PERFORMANCE PREDICTION OF WATER DRIVE GAS RESERVOIR

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By

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CERTIFICATE

This is to certify that the Project Report on **"Performance Prediction of Water Drive Gas Reservoir Using Eclipse Simulator"** submitted to University of Petroleum & Energy Studies, Dehradun, by **MUKUL PANDEY** in partial fulfillment of the requirement for the award of Degree of **Bachelor of Technology** in **Applied Petroleum Engineering** (Academic Session 2003 – 07) is a bonafide work carried out by him under my supervision and guidance. This work has not been submitted anywhere else for any other degree or diploma.

Date: 09.05.07

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ABSTRACT

Water influx and well completions affect recovery from water-drive gas reservoir. Material balance, aquifer models and well inflow equations are used to examine and predict the pressure depletion, water influx, and production rates of water-drive gas reservoirs. A simple rectangular reservoir model of gas reservoir is assumed. Reservoir is modeled in 20*20*1 rectangular block centered grid blocks. It is assumed reservoir is producing under active water drive with aquifer encroaching from two sides.

Eclipse 100 is used to model the performance of the reservoir considering dominant parameters only, performance prediction is done for 26 years taking time step of 1 year.In contrast to earlier investigations, this study indicates that water-drive gas recovery is often higher for higher permeability water-drive gas reservoirs.

Simulated results and report is attached in chapter 5 and it is found that due to active water drive reservoir is depleting at a slow rate. Material balance and related models are discussed in Chapter 3, water-drive gas material balance include aquifer models. The aquifer water influx can be estimated using the Schilthuis steady-state method; Hurst modified steady-state method, and various unsteady-state methods such as those of van Everdingen and Hurst (1949), Hurst (1958), and Carter and Tracy (1960). The unsteady state influx theory of Hurst and van Everdingen is the most rigorous method for radial and linear aquifers. Unfortunately, this method requires awkward, time-consuming superposition calculations. This drawback is exacerbated by the repetition in most influx calculations when history matching. Because of this, engineers have sought a more direct method of water influx calculation that duplicates results obtained with the Hurst and van Everdingen method without requiring superposition (Dake, 1978). The most successful of the methods was proposed by Fetkovitch (1971). Chapter 3 details the Fetkovitch method. The aquifer productivity index in the Fetkovitch approach is one important parameter used to predict the water influx. It is determined by the reservoir properties, reservoir geometry, and fluid properties. The simple mechanistic model for the relationship between aquifer productivity index and those factors is available (Dake, 1978). But for specific cases, when there exists a dip or the reservoir is in special shape or more complex, how these factors interact in the model make it difficult to use those simple models.

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1. INTRODUCTION

Prediction of gas production is an important part of reservoir development and management, pipeline and distribution management, and economic evaluation. The production of gas reservoirs that have no associated aquifers is relatively simple to predict and recovery efficiency is usually high. However, gas recovery from water-drive reservoirs may decrease because water influx may trap gas. The gas is trapped as an immobile, immiscible phase within the portion of the reservoir invaded by water.

At higher abandonment pressure, the amount of trapped gas within the water-invaded pore space is higher. Efforts to predict water-drive gas reservoir performance have focused on material balances. Material balances are a fundamental reservoir engineering tool that describe and predict the relation between fluid withdrawal, expansion, influx and pressure. Material balances provide a simple but effective alternative to volumetric methods based on isopach maps. Material balances can predict original gas in place and gas reserves at any stage of reservoir depletion . For a constant-volume (or volumetric) gas reservoir without water influx, the p/z versus cumulative gas production plot can predict the gas reservoir behavior. If the rock and water compressibility are small, the p/z versus cumulative gas production plot is a straight line. For a water-drive gas reservoir, the aquifer affects the reservoir behavior. The p/z vs. G_p plots for these water-drive gas reservoirs are no longer straight lines .The deviation from a straight line is determined by the aquifer properties, size and the production means.

2.WATER INFLUX

Nearly all hydrocarbon reservoirs are surrounded by water-bearing rocks called aquifers. These aquifers may be substantially larger than the oil or gas reservoirs they adjoin as to appear infinite in size, or they may be so small in size as to be negligible in their effect on reservoir performance. As reservoir fluids are produced and reservoir pressure declines, a pressure differential develops from the surrounding aquifer into the reservoir. Following the basic law of fluid flow in porous media, the aquiferreacts by encroaching across the original hydrocarbon-water contact. In some cases, water encroachment occurs due to hydrodynamic conditions and recharge of the formation by surface waters at an outcrop. In many cases, the pore volume of the aquifer is not significantly larger than the pore volume of the reservoir itself. Thus, the expansion of thewater in the aquifer is negligible relative to the overall energy system,and the reservoir behaves volumetrically. In this case, the effects of water influx can be ignored. In other cases, the aquifer permeability may be sufficiently low such that a very large pressure differential is required before an appreciable amount of water can encroach into the reservoir.In this instance, the effects of water influx can be ignored as well.

This chapter focuses on those those reservoir-aquifer systems in which the size of the aquifer is large enough and the permeability of the rock is high enough that water influx occurs as the reservoir is depleted. This chapter also provides various water influx calculation models and a detailed description of the computational steps involved in applying these models.

2.1classification of aquifers

Many gas and oil reservoirs produced by a mechanism termed water drive. Often this is called natural water drive to distinguish it from artificial water drive that involves the injection of water into the formation. Hydrocarbon production from the reservoir and the subsequent pressure drop prompt a response from the aquifer to offset the pressure decline. This response comes in a form of water influx, commonly called water encroachment, which is attributed to:

• Expansion of the water in the aquifer

• Compressibility of the aquifer rock

• Artesian flow where the water-bearing formation outcrop is located structurally higher than the pay zone

Reservoir-aquifer systems are commonly classified on the basis of:

• Degree of pressure maintenance • Flow regimes

• Outer boundary conditions • Flow geometries

Degree of Pressure Maintenance:

Based on the degree of the reservoir pressure maintenance provided by the aquifer, the natural water drive is often qualitatively described as:

• Active water drive

• Partial water drive

• Limited water drive

The term active water drive refers to the water encroachment mechanism in which the rate of water influx equals the reservoir total production rate. Active water-drive reservoirs are typically characterized by a gradual and slow reservoir pressure decline. If, during any long period the production rate and reservoir pressure remain reasonably constant, the reservoir voidage rate must be equal to the water influx rate.

$$\begin{bmatrix}\text{water influx}\\ \text{rate}\end{bmatrix}=\begin{bmatrix}\text{oil flow}\\ \text{rate}\end{bmatrix}+\begin{bmatrix}\text{free gas}\\ \text{flow rate}\end{bmatrix}+\begin{bmatrix}\text{water production}\\ \text{rate}\end{bmatrix}$$

or

$$e_w = Q_o B_o + Q_g B_g + Q_w B_w$$

where

ew = water influx rate, bbl/day

Qo = oil flow rate, STB/day

Bo = oil formation volume factor, bbl/STB

Qg = free gas flow rate, scf/day

Bg = gas formation volume factor, bbl/scf

Qw = water flow rate, STB/day

Bw = water formation volume factor, bbl/STB

Equation 10-1 can be equivalently expressed in terms of cumulative production by introducing the following derivative terms:

$$e_w = \frac{dW_e}{dt} = B_o \frac{dN_p}{dt} + (GOR - R_s)\frac{dN_p}{dt}B_g + \frac{dW_p}{dt}B_w$$

where

We = cumulative water influx, bbl

t = time, days

Np = cumulative oil production, STB

GOR = current gas-oil ratio, scf/STB

Rs = current gas solubility, scf/STB

Bg = gas formation volume factor, bbl/scf

Wp = cumulative water production, STB

dNp/dt = daily oil flow rate Qo, STB/day

dWp/dt = daily water flow rate Qw, STB/day

dWe/dt = daily water influx rate ew, bbl/day

(GOR - Rs)dNp/dt = daily free gas flow rate, scf/day

2.1.1Outer Boundary Conditions

The aquifer can be classified as infinite or finite (bounded). Geologically all formations are finite, but may act as infinite if the changes in the pressure at the oil-water contact are not "felt" at the aquifer boundary. Some aquifers outcrop and are infinite acting because of surface replenishment. In general, the outer boundary governs the behavior of the aquifer and, therefore:

a. Infinite system indicates that the effect of the pressure changes at the oil/aquifer boundary can never be felt at the outer boundary. This boundary is for all intents and purposes at a constant pressure equal to initial reservoir pressure.

b. Finite system indicates that the aquifer outer limit is affected by the influx into the oil zone and that the pressure at this outer limit changes with time.

2.1.2Flow Regimes

There are basically three flow regimes that influence the rate of water influx into the reservoir. As previously described in Chapter 6, those flow regimes are:

a. Steady-state

b. Semisteady (pseudosteady)-state

c. Unsteady-state

Flow Geometries

Reservoir-aquifer systems can be classified on the basis of flow geometry as:

a. Edge-water drive

b. Bottom-water drive

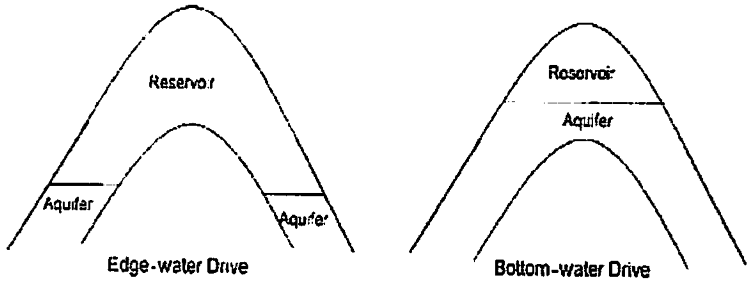
c. Linear-water drive

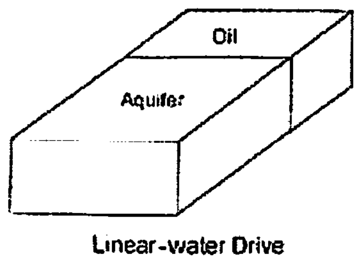
In edge-water drive, as shown in Figure water moves into the flanks of the reservoir as a result of hydrocarbon production and pressure drop at the reservoir-aquifer boundary. The flow is essentially radial with negligible flow in the vertical direction. Bottom-water drive occurs in reservoirs with large areal extent and gentle dip where the reservoir-water contact completely underlies the reservoir. The flow is essentially radial and, in contrast to the edge-water drive, the bottom-water drive has significant vertical flow. In linear-water drive, the influx is from one flank of the reservoir. The flow is strictly linear with a constant cross-sectional area.

2.2 Recognition of natural water influx

Normally very little information is obtained during the exploration-development period of a reservoir concerning the presence or characteristics of an aquifer that could provide a source of water influx during the depletion period. Natural water drive may be assumed by analogy with nearby producing reservoirs, but early reservoir performance trends can provide clues.

A comparatively low, and decreasing, rate of reservoir pressure decline with increasing cumulative withdrawals is indicative of fluid influx.





Successive calculations of barrels withdrawn per psi change in reservoir pressure can supplement performance graphs. If the reservoir limits have not been delineated by developed dry holes, however, the influx could be from an undeveloped area of the reservoir not accounted for in averaging reservoir pressure. If the reservoir pressure is below the oil saturation pressure, a low rate of increase in produced gas-oil ratio is also
indicative of fluid influx. Early water production from edge wells is indicative of water encroachment. Such observations must be tempered by the possibility that the early water production is due to formation fractures; thin, high permeability streaks; or to coning in connection with a limited aquifer. The water production may be due to casing leaks.
Calculation of increasing original oil-in-place from successive reservoir pressure surveys by using the material balance assuming no water influx is also indicative of fluid influx.

2.3water influx models

It should be appreciated that in reservoir engineering there are moreuncertainties attached to this subject than to any other. This is simply because one seldom drills wells into an aquifer to gain the necessary information about the porosity, permeability, thickness and fluid properties.
Instead, these properties frequently have to be inferred from what has been observed in the reservoir. Even more uncertain, however, is the geometry and areal continuity of the aquifer itself.

Several models have been developed for estimating water influx thatare based on assumptions that describe the characteristics of the aquifer.

Due to the inherent uncertainties in the aquifer characteristics, all of thenproposed models require historical reservoir performance data to evaluate constants representing aquifer property parameters since these arerarely known from exploration-development drilling with sufficient accuracy for direct application. The material balance equation can be used to determine historical water influx provided original oil-in-place is known from pore volume estimates. This permits evaluation of the constants in the influx equations so that future water influx rate can be forecasted.

The mathematical water influx models that are commonly used in the petroleum industry include:

- Pot aquifer
- Schilthuis' steady-state
- Hurst's modified steady-state
- The Van Everdingen-Hurst unsteady-state
  - Edge-water drive
  - Bottom-water drive
- The Carter-Tracy unsteady-state
- Fetkovich's method
  - Radial aquifer
  - Linear aquifer

3. MATERIAL BALANCE

Water-drive gas recovery increases with decreasing permeability, trapped gas saturation, and increasing withdrawal rates (Agarwal et al., 1965). Gas recovery decreases with increasing aquifer size (Al-Hashim et al., 1988). Gas recovery under water drive depends on geologic uncertainties and engineering factors, which are all interrelated and complicate the analysis. These parameters determine the shape of the p/z performance curves for the reservoir. The *p/z* method (volumetric material balance) is a common procedure used in an attempt to describe and predict the behavior of a petroleum reservoir. It can be used to predict the ultimate gas recovery.

3.1 Water-drive Gas Reservoir Material Balance

If the gas reservoir has a water drive, then there will be two unknowns in the material balance equation, even though production data, pressure, temperature, and gas gravity are known. These two unknowns are initial gas in place and cumulative water influx. In order to use the material balance equation to calculate initial gas in place, some independent method

of estimating We, the cumulative water influx, must be developed. Equation including the cumulative water influx

and water production is:

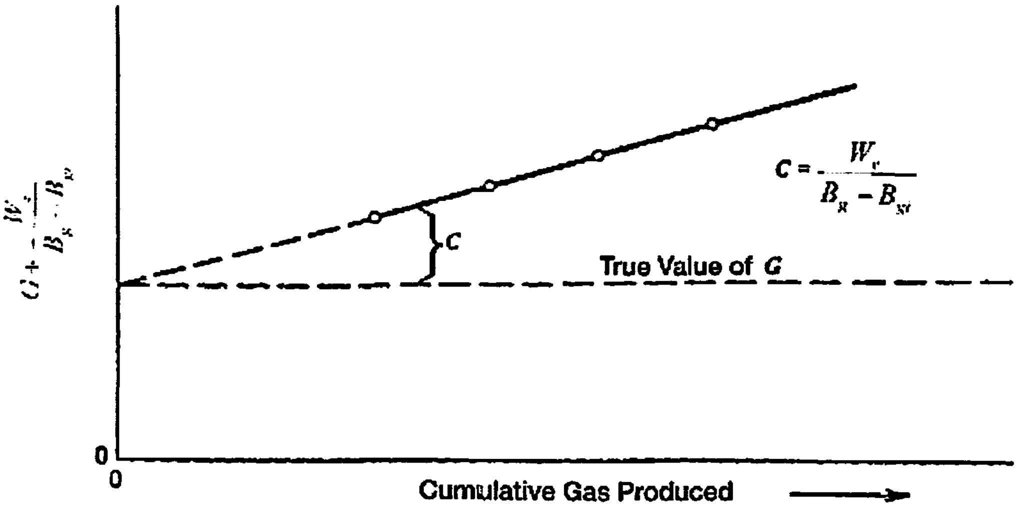
$$G = \frac{G_p B_g - (W_e - W_p B_w)}{B_g - B_{gi}}$$

The above equation can be arranged and expressed as:

$$G + \frac{W_e}{B_g - B_{gi}} = \frac{G_p B_g + W_p B_w}{B_g - B_{gi}}$$

Equation 13-16 reveals that for a volumetric reservoir, i.e., We = 0, the right-hand side of the equation will be constant regardless of the amount of gas Gp which has been produced. For a water-drive reservoir, the values of the right-hand side of Equation 13-16 will continue to increase because of the We/(Bg - Bgi) term. A plot of several of these values at successive time intervals is illustrated in Figure 13-7. Extrapolation of the line formed by these points back to the point where Gp = 0 shows the true value of G, because when Gp = 0, then We/(Bg - Bgi) is also zero. This graphical technique can be used to estimate the value of We, because at any time the difference between the horizontal line (i.e., truen value of G) and the sloping line [G + (We)/(Bg - Bgi) will give the value of We/(Bg - Bgi).

