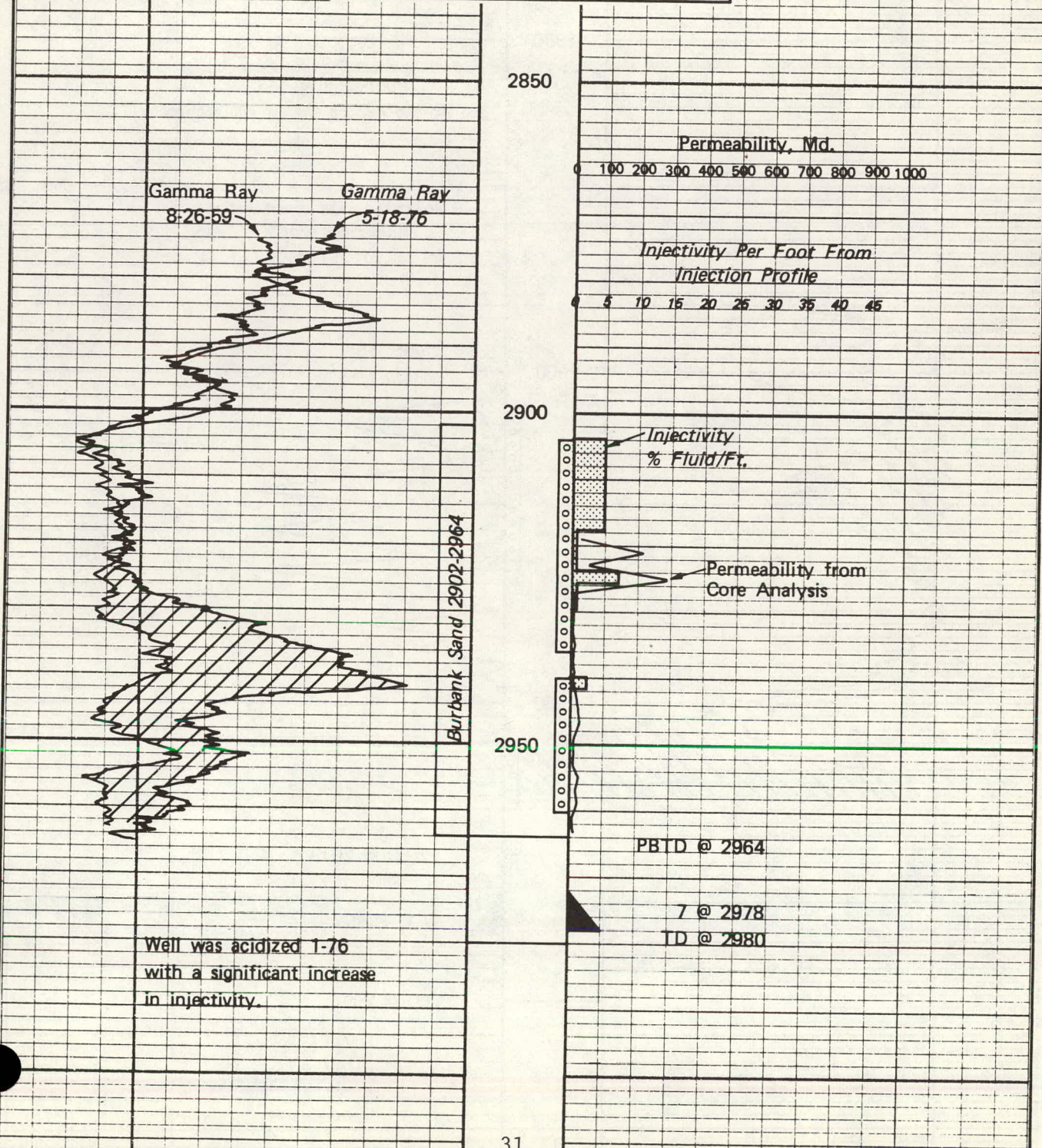
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<p><b>LEGEND</b></p> <ul style="list-style-type: none"> <li>● Oil Well</li> <li>▲ Abdn Oil Well</li> <li>○ Location</li> <li>◇ Dry Hole</li> <li>☆ Gas Well</li> <li>* Abdn Gas Well</li> <li>○ Inactive Well</li> <li>● Water Input Well</li> <li>▲ S.W.D.</li> <li>◇ W.S.W.</li> <li>● Gas Input Well</li> </ul>		<p><b>KEWANEE OIL COMPANY</b></p> <p><b>STANLEY POLYMER PROJECT</b></p> <p>OSAGE CO., OKLAHOMA</p>		<p><b>DISTRICT: BURBANK</b></p> <p><b>AREA: EAST AREA</b></p> <p>SCALE 660' 0" 1320' 2640'</p>		<p>Drawn <b>PLM</b></p> <p>Traced</p> <p>Checked</p> <p>Date <b>6-21-59</b></p>		<p><b>REVISED</b></p> <table border="1"> <tr> <th>DATE</th> <th>BY</th> </tr> <tr> <td>4-1-76</td> <td>MLA</td> </tr> <tr> <td>5-7-76</td> <td>J.S.</td> </tr> </table> <p>File <b>B-6A</b></p>		DATE	BY	4-1-76	MLA	5-7-76	J.S.
DATE	BY														
4-1-76	MLA														
5-7-76	J.S.														

Tubing packer @ 2805

FIGURE 4  
BIG EAGLE 9WI  
INJECTIVITY OF FRESH WATER  
5 - 76



Tubing packer @ 2785

FIGURE 5  
ART 8WI  
INJECTIVITY OF FRESH WATER  
5 - 76

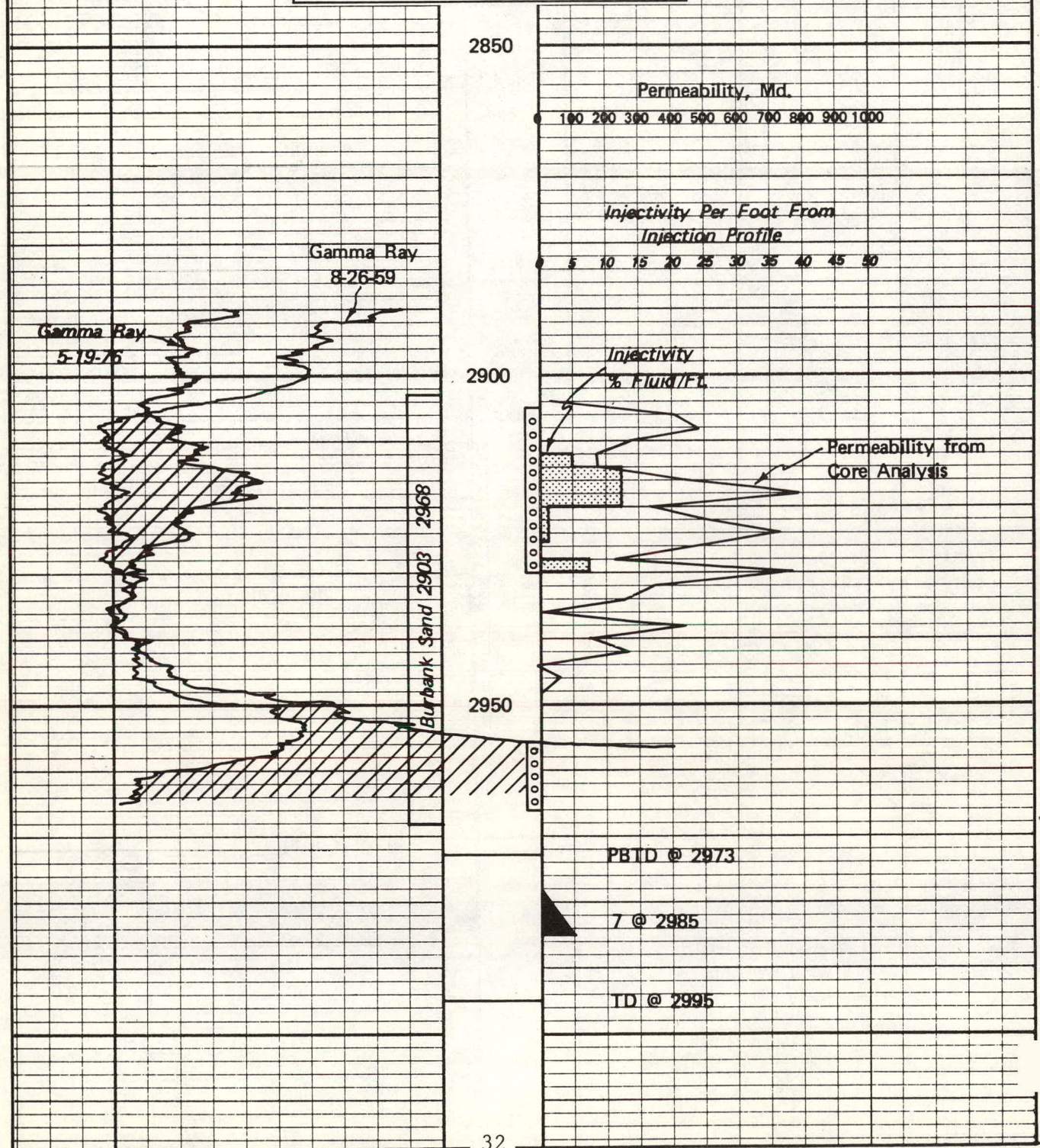


FIGURE 6  
 FANNY 5WI  
 INJECTIVITY OF FRESH WATER  
 5 - 76

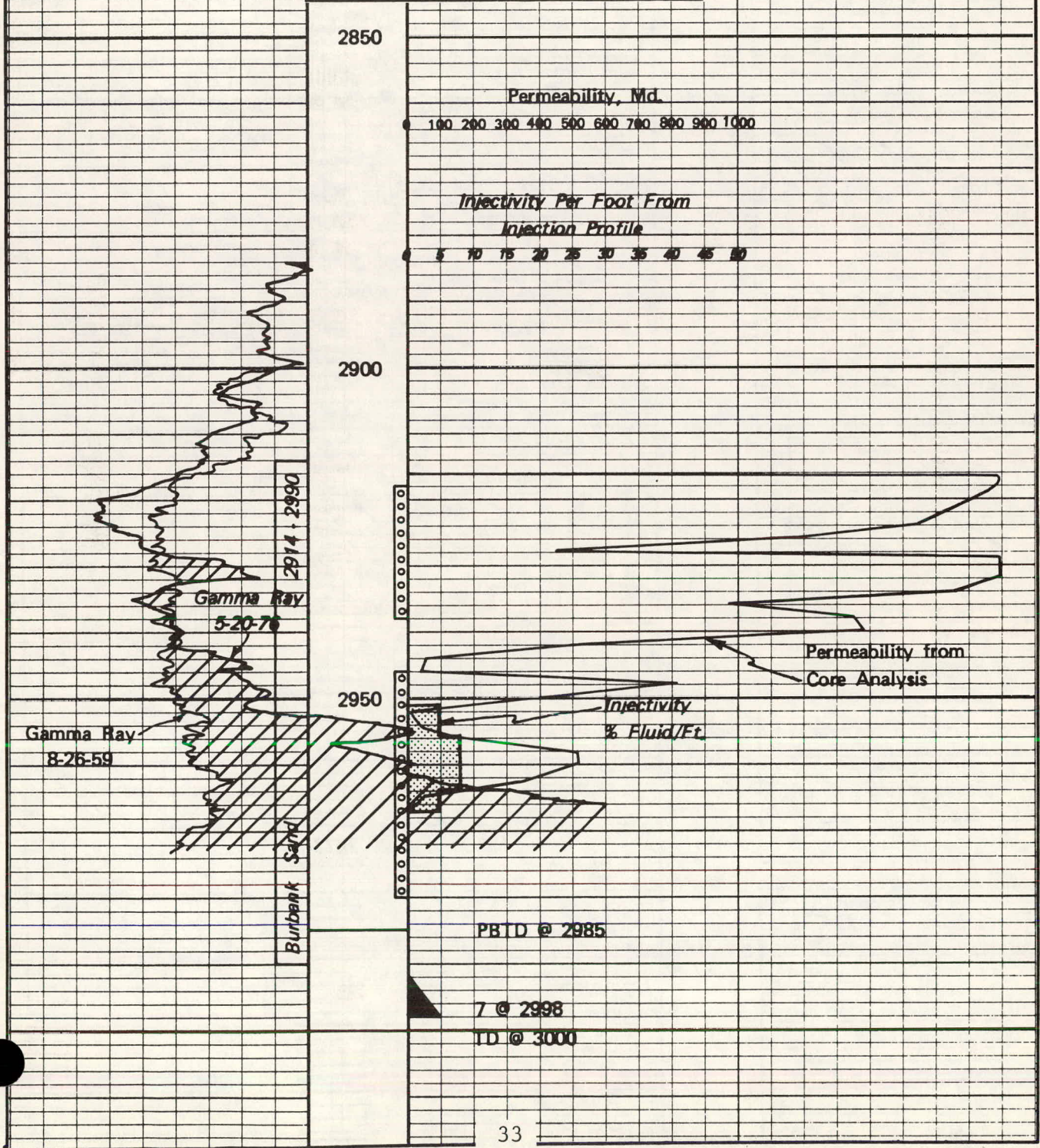


FIGURE 7  
 HIRAM 17WI  
 INJECTIVITY OF FRESH WATER  
 5 - 76

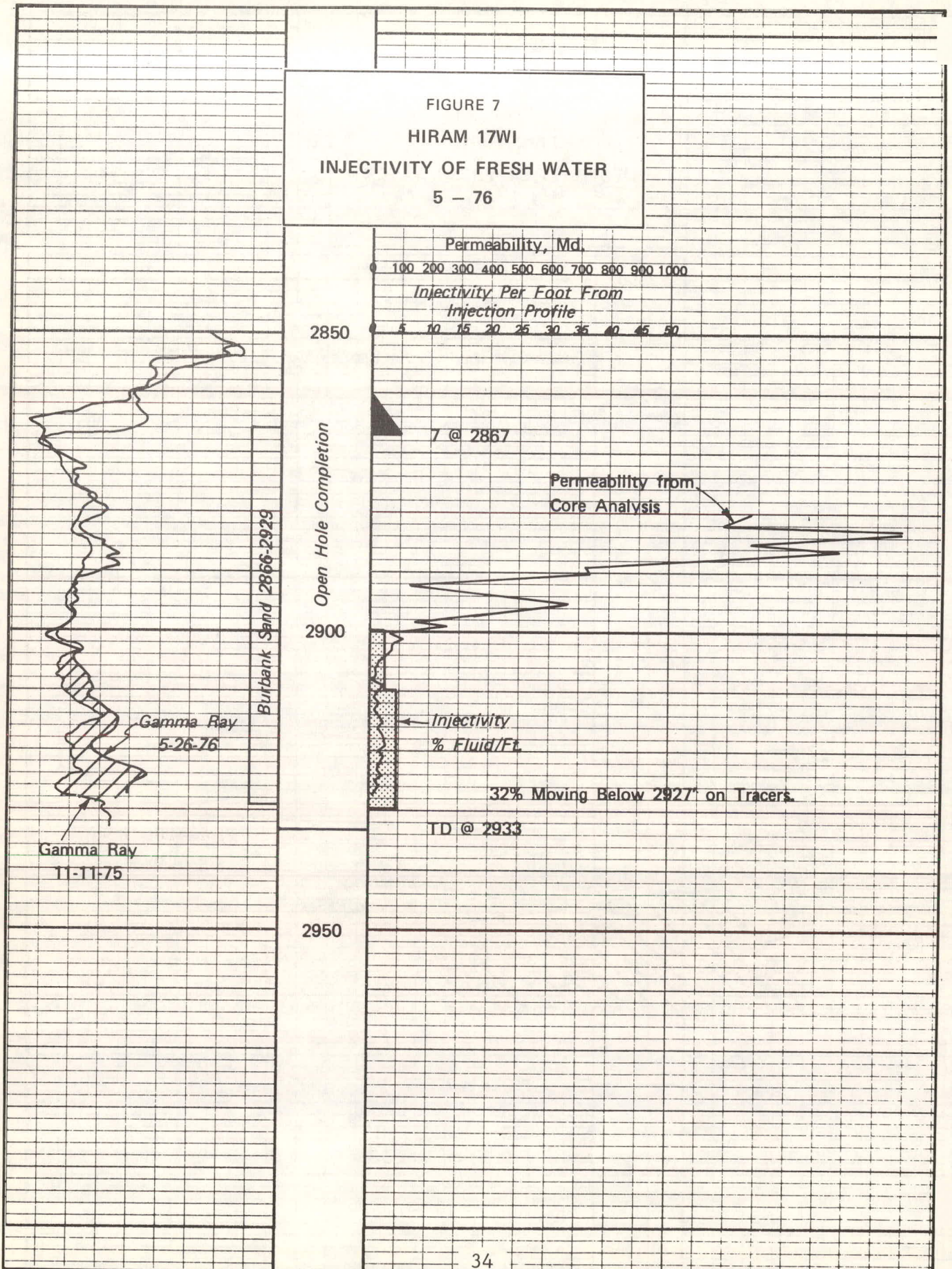
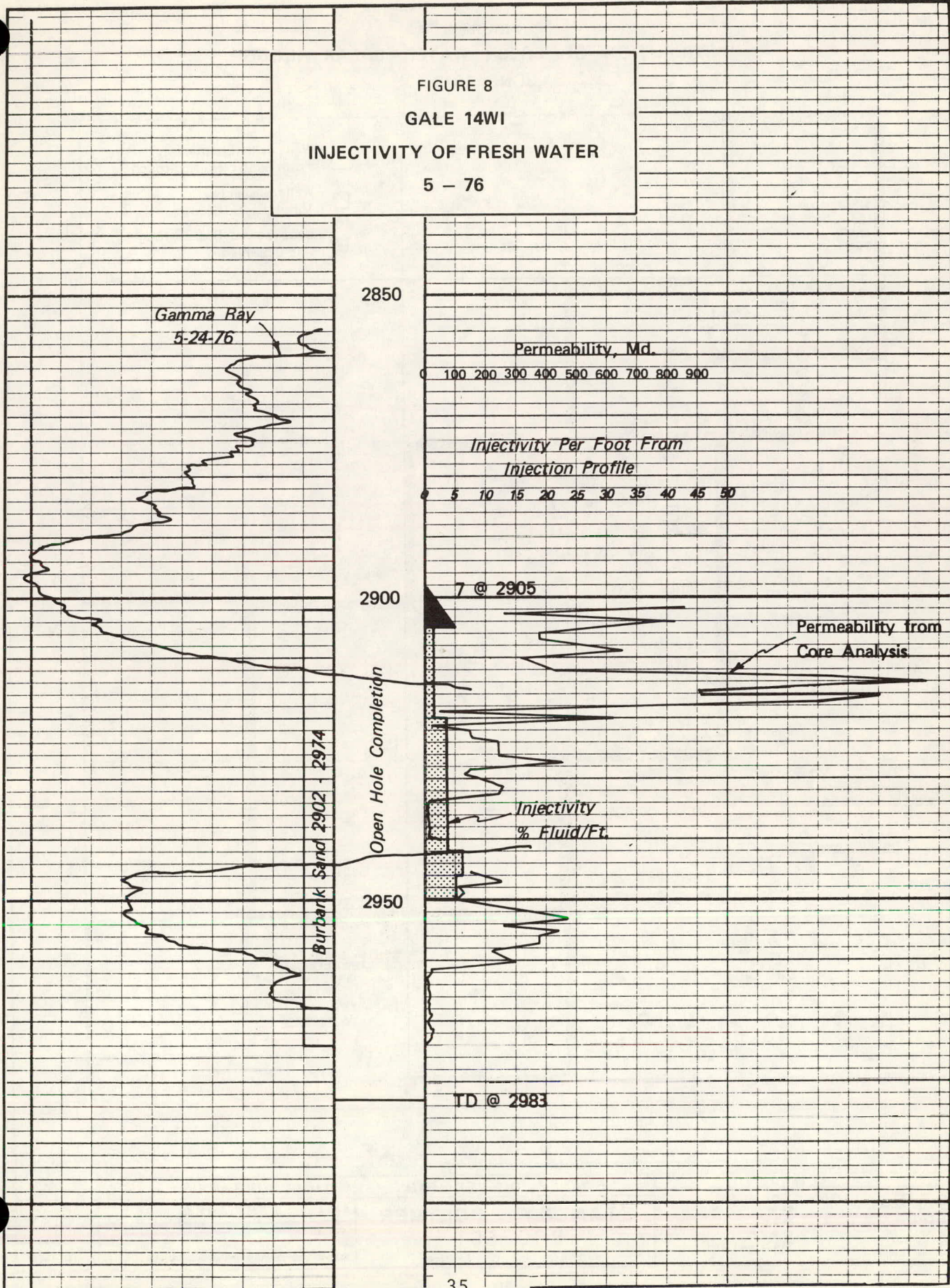
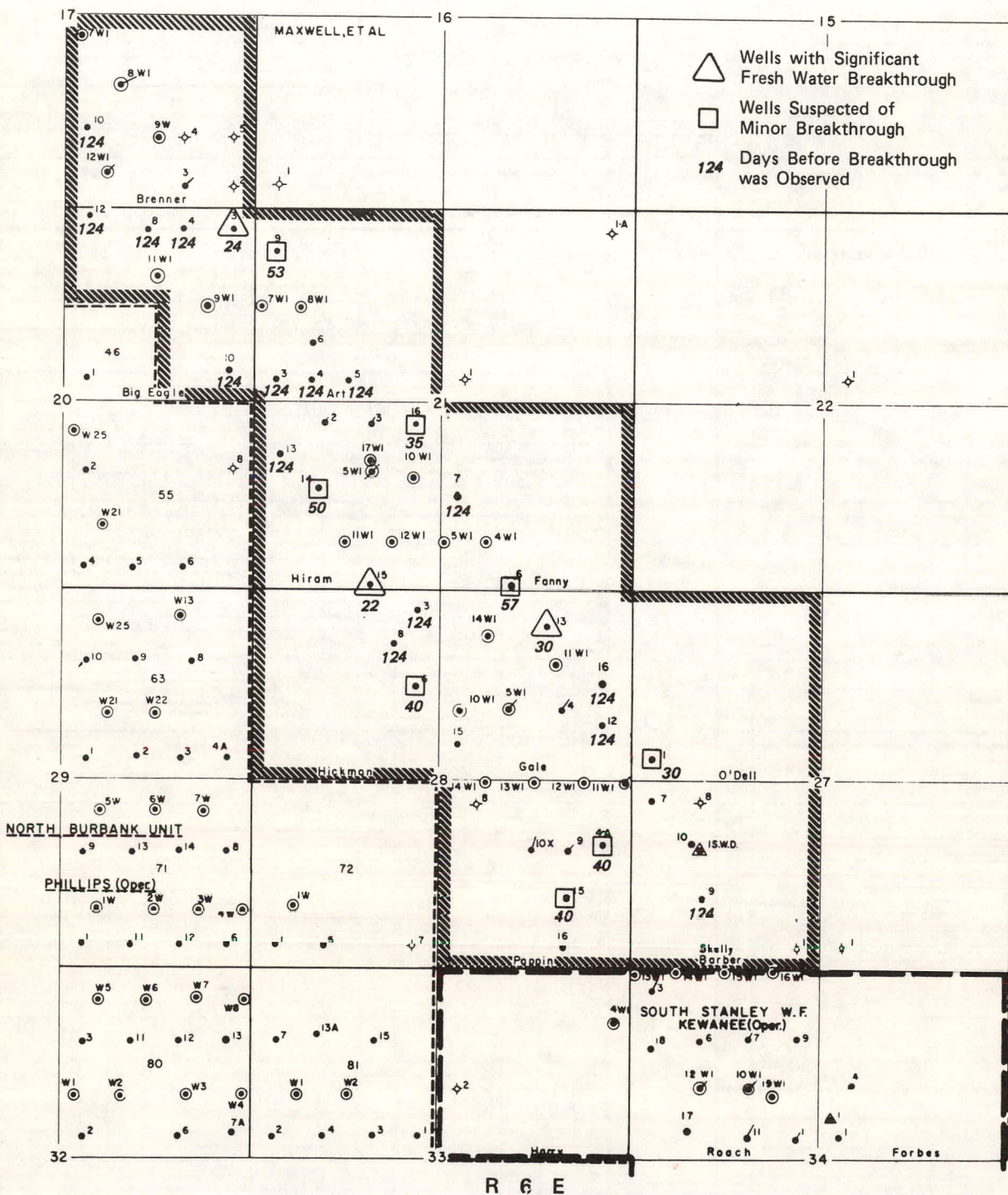


FIGURE 8  
 GALE 14WI  
 INJECTIVITY OF FRESH WATER  
 5 - 76



**FIGURE 9**  
**DISTRIBUTION OF FRESH WATER BREAKTHROUGH**  
**JUNE, 1976**

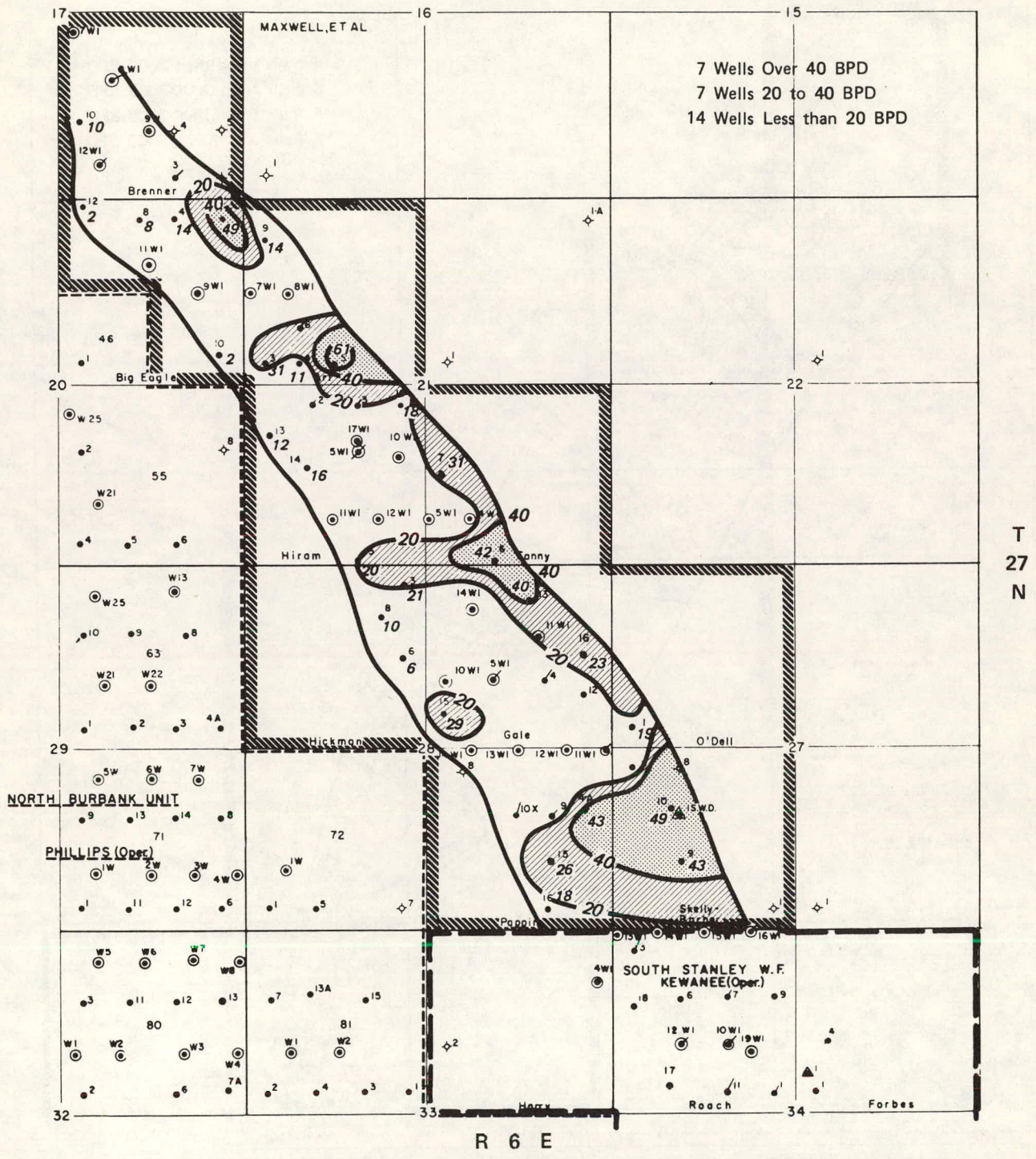


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<b>LEGEND</b> ● Oil Well ▲ Abdn Oil Well ○ Location ✦ Dry Hole * Gas Well * Abdn Gas Well ○ Inactive Well ● Water Input Well ▲ S.W.D. ■ W.S.W. ● Gas Input Well		<b>KEWANEE OIL COMPANY</b> <b>STANLEY POLYMER PROJECT</b> OSAGE CO., OKLAHOMA		DISTRICT: <b>BURBANK</b> AREA: <b>EAST AREA</b> SCALE 660' 0' 1320' 2640'	Drawn <b>PLM</b> Traced Checked Date <b>6-21-79</b> File	REVISED DATE BY 4-1-76 M.H. 5-7-76 J.S. <b>B-6A</b>
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FIGURE 10  
 DISTRIBUTION OF OIL PRODUCTION  
 JUNE, 1976



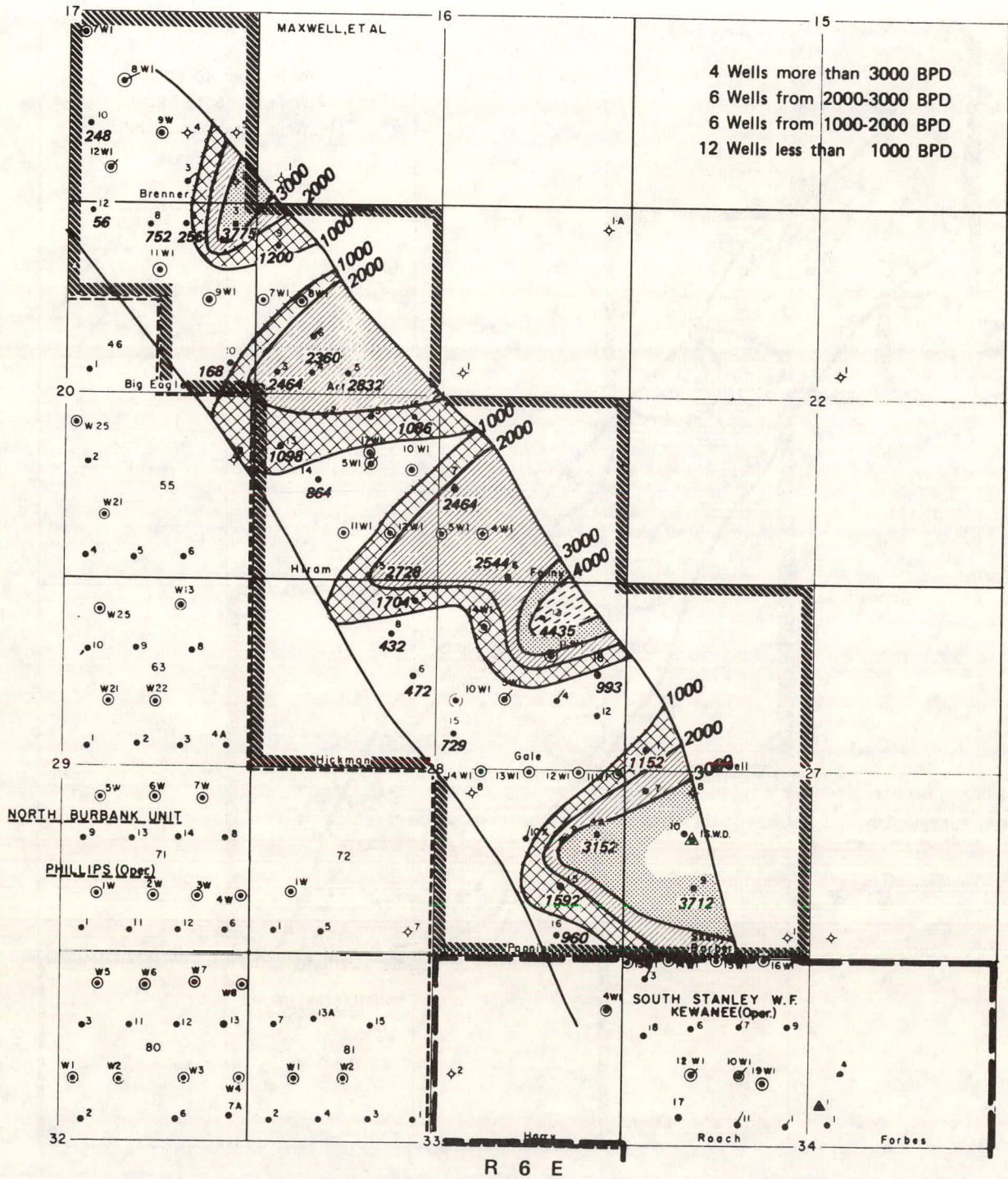
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<b>LEGEND</b> ● Oil Well ◐ Abdn Oil Well ○ Location ◇ Dry Hole ☆ Gas Well ✱ Abdn Gas Well ◐ Inactive Well ● Water Input Well ▲ S.W.D. ◐ W.S.W. ● Gas Input Well	<b>KEWANEE OIL COMPANY</b> <b>STANLEY POLYMER PROJECT</b> OSAGE CO., OKLAHOMA	<b>DISTRICT: BURBANK</b>	Drawn <b>PLM</b>	REVISED DATE BY 4-1-76 M.H. 5-7-76 J.S.
		<b>AREA: EAST AREA</b>	Checked Date 6-21-76	File <b>B-6A</b>

**FIGURE 11**  
**DISTRIBUTION OF TOTAL FLUID PRODUCING RATE**  
**JUNE, 1976**

4 Wells more than 3000 BPD  
 6 Wells from 2000-3000 BPD  
 6 Wells from 1000-2000 BPD  
 12 Wells less than 1000 BPD



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R 6 E

<b>LEGEND</b> ● Oil Well ◐ Abdn Oil Well ○ Location ◇ Dry Hole ☆ Gas Well * Abdn Gas Well ● Inactive Well ● Water Input Well ▲ S.W.D. ◐ W.S.W. ● Gas Input Well		<b>KEWANEE OIL COMPANY</b> <b>STANLEY POLYMER PROJECT</b> OSAGE CO., OKLAHOMA		DISTRICT: <b>BURBANK</b> AREA: <b>EAST AREA</b> SCALE: 660' 0" 1320' 2640' Date: 6-21-59		Drawn: <b>PLM</b> Traced: 6-17-59 Checked: 5-7-76 Date: 6-21-59 File: <b>B-6A</b>	
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FIGURE 12

WATER ANALYSIS HISTORY OF WELLS  
EXPERIENCING MAJOR BREAKTHROUGH

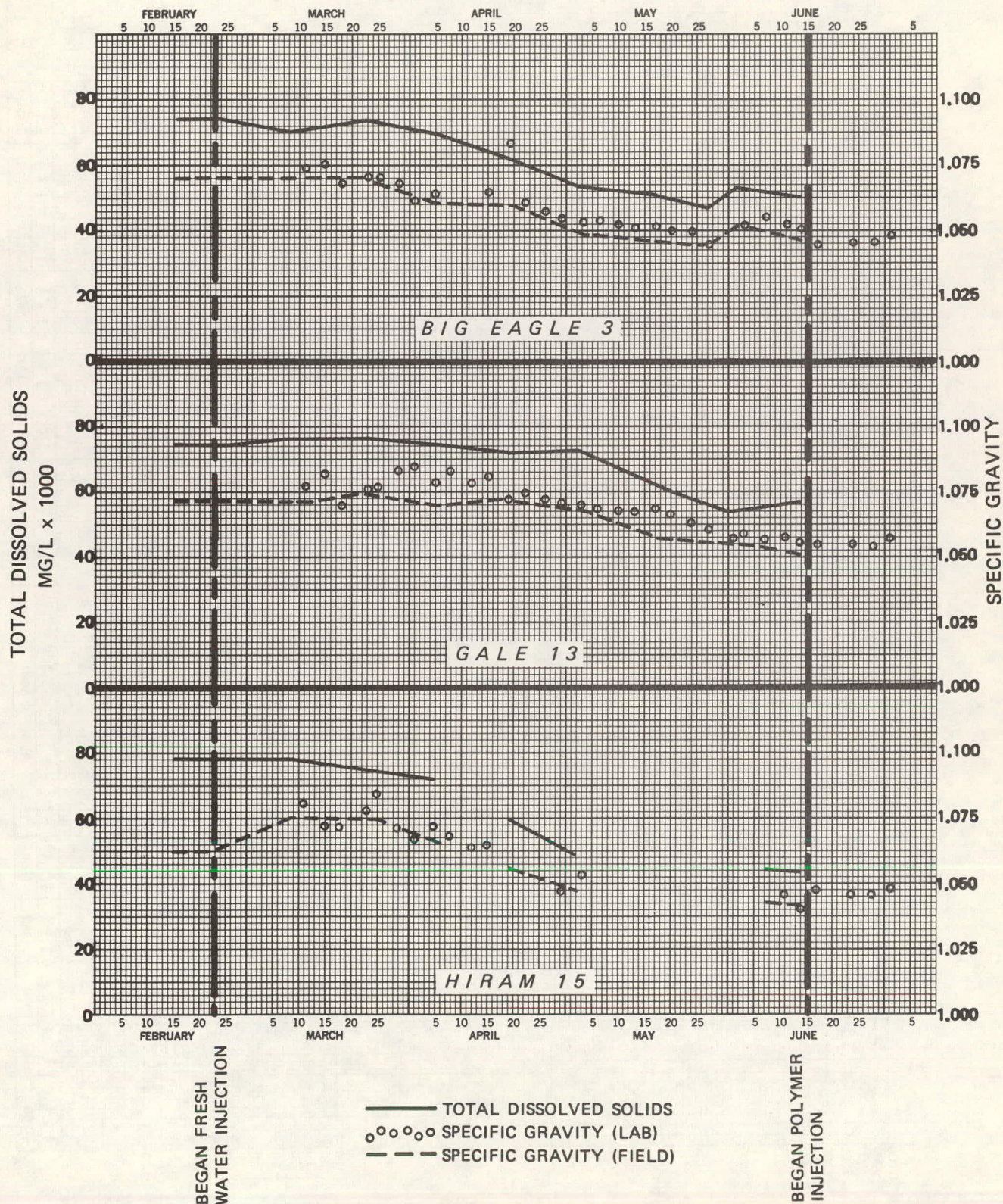


FIGURE 13  
 COMPARISON OF ACTUAL WATERFLOOD PERFORMANCE  
 vs COMPUTER PREDICTION FOR PROJECT AREA

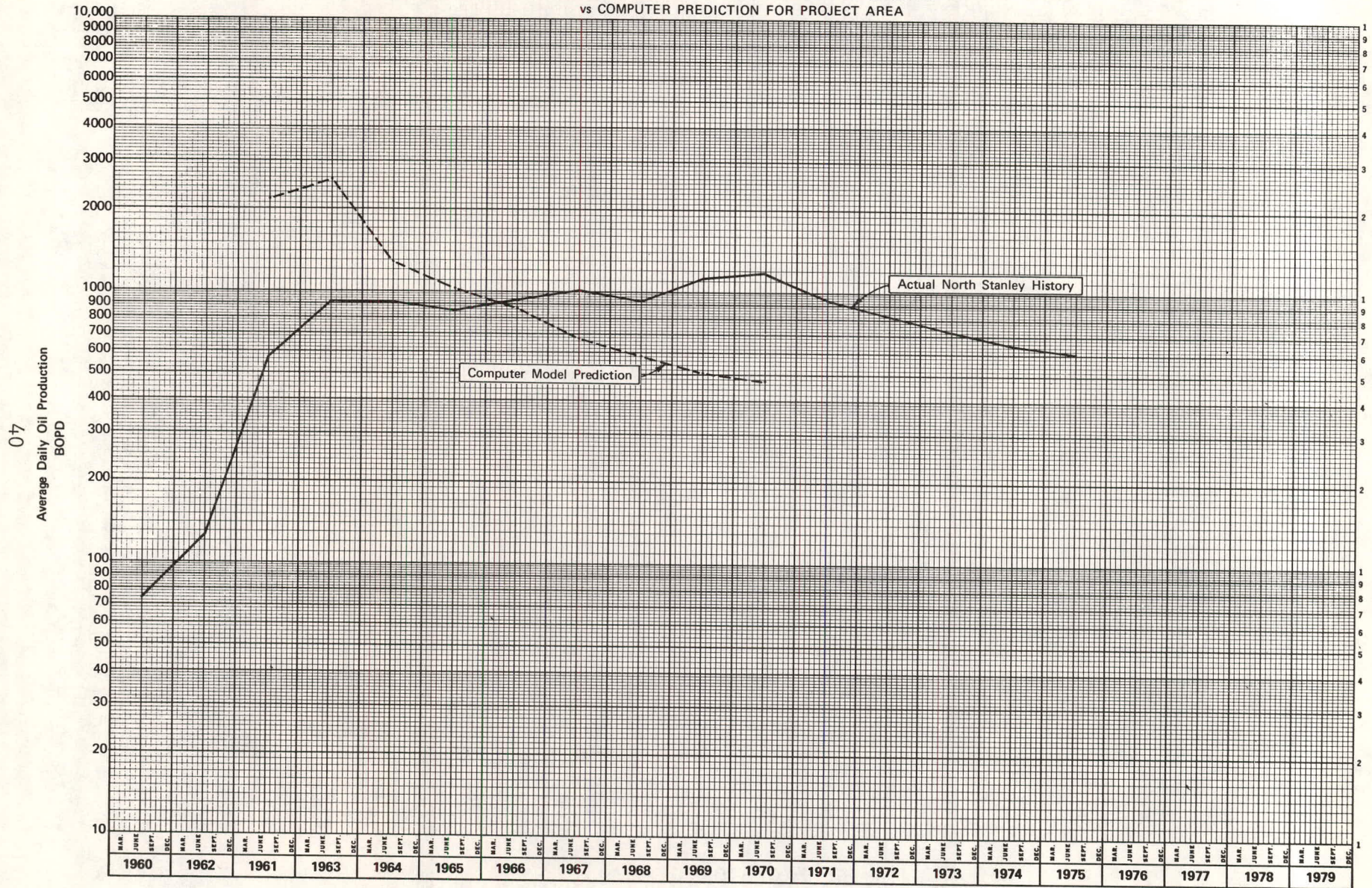


FIGURE 14  
 PREDICTED POLYMER RESPONSE

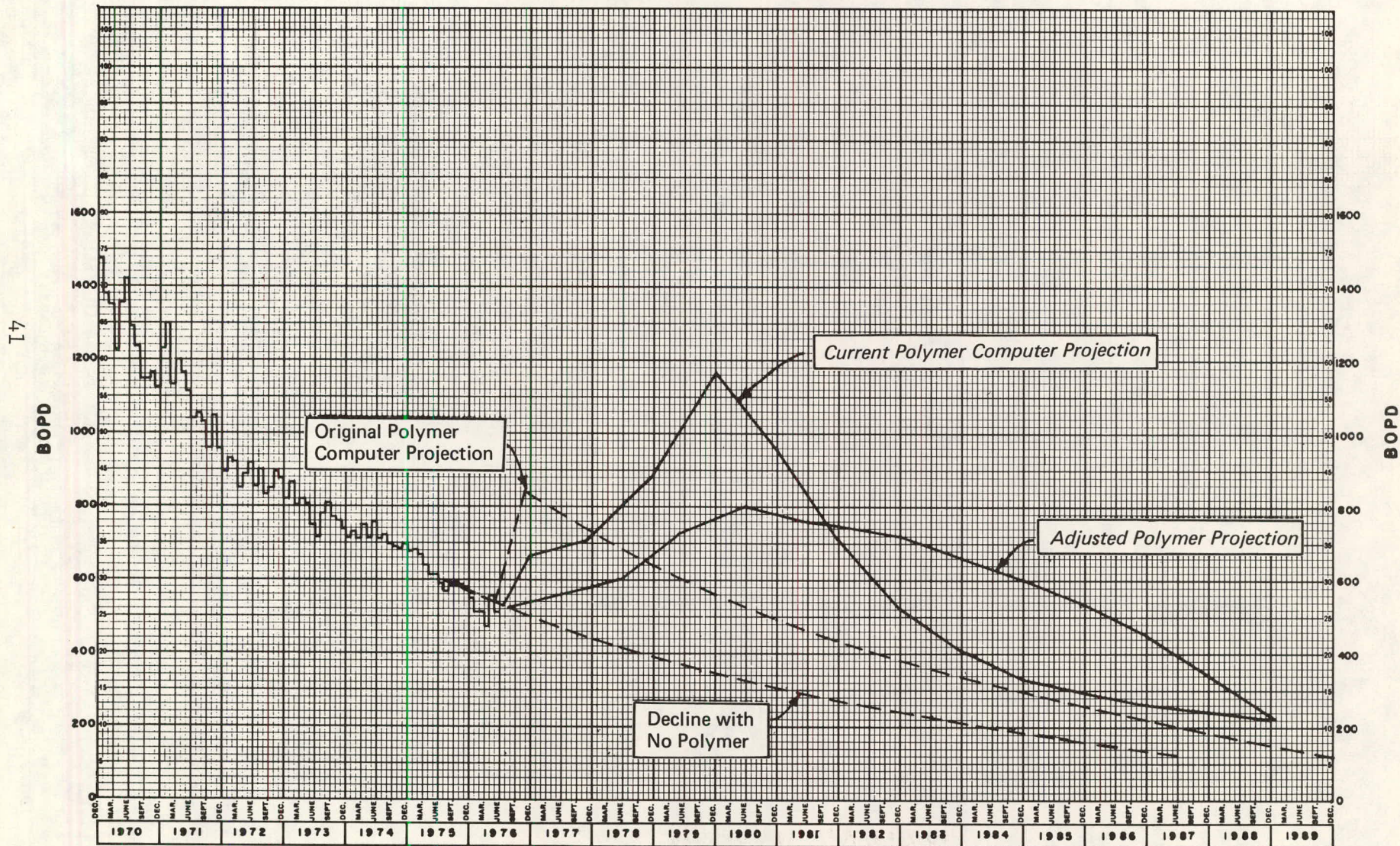
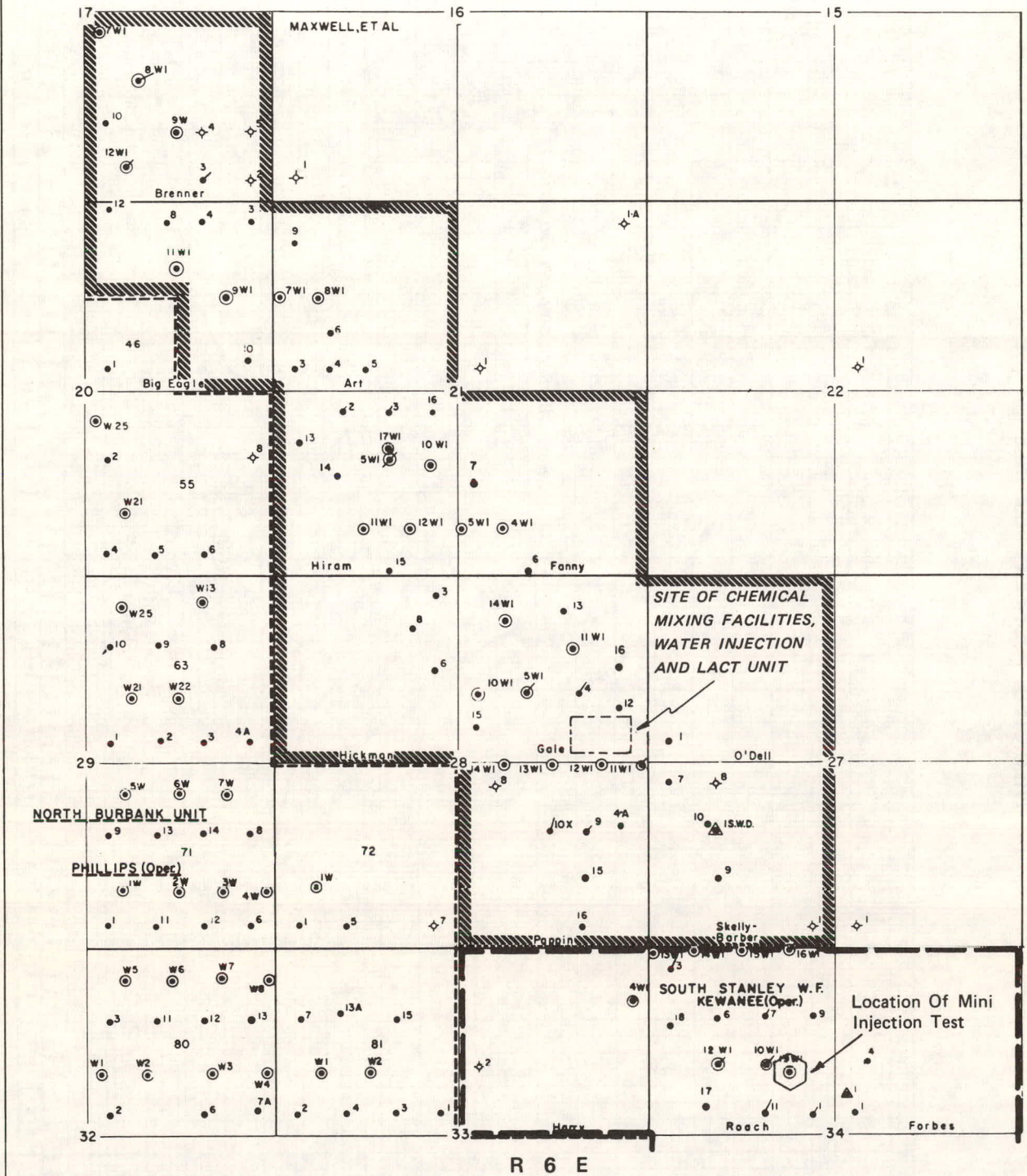