Because gas often is bypassed and trapped by the encroaching water, recovery factors for gas reservoirs with water drive can be significantly lower than for volumetric reservoirs produced by simple gas expansion. In addition, the presence of reservoir heterogeneities, such as low-permeability stringers or layering, may reduce gas recovery further. As noted previously, ultimate recoveries of 80% to 90% are common in volumetric gas reservoirs, while typical recovery factors in water-drive gas reservoirs can range from 50% to 70%.



Effect of water influx on calculating the gas initially in place.

3.2 Fetkovitch Aquifer Model

In this approach the flow of aquifer water into a hydrocarbon reservoir is modeled in precisely the same way as the pseudosteady flow of oil from a reservoir into a well. An inflow equation of the form

$$q_w = \frac{dW_e}{dt} = J_w(\bar{p}_a - p) \qquad \text{..............1}$$

is used where

J_w = aquifer productivity index

q_w = water influx rate

p = reservoir pressure, i.e. pressure at the oil or gas water contact

p_a = average pressure in the aquifer

W_e = water influx

The latter is evaluated using the simple aquifer material balance

$$W_e = \bar{c}W_i(p_i - \bar{p}_a) \qquad \text{..............................2}$$

where

W_i = initial volume of water in the aquifer and is therefore dependent upon aquifer geometry

c = total aquifer compressibility

in which p_i is the initial pressure in the aquifer and reservoir. This balance can be alternatively expressed as

$$\bar{p}_a = p_i\left(1-\frac{W_e}{\bar{c}W_i p_i}\right) = p_i\left(1-\frac{W_e}{W_{ei}}\right) \qquad \text{.........................3}$$

where $W_{ei} = cW_i p_i$ is defined as the initial amount of encroachable water and represents the maximum possible expansion of the aquifer. Differentiating equation-3 with respect to time gives

$$\frac{dW_e}{dt} = -\frac{W_{ei}}{p_i}\frac{d\bar{p}_a}{dt} \qquad \text{..................4}$$

and substituting equation -3into equation -2 and separating the variables gives

$$\frac{d\bar{p}_a}{\bar{p}_a - p} = -\frac{J_w p_i}{W_{ei}}dt \qquad \text{.........................5}$$

this equation can be integrated for the initial condition that at $t=0$, $W_e=0$, $p_a=p_i$. There is a pressure drop $\Delta p = p_i - p$ imposed at the reservoir boundary. Furthermore, the boundary pressure p remains constant during the period of interest so that

$$\ln(\bar{p}_a - p) = -\frac{J_w p_i t}{W_{ei}} + C1 \qquad \text{..........................6}$$

where C1 is an arbitrary constant of integration which can be evaluated from the initial conditions as $C1=\ln(p_i - p)$, and therefore

$$\bar{p}_a - p = (p_i - p)e^{-J_w p_i t / W_{ei}} \qquad \text{.....................7}$$

which on substituting in the inflow equation gives

$$\frac{dW_e}{dt} = J_w(p_i - p)e^{-J_w p_i t / W_{ei}} \qquad \text{.....................8}$$

Finally, integrating equation for the stated initial conditions yields the following expression for the cumulative water influx

$$W_e = \frac{W_{ei}}{p_i}(p_i - p)\left(1 - e^{-J_w p_i t / W_{ei}}\right) \qquad \text{..................9}$$

As t tends to infinity, then

$$W_e = \frac{W_{ei}}{p_i}(p_i - p) = \bar{c}W_i(p_i - p) \qquad \text{..................10}$$

which is the maximum amount of water influx that could occur once the pressure drop $p_i = p$ has been transmitted throughout the aquifer.

As it stands, the equation is not particularly useful since it was derived for a constant inner boundary pressure. To use this solution in the practical case, in which the boundary pressure is varying continuously as a function of time, it should again to apply the superposition theorem. Fetkovitch has shown, however, that a difference form of equation (10) can be used which eliminates the need for superposition.

That is, for influx during the first time step Δt_1, equation -10 can be expressed as

$$\Delta W_{e1} = \frac{W_{ei}}{p_i}(p_i - \overline{p}_1)\left(1 - e^{-J_w p_i \Delta t_1 / W_{ei}}\right) \qquad \text{.................11}$$

where p_1 is the average reservoir boundary pressure during the first time interval.

$\overline{p}_1 = \frac{p_i + p_1}{2}$ is the reservoir boundary pressure at the end of the first time interval. For the second interval Δt_2

$$\Delta W_{e2} = \frac{W_{ei}}{p_i}(\overline{p}_{a1} - \overline{p}_2)\left(1 - e^{-J_w p_i \Delta t_2 / W_{ei}}\right) \qquad \text{.................................12}$$

where p_{a1} is the average aquifer pressure at the end of the first time interval and is evaluated using equation -7 as

$$\overline{p}_{a1} = p_i\left(1 - \frac{\Delta W_{e1}}{W_{ei}}\right) \qquad \text{.....................13}$$

In general for the nth time period,

$$\Delta W_{en} = \frac{W_{ei}}{p_i}(\overline{p}_{an-1} - \overline{p}_n)\left(1 - e^{-J_w p_i \Delta t_n / W_{ei}}\right) \qquad \text{.........................14}$$

Where

$$\overline{p}_{an-1} = p_i \left(1 - \frac{\sum_{i-1}^{n-1} \Delta W_e}{W_{ei}} \right) \quad \text{.................................15}$$

The values of p_n, the average reservoir boundary pressure, are calculated as

$$\overline{p}_n = \frac{p_{n-1} + p_n}{2}$$

Fetkovitch has demonstrated that using equations (3.16) and (3.17), in stepwise fashion, the water influx calculated for a variety of different aquifer geometries matches closely the results obtained using the unsteady state influx theory of Hurst and van Everdingen (1949) for finite aquifers.

Values of the aquifer productivity index J_w depend both on the geometry and flowing conditions, and are tabulated

Type of Outer Aquifer Boundary	J for Radial flow, bbl/day/psi	J for linear Flow, bbl/day/psi	Equation #
Finite, no flow	$J = \frac{0.00708\, kh\, f}{\mu_w [\ln r_D - 0.75]}$	$J = \frac{0.003381\, kwh}{\mu_w L}$	(10-45)
Finite, constant pressure	$J = \frac{0.00708\, kh\, f}{\mu_w [\ln (r_D)]}$	$J = \frac{0.001127\, k\, wh}{\mu_w L}$	(10-46)
Infinite	$J = \frac{0.00708\, kh\, f}{\mu_w \ln (a/r_e)}$ $a = \sqrt{0.0142\, kt / (f \mu_w c_t)}$	$J = \frac{0.001\, k\, wh}{\mu_w \sqrt{0.0633\, kt / (f \mu_w c_t)}}$	(10-47)

Material balance Equation and water influx Equation can be jointly used to predict the reservoir performance. However all these depend on the depletion performance of the well.

3.3 Effect of Gas Production Rate on Ultimate Recovery

Volumetric gas reservoirs are essentially depleted by expansion and, therefore, the ultimate gas recovery is independent of the field production rate. The gas saturation in this type of reservoir is never reduced; only the number of pounds of gas occupying the pore spaces is reduced. Therefore, it is important to reduce the abandonment pressure to the lowest possible level. In closed-gas reservoirs, it is not uncommon to recover as much as 90 percent of the initial gas in place.Cole (1969) points out that for water-drive gas reservoirs, recovery may be rate dependent. There are two possible influences which producing rate may have on ultimate recovery. First, in an active water-drive reservoir, the abandonment pressure may be quite high, sometimes only a few psi below initial pressure. In such a case, the number of pounds of gas remaining in the pore spaces at abandonment will be relatively great. The encroaching water, however, reduces the initial gas saturation. Therefore, the high abandonment pressure is somewhat offset by the reduction in initial gas saturation. If the reservoir can be produced at a rate greater than the rate of water influx rate, without water coning, then a high producing rate could result in maximum recovery by taking advantage of a combination of reduced abandonment pressure and reduction in initial gas saturation. Second, the water coning problems may be very severe in gas reservoirs, in which case it will be necessary to restrict withdrawal rates to reduce the magnitude of this problem. Cole suggests that the recovery from water-drive gas reservoirs is substantially less than recovery from closed-gas reservoirs.

As a rule of thumb, recovery from a water-drive reservoir will be approximately 50 to 80 percent of the initial gas in place. The structural location of producingwells and the degree of water coning are important considerations in determining ultimate recovery. A set of circumstances could exist—such as the location of wells very high on the structure with very little coning tendencies—where waterdrive recovery would be greater than depletion-drive recovery. Abandonment pressure is a major factor in determining recovery efficiency, and permeability is usually the most important factor in determining the magnitude of the abandonment pressure. Reservoirs with low permeability will have higher abandonment pressures than reservoirs with high permeability. A certain minimum flow rate must be sustained, and a higher permeability will permit this minimum flow rate at a lower pressure.

4. ESSENTIALS OF RESERVOIR SIMULATION

Reservoir simulation involves solving partial differential equations that describe fluid flow in porous media with a numerical method, such as the finite difference method. The partial differential equations are discretized in time and space. A linear equation solver is used to solve all the equations generated in the discretization process.

The general reservoir simulation process involves the following steps:

- Characterization of reservoir
- Simulation
- Simulation validation
- Efficient Reservoir management

4.1 Characterization of reservoir

- Field mapping
  - Areal and vertical extent of producing formation
  - Isopach maps of gross and net sand
  - Correlation of layers of and other zones
- Reservoir rock characterization and petrophysical analysis
  - Areal variations of average permeability, including directional trends derived from the geological interpretations
  - Areal variation of the porosity
  - Reservoir heterogeneity, particularly the variation of permeability with thickness and zone
- Fluid characterization
  - Relative permeability data for the reservoir rock. Reservoir fluid properties (PVT data) included fluid viscosities, densities, formation volume factors, gas solubilities, etc. These data are usually obtained by laboratory tests.
- Volumetric analysis and production data analysis

  Included in the field performance history are the production and injection histories, time dependent pressure distributions, and well indexes. The production and injection histories include WOR, GOR, gas and water production and injection data; and fluid break through times the simulator calculates production.

- Identification of producing mechanisms, such as fluid expansion, solution gas or water drive.
- Existence of gas caps or aquifers
- Estimation of oil remaining to be produced under primary operations
- Pressure distribution in the reservoir
- Trapped gas saturation from solution gas drive
- Vertical variation of saturation as a result of gravity segregation
- Presence of mobile connate water
- Areas already flooded by natural water drive

4.2 Reservoir simulation

Input file construction

A necessary phase of every simulation study is the gathering of data to be used in the simulator. Values for the physical quantities must be specified before a simulation can begin. The particular data needed will depend on the nature and complexity of the study.

The required data can be classified into three groups: reservoir rock properties, fluid properties and field performance. Each data will fit into three different sections, the input file also contains the run control parameters including the no. of time steps, maximum number of iteratons.

History Matching

The objective of the history match is to reproduce with the simulator the actual reservoir performance. This is achieved by manipulating two fundamental processes that are controlled during history matching; the quantity and distribution of fluid within the system; and the movement of fluid within the system. These processes are manipulated by adjusting input data within reasonable limits of conditional existing in the field until a minimal difference remains between the historical data and the simulator caaulations at the same point in time.

Thus history matching is the process of determining the value of poorly known or unknown parameters, which are needed as input to the mathematical reservoir model. Much, if not most of the physically measurable information used in the simulatotr is based on the incomplete or inaccurate field measurements.

Prediction runs

After a satisfactory history match of field performance is obtained with the simulator, prediction runs can be made. A number of alternative field operations or developments can be evaluated and compared in a short period of time to optimize future reservoir management planning for the field. Because there is no field history to use for comparison with the simulation results for a prediction run, it is even more important that critical engineering judgment and experience be applied to the results using the test of reasonableness.

Less accuracy in the simulation predictions should be expected when the prediction runs are simulating operations under a different flow system than that of the history matching process. A common example of this is the history matching primary production performance (dominantly a gas/oil flow system) and then making predictions of performance under water flood operation (dominantly water/oil flow system). The reason for this is that some uncertain reservoir parameters may have little effect on performance under flow in a gas/oil system but may be of critical importance in a water/oil system.

4.3 Simulation validation

Perhaps the most pervasive source of error in the history matching process is the lack of reliable data. There are many reasons why reported field data may be unreliable. Furthermore, the amount of data is usually limited. Thus, the history match may characterize the reported data, but the reported data may not characterize the reservoir.

Another source of error arises when the derivatives in the mathematical formulation of the model are replaced by finite differences. This error is the truncation error called numerical dispersion. It can cause a correct set of parameters to yield incorrect results such as predicting the premature water breakthrough. The non uniqueness of parameters sets the inaccuracy or incompleteness of field data,

and presence of truncation errors are the most typical errors encountered during the history match process. The engineer should be aware of that these problems exist and can cause inexact performance projections. Because of the uniqueness problems, results from any reservoir simulation should be judged critically as to their reasonableness in the light of their experience with the type of the reservoir, the area, and the production system being used in the field.
Accurate simulation results are dependent on having high quality data on a large number of reservoir parameters. Much of this data may be of questionable accuracy or even missing for any given study. Also it is generally not possible to predict a priori which parameters will control model performance.

One technique that is frequently used to help guide the data gathering effort and to allocate the data collection time to the critical parameters is to use the simulation model to do sensitivity analysis on selected parameters. By varying each of several selected parameters over a reasonable range of uncertainty and observing the effect on simulator performance, the critical parameters controlling performance can be identified. Further efforts to gather better data should be concentrated on these critical parameters.
Some estimate of oil in place, either by volumetric or material balance calculations, should be made before beginning any field-wide simulation study. This independent oil in place calculation provides a check on the simulator input data and reservoir description.
Also in a larger study the material balance calculation will provide a check on the consistency of the pressure, production and fluid PVT data. If these data cannot give a reasonably consistent material balance calculation then proceeding to an inexpensive simulation study probably is not justified until the inconsistency in the data is corrected or additional data are obtained.

4.3 Efficient reservoir management

Reservoir management includes data management, integrated reservoir management model, production rates and recovery forecasts, and economic considerations. Reservoir management plans for newly discovered fields, and plans for primary and tertiary management program.

5. CASE MODELLING AND PREDICTION RUNS

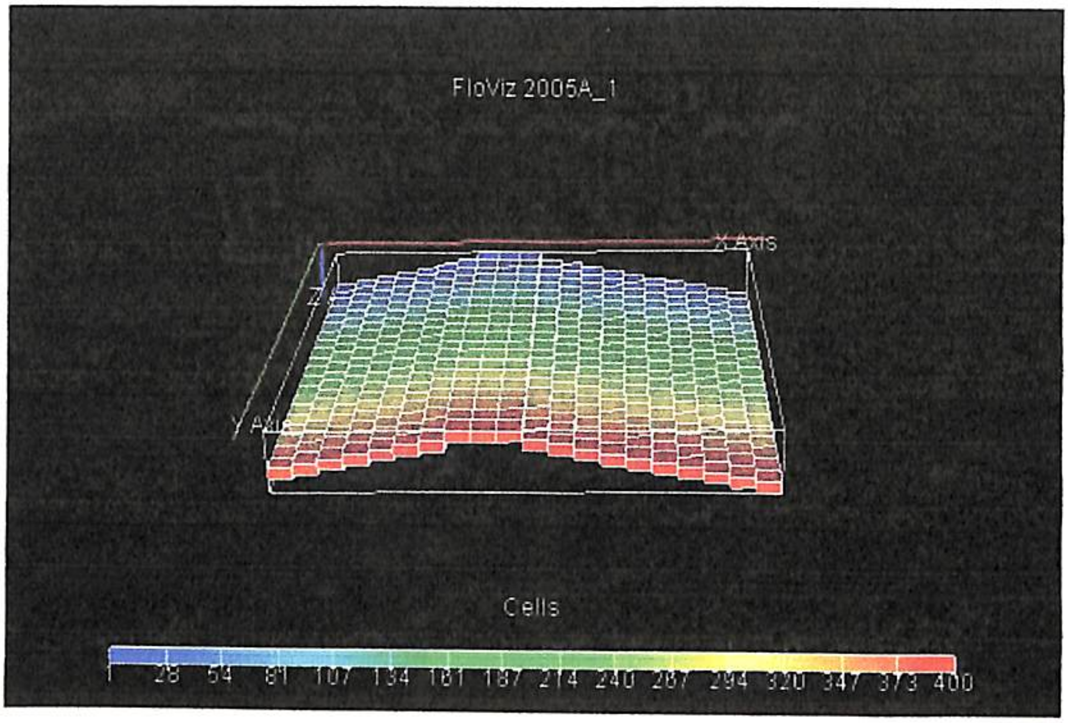
The reservoir to be studied is under development stage. Reservoir under study is under active water drive and it is planned to simulate the performance assuming aquifer to be fetkovich type of the reservoir using eclipse simulator.