FIGURE 15

LOCATION OF MINI INJECTION TEST SITE



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LEGEND	
● Oil Well	○ Inactive Well
● Abdn Oil Well	● Water Input Well
○ Location	● S.W.D.
◇ Dry Hole	■ W.S.W.
★ Gas Well	● Gas Input Well
★ Abdn Gas Well	

KEWANEE OIL COMPANY  
**STANLEY POLYMER PROJECT**  
 OSAGE CO., OKLAHOMA

DISTRICT: <b>BURBANK</b>	Drawn <b>PLM</b>	REVISID
AREA: <b>EAST AREA</b>	Traced <b>4-1-76</b>	DATE BY
SCALE	Checked	5-7-76
660' 0' 1320' 2640'	Date <b>6-21-59</b>	File <b>B-6A</b>

FIGURE 16  
CONFIGURATION OF EQUIPMENT  
FOR MINI INJECTION TEST

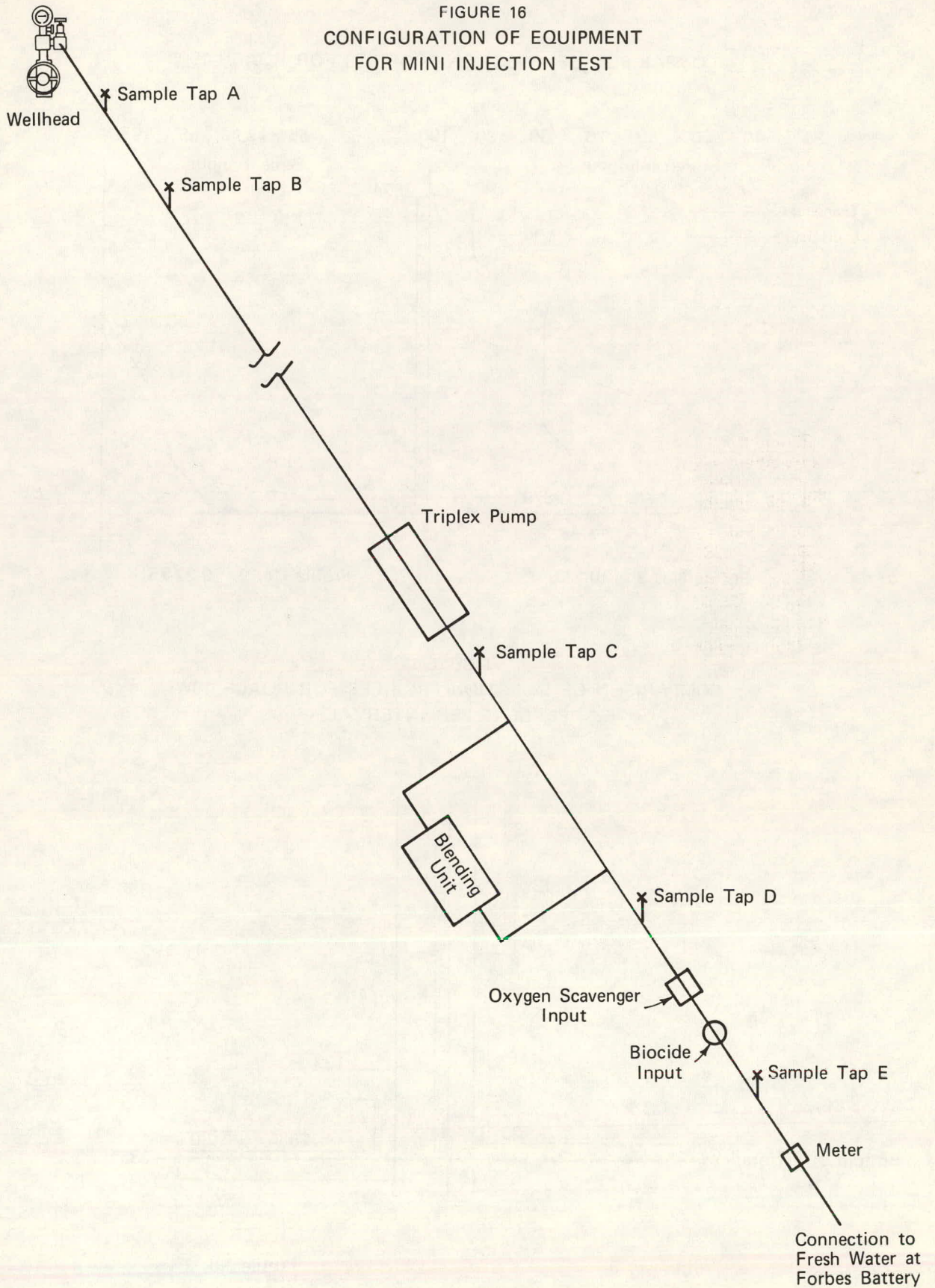


FIGURE 17  
COMPARISON OF INJECTION PROFILES FOR ROACH 19W1

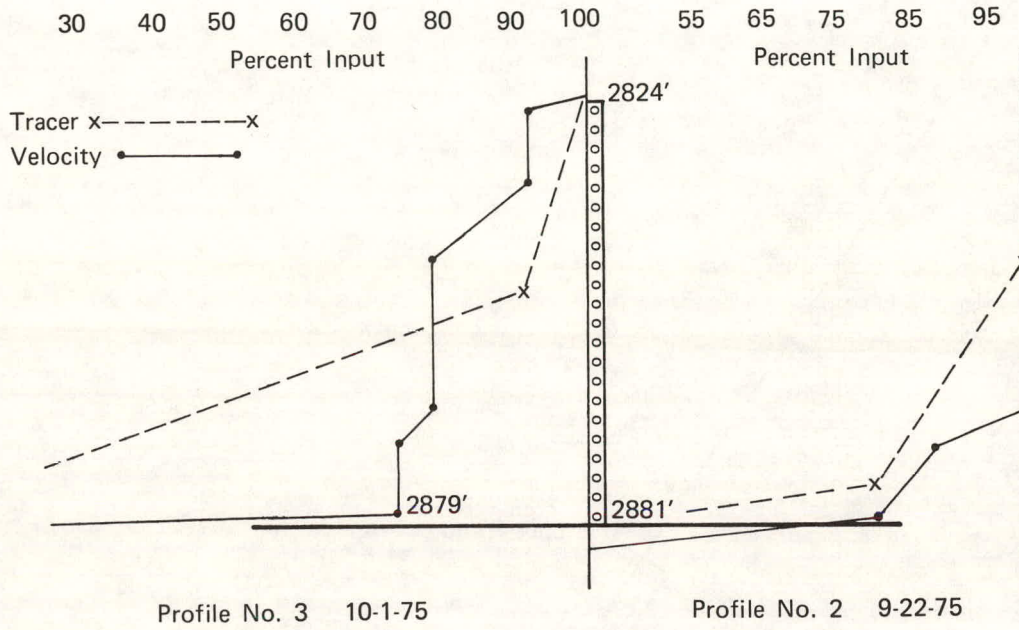


FIGURE 18  
COMPARISON OF INJECTION PROFILES FOR ROACH 19W1  
(PERCENT PER INTERVAL)

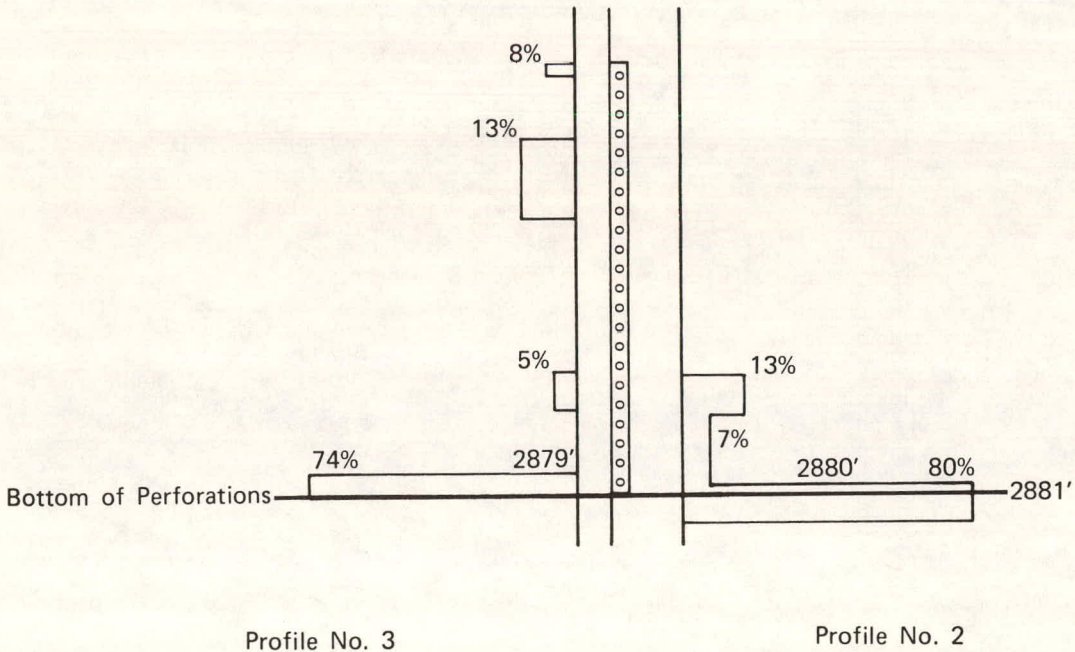


FIGURE 19

TOTAL DISSOLVED SOLIDS VS. TIME  
FOR WELLS OFFSETTING ROACH 19WI (MINI-TEST INJECTION WELL)

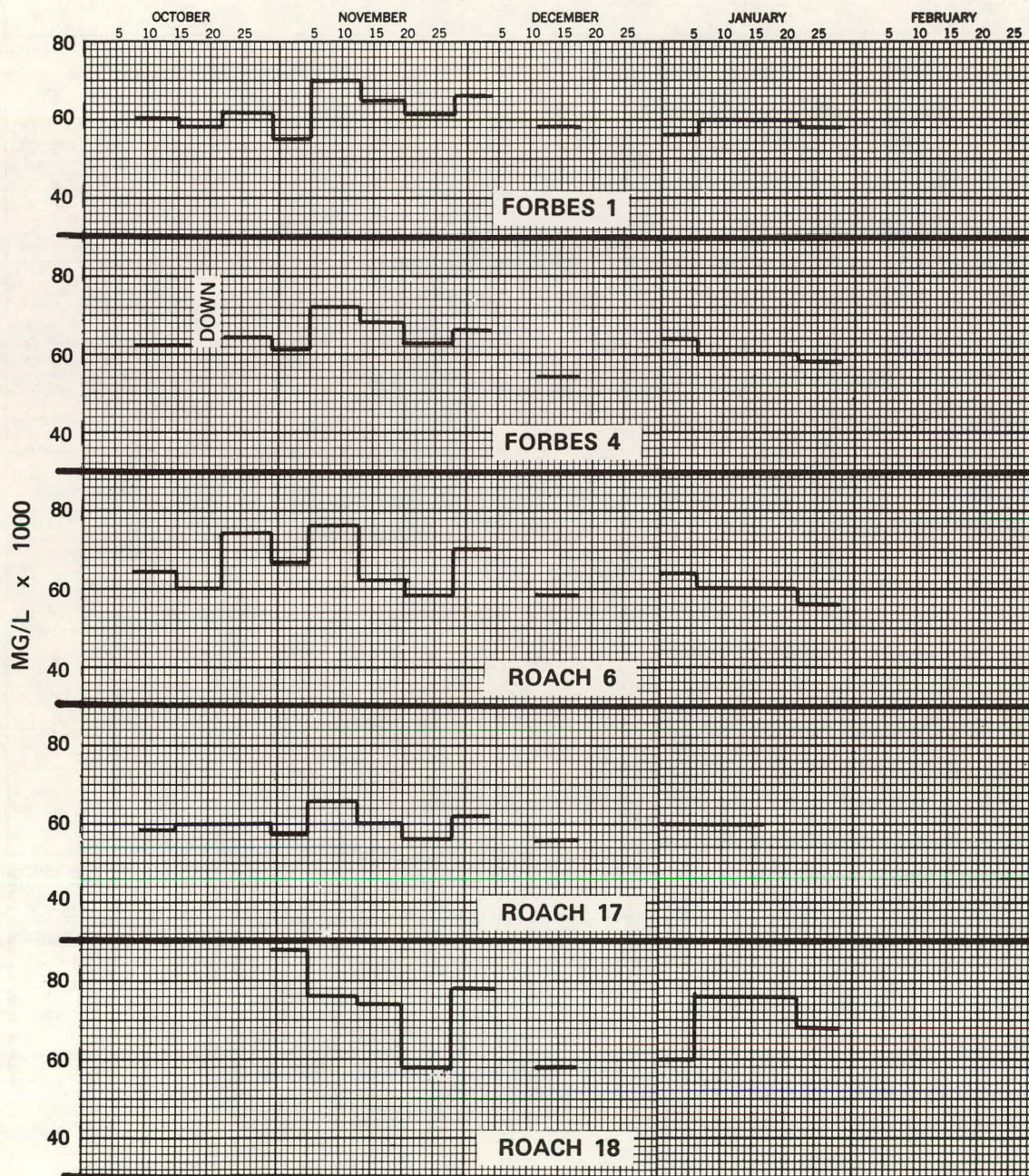
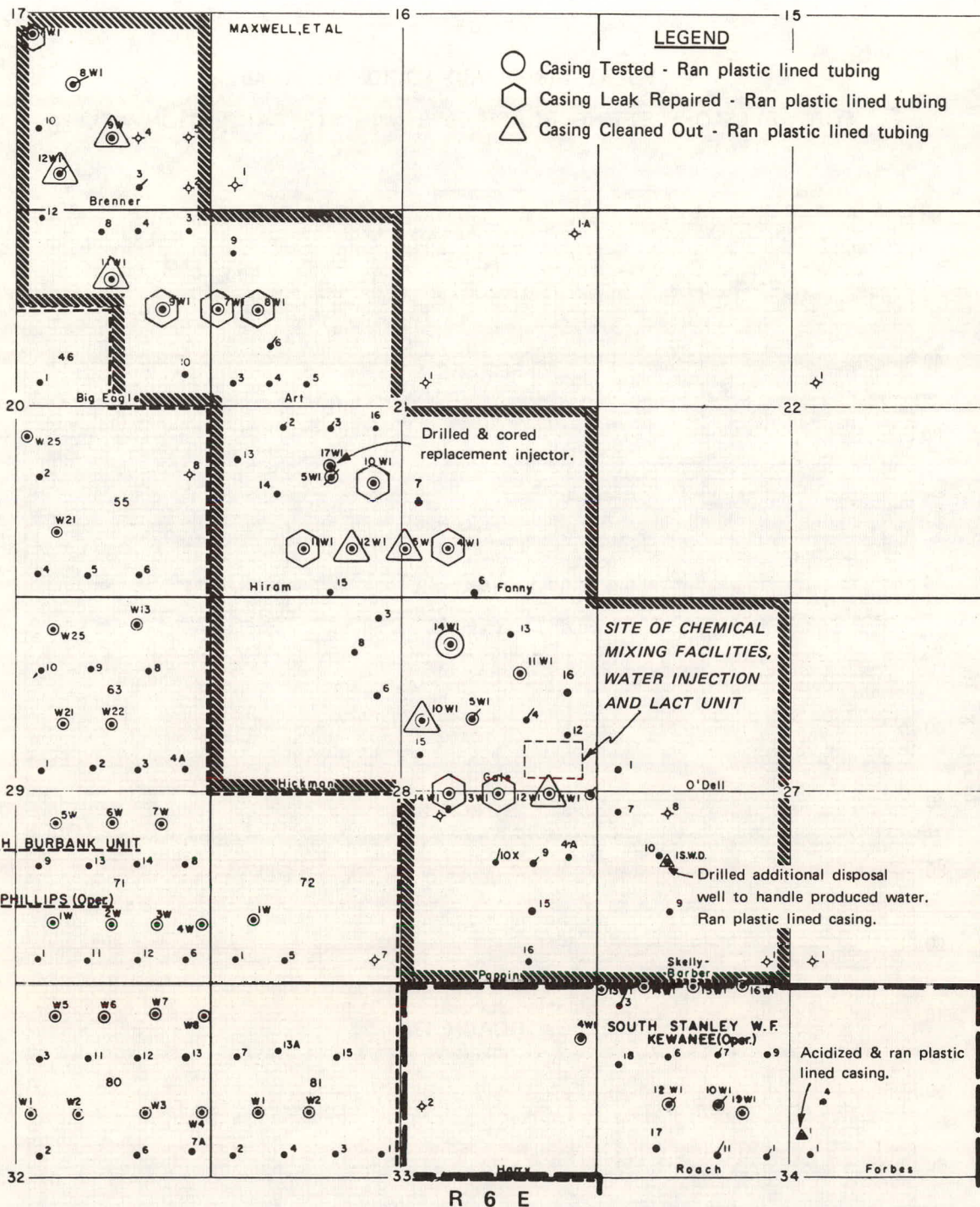


FIGURE 20

INJECTION WELL REMEDIAL SUMMARY



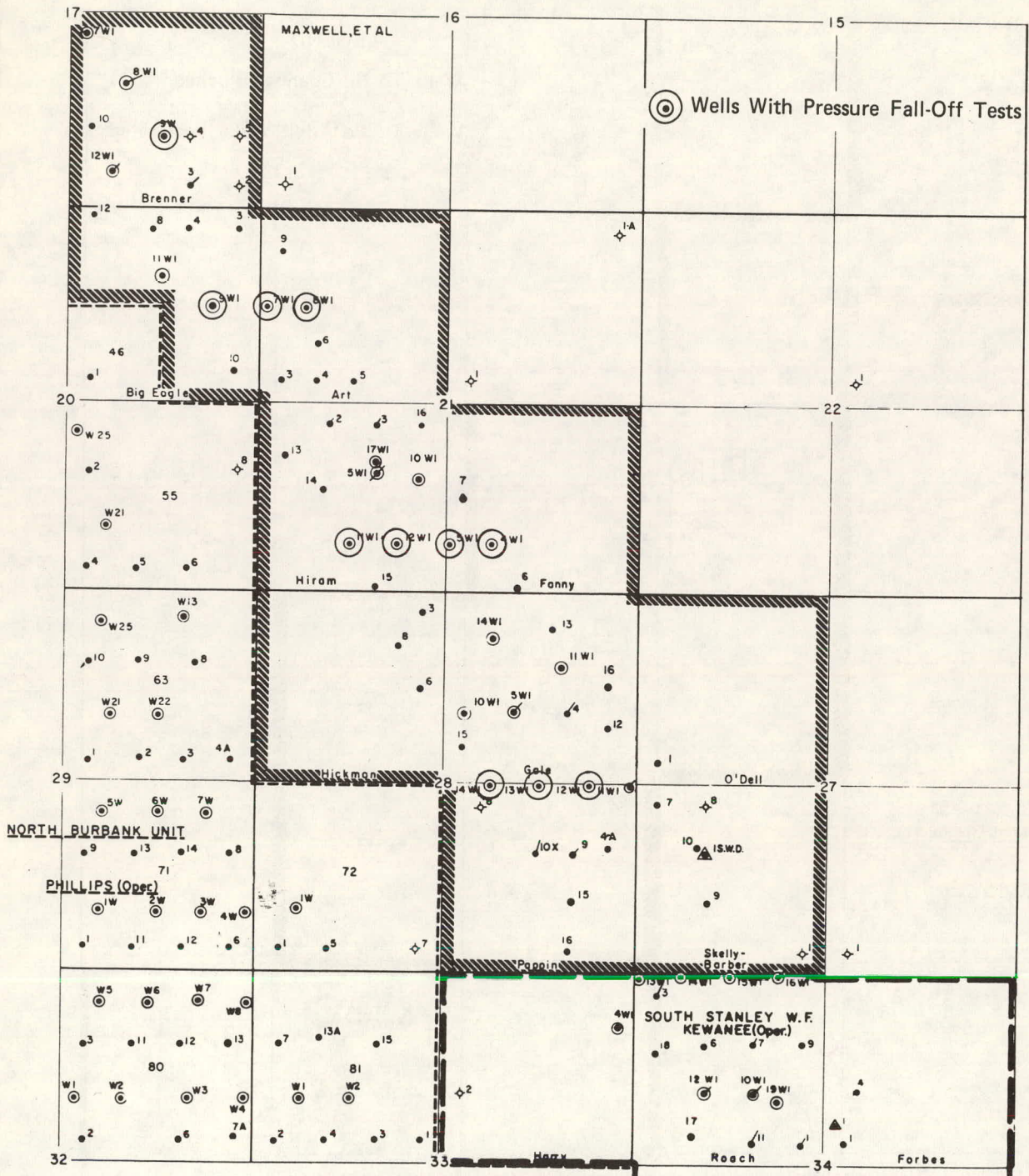
T  
27  
N

R 6 E

<p><b>LEGEND</b></p> <ul style="list-style-type: none"> <li>● Oil Well</li> <li>▲ Abdn Oil Well</li> <li>○ Location</li> <li>◇ Dry Hole</li> <li>☆ Gas Well</li> <li>* Abdn Gas Well</li> <li>○ Inactive Well</li> <li>● Water Input Well</li> <li>▲ S.W.D.</li> <li>■ W.S.W.</li> <li>● Gas Input Well</li> </ul>	<p>KEWANEE OIL COMPANY</p> <p><b>STANLEY POLYMER PROJECT</b></p> <p>OSAGE CO., OKLAHOMA</p>	<p>DISTRICT: <b>BURBANK</b></p> <p>AREA: <b>EAST AREA</b></p> <p>SCALE: 660' 0" 1320' 2640'</p>	<p>Drawn <b>PLM</b></p> <p>Traced</p> <p>Checked</p> <p>Date <b>6-21-59</b></p>	<p>REVISED</p> <table border="1"> <thead> <tr> <th>DATE</th> <th>BY</th> </tr> </thead> <tbody> <tr> <td>4-1-76</td> <td>MLA</td> </tr> <tr> <td>5-7-76</td> <td>J.S.</td> </tr> </tbody> </table> <p>File <b>B-6A</b></p>	DATE	BY	4-1-76	MLA	5-7-76	J.S.
		DATE	BY							
4-1-76	MLA									
5-7-76	J.S.									
		<p>660' 0" 1320' 2640'</p>								

FIGURE 21

LOCATION OF PRESSURE FALL-OFF TESTS



T  
27  
N

R 6 E

LEGEND

- Oil Well
- Abdn Oil Well
- location
- Dry Hole
- Gas Well
- Abdn Gas Well
- Inactive Well
- Water Input Well
- S.W.D.
- W.S.W.
- Gas Input Well

KEWANEE OIL COMPANY

STANLEY POLYMER PROJECT

OSAGE CO., OKLAHOMA

DISTRICT: BURBANK

AREA: EAST AREA

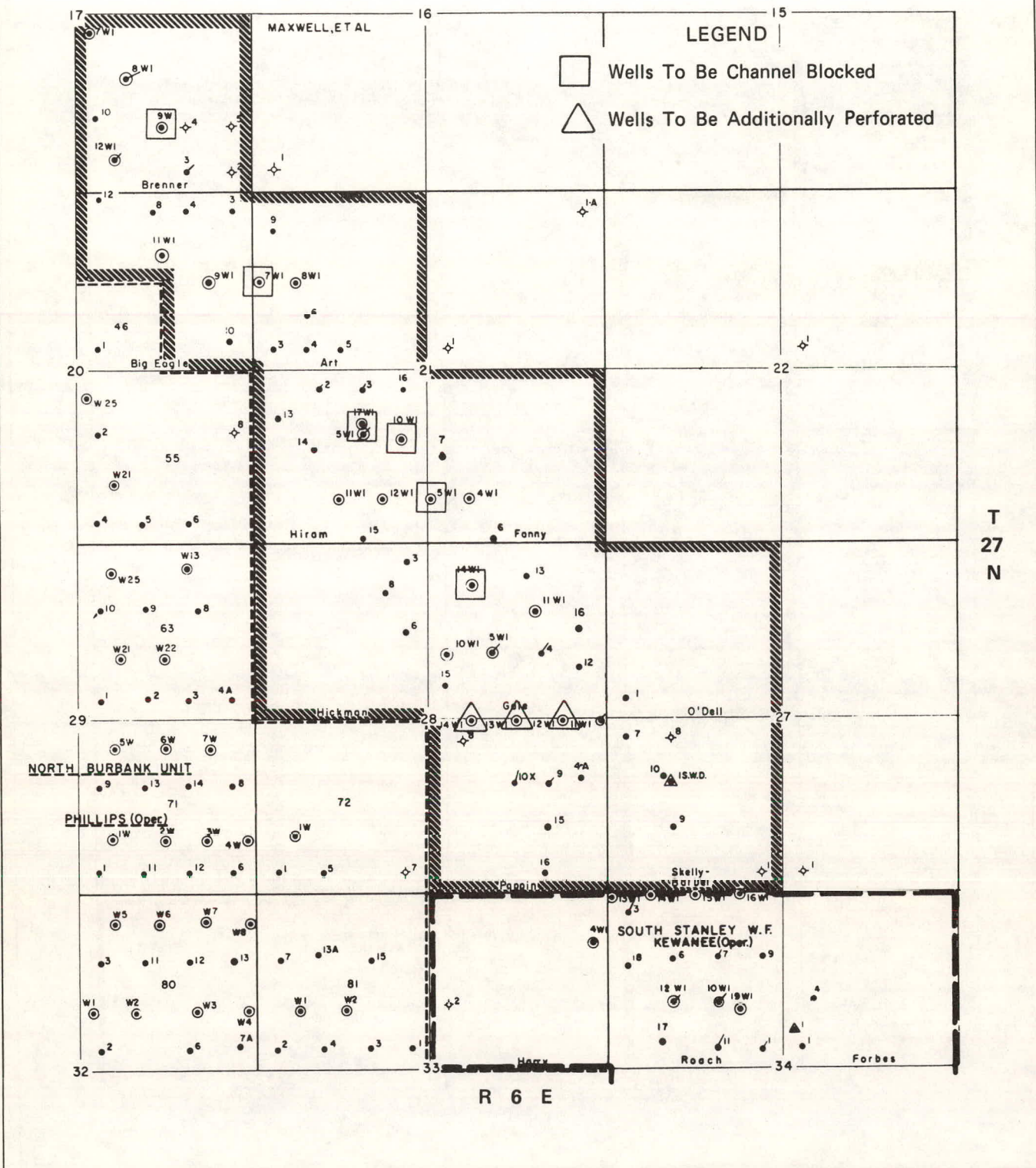
SCALE

660' 0' 1320' 2640'

Drawn	REVISED	
	DATE	BY
PLM	4-1-76	M.H.
Traced	5-7-76	J.S.
Checked		
Date	6-21-59	File
		B-6A

FIGURE 22

ADDITIONAL REMEDIAL ON INJECTION WELLS

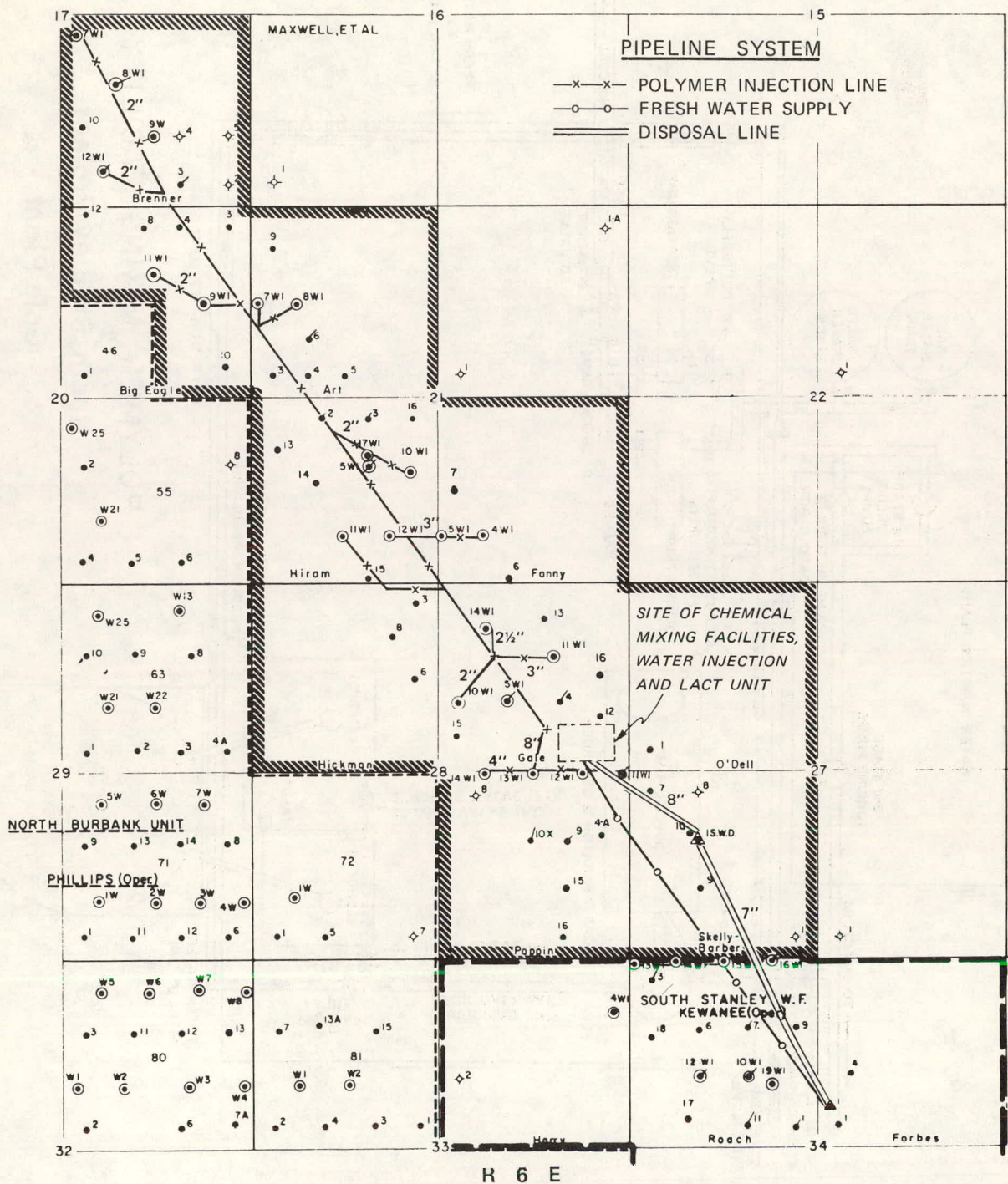


T  
27  
N

R 6 E

<p><b>LEGEND</b></p> <ul style="list-style-type: none"> <li>● Oil Well</li> <li>▲ Abdn Oil Well</li> <li>○ Location</li> <li>◇ Dry Hole</li> <li>★ Gas Well</li> <li>* Abdn Gas Well</li> <li>○ Inactive Well</li> <li>● Water Input Well</li> <li>▲ S.W.D</li> <li>■ W.S.W</li> <li>● Gas Input Well</li> </ul>	<p><b>KEWANEE OIL COMPANY</b></p> <p><b>STANLEY POLYMER PROJECT</b></p> <p>OSAGE CO., OKLAHOMA</p>	<p>DISTRICT: <b>BURBANK</b></p> <p>AREA: <b>EAST AREA</b></p> <p>SCALE 660' 0" 1320' 2640'</p>	<p>Drawn <b>PLM</b></p>	<p>REVISED</p>	
			<p>Traced</p>	<p>DATE</p> <p>4-1-76</p> <p>5-7-76</p>	<p>BY</p> <p>MJ</p> <p>ZS</p>
			<p>Checked</p>	<p>Date</p> <p>6-21-59</p>	<p>File</p> <p><b>B-6A</b></p>

FIGURE 23  
WATER DISTRIBUTION SYSTEMS



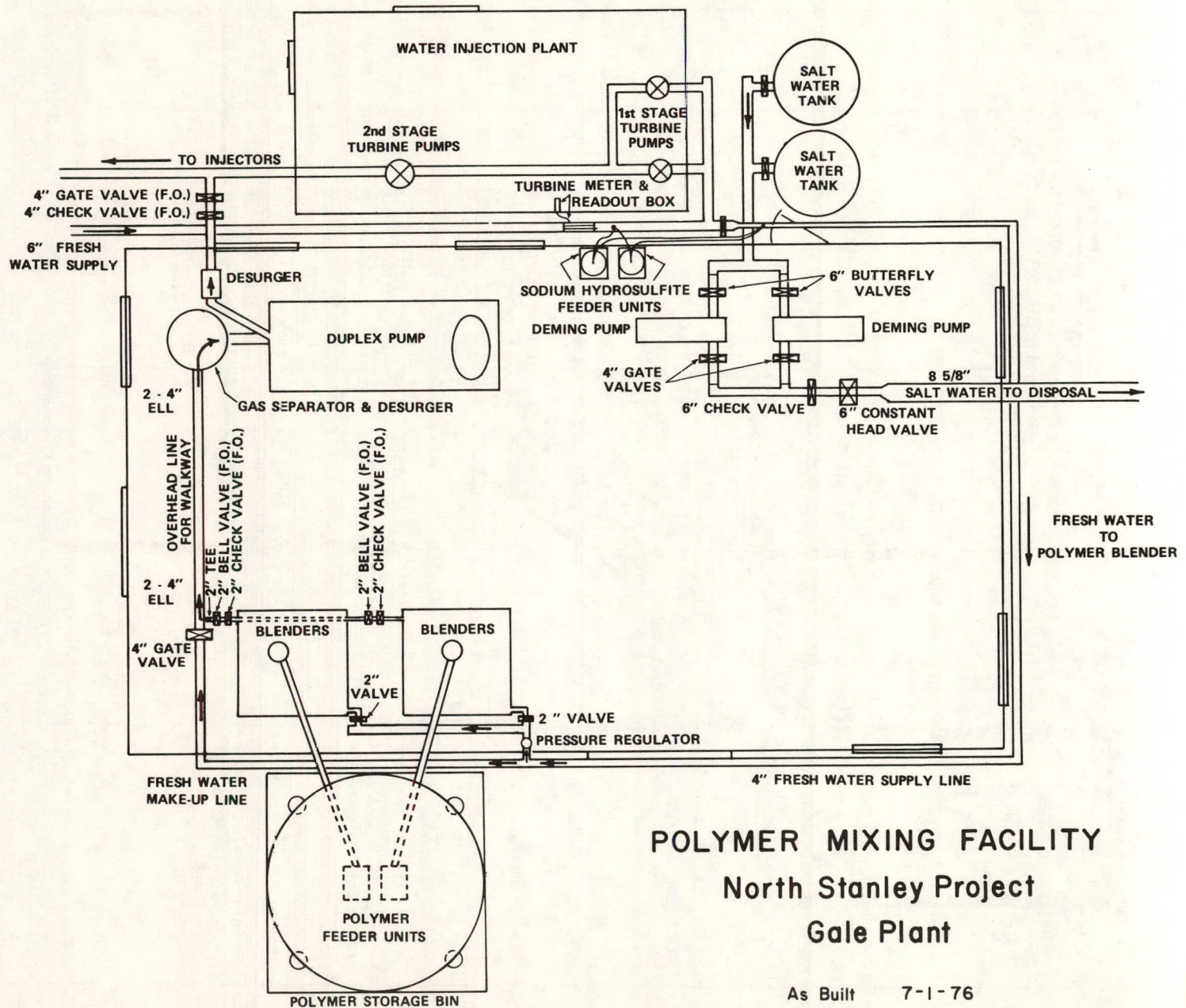
LEGEND	
● Oil Well	○ Inactive Well
⊗ Abdn Oil Well	● Water Input Well
○ Location	▲ S.W.D.
⊕ Dry Hole	⊗ W.S.W.
⊙ Gas Well	● Gas Input Well
⊛ Abdn Gas Well	

KEWANEE OIL COMPANY  
**STANLEY POLYMER PROJECT**  
OSAGE CO., OKLAHOMA

DISTRICT **BURBANK**  
AREA **EAST AREA**  
SCALE  
660' 0' 1320' 2640'

Drawn	REVISOR
PLM	DATE
Traced	BY
Checked	
Date	File
6-21-59	B-6A

FIGURE 24

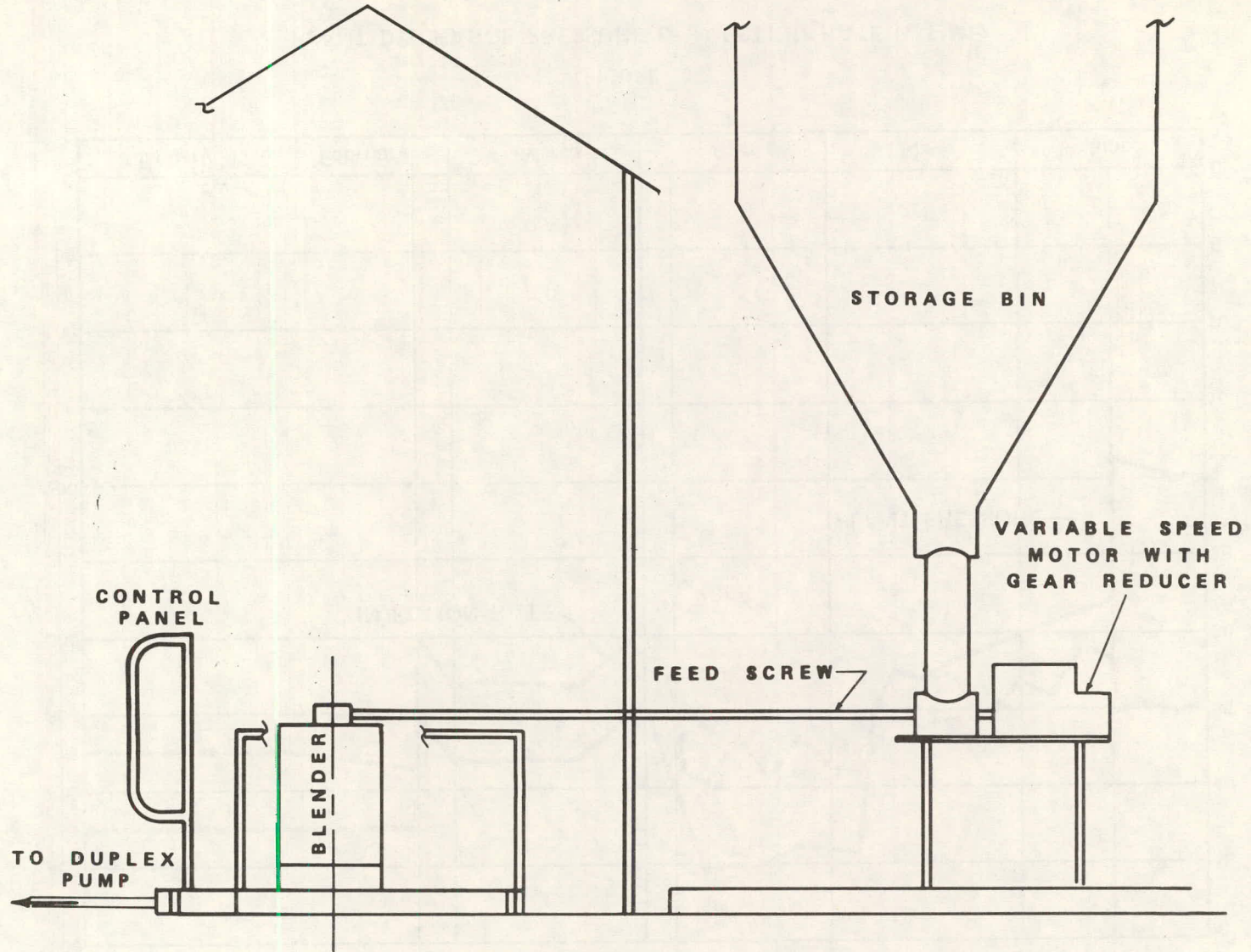


50

**POLYMER MIXING FACILITY**  
**North Stanley Project**  
**Gale Plant**

As Built 7-1-76

FIGURE 25



51

**BULK FEED SYSTEM**  
**North Stanley Project**

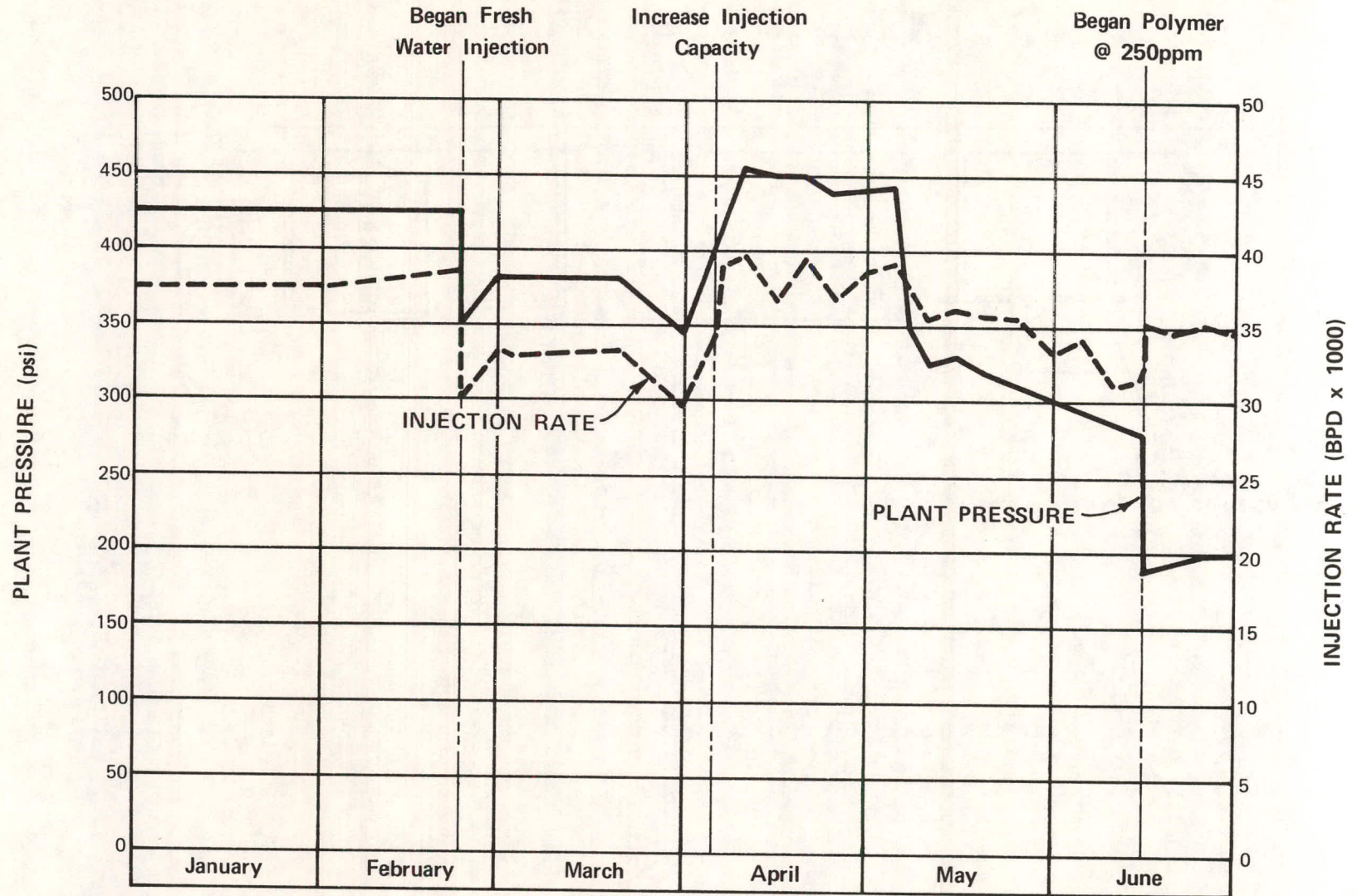


FIGURE 26  
PLANT DISCHARGE PRESSURE & INJECTION RATE vs TIME

INTRODUCTION

The United States Energy Research and Development Administration (ERDA) has contracted with Kewanee Oil Company to share in the costs of conducting a polymer flood demonstration project in the North Stanley Field, Osage County, Oklahoma. The Dow Chemical Company's PUSHHER® 700 polyacrylamide polymer was selected for this application.

In order to properly plan and design the chemical slug, additional reservoir and formation data were required. Preparatory work during Phase I and II of the project has provided pertinent data necessary for a more detailed reservoir analysis. Particularly important among these data is the information obtained in drilling the Hiram No. 17 WI, such as the conventional core data and the water-oil relative permeability data. These data from the relative permeability tests are similar to data reported for the North Burbank Unit by Phillips Petroleum Company in a recent paper.<sup>1</sup>

Using these data we have completed the computer simulation work needed to provide a supplemental base of technical support for this project, some guidance during the operation and some insight during the interpretation of the results.

In summary, these computer simulations:

1. are based on a reservoir model that is described by and adheres to data obtained from the specific project area;

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<sup>1</sup>Trantham, J.C. and Clampitt, R.L., "Determination of Oil Saturation After Waterflooding in an Oil-Wet Reservoir - The North Burbank Unit Tract 97 Project", (SPE5802), Improved Oil Recovery Symposium, Tulsa, Okla., Mar. 22-24, 1976. (Figure 4).

2. yield a reasonably close match with actual historical waterflood performance in the project area;
3. project remaining waterflood reserves.
4. project an incremental process recovery.

There are certain limitations in the ability of our computer program to adequately consider all of the interacting aspects of the flood. These restrict our confidence level in the computer to define overly fine details in two main areas:

The effect of minor changes in the programming of the polymer slug concentrations and volumes;

The exact timing and magnitude of the oil production response attributable to process application.

These limitations come about principally because of the irregular reservoir configuration (offshore bar instead of blanket sand) and the scaling problems associated with the variation in individual well rates affiliated with unknown sand volumes.

Therefore, while the program is definitely useful to demonstrate the feasibility of polymer flooding over continued water injection, other observations in the field and factors not considered by the program must enter into the decision on polymer slug programming and CHANNELBLOCK® treatment designs.

## RESERVOIR MODEL

The computer program employed is basically a multi-layered Buckley-Leverett model (without crossflow) that can accommodate multiple fluid banks.<sup>2</sup> It is two dimensional in scope and therefore cannot simulate the effects of pressure interference between an irregular array of wells. However, this does not limit its utility in projecting process feasibility on a unit per-acre-foot basis or in simulating the performance of regular patterns or well-defined groupings of wells.

In November, 1975 the Burbank Sand was cored while drilling Well Hiram 17 WI. The permeability distribution from this core analysis was modeled into six layers of varying thickness, as shown in Figure 1. The core analysis also shows a variation in porosity which generally correlates with permeability. This porosity variation was incorporated into our model. The porosity levels used were scaled down somewhat to reflect the field-wide average of 18%; the core averaged approximately 21%.

The connate water saturation in the layers of the model varies inversely with permeability; the average value of 0.30, weighted by thickness and porosity. The oil saturations in the model layers weighted by thickness and porosity average 0.456, the average value in the reservoir at the time

---

<sup>2</sup>The computer program is described in more detail in the following technical publications:

Jewett, R.L. and Schurz, G.F., "Polymer Flooding---A Current Appraisal", JPT (June 1970), 675-684,

Uzoigwe, A.C., Scanlon, F.C. and Jewett, R.L., "Improvements in Polymer Flooding: The Programmed Slug", JPT (January 1974), 33-41.

waterflooding was started. Each layer in the model is assumed to have been depleted to 65% of its virgin saturation prior to waterflooding.

The relative permeability data were taken from Report SCAL-75410, Sample #1. For layer 1 in the model the data were used exactly as reported. For the other layers the values for water saturation were normalized over the span of the displacable pore volume, since the connate water saturation has been varied with absolute permeability.