As described earlier, the ultimate goal of a reservoir simulator is to determine the optimum production scheme of an oil and gas field. The reservoir simulation phase of this study was carried out with the use of Eclipse 100 – black oil option. The water drive optimization procedure developed in this research was tested on various 2-D Cartesian reservoir models consisting of 20 x 20 x 1 grid lattice. In this study, a reservoir with two-flow boundaries was considered(located on the grid sketch). The phases present in the reservoir were gas and water. The model represents 9182.7346-acre field (approximately 20000 ft x 20000 ft) with 4 vertical producer well. The wells are drilled with a 40-acre spacing and are all brought to operation at the same time. The depth of the top surface of the reservoir is 7420 ft with a net pay thickness of 100 ft.

5.1 Grid

The basic geometry of the simulation grid and various rock properties (porosity, absolute permeability, etc) in each grid cell are specified in the grid section. From these properties, the pore volumes of the grid blocks and the inter-block transmissibilities are calculated by the simulator. The keywords used in this section usually depend on the geometry option selected in the initialization section. In this case, we used the Cartesian, block-centered geometry option. The porosity distribution in the reservoir is varying in the range(.08-.16) & the permeability is heterogeneous with an average value of 250md for the case.

The original fluids in place in the reservoir consist of water at a pore volume saturation of 20% and gas contained in 80% of the pore volume. The connate water saturation is 0.25 .The initial reservoir pressure is 3000 psi.

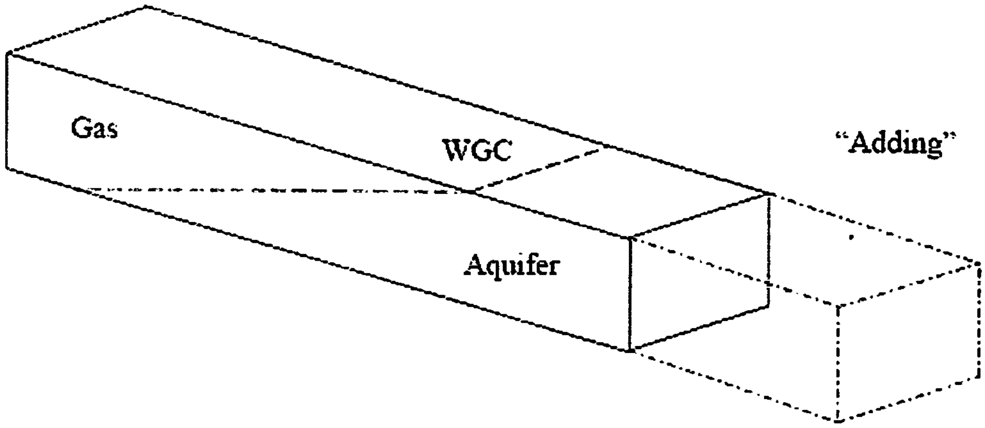


5.2 Reservoir Geometry and Properties

In this study, a simple rectangular reservoir model with simple dip is used. The reservoir length, width and thickness is fixed in fts(20000,20000,100) for the simulation designs. In this study, the gas was assumed to occupy whole reservoir volume.

Aquifer is encroaching the reservoir via two sides along x axis& y axix(as shown in grid block sketch).

sketch of the simple gas-water system is illustrated in Figure 4.1.



Sketch of the Simple Rectangular Reservoir Model

The center elevation of the gas zone was set at7030 feet. The ground surface temperature was set to 60°F and the temperature gradient was set to 1.2°F per 10 feet. The reservoir temperature is 120°F.

The gas-water two-phase relative permeabilities have been used. Capillary pressure was ignored in this study. This study considered four producing well.

The reservoir fluids are gas and water.. At a reference pressure of 1025, the gas has a viscosity of 0.0153cp. The gas formation volume factor (Bg) is 3.317898486. At surface conditions, the gas is assumed to have a density of 0.07020lb/cuft while the density of water is assumed to be 62.30lb/cuft. Water compressibility is set at 3.03 x 10-6 psi-1, water formation volume factor (Bw) of 1.06 rb/stb and viscosity of 0.70 cp at a reference pressure of 1025psi. The bulk compressibility of the rock was set at 5 x 10-6 psi-1.The gas reserve for the reservoir is 4448.4 MSTB. Reservoir is a homogeneous one and the reservoir pressure is 4377.4 psi.

Summary of reservoir properties

Number of grid blocks	20 x20 x1
Grid block size	1000ft x 1000ft x 100ft
Gas production rate	600 STB/D
Reservoir thickness	100 ft

Porosity(avg)	14%
Actual reservoir area	9182.7346acres
Initial gas Saturation	80%
Initial Water Saturation	0.2
Well Depth	7340ft
Initial reservoir pressure	3000psi
Ave. Reservoir Temperature	284F
Production period	28 years
Time step	1 year

5.3 Methodology involved

The gas production rate is kept constant at 550,350,400,200 MMSCMD respectively for wells P1,P2,P3,P4 STB/D.The performance is predicted at this rate for a water drive gas reservoir as in the figure above.

5.4 Input data file preparation.

An ECLIPSE data input file is split into sections, each of which is introduced by a keyword. A list of all section-header keywords used in the simulation is given below, together with a brief description of the contents of each section.

5.4.1Data file sections

It is recommended that the body of sections that are not frequently changed be held in separate files, which are included in the data using the INCLUDE keyword.

RUNSPEC -Title, problem dimensions, switches, phases present, components etc.

GRID -Specification of geometry of computational grid (location of grid block corners), and of rock properties (porosity, absolute permeability, etc.) in each grid block.

EDIT- Modifications to calculated pore volumes, grid block centre depths and transmissibility's.

PROPS -Tables of properties of reservoir rock and fluids as functions of fluid pressures, saturations and compositions (density, viscosity, relative permeability, capillary pressure, etc.). Contains the equation of state description in compositional runs.

REGIONS- Splits computational grid into regions for calculation of

- PVT properties (Fluid densities and viscosities)
- Saturation properties (Relative permeability's and capillary
Pressures)
- Initial conditions (Equilibrium pressures and saturations)
- Fluids in place (Fluid in place and inter-region flows)
- EOS regions (For compositional runs)

SOLUTION -Specification of initial conditions in reservoir - may be:

- Calculated using specified fluid contact depths to give potential equilibrium
- Read from a restart file set up by an earlier run
- Specified by the user for every grid block

SUMMARY- Specification of data to be written to the Summary file after each time step. Necessary if certain types of graphical output (for example watercut as a function of time) are to be generated after the run has finished. If this section is omitted no Summary files are created.

SCHEDULE- Specifies the operations to be simulated (production and injection controls and constraints) and the times at which output reports are required. Vertical flow performance curves and simulator tuning parameters may also be specified in the SCHEDULE section.

OPTIMIZE- Specifies a reservoir optimization problem (objective function, control parameters, constraints.

RUNSPEC section overview

The RUNSPEC section is the first section of an ECLIPSE data input file. It contains the run title, start date, units, various problem dimensions (numbers of blocks, wells, tables etc.), flags for phases or components present and option switches. It may be preceded only by comments, global keywords.

The RUNSPEC section consists of a series of keywords, which turn on the various modelling options, or contain data (for example problem dimensions). For keywords that have associated data, the data record must be terminated by a slash (/). If a data record is terminated early with a slash, the remaining data items are set to their default values. Similarly, if a keyword is omitted all its associated data items are set to their default values. For most runs, the majority of the data items can be defaulted to give:

- A Cartesian geometry, dispersed flow model.
- One set of PVT, Saturation, and Equilibration tables.
- One reporting region.
- Unformatted non-unified restart and graphics files.

Oil and gas are included automatically, but the WATER keyword should be entered if there is a water phase. The GASWAT keyword requests water and gas phases only, using an equation of state to define the equilibrium between these phases.

TITLE Title

DIMENS Number of blocks in X,Y,Z directions

OIL, WATER, GAS, VAPOIL, DISGAS

The active phases present, that is which of the saturations (Rs or Rv) vary

FIELD / METRIC / LAB

Unit convention

START Start date of the simulation.

WELLDIMS Well and group dimensions

GRID section overview

The GRID section determines the basic geometry of the simulation grid and various rock properties (porosity, absolute permeability, net-to-gross ratios) in each grid cell. From this information, the program calculates the grid block pore volumes, mid-point depths and inter-block transmissibilities. The actual keywords used depend upon the use of the radial or cartesian geometry options.

Specifying the basic grid dimensions

The reservoir geometry may be set using keywords CART or RADIAL in the RUNSPEC section to either

- Cartesian (X,Y,Z)
- Radial (R, Theta, Z)

and may be specified in either of two ways:

• Block Centered Geometry

Where the blocks are horizontal and all eight corners are right angles. Each block is defined by the dimensions of its three sides and the depth of the top surface.

• Corner Point Geometry

Where the locations of all the eight corners are provided independently and there is no requirement that all the angles of the block are right angles.

The program recognizes that the keywords COORD and ZCORN specify Corner Point Geometry. Any other specification of the grid block sizes results in Block Centered Geometry.

All depths and thicknesses are measured along the Z axis, which is taken to be vertical, with larger values indicating greater depths.

The origin in cartesian geometry is the top left back corner. Coordinates on the X axis are taken to increase from left to right, and on the Y axis from back to front.

In radial geometry, the origin is the center of the model, where usually a well is located

The inner radius of the reservoir must be provided. Refer to keywords INRAD and RADFIN for more information. R increases towards the right for Theta = 0; Theta increases in the clockwise direction.

The input is such that data specified using GRID and EDIT section keywords is entered always in natural order, the I-index changing most quickly, then the J-index, and the K-index most slowly. This enables the data to be read from the top left corner of a page along a line (I), then next line (J), then turn the page for the next layer (K).

Data may be set to constant values using the EQUALS keyword, and manipulated with keywords ADD, MULTIPLY, COPY, MINVALUE and MAXVALUE.

EDIT section overview

The EDIT section contains instructions for modifying the pore volumes, block center depths, transmissibilities, diffusivities (for the Molecular Diffusion option), and non neighbor connections (NNCs) computed by the program from the data entered in the

GRID section.

It is entirely optional.

The GRID output array keywords may be used in the EDIT section to overwrite data either for the entire reservoir, or for a set of the grid blocks defined using the BOX keyword.

Alternatively, the multiplier keywords and the operational keywords may be used to modify the arrays exactly as in the GRID section.

In addition, the MULTFLT keyword may be used to modify the transmissibility across faults entered using the keyword FAULTS in the GRID section.

Changing cell depths

The cell center depths obtained in the GRID section calculations are used to obtain hydrostatic pressure differences between cells during the simulation. These may be changed by using the DEPTH keyword to set depths for all the cells, or ADD, COPY, EQUALS and MULTIPLY to alter boxes of values. Note that changing the depths does not alter the plotted grid.

DEPTH PORV TRANX TRANR DIFFX DIFFR

PROPS section overview

The PROPS section of the input data contains pressure and saturation dependent properties of the reservoir fluids and rocks.

Data input

The data is input in multi-tabular keywords, with only one entry of any keyword being accepted. The number of tables of each type is specified in the RUNSPEC section of data.

The correct number of tables must be supplied. The RUNSPEC section also specifies the maximum size of each table. When multiple tables are entered after a keyword, each table is terminated by a slash (/),

The keywords required are determined by whether an ECLIPSE 100 or ECLIPSE 300 Black Oil or an ECLIPSE 300 Compositional Model is used.

The data must always contain the rock compressibility, and relative permeabilities and capillary pressures as a function of saturation for the phases present.

In a black oil run (ECLIPSE 100 or ECLIPSE 300), the PVT keywords required are determined by the phases selected in the RUNSPEC section (keywords OIL, WATER, GAS, DISGAS, VAPOIL) and any special options selected (keywords API, BRINE, COAL, DIFFUSE, ENDSCALE, FOAM ETC).

REGIONS section overview

The REGIONS section divides the computational grid into regions for:

If there is no REGIONS section, ECLIPSE puts all grid blocks into a single region for all the above operations.

SOLUTION section overview

The SOLUTION section contains sufficient data to define the initial state (pressure, saturations, compositions) of every grid block in the reservoir.

The keywords in the SOLUTION section may be specified in any order. All keywords must start in column.

This data may take any one of the following forms:

Equilibration:

Initial pressures and saturations are computed by ECLIPSE using data entered with the EQUIL keyword (fluid contact depths etc.).

Restart:

The initial solution may be read from a Restart file created by an earlier run of ECLIPSE. The name of the Restart file is entered using the RESTART keyword.

Equilibration - the EQUIL keyword

The EQUIL data specifies the initial pressure at a reference depth, the initial water-oil and gas-oil contact depths and the capillary pressures at these depths, and the equilibration options. For example:

This specifies:

- The pressure at datum depth of 9035 is 3600.
- Water oil contact ( ) is at 9209 ft.
- Gas-oil contact ( ) is at 9035 ft.
- 20 sub-intervals used in each cell for initial averaging.

SCHEDULE section overview

The SCHEDULE section specifies the operations to be simulated (production and injection controls and constraints) and the times at which output reports are required. Vertical flow performance curves and simulator tuning parameters may also be specified in the SCHEDULE section.

All keywords in this section are optional, except for those necessary to define the status of the wells, and the END keyword, which should mark the end of the scheduling data.

To define a well and its connection properties and controls, the following keywords should be used:

1 WELSPECS or WELSPECL (to introduce the well)

2 COMPDAT or COMPDATL (to specify its completion data) 3 either

WCONPROD (production controls, if the well is a producer) or

WCONINJE (injection controls, if the well is an injector) or

WCONHIST (measured flows and pressures, if it is a history matching producer) or

WCONINJH (measured flow and pressures, if it is a history matching injector) or

WCONINJP (control of a pattern flood injector)

Any other keywords that refer to a particular well must be positioned after the well and its connections have been defined.

Wells can be introduced at any time in the simulation, but once a well has been introduced using the keyword WELSPECS or WELSPECL its connection properties and operating status must be defined as shown above. Data concerning the well can be changed later in the simulation by repeating the appropriate keyword(s).

A new group is automatically introduced immediately its name appears in either keyword WELSPECS or GRUPTREE. Any other keywords that refer to a particular group must be positioned after the group has been introduced.

Well and group names, and other character strings in the scheduling data, may be enclosed in quotes (' '), but generally this is not essential. Such quotes are only usually required if a name contains embedded blanks, starts with a number or contains nonalphanumeric characters. Quotes are also required for name roots and well list names

In most of the well scheduling keywords a well name root, ending with an asterisk (*), can be used to refer to several wells in one record.