Resistance factors for various concentrations of Pusher chemicals have been measured in our laboratory on core samples from Well Hiram 17 WI. Effective resistance was generated in all levels of polymer treatment ranging from 100 ppm to 1000 ppm concentration. Values obtained are comparable to previous data generated from tests on Burbank sand cores from the Stanley Stringer Field and Phillips North Burbank Unit. Lab data also correlates with field screen factor measurements obtained during injectivity tests observed earlier at the Roach 19 WI Mini-Test. Particularly important was the verification of low polymer adsorption factors for the Burbank sand. Preliminary calculations had used an adsorption factor of 30 pounds per acre foot. Measured adsorption level from tests on the Hiram 17 WI samples showed 41 pounds per acre foot, indicative of the low range of adsorption seen from previous Burbank sand tests.

Reservoir data for this computer model are listed in Table I.

## WATERFLOOD HISTORY

In analyzing waterflood performance we frequently examine the production history in terms of a graph of the logarithm of the producing water-oil ratio at any point in time against the cumulative oil recovery for that point in time. This type of plot tends to emphasize the actual displacement efficiency within the reservoir, removing as much as possible the masking effects of such operational conditions as changes in injection rate, plant and well down time, workovers and stimulations, etc.

The production history of the wells in the North Stanley project has recently been composited by Kewanee. Figure 2 is a graph of this history, based on a floodable reservoir volume of 48,114 acre-feet. The last segment of this graph, between 61 BAF and 91 BAF, is a relatively smooth curve. It is probably the most significant part of the graph for history matching from two standpoints

1. It represents the most recent five-year period, from mid-1975 back through mid-1970, when a fairly uniform decline trend began. This follows over seven years of essentially flat oil production rate; we assume this to be an effect of production curtailment.
2. An extrapolation of this segment would be a reasonable expectation for future waterflood performance.

## WATERFLOOD CALCULATION

Figure 3 is a graph of the calculated waterflood performance, with the actual history shown again for comparison. The calculation shows a very close conformance with the actual history over the most recent five year period. Before that, the historical performance is at much higher water-oil ratios than the calculated. This could possibly be due to directional permeability trends in the earlier flood life that were later compensated for by adjustments in the flooding pattern.

Because the computer model does not match the earlier WOR performance in the history, that portion of the calculation will also be low in terms of cumulative injection and therefore in terms of elapsed time. However, it is believed that the computer model will be of most value for projecting (and interpreting) future performance if it adheres to actual reservoir data rather than invoking arbitrary changes for the sake of a better match with the earlier history.

The computer listing for this calculation is attached as Table II. In this calculation Step 30 has been taken to represent the current point in time; a water-oil ratio of 65, a cumulative flood recovery of 4.15 million barrels and a production rate of 576 BOPD.

A preliminary investigation of polymer flood feasibility shown in a report of June, 1974 had estimated remaining waterflood reserves of 1.22 million barrels. The current computer calculation shows a comparable additional oil recovery to be achieved by the time a WOR of approximately 100 is reached. The oil production rate then would approximate 210 B/D. This is Step 68 in the listing.

## POLYMER FLOOD CALCULATION

The same reservoir model for the waterflood calculation above was used to simulate a polymer flood. Again, Step 30 is taken to represent the current point in time. The polymer injection period is the next 12 steps of one month each; all other steps in the calculations are for three months each.

The concentrations are as recommended in our report of June, 1974 with resistance factors assigned as shown below:

<u>Month</u>	<u>Concentration, ppm</u>	<u>Resistance Factor</u>
1	1000	20
1	500	15
4	250	10
6	100	5

The response to the polymer injection, as an indication of what to anticipate in the field project over the near term, is best seen in the computer listing rather than a graph. This is shown in Table III.

The calculated oil production rate is seen to show a modest increase, or stabilization, for a year following the start of polymer. This is followed by a sharp kick to approximately four times the pre-chemical rate. We do not believe this is a reasonable expectation for actual performance in the field, since the computer program has assumed that all wells will be acting in concert. In reality, response from most wells would be staggered and would tend to smooth out the abrupt changes shown in the computer model. Such a response was projected in our report of June, 1974. That projection was based on a comparison between the calculated and the actual responses in the North Burbank pilot.

From the time of polymer start until a water-oil ratio of 180 is reached, the calculated oil recovery is 1.91 million barrels. This would be 690,000 barrels more than for continued waterflooding without polymer. This is slightly more

than half of the incremental oil that we projected in our June, 1974 report. It is calculated on the basis of only one of the products that will be used in the project, Pusher chemical. It does not account for the results of the other product that we will be using, CHANNELBLOCK® Bypass Control Agents. The physical properties of Channelblock agents have not been defined to the extent where the behavior could be reliably simulated by our computer program.

Another polymer flood calculation was made but instead of using the programmed slug, the polymer was injected at a constant concentration of 250 ppm for one year. This is the same amount of chemical within three per cent. This calculation is included as Table IV. A comparison of the oil production rates with those for the programmed slug shows only minor differences but with a slight advantage for the programmed slug.

Our rationale for starting with the higher concentrations and then tapering the slugs stems partly from influences outside of the computer reservoir simulation. On a microscopic scale, the effect of resistance factor, which is concentration dependent, is very strong on the displacement efficiency. This can be seen in Figure 4 which is a graph of Buckley-Leverett calculations made for different values of resistance factor. (These are based on the relative permeability data obtained from Well Hiram 17 WI, Sample 1). These curves show major changes in displacement efficiency up to a resistance factor of 20, then the dependency diminishes. We feel that this is an important factor in building another oil bank after such extensive prior water injection.

## HIGH PERMEABILITY STREAK

While the foregoing study was in progress, injection of the fresh water pre-flush was started in the field. After more than 16 years of salt water injection, the fresh water will provide the secondary benefit of offering tracer surveys of existing flow channels. Although it is still too early to assess the overall results, preliminary indications are that in at least some of the wells, the produced water stream contained 25% fresh water in less than a month's time. Our computer simulation of the waterflood did not show this; it shows that it would take a year, as tabulated below:

<u>Months</u>	<u>Per cent Fresh Water In Produced Water Stream</u>
3	.5
6	4
9	12
12	25
18	53
24	72
30	80
36	85

The field observations, together with individual well production data, lead to the speculation that some form of highly conductive flow channels exist that are not defined by conventional reservoir sampling techniques. While the effects of these channels are apparent in an analysis of well performance, the petrographic description is difficult to define quantitatively.

We have attempted to incorporate this channeling effect in our computer simulation on a trial-and-error basis by including a layer of unusually high permeability in the reservoir model. Without any direct measurements on such a condition and desiring to remain within the realm of credibility, we have added to the reservoir model another layer that is one foot in thickness with a permeability of 15 darcies. We assigned to this layer the same

values of porosity, saturations and relative permeability as for the most permeable layer of the previously described model. This new layer then represents 2% of the total thickness and 46% of the total flow capacity of the model.

The fresh water breakthroughs for the waterflood calculation with this model are shown below:

<u>Months</u>	<u>Per cent Fresh Water In Produced Water Stream</u>
3	29
6	50
9	56
12	57
18	60
24	65
30	73
36	79

This represents substantially more channeling than the original reservoir model. How well it checks with field-wide measurements, it is too early to tell. Undoubtedly, it will check with some of the wells and then may be of some value in understanding the performance of those wells. In the meanwhile, we are hesitant to add other variations to the model, since we believe that the further the model deviates from known reservoir conditions, the less assistance it will provide in understanding the performance.

The calculated waterflood performance for this model is graphed in Figure 5 with the actual field history included for comparison. This calculation would probably match the history for certain wells or groups of wells located on-strike, provided that the drainage area for those wells could be ascertained. This fairly drastic change in the reservoir model did not produce such a drastic change in the calculated recoveries as shown below:

	<u>Basic Reservoir Model</u>	<u>With High Permeability Streak</u>
Performance to Date (Step 30)		
Water-oil Ratio	65	69
Recovery, BAF	86	70
At Economic Limit:		
Water-oil Ratio	180	180
Recovery, BAF	112	105

The computer calculation is attached as Table V. The calculated performance for the polymer flood with this reservoir model is closer to the projection that we had made in June, 1974 than the basic reservoir model is. The calculation for the programmed slug, attached as Table VI, shows the oil production rate rising to over 900 B/D in approximately five months. Taking Step 30 to represent the present time and a WOR of 180 as the economic limit, the projected reserves are:

Waterflooding	1.69 million barrels
Dow Flooding Process	2.61 million barrels
Incremental	0.92 million barrels

This incremental recovery is approximately 72% of that projected in June, 1974 but, as stated previously, it is for only one of the two products which will be used.

A similar calculation for a polymer flood at a constant concentration of 250 ppm for one year is attached as Table VII. A comparison shows that the early oil response is slightly more pronounced with the programmed slug. Our same comments regarding this difference for the two calculations on the previous reservoir model apply here also.

## SUMMARY AND RECOMMENDATIONS

A complete suite of reservoir data specific to the project area has now become available. Using this data for a reservoir model in our computer simulation program yields a very close match with actual waterflood performance over the past five years.

Computer simulations show a technical and economic justification for polymer flooding. However, we believe it would be unrealistic to rely solely upon the simulations to differentiate between minor changes in polymer concentration or for the exact magnitude and timing of the oil production response. This is because of such factors as directional trends and well interactions that are not adequately accounted for in our reservoir model or computer program.

We feel strongly that a programmed slug which starts at a relatively high concentration and tapers downward is preferable to a constant concentration. The constant concentration would be lower than the initial concentration of the programmed slug. The extensive prior water injection and the Buckley-Leverett analysis support this view.

However, we have reservations about starting at a concentration as high as 1000 ppm which we recommended in June, 1974. This is because of the very high chemical use rates at that concentration and the as-yet undetermined extent of severe channeling which the preliminary fresh water breakthroughs might indicate.

We recommend an initial injection period at 250 ppm to precede the programmed slug. This would be for one or two months. The purpose is to:

- Thoroughly check out all equipment components.
- Allow personnel the opportunity to gain familiarity with the operation.
- More importantly, assess the degree of any early and serious polymer breakthroughs. This will require qualitative tests in the field since shipment of samples to our laboratories would involve inordinate time delays.

During this early phase of the project we also need to assimilate other current data relative to channeling and to plan and execute the Channelblock treatments in the appropriate wells. Since time will be of the essence, this phase will require close coordination between Dow's Houston office and Kewanee's Shidler office. We foresee that these treatments would be essentially completed before starting the high initial concentration of the programmed slug.

It is tentatively recommended that the initial period of lower polymer concentration be followed by a period of polymer concentration in the range of 600 ppm for three months. Injection at 250 ppm of polymer would follow for the balance of the first six months of chemical application. The polymer slug would be completed with an additional six months at a concentration of 100 ppm. Such a program could reflect the following schedule:

<u>Days</u>	<u>Polymer Concentration</u>	<u>@ 38,000 B/D Chemical Use</u>
45	250	150,000
90	600	720,000
45	250	150,000
180	100	230,000
360	261	1,250,000

The above schedule would provide application time for desirable Channelblock treatments prior to the period of high polymer concentration. For the first

4-1/2 months of polymer injection, the total volume of polymer utilized would approximate 850,000 pounds, the same amount originally called for under the schedule starting with 1000 ppm.

Performance of the project will be followed closely to determine any causes which might support further alteration of this tentative schedule.

TABLE I

JOB 1

MAR. 3, 1976

BASIC RESERVOIR DATA

STANLEY STRINGER

WATERFLOODING

0◆◆0◆◆0

PATTERN AREA, AC.	1024.0
PATTERN VOLUME, AF	49128.00
DISTANCE FROM INJECTOR TO PRODUCER, FT.	650.0
WELLBORE RADIUS, INJECTOR, FT.	1.00
WELLBORE RADIUS, PRODUCER, FT.	1.00
NO. OF SEGMENTS IN EACH LAYER,	14
FORMATION VOLUME FACTOR	1.050
OIL VISCOSITY, CPS.	2.36
WATER VISCOSITY, CPS.	.63

LAYER CHARACTERISTICS

LAYER	THICK., FT.	PERM. MD.	POROSITY	SO	SW	SG	ADS. (LB/AF)
1	3.00	1400.00	.248	.563	.136	.301	30.0
2	4.70	739.00	.226	.489	.250	.261	30.0
3	4.70	370.00	.201	.460	.300	.240	30.0
4	4.70	109.00	.165	.460	.300	.240	30.0
5	4.70	60.00	.157	.410	.370	.220	30.0
6	20.20	33.00	.146	.380	.410	.210	30.0

RELATIVE PERMEABILITY DATA

LAYER = 1

SW	KRW	SO	KRO
.0000	.000000	.0000	.000001
.1360	.000000	.3250	.000001
.2940	.003000	.3470	.002300
.3410	.010000	.3600	.003800
.3920	.029000	.3730	.004600
.4320	.054000	.3920	.006700
.4700	.081000	.4060	.008600
.5080	.114000	.4260	.011000
.5310	.135000	.4480	.015000
.5520	.157000	.4690	.021000
.5740	.181000	.4920	.029000
.5940	.195000	.5300	.040000
.6080	.210000	.5680	.062000
.6270	.229000	.6080	.093000
.6400	.246000	.6590	.147000
.6530	.256000	.7060	.226000
.6750	.285000	.8640	1.000000

LAYER = 2

SW	KRW	SO	KRO
.0000	.000000	.0000	.000001
.2500	.000000	.3250	.000001
.3746	.003000	.3423	.002300
.4116	.010000	.3526	.003800
.4519	.029000	.3623	.004600
.4834	.054000	.3773	.006700
.5134	.081000	.3889	.008600
.5433	.114000	.4046	.011000
.5615	.135000	.4220	.015000
.5730	.157000	.4385	.021000
.5954	.181000	.4567	.029000
.6111	.195000	.4866	.040000
.6222	.210000	.5166	.062000
.6372	.229000	.5481	.093000
.6474	.246000	.5884	.147000
.6577	.256000	.6254	.226000
.6750	.285000	.7500	1.000000

LAYER = 3

SW	KRW	SO	KRO
.0000	.000000	.0000	.000001
.3000	.000000	.3250	.000001
.4099	.003000	.3403	.002300
.4426	.010000	.3494	.003800
.4731	.029000	.3584	.004600
.5059	.054000	.3716	.006700
.5324	.081000	.3814	.008600
.5583	.114000	.3953	.011000
.5748	.135000	.4106	.015000
.5894	.157000	.4252	.021000
.6047	.181000	.4412	.029000
.6196	.195000	.4676	.040000
.6284	.210000	.4941	.062000
.6416	.229000	.5219	.093000
.6506	.246000	.5574	.147000
.6597	.256000	.5901	.226000
.6750	.285000	.7000	1.000000

LAYER = 4

SW	KRW	SD	KRD
.0000	.000000	.0000	.000001
.3000	.000000	.3250	.000001
.4099	.003000	.3403	.002300
.4426	.010000	.3494	.003800
.4781	.029000	.3584	.004600
.5059	.054000	.3716	.006700
.5324	.081000	.3814	.008600
.5588	.114000	.3953	.011000
.5748	.135000	.4106	.015000
.5894	.157000	.4252	.021000
.6047	.181000	.4412	.029000
.6186	.195000	.4676	.040000
.6284	.210000	.4941	.062000
.6416	.229000	.5219	.093000
.6506	.246000	.5574	.147000
.6597	.256000	.5901	.226000
.6750	.285000	.7000	1.000000

LAYER = 5

SW	KRW	SD	KRD
.0000	.000000	.0000	.000001
.3700	.000000	.3250	.000001
.4594	.003000	.3374	.002300
.4860	.010000	.3448	.003800
.5149	.029000	.3522	.004600
.5375	.054000	.3629	.006700
.5590	.081000	.3708	.008600
.5805	.114000	.3822	.011000
.5935	.135000	.3946	.015000
.6054	.157000	.4065	.021000
.6178	.181000	.4195	.029000
.6292	.195000	.4410	.040000
.6371	.210000	.4625	.062000
.6478	.229000	.4851	.093000
.6552	.246000	.5140	.147000
.6626	.256000	.5406	.226000
.6750	.285000	.6300	1.000000

L<sub>20</sub> = 6

SW	KRW	SO	KRO
.0000	.000000	.0000	.000001
.4100	.000000	.3250	.000001
.4877	.003000	.3358	.002300
.5108	.010000	.3422	.003800
.5359	.029000	.3486	.004600
.5555	.054000	.3579	.006700
.5742	.091000	.3648	.008600
.5929	.114000	.3747	.011000
.6042	.135000	.3855	.015000
.6145	.157000	.3958	.021000
.6253	.181000	.4071	.029000
.6352	.195000	.4258	.040000
.6421	.210000	.4445	.062000
.6514	.229000	.4641	.093000
.6578	.246000	.4892	.147000
.6642	.256000	.5123	.226000
.6750	.285000	.5900	1.000000

BRINE NO.	CHEMICAL CONC., PPM	VISCOSITY, CPS.	RRF	ACON
1	.00	.630	2.000	1.00

FLUID	INJECTION SCHEDULE PLAN PORE VOLUMES INJECTED
WATER	5.0000
POLYMER 1	.0000
POLYMER 2	.0000
POLYMER 3	.0000
POLYMER 4	.0000
POLYMER 5	.0000
POLYMER 6	.0000
BRINE 1	.0000
BRINE 2	.0000

NOTE - ACON = (COST OF OIL IN \$/BBU) / (COST OF CHEMICAL IN \$/LB)

RRF = RESIDUAL RESISTANCE FACTOR

TABLE II

STEP	WOR	BAF	TIME (MOS.)	PVINJ	CUM.OIL (BBL)	INJ. RATE (B/D)	TF RATE (B/D)	OIL RATE (B/D)
1	.01	.0	3.0	.0516	0.	38000.0	.1	.0
2	.01	.0	6.0	.1032	0.	38000.0	.1	.0
3	1.17	12.9	9.0	.1548	617064.	38000.0	14617.2	6766.1
4	3.52	21.9	12.0	.2064	1052331.	38000.0	21530.0	4772.7
5	6.14	29.2	15.0	.2580	1405103.	38000.0	27585.0	3868.2
6	9.32	34.5	18.0	.3096	1657313.	38000.0	28517.9	2765.4
7	11.65	38.9	21.0	.3612	1869304.	38000.0	29391.7	2324.5
8	12.91	43.0	24.0	.4128	2068242.	38000.0	30322.1	2181.3
9	14.73	46.9	27.0	.4644	2255690.	38000.0	32311.6	2055.4
10	16.90	50.4	30.0	.5161	2421984.	38000.0	32628.4	1823.4
11	19.28	53.5	33.0	.5677	2572538.	38000.0	33465.2	1650.8
12	21.60	56.4	36.0	.6193	2710894.	38000.0	34274.7	1517.1
13	24.40	58.9	39.0	.6709	2834755.	38000.0	34492.7	1358.1
14	26.80	61.3	42.0	.7225	2948331.	38000.0	34614.4	1245.4
15	29.01	63.5	45.0	.7741	3054265.	38000.0	34847.1	1161.6
16	32.39	65.6	48.0	.8257	3156586.	38000.0	37452.5	1121.9
17	34.73	67.6	51.0	.8773	3253457.	38000.0	37946.9	1062.2
18	36.66	69.6	54.0	.9289	3345366.	38000.0	37949.7	1007.8
19	39.18	71.3	57.0	.9805	3431526.	38000.0	37952.8	944.7
20	41.85	73.0	60.0	1.0321	3512328.	38000.0	37955.7	886.0
21	44.60	74.6	63.0	1.0837	3588258.	38000.0	37958.4	832.6
22	46.13	76.1	66.0	1.1353	3661719.	38000.0	37959.8	805.5
23	48.12	77.6	69.0	1.1869	3732206.	38000.0	37961.4	772.9
24	50.11	79.0	72.0	1.2385	3799953.	38000.0	37962.9	742.8
25	52.30	80.4	75.0	1.2901	3864923.	38000.0	37964.4	712.4
26	54.97	81.6	78.0	1.3417	3926796.	38000.0	37966.1	678.4
27	57.55	82.9	81.0	1.3933	3985944.	38000.0	37967.6	648.6
28	59.87	84.0	84.0	1.4449	4042838.	38000.0	37968.9	623.8
29	62.86	85.2	87.0	1.4965	4097071.	38000.0	37970.3	594.7
30	64.91	86.3	90.0	1.5482	4149613.	38000.0	37971.2	576.1
31	65.08	87.4	93.0	1.5998	4202026.	38000.0	37971.3	574.7
32	68.30	88.4	96.0	1.6514	4252005.	38000.0	37972.6	548.0
33	68.11	89.4	99.0	1.7030	4302121.	38000.0	37972.6	549.5
34	71.06	90.4	102.0	1.7546	4350182.	38000.0	37973.7	527.0
35	74.09	91.4	105.0	1.8062	4396309.	38000.0	37974.8	505.8
36	75.08	92.3	108.0	1.8578	4441834.	38000.0	37975.1	499.2
37	78.73	93.2	111.0	1.9094	4485279.	38000.0	37976.2	476.4
38	80.17	94.1	114.0	1.9610	4527950.	38000.0	37976.7	467.9
39	83.02	95.0	117.0	2.0126	4569174.	38000.0	37977.4	452.0
40	84.36	95.8	120.0	2.0642	4609751.	38000.0	37977.8	444.9
41	87.59	96.6	123.0	2.1158	4648850.	38000.0	37978.6	428.7
42	91.17	97.4	126.0	2.1674	4686434.	38000.0	37979.4	412.1
43	93.06	98.2	129.0	2.2190	4723261.	38000.0	37979.9	403.8
44	97.59	98.9	132.0	2.2706	4758395.	38000.0	37980.8	385.2
45	99.40	99.6	135.0	2.3222	4792896.	38000.0	37981.1	378.3

46	106.08	100.3	138.0	2.3738	4825246.	38000.0	37982.3	354.7
47	106.76	101.0	141.0	2.4254	4857392.	38000.0	37982.4	352.5
48	107.50	101.6	144.0	2.4770	4889319.	38000.0	37982.5	350.1
49	111.94	102.3	147.0	2.5286	4919992.	38000.0	37983.2	336.3
50	113.19	102.9	150.0	2.5803	4950329.	38000.0	37983.4	332.6
51	118.02	103.5	153.0	2.6319	4979436.	38000.0	37984.1	319.2
52	120.20	104.1	156.0	2.6835	5008019.	38000.0	37984.4	313.4
53	126.17	104.7	159.0	2.7351	5035262.	38000.0	37985.1	298.7
54	124.76	105.2	162.0	2.7867	5062810.	38000.0	37984.9	302.1
55	136.31	105.8	165.0	2.8383	5090041.	38000.0	37986.2	276.7
56	141.65	106.3	168.0	2.8899	5112327.	38000.0	37986.7	266.3
57	147.37	106.8	171.0	2.9415	5135679.	38000.0	37987.2	256.0
58	146.46	107.2	174.0	2.9931	5159173.	38000.0	37987.2	257.6
59	147.15	107.7	177.0	3.0447	5182558.	38000.0	37987.2	256.4
60	151.72	108.2	180.0	3.0963	5205245.	38000.0	37987.6	248.8
61	157.57	108.7	183.0	3.1479	5227094.	38000.0	37988.1	239.6
62	157.02	109.1	186.0	3.1995	5249018.	38000.0	37988.0	240.4
63	159.86	109.6	189.0	3.2511	5270556.	38000.0	37988.2	236.2
64	161.97	110.0	192.0	3.3027	5291816.	38000.0	37988.4	233.1
65	169.20	110.4	195.0	3.3543	5312172.	38000.0	37988.9	223.2
66	168.19	110.8	198.0	3.4059	5332650.	38000.0	37988.8	224.5
67	167.83	111.3	201.0	3.4575	5353172.	38000.0	37988.8	225.0
68	180.28	111.7	204.0	3.5091	5372284.	38000.0	37989.6	209.6
69	178.24	112.1	207.0	3.5607	5391614.	38000.0	37989.5	212.0
70	187.50	112.5	210.0	3.6124	5409995.	38000.0	37990.0	201.5
71	182.84	112.8	213.0	3.6640	5428841.	38000.0	37989.7	206.6
72	185.58	113.2	216.0	3.7156	5447410.	38000.0	37989.9	203.6
73	186.31	113.6	219.0	3.7672	5465908.	38000.0	37989.9	202.8
74	190.80	114.0	222.0	3.8188	5483973.	38000.0	37990.1	198.1
75	195.85	114.4	225.0	3.8704	5501574.	38000.0	37990.4	193.0
76	199.75	114.7	228.0	3.9220	5518833.	38000.0	37990.6	189.2
77	193.09	115.1	231.0	3.9736	5536885.	38000.0	37990.3	195.7
78	201.83	115.4	234.0	4.0252	5553767.	38000.0	37990.7	187.3

CUM. INCOME = 88.8      DISC. CUM. INCOME = 61.6 - (BAF)

ASSUMED INTEREST RATE - (PERCENT) = 12.0

MAR. 3, 1976

STANLEY STRINGER  
0◆◆0◆◆0

WATERFLOODING

◆◆◆SUMMARY

OF

YEARLY

TOTALS◆◆◆

YEAR

OIL PROD.  
(BBLS/YR)

1	1052331.
2	1015911.
3	642652.
4	445692.
5	355743.
6	287624.
7	242885.
8	209167.
9	189829.
10	167917.
11	148644.
12	130924.
13	118700.
14	104308.
15	92918.
16	86571.
17	80469.
18	75126.
19	71423.
20	34934.

20

5553766.7

PERMEABILITY VARIATION BASED ON CORE ANALYSIS FROM WELL HIRAM #17  
RELATIVE PERMEABILITY DATA FROM SCAL-75410 (HIRAM 17 - SAMPLE 1)

TABLE III

MAR. 3, 1976		STANLEY STRINGER			DOW FLOODING PROCESS			
STEP	WOR	BAF	TIME (MOS.)	PVINJ	CUM.OIL (BBL)	INJ. RATE (B/D)	TF RATE (B/D)	OIL RATE (B/D)
1	.01	.0	3.0	.0516	0.	38000.0	.1	.0
2	.01	.0	6.0	.1032	0.	38000.0	.1	.0
3	1.17	12.9	9.0	.1548	617064.	38000.0	14617.2	6766.1
4	3.52	21.9	12.0	.2064	1052331.	38000.0	21530.0	4772.7
5	6.14	29.2	15.0	.2590	1405108.	38000.0	27585.0	3868.2
6	9.32	34.5	18.0	.3096	1657313.	38000.0	28517.9	2765.4
7	11.65	38.9	21.0	.3612	1869304.	38000.0	29391.7	2324.5
8	12.91	43.0	24.0	.4128	2068242.	38000.0	30322.1	2181.3
9	14.73	46.9	27.0	.4644	2255690.	38000.0	32311.6	2055.4
10	16.90	50.4	30.0	.5161	2421984.	38000.0	32629.4	1823.4
11	19.28	53.5	33.0	.5677	2572538.	38000.0	33465.2	1650.8
12	21.60	56.4	36.0	.6193	2710894.	38000.0	34274.7	1517.1
13	24.40	58.9	39.0	.6709	2834755.	38000.0	34492.7	1358.1
14	26.80	61.3	42.0	.7225	2948331.	38000.0	34614.4	1245.4
15	29.01	63.5	45.0	.7741	3054265.	38000.0	34847.1	1161.6
16	32.39	65.6	48.0	.8257	3156586.	38000.0	37452.5	1121.9
17	34.73	67.6	51.0	.8773	3253457.	38000.0	37946.9	1062.2
18	36.66	69.6	54.0	.9289	3345366.	38000.0	37949.7	1007.8
19	39.18	71.3	57.0	.9805	3431526.	38000.0	37952.8	944.7
20	41.85	73.0	60.0	1.0321	3512328.	38000.0	37955.7	886.0
21	44.60	74.6	63.0	1.0837	3588258.	38000.0	37958.4	832.6
22	46.13	76.1	66.0	1.1353	3661719.	38000.0	37959.8	805.5
23	48.12	77.6	69.0	1.1869	3732206.	38000.0	37961.4	772.9
24	50.11	79.0	72.0	1.2385	3799953.	38000.0	37962.9	742.8
25	52.30	80.4	75.0	1.2901	3864923.	38000.0	37964.4	712.4
26	54.97	81.6	78.0	1.3417	3926796.	38000.0	37966.1	678.4
27	57.55	82.9	81.0	1.3933	3985944.	38000.0	37967.6	648.6
28	59.87	84.0	84.0	1.4449	4042838.	38000.0	37968.9	623.8
29	62.86	85.2	87.0	1.4965	4097071.	38000.0	37970.3	594.7
30	64.91	86.3	90.0	1.5482	4149613.	38000.0	37971.2	576.1
31	62.26	86.6	91.0	1.5654	4167861.	38000.0	37970.0	600.3
32	57.80	87.1	92.0	1.5826	4187491.	38000.0	37967.8	645.8
33	60.37	87.4	93.0	1.5998	4206302.	38000.0	37969.1	618.8
34	61.19	87.8	94.0	1.6170	4224865.	38000.0	37969.5	610.6
35	62.12	88.2	95.0	1.6342	4243155.	38000.0	37970.0	601.6
36	63.26	88.6	96.0	1.6514	4261119.	38000.0	37970.5	590.9
37	63.00	89.0	97.0	1.6686	4279155.	38000.0	37970.4	593.3
38	65.75	89.3	98.0	1.6858	4296449.	38000.0	37971.6	568.9
39	65.12	89.7	99.0	1.7030	4313910.	38000.0	37971.3	574.4
40	65.56	90.0	100.0	1.7202	4331254.	38000.0	37971.5	570.5
41	66.65	90.4	101.0	1.7374	4348318.	38000.0	37972.0	561.3
42	65.19	90.8	102.0	1.7546	4365759.	38000.0	37971.4	573.7
43	48.66	92.2	105.0	1.8062	4435487.	38000.0	37961.8	764.6
44	15.69	96.5	108.0	1.8578	4642627.	38000.0	37886.5	2271.3
45	16.13	100.7	111.0	1.9094	4844357.	38000.0	37889.5	2212.0

46	23.85	103.6	114.0	1.9610	4983551.	38000.0	37923.7	1526.2
47	31.94	105.8	117.0	2.0126	5088622.	38000.0	37942.4	1152.1
48	35.63	107.7	120.0	2.0642	5183126.	38000.0	37948.2	1036.2
49	37.04	109.6	123.0	2.1158	5274121.	38000.0	37950.2	997.8
50	41.35	111.3	126.0	2.1674	5355870.	38000.0	37955.2	896.4
51	48.08	112.8	129.0	2.2190	5426414.	38000.0	37961.4	773.5
52	53.77	114.1	132.0	2.2706	5489643.	38000.0	37965.4	693.3
53	58.64	115.3	135.0	2.3222	5547712.	38000.0	37968.2	636.7
54	63.03	116.4	138.0	2.3738	5601797.	38000.0	37970.4	593.0
55	69.18	117.5	141.0	2.4254	5651147.	38000.0	37973.0	541.1
56	76.45	118.4	144.0	2.4770	5695869.	38000.0	37975.5	490.4
57	84.31	119.2	147.0	2.5286	5736471.	38000.0	37977.8	445.2
58	91.40	120.0	150.0	2.5803	5773961.	38000.0	37979.5	411.1
59	101.17	120.7	153.0	2.6319	5807866.	38000.0	37981.5	371.8
60	110.11	121.4	156.0	2.6835	5839044.	38000.0	37983.0	341.9
61	118.76	122.0	159.0	2.7351	5867971.	38000.0	37984.2	317.2
62	127.44	122.5	162.0	2.7867	5894944.	38000.0	37985.3	295.8
63	134.56	123.1	165.0	2.8383	5920500.	38000.0	37986.0	280.2
64	141.27	123.6	168.0	2.8899	5944852.	38000.0	37986.7	267.0
65	147.47	124.1	171.0	2.9415	5968187.	38000.0	37987.3	255.9
66	154.65	124.5	174.0	2.9931	5990446.	38000.0	37987.8	244.1
67	162.16	125.0	177.0	3.0447	6011681.	38000.0	37988.4	232.8
68	169.14	125.4	180.0	3.0963	6032045.	38000.0	37988.9	223.3
69	175.60	125.8	183.0	3.1479	6051663.	38000.0	37989.3	215.1
70	182.20	126.2	186.0	3.1995	6070576.	38000.0	37989.7	207.4
71	188.60	126.6	189.0	3.2511	6088850.	38000.0	37990.0	200.4
72	194.93	126.9	192.0	3.3027	6106534.	38000.0	37990.4	193.9
73	201.50	127.3	195.0	3.3543	6123644.	38000.0	37990.7	187.6

CUM. INCOME = 100.1      DISC. CUM. INCOME = 65.2 - (BAF)

ASSUMED INTEREST RATE - (PERCENT) = 12.0

CHEMICAL NO.	CHEMICAL CHARACTERISTICS		
	CONC., PPM	RESISTANCE FACTOR	ACON
1	1000.00	20.00	5.00
2	500.00	15.00	5.00
3	250.00	10.00	5.00
4	100.00	5.00	5.00

BRINE NO.	BRINE CHARACTERISTICS			
	CHEMICAL CONC., PPM	VISCOSITY, CPS.	RRF	ACON
1	.00	.630	2.000	1.00

INJECTION SCHEDULE PLAN	
FLUID	PORE VOLUMES INJECTED
WATER	1.5482
POLYMER 1	.0172
POLYMER 2	.0172
POLYMER 3	.0688
POLYMER 4	.1032
POLYMER 5	.0000
POLYMER 6	.0000
BRINE 1	2.0000
BRINE 2	.0000

MAR. 3, 1976

STANLEY STRINGER  
0◆◆0◆◆0

DOW FLOODING PROCESS

◆◆◆SUMMARY OF YEARLY TOTALS◆◆◆

YEAR	OIL PROD. (BBLs/YR)
1	1052331.
2	1015911.
3	642652.
4	445692.
5	355743.
6	287624.
7	242885.
8	218280.
9	391508.
10	540499.
11	306517.
12	206226.
13	143174.
14	105809.
15	87193.
16	74489.
17	17111.

17 6123644.1  
PERMEABILITY VARIATION BASED ON CORE ANALYSIS FROM WELL HIRAM #17  
RELATIVE PERMEABILITY DATA FROM SCAL-75410 (HIRAM 17 - SAMPLE 1)

TABLE IV

MAR. 3, 1976

STANLEY STRINGER

DFP - 250 PPM FOR 1 YEAR

STEP	WOR	BAF	TIME (MOS.)	PVINJ	CUM.OIL (BBLs)	INJ. RATE (B/D)	TF RATE (B/D)	OIL RATE (B/D)
1	.01	.0	3.0	.0516		0. 38000.0	.1	.0
2	.01	.0	6.0	.1032		0. 38000.0	.1	.0
3	1.17	12.9	9.0	.1548	617064.	38000.0	14617.2	6766.1
4	3.52	21.9	12.0	.2064	1052331.	38000.0	21530.0	4772.7
5	6.14	29.2	15.0	.2580	1405108.	38000.0	27585.0	3868.2
6	9.32	34.5	18.0	.3096	1657313.	38000.0	28517.9	2765.4
7	11.65	38.9	21.0	.3612	1869304.	38000.0	29391.7	2324.5
8	12.91	43.0	24.0	.4128	2068242.	38000.0	30322.1	2181.3
9	14.73	46.9	27.0	.4644	2255690.	38000.0	32311.6	2055.4
10	16.90	50.4	30.0	.5161	2421994.	38000.0	32629.4	1823.4
11	19.28	53.5	33.0	.5677	2572538.	38000.0	33465.2	1650.8
12	21.60	56.4	36.0	.6193	2710894.	38000.0	34274.7	1517.1
13	24.40	58.9	39.0	.6709	2834755.	38000.0	34492.7	1358.1
14	26.80	61.3	42.0	.7225	2948331.	38000.0	34614.4	1245.4
15	29.01	63.5	45.0	.7741	3054265.	38000.0	34847.1	1161.6
16	32.39	65.6	48.0	.8257	3156586.	38000.0	37452.5	1121.9
17	34.73	67.6	51.0	.8773	3253457.	38000.0	37946.9	1062.2
18	36.66	69.6	54.0	.9289	3345366.	38000.0	37949.7	1007.8
19	39.18	71.3	57.0	.9805	3431526.	38000.0	37952.8	944.7
20	41.85	73.0	60.0	1.0321	3512328.	38000.0	37955.7	886.0
21	44.60	74.6	63.0	1.0837	3588258.	38000.0	37958.4	832.6
22	46.13	76.1	66.0	1.1353	3661719.	38000.0	37959.8	805.5
23	48.12	77.6	69.0	1.1869	3732206.	38000.0	37961.4	772.9
24	50.11	79.0	72.0	1.2385	3799953.	38000.0	37962.9	742.8
25	52.30	80.4	75.0	1.2901	3864923.	38000.0	37964.4	712.4
26	54.97	81.6	78.0	1.3417	3926796.	38000.0	37966.1	678.4
27	57.55	82.9	81.0	1.3933	3985944.	38000.0	37967.6	648.6
28	59.87	84.0	84.0	1.4449	4042838.	38000.0	37968.9	623.8
29	62.86	85.2	87.0	1.4965	4097071.	38000.0	37970.3	594.7
30	64.91	86.3	90.0	1.5482	4149613.	38000.0	37971.2	576.1
31	62.26	86.6	91.0	1.5654	4167861.	38000.0	37970.0	600.3
32	58.49	87.1	92.0	1.5826	4187264.	38000.0	37968.1	638.3
33	60.99	87.4	93.0	1.5998	4205886.	38000.0	37969.4	612.6
34	61.24	87.8	94.0	1.6170	4224433.	38000.0	37969.5	610.1
35	62.05	88.2	95.0	1.6342	4242742.	38000.0	37969.9	602.3
36	63.07	88.6	96.0	1.6514	4260759.	38000.0	37970.4	592.7
37	62.83	89.0	97.0	1.6686	4278845.	38000.0	37970.3	595.0
38	64.78	89.3	98.0	1.6858	4296395.	38000.0	37971.2	577.3
39	64.26	89.7	99.0	1.7030	4314084.	38000.0	37971.0	581.9
40	65.16	90.0	100.0	1.7202	4331534.	38000.0	37971.3	574.0
41	66.76	90.4	101.0	1.7374	4348570.	38000.0	37972.0	560.4
42	66.91	90.8	102.0	1.7546	4365570.	38000.0	37972.1	559.2
43	55.98	92.0	105.0	1.8062	4426344.	38000.0	37966.7	666.4
44	18.29	95.7	108.0	1.8578	4605605.	38000.0	37901.8	1965.6

45	13.52	100.7	111.0	1.9094	4843528.	38000.0	37869.6	2608.8
46	19.19	104.2	114.0	1.9610	5014810.	38000.0	37906.1	1879.1
47	31.26	106.5	117.0	2.0126	5122086.	38000.0	37941.2	1176.3
48	39.70	108.2	120.0	2.0642	5207140.	38000.0	37953.4	932.6
49	42.16	109.9	123.0	2.1158	5287357.	38000.0	37956.1	879.6
50	46.43	111.4	126.0	2.1674	5360358.	38000.0	37960.0	800.5
51	49.87	112.8	129.0	2.2190	5428420.	38000.0	37962.7	746.3
52	55.49	114.1	132.0	2.2706	5489722.	38000.0	37966.4	672.2
53	58.42	115.3	135.0	2.3222	5548004.	38000.0	37968.1	639.0
54	62.24	116.5	138.0	2.3738	5602767.	38000.0	37970.0	600.5
55	66.44	117.5	141.0	2.4254	5654118.	38000.0	37971.9	563.1
56	70.70	118.5	144.0	2.4770	5702426.	38000.0	37973.6	529.7
57	74.97	119.5	147.0	2.5286	5748016.	38000.0	37975.1	499.9
58	78.85	120.4	150.0	2.5803	5791395.	38000.0	37976.3	475.6
59	84.78	121.2	153.0	2.6319	5831777.	38000.0	37977.9	442.8
60	93.04	122.0	156.0	2.6835	5868610.	38000.0	37979.9	403.9
61	105.22	122.7	159.0	2.7351	5901224.	38000.0	37982.2	357.6
62	117.67	123.3	162.0	2.7867	5930417.	38000.0	37984.0	320.1
63	131.41	123.8	165.0	2.8383	5956581.	38000.0	37985.7	286.9
64	144.43	124.3	168.0	2.8899	5980404.	38000.0	37987.0	261.2
65	155.72	124.8	171.0	2.9415	6002511.	38000.0	37987.9	242.4
66	164.64	125.2	174.0	2.9931	6023428.	38000.0	37988.6	229.4
67	173.23	125.6	177.0	3.0447	6043314.	38000.0	37989.1	218.0
68	181.42	126.0	180.0	3.0963	6062308.	38000.0	37989.6	208.3
69	189.77	126.4	183.0	3.1479	6080470.	38000.0	37990.1	199.1
70	195.26	126.8	186.0	3.1995	6098124.	38000.0	37990.4	193.6
71	203.77	127.1	189.0	3.2511	6115045.	38000.0	37990.8	185.5

CUM. INCOME = 100.8      DISC. CUM. INCOME = 65.4 - (BAF)  
 ASSUMED INTEREST RATE - (PERCENT) = 12.0

CHEMICAL NO.	CHEMICAL CHARACTERISTICS		ACON
	CONC., PPM	RESISTANCE FACTOR	
1	250.00	10.00	5.00

BRINE NO.	BRINE CHARACTERISTICS		RRF	ACON
	CHEMICAL CONC., PPM	VISCOSITY, CPS.		
1	.00	.630	2.000	1.00

INJECTION SCHEDULE PLAN	
FLUID	PORE VOLUMES INJECTED
WATER	1.5482
POLYMER 1	.2064
POLYMER 2	.0000
POLYMER 3	.0000
POLYMER 4	.0000
POLYMER 5	.0000
POLYMER 6	.0000
BRINE 1	3.0000
BRINE 2	.0000

MAR. 3, 1976

STANLEY STRINGER

DFP - 250 PPM FOR 1 YEAR

0◆◆0◆◆0

◆◆◆SUMMARY OF YEARLY TOTALS◆◆◆

YEAR	OIL PROD. (BBLs/YR)
1	1052331.
2	1015911.
3	642652.
4	445692.
5	355743.
6	297624.
7	242895.
8	217921.
9	344847.
10	601535.
11	282582.
12	212704.
13	166184.
14	111794.
15	31904.
16	52737.

16

6115044.5

PERMEABILITY VARIATION BASED ON CORE ANALYSIS FROM WELL HIRAM #17  
RELATIVE PERMEABILITY DATA FROM SCAL-75410 (HIRAM 17 - SAMPLE 1)

TABLE V

MAR 30, 1976

STANLEY STRINGER

WATERFLOODING

STEP	WOR	BAF	TIME (MOS.)	PVINJ	CUM.OIL (BBLs)	INJ. RATE (B/D)	TF RATE (B/D)	OIL RATE (B/D)
1	7.24	2.5	3.0	.0501	119254.	38000.0	10771.6	1307.6
2	12.99	3.6	6.0	.1003	173043.	38000.0	8246.5	589.8
3	19.59	4.4	9.0	.1504	215438.	38000.0	9570.7	464.9
4	2.17	16.3	12.0	.2005	798034.	38000.0	20198.4	6388.1
5	5.67	23.3	15.0	.2507	1167515.	38000.0	27006.0	4051.3
6	12.30	27.9	18.0	.3008	1366554.	38000.0	29015.5	2182.5
7	12.79	32.3	21.0	.3509	1584964.	38000.0	33006.3	2394.3
8	18.20	35.5	24.0	.4011	1744972.	38000.0	33672.4	1754.5
9	21.45	38.4	27.0	.4512	1882691.	38000.0	33890.2	1510.1
10	24.51	40.3	30.0	.5013	2004623.	38000.0	34102.9	1337.0
11	27.34	43.1	33.0	.5515	2114676.	38000.0	34196.3	1206.7
12	30.00	45.1	36.0	.6016	2215731.	38000.0	34342.1	1109.1
13	32.33	47.0	39.0	.6517	2310154.	38000.0	34507.1	1035.3
14	34.53	48.9	42.0	.7019	2398851.	38000.0	34550.5	972.6
15	36.08	50.6	45.0	.7520	2484227.	38000.0	34705.3	936.1
16	30.48	52.7	48.0	.8021	2586619.	38000.0	35339.6	1122.7
17	35.90	54.5	51.0	.8523	2674602.	38000.0	35591.7	964.7
18	38.91	56.1	54.0	.9024	2756066.	38000.0	35643.0	893.2
19	41.55	57.7	57.0	.9526	2832587.	38000.0	35694.9	839.0
20	45.54	59.1	60.0	1.0027	2902692.	38000.0	35770.3	768.7
21	48.50	60.4	63.0	1.0528	2968709.	38000.0	35824.3	723.9
22	51.41	61.7	66.0	1.1030	3031743.	38000.0	36218.4	691.2
23	54.14	63.0	69.0	1.1531	3091980.	38000.0	36419.6	660.5
24	56.48	64.1	72.0	1.2032	3149792.	38000.0	36435.5	633.9
25	58.74	65.3	75.0	1.2534	3205474.	38000.0	36471.3	610.5
26	61.35	66.3	78.0	1.3035	3258872.	38000.0	36502.7	585.5
27	62.77	67.4	81.0	1.3536	3311093.	38000.0	36509.1	572.6
28	64.67	68.4	84.0	1.4038	3361823.	38000.0	36528.3	556.3
29	67.89	69.4	87.0	1.4539	3410293.	38000.0	36608.3	531.5
30	69.34	70.4	90.0	1.5040	3457770.	38000.0	36615.7	520.6
31	71.48	71.3	93.0	1.5542	3503877.	38000.0	36641.5	505.6
32	73.61	72.2	96.0	1.6043	3548833.	38000.0	36777.1	492.9
33	76.14	73.2	99.0	1.6544	3593683.	38000.0	37935.1	491.8
34	77.99	74.1	102.0	1.7046	3637530.	38000.0	37976.0	480.8
35	79.60	74.9	105.0	1.7547	3680505.	38000.0	37976.5	471.2
36	81.61	75.8	108.0	1.8048	3722435.	38000.0	37977.1	459.8
37	84.16	76.6	111.0	1.8550	3763110.	38000.0	37977.7	446.0
38	85.68	77.4	114.0	1.9051	3803070.	38000.0	37978.1	438.2
39	88.27	78.2	117.0	1.9552	3841874.	38000.0	37978.3	425.5
40	90.69	79.0	120.0	2.0054	3879651.	38000.0	37979.3	414.2
41	92.11	79.7	123.0	2.0555	3916854.	38000.0	37979.7	407.9
42	93.73	80.5	126.0	2.1056	3953422.	38000.0	37980.0	401.0
43	96.08	81.2	129.0	2.1558	3989104.	38000.0	37980.5	391.3
44	97.49	81.9	132.0	2.2059	4024276.	38000.0	37980.8	385.7
45	99.49	82.6	135.0	2.2560	4058746.	38000.0	37981.2	378.0

46	101.21	83.3	138.0	2.3062	4092638.	38000.0	37981.5	371.6
47	103.69	84.0	141.0	2.3563	4125727.	38000.0	37981.9	362.8
48	104.13	84.7	144.0	2.4064	4158680.	38000.0	37982.0	361.3
49	106.02	85.3	147.0	2.4566	4191049.	38000.0	37982.3	354.9
50	109.23	86.0	150.0	2.5067	4222475.	38000.0	37982.8	344.6
51	110.29	86.6	153.0	2.5568	4253604.	38000.0	37983.0	341.3
52	113.29	87.2	156.0	2.6070	4283914.	38000.0	37983.4	332.3
53	114.10	87.8	159.0	2.6571	4314010.	38000.0	37983.5	330.0
54	115.87	88.4	162.0	2.7072	4343652.	38000.0	37983.8	325.0
55	120.26	89.0	165.0	2.7574	4372220.	38000.0	37984.4	313.3
56	119.63	89.6	168.0	2.8075	4400938.	38000.0	37984.3	314.9
57	123.14	90.2	171.0	2.8577	4428845.	38000.0	37984.7	306.0
58	124.38	90.7	174.0	2.9078	4456476.	38000.0	37984.9	303.0
59	129.57	91.3	177.0	2.9579	4483009.	38000.0	37985.5	290.9
60	126.79	91.8	180.0	3.0081	4510119.	38000.0	37985.2	297.3
61	130.88	92.3	183.0	3.0582	4536389.	38000.0	37985.6	288.0
62	129.99	92.9	186.0	3.1083	4562837.	38000.0	37985.5	290.0
63	134.18	93.4	189.0	3.1585	4588465.	38000.0	37986.0	281.0
64	135.80	93.9	192.0	3.2086	4613789.	38000.0	37986.2	277.7
65	136.00	94.4	195.0	3.2587	4639076.	38000.0	37986.2	277.3
66	140.05	94.9	198.0	3.3089	4663639.	38000.0	37986.6	269.3
67	142.57	95.4	201.0	3.3590	4687770.	38000.0	37986.8	264.6
68	140.93	95.9	204.0	3.4091	4712180.	38000.0	37986.7	267.6
69	141.56	96.4	207.0	3.4593	4736482.	38000.0	37986.7	266.5
70	143.15	96.9	210.0	3.5094	4760515.	38000.0	37986.9	263.5
71	145.77	97.4	213.0	3.5595	4784120.	38000.0	37987.1	258.8
72	147.25	97.9	216.0	3.6097	4807490.	38000.0	37987.2	256.3
73	148.46	98.3	219.0	3.6598	4830671.	38000.0	37987.3	254.2
74	149.96	98.8	222.0	3.7099	4853620.	38000.0	37987.5	251.6
75	154.29	99.2	225.0	3.7601	4875930.	38000.0	37987.8	244.6
76	152.38	99.7	228.0	3.8102	4898518.	38000.0	37987.7	247.7
77	159.70	100.1	231.0	3.8603	4920079.	38000.0	37988.2	236.4
78	156.60	100.6	234.0	3.9105	4942063.	38000.0	37988.0	241.1
79	161.02	101.0	237.0	3.9606	4963447.	38000.0	37988.3	234.5
80	161.72	101.5	240.0	4.0107	4984738.	38000.0	37988.4	233.5
81	165.94	101.9	243.0	4.0609	5005492.	38000.0	37988.7	227.6
82	165.85	102.3	246.0	4.1110	5026258.	38000.0	37988.7	227.7
83	168.36	102.7	249.0	4.1611	5046716.	38000.0	37988.8	224.3
84	168.11	103.1	252.0	4.2113	5067203.	38000.0	37988.8	224.6
85	172.94	103.5	255.0	4.2614	5087122.	38000.0	37989.1	218.4
86	173.01	104.0	258.0	4.3115	5107033.	38000.0	37989.1	218.3
87	175.10	104.4	261.0	4.3617	5126707.	38000.0	37989.3	215.7
88	180.22	104.7	264.0	4.4118	5145826.	38000.0	37989.6	209.6
89	181.80	105.1	267.0	4.4619	5164779.	38000.0	37989.7	207.8
90	182.64	105.5	270.0	4.5121	5183647.	38000.0	37989.7	206.9
91	187.26	105.9	273.0	4.5622	5202051.	38000.0	37990.0	201.8
92	186.56	106.3	276.0	4.6124	5220523.	38000.0	37989.9	202.6
93	191.95	106.6	279.0	4.6625	5238481.	38000.0	37990.2	196.9
94	197.04	107.0	282.0	4.7126	5255977.	38000.0	37990.5	191.8
95	199.24	107.3	285.0	4.7628	5273280.	38000.0	37990.6	189.7
96	198.94	107.7	288.0	4.8129	5290609.	38000.0	37990.5	190.0
97	203.73	108.0	291.0	4.8630	5307533.	38000.0	37990.8	185.6

CUM. INCOME = 75.6      DISC. CUM. INCOME = 49.8 - (BAF)

81      ASSUMED INTEREST RATE - (PERCENT) = 12.0

JOB 1

MAR 30, 1976

BASIC RESERVOIR DATA

STANLEY STRINGER

WATERFLOODING

0◆◆0◆◆0

PATTERN AREA, AC.	1024.0
PATTERN VOLUME, AF	49152.00
DISTANCE FROM INJECTOR TO PRODUCER, FT.	660.0
WELLBORE RADIUS, INJECTOR, FT.	1.00
WELLBORE RADIUS, PRODUCER, FT.	1.00
NO. OF SEGMENTS IN EACH LAYER,	14
FORMATION VOLUME FACTOR	1.050
OIL VISCOSITY, CPS.	2.36
WATER VISCOSITY, CPS.	.63

LAYER CHARACTERISTICS

LAYER	THICK., FT.	PERM. MD.	POROSITY	S0	SW	S5	ADS. (LB/AF)
1	3.00	1400.00	.249	.563	.136	.301	30.0
2	4.70	739.00	.226	.499	.250	.261	30.0
3	4.70	370.00	.201	.460	.300	.240	30.0
4	4.70	109.00	.165	.460	.300	.240	30.0
5	4.70	60.00	.157	.410	.370	.220	30.0
6	20.20	33.00	.146	.390	.410	.210	30.0
7	1.00	15000.00	.249	.563	.136	.301	5.2

MAR 30, 1976

STANLEY STRINGER WATERFLOODING  
0◆◆0◆◆0

◆◆◆SUMMARY OF YEARLY TOTALS◆◆◆

YEAR	OIL PROD. (BBLs/YR)
1	798034.
2	946938.
3	470759.
4	370888.
5	316073.
6	<del>247099.</del>
7	212031.
8	187010.
9	173602.
10	157216.
11	144624.
12	134404.
13	125234.
14	117024.
15	109131.
16	103669.
17	98391.
18	95311.
19	91028.
20	86220.
21	82465.
22	78623.
23	74698.
24	70086.
25	16924.

25 5307532.9

PERMEABILITY VARIATION BASED ON CORE ANALYSIS FROM WELL HIRAM #17  
RELATIVE PERMEABILITY DATA FROM SCAL-75410 (HIRAM 17 - SAMPLE 1)

TABLE VI

MAR 30, 1976		STANLEY STRINGER			DFP PROGRAMMED SLUG			
STEP	WOR	BAF	TIME (MOS.)	PYINJ	CUM.OIL (BBLs)	INJ. RATE (B/D)	TF RATE (B/D)	QIL RATE (B/D)
1	7.24	2.5	3.0	.0501	119254.	38000.0	10771.6	1307.6
2	12.99	3.6	6.0	.1003	173043.	38000.0	8246.5	589.8
3	19.59	4.4	9.0	.1504	215438.	38000.0	9570.7	464.9
4	2.17	16.3	12.0	.2005	798034.	38000.0	20198.4	6388.1
5	5.67	23.8	15.0	.2507	1167515.	38000.0	27006.0	4051.3
6	12.30	27.9	18.0	.3008	1366554.	38000.0	29015.5	2182.5
7	12.79	32.3	21.0	.3509	1584964.	38000.0	33006.3	2394.8
8	18.20	35.5	24.0	.4011	1744972.	38000.0	33672.4	1754.5
9	21.45	38.4	27.0	.4512	1982691.	38000.0	33890.2	1510.1
10	24.51	40.8	30.0	.5013	2004623.	38000.0	34102.9	1337.0
11	27.34	43.1	33.0	.5515	2114676.	38000.0	34196.8	1206.7
12	30.00	45.1	36.0	.6016	2215731.	38000.0	34342.1	1108.1
13	32.33	47.0	39.0	.6517	2310154.	38000.0	34507.1	1035.3
14	34.53	48.9	42.0	.7019	2398851.	38000.0	34550.5	972.6
15	36.08	50.6	45.0	.7520	2484227.	38000.0	34705.8	936.1
16	30.48	52.7	48.0	.8021	2586619.	38000.0	35339.6	1122.7
17	35.90	54.5	51.0	.8523	2674602.	38000.0	35591.7	964.7
18	38.91	56.1	54.0	.9024	2756066.	38000.0	35643.0	893.2
19	41.55	57.7	57.0	.9526	2832587.	38000.0	35694.9	839.0
20	45.54	59.1	60.0	1.0027	2902692.	38000.0	35770.8	768.7
21	48.50	60.4	63.0	1.0528	2968709.	38000.0	35824.3	723.9
22	51.41	61.7	66.0	1.1030	3031743.	38000.0	36218.4	691.2
23	54.14	63.0	69.0	1.1531	3091980.	38000.0	36418.6	660.5
24	56.48	64.1	72.0	1.2032	3149792.	38000.0	36435.5	633.9
25	58.74	65.3	75.0	1.2534	3205474.	38000.0	36471.3	610.5
26	61.35	66.3	78.0	1.3035	3258872.	38000.0	36502.7	585.5
27	62.77	67.4	81.0	1.3536	3311093.	38000.0	36509.1	572.6
28	64.67	68.4	84.0	1.4038	3361823.	38000.0	36528.3	556.3
29	67.89	69.4	87.0	1.4539	3410293.	38000.0	36608.3	531.5
30	69.34	70.4	90.0	1.5040	3457770.	38000.0	36615.7	520.6
31	66.71	70.7	91.0	1.5207	3474222.	38000.0	36639.7	541.2
32	45.09	71.2	92.0	1.5375	3498108.	38000.0	36211.6	785.7
33	45.11	71.7	93.0	1.5542	3522453.	38000.0	36925.8	800.8
34	40.00	72.3	94.0	1.5709	3549838.	38000.0	36930.3	900.8
35	39.09	72.8	95.0	1.5876	3577604.	38000.0	36607.1	913.3
36	40.35	73.4	96.0	1.6043	3604612.	38000.0	36728.5	888.4
37	43.43	73.9	97.0	1.6210	3630588.	38000.0	37957.3	854.5
38	44.61	74.4	98.0	1.6377	3655891.	38000.0	37958.4	832.3
39	45.94	74.9	99.0	1.6544	3680478.	38000.0	37959.6	808.8
40	49.11	75.4	100.0	1.6711	3703512.	38000.0	37962.2	757.7
41	51.75	75.8	101.0	1.6879	3725392.	38000.0	37964.1	719.7
42	53.35	76.3	102.0	1.7046	3746631.	38000.0	37965.1	698.7
43	54.56	77.5	105.0	1.7547	3808957.	38000.0	37965.9	683.4
44	62.85	78.6	108.0	1.8048	3863197.	38000.0	37970.3	594.7
45	64.85	79.7	111.0	1.8550	3915790.	38000.0	37971.2	576.7

Table VI (continued)  
Page 2 of 4

46	54.29	31.0	114.0	1.9051	3973418.	38000.0	37965.7	686.7
47	36.76	32.9	117.0	1.9552	4070086.	38000.0	37949.8	1005.1
48	28.92	35.2	120.0	2.0054	4195726.	38000.0	37936.6	1268.0
49	29.16	37.5	123.0	2.0555	4300452.	38000.0	37937.2	1258.0
50	30.91	39.7	126.0	2.1056	4408908.	38000.0	37940.6	1189.2
51	32.55	91.9	129.0	2.1558	4512065.	38000.0	37943.5	1131.1
52	33.88	93.9	132.0	2.2059	4611297.	38000.0	37945.6	1088.1
53	35.02	95.8	135.0	2.2560	4707398.	38000.0	37947.4	1053.7
54	37.32	97.7	138.0	2.3062	4797741.	38000.0	37950.5	990.6
55	40.21	99.4	141.0	2.3563	4881745.	38000.0	37954.0	921.1
56	42.73	101.0	144.0	2.4064	4960916.	38000.0	37956.6	868.1
57	46.53	102.5	147.0	2.4566	5033683.	38000.0	37960.2	797.9
58	50.89	103.9	150.0	2.5067	5100411.	38000.0	37963.5	731.7
59	55.06	105.1	153.0	2.5568	5162184.	38000.0	37966.2	677.3
60	59.49	106.2	156.0	2.6070	5219436.	38000.0	37968.7	627.8
61	64.61	107.3	159.0	2.6571	5272221.	38000.0	37971.1	578.8
62	69.29	108.3	162.0	2.7072	5321495.	38000.0	37973.0	540.3
63	74.02	109.3	165.0	2.7574	5367665.	38000.0	37974.7	506.3
64	79.35	110.1	168.0	2.8075	5410774.	38000.0	37976.4	472.7
65	84.65	111.0	171.0	2.8577	5451213.	38000.0	37977.9	443.4
66	89.38	111.7	174.0	2.9078	5489541.	38000.0	37979.0	420.3
67	93.98	112.5	177.0	2.9579	5526013.	38000.0	37980.1	399.9
68	98.80	113.2	180.0	3.0081	5560721.	38000.0	37981.0	380.6
69	104.10	113.9	183.0	3.0582	5593681.	38000.0	37982.0	361.4
70	109.83	114.5	186.0	3.1083	5624937.	38000.0	37982.9	342.7
71	114.85	115.1	189.0	3.1585	5654839.	38000.0	37983.7	327.9
72	119.40	115.7	192.0	3.2086	5683613.	38000.0	37984.3	315.5
73	123.34	116.2	195.0	3.2587	5711474.	38000.0	37984.8	305.5
74	127.08	116.8	198.0	3.3089	5738522.	38000.0	37985.2	296.6
75	130.65	117.3	201.0	3.3590	5764837.	38000.0	37985.6	288.5
76	134.06	117.9	204.0	3.4091	5790489.	38000.0	37986.0	281.3
77	137.05	118.4	207.0	3.4593	5815584.	38000.0	37986.3	275.2
78	139.01	118.9	210.0	3.5094	5840329.	38000.0	37986.5	271.3
79	141.99	119.4	213.0	3.5595	5864558.	38000.0	37986.8	265.7
80	145.00	119.8	216.0	3.6097	5888287.	38000.0	37987.0	260.2
81	148.23	120.3	219.0	3.6598	5911503.	38000.0	37987.3	254.6
82	151.81	120.8	222.0	3.7099	5934176.	38000.0	37987.6	248.6
83	155.16	121.2	225.0	3.7601	5956362.	38000.0	37987.9	243.3
84	159.54	121.7	228.0	3.8102	5978078.	38000.0	37988.1	238.1
85	161.57	122.1	231.0	3.8603	5999390.	38000.0	37988.4	233.7
86	166.19	122.5	234.0	3.9105	6020113.	38000.0	37988.7	227.2
87	170.14	122.9	237.0	3.9606	6040353.	38000.0	37988.9	222.0
88	175.64	123.3	240.0	4.0107	6059972.	38000.0	37989.3	215.1
89	181.16	123.7	243.0	4.0609	6078992.	38000.0	37989.6	208.6
90	186.12	124.1	246.0	4.1110	6097508.	38000.0	37989.9	203.0
91	191.86	124.5	249.0	4.1611	6115473.	38000.0	37990.2	197.0
92	196.75	124.8	252.0	4.2113	6132995.	38000.0	37990.4	192.1
93	201.86	125.2	255.0	4.2614	6150074.	38000.0	37990.7	187.3

CUM. INCOME = 91.9      DISC. CUM. INCOME = 54.1 - (BAF)

ASSUMED INTEREST RATE - (PERCENT) = 12.0

JOB 1

MAR 30, 1976

BASIC RESERVOIR DATA

STANLEY STRINGER

DFP PROGRAMMED SLUG

0♦♦0♦♦0

PATTERN AREA, AC. 1024.0  
 PATTERN VOLUME, AF 49152.00  
 DISTANCE FROM INJECTOR TO PRODUCER, FT. 660.0  
 WELLBORE RADIUS, INJECTOR, FT. 1.00  
 WELLBORE RADIUS, PRODUCER, FT. 1.00  
 NO. OF SEGMENTS IN EACH LAYER, 14  
 FORMATION VOLUME FACTOR 1.050  
 OIL VISCOSITY, CPS. 2.35  
 WATER VISCOSITY, CPS. .63

LAYER CHARACTERISTICS

LAYER	THICK., FT.	PERM. MD.	POROSITY	SO	SW	SG	ADS. (LB/AF)
1	3.00	1400.00	.248	.563	.136	.301	30.0
2	4.70	739.00	.226	.489	.250	.261	30.0
3	4.70	370.00	.201	.460	.300	.240	30.0
4	4.70	109.00	.165	.460	.300	.240	30.0
5	4.70	60.00	.157	.410	.370	.220	30.0
6	20.20	33.00	.146	.380	.410	.210	30.0
7	1.00	15000.00	.248	.563	.136	.301	5.2

CHEMICAL CHARACTERISTICS

CHEMICAL NO.	CONC., PPM	RESISTANCE FACTOR	ACON
1	1000.00	20.00	5.00
2	500.00	15.00	5.00
3	250.00	10.00	5.00
4	100.00	5.00	5.00

BRINE CHARACTERISTICS

BRINE NO.	CHEMICAL CONC., PPM	VISCOSITY, CPS.	RRF	ACON
1	.00	.630	2.000	1.00

INJECTION SCHEDULE PLAN

FLUID	PORE VOLUMES INJECTED
WATER	1.5040
POLYMER 1	.0167
POLYMER 2	.0167
POLYMER 3	.0668
POLYMER 4	.1003
POLYMER 5	.0000
POLYMER 6	.0000
BRINE 1	2.0000
BRINE 2	.0000

MAR 30, 1976

STANLEY STRINGER

DFP PROGRAMMED SLUG

0◆◆0◆◆0

◆◆◆SUMMARY	OF	YEARLY	TOTALS◆◆◆
YEAR			OIL PROD. (BBLS/YR)
1			798034.
2			946938.
3			470759.
4			370888.
5			316073.
6			247099.
7			212031.
8			242789.
9			258584.
10			322530.
11			425570.
12			349619.
13			258521.
14			191338.
15			143348.
16			122891.
17			106876.
18			97799.
19			89791.
20			81894.
21			73022.
22			17080.

22

6150074.2

PERMEABILITY VARIATION BASED ON CORE ANALYSIS FROM WELL HIRAM #17  
RELATIVE PERMEABILITY DATA FROM SCAL-75410 (HIRAM 17 - SAMPLE 1)

TABLE VII

MAR 30, 1976

STANLEY STRINGER

DFP - 250 PPM FOR 1 YEAR

STEP	WOR	BAF	TIME (MOS.)	PVINJ	CUM.OIL (BBLs)	INJ. RATE (B/D)	TF RATE (B/D)	OIL RATE (B/D)
1	7.24	2.5	3.0	.0501	119254.	38000.0	10771.6	1307.6
2	12.99	3.6	6.0	.1003	173043.	38000.0	8246.5	589.8
3	19.59	4.4	9.0	.1504	215438.	38000.0	9570.7	464.9
4	2.17	16.3	12.0	.2005	798034.	38000.0	20198.4	6388.1
5	5.67	23.3	15.0	.2507	1167515.	38000.0	27006.0	4051.3
6	12.30	27.9	18.0	.3008	1366554.	38000.0	29015.5	2182.5
7	12.79	32.3	21.0	.3509	1584964.	38000.0	33006.3	2394.8
8	18.20	35.5	24.0	.4011	1744972.	38000.0	33672.4	1754.5
9	21.45	38.4	27.0	.4512	1882691.	38000.0	33890.2	1510.1
10	24.51	40.8	30.0	.5013	2004623.	38000.0	34102.9	1337.0
11	27.34	43.1	33.0	.5515	2114676.	38000.0	34196.8	1206.7
12	30.00	45.1	36.0	.6016	2215731.	38000.0	34342.1	1108.1
13	32.33	47.0	39.0	.6517	2310154.	38000.0	34507.1	1035.3
14	34.53	48.9	42.0	.7019	2398851.	38000.0	34550.5	972.6
15	36.08	50.6	45.0	.7520	2484227.	38000.0	34705.8	936.1
16	30.48	52.7	48.0	.8021	2586619.	38000.0	35339.6	1122.7
17	35.90	54.5	51.0	.8523	2674602.	38000.0	35591.7	964.7
18	38.91	56.1	54.0	.9024	2756066.	38000.0	35643.0	893.2
19	41.55	57.7	57.0	.9526	2832587.	38000.0	35694.9	839.0
20	45.54	59.1	60.0	1.0027	2902692.	38000.0	35770.8	768.7
21	48.50	60.4	63.0	1.0528	2968709.	38000.0	35824.3	723.9
22	51.41	61.7	66.0	1.1030	3031743.	38000.0	36218.4	691.2
23	54.14	63.0	69.0	1.1531	3091980.	38000.0	36419.6	660.5
24	56.48	64.1	72.0	1.2032	3149792.	38000.0	36435.5	633.9
25	58.74	65.3	75.0	1.2534	3205474.	38000.0	36471.3	610.5
26	61.35	66.3	78.0	1.3035	3258872.	38000.0	36502.7	585.5
27	62.77	67.4	81.0	1.3536	3311093.	38000.0	36509.1	572.6
28	64.67	68.4	84.0	1.4038	3361823.	38000.0	36528.3	556.3
29	67.89	69.4	87.0	1.4539	3410293.	38000.0	36608.3	531.5
30	69.34	70.4	90.0	1.5040	3457770.	38000.0	36615.7	520.6
31	66.90	70.7	91.0	1.5207	3474175.	38000.0	36639.8	539.6
32	47.17	71.2	92.0	1.5375	3497037.	38000.0	36219.1	752.0
33	45.58	71.7	93.0	1.5542	3521040.	38000.0	36776.1	789.6
34	42.74	72.2	94.0	1.5709	3546581.	38000.0	36742.2	840.1
35	41.21	72.7	95.0	1.5876	3572925.	38000.0	36572.3	866.6
36	42.73	73.3	96.0	1.6043	3598720.	38000.0	37103.2	848.5
37	44.20	73.8	97.0	1.6210	3624253.	38000.0	37958.1	839.9
38	45.56	74.3	98.0	1.6377	3649038.	38000.0	37959.3	815.3
39	46.89	74.8	99.0	1.6544	3673135.	38000.0	37960.4	792.7
40	48.41	75.3	100.0	1.6711	3696492.	38000.0	37961.6	768.3
41	49.76	75.7	101.0	1.6879	3719229.	38000.0	37962.7	747.9
42	51.19	76.2	102.0	1.7046	3741345.	38000.0	37963.7	727.5
43	52.03	77.5	105.0	1.7547	3806640.	38000.0	37964.3	716.0
44	59.88	78.7	108.0	1.8048	3863523.	38000.0	37968.9	623.7
45	61.48	79.3	111.0	1.8550	3918952.	38000.0	37969.7	607.8

Table VII (continued)  
Page 2 of 4

46	51.33	31.1	114.0	1.9051	3985118.	38000.0	37963.3	725.5
47	36.25	33.0	117.0	1.9552	4073055.	38000.0	37949.1	1019.0
48	28.77	35.4	120.0	2.0054	4194307.	38000.0	37936.3	1274.7
49	29.73	37.7	123.0	2.0555	4306916.	38000.0	37938.3	1234.7
50	31.91	39.8	126.0	2.1056	4412065.	38000.0	37942.4	1153.0
51	33.38	91.9	129.0	2.1559	4512734.	38000.0	37944.9	1103.3
52	34.96	93.8	132.0	2.2059	4608980.	38000.0	37947.3	1055.3
53	36.63	95.7	135.0	2.2560	4700961.	38000.0	37949.6	1008.6
54	37.33	97.5	138.0	2.3062	4790119.	38000.0	37951.2	977.6
55	38.18	99.3	141.0	2.3563	4878477.	38000.0	37951.6	968.8
56	39.51	101.0	144.0	2.4064	4963932.	38000.0	37953.2	937.0
57	40.41	102.7	147.0	2.4566	5047527.	38000.0	37954.2	916.6
58	42.21	104.4	150.0	2.5067	5127652.	38000.0	37956.1	878.6
59	44.42	105.9	153.0	2.5568	5203870.	38000.0	37958.3	835.7
60	47.07	107.4	156.0	2.6070	5275904.	38000.0	37960.6	789.8
61	51.37	108.7	159.0	2.6571	5341393.	38000.0	37964.1	719.1
62	58.35	109.9	162.0	2.7072	5399252.	38000.0	37968.3	634.4
63	67.30	110.9	165.0	2.7574	5449958.	38000.0	37972.2	556.0
64	76.07	111.8	168.0	2.8075	5494898.	38000.0	37975.4	492.8
65	86.32	112.6	171.0	2.8577	5534566.	38000.0	37978.3	435.0
66	97.19	113.4	174.0	2.9078	5569846.	38000.0	37980.7	386.8
67	105.87	114.0	177.0	2.9579	5602259.	38000.0	37982.3	355.4
68	112.01	114.6	180.0	3.0081	5632914.	38000.0	37983.2	336.1
69	117.88	115.2	183.0	3.0582	5662056.	38000.0	37984.1	319.5
70	120.98	115.8	186.0	3.1083	5690456.	38000.0	37984.5	311.4
71	126.73	116.4	189.0	3.1585	5717580.	38000.0	37985.2	297.4
72	129.22	116.9	192.0	3.2086	5744184.	38000.0	37985.5	291.7
73	133.12	117.4	195.0	3.2587	5770015.	38000.0	37985.9	283.2
74	136.17	118.0	198.0	3.3089	5795272.	38000.0	37986.2	276.9
75	141.08	118.4	201.0	3.3590	5819656.	38000.0	37986.7	267.4
76	143.97	118.9	204.0	3.4091	5843554.	38000.0	37986.9	262.1
77	147.20	119.4	207.0	3.4593	5866931.	38000.0	37987.2	256.3
78	150.04	119.9	210.0	3.5094	5889869.	38000.0	37987.5	251.5
79	153.37	120.3	213.0	3.5595	5912313.	38000.0	37987.7	246.1
80	155.88	120.8	216.0	3.6097	5934398.	38000.0	37987.9	242.2
81	159.93	121.2	219.0	3.6598	5955927.	38000.0	37988.2	236.1
82	161.46	121.7	222.0	3.7099	5977252.	38000.0	37988.4	233.8
83	165.00	122.1	225.0	3.7601	5998124.	38000.0	37988.6	228.9
84	168.52	122.5	228.0	3.8102	6018562.	38000.0	37988.8	224.1
85	169.61	122.9	231.0	3.8603	6038870.	38000.0	37988.9	222.7
86	171.76	123.3	234.0	3.9105	6058925.	38000.0	37989.1	219.9
87	175.64	123.7	237.0	3.9606	6078540.	38000.0	37989.3	215.1
88	178.98	124.1	240.0	4.0107	6097790.	38000.0	37989.5	211.1
89	181.61	124.5	243.0	4.0609	6116764.	38000.0	37989.6	208.0
90	184.63	124.9	246.0	4.1110	6135428.	38000.0	37989.8	204.7
91	187.20	125.2	249.0	4.1611	6153838.	38000.0	37989.0	201.9
92	189.66	125.6	252.0	4.2113	6172010.	38000.0	37990.1	199.3
93	192.56	126.0	255.0	4.2614	6189910.	38000.0	37990.2	196.3
94	196.74	126.3	258.0	4.3115	6207432.	38000.0	37990.4	192.1
95	199.28	126.7	261.0	4.3617	6224732.	38000.0	37990.6	189.7
96	204.97	127.0	264.0	4.4118	6241553.	38000.0	37990.8	184.4

CUM. INCOME = 92.9      DISC. CUM. INCOME = 54.5 - (BAF)  
ASSUMED INTEREST RATE - (PERCENT) = 12.0

JOB 1

MAR 30, 1976

BASIC RESERVOIR DATA

STANLEY STRINGER

DFP - 250 PPM FOR 1 YEAR

0◆◆0◆◆0

PATTERN AREA, AC.	1024.0
PATTERN VOLUME, AF	49152.00
DISTANCE FROM INJECTOR TO PRODUCER, FT.	560.0
WELLBORE RADIUS, INJECTOR, FT.	1.00
WELLBORE RADIUS, PRODUCER, FT.	1.00
NO. OF SEGMENTS IN EACH LAYER,	14
FORMATION VOLUME FACTOR	1.050
OIL VISCOSITY, CPS.	2.36
WATER VISCOSITY, CPS.	.63

LAYER CHARACTERISTICS

LAYER	THICK., FT.	PERM. MD.	POROSITY	SO	SW	SG	ADS. (LB/AF)
1	3.00	1400.00	.243	.563	.136	.301	30.0
2	4.70	739.00	.226	.439	.250	.261	30.0
3	4.70	370.00	.201	.460	.300	.240	30.0
4	4.70	109.00	.165	.460	.300	.240	30.0
5	4.70	60.00	.157	.410	.370	.220	30.0
6	20.20	33.00	.146	.380	.410	.210	30.0
7	1.00	15000.00	.243	.563	.136	.301	5.2

STANLEY STRINGER  
0♦♦♦0♦♦♦0

MAR 30, 1976  
DFP - 250 PPM FOR 1 YEAR

♦♦♦SUMMARY	OF	YEARLY	TOTALS♦♦♦
YEAR			OIL PROD. (BBLS/YR)
1			798034.
2			946938.
3			470759.
4			370888.
5			316073.
6			247099.
7			212031.
8			236897.
9			264803.
10			330794.
11			414673.
12			354952.
13			311972.
14			218994.
15			138017.
16			111270.
17			99370.
18			90843.
19			84165.
20			79228.
21			74220.
22			69543.
22			6241553.4

PERMEABILITY VARIATION BASED ON CORE ANALYSIS FROM WELL HIRAM #17  
RELATIVE PERMEABILITY DATA FROM SCAL-75410 (HIRAM 17 - SAMPLE 1)

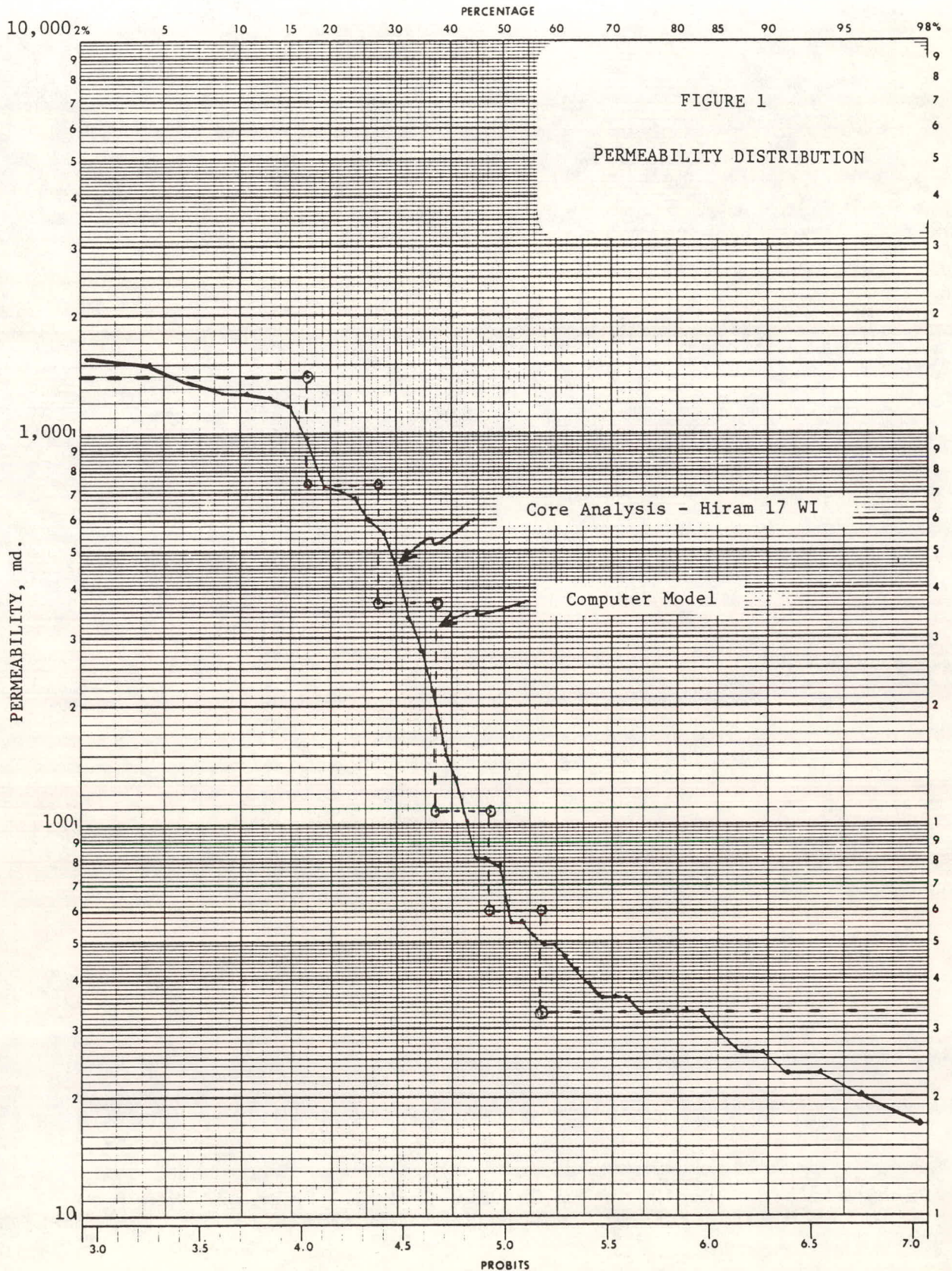


FIGURE 1  
PERMEABILITY DISTRIBUTION

Core Analysis - Hiram 17 WI

Computer Model

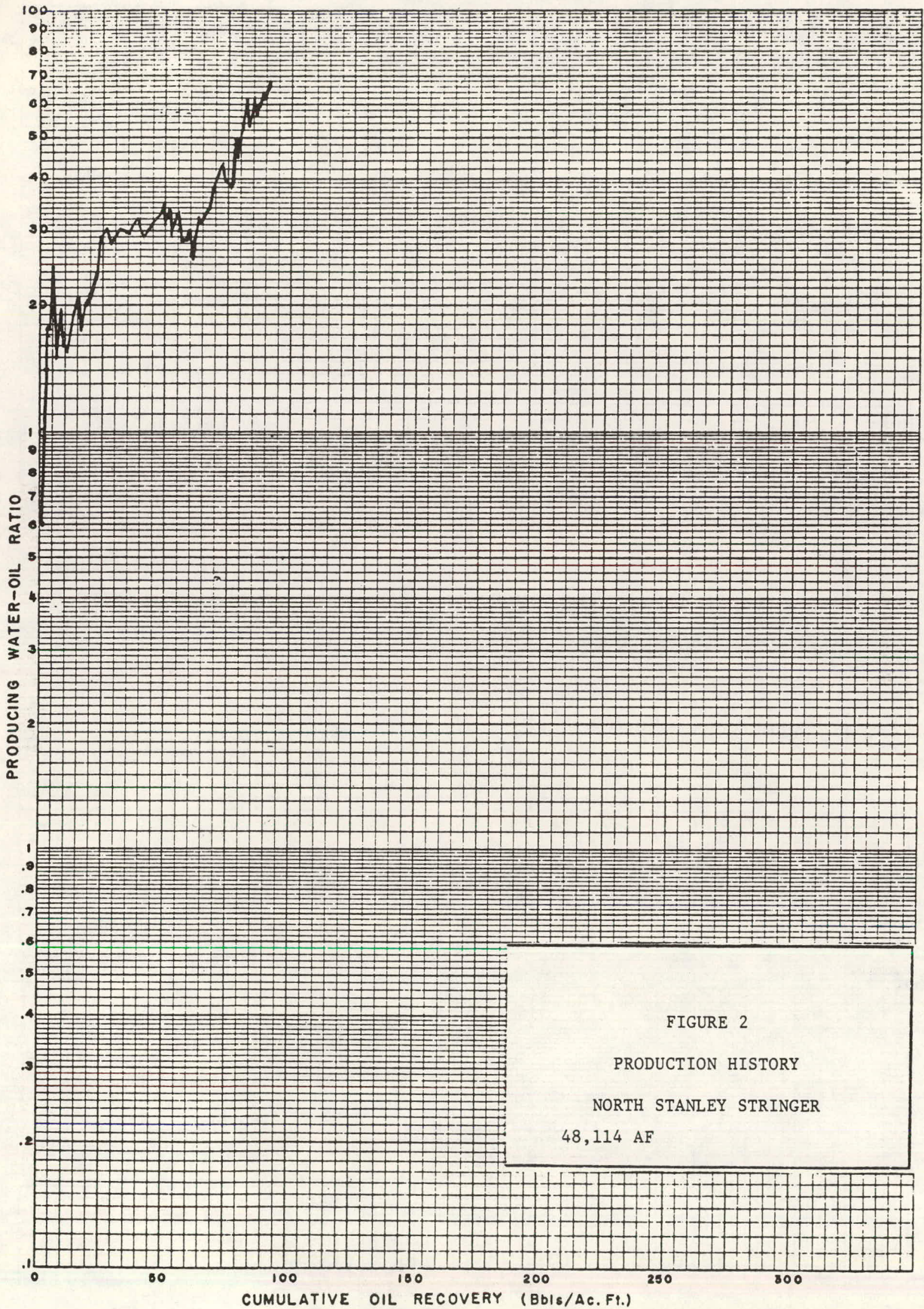


FIGURE 2  
 PRODUCTION HISTORY  
 NORTH STANLEY STRINGER  
 48,114 AF

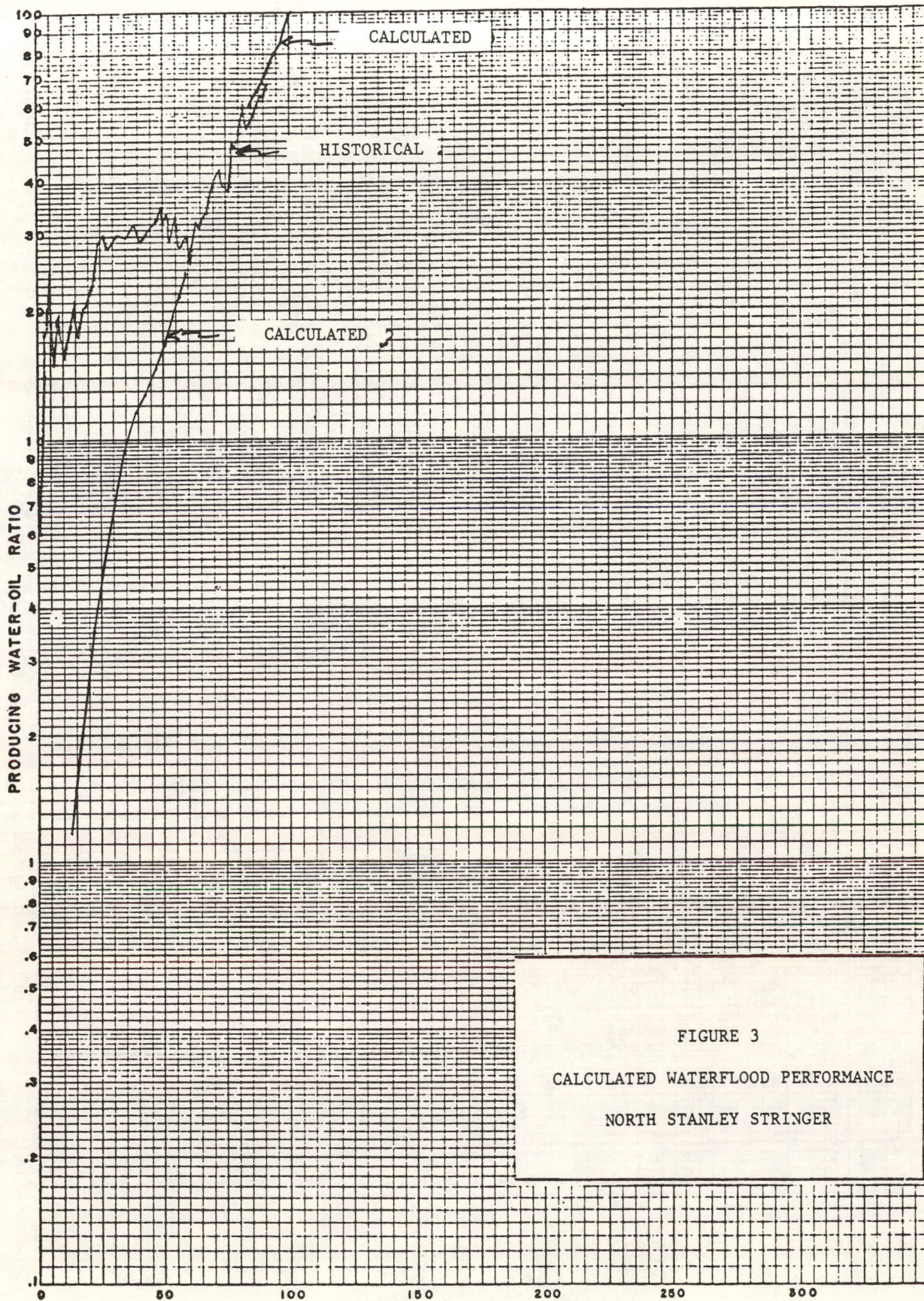
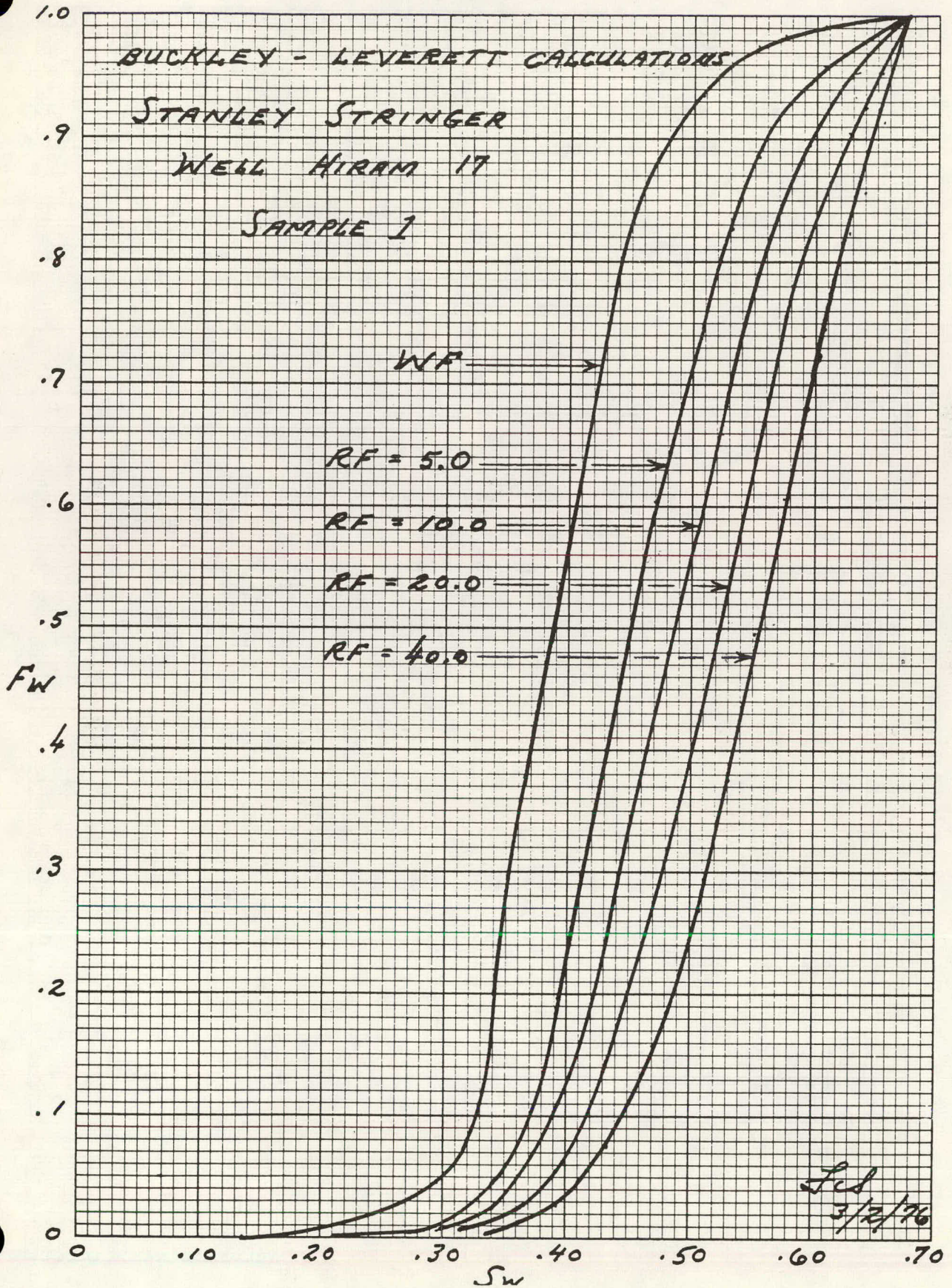


FIGURE 3  
 CALCULATED WATERFLOOD PERFORMANCE  
 NORTH STANLEY STRINGER

FIGURE 4



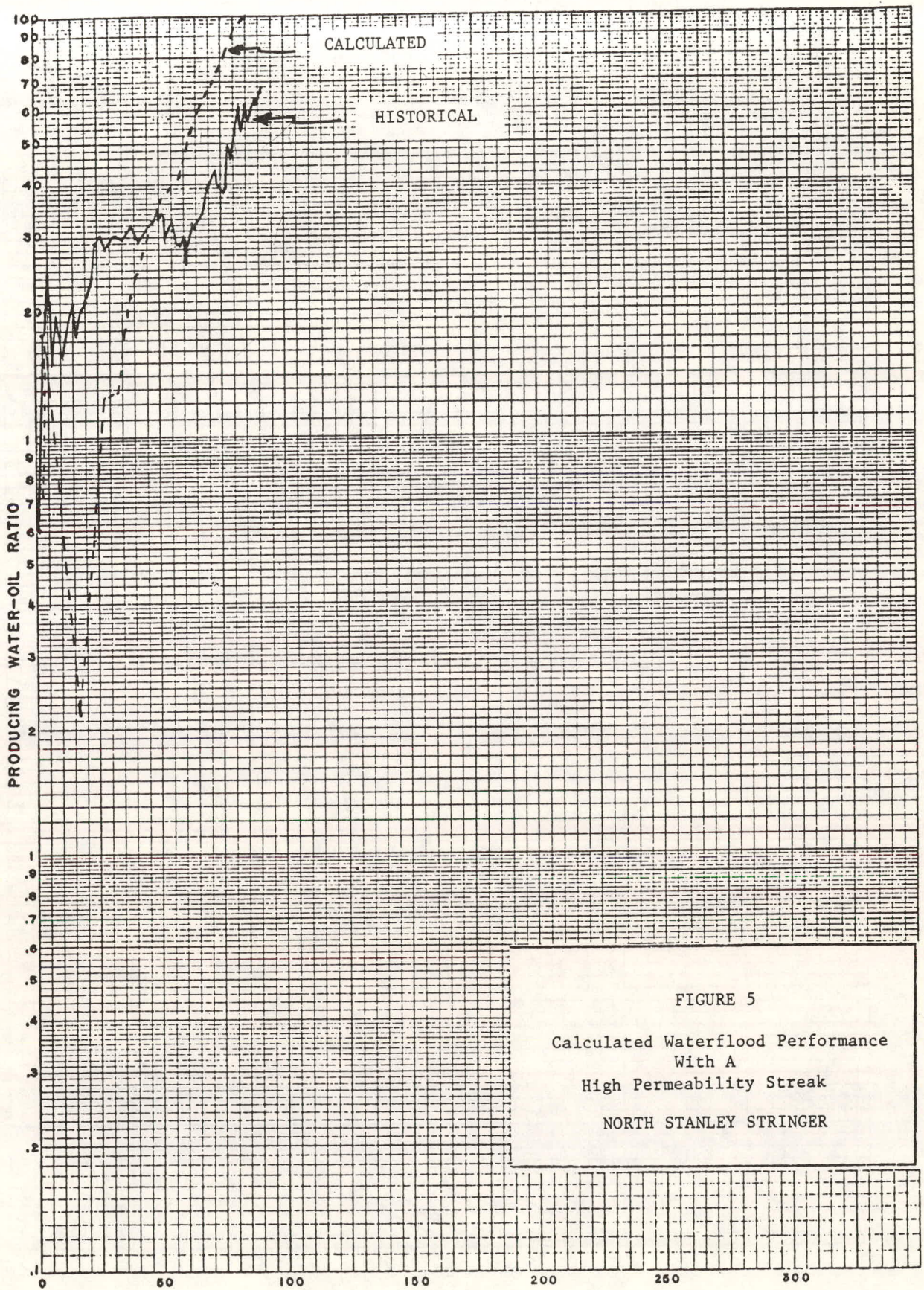
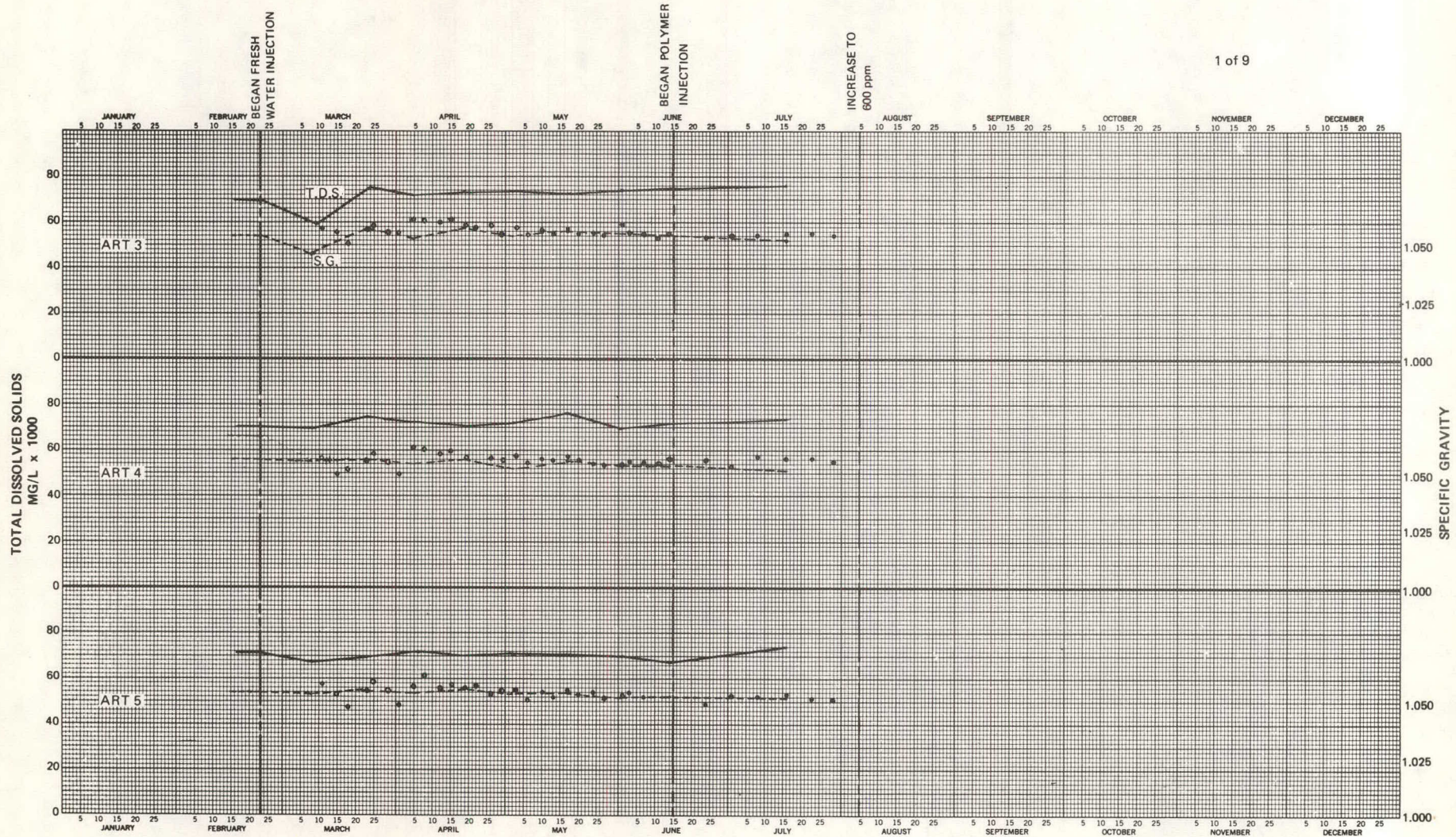
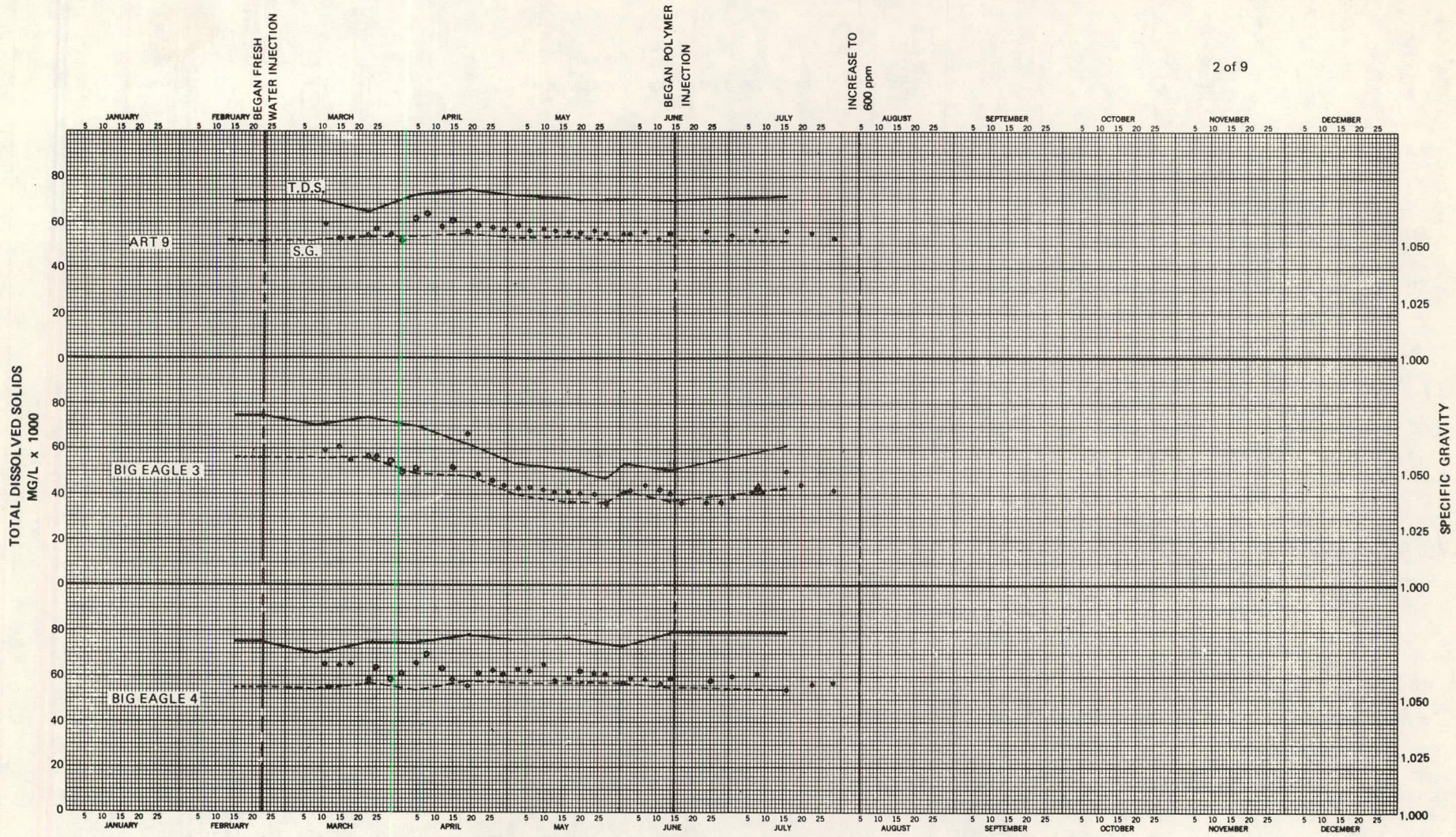