5.5 Input data file

```
--water drive gas reservoir
--areal extent 9182.7346-acre

RUNSPEC

--TITLE
MISSION-007

DIMENS
20 20     1     /

GAS

WATER

FIELD

EQLDIMS
1* 100    /

WELLDIMS
4 1 4     /

AQUDIMS
0 0 0 0 1 80 /

START
1 'JAN' 2007 /

UNIFOUT

--
```

```
GRID


BOX
1  20    1     20    1     1     /

DXV
20*1000 /

DYV
20*1000 /

DZ
100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100
100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100
100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100
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/

PORO

0.16 0.14 0.12 0.1 0.08 0.09 0.1 0.11 0.12 0.13 0.16 0.14 0.12 0.1 0.08 0.09 0.1 0.11 0.12 0.13
0.16 0.14 0.12 0.1 0.09 0.09 0.1 0.11 0.12 0.13 0.16 0.14 0.12 0.1 0.09 0.09 0.1 0.11 0.12 0.13
0.15 0.14 0.12 0.1 0.10 0.09 0.1 0.11 0.12 0.13 0.15 0.14 0.12 0.1 0.10 0.09 0.1 0.11 0.12 0.13
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0.16 0.14 0.12 0.1 0.08 0.09 0.1 0.11 0.12 0.13 0.16 0.14 0.12 0.1 0.08 0.09 0.1 0.11 0.12 0.13
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0.15 0.14 0.12 0.1 0.10 0.09 0.1 0.11 0.12 0.13 0.15 0.14 0.12 0.1 0.10 0.09 0.1 0.11 0.12 0.13
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0.14 0.14 0.12 0.1 0.08 0.09 0.1 0.11 0.12 0.13 0.14 0.14 0.12 0.1 0.08 0.09 0.1 0.11 0.12 0.13
0.16 0.14 0.12 0.1 0.08 0.09 0.1 0.11 0.12 0.13 0.16 0.14 0.12 0.1 0.08 0.09 0.1 0.11 0.12 0.13
0.16 0.14 0.12 0.1 0.09 0.09 0.1 0.11 0.12 0.13 0.16 0.14 0.12 0.1 0.09 0.09 0.1 0.11 0.12 0.13
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/

PERMX

250 250 8*360 3*340 4*3160 2*280 246
240 250 8*360 3*350 4*334 2*268 247
330 250 8*365 3*340 4*332 2*275 249
210 250 8*370 3*355 4*360 2*277 257
210 220 8*375 3*340 4*332 2*264 252
200 250 8*375 3*334 4*335 2*258 256
290 250 8*360 3*347 4*3144 2*274 233
280 250 8*360 3*354 4*354 2*286 233

```
260 250 8*375 3*370 4*360 2*269 262
250 250 8*375 3*330 4*350 2*280 246
250 250 8*360 3*340 4*360 2*280 246
240 250 8*360 3*350 4*334 2*268 247
230 250 8*365 3*340 4*342 2*275 249
220 250 8*370 3*355 4*360 2*277 257
210 250 8*375 3*340 4*332 2*264 252
200 250 8*375 3*334 4*335 2*258 256
290 250 8*360 3*347 4*344 2*274 233
220 250 8*360 3*354 4*354 2*286 233
260 250 8*375 3*370 4*360 2*269 262
350 250 8*375 3*330 4*350 2*280 246
/
PERMY
250 250 8*260 3*240 4*360 2*280 346
340 350 8*260 3*350 4*234 2*268 247
330 250 8*265 3*240 4*342 2*375 349
320 250 8*270 3*255 4*260 2*277 257
310 250 8*275 3*240 4*232 2*364 232
300 250 8*275 3*234 4*235 2*258 256
290  250 8*260 3*247 4*244 2*374 333
280  250 8*260 3*254 4*254 2*286 333
360  250 8*275 3*270 4*260 2*369 262
250  250 8*275 3*230 4*250 2*280 246
350 250 8*360 3*240 4*360 2*380 246
240 250 8*260 3*250 4*334 2*268 247
340 250 8*365 3*240 4*342 2*375 249
312 250 8*270 3*255 4*260 2*277 257
210 250 8*375 3*240 4*3132 2*364 252
300 250 8*275 3*234 4*235 2*258 256
290  250 8*260 3*247 4*344 2*374 233
380  250 8*260 3*254 4*254 2*286 233
260  350 8*375 3*270 4*360 2*369 262
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250  250 8*275 3*230 4*350 2*280 246
/
PERMZ

400*100 /
ENDBOX
/
TOPS
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
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7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
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7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
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7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420
7300 7260 7220 7180 7140 7100 7060 6980 6980 6980 7060 7100 7140 7180 7220 7260 7300 7340 7380 7420

INIT

--*******************************************
EDIT

--*******************************************
PROPS
```

SGWFN

-- Sg	krg	krw	Pcwg
0.00	0.000000	0.900000	0
0.05	0.004389	0.724054	0
0.10	0.016608	0.570544	0
0.15	0.036175	0.438425	0
0.20	0.062847	0.326599	0
0.25	0.096462	0.233902	0
0.30	0.136893	0.159099	0
0.35	0.184043	0.100859	0
0.40	0.237829	0.057735	0
0.45	0.298179	0.028125	0
0.50	0.365033	0.010206	0
0.55	0.438335	0.001804	0
0.60	0.518036	0.000000	0
0.65	0.604092	0.000000	0
0.70	0.696463	0.000000	0
0.75	0.795110	0.000000	0
0.80	0.900000	0.000000	0

/

-- Specifies PVT properties of gas: Pressure, Bg and gasvisc

PVDG

-- Pressure	Bg (RB/MSCF)	Gas visc, cP
178	18.69991095	0.0118
288	11.72751558	0.0119
525	6.747996438	0.0137
750	4.464826358	0.0145
1025	3.317898486	0.0153
1250	2.632235085	0.0158
1500	2.181656278	0.0168
1750	1.857524488	0.0176

```
2000        1.620658949     0.0184
2250        1.442564559     0.0193
2500        1.296527159     0.0203
/


PVTW
1025    1.06   3.03E-06    0.7 /

DENSITY
0   63.0200  0.07020 /

ROCK
525.0     5.0E-06 /

--******************************************
REGIONS

--******************************************

SOLUTION

EQUIL
7030      3000   7380   0      4*                      0     /

AQUFETP
1 7000.0 5000.0 2.0E7 1.0E-5 50.0 1 /

AQUANCON

1 1  20 20 20 1 1 'J+' /
1 20 20 1  20 1 1 'I+' /
/
```

```
--****************************************

SUMMARY

-- Average pressure for field.
FPR

-- GAS production total
FGPT

--Water cut
FWCT

--WELL BHP
WBHP
P1 P2 P3 P4/

--WELL PR
WWPR
P1 P2 P3 P4/

--WELL WATER CUT
WWCT
P1 P2 P3 P4 /

--GAS IN PLACE
FGIP

-- FORMATION WATER SATURATION
FWSAT

--Water Reservoir Volume in Place
FWIPR
```

```
FORM GAS PORE VOL
FGPV

--FORM WATER PORE VOL
FWPV

--CUMM AQUIFER INFLUX
FAQT

--Water production
FWPT

--FIELD FWGR
FWGR

EXCEL

--*******************************************
SCHEDULE

WELSPECS
P1 G1 11  4 7030 GAS  0    P-P   STOP /
P2 G2  5  11 7030   GAS  0   P-P   STOP /
P3 G3  3  2 7030 GAS  0   P-P   STOP/
P4 G4  18  11 7030   GAS  0   P-P   STOP/
/

COMPDAT
P1 11  4   1 1 OPEN  0   0.0   0.40   0 /
P2 5   11  1 1 OPEN  0   0.0   0.40   0 /
P3 3   2   1 1 OPEN  0   0.0   0.40   0 /
P4 18  11  1 1 OPEN  0   0.0   0.40   0 /
/
```

```
WCONPROD
P1  OPEN  GRAT 2*          550    /
P2  OPEN  GRAT 2*          350    /
P3  OPEN  GRAT 2*          400    /
P4  OPEN  GRAT 2*          200    /
/

TSTEP
365 365 365 365 365 365 365 365 365 365 365 365 365
365 365 365 365 365 365 365 365 365 365 365 365 365
/

END
```

5.5OUTPUT DATA FILE

```
************************
  1 READING RUNSPEC
  2 READING TITLE
  3 READING DIMENS
  4 READING GAS
  5 READING WATER
  6 READING FIELD
  7 READING EQLDIMS
  8 READING WELLDIMS
  9 READING AQUDIMS
 10 READING START
 11 READING UNIFOUT
 12 READING GRID
 14 READING BOX
 15 READING DXV
 16 READING DYV
 17 READING DZ
```

```
18 READING PORO
19 READING PERMX
20 READING PERMY
21 READING PERMZ
22 READING ENDBOX
23 READING TOPS
24 READING INIT
25 READING EDIT

@--MESSAGE  AT TIME      0.0   DAYS    ( 1-JAN-2007):
@          NEITHER OLDTRAN,OLDTRANR NOR NEWTRAN SPECIFIED
@          BLOCK CENTRE TRANSMISSIBILITIES TO BE CALCULATED
@          USING  OLDTRAN
26 READING PROPS

@--COMMENT  AT TIME      0.0   DAYS    ( 1-JAN-2007):
@          NO NON-NEIGHBOUR CONNECTIONS FOUND

@--MESSAGE  AT TIME      0.0   DAYS    ( 1-JAN-2007):
@          NUMBER OF ACTIVE CELLS IS     400

@--MESSAGE  AT TIME      0.0   DAYS    ( 1-JAN-2007):
@          PROBLEM REQUIRES      0.576 MEGABYTES
@             1511 ( BYTES PER ACTIVE CELL )

@--MESSAGE  AT TIME      0.0   DAYS    ( 1-JAN-2007):
@            48531 CHARACTER VARIABLES USED
27 READING SGWFN
28 READING PVDG
29 READING PVTW
30 READING DENSITY
31 READING ROCK
32 READING REGIONS
```

```
 33 READING SOLUTION
 34 READING EQUIL
 35 READING AQUFETP
 36 READING AQUANCON

@--MESSAGE  AT TIME        0.0   DAYS    ( 1-JAN-2007):
@           AQUIFER      1 HAS     39 CONNECTIONS

@--COMMENT  AT TIME        0.0   DAYS    ( 1-JAN-2007):
@           THE MINIMUM VALUE FOR NCAMAX IN THE AQUDIMS KEYWORD
@           IN RUNSPEC IS        39
 37 READING SUMMARY
 38 READING FPR
 39 READING FGPT
 40 READING FWCT
 41 READING WBHP
 42 READING WPIG

@--WARNING  AT TIME        0.0   DAYS    ( 1-JAN-2007):
@           UNRECOGNISED KEYWORD WPIG     IN SUMMARY FILE SPECIFICATION
 43 READING P1 P2 P3