FIGURE 5  
 Calculated Waterflood Performance  
 With A  
 High Permeability Streak  
 NORTH STANLEY STRINGER

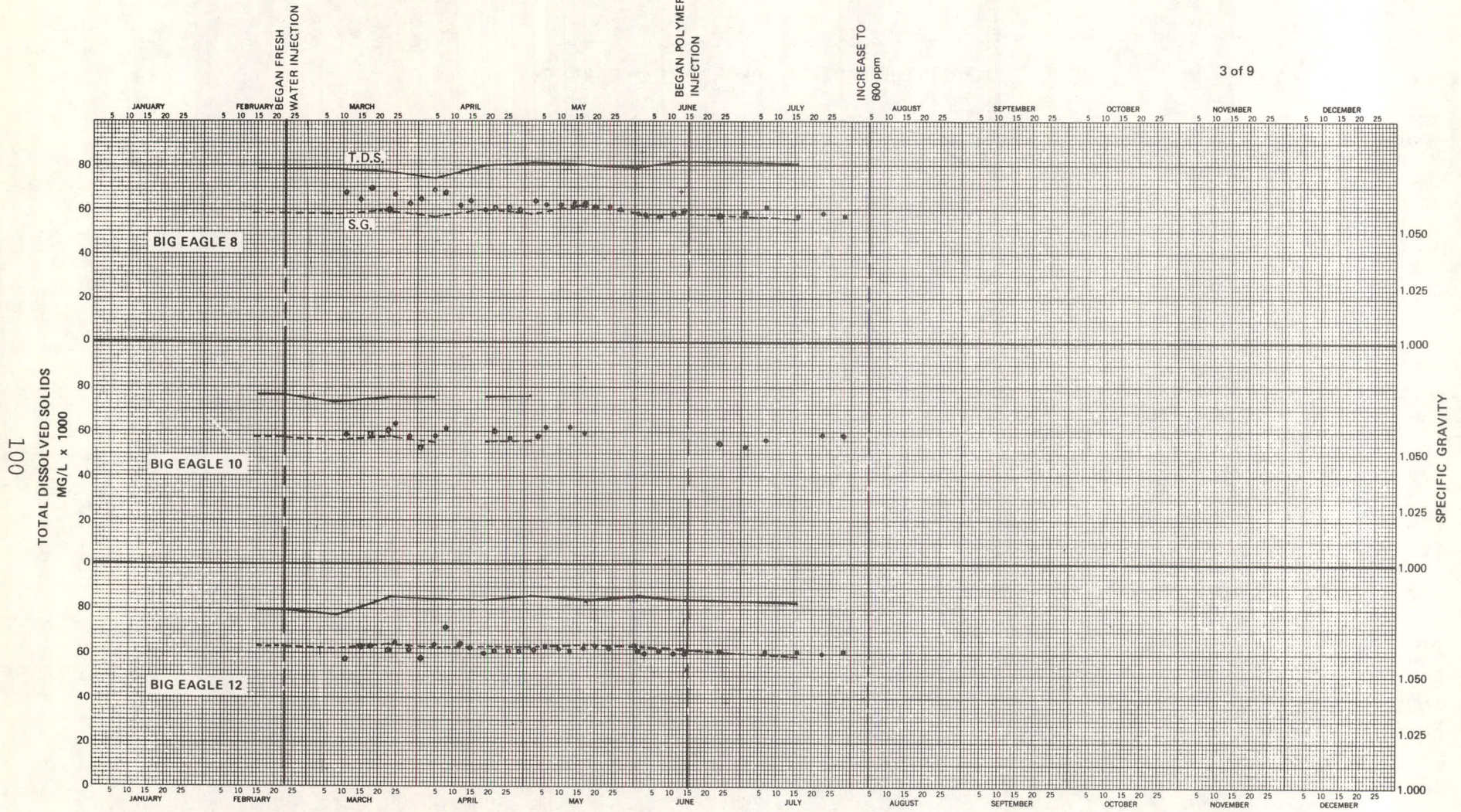
APPENDIX B  
TOTAL DISSOLVED SOLIDS AND SPECIFIC  
GRAVITY VERSUS TIME FOR  
PRODUCING WELLS



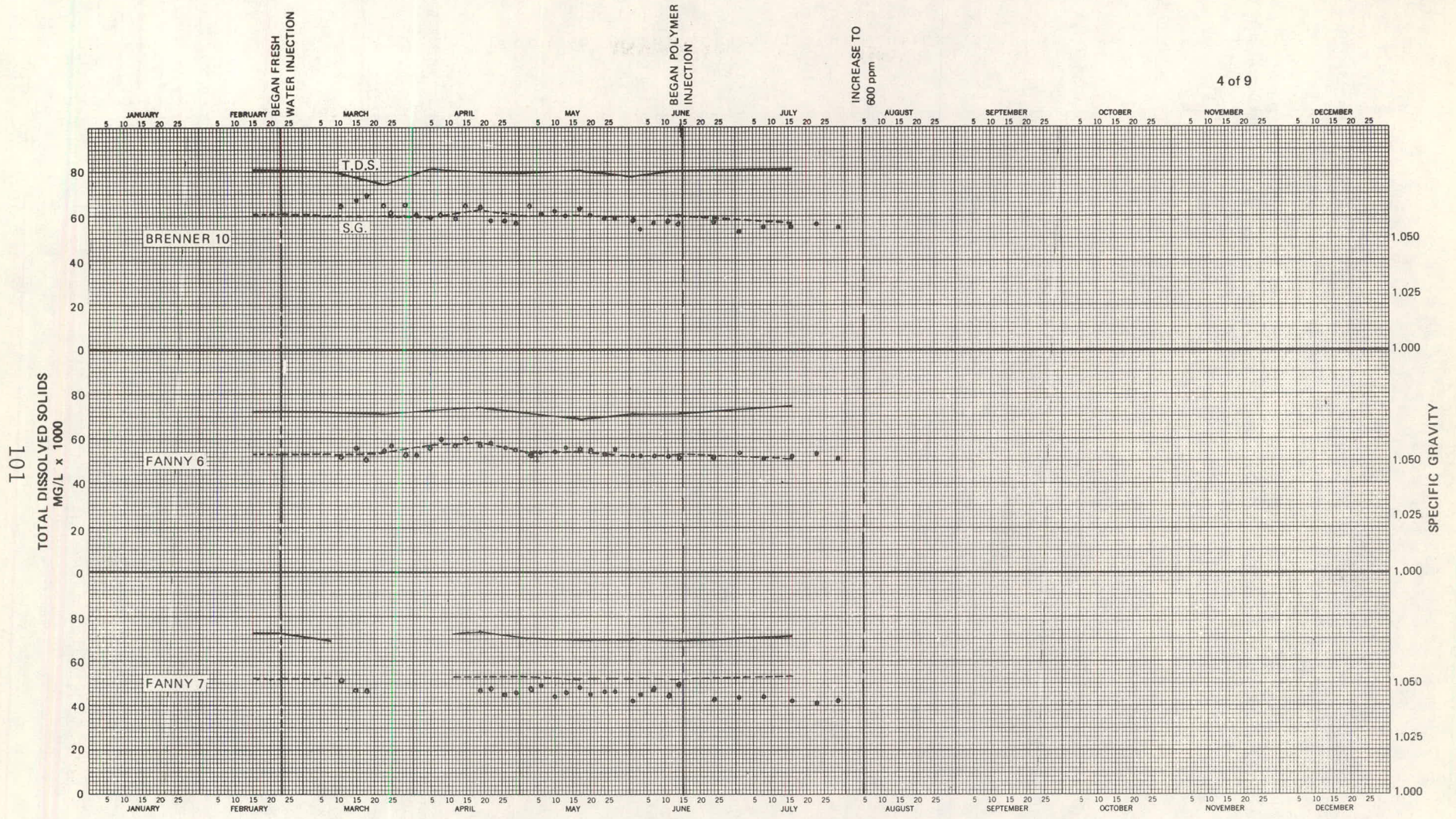
PRODUCED WATER - TOTAL DISSOLVED SOLIDS



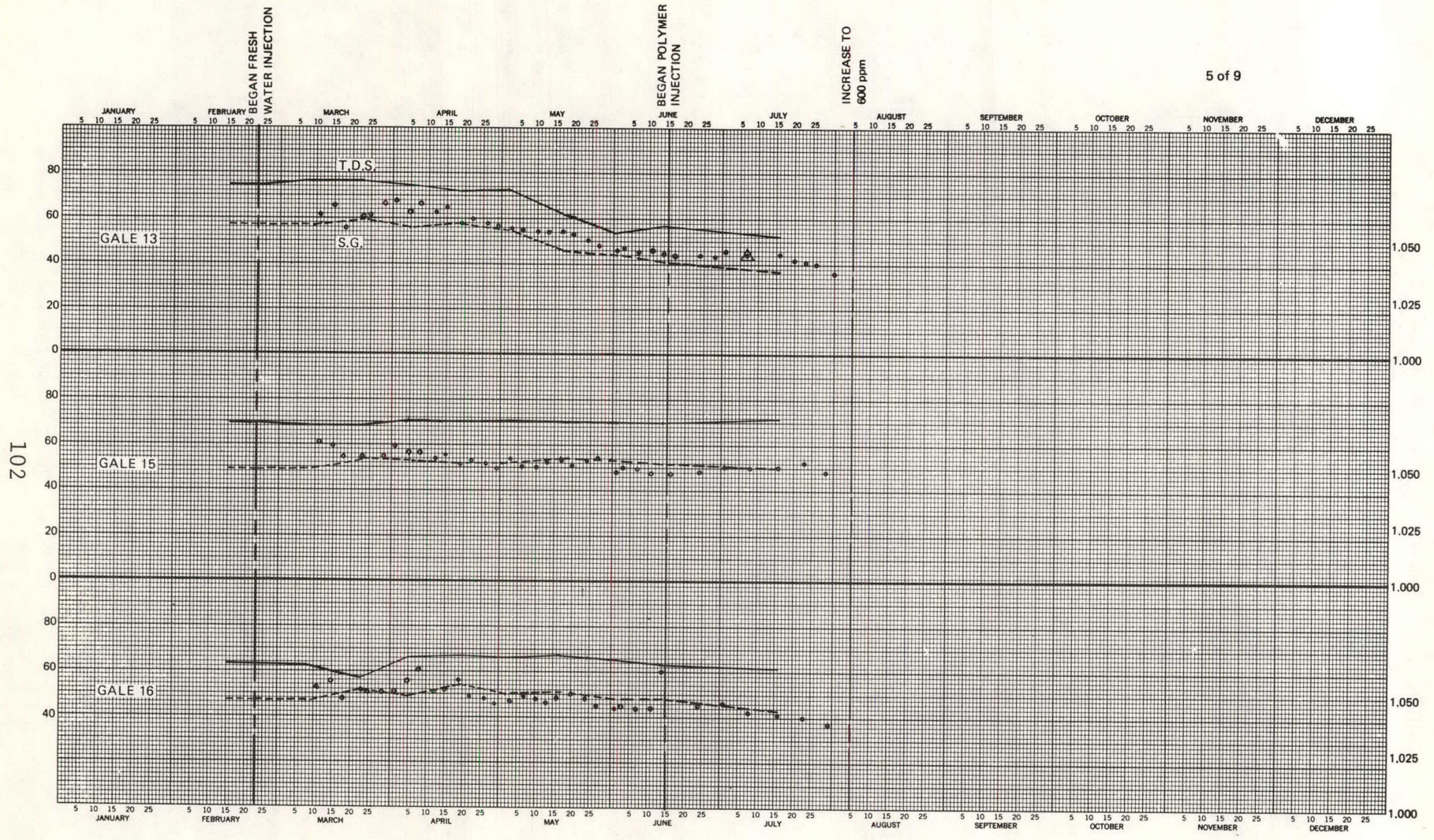
PRODUCED WATER - TOTAL DISSOLVED SOLIDS



PRODUCED WATER - TOTAL DISSOLVED SOLIDS



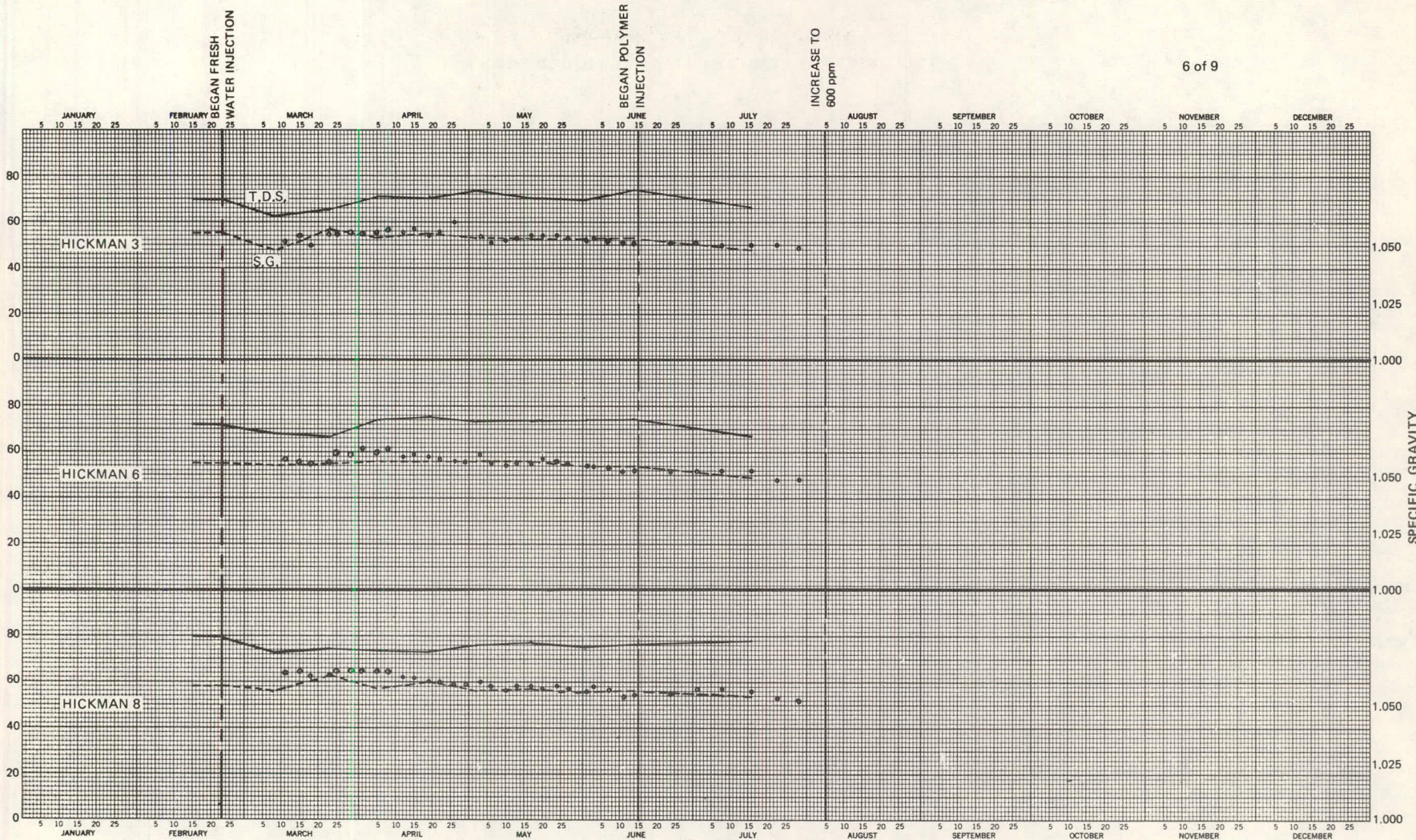
PRODUCED WATER - TOTAL DISSOLVED SOLIDS



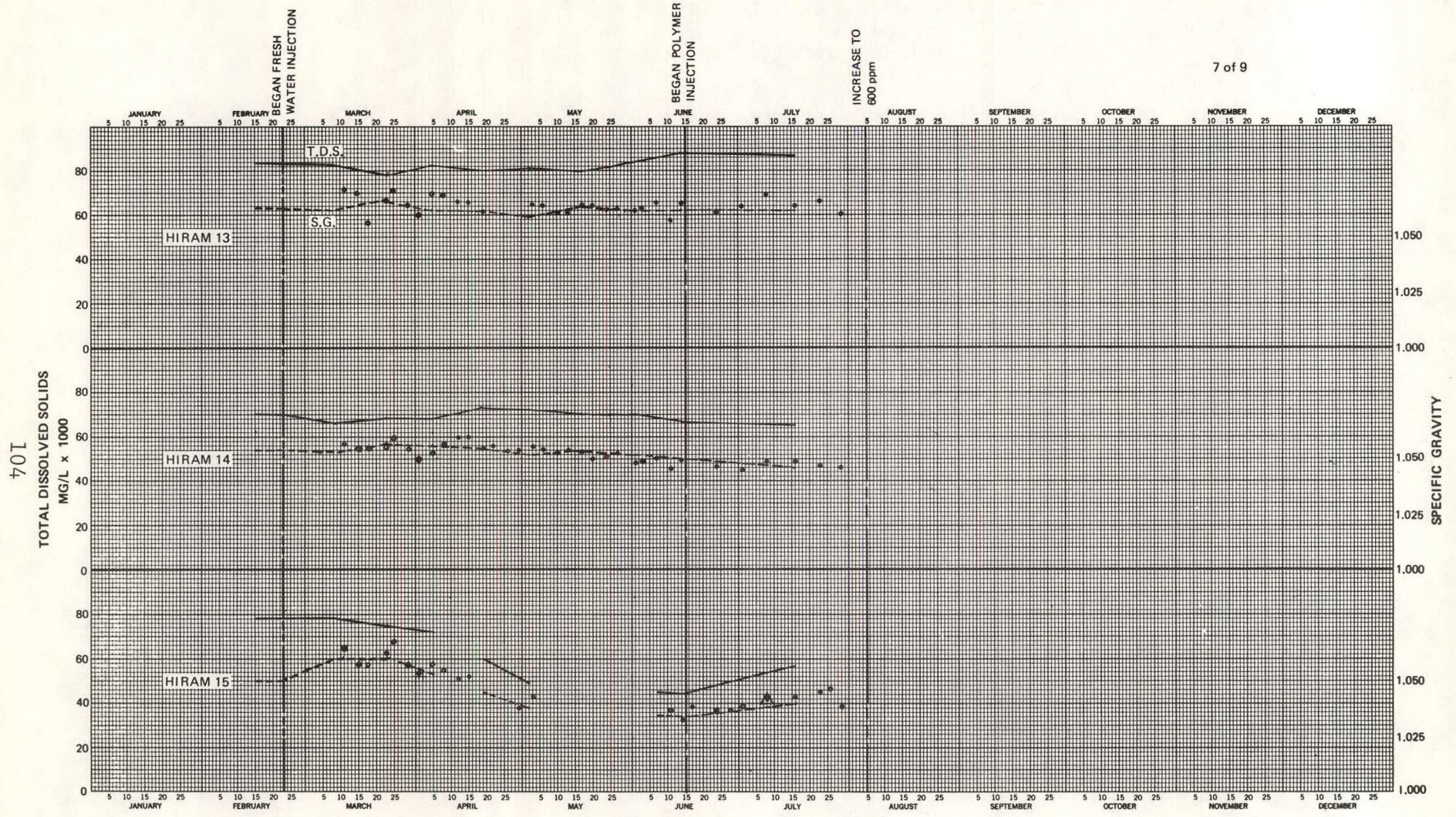
102

PRODUCED WATER - TOTAL DISSOLVED SOLIDS

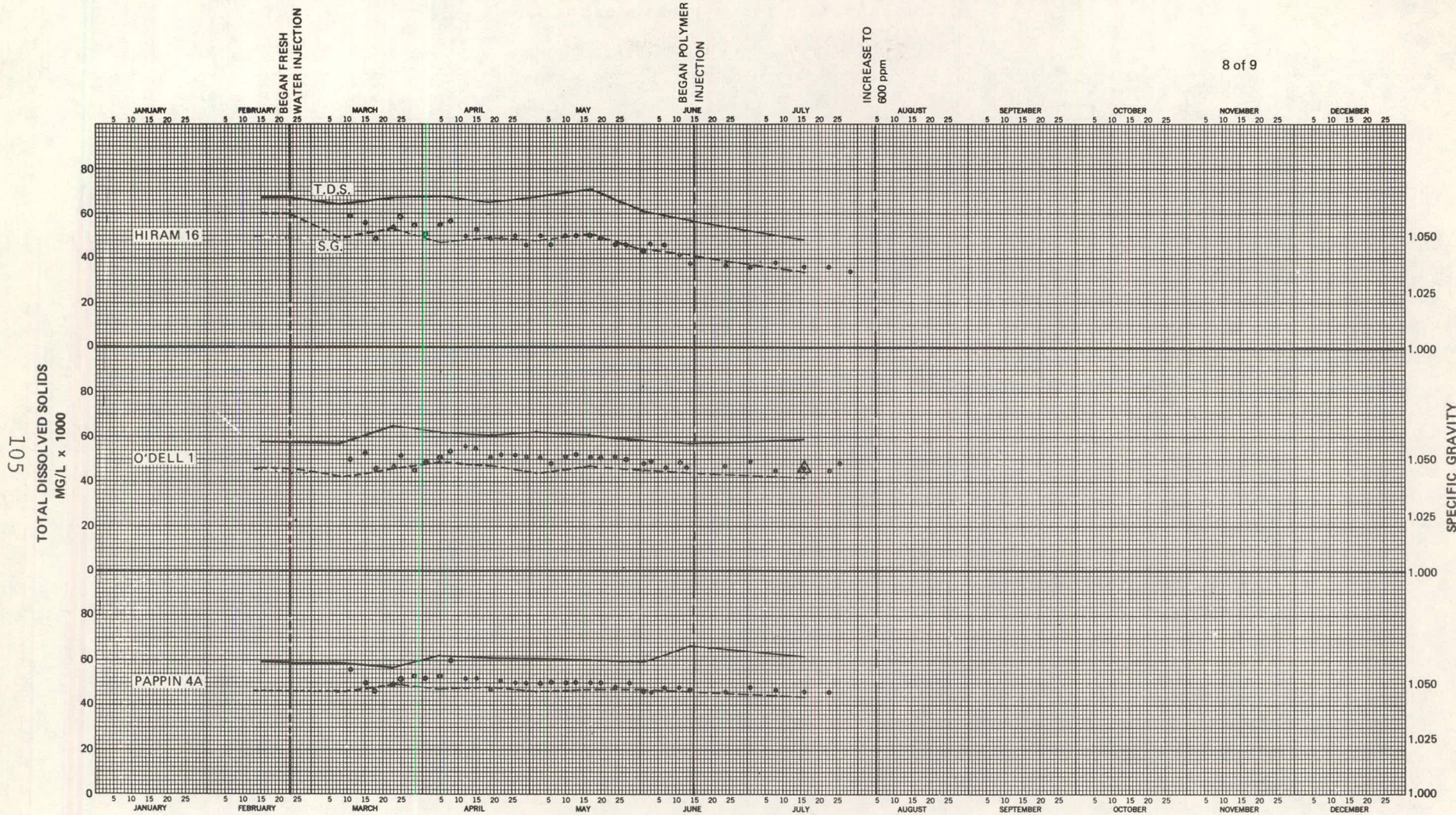
101  
TOTAL DISSOLVED SOLIDS  
MG/L x 1000



PRODUCED WATER - TOTAL DISSOLVED SOLIDS



PRODUCED WATER - TOTAL DISSOLVED SOLIDS

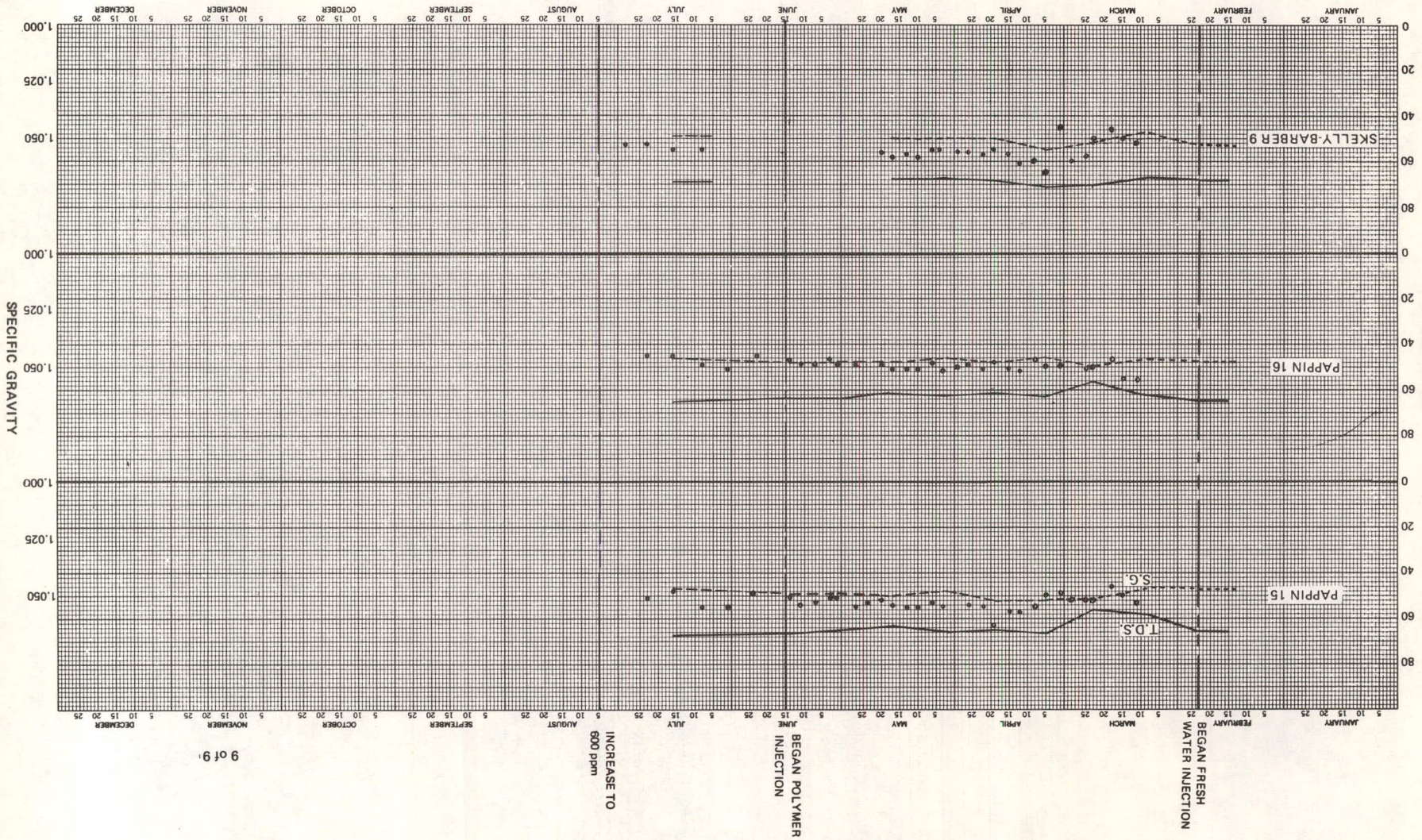


PRODUCED WATER - TOTAL DISSOLVED SOLIDS

501  
TOTAL DISSOLVED SOLIDS  
MG/L x 1000

SPECIFIC GRAVITY

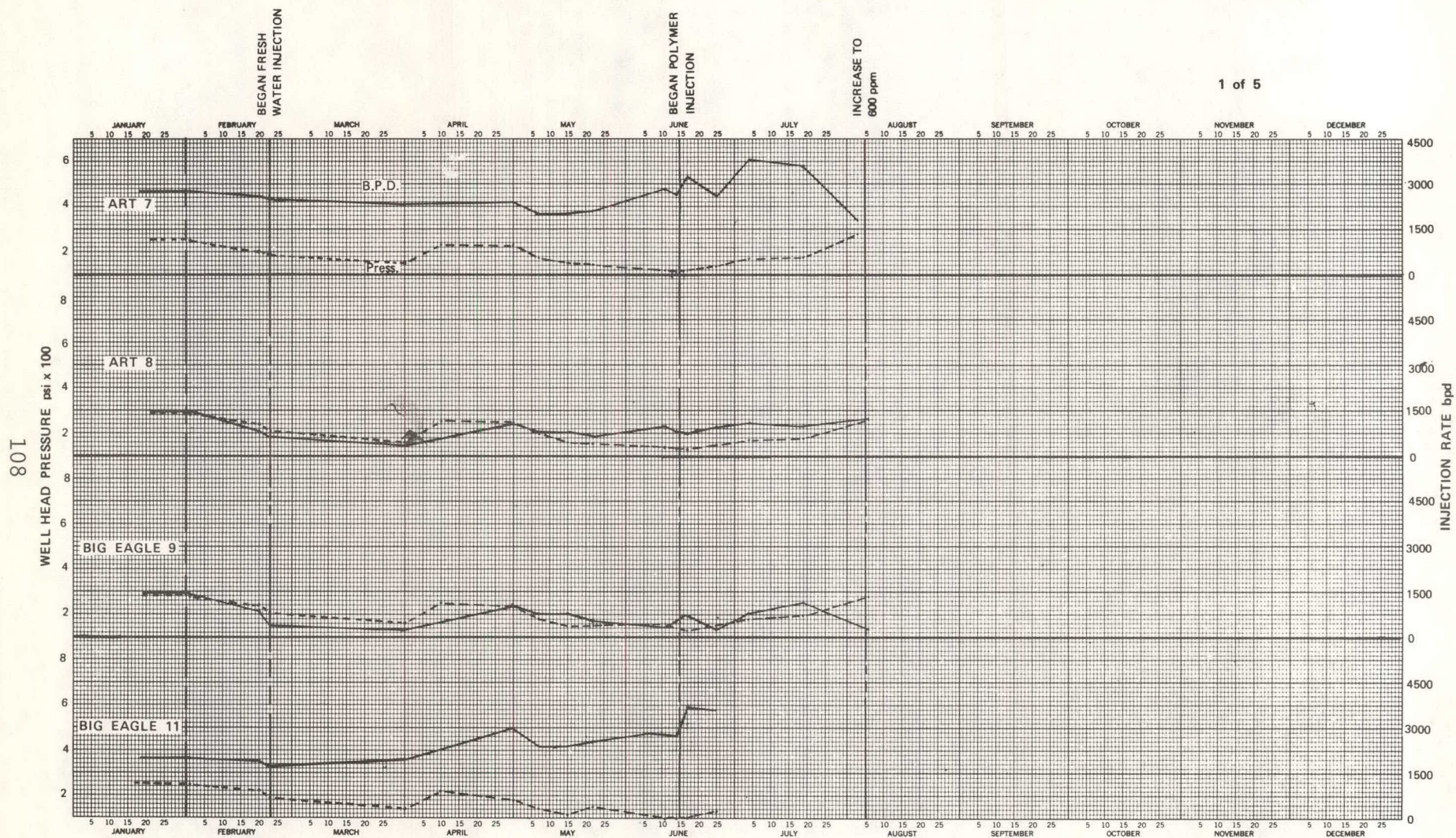
PRODUCED WATER - TOTAL DISSOLVED SOLIDS



TOTAL DISSOLVED SOLIDS  
MG/L x 1000

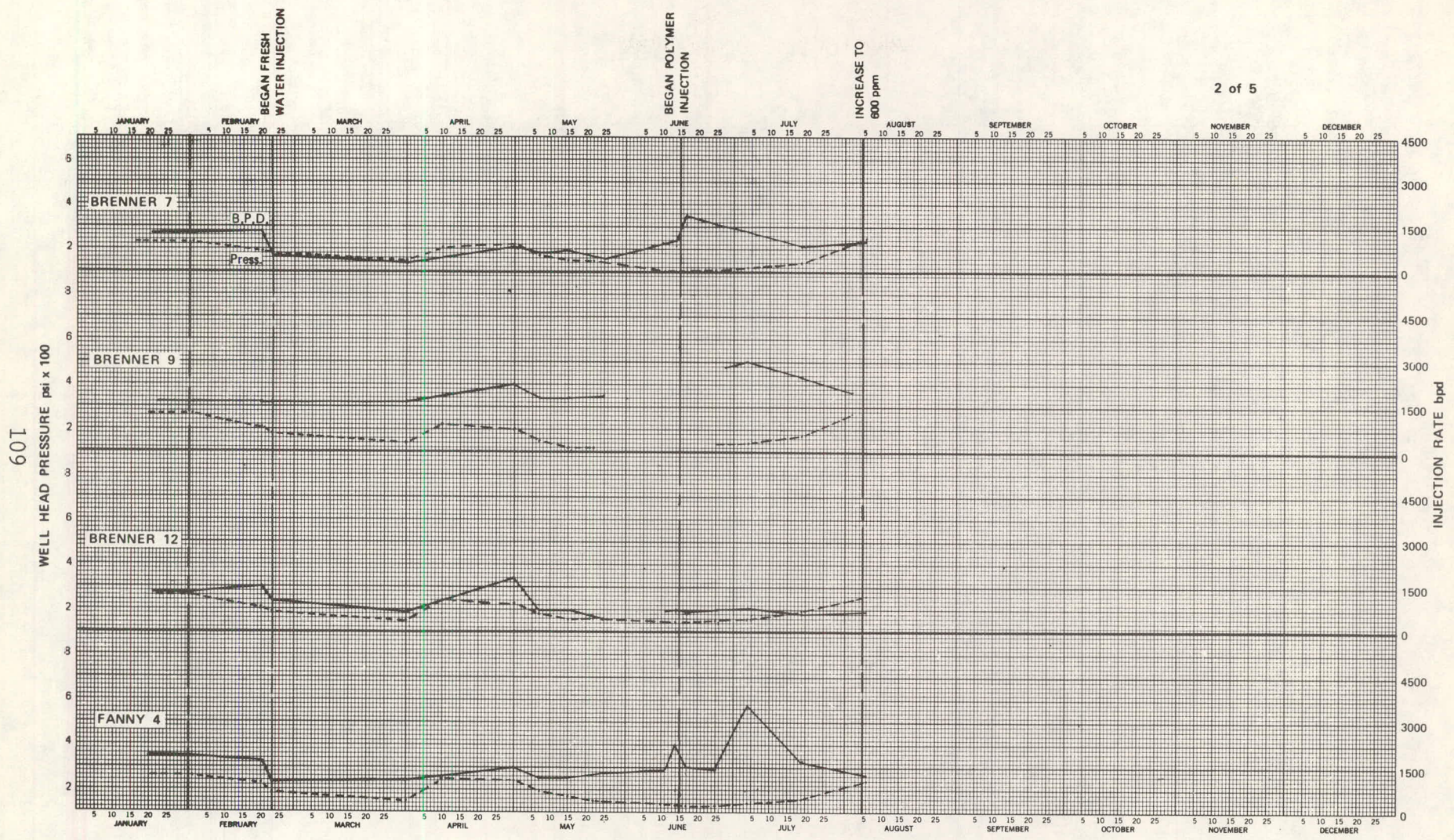
901

APPENDIX C  
WELLHEAD PRESSURE AND INJECTION RATE  
VERSUS TIME FOR INJECTION WELLS

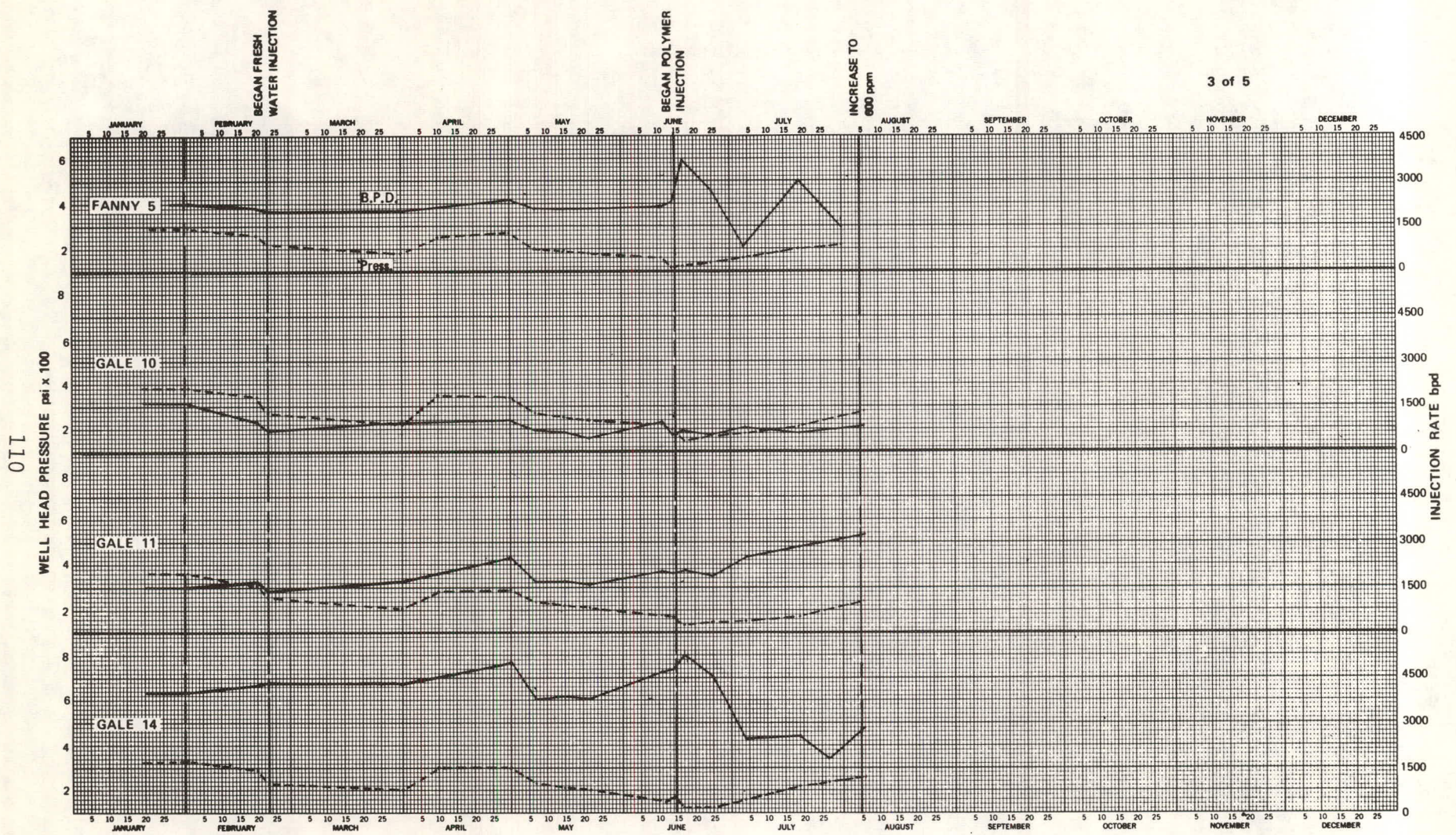


INJECTION WELL DATA

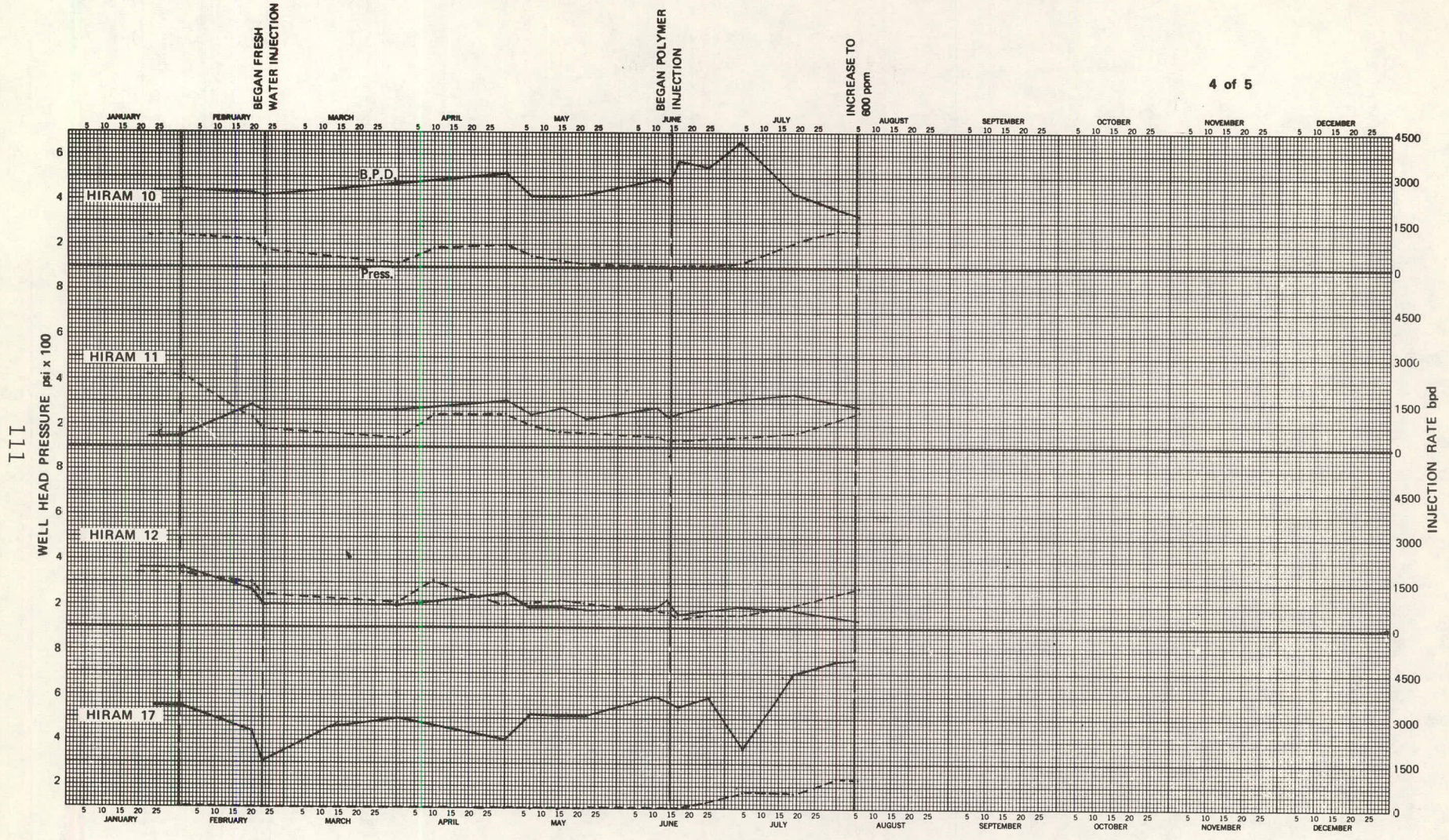
801



INJECTION WELL DATA



INJECTION WELL DATA



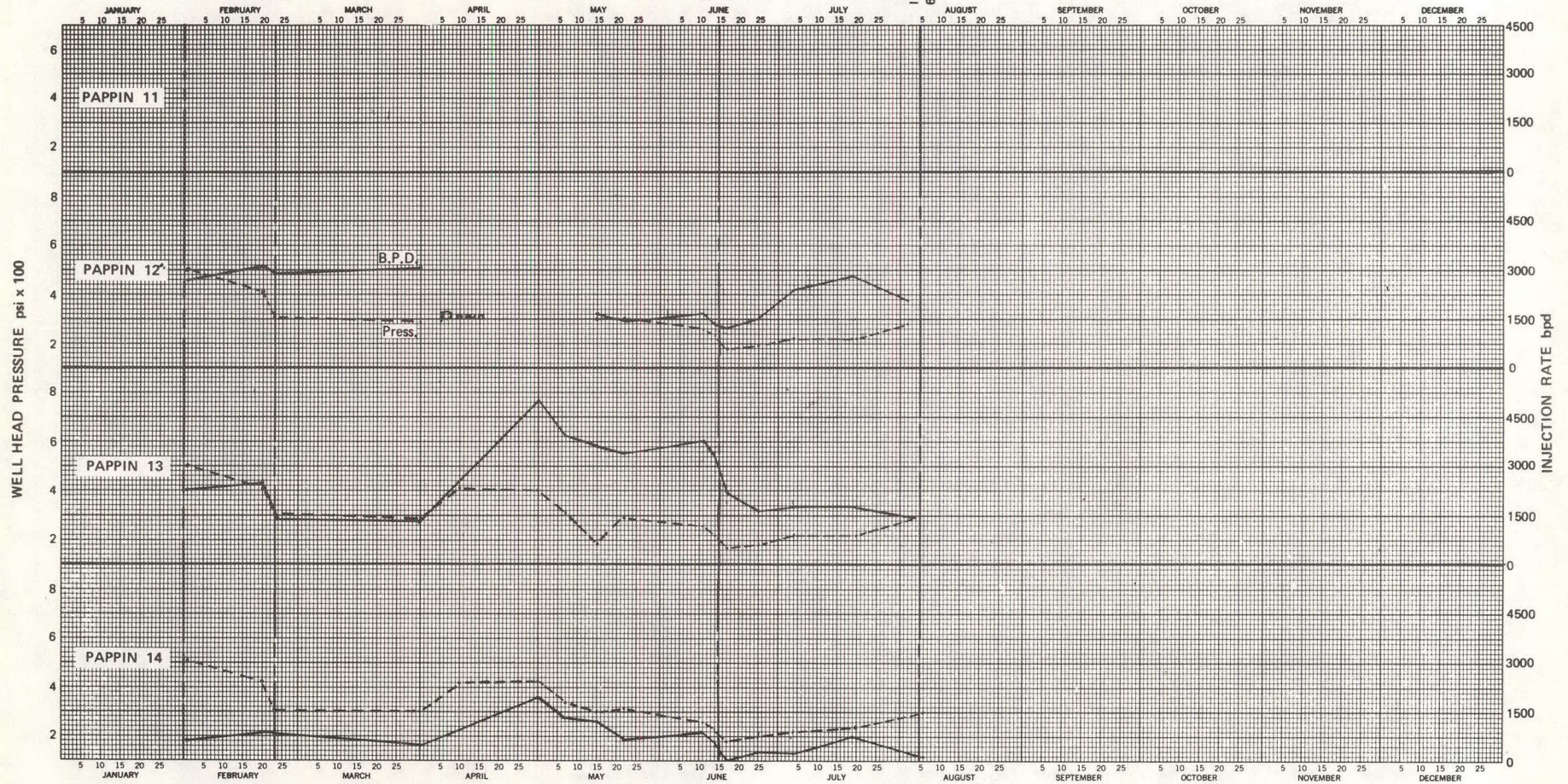
III

INJECTION WELL DATA

BEGAN FRESH  
WATER INJECTION

BEGAN POLYMER  
INJECTION

INCREASE TO  
600 ppm



INJECTION WELL DATA

APPENDIX D  
CORE ANALYSIS FOR HIRAM 17 WI

KEWANEE OIL COMPANY  
HIRAM NO. 17 WI WELL  
N. STANLEY PROJECT FIELD  
OSAGE COUNTY, OKLAHOMA

DATE: 11/13/75  
FORMATION: BURBANK  
DRLG. FLUID: PRODUCED WATER  
LOCATION:

FILE NO: 3402-8476  
ENGINEER: PUGH  
ELEVATION:

SMP. NO.	DEPTH	PERM. TO AIR MD.		POROSITY GEX. FLD.	FLUID SATS.		GR. DEN.	DESCRIPTION
		MAXIMUM	90 DEG VERT.		OIL	WTR.		
CONVENTIONAL ANALYSIS								
1	2880.0-81.0	1271.0		28.9	5.9	66.2		SD
2	2881.0-82.0	1239.0		28.5	6.0	67.4		SD
3	2882.0-83.0	1184.0		28.1	9.4	61.7		SD
4	2883.0-84.0	1891.0		28.8	10.6	62.4		SD
5	2884.0-85.0	1500.0		27.9	10.7	69.0		SD
6	2885.0-86.0	1271.0		29.2	14.5	73.2		SD
7	2886.0-87.0	1565.0		29.0	14.2	76.7		SD
8	2887.0-88.0	1325.0		29.7	12.3	76.6		SD
9	2888.0-89.0	967.0		27.4	10.0	77.2		SD
10	2889.0-90.0	717.0		27.8	12.8	76.7		SD
11	2890.0-91.0	728.0		28.0	11.5	67.7		SD
12	2891.0-92.0	554.0		22.2	22.8	70.5		SD
13	2892.0-93.0	130.0		20.3	34.4	56.1		SD, SL/SLTY
14	2893.0-94.0	218.0		21.5	30.0	61.1		SD, SL/SLTY
15	2894.0-95.0	466.0		25.5	20.7	63.8		SD
16	2895.0-96.0	684.0		24.9	22.4	60.9		SD
17	2896.0-97.0	600.0		27.2	18.5	64.4		SD
18	2897.0-98.0	336.0		23.7	23.6	63.8		SD
19	2898.0-99.0	150.0		21.9	21.8	68.5		SD, SL/SLTY
20	2899.0-00.0	277.0		22.0	21.8	64.4		SD
21	2900.0-01.0	78.0		19.4	18.0	69.5		SD, SL/SLTY
22	2901.0-02.0	101.0		17.4	21.6	67.6		SD, SL/SLTY
23	2902.0-03.0	82.0		18.4	17.7	66.0		SD, SL/SLTY
24	2903.0-04.0	82.0		16.7	14.9	64.0		SD, SL/SLTY
25	2904.0-05.0	49.0		16.9	19.6	67.1		SD, SLTY
26	2905.0-06.0	36.0		17.1	20.7	69.9		SD, SLTY

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KEWANEE OIL COMPANY  
HIRAM NO. 17 WI WELL

DATE: 11/13/75  
FORMATION: BURBANK

FILE NO: 3402-8476  
ENGINEER: PUGH

SMP. NO.	DEPTH	PERM. TO AIR MD.		POROSITY GEX. FLD.	FLUID SATS.		GR. DEN.	DESCRIPTION
		MAXIMUM	90 DEG VERT.		OIL	WTR.		
27	2906.0-07.0	23.0		15.9	22.4	67.2		SD,SLTY
28	2907.0-08.0	20.0		16.5	23.0	67.6		SD,SLTY
29	2908.0-09.0	<0.1		13.0	19.6	70.8		SD,SLTY,SHY
30	2909.0-10.0	56.0		16.8	26.2	59.6		SD,SLTY
31	2910.0-11.0	49.0		17.3	31.5	60.3		SD,SLTY
32	2911.0-12.0	26.0		17.8	28.1	62.8		SD,SLTY
33	2912.0-13.0	33.0		17.8	26.4	60.7		SD,SLTY
34	2913.0-14.0	26.0		15.6	29.0	62.5		SD,SLTY
35	2914.0-15.0	36.0		17.4	28.3	55.3		SD,SLTY
36	2915.0-16.0	42.0		17.3	25.7	62.3		SD,SLTY
37	2916.0-17.0	33.0		16.8	24.2	62.6		SD,SLTY
38	2917.0-18.0	39.0		16.6	20.0	62.8		SD,SLTY
39	2918.0-19.0	52.0		17.2	27.5	63.6		SD,SLTY
40	2919.0-20.0	56.0		16.9	19.8	63.4		SD,SLTY
41	2920.0-21.0	33.0		15.2	17.6	69.3		SD,SLTY
42	2921.0-22.0	46.0		16.1	18.3	67.4		SD,SLTY
43	2922.0-23.0	36.0		17.4	20.1	64.9		SD,SLTY
44	2923.0-24.0	29.0		14.8	26.1	66.8		SD,SLTY
45	2924.0-25.0	33.0		15.7	21.2	66.6		SD,SLTY
46	2925.0-26.0	23.0		15.7	27.2	55.9		SD,SLTY
47	2926.0-27.0	33.0		15.6	26.1	59.8		SD,SLTY
48	2927.0-27.5	17.0		14.4	30.1	60.2		SD,SLTY
	2927.5-30.0	LOST CORE						

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CORE SUMMARY

COMPANY KEWANEE OIL COMPANY  
WELL HIRAM NO. 17 WI  
PAGE 3 OF 3 FILE 3402-8476

<u>DEPTH</u>	<u>PERMEABILITY MILLIDARCY</u>	<u>POROSITY</u>	<u>SATURATION</u>		<u>PRODUCTIVITY</u>	<u>COMMENTS</u>
			<u>OIL</u>	<u>WATER</u>		
2880-2883	1231	28.5	7.1	65.1		
2883-2888	1510	28.9	12.5	71.6		
2888-2891	804	27.7	11.4	73.9		
2891-2900	379	23.2	24.0	63.7		
2900-2904	85	18.0	18.1	66.8		
2904-2927.5	35	16.5	24.3	63.4		

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*Petroleum Reservoir Engineering*  
DALLAS, TEXAS

Page 1 of 11  
File SCAL-75410

Company Kewanee Oil Company Formation Burbank  
Well Hiram No. 17 County Osage  
Field N. Stanley Project State Oklahoma

Identification and Description of Samples

<u>Sample Number</u>	<u>Depth, Feet</u>	<u>Lithological Description</u>
1	2885-86	Ss, gry, med-fngrn, v/sl/calc, mod indurated
2	2893-94	Ss, gry, fn grn, well indurated, w/lignite stks
3	2913-14	Ss, gry, v/fn-fn grn, well indurated, w/sh lamin and several relatively more permeable and porous sand stks

Summary of Waterflood Test Results

Sample Number	Depth, Feet	Air Permeability, Millidarcys	Porosity, Per Cent	Initial Conditions		Terminal Conditions		Oil Recovered,	
				Water Saturation, Per Cent Pore Space	Oil Permeability, Millidarcys	Oil Saturation, Per Cent Pore Space	Water Permeability, Millidarcys	Per Cent Pore Space	Per Cent Oil in Place
1	2885-86	1790	29.5	13.6	1480	32.5	422	53.9	62.3
2	2893-94	94	20.0	21.1	78	34.5	21	44.4	56.3
3	2913-14	19	14.8	24.2	9.1	53.3	5.3	22.5	29.7

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*Petroleum Reservoir Engineering*  
**DALLAS, TEXAS**

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 File SCAL-75410

**Water-Oil Relative Permeability Data**

Sample Number 1 Initial Water Saturation,  
 Per Cent Pore Space 13.6  
 Air Permeability, Md. 1790 Porosity, Per Cent 29.5  
 Oil Permeability at  
 Initial Water Saturation, Md. 1480

<u>Water Saturation, Per Cent Pore Space</u>	<u>Water-Oil Relative Permeability Ratio</u>	<u>Relative Permeability To Water*, Fraction</u>	<u>Relative Permeability to Oil*, Fraction</u>
13.6		.000	1.000
29.4	.013	.0030	.226
34.1	.068	.010	.147
39.2	.312	.029	.093
43.2	.872	.054	.062
47.0	2.02	.081	.040
50.8	3.91	.114	.029
53.1	6.52	.135	.021
55.2	10.3	.157	.015
57.4	16.7	.181	.011
59.4	22.7	.195	.0086
60.8	31.3	.210	.0067
62.7	49.8	.229	.0046
64.0	72.4	.246	.0038
65.3	113	.256	.0023
67.5		.285	

\* Relative to oil permeability.

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*Petroleum Reservoir Engineering*  
**DALLAS, TEXAS**

Page 4 of 11  
 File SCAL-75410

**Water-Oil Relative Permeability Data**

Sample Number <u>2</u>	Initial Water Saturation, Per Cent Pore Space <u>21.1</u>
Air Permeability, Md. <u>94</u>	Porosity, Per Cent <u>20.0</u>
Oil Permeability at Initial Water Saturation, Md. <u>78</u>	

<u>Water Saturation, Per Cent Pore Space</u>	<u>Water-Oil Relative Permeability Ratio</u>	<u>Relative Permeability To Water*, Fraction</u>	<u>Relative Permeability to Oil*, Fraction</u>
21.1		.000	1.000
32.9	.140	.043	.308
35.2	.272	.066	.243
37.2	.428	.083	.194
38.9	.634	.099	.158
40.4	.808	.110	.137
43.4	1.35	.134	.099
44.7	1.67	.146	.087
47.0	2.57	.161	.063
51.5	5.82	.192	.033
53.5	9.04	.208	.023
57.8	23.2	.232	.010
59.2	32.0	.240	.0075
60.5	48.6	.248	.0051
62.0	83.2	.258	.0031
65.5		.274	

\* Relative to oil permeability.

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**DALLAS, TEXAS**

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File SCAL-75410

**Water-Oil Relative Permeability Data**

Sample Number _____	<u>3</u>	Initial Water Saturation,	
Air Permeability, Md. _____	<u>19</u>	Per Cent Pore Space _____	<u>24.2</u>
Oil Permeability at		Porosity, Per Cent _____	<u>14.8</u>
Initial Water Saturation, Md. _____	<u>9.1</u>		

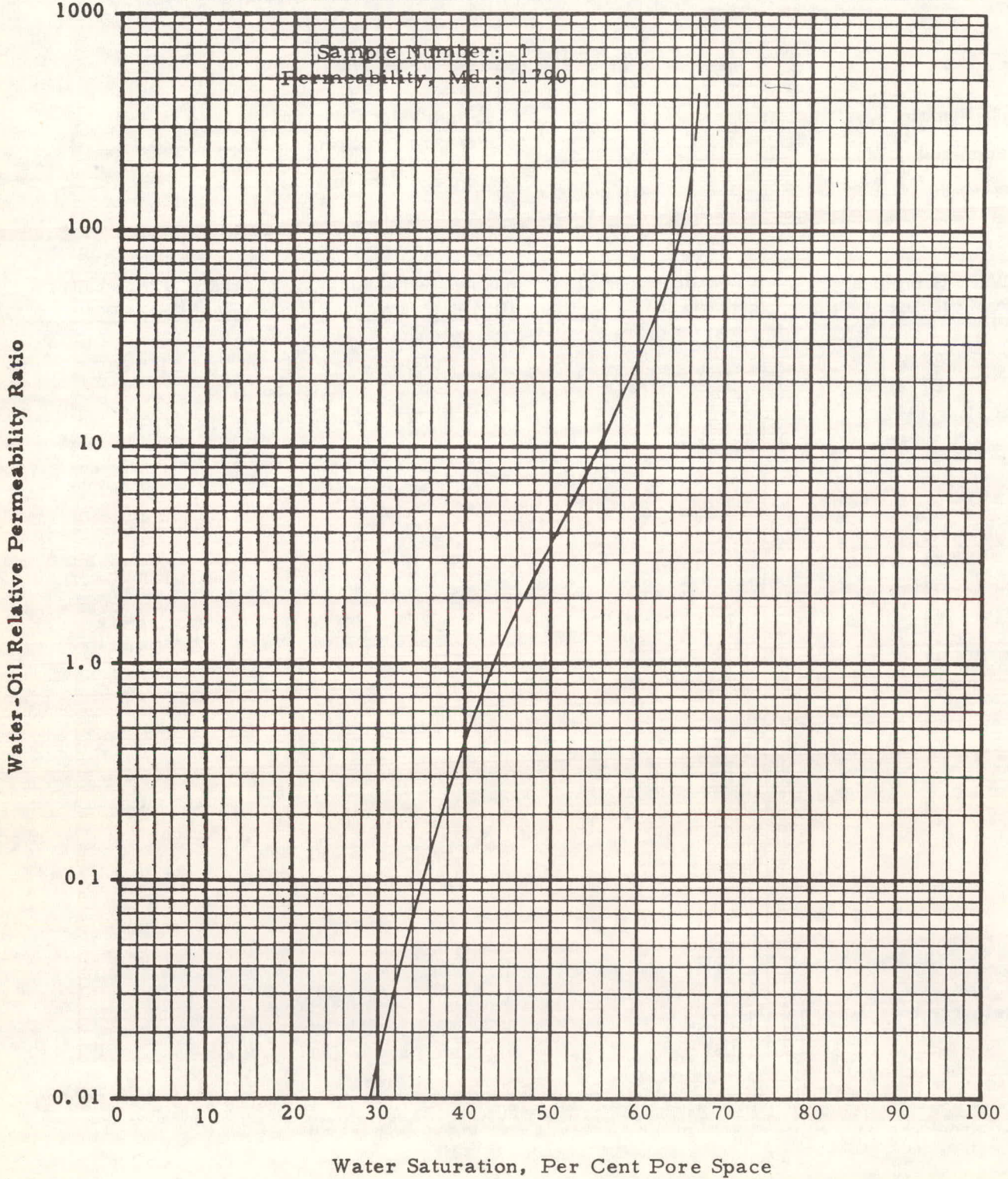
<u>Water Saturation, Per Cent Pore Space</u>	<u>Water-Oil Relative Permeability Ratio</u>	<u>Relative Permeability To Water*, Fraction</u>	<u>Relative Permeability to Oil*, Fraction</u>
24.2		.000	1.000
27.2	.233	.042	.180
29.4	.838	.093	.111
30.8	1.41	.127	.090
31.9	2.14	.162	.076
32.9	2.81	.192	.068
34.9	4.54	.254	.056
37.7	9.01	.327	.036
40.1	17.4	.390	.022
42.6	37.4	.461	.012
44.1	69.2	.505	.0073
45.4	159	.544	.0034
46.7		.580	

\* Relative to oil permeability.

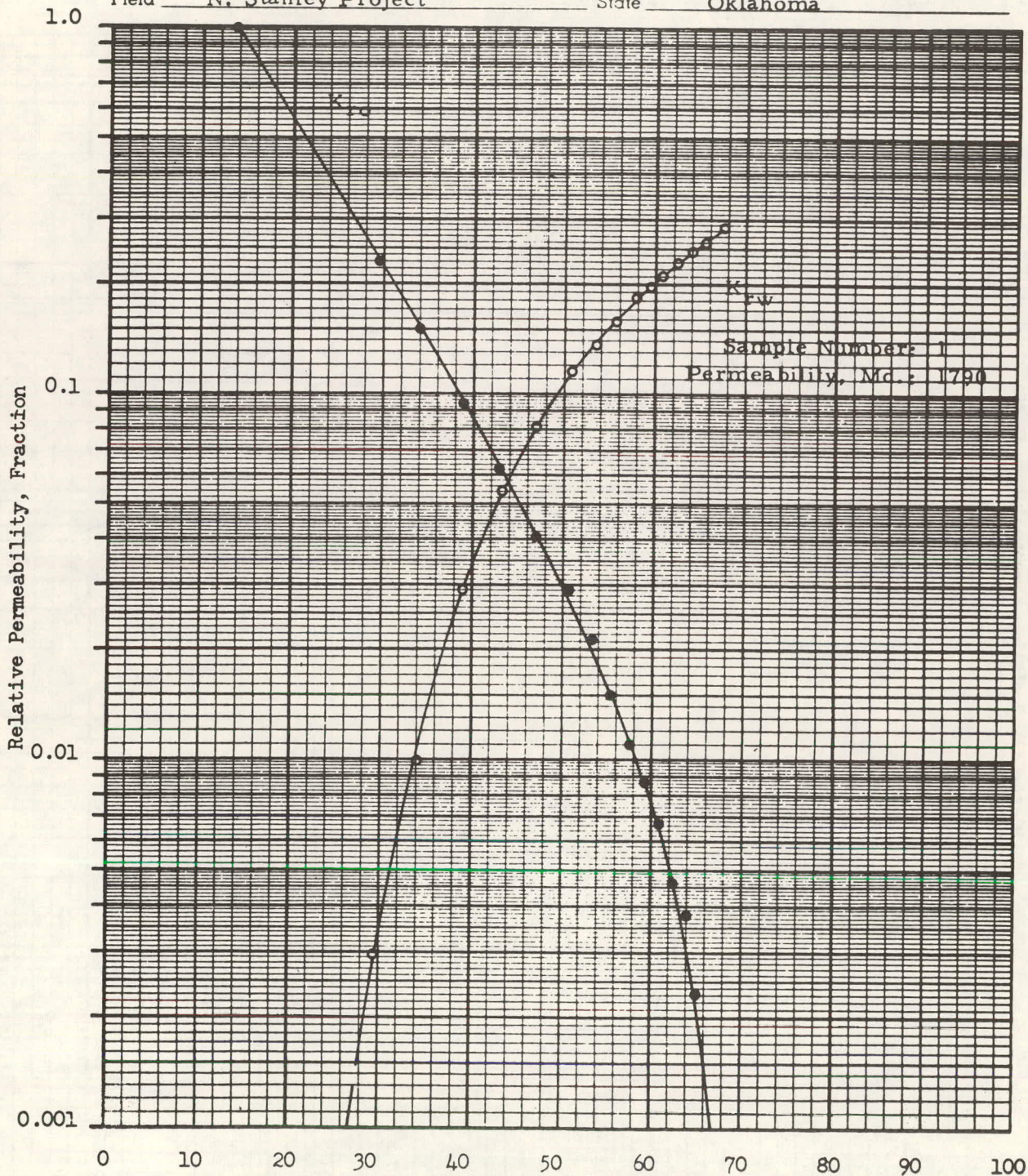
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Company Kewanee Oil Company Formation Burbank  
Well Hiram No. 17 County Osage  
Field N. Stanley Project State Oklahoma

Sample Number: 1  
Permeability, Md.: 1790

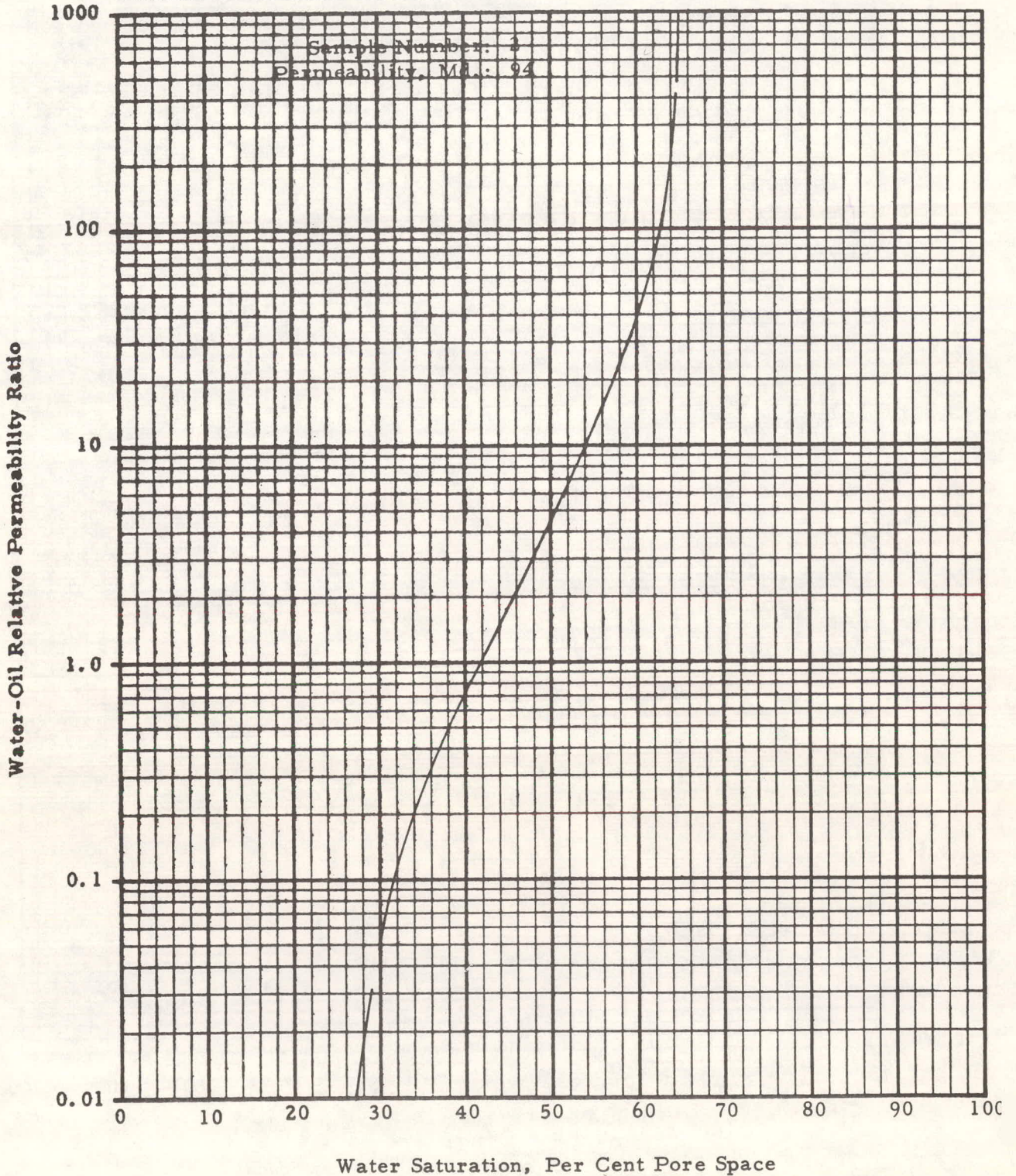


Company Kewanee Oil Company Formation Burbank  
 Well Hiram No. 17 County Osage  
 Field N. Stanley Project State Oklahoma

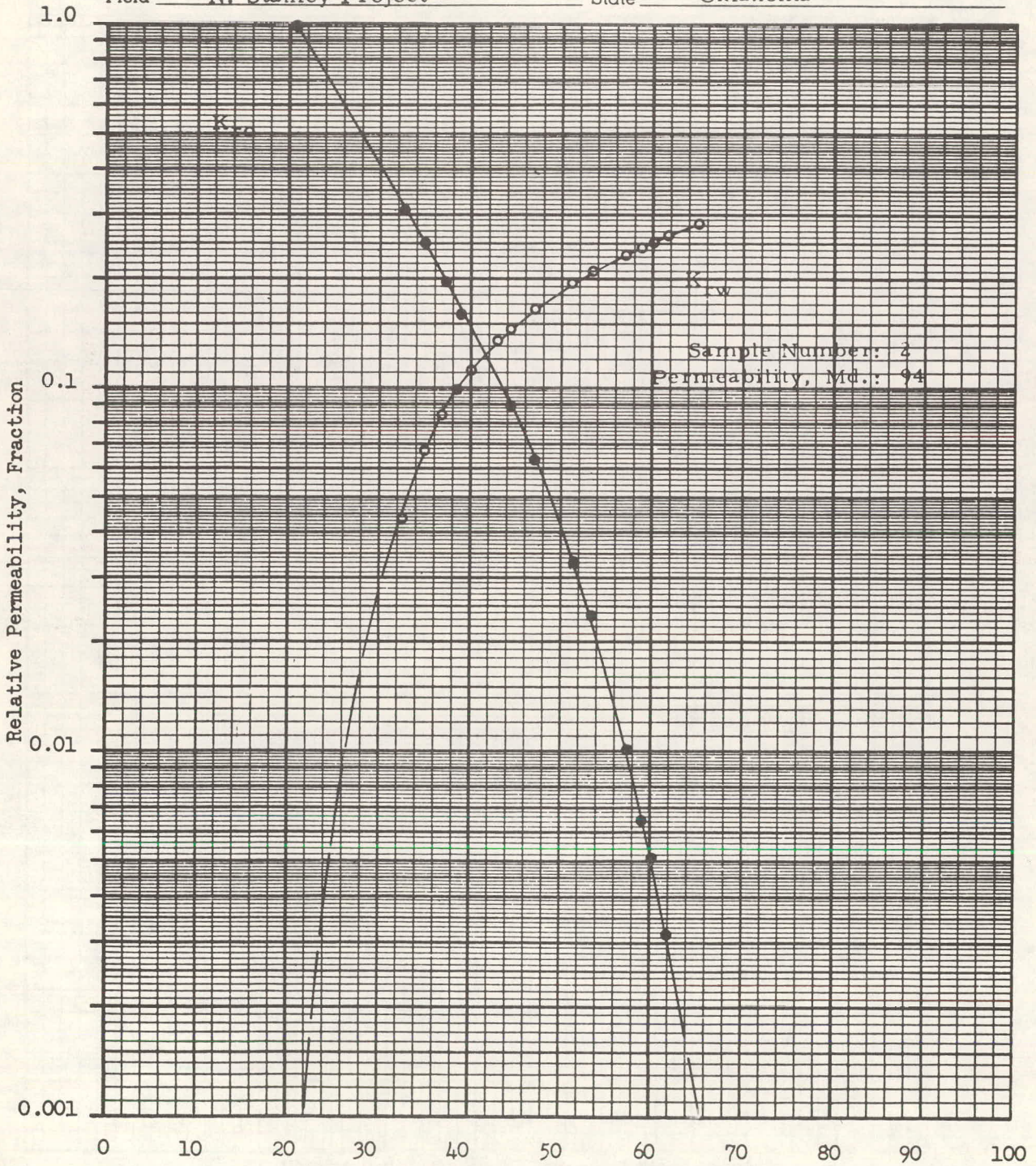


Water Saturation, Per Cent Pore Space

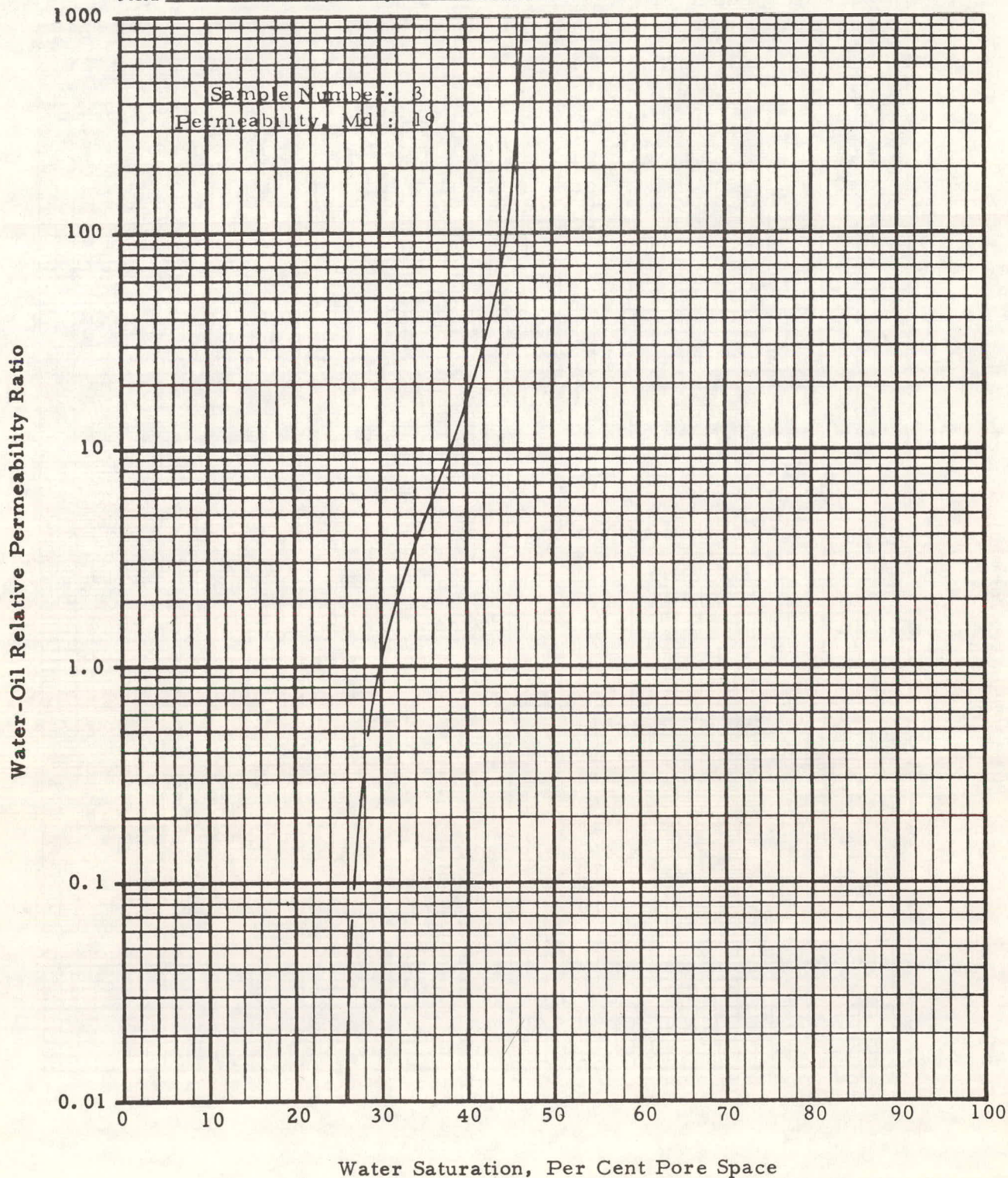
Company Kewanee Oil Company Formation Burbank  
Well Hiram No. 17 County Osage  
Field N. Stanley Project State Oklahoma



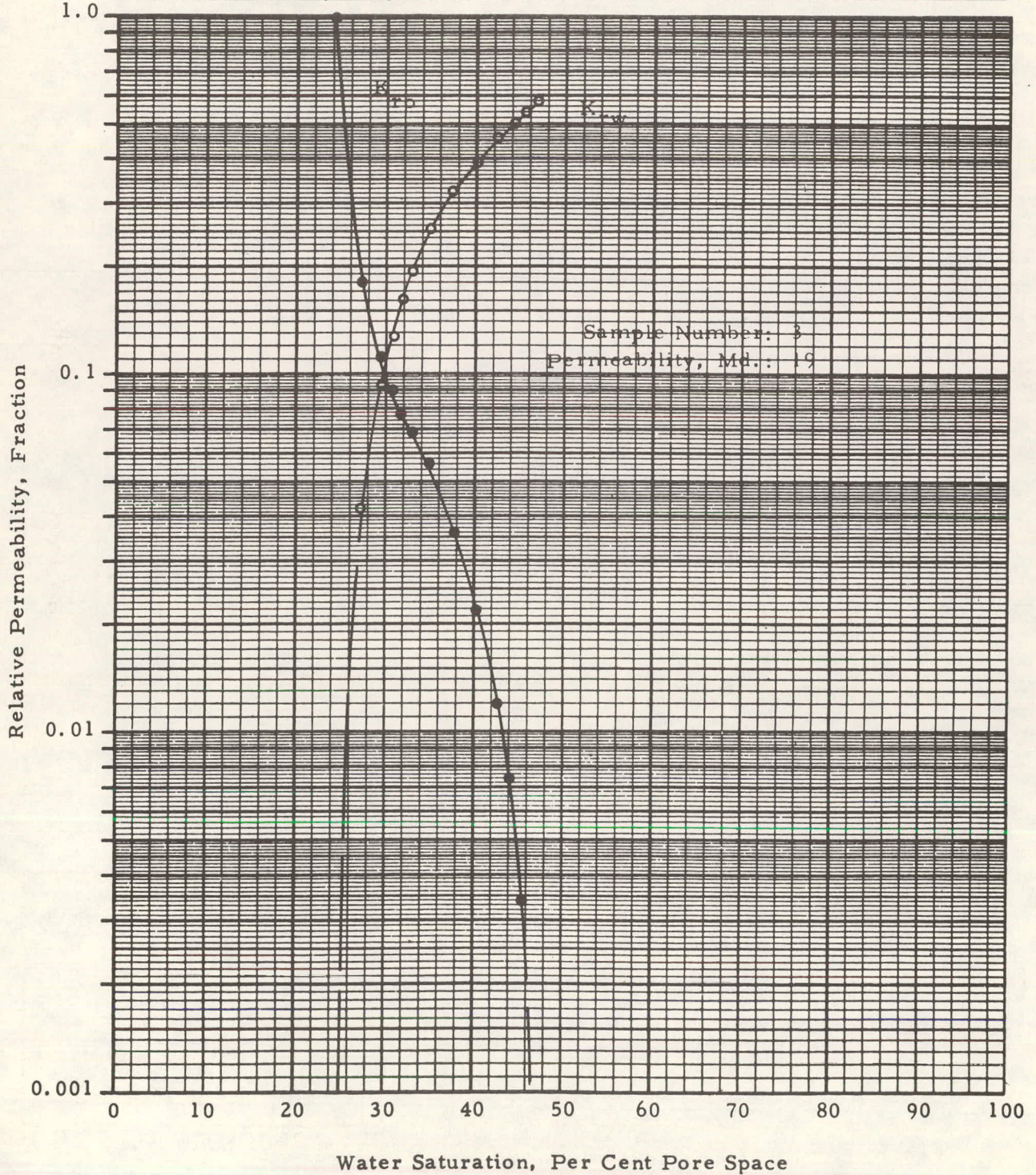
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Company Kewanee Oil Company Formation Burbank  
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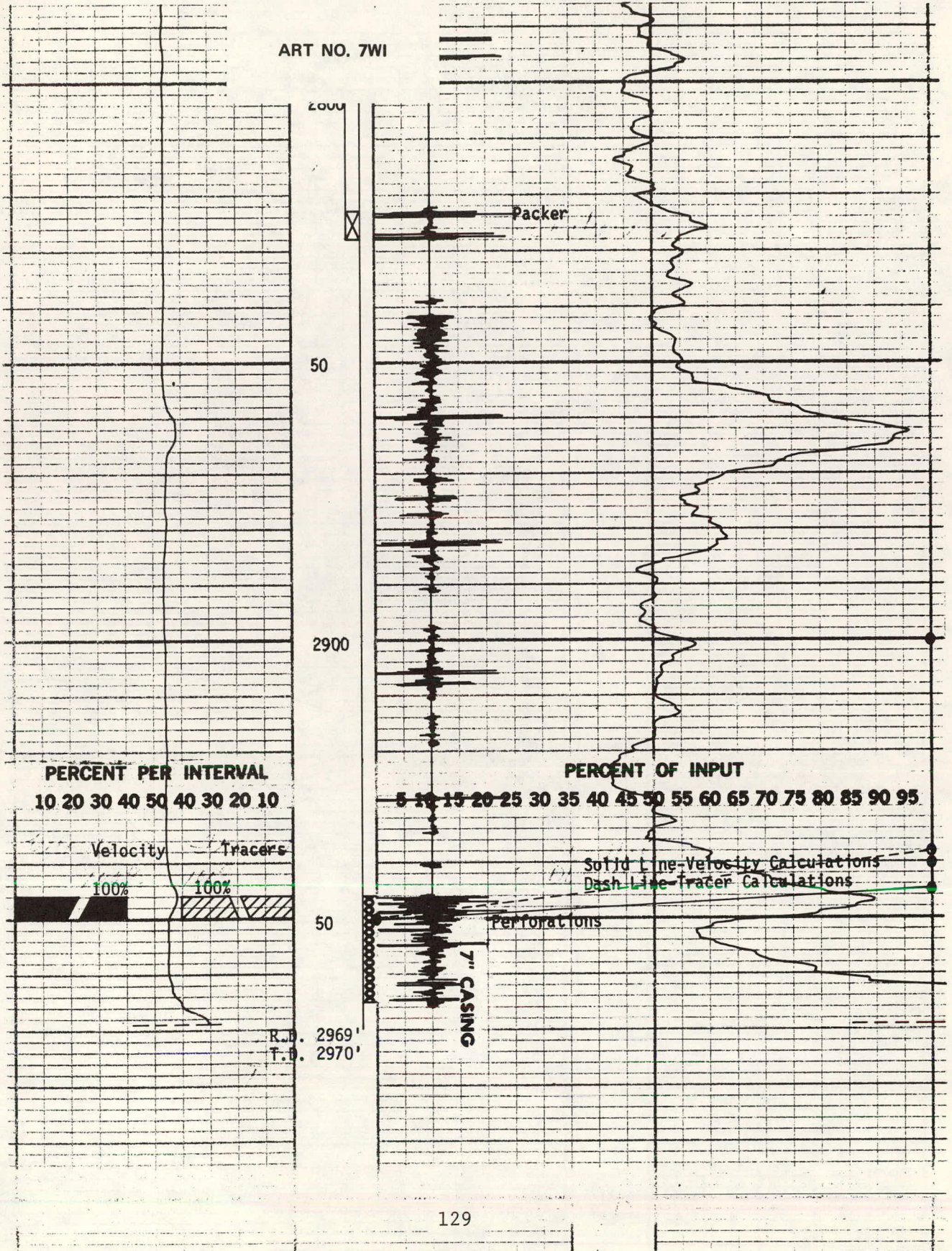


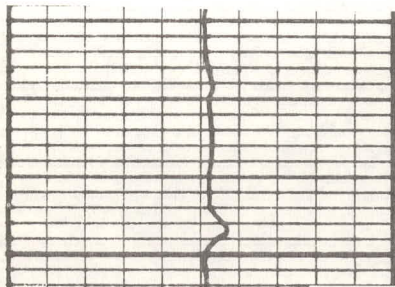
Company Kewanee Oil Company Formation Burbank  
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 Field N. Stanley Project State Oklahoma



APPENDIX E  
INJECTION PROFILE SURVEYS FOR  
ALL INJECTION WELLS

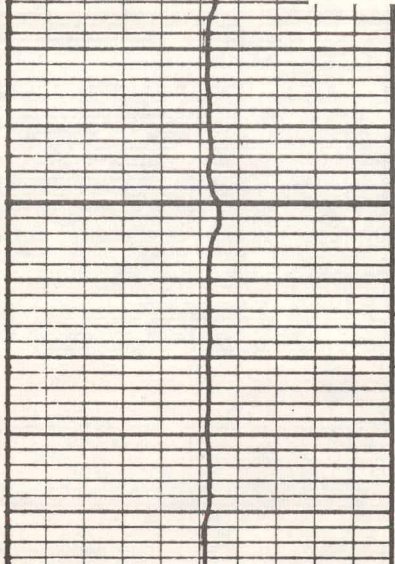
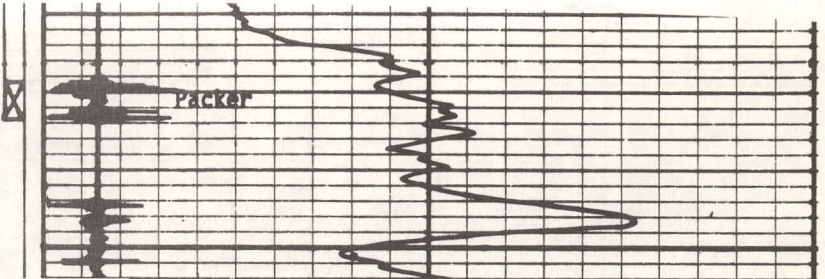
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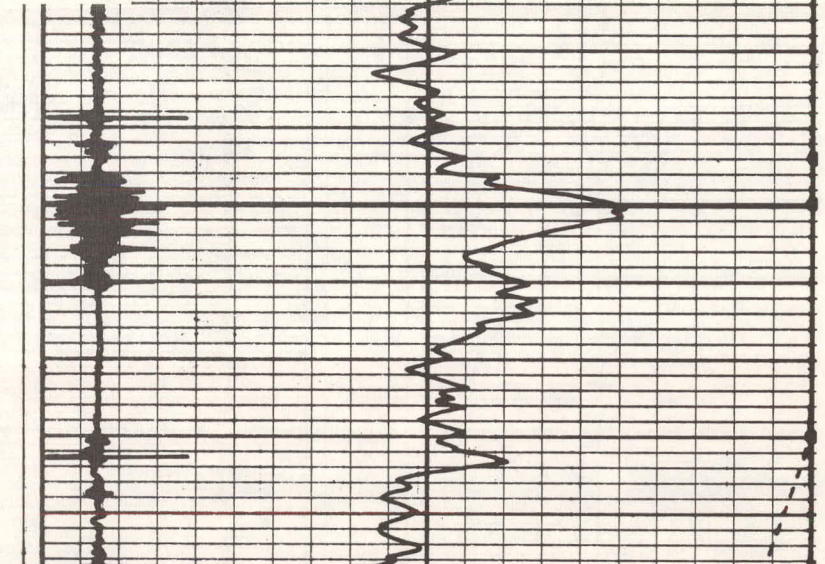
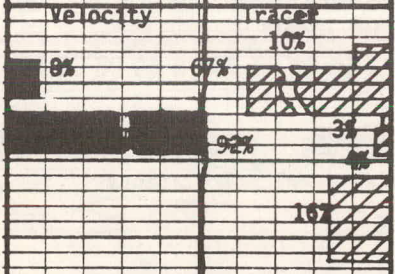
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ART NO. 8WI



50

2900



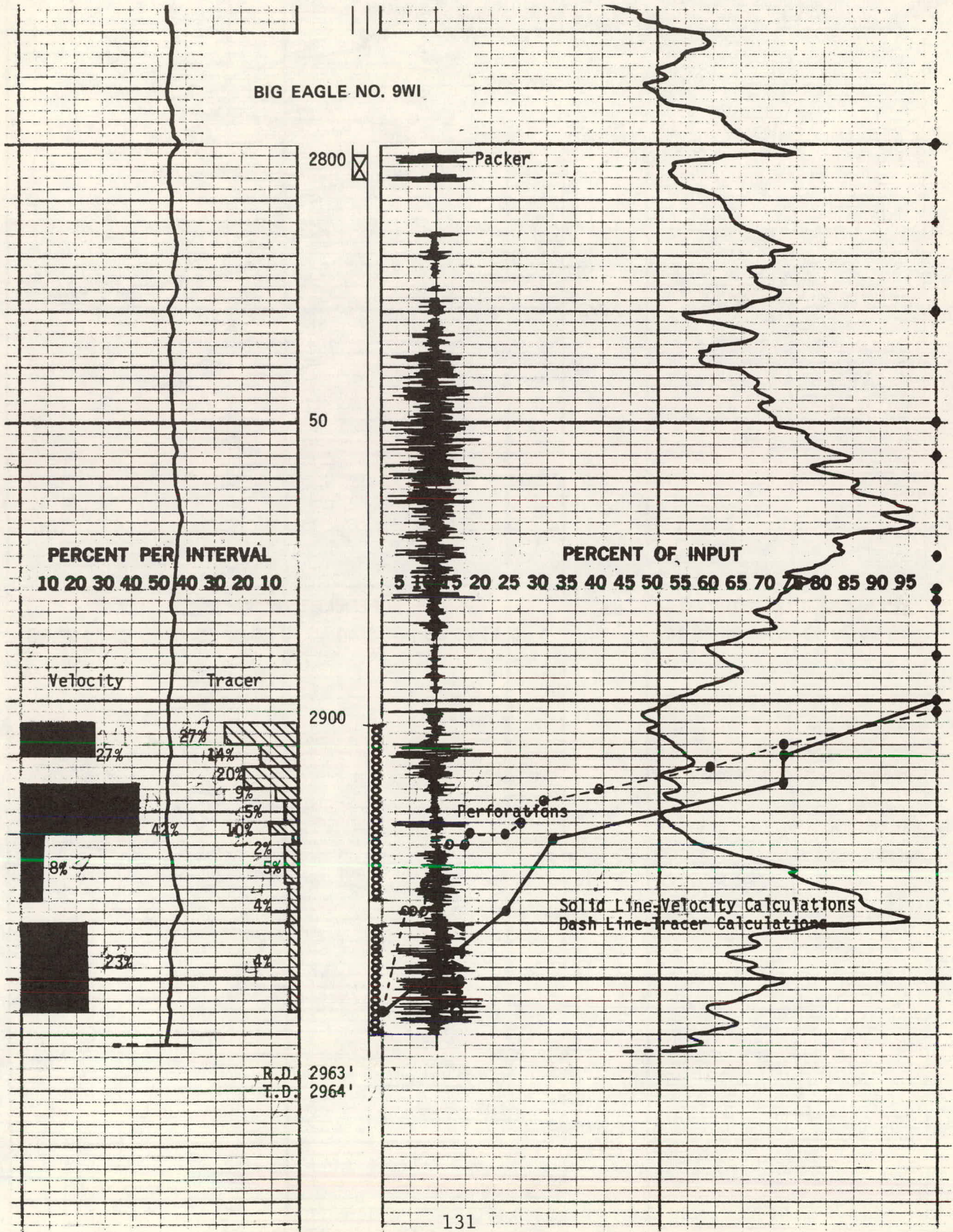
50

R.O.  
T.D.