@--WARNING  AT TIME        0.0   DAYS    ( 1-JAN-2007):
@           UNRECOGNISED KEYWORD P1 P2 P3 IN SUMMARY FILE SPECIFICATION
 44 READING WWPR
 45 READING WWCT
 46 READING FGIP
 47 READING FWSAT
 48 READING FWIPR
 49 READING FGRFW
 50 READING FGPV
 51 READING FWPV
 52 READING FGE
```

53 READING FAQT

54 READING FWPT

55 READING FWGR

56 READING EXCEL

57 READING SCHEDULE

58 READING WELSPECS

59 READING COMPDAT

60 READING WCONPROD

@--WARNING AT TIME 0.0 DAYS (1-JAN-2007):
@ THE BOTTOM HOLE PRESSURE LIMIT FOR WELL P1
@ HAS BEEN DEFAULTED. THE DEFAULT VALUE IS
@ 14.7 PSIA

@--WARNING AT TIME 0.0 DAYS (1-JAN-2007):
@ THE BOTTOM HOLE PRESSURE LIMIT FOR WELL P2
@ HAS BEEN DEFAULTED. THE DEFAULT VALUE IS
@ 14.7 PSIA

@--WARNING AT TIME 0.0 DAYS (1-JAN-2007):
@ THE BOTTOM HOLE PRESSURE LIMIT FOR WELL P3
@ HAS BEEN DEFAULTED. THE DEFAULT VALUE IS
@ 14.7 PSIA

@--WARNING AT TIME 0.0 DAYS (1-JAN-2007):
@ THE BOTTOM HOLE PRESSURE LIMIT FOR WELL P4
@ HAS BEEN DEFAULTED. THE DEFAULT VALUE IS
@ 14.7 PSIA

61 READING TSTEP

1

** 1

SIMULATE AT 0.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 0 1 JAN 2007 *WIN32 RUN * RUN AT
12:06 ON 27 APR 2007

****

STEP 1 TIME= 2.40 HOURS (+2.40 HOURS CHOP 5 ITS) (1-JAN-2007)
PAV= 3013.2 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 28.7973 STB/MSCF

STEP 2 TIME= 5.40 HOURS (+3.00 HOURS DIFF 2 ITS) (1-JAN-2007)
PAV= 3013.2 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 15.0608 STB/MSCF

STEP 3 TIME= 10.09 HOURS (+4.69 HOURS DIFF 2 ITS) (1-JAN-2007)
PAV= 3013.2 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 10.1080 STB/MSCF

STEP 4 TIME= 17.41 HOURS (+7.32 HOURS DIFF 2 ITS) (1-JAN-2007)
PAV= 3013.3 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 7.5132 STB/MSCF

STEP 5 TIME= 1.20 DAYS (+11.44 HOURS DIFF 2 ITS) (2-JAN-2007)
PAV= 3013.4 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 5.9567 STB/MSCF

STEP 6 TIME= 1.95 DAYS (+17.88 HOURS DIFF 2 ITS) (2-JAN-2007)
PAV= 3013.5 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 4.9547 STB/MSCF

STEP 7 TIME= 3.11 DAYS (+1.2 DAYS DIFF 2 ITS) (4-JAN-2007)
PAV= 3013.8 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 4.2575 STB/MSCF

STEP 8 TIME= 4.93 DAYS (+1.8 DAYS DIFF 2 ITS) (5-JAN-2007)
PAV= 3014.1 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 3.6737 STB/MSCF

STEP 9 TIME= 7.77 DAYS (+2.8 DAYS DIFF 2 ITS) (8-JAN-2007)
PAV= 3014.5 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 3.0640 STB/MSCF

STEP 10 TIME= 12.21 DAYS (+4.4 DAYS DIFF 2 ITS) (13-JAN-2007)
PAV= 3014.7 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 2.4233 STB/MSCF

STEP 11 TIME= 19.15 DAYS (+6.9 DAYS DIFF 2 ITS) (20-JAN-2007)
PAV= 3014.7 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 1.8229 STB/MSCF

STEP 12 TIME= 29.99 DAYS (+10.8 DAYS DIFF 2 ITS) (30-JAN-2007)
PAV= 3014.5 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 1.3419 STB/MSCF

STEP 13 TIME= 46.94 DAYS (+16.9 DAYS DIFF 2 ITS) (16-FEB-2007)
PAV= 3014.3 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.9828 STB/MSCF

STEP 14 TIME= 73.40 DAYS (+26.5 DAYS DIFF 2 ITS) (15-MAR-2007)
PAV= 3014.0 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.7132 STB/MSCF

STEP 15 TIME= 114.76 DAYS (+41.4 DAYS DIFF 2 ITS) (25-APR-2007)
PAV= 3013.5 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.4186 STB/MSCF

STEP 16 TIME= 179.39 DAYS (+64.6 DAYS DIFF 3 ITS) (29-JUN-2007)
PAV= 3012.8 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.2787 STB/MSCF

STEP 17 TIME= 272.19 DAYS (+92.8 DAYS HALF 2 ITS) (30-SEP-2007)
PAV= 3011.9 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.2016 STB/MSCF

STEP 18 TIME= 365.00 DAYS (+92.8 DAYS REPT 2 ITS) (1-JAN-2008)
PAV= 3011.0 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.1620 STB/MSCF
1
** 2
SIMULATE AT 365.00 DAYS *MISSIONS 007 *
ECLIPSE VERSION 2005a

REPORT 1 1 JAN 2008 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 19 TIME= 547.50 DAYS (+182.5 DAYS HALF 2 ITS) (1-JLY-2008)

PAV= 3009.3 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.1171 STB/MSCF

STEP 20 TIME= 730.00 DAYS (+182.5 DAYS REPT 2 ITS) (31-DEC-2008)

PAV= 3007.6 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0928 STB/MSCF

1

** 3

SIMULATE AT 730.00 DAYS *MISSIONS 007 ECLIPSE

VERSION 2005a

REPORT 2 31 DEC 2008 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 21 TIME= 1095.00 DAYS (+365.0 DAYS REPT 2 ITS) (31-DEC-2009)

PAV= 3004.4 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0696 STB/MSCF

1

** 4

SIMULATE AT 1095.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 3 31 DEC 2009 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 22 TIME= 1460.00 DAYS (+365.0 DAYS REPT 2 ITS) (31-DEC-2010)

PAV= 3001.2 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0570 STB/MSCF

1

** 5

SIMULATE AT 1460.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 4 31 DEC 2010 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 23 TIME= 1825.00 DAYS (+365.0 DAYS REPT 2 ITS) (31-DEC-2011)

PAV= 2998.0 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0486 STB/MSCF

1

** 6

SIMULATE AT 1825.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 5 31 DEC 2011 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 24 TIME= 2190.00 DAYS (+365.0 DAYS REPT 2 ITS) (30-DEC-2012)

PAV= 2994.8 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0424 STB/MSCF

1

** 7

SIMULATE AT 2190.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 6 30 DEC 2012 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 25 TIME= 2555.00 DAYS (+365.0 DAYS REPT 2 ITS) (30-DEC-2013)

PAV= 2991.7 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0380 STB/MSCF

1

** 8

SIMULATE AT 2555.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 7 30 DEC 2013 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 26 TIME= 2920.00 DAYS (+365.0 DAYS REPT 1 ITS) (30-DEC-2014)

PAV= 2988.5 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0347 STB/MSCF

1

** 9

SIMULATE AT 2920.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 8 30 DEC 2014 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 27 TIME= 3285.00 DAYS (+365.0 DAYS REPT 1 ITS) (30-DEC-2015)

PAV= 2985.4 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0322 STB/MSCF

1

** 10

SIMULATE AT 3285.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 9 30 DEC 2015 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 28 TIME= 3650.00 DAYS (+365.0 DAYS REPT 1 ITS) (29-DEC-2016)

PAV= 2982.3 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0301 STB/MSCF

1

*** 11

SIMULATE AT 3650.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 10 29 DEC 2016 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 29 TIME= 4015.00 DAYS (+365.0 DAYS REPT 1 ITS) (29-DEC-2017)

PAV= 2979.2 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0284 STB/MSCF

1

*** 12

SIMULATE AT 4015.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 11 29 DEC 2017 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 30 TIME= 4380.00 DAYS (+365.0 DAYS REPT 1 ITS) (29-DEC-2018)

PAV= 2976.0 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0269 STB/MSCF

1

*** 13

SIMULATE AT 4380.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 12 29 DEC 2018 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 31 TIME= 4745.00 DAYS (+365.0 DAYS REPT 1 ITS) (29-DEC-2019)

PAV= 2972.9 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0257 STB/MSCF

1

** 14

SIMULATE AT 4745.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 13 29 DEC 2019 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 32 TIME= 5110.00 DAYS (+365.0 DAYS REPT 1 ITS) (28-DEC-2020)

PAV= 2969.8 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0247 STB/MSCF

1

** 15

16

SIMULATE AT 5475.00 SIMULATE AT 5110.00 DAYS *MISSIONS 007

ECLIPSE VERSION 2005a

REPORT 14 28 DEC 2020 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 33 TIME= 5475.00 DAYS (+365.0 DAYS REPT 1 ITS) (28-DEC-2021)

PAV= 2966.7 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0237 STB/MSCF

1

** DAYS

*MISSIONS 007 * ECLIPSE VERSION 2005a

REPORT 15 28 DEC 2021 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 34 TIME= 5840.00 DAYS (+365.0 DAYS REPT 1 ITS) (28-DEC-2022)

PAV= 2963.6 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0229 STB/MSCF

1

*** 17

SIMULATE AT 5840.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 16 28 DEC 2022 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 35 TIME= 6205.00 DAYS (+365.0 DAYS REPT 1 ITS) (28-DEC-2023)

PAV= 2960.5 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0222 STB/MSCF

1

*** 18

SIMULATE AT 6205.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 17 28 DEC 2023 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 36 TIME= 6570.00 DAYS (+365.0 DAYS REPT 1 ITS) (27-DEC-2024)

PAV= 2957.4 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0215 STB/MSCF

1

*** 19

SIMULATE AT 6570.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 18 27 DEC 2024 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 37 TIME= 6935.00 DAYS (+365.0 DAYS REPT 1 ITS) (27-DEC-2025)

PAV= 2954.3 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0209 STB/MSCF

1

*** 20

SIMULATE AT 6935.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 19 27 DEC 2025 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 38 TIME= 7300.00 DAYS (+365.0 DAYS REPT 1 ITS) (27-DEC-2026)

PAV= 2951.2 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0204 STB/MSCF

1

*** 21

SIMULATE AT 7300.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 20 27 DEC 2026 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 39 TIME= 7665.00 DAYS (+365.0 DAYS REPT 1 ITS) (27-DEC-2027)

PAV= 2948.1 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0199 STB/MSCF

1

*** 22

SIMULATE AT 7665.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 21 27 DEC 2027 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 40 TIME= 8030.00 DAYS (+365.0 DAYS REPT 1 ITS) (26-DEC-2028)

PAV= 2945.0 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0194 STB/MSCF

1

** 23

SIMULATE AT 8030.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 22 26 DEC 2028 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 41 TIME= 8395.00 DAYS (+365.0 DAYS REPT 1 ITS) (26-DEC-2029)

PAV= 2941.9 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0191 STB/MSCF

1

** 24

SIMULATE AT 8395.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 23 26 DEC 2029 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 42 TIME= 8760.00 DAYS (+365.0 DAYS REPT 1 ITS) (26-DEC-2030)

PAV= 2938.8 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0187 STB/MSCF

1

** 25

SIMULATE AT 8760.00 DAYS *MISSIONS 007 *

ECLIPSE VERSION 2005a

REPORT 24 26 DEC 2030 *WIN32 RUN * RUN AT

12:06 ON 27 APR 2007

****

STEP 43 TIME= 9125.00 DAYS (+365.0 DAYS REPT 1 ITS) (26-DEC-2031)

PAV= 2935.7 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0184 STB/MSCF