2961'  
2962'

130

BIG EAGLE NO. 9WI



PERCENT PER INTERVAL  
10 20 30 40 50 40 30 20 10

PERCENT OF INPUT  
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

Velocity

Tracer

2800

50

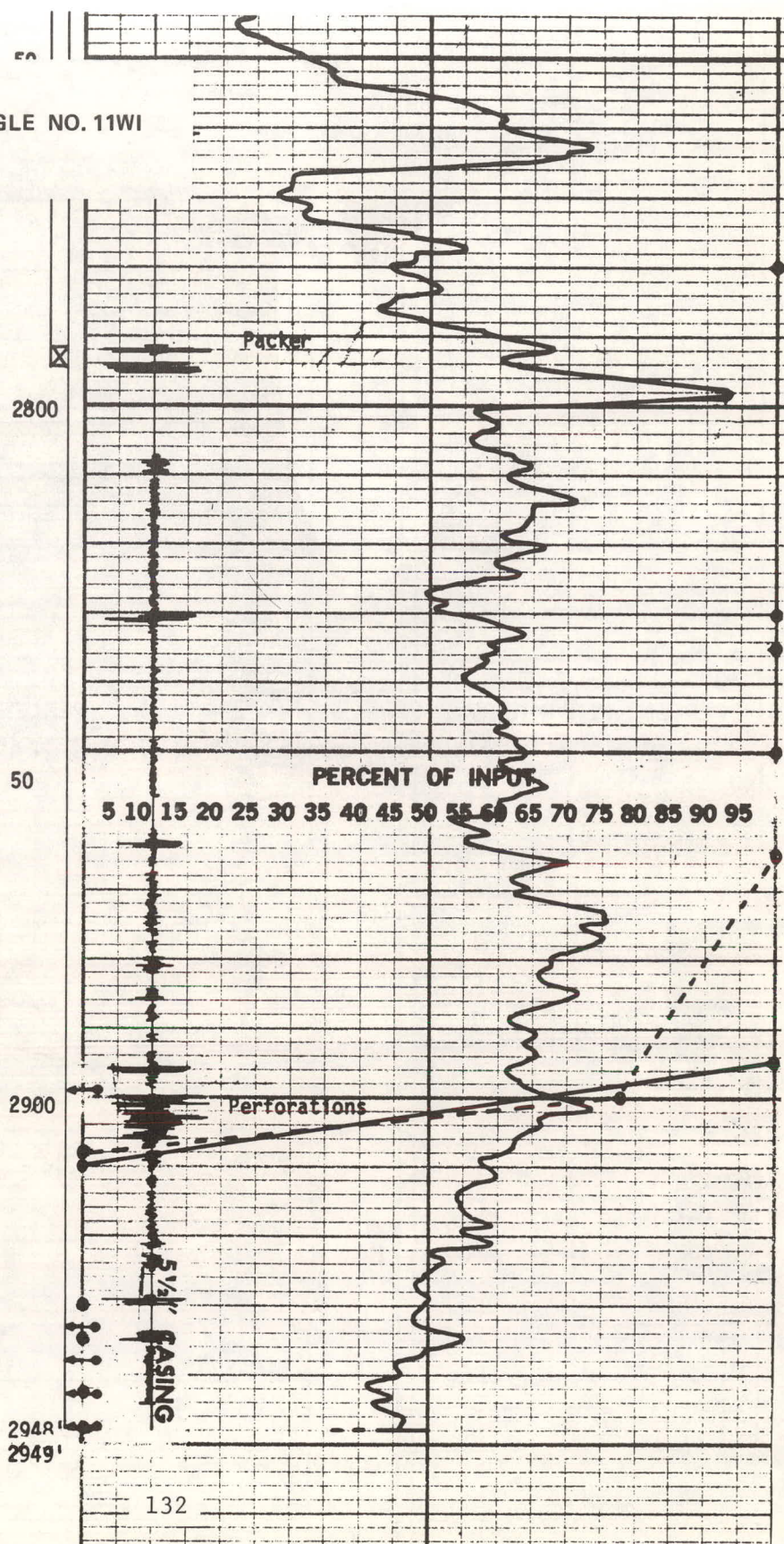
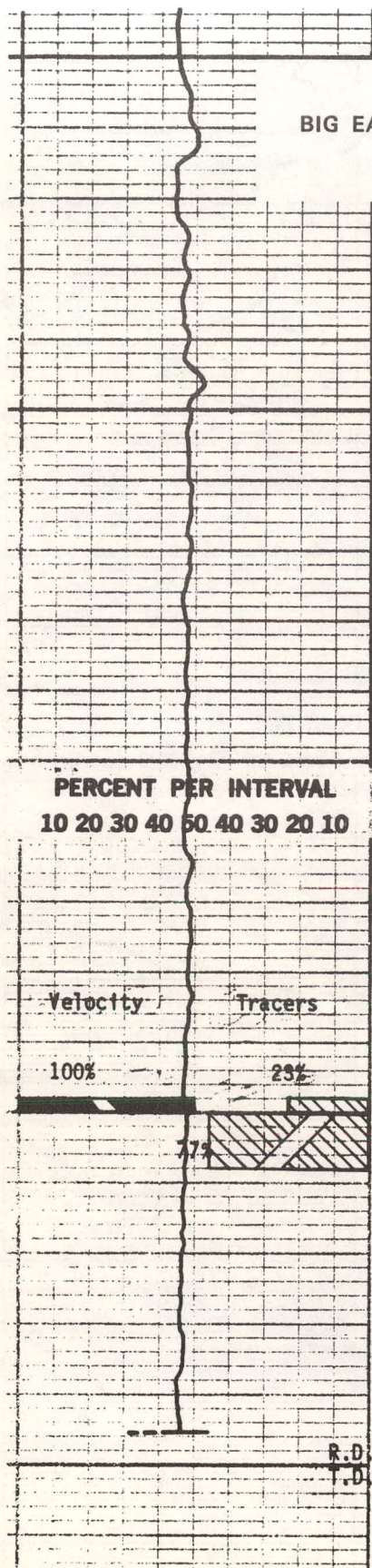
2900

Perforations

Solid Line-Velocity Calculations  
Dash Line-Tracer Calculations

R.D. 2963'  
T.D. 2964'

BIG EAGLE NO. 11WI



BRENNER NO. 7WI



Packer

PERCENT PER INTERVAL  
10 20 30 40 50 40 30 20 10

Tracer

17%

Velocity

48%

20%

27%

30%

22%

13%

23%

R.D.  
T.D.

2930  
2931

PERCENT OF INPUT

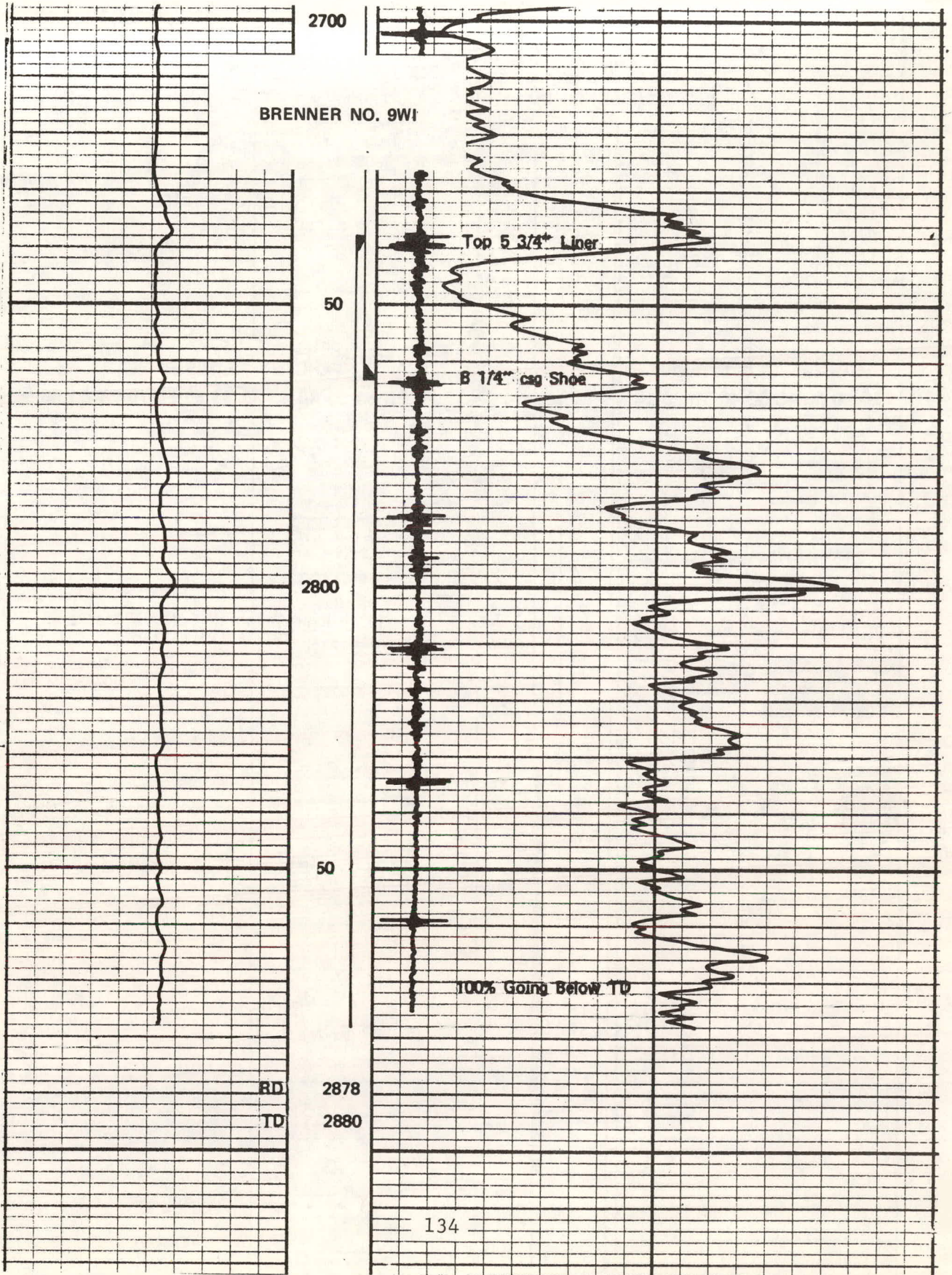
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

Solid Line-Velocity Calculations  
Dash Line-Tracer Calculations

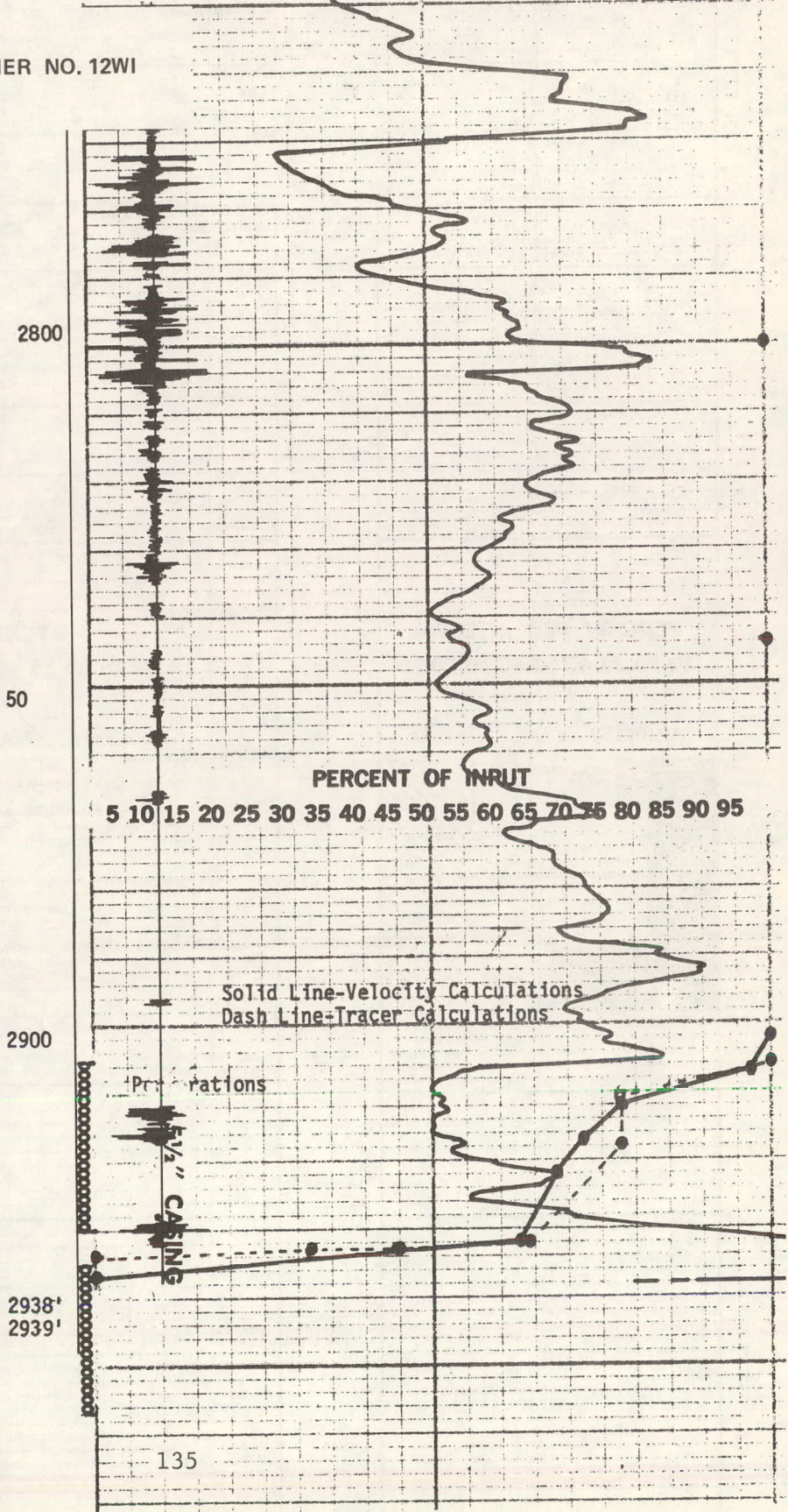
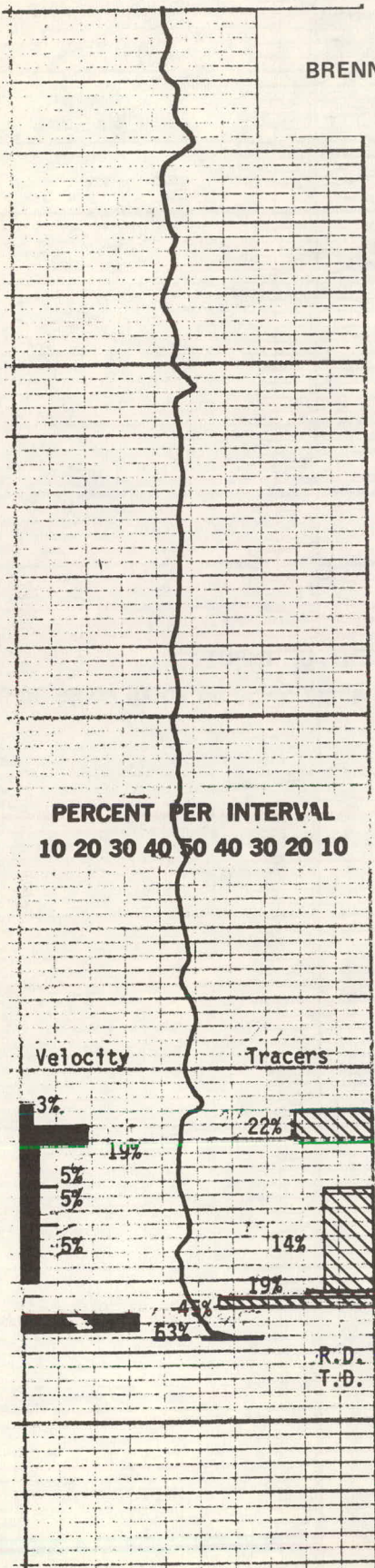
Perforations

5 1/2"

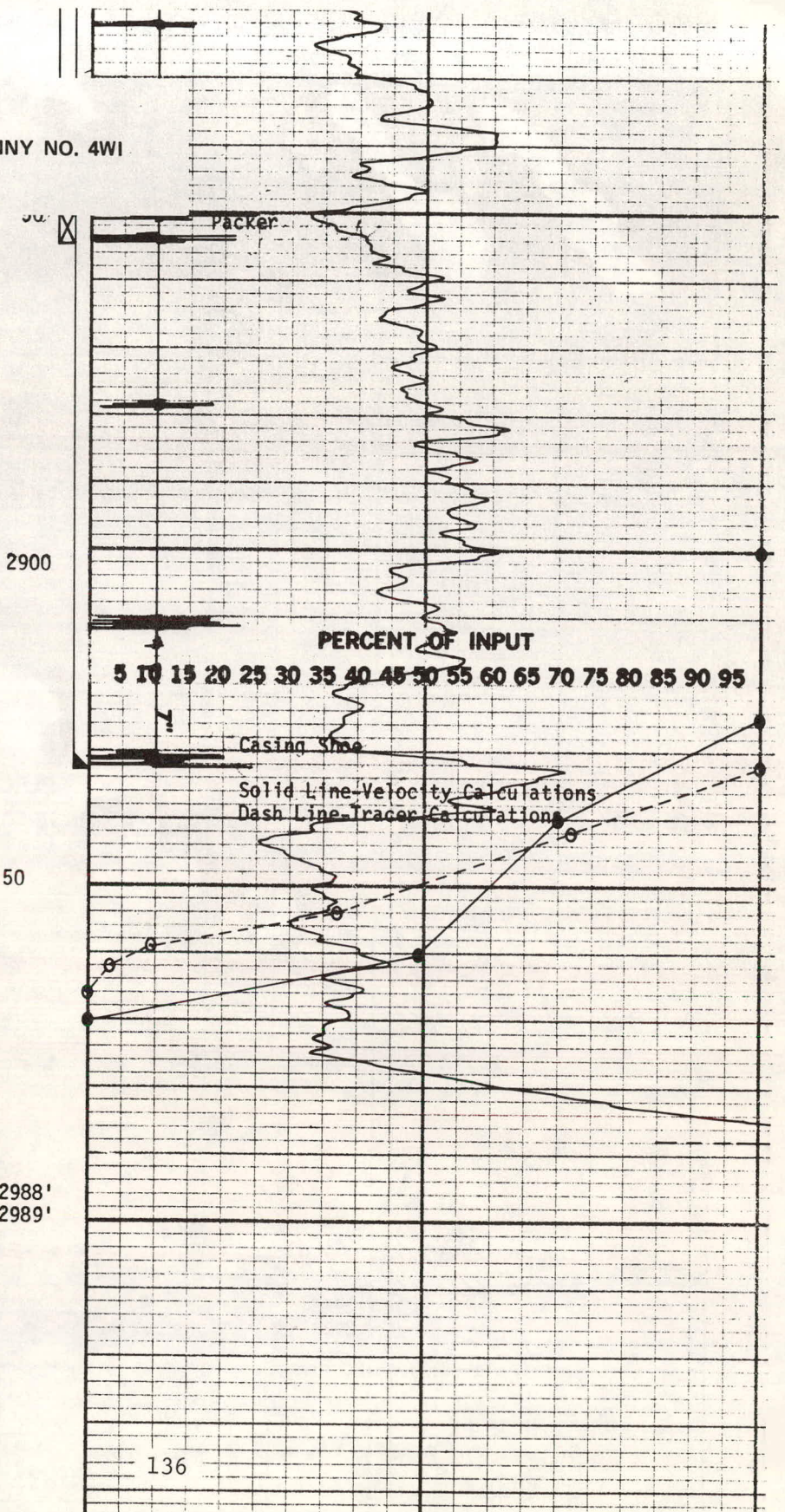
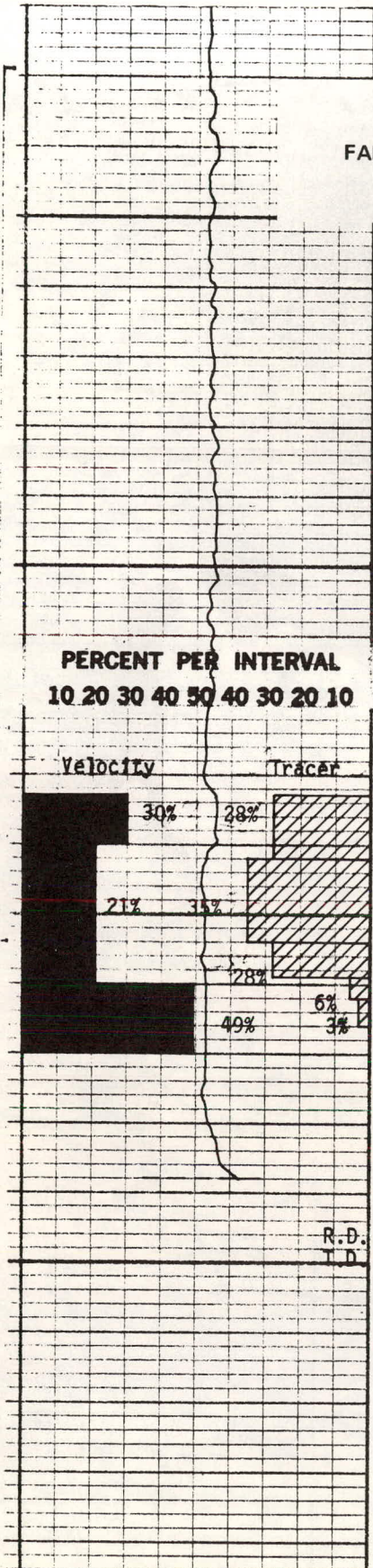
BRENNER NO. 9WI



BRENNER NO. 12WI



FANNY NO. 4WI



R.D. 2988'  
T.D. 2989'

FANNY NO. 5WI

PERCENT PER INTERVAL  
10 20 30 40 50 40 30 20 10

PERCENT OF INPUT  
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

Tracer

9%

Velocity

34%

14%

66%

54%

23%

R.D.  
T.D.

50

2900

50

2967'  
2968'

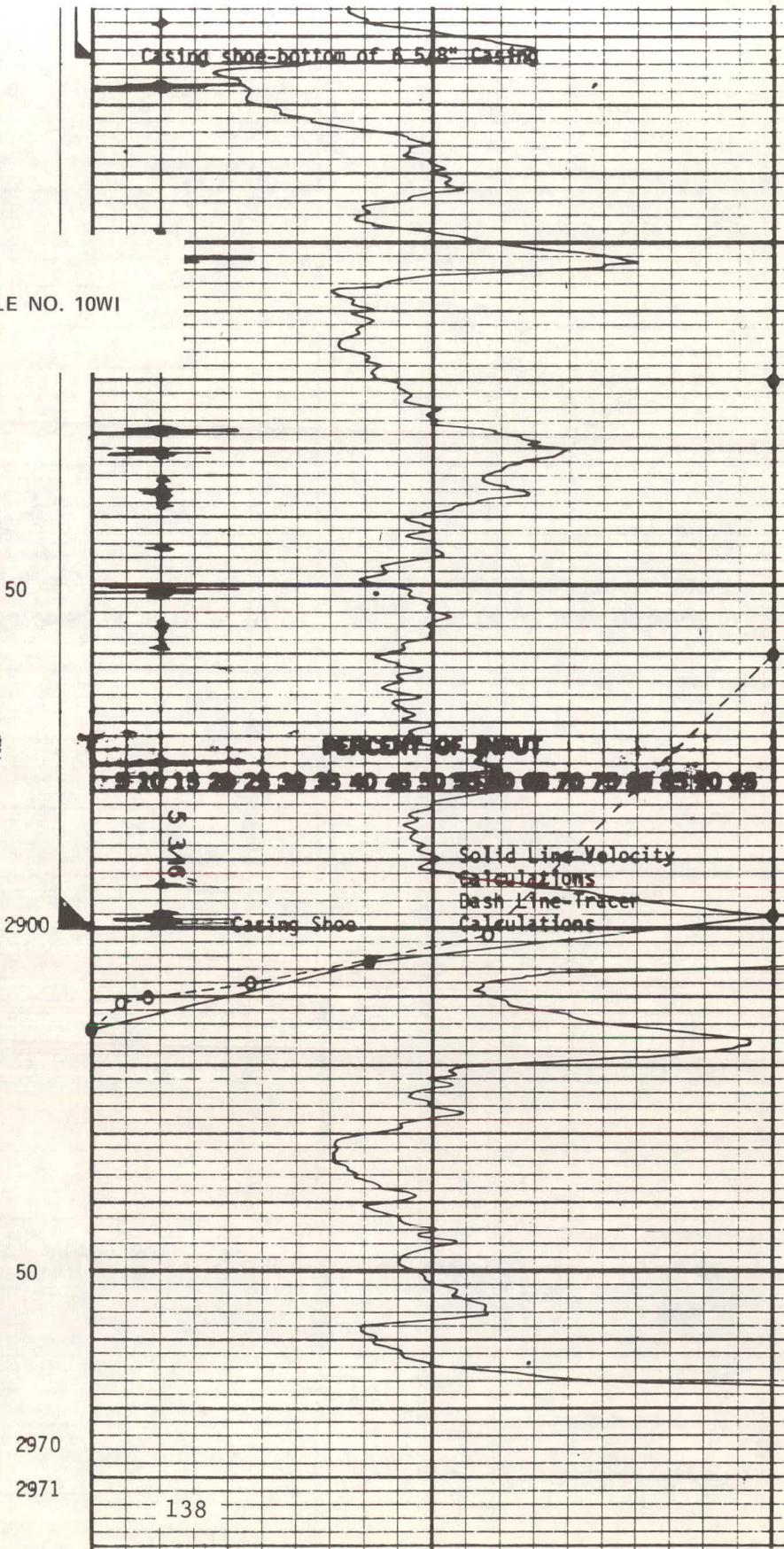
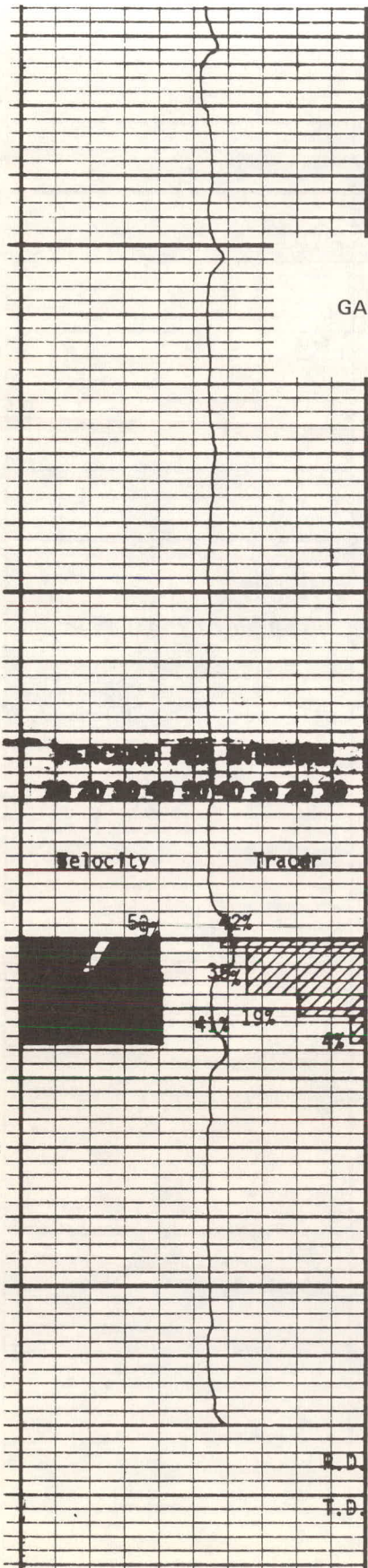
packer

Perfs.

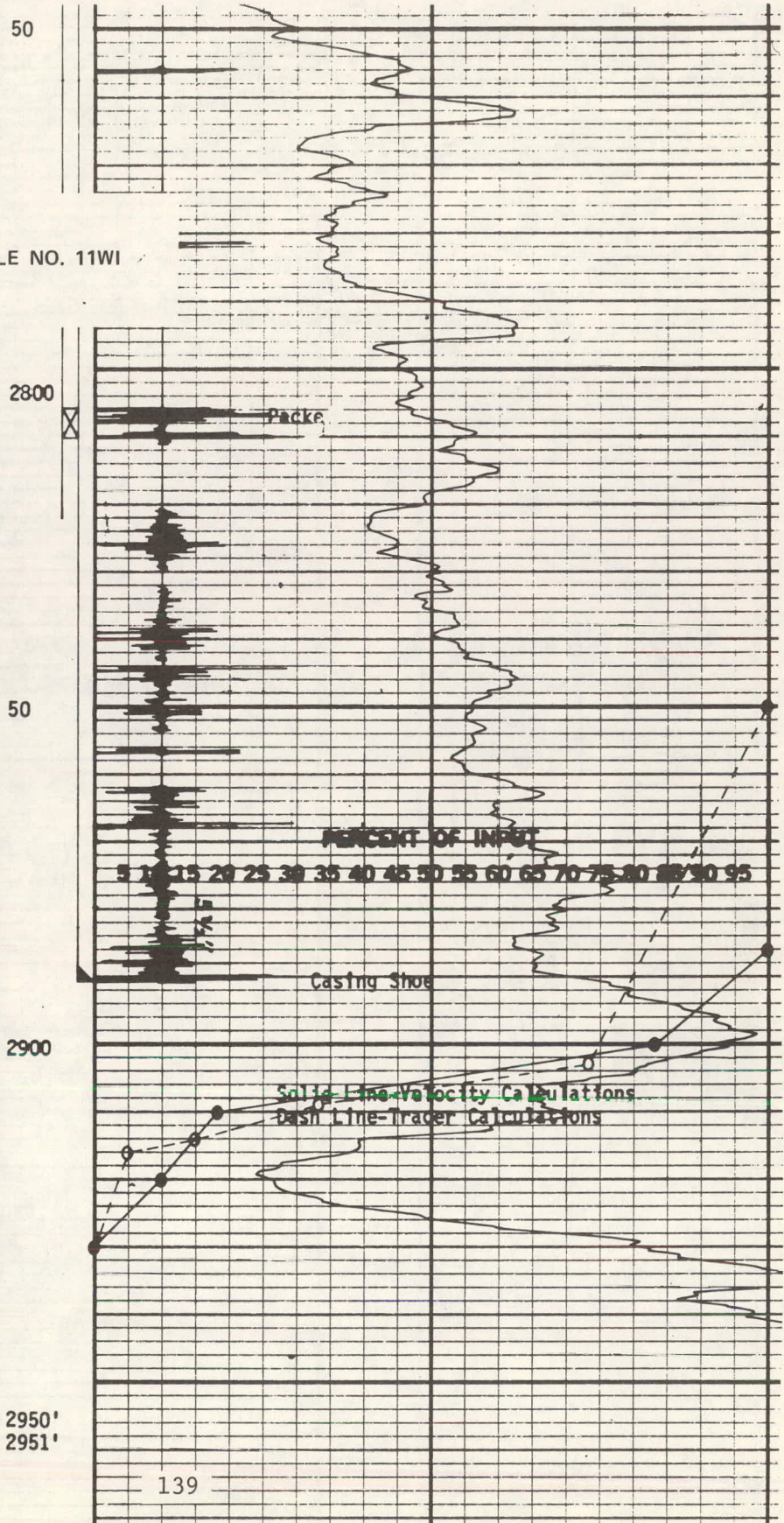
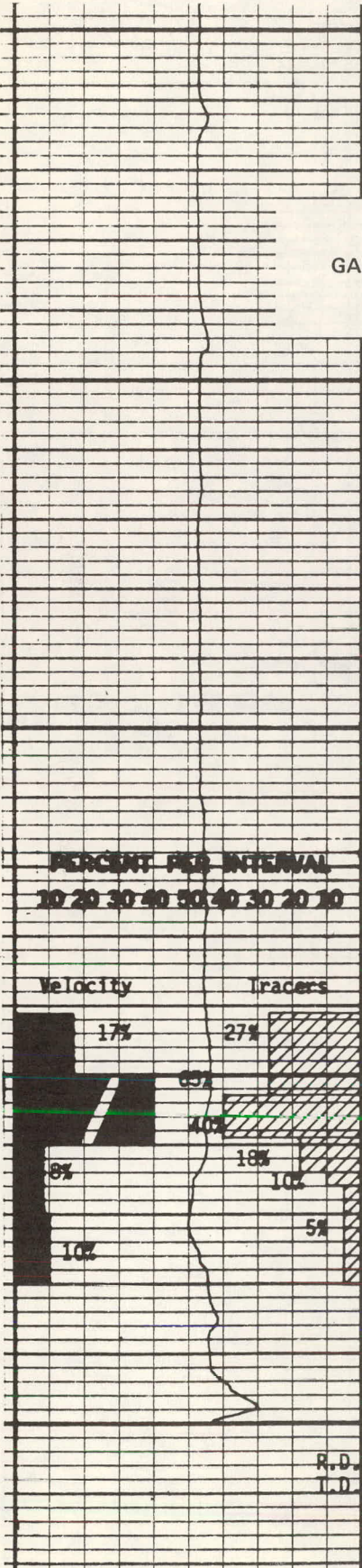
7" CASING

Solid Line-Velocity Calculations  
Dash Line-Tracer Calculations

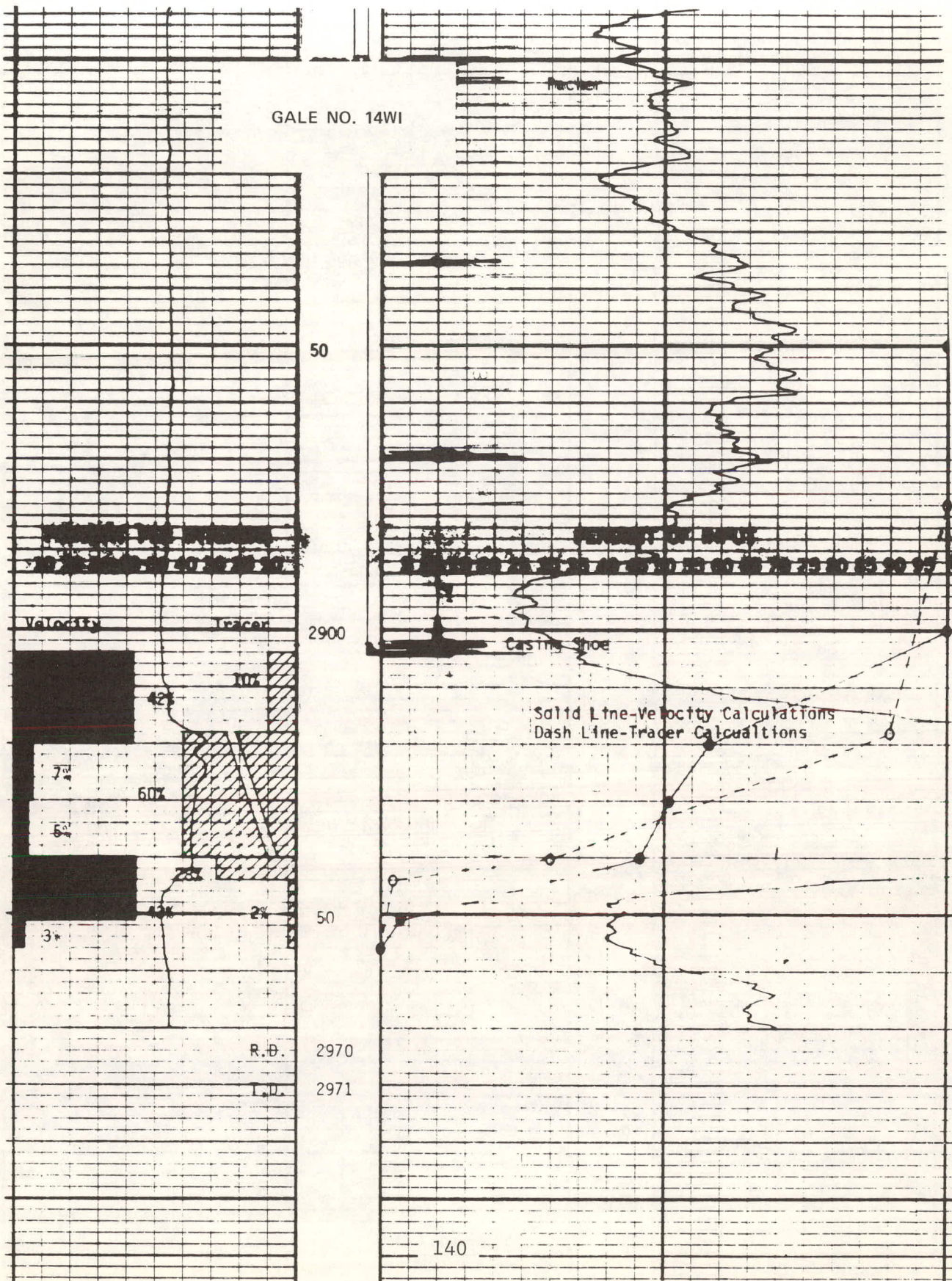
GALE NO. 10WI



GALE NO. 11WI



GALE NO. 14WI



2800

HIRAM NO. 10WI

Solid Line-Velocity Calculations  
Dash Line-Tracer Calculations

Velocity

Tracer

4%

46%

100%

50%

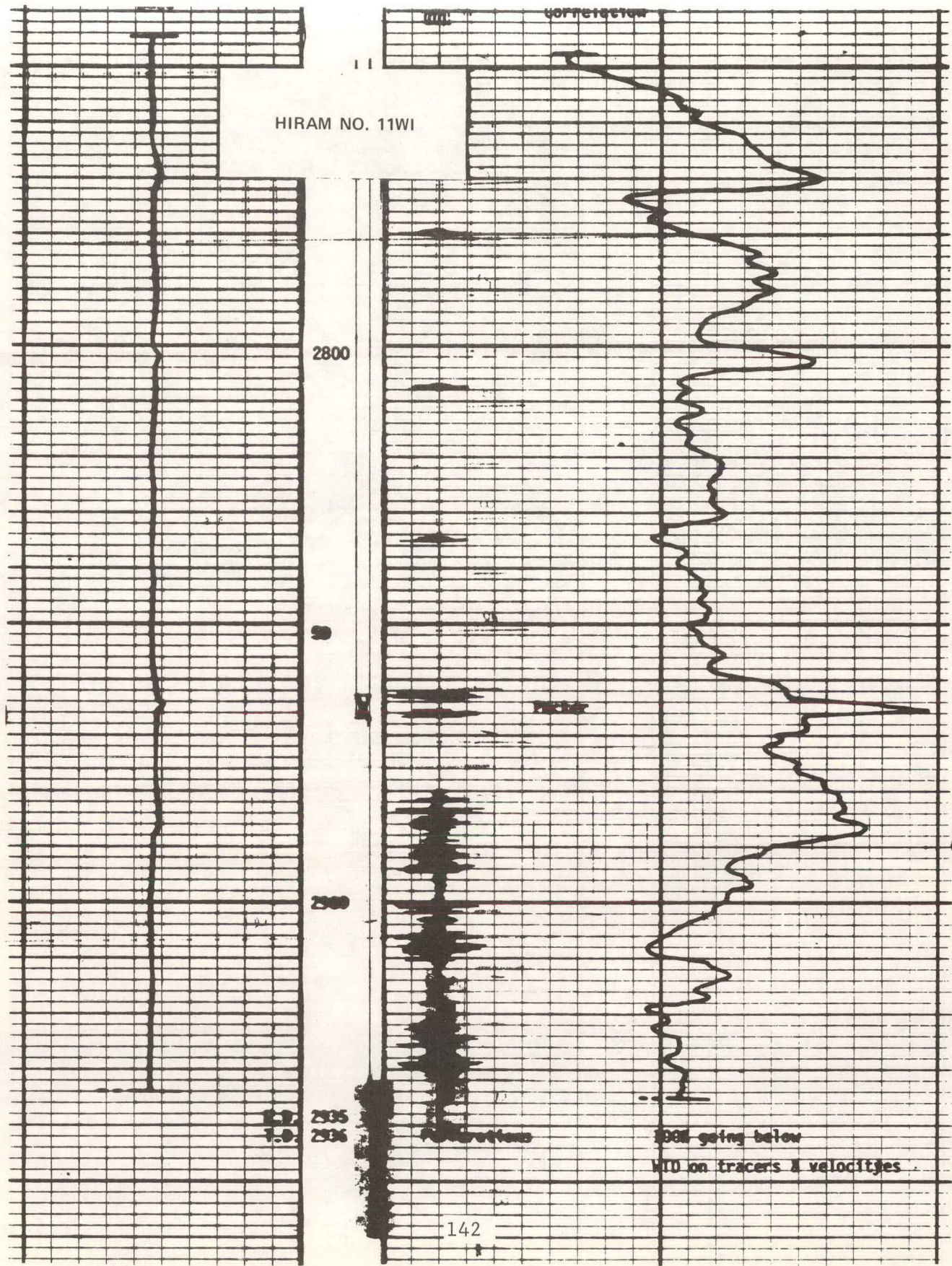
5 1/2" Casing Shoe

50

2900

50

R.D. 2968'  
T.D. 2969'



HIRAM NO. 11WI

CORRECTION

2800

2900

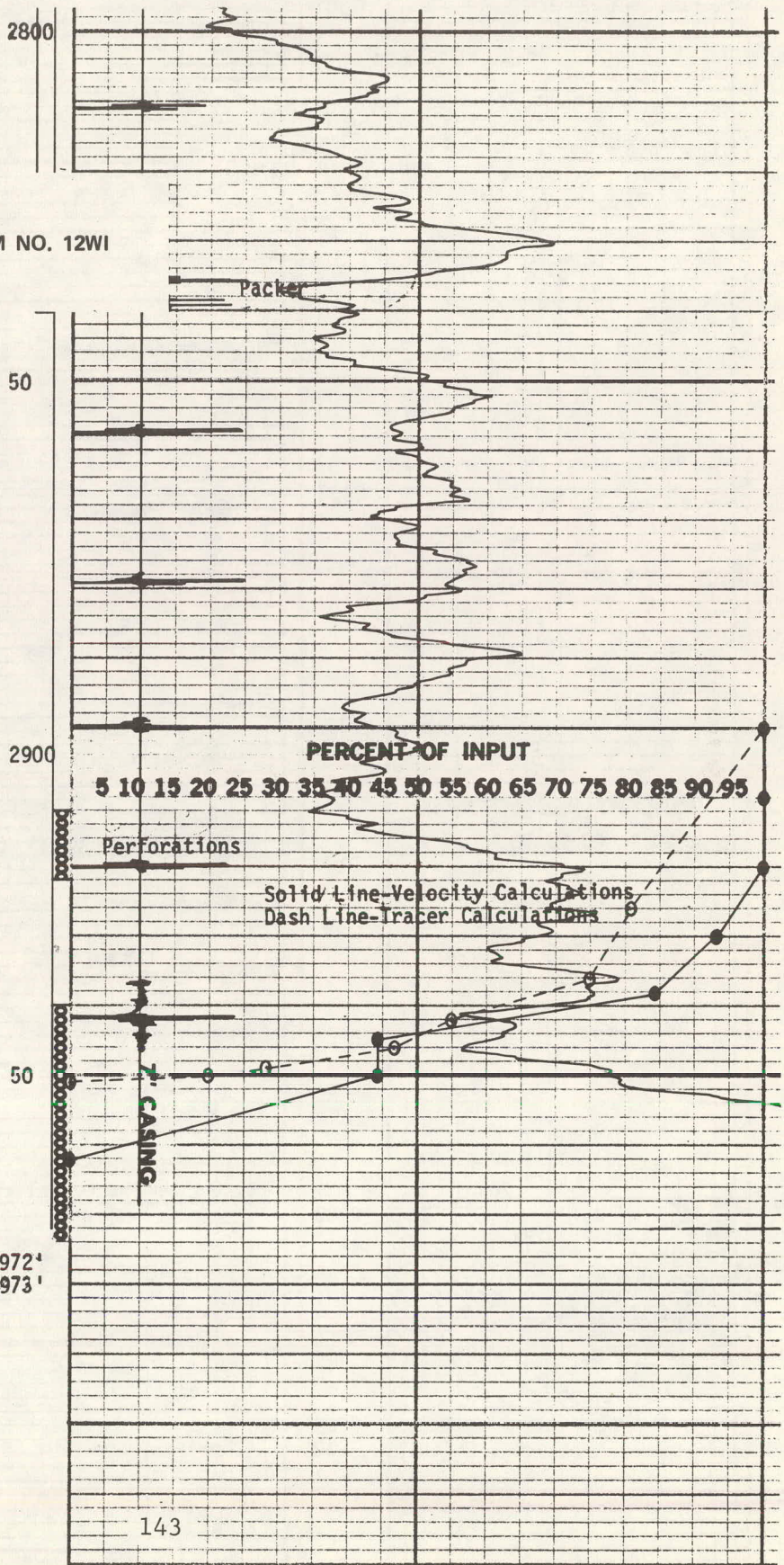
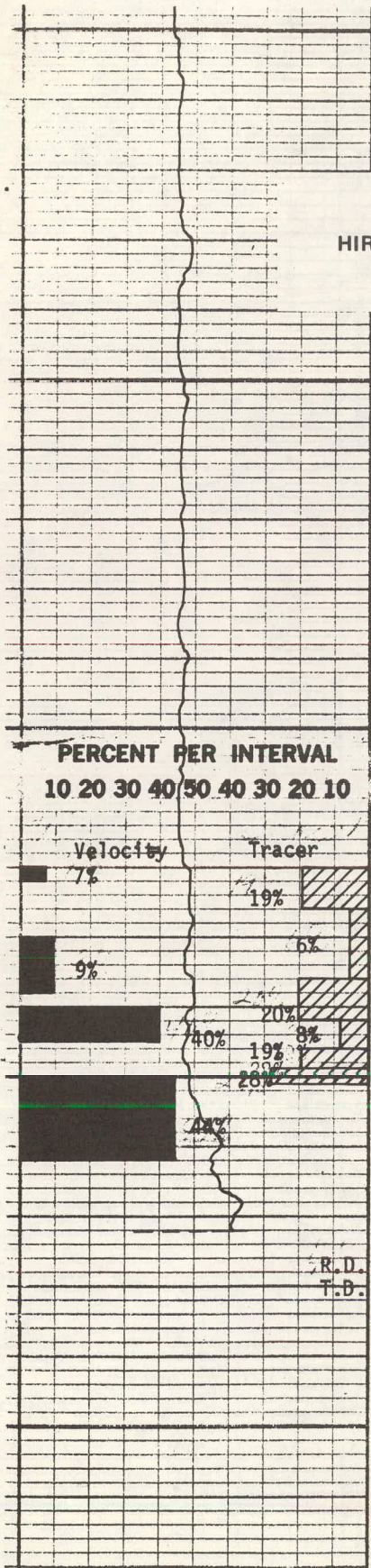
2950