1
** 26
SIMULATE AT 9125.00 DAYS *MISSIONS 007 *
ECLIPSE VERSION 2005a
REPORT 25 26 DEC 2031 *WIN32 RUN * RUN AT
12:06 ON 27 APR 2007

****

STEP 44 TIME= 9490.00 DAYS (+365.0 DAYS REPT 1 ITS) (25-DEC-2032)
PAV= 2932.6 PSIA WCT=1.000 GOR= 0.00000 MSCF/STB WGR= 0.0181 STB/MSCF
62 READING END

Error summary

Comments	2
Warnings	6
Problems	1
Errors	0
Bugs	0

6.RESULTS AND DISCUSSION

From the graph obtained following points can be said about the reservoir

- Gas production total from the reservoir at the end of 9490 days is 14000000MSCF from 5*10^8 to
- There has been a marginal decrease in the gas in place value, this is due to active water drive.
- Field water gas ratio has decreased due to presence of water drive
- Reservoir pressure is declining slowly due filling of voidage by the encroaching water
- Field water production is increasing with time as aquifer progresses into the reservoir
- Reservoir has recovery factor of about 70%
- Recovery from reservoir is 273mscf/acft

RECOVERY CALCULATION

Resevoir is under active water drive , so the reservoir pressure is stabilized near initial reservoir pressure. Recover from reservoir and reservoir factor is calculated below:

Value of Bg at final pressure of 2932 psia = (2932*60)/(14.7*120)
= 102 scf/cf

Recovery = 43560*porosity*(1-Swi-Sgr)*Bg
= 273mscf/acft

Recovery factor = 100*(1-Swi-Sgr)/(1-Swi)
= 70%

CONCLUSION AND RECOMMENDATION

The given reservoir is under active water drive reservoir and producing through 4 wells and the recovery achieved is 273 mscf/acft . the recovery factor of reservoir is 70% and reservoir pressure has depleted very less .

Following recommendation are given for increasing recovery and efficient production of reservoir

- As very few wells are draining the reservoir, new wells are to be dilled in order to increase production

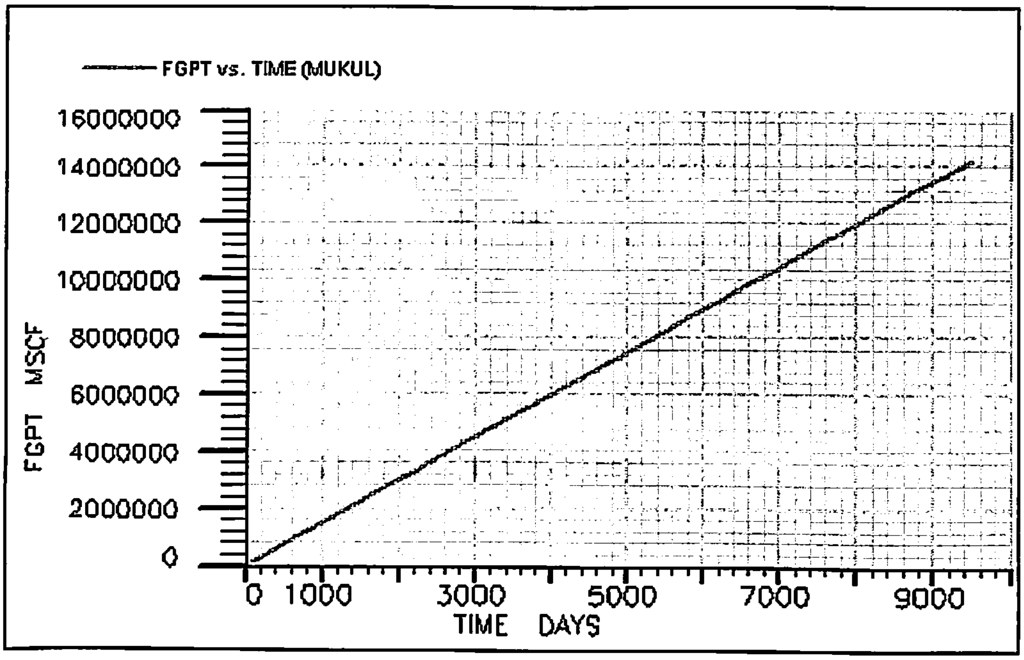
- Wells to be drilled should be up-dip as low dip wells my loosr its share of gas

- Production rate from wells may be increased

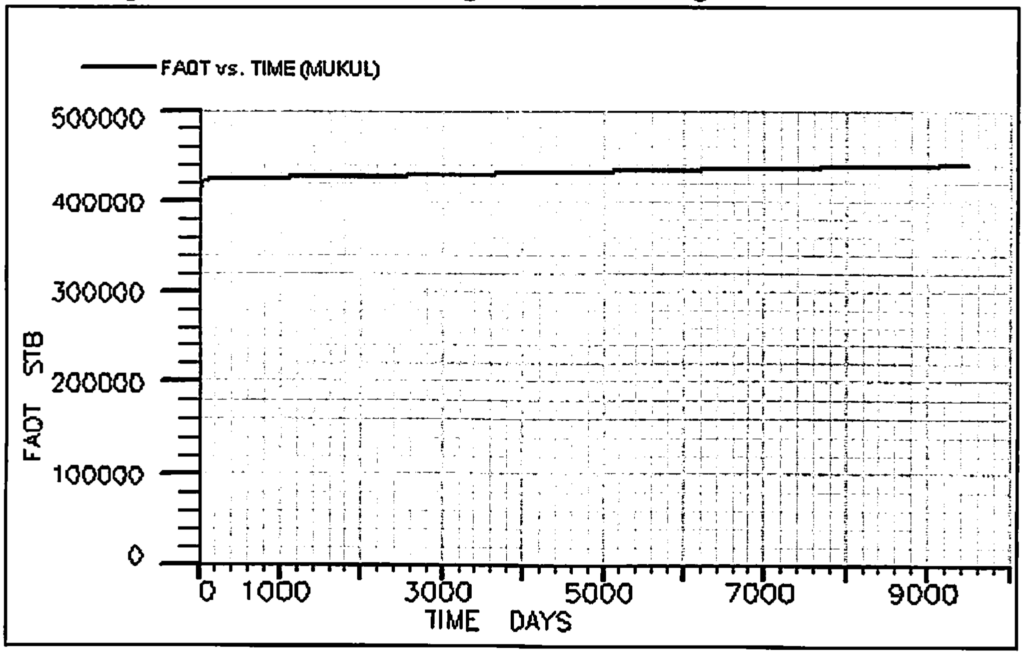
- New wells drilled should be drilled keeping in view the gas oil contact

GRAPHS AND REPORT

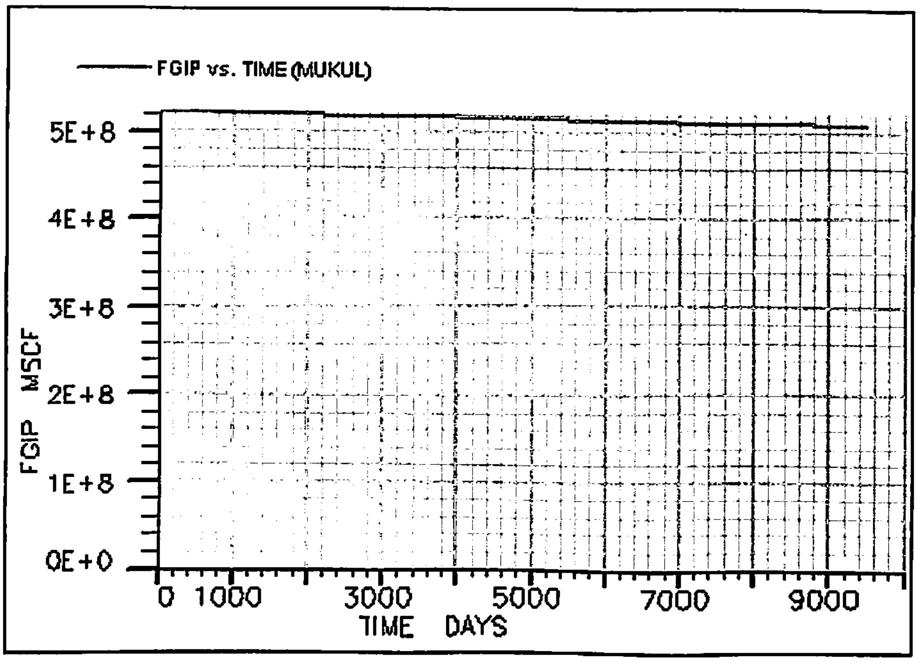
PLOT OF FIELD GAS PRODUCTION V/S TIME



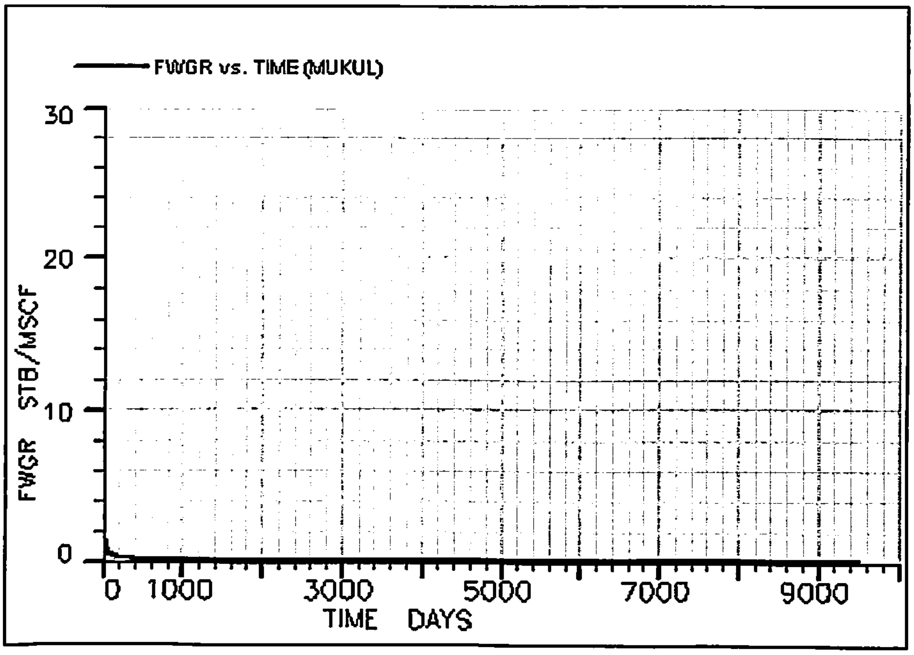
PLOT OF CUMMULATIVE AQUIFER INFLUX V/S TIME



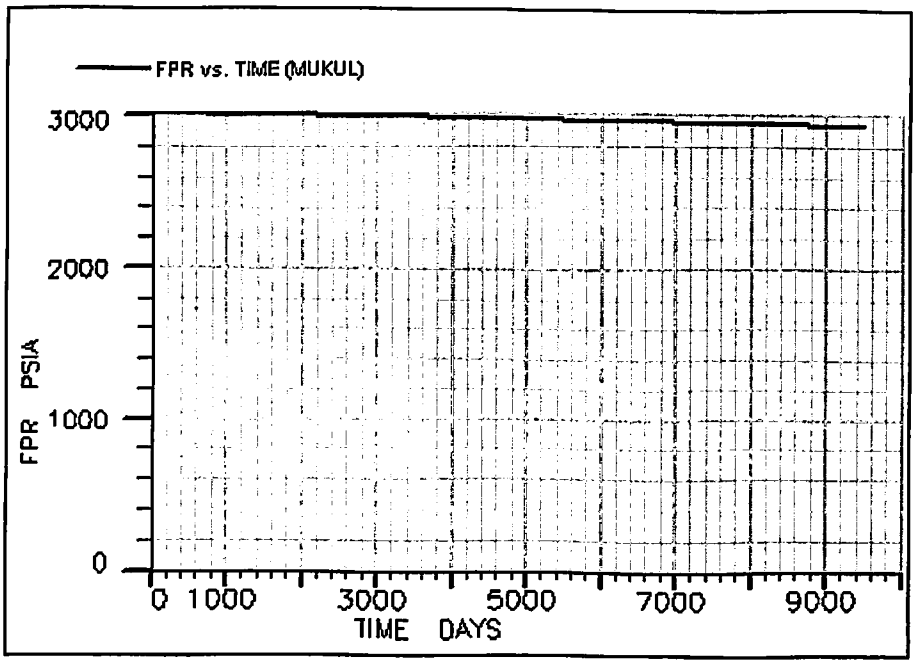
PLOT OF FIELD GAS IN PLACE V/S TIME



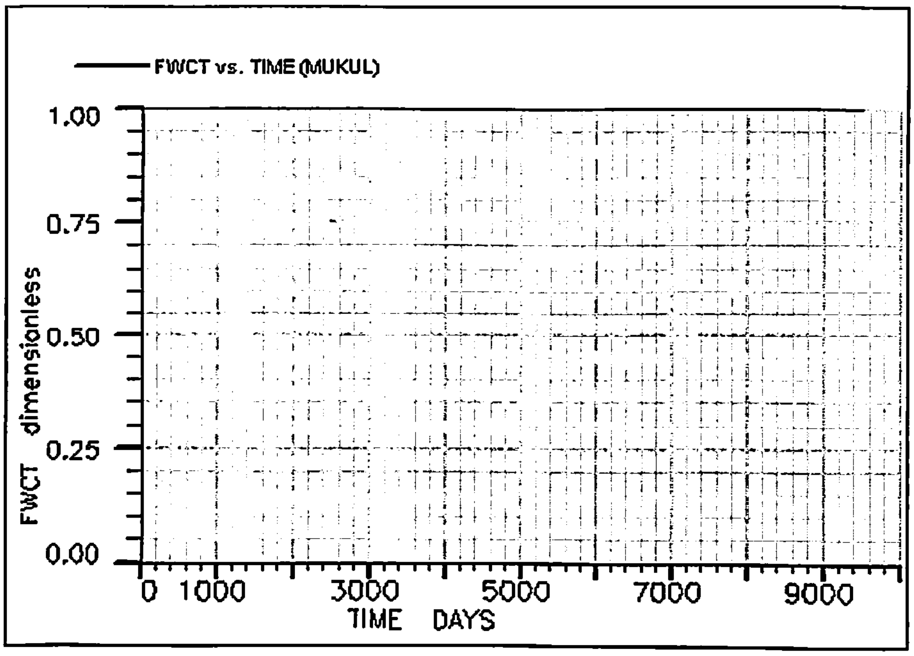
PLOT OF FIELD WATER GAS RATIO V/S TIME



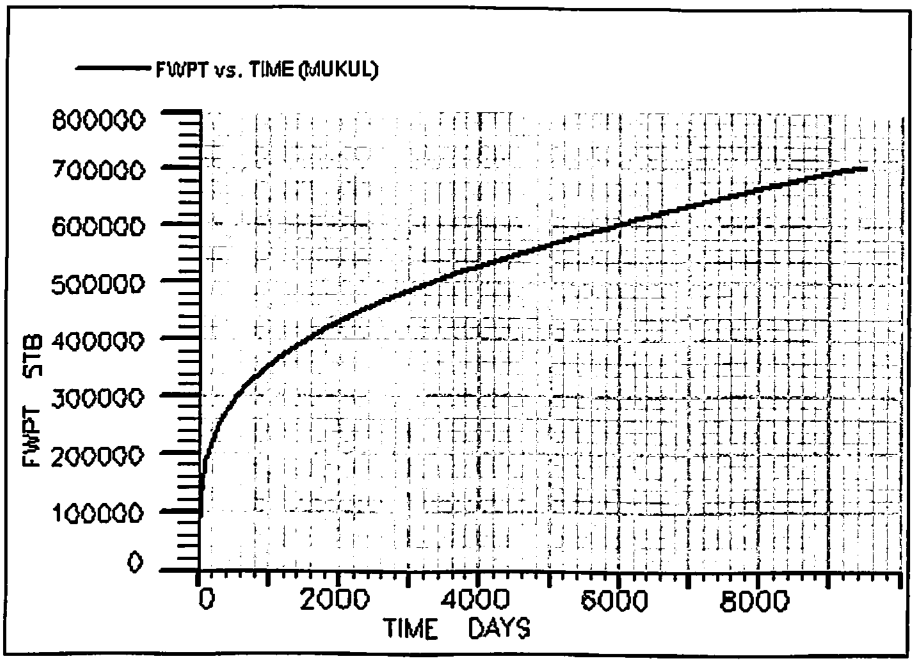
PLOT OF AVG.FIELD PRESSURE V/S TIME



PLOT OF FIELD WATER CUT V/S TIME



PLOT OF WATER PRODUCTION TOTAL V/S TIME



REPORT

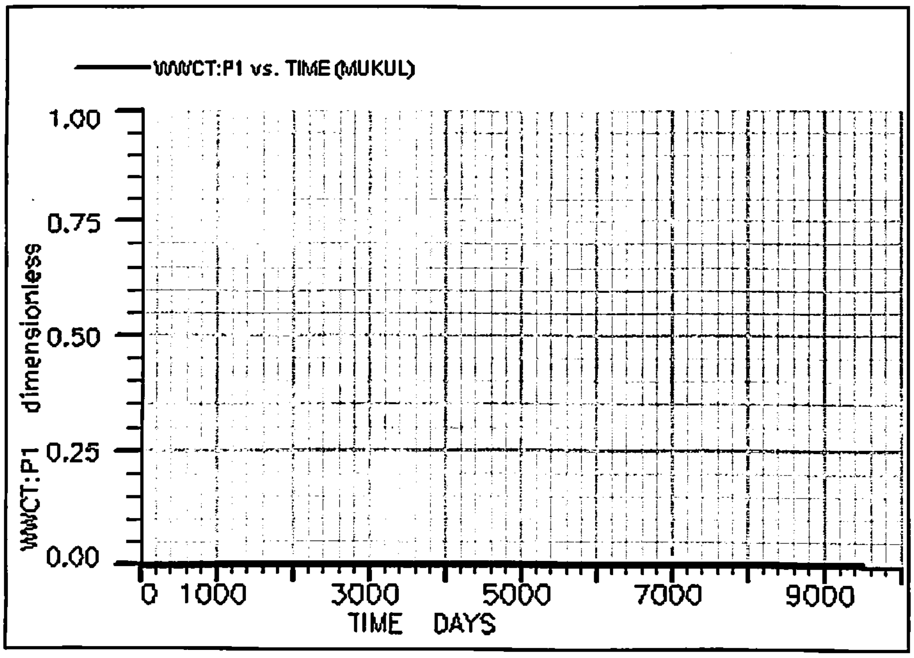
TIME	FAQT	FGIP	FGPT	FGPV	FPR	FWCT	FWGR	FWPT
(DAYS)	(STB)	(MSCF)	(MSCF)	(RB)	(PSIA)		(STB/MSCF)	(STB)
0	0	5.23E+08	0	5.61E+08	3013.16	0	0	0
0.1	10349.57	5.23E+08	150	5.61E+08	3013.165	1	28.7973	4319.594
0.225	22876.68	5.23E+08	337.5	5.61E+08	3013.179	1	15.06084	7143.502
0.420312	41586.02	5.23E+08	630.4688	5.61E+08	3013.208	1	10.10799	10104.83
0.725488	68877.82	5.23E+08	1088.232	5.61E+08	3013.262	1	7.513249	13544.12
1.202326	107291.8	5.23E+08	1803.488	5.61E+08	3013.362	1	5.956706	17804.69
1.947384	158525.3	5.23E+08	2921.075	5.61E+08	3013.534	1	4.954712	23342.01
3.111537	221536.3	5.23E+08	4667.305	5.61E+08	3013.795	1	4.257486	30776.56
4.930526	290107	5.23E+08	7395.789	5.61E+08	3014.127	1	3.673745	40800.31
7.772697	352100.3	5.23E+08	11659.05	5.61E+08	3014.453	1	3.063975	53862.82
12.21359	394469.2	5.23E+08	18320.39	5.61E+08	3014.662	1	2.42328	70005.11
19.15248	413638.5	5.23E+08	28728.73	5.61E+08	3014.682	1	1.82289	88978.38
29.99451	419671.7	5.23E+08	44991.76	5.61E+08	3014.545	1	1.341857	110801.1
46.93517	422028.4	5.23E+08	70402.75	5.61E+08	3014.306	1	0.982756	135773.8
73.40495	423321	5.23E+08	110107.4	5.61E+08	3013.961	1	0.713224	164092.2
114.764	424096	5.23E+08	172146	5.61E+08	3013.493	1	0.418629	190063.3
179.3875	424559.8	5.23E+08	269081.2	5.61E+08	3012.815	1	0.278687	217077.9
272.1937	424873.8	5.23E+08	408290.6	5.61E+08	3011.892	1	0.201562	245137.2
365	425102.5	5.23E+08	547500	5.61E+08	3010.997	1	0.162018	267691.7
547.5	425414.3	5.22E+08	821250	5.61E+08	3009.303	1	0.117112	299751.1
730	425738.8	5.22E+08	1095000	5.61E+08	3007.645	1	0.092779	325149.3
1095	426283.5	5.21E+08	1642500	5.61E+08	3004.398	1	0.069636	363275.3
1460	426893.8	5.21E+08	2190000	5.61E+08	3001.19	1	0.05704	394504.5
1825	427523.1	5.20E+08	2737500	5.61E+08	2998.006	1	0.048566	421094.6
2190	428156.3	5.20E+08	3285000	5.61E+08	2994.842	1	0.042377	444296.3
2555	428789.2	5.19E+08	3832500	5.61E+08	2991.69	1	0.037986	465093.6
2920	429420.4	5.19E+08	4380000	5.61E+08	2988.549	1	0.034722	484103.6
3285	430050.3	5.18E+08	4927500	5.61E+08	2985.415	1	0.032161	501711.7
3650	430679.2	5.18E+08	5475000	5.61E+08	2982.287	1	0.030091	518186.4
4015	431307	5.17E+08	6022500	5.61E+08	2979.164	1	0.028382	533725.4
4380	431933.9	5.17E+08	6570000	5.61E+08	2976.045	1	0.026946	548478.2
4745	432560.1	5.16E+08	7117500	5.61E+08	2972.93	1	0.025718	562559
5110	433185.6	5.15E+08	7665000	5.61E+08	2969.818	1	0.024659	576059.7
5475	433810.5	5.15E+08	8212500	5.61E+08	2966.708	1	0.023736	589055.3
5840	434435	5.14E+08	8760000	5.61E+08	2963.601	1	0.022926	601607.3
6205	435058.9	5.14E+08	9307500	5.61E+08	2960.496	1	0.022193	613757.9
6570	435683	5.13E+08	9855000	5.61E+08	2957.393	1	0.021501	625529.8
6935	436305.8	5.13E+08	10402500	5.61E+08	2954.292	1	0.020904	636974.9
7300	436928.7	5.12E+08	10950000	5.61E+08	2951.192	1	0.020371	648127.9
7665	437551.7	5.12E+08	11497500	5.61E+08	2948.094	1	0.019879	659011.6
8030	438173.8	5.11E+08	12045000	5.61E+08	2944.996	1	0.019446	669658.4
8395	438796.1	5.10E+08	12592500	5.61E+08	2941.9	1	0.019051	680089.1
8760	439417.9	5.10E+08	13140000	5.61E+08	2938.805	1	0.018693	690323.6
9125	440039.8	5.09E+08	13687500	5.61E+08	2935.711	1	0.018359	700375.1
9490	440661.2	5.09E+08	14235000	5.61E+08	2932.617	1	0.018058	710261.9

TIME	FWPV	FWSAT	WBHP:P1	WBHP:P2	WBHP:P3	WBHP:P4	WWPR:P4
(DAYS)	(RB)		(PSIA)	(PSIA)	(PSIA)	(PSIA)	(STB/DAY)
0	2.70E+08	0.324892	3006.445	3012.904	3019.377	3032.452	0
0.1	2.70E+08	0.324893	2999.49	2999.734	2999.679	1806.109	43195.94
0.225	2.70E+08	0.324896	2999.441	2999.66	2999.536	2301.263	22591.26
0.420312	2.70E+08	0.324903	2999.411	2999.644	2999.513	2488.688	15161.98
0.725488	2.70E+08	0.324916	2999.386	2999.632	2999.493	2588.344	11269.87
1.202326	2.70E+08	0.32494	2999.366	2999.625	2999.473	2649.249	8935.059
1.947384	2.70E+08	0.324981	2999.362	2999.627	2999.452	2689.289	7432.067
3.111537	2.70E+08	0.325044	2999.413	2999.663	2999.426	2717.618	6386.229
4.930526	2.70E+08	0.325123	2999.566	2999.781	2999.407	2741.173	5510.617
7.772697	2.71E+08	0.325204	2999.826	3000.033	2999.429	2765.06	4595.963
12.21359	2.71E+08	0.32526	3000.104	3000.402	2999.553	2789.73	3634.92
19.15248	2.71E+08	0.325278	3000.276	3000.743	2999.8	2813	2734.335
29.99451	2.71E+08	0.325268	3000.302	3000.889	3000.066	2832.467	2012.786
46.93517	2.71E+08	0.325246	3000.21	3000.789	3000.18	2848.219	1474.134
73.40495	2.71E+08	0.325218	2999.971	3000.479	3000.039	2861.458	1069.836
114.764	2.70E+08	0.32519	2999.554	3000.002	2999.638	2878.442	627.9435
179.3875	2.70E+08	0.32516	2998.895	2999.315	2998.971	2894.061	418.0309
272.1937	2.70E+08	0.325127	2997.976	2998.386	2998.042	2906.439	302.3427
365	2.70E+08	0.325101	2997.083	2997.491	2997.145	2916.271	243.0276
547.5	2.70E+08	0.325066	2995.391	2995.797	2995.446	2923.148	175.6677
730	2.70E+08	0.325038	2993.739	2994.143	2993.79	2932.439	139.1685
1095	2.70E+08	0.324999	2990.501	2990.902	2990.543	2937.221	104.4547
1460	2.70E+08	0.324969	2987.304	2987.706	2987.346	2942.712	85.55969
1825	2.70E+08	0.324944	2984.134	2984.534	2984.174	2945.199	72.84954
2190	2.70E+08	0.324924	2980.982	2981.383	2981.022	2946.31	63.56615
2555	2.70E+08	0.324907	2977.843	2978.244	2977.882	2946.514	56.97892
2920	2.70E+08	0.324892	2974.714	2975.115	2974.754	2945.903	52.08228
3285	2.70E+08	0.324879	2971.594	2971.994	2971.633	2944.74	48.24135
3650	2.70E+08	0.324867	2968.479	2968.88	2968.517	2943.215	45.13611
4015	2.70E+08	0.324856	2965.368	2965.77	2965.408	2941.427	42.57265
4380	2.70E+08	0.324846	2962.263	2962.664	2962.302	2939.439	40.41868
4745	2.70E+08	0.324837	2959.16	2959.562	2959.199	2937.295	38.57742
5110	2.70E+08	0.324829	2956.061	2956.463	2956.1	2935.028	36.98831
5475	2.70E+08	0.324822	2952.965	2953.367	2953.004	2932.662	35.60434
5840	2.70E+08	0.324815	2949.871	2950.273	2949.91	2930.211	34.38915
6205	2.70E+08	0.324808	2946.779	2947.181	2946.818	2927.694	33.28929
6570	2.70E+08	0.324802	2943.689	2944.092	2943.728	2925.137	32.25176
6935	2.70E+08	0.324797	2940.6	2941.004	2940.64	2922.551	31.3565
7300	2.70E+08	0.324791	2937.514	2937.917	2937.553	2919.904	30.55596
7665	2.70E+08	0.324787	2934.428	2934.832	2934.468	2917.215	29.81853
8030	2.70E+08	0.324782	2931.344	2931.748	2931.383	2914.498	29.16928
8395	2.70E+08	0.324778	2928.261	2928.665	2928.301	2911.742	28.57709
8760	2.70E+08	0.324774	2925.179	2925.584	2925.218	2908.96	28.03986
9125	2.70E+08	0.32477	2922.098	2922.502	2922.138	2906.153	27.5383
9490	2.70E+08	0.324766	2919.017	2919.423	2919.057	2903.329	27.08733

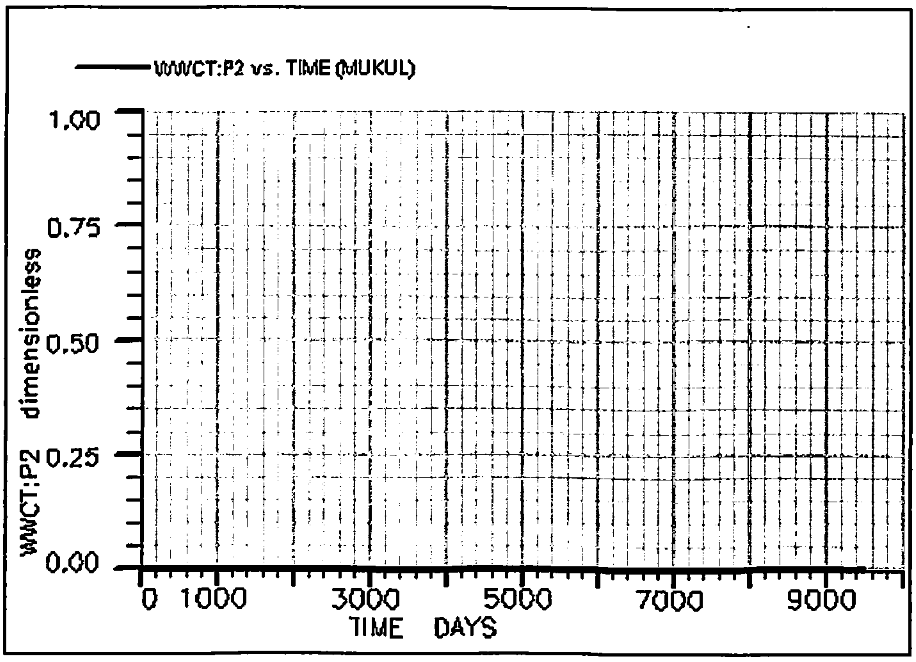
APPENDIX..1

OTHER PLOTS

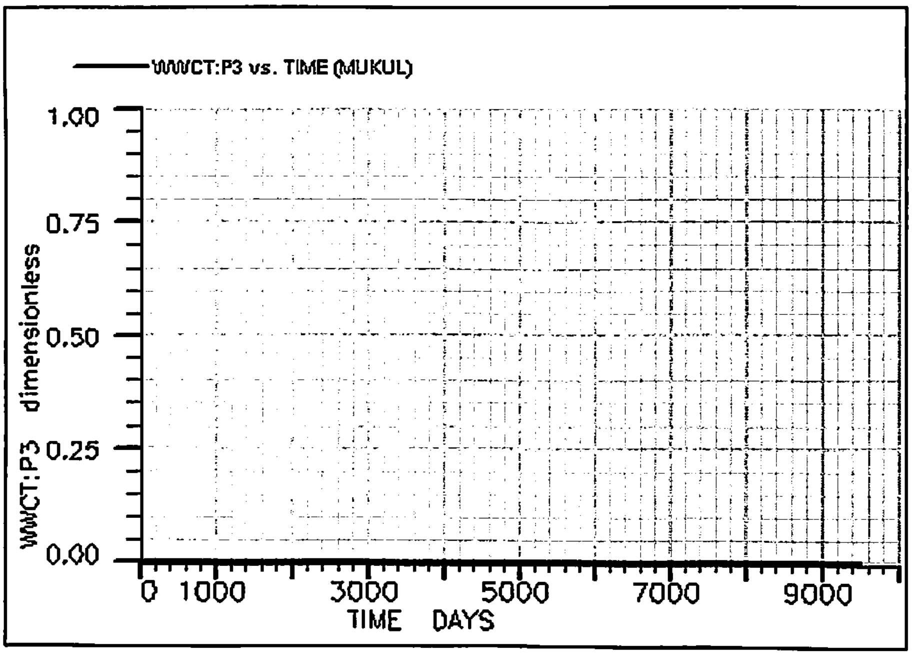
PLOT OF WELL WATER CUT(P1) V/S TIME



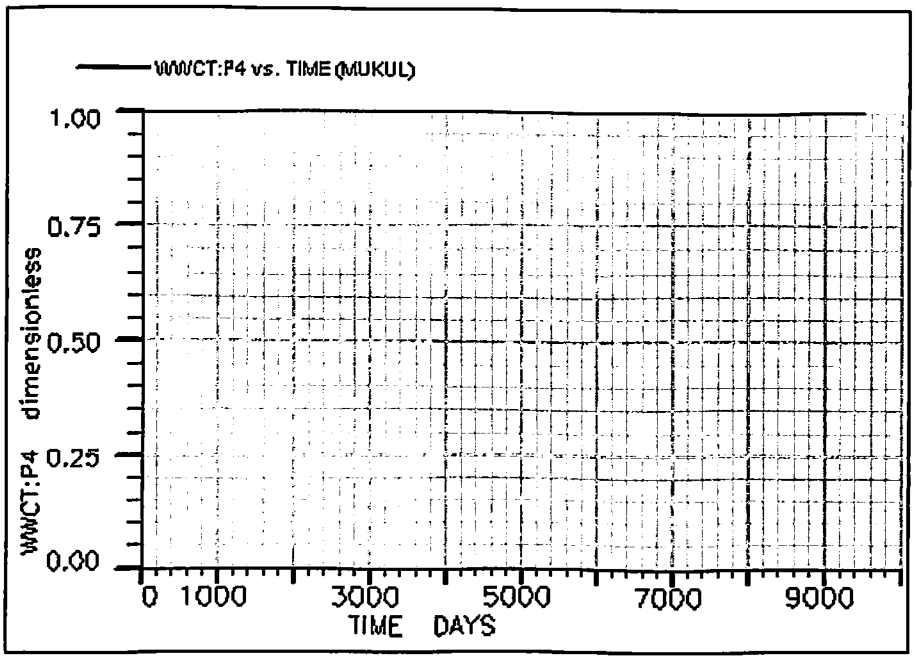
PLOT OF WELL WATER CUT(P2) V/S TIME



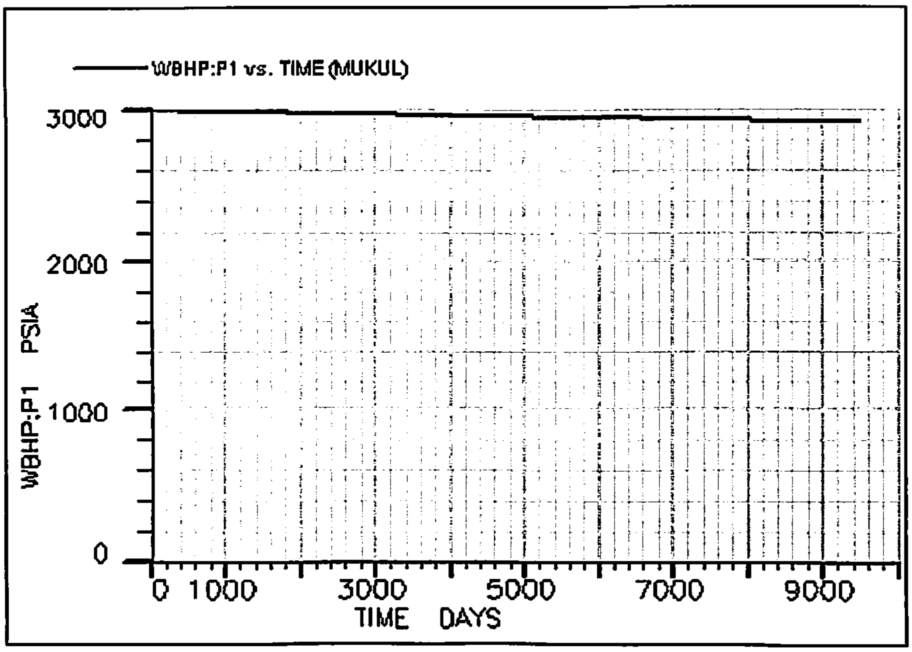
PLOT OF WELL WATER CUT(P3) V/S TIME



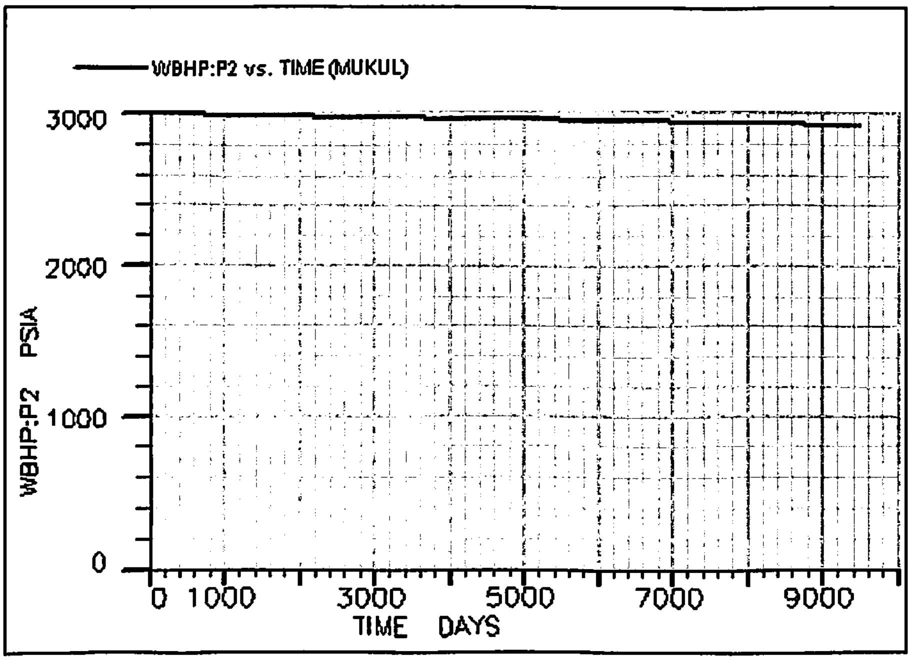
PLOT OF WELL WATER CUT(P4) V/S TIME



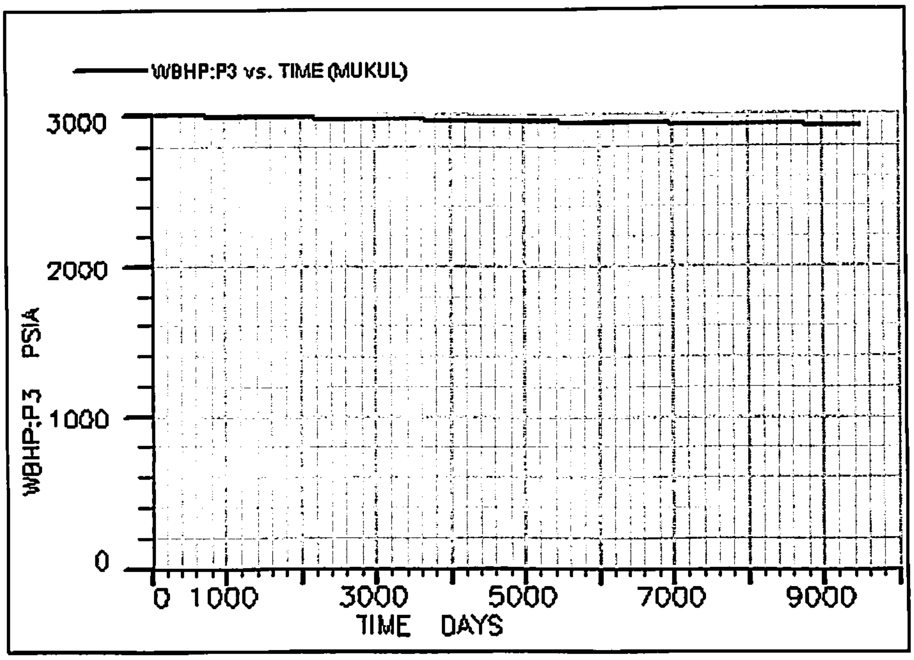
PLOT OF WELL BOTTOM HOLE PRESSURE(P1) V/S TIME



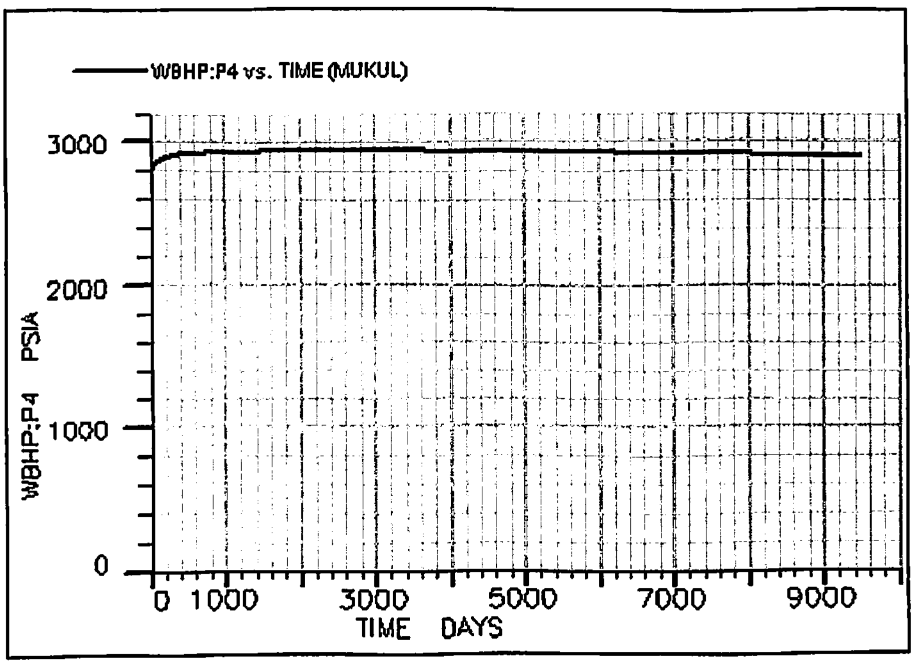
PLOT OF WELL BOTTOM HOLE PRESSURE(P2) V/S TIME



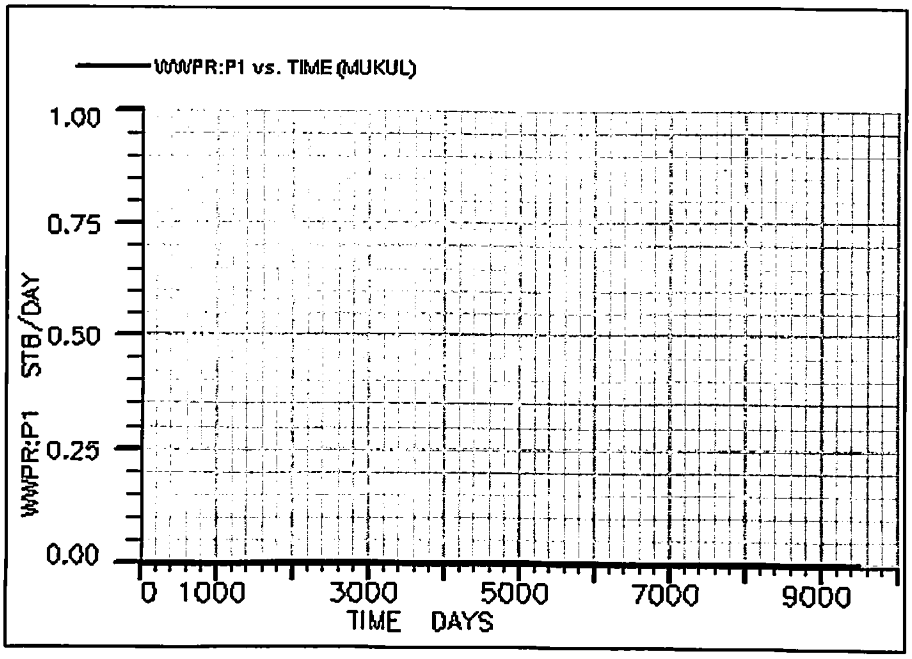
PLOT OF WELL BOTTOM HOLE PRESSURE(P3) V/S TIME



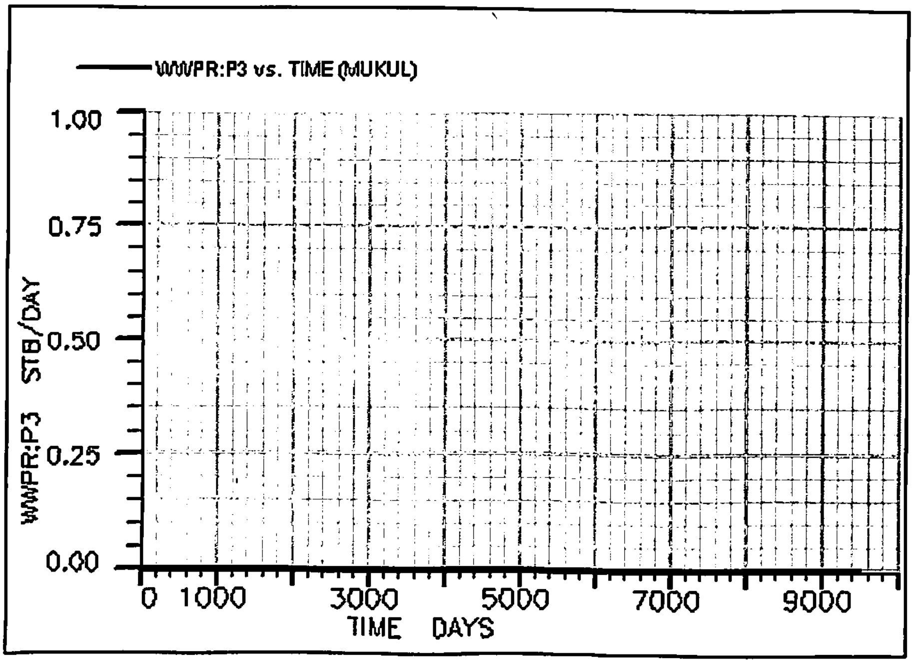
PLOT OF WELL BOTTOM HOLE PRESSURE(P4) V/S TIME



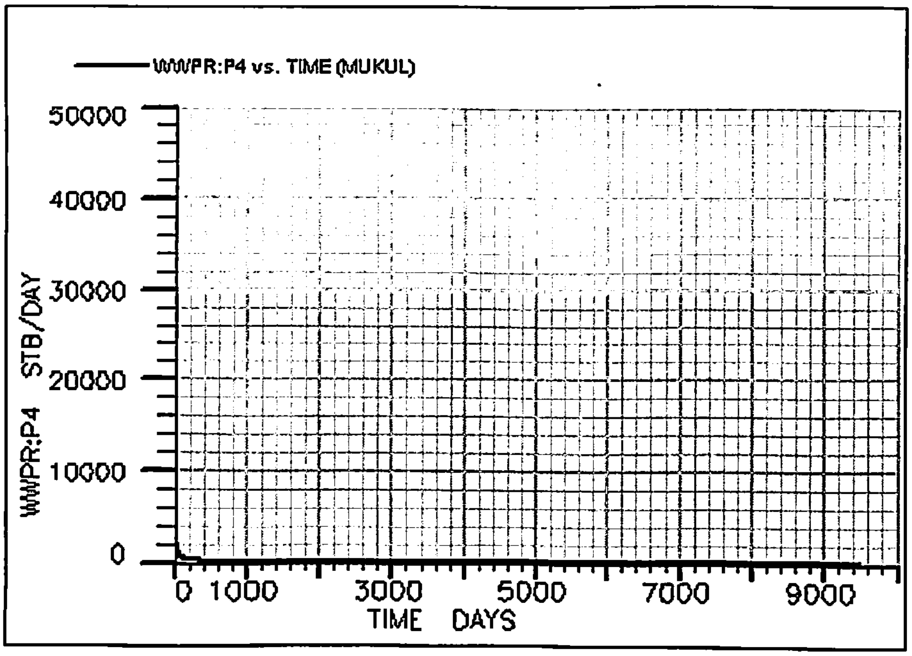
PLOT OF WELL WATER PRESSURE(P1) V/S TIME



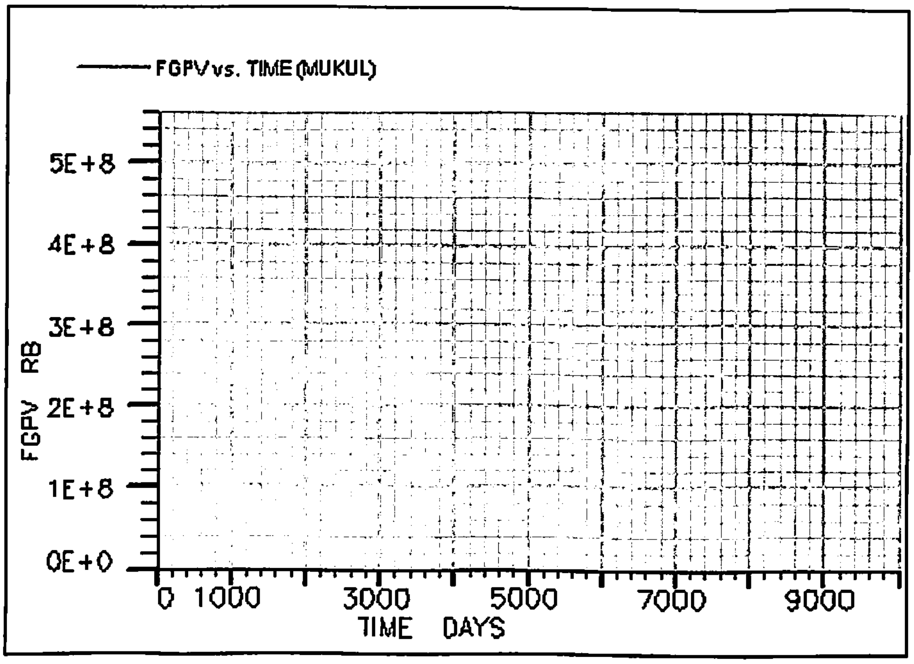
PLOT OF WELL BOTTOM HOLE PRESSURE(P3) V/S TIME



PLOT OF WELL BOTTOM HOLE PRESSURE(P4) V/S TIME

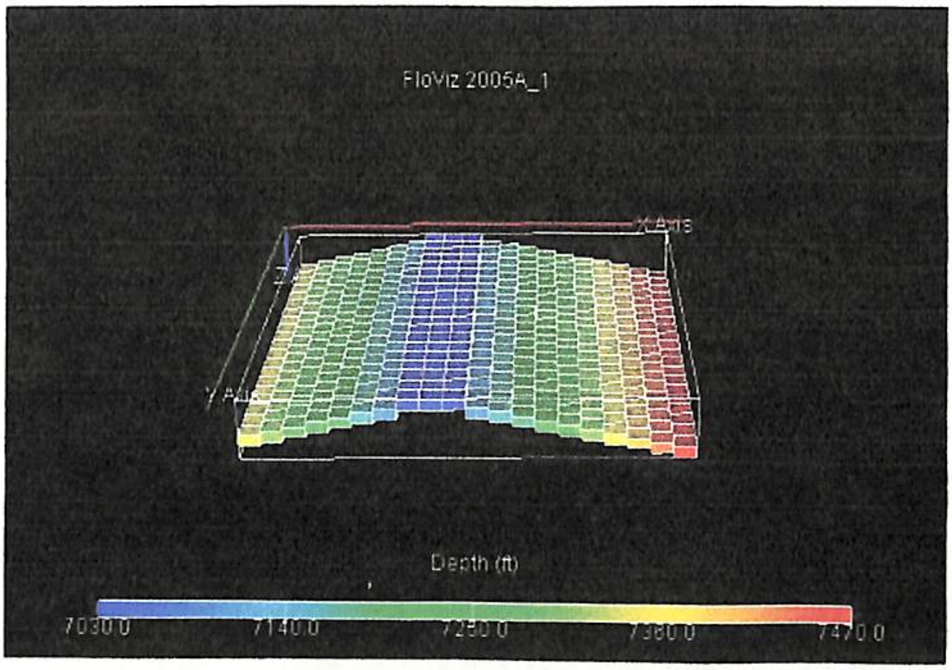


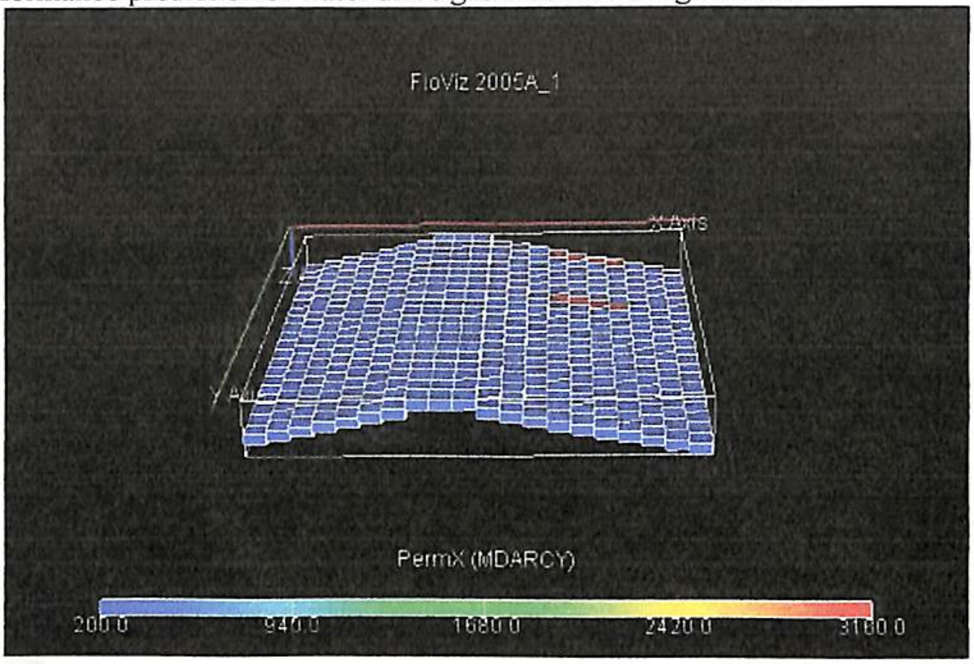
PLOT OF FIELD GAS PORE VOLUME V/S TIME



APPENDIX…………..2

MODEL VIEWS

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Y Axis
PermX (MDARCY)
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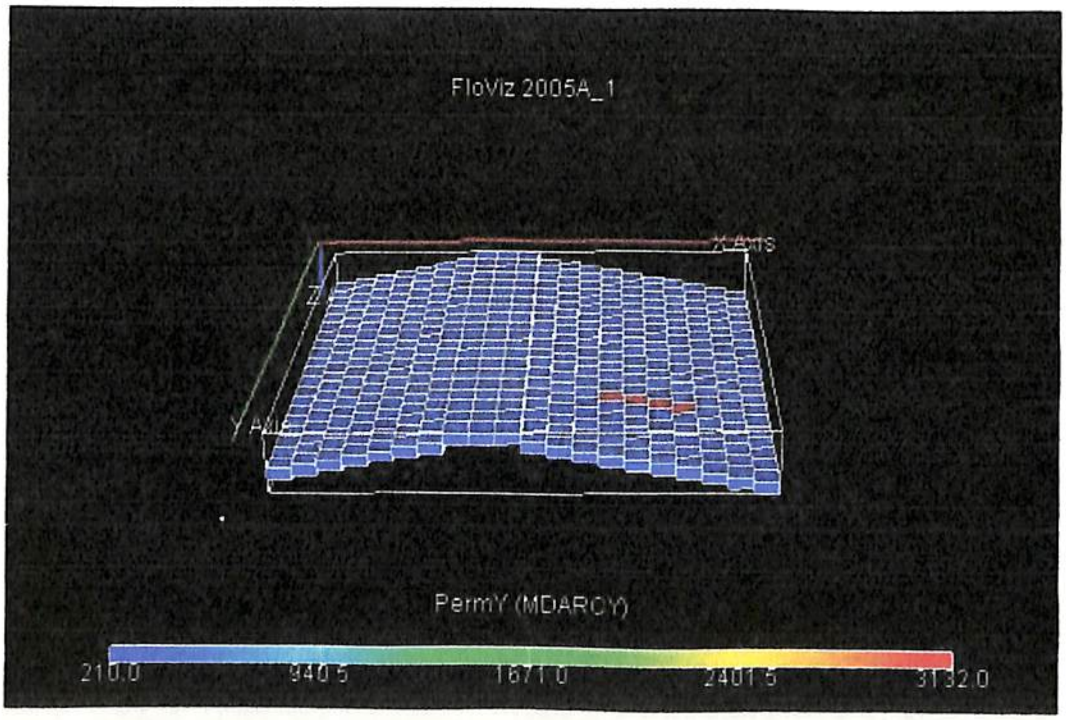
1680.0
2420.0
3160.0


FloViz 2005A_1
X Axis
Y Axis
PermY (MDARCY)
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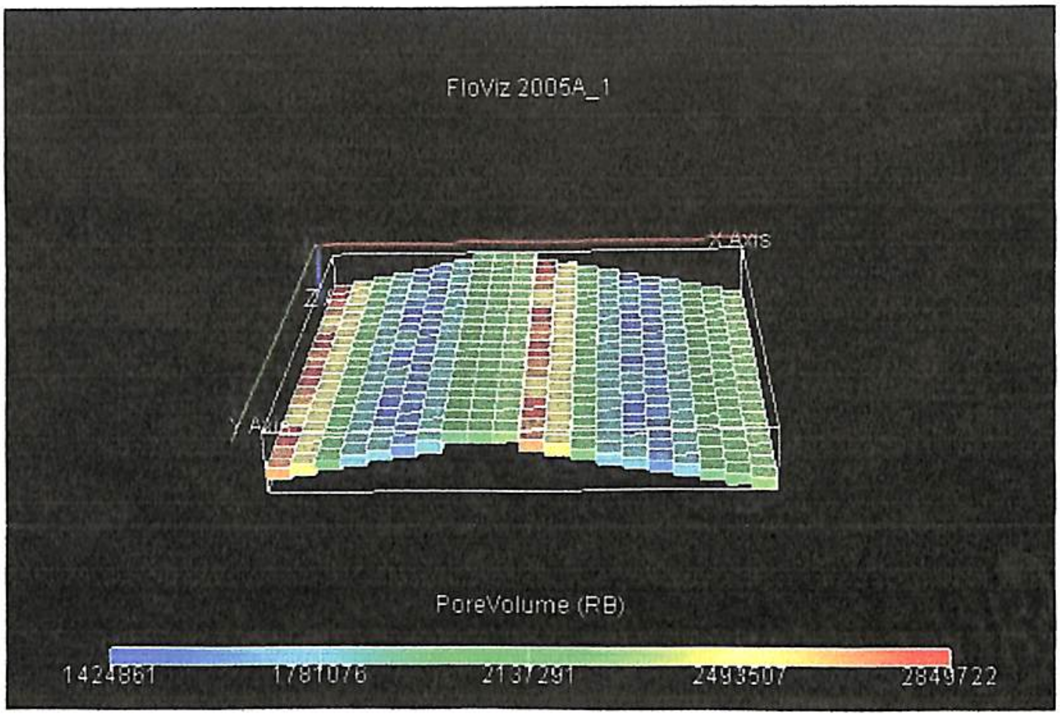
940.5
1671.0
2401.5
3132.0


FloViz 2005A_1
X Axis
Y Axis
PoreVolume (RB)
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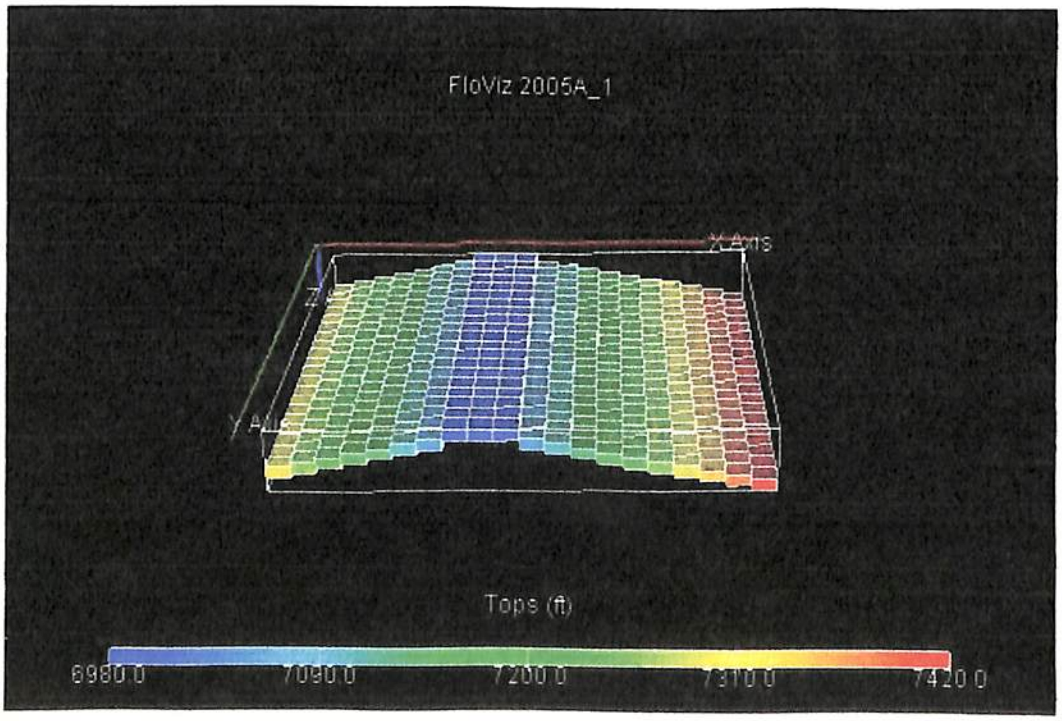
1781076
2137291
2493507
2849722


FloViz 2005A_1
X Axis
Y Axis
Tops (ft)
6980.0
7090.0
7200.0
7310.0
7420.0

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