2935  
1.0  
2936

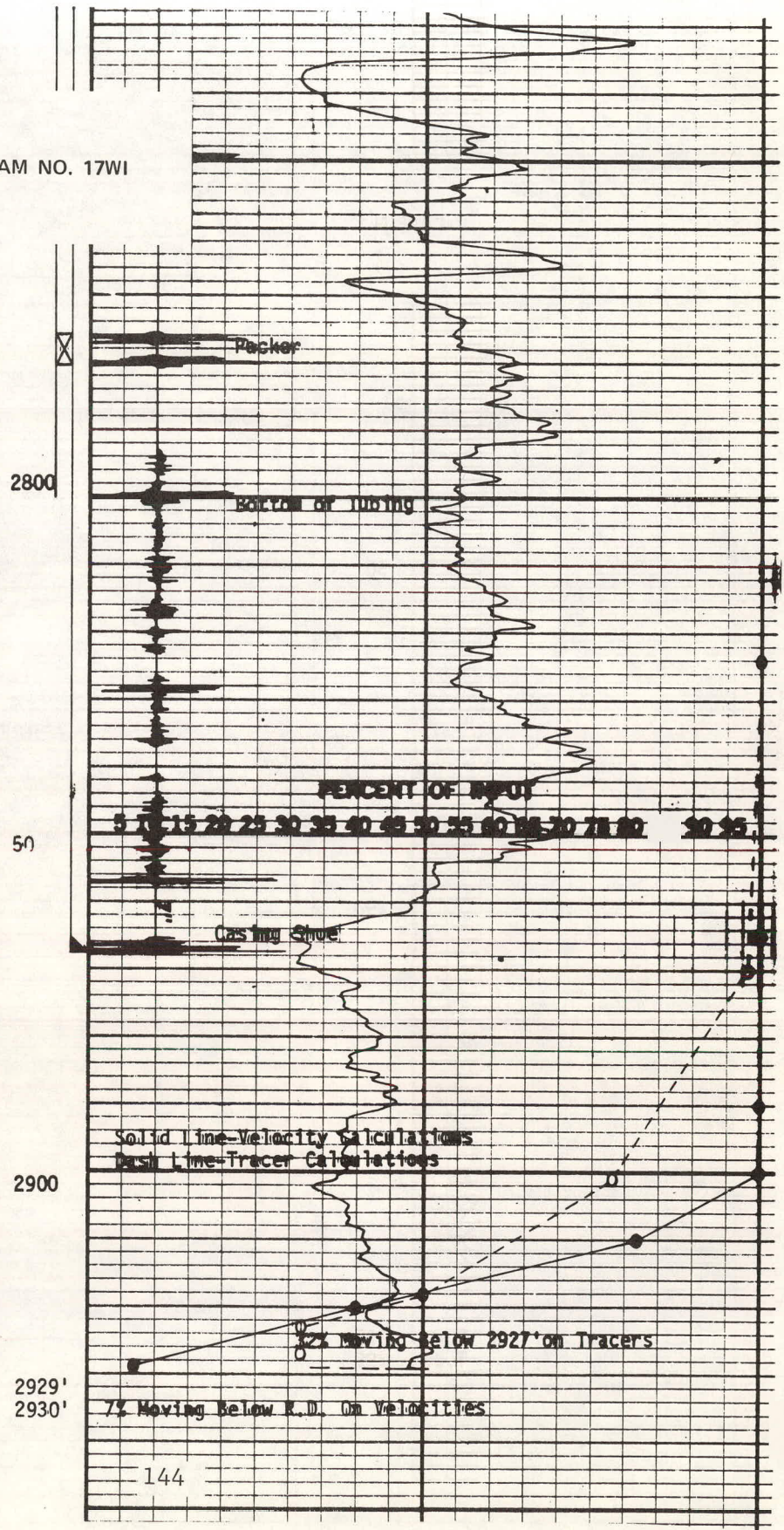
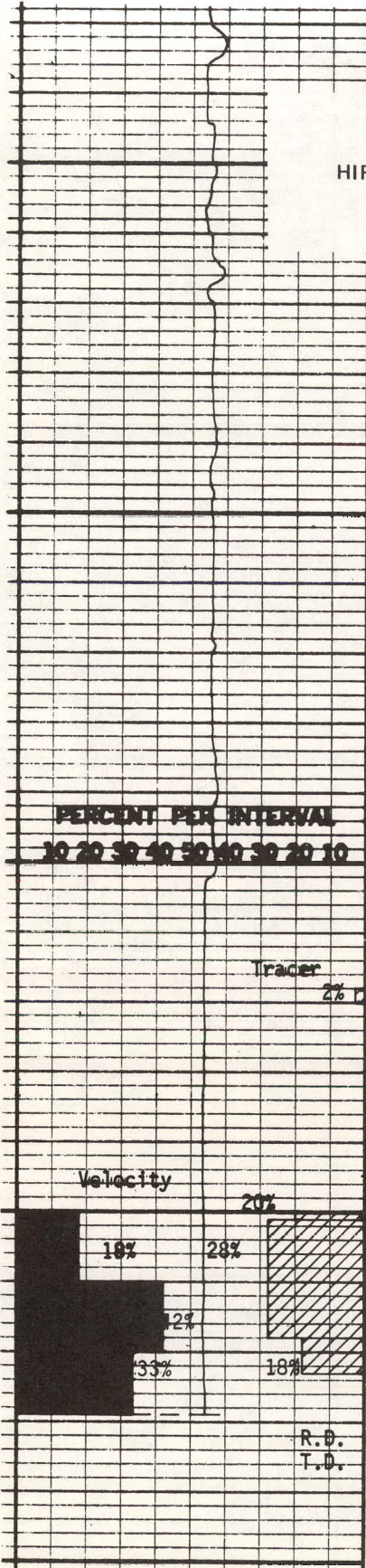
2936

2900 going below  
WTO on tracers & velocities

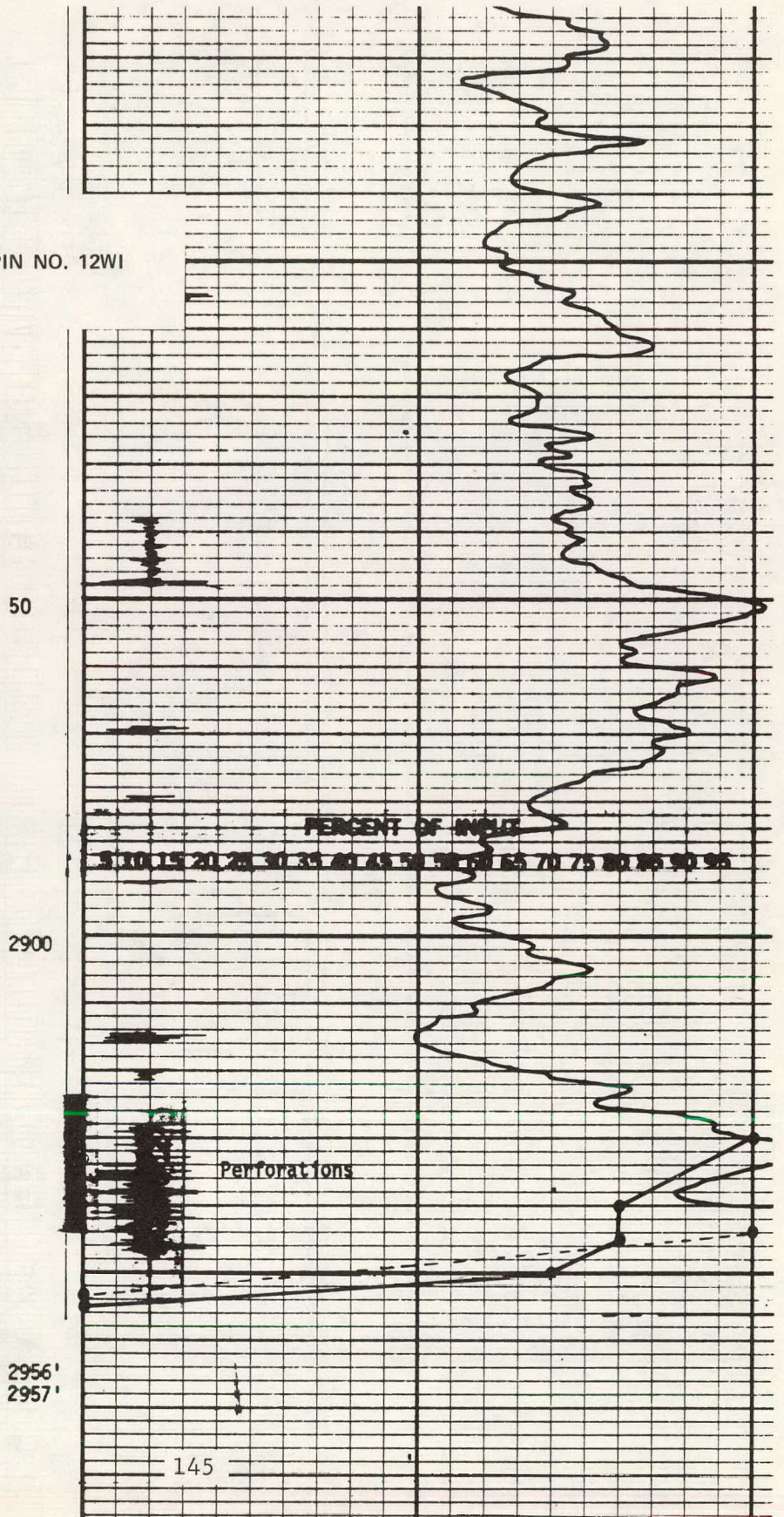
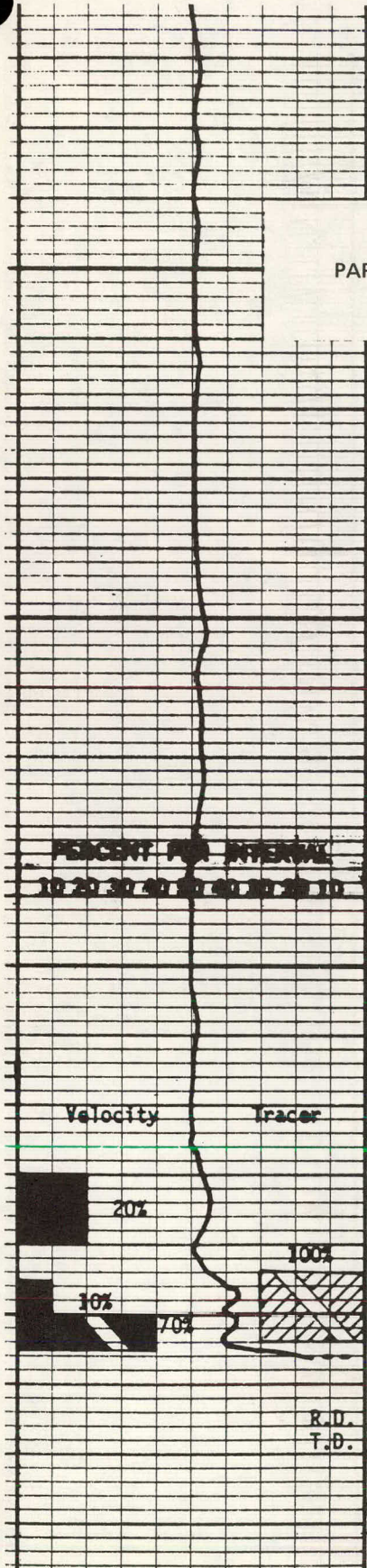
HIRAM NO. 12WI



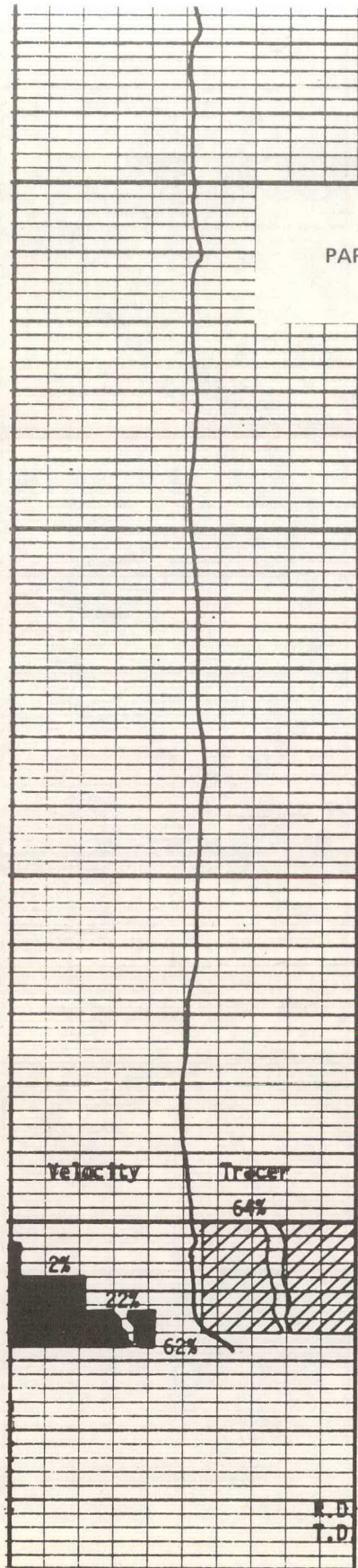
HIRAM NO. 17WI



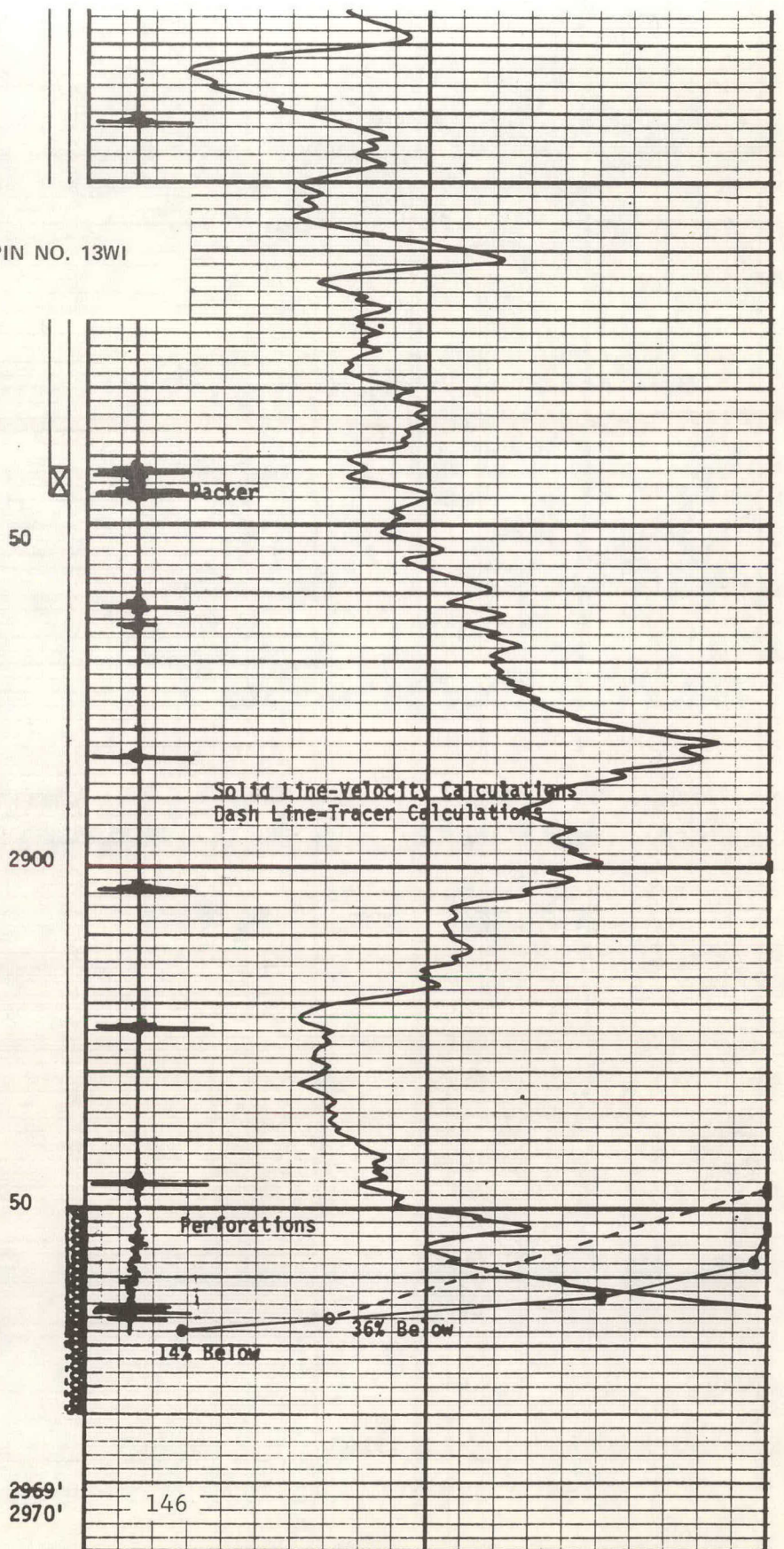
PAPPIN NO. 12WI



PAPPIN NO. 13WI

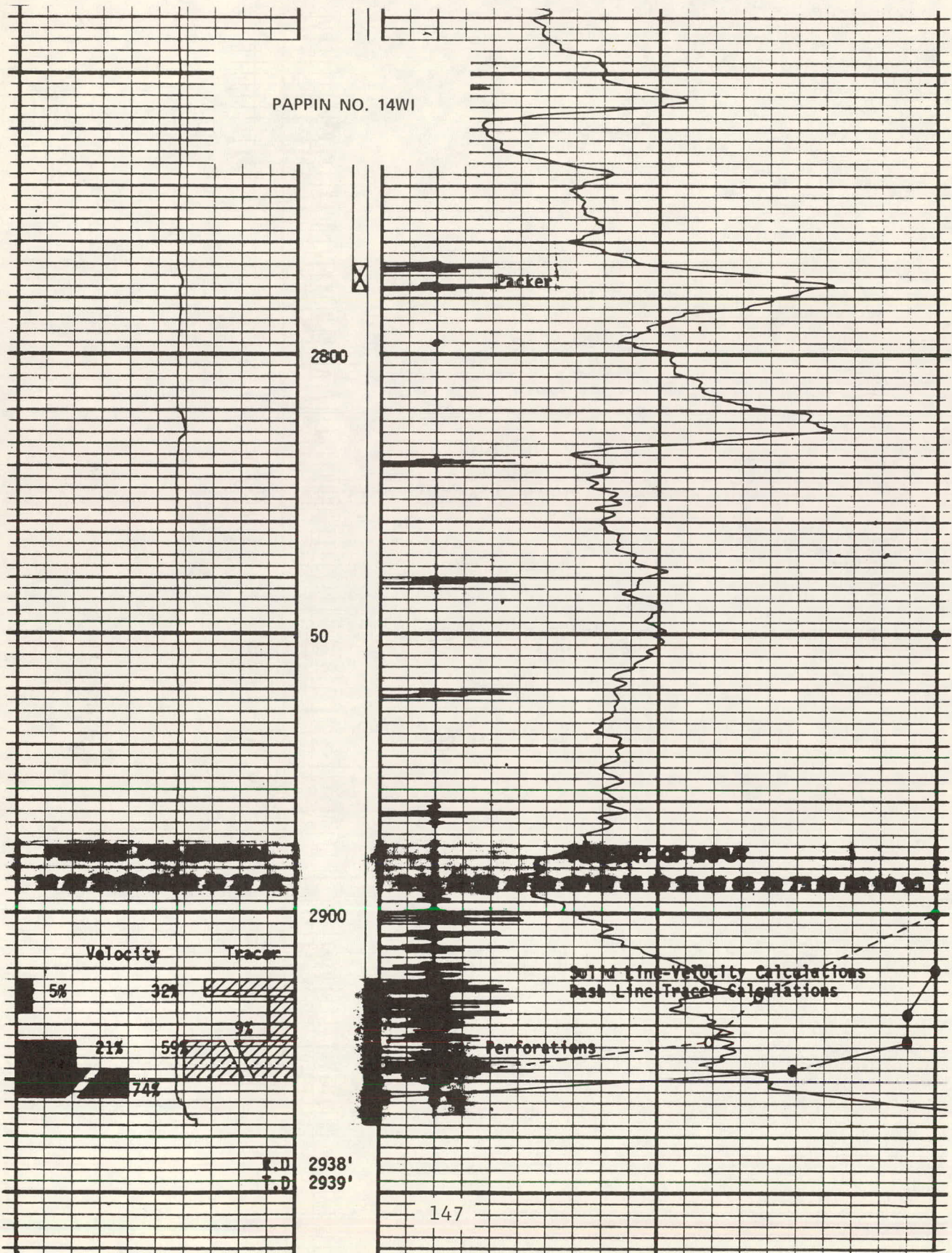


R.D. 2969'  
T.D. 2970'



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PAPPIN NO. 14WI



APPENDIX F

THE KEWANEE NORTH STANLEY POLYMER PROJECT

BY

JARL P. JOHNSON

## THE KEWANEE NORTH STANLEY POLYMER PROJECT

Jarl P. Johnson  
Manager of Engineering, Kewanee Oil Company

Prepared with the cooperation of the Energy  
Research and Development Administration under  
Contract No. E(34-1)-0029.

### ABSTRACT

A test is being conducted to determine whether additional oil can be economically recovered from a waterflood in an advanced stage of depletion by injection of a polyacrylamide polymer. The test is in the Stanley Stringer, Osage County, Oklahoma, and includes the entire north half of the Stringer. Secondary objectives are: a better understanding of polymer displacement and to determine whether polymers can condition a reservoir for micellar flooding.

The site consists of 1,010 productive acres containing 51,000 acre feet with 42,000,000 barrels of oil in place. The property has 27 active producers and 17 injectors. It produces approximately 600 BOPD and 38,000 BWPD after having recovered 15.7 MMBO by the combination of primary, gas injection, vacuum, and water injection mechanisms. It has a remaining reserve of 2,000,000 barrels if the polymer injection program is modestly successful. Similar reservoirs containing 800,000,000 barrels of oil are located in Osage County.

Illustrations at end of paper.

Other companies with smaller experiments have established that additional oil can be recovered by injecting one of the polyacrylamide polymers.

### INTRODUCTION

The objectives of the polymer test at the Stanley Stringer are: (1) to determine if oil can be economically recovered from a Bartlesville sand reservoir by injecting a polyacrylamide polymer during the mature stage of waterflooding, (2) to gain a better understanding of the mechanics of polymer displacement, and (3) to ascertain whether a polymer flood will enhance the probability of success of a subsequent micellar flood by replacing the connate water with water containing lower concentrations of calcium and magnesium ions and by reducing the effect of high permeability variance.

### BACKGROUND

In arriving at the decision to conduct the polymer test, consideration was given to several methods of replacing company reserves. A survey was made of the cost of

replacement alternatives: acquisition, exploration, heavy oil recovery, and tertiary recovery. Having decided that enhanced recovery could be competitive, a review of the Company's holdings was made to obtain a feel for how much time remained for developing some means of improved recovery to salvage known oil in place reserves. Reservoirs were then cataloged as to rock type, fluid type, depth, physical condition, and quantity of oil in place in order to select a project representing the highest probability of success and the best recovery potential if successful.

The next step was to investigate the possible recovery processes. Those presently believed to have the greatest chance of success are: in-situ combustion, CO<sub>2</sub> injection, micellar injection, and polymer injection. Matching of a process to a reservoir came next. Because timing is important, consideration had to be given to the state of the art. What has been established as to performance of the process? What is the availability of required material? What is a plausible expectation in recovery relative to the cost? What is the suitability of the process to the greatest reserve potential?

Kewanee's decision was to give the polymer flood a try in an Osage County, Oklahoma, reservoir.

Locating the site for a test was the next problem. The test must be large enough to permit averaging of varieties of well performance and reservoir heterogeneity, but small enough to represent a capital risk. It was considered important that the site be definable, having available good reservoir data and performance records. It must also be confinable, i.e. have well established boundaries. The site should, of course, be representative of a substantial reserve potential in terms of reservoir character, state of depletion, and mechanical condition. The north one half of the Stanley Stringer was selected as having most of the desired characteristics.

#### PROJECT AREA

The Stanley Stringer is a shoestring sand or offshore bar about fifteen miles long and one half mile wide. The reservoir is the Bartlesville and Burbank sands as

depicted in the cross section (Figure 1) and isopach map of the Stanley Flood area (Figure 2).

The sand is somewhat fractured and has a high permeability variance. This characteristic is depicted in Figure 3 which shows the sand to have much higher permeability in the upper layers than in the lower layers. Fractures are oriented primarily in an east-west direction, but because the waterflood pattern was designed to compensate for this feature, fluids have tended to move in a direction parallel with the strike of the sand body. This is illustrated in Figure 4. Reservoir rock and fluid properties are summarized in Table I.

The field was discovered in 1926. It has been produced by depletion of its primary solution gas, gas injection, application of vacuum, and by waterflooding. Total recovery represents about forty percent of the original oil in place.

Of interest to this study is the north one half of the Stanley Flood which is outlined in Figure 1. Statistics for the project area are given in Table II. Figure 5 shows the production history for the Stanley Waterflood from the beginning of waterflooding. Important to the objectives of the test, this project is representative of reservoirs in Osage County, Oklahoma, containing 800 million barrels of oil in place.

#### PROGRAM PLAN

Figure 6 is a graphic of the program plan for the polymer flood. The work has been divided into five phases. The first phase, the Site Selection, has been described above and has been completed. The second phase, Preparation of Site and Equipment, is under way. As would be true of most fields of this vintage, a careful survey of well condition and appropriate remedial work is an essential effort. This work must be done sufficiently ahead of the polymer injection phase to allow time for stabilization of thruput rates and evaluation of a base line of performance against which the effect of polymer injection can be measured. During this phase, facility changes will be made to provide SWD disposal for approximately 38,000 barrels of produced water daily, which is currently being

njected into the reservoir. A plant for lining and injecting the polymer will be built.

A mini injection test is being conducted to evaluate injectivity and to test for polymer quality. The amount of degradation thru various items of surface equipment and thru well perforations will be measured. Oxygen scavengers and bacteriocides will also be screened during the test.

During Phase III, the Preflush Phase, fresh water will be injected at approximately the rate anticipated during polymer injection. This will be a stabilization time during which base lines will be established. Produced water will be closely monitored during this time in anticipation of the appearance of fresh water which will provide an indication of the flow patterns in the reservoir. If this information, together with injection profiles and pressure falloff tests, should indicate adverse conditions, further remedial action or pattern alterations will be considered. An effort will be made to make as few changes in pattern as possible in order to introduce no more variables into the evaluation than necessary.

Polymer injection occurs in Phase IV. Dow Chemical Company's Pusher 700 polyacrylamide polymer will be injected in varying concentrations. Subject to further refinement, the plan is to inject 38,000 BPD at concentrations of 1,000 PPM for one month, 500 PPM for one month, 250 PPM for four months, and 100 PPM for six months. A total of 1,250,000 pounds will be injected. Consideration will be given to the use of the heavier molecular weight Pusher 1000 for the final six month period. A sequence of injection profiles and pressure falloff tests will be conducted while the polymer is being injected. Produced fluids will be monitored to note changes in water composition as well as oil and water volumes.

The polymer slug will be followed by fresh water, Phase V. During this time, produced fluids will continue to be monitored, effects of polymer injection will be analyzed, and an effort will be made to construct some type of model with which to describe project performance.

### EXPECTED RESULTS

Only modest results are expected from the process. If the project performs as expected, a minimum of 1,000,000 barrels will be recovered, representing a recovery improvement of 2.4% of the original oil in place. (Figure 7) While this is not ambitious, it involves a process that is available now, one that has been considered effective in smaller tests, and one which will develop reserves at a price competitive with exploration.

The project site has mechanical problems, has high permeability variance, and is in the later stages of waterflood depletion. It is recognized that these factors detract from the recovery potential of a polymer flood, but they are common to many of our reservoirs.

### SUMMARY

In summary, this test does not represent an ideal process or an optimum application of it, but it represents the state of the art as we find it and will establish whether additional reserves can be economically recovered from properties which otherwise will be abandoned in the near future.

Average Porosity	18%
Average Specific Permeability	300 md
Initial Reservoir Pressure	1200 psi
Saturation Pressure	1150 psi
Solution GOR	300
Initial FVF	1.18
Connate Water Saturation	30%
Reservoir Temperature	105° F

TABLE 1  
BASIC RESERVOIR DATA

1. AREA
  - a. 1,560 SURFACE ACRES
  - b. 1,010 PRODUCTIVE ACRES
2. VOLUME
  - a. 51,000 ACRE FEET
  - b. 42 MM BBLs OOIP
  - c. 72 MM BBLs PORE VOLUME
3. WELLS (44)
  - a. 27 PRODUCERS
  - b. 17 INJECTORS
  - c. 22 ACRES/WELL
4. PRODUCTION
  - a. 600 BOPD
  - b. 38,000 BBLs
5. RESERVES (1 MM BBLs)

TABLE 2  
PROJECT SCOPE

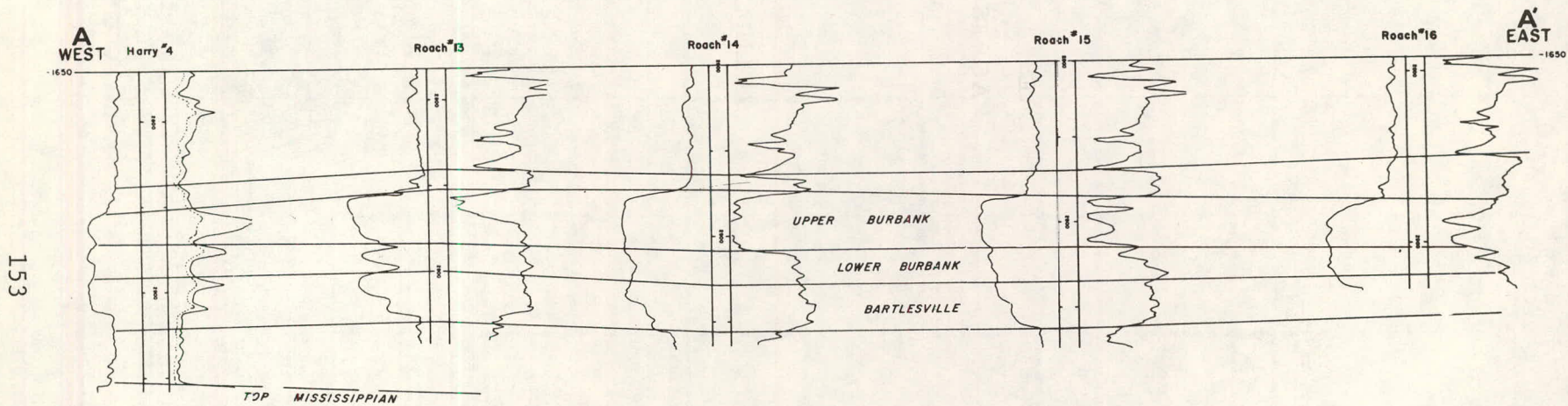


Fig. 1 Cross Section, Stanley Flood Area

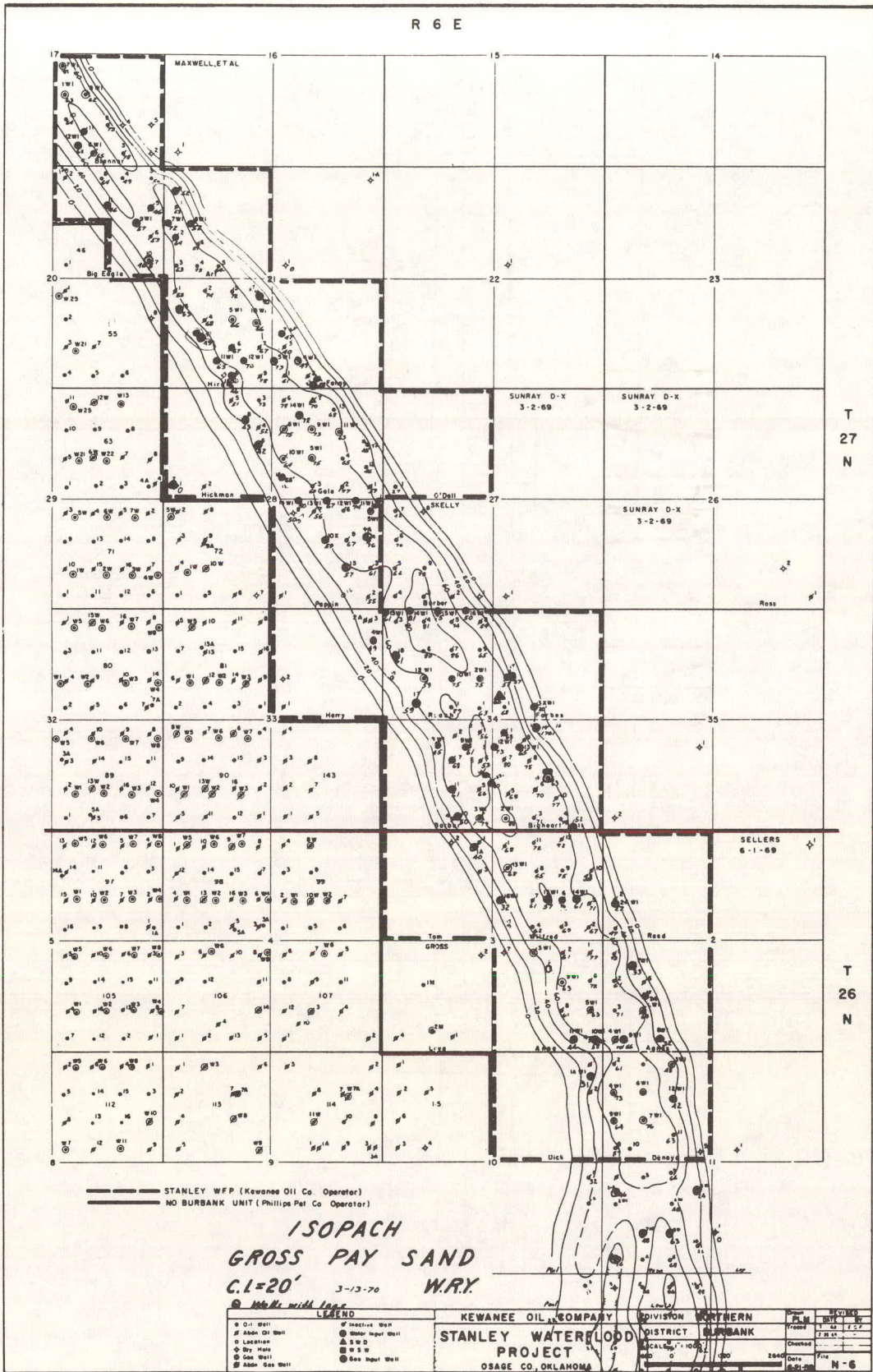


Fig. 2 Isopach Gross Pay Sand, Stanley Flood Area

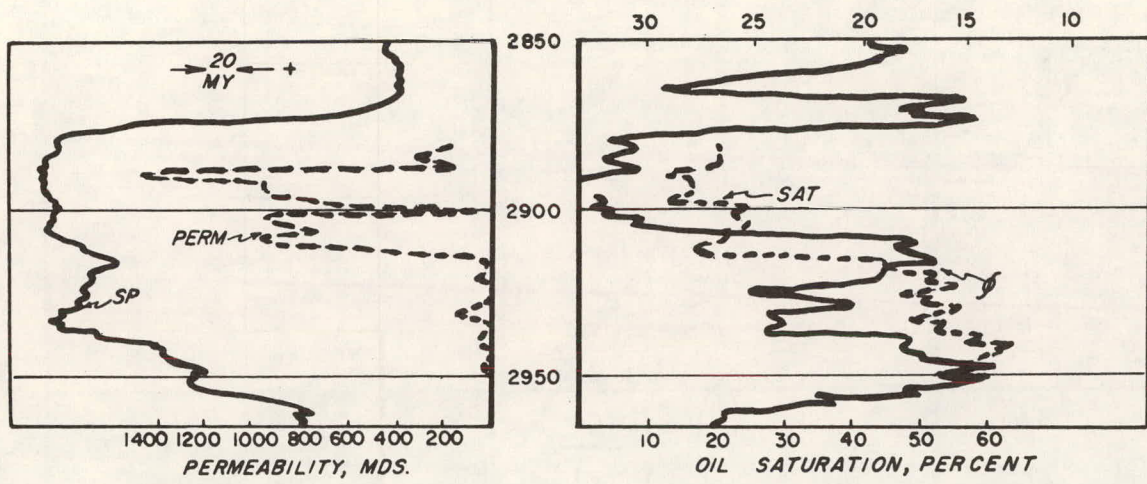
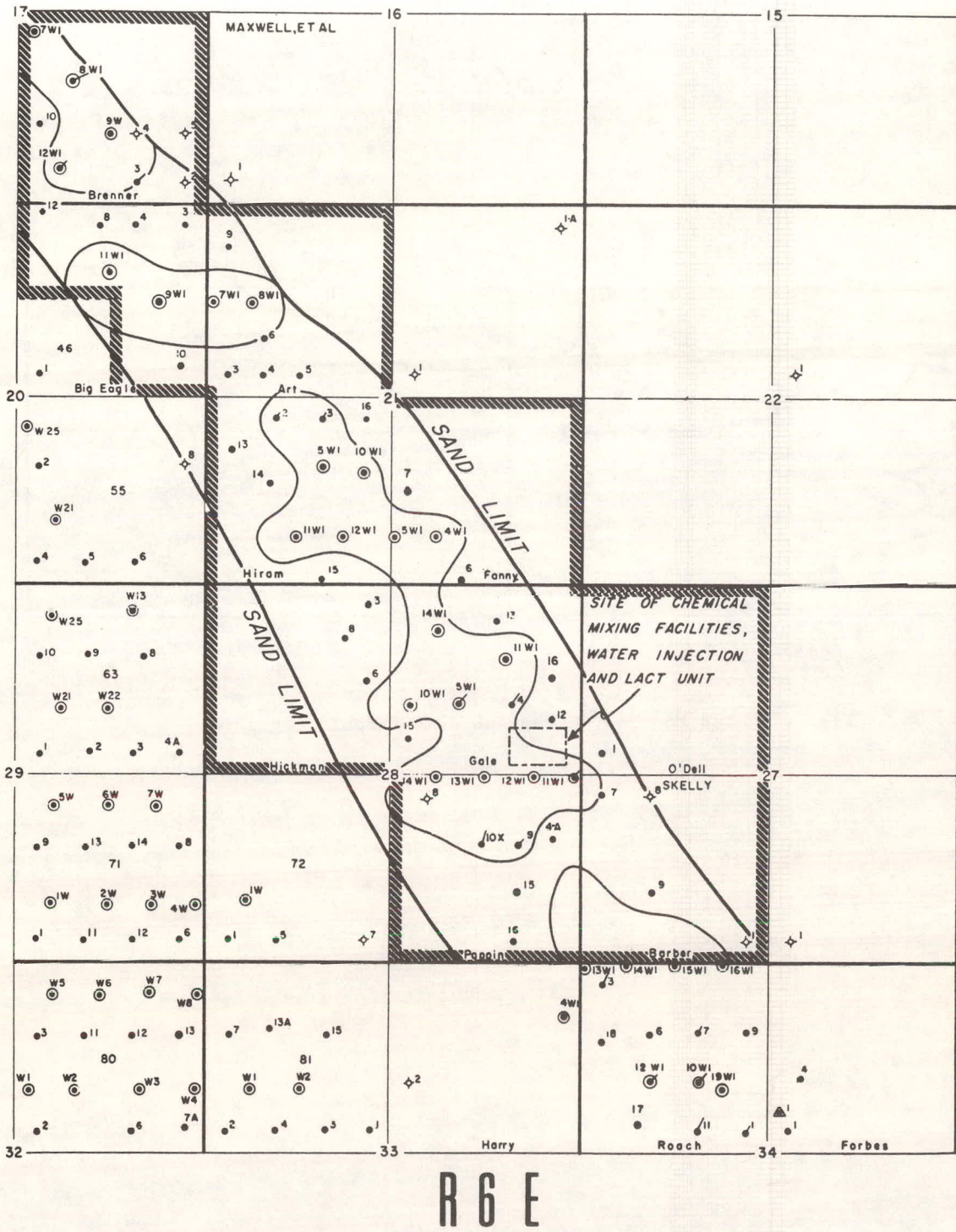


Fig. 3 Roach No. 14W, Coregraph and Sp-Sonic Log



T  
27  
N

Fig. 4 Stanley Polymer Project, Osage County, Oklahoma

157

BPD

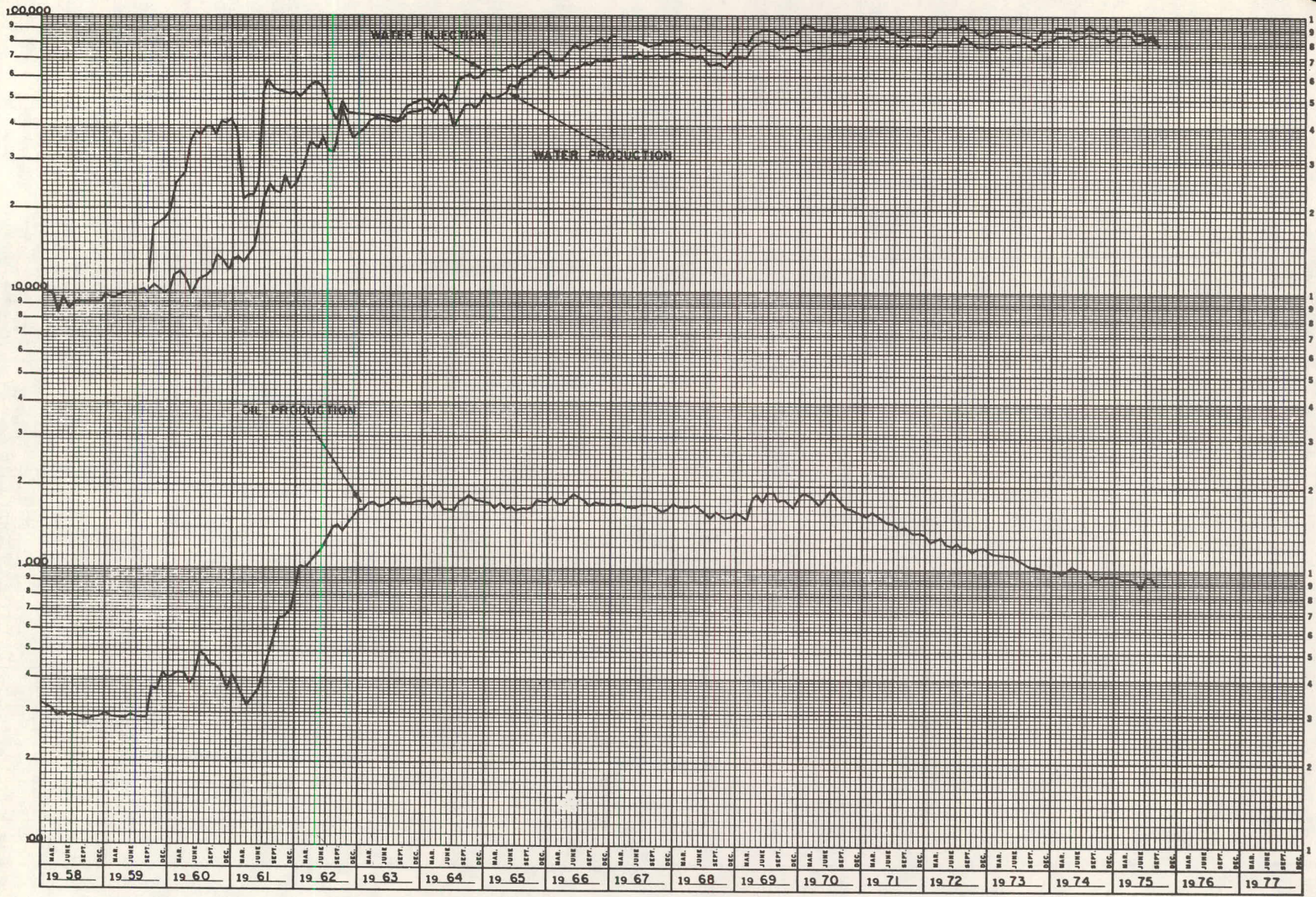


Fig. 5 Stanley Waterflood Production History

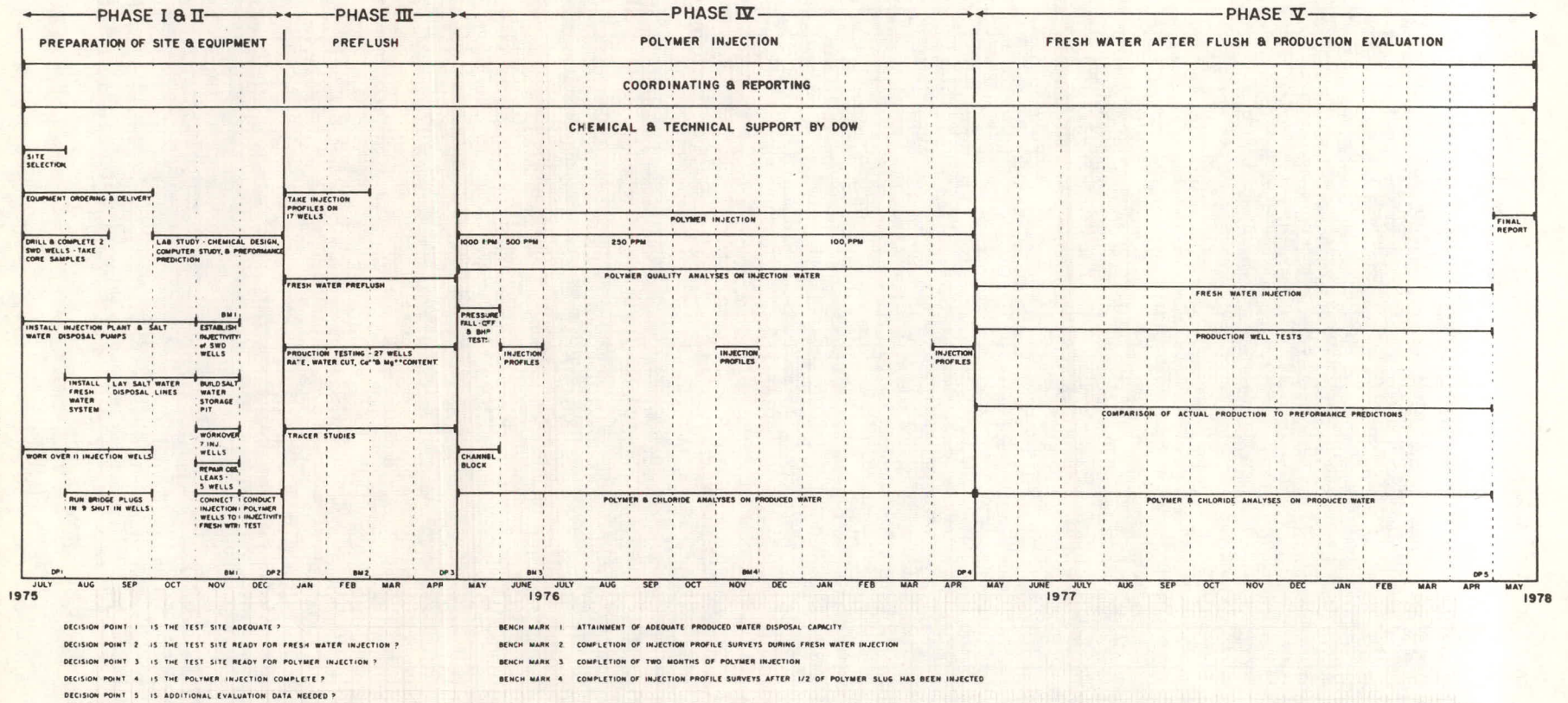


Fig. 6 Program Plan, Kewanee Oil Company, Polymer Injection Project Controlled Water Flooding

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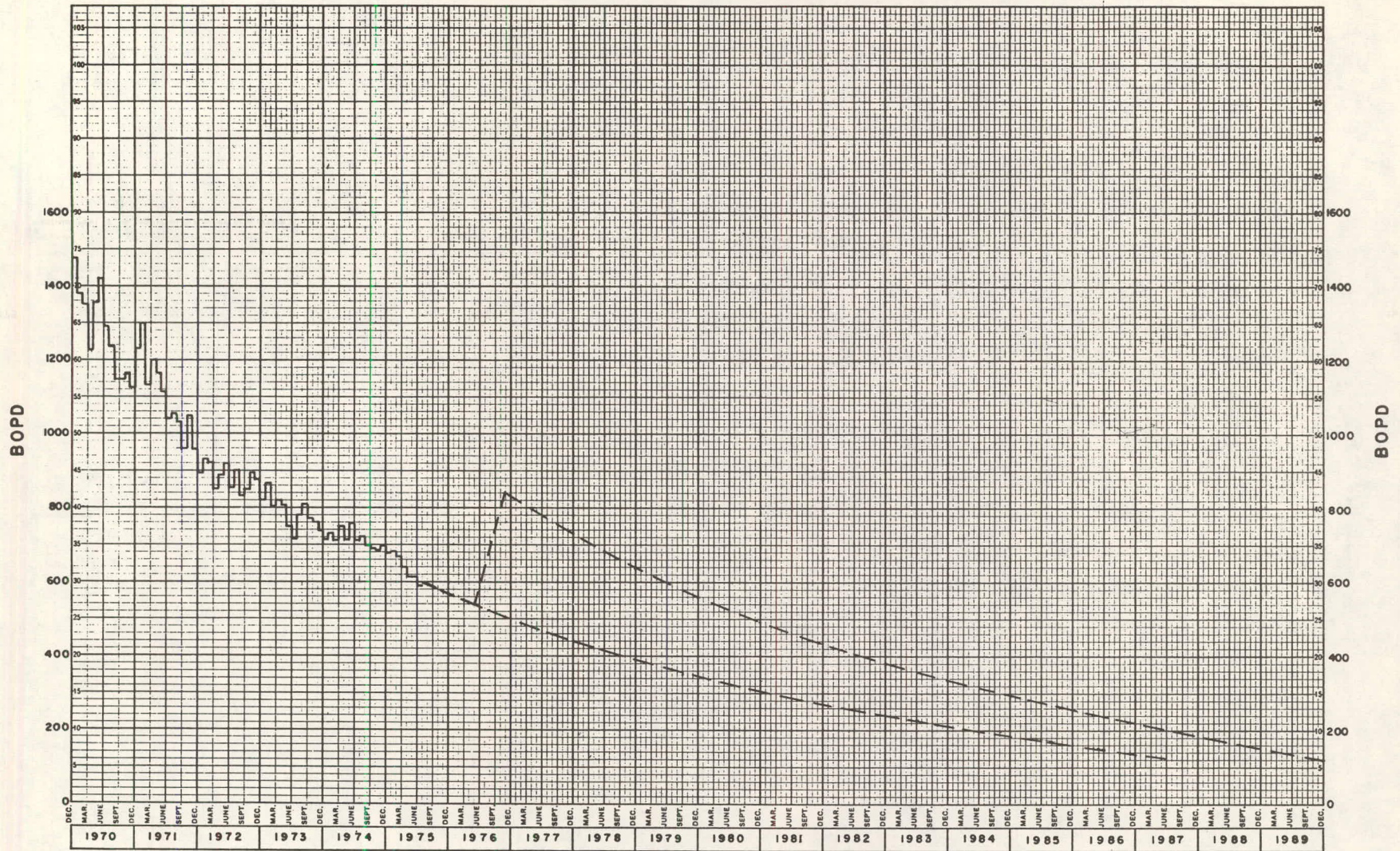


Fig. 7 Anticipated Project Response