RESERVOIR ENGINEERING STUDY OF HARIPUR OIL FIELD

By

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ABSTRACT

In a reservoir engineering study, pressure transient analysis and reservoir simulation are very important to know different reservoir information and predict future production performance. This study uses pressure transient analysis software SAPHIR and simulation software EXODUS to find out reservoir characteristics and production scenarios of Haripur oil field. A reservoir model has been built both for pressure transient analysis and reservoir simulation. Two different cases have been simulated to study the possibility of a gas cap. The reservoir model takes into account the high viscosity effect, wellbore storage, skin, heavier hydrocarbon, wax accumulation inside the tubing and different possible inner and outer boundary conditions.

The model has been validated by comparing the results of the pressure transient analysis with those of IKM analysis published in the literature. Also the simulation results have been verified by comparing total simulated production from the Haripur 1 (Sylhet 7) with the actual production until its production stopped on the 14th of July, 1994.

The pressure transient analysis has yielded the wellbore storage coefficient, permeability, reservoir capacity and skin factor which are very close to those obtained from the IKM study. In the simulation study, the well has produced at much lower flowrates than the actual flowrates, but the total production figures are very close. From the simulation study, it has been established that initially the reservoir has no gas cap. The causes of the production stoppage have also been analyzed using the available information in the literature

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

Chapter I

INTRODUCTION

Sound reservoir engineering judgement and techniques in identifying the reservoir characteristics and controlling the production play a significant role to meet the present demand and maximize the gas or oil recovery from the reservoir. The scope of a reservoir engineering study includes a detailed integrated approach The study uses all core data, PVT studies, production and pressure data to develop a description of the reservoir rock and fluid properties, well test analysis, history matching, future reservoir performance and production forecasting assuming alternative development and operating scenarios

Only one oil field was discovered in the upper Bhuban formation in Sylhet. The field was developed by drilling only one well, known as Sylhet 7 or Haripur 1. The well was on trial production from 1987 and total withdrawal from the pool was 636956 standard tank barrel oil (0.63 MMSTB) and 891.57 million standard cubic feet (892 MMSCF) of associated gas But this oil field is not producing any longer The production from this field has stopped since the 14th of July, 1994 Previous studies have shown that the production ceased due to the wax formation in the wellbore.

The focus of this study is well test analysis of Haripur oil field using a pressure transient analysis software and reservoir performance and production forecasting using a commercial simulator. Information like reservoir pressure, permeability, porosity, reservoir heterogeneity, wellbore volume, wellbore damage or improvement and other relevant information may be obtained from the pressure transient analysis All these information can be used in reservoir simulation to assist in analyzing, improving and forecasting reservoir performance and reservoir drive mechanism

The pressure data from the pressure survey conducted by IKM (1993) is used for creating log-log, semi-log pressure and pressure derivatives plots Well data and reservoir properties have been taken from the studies of Khan et al (1991), Arafin et al. (1991) and Whitmee (1987). The simulation of the reservoir has been conducted using the EXODUS in a three-dimensional reservoir model. Also, all the existing documents have been analyzed to ascertain the causes of the production stoppage

Chapter 2

LITERATURE REVIEW

2.1 Field Data and Properties

Availability of field data and reservoir properties has been a great problem for Haripur field. Available field data and reservoir properties are described below.

2.1.1 History of drilling

The old Sylhet gas fields, discovered in the fifties by Burma Oil Company (BOC) and Pakistan Petroleum Ltd (Whitmee, 1987) were made on a culmination in the north-east part of the major Sylhet-Kailashtila uplift According to surface geological mapping by BOC, gas was discovered in Boka Bil sands beneath the Upper Marine Shale. Six wells were drilled in the field by Pakistan Petroleum Limited (PPL). Only two (well 3 and well 6) were completed as gas producers Here field history of all wells have summarized given below:

Sylhet 1 was drilled in 1955 to a depth of 2377 meters Due to mechanical difficulties the casing of the well blew out of control, ignited and destroyed the rig. which later sank into the crater and is now below water

Sylhet 2 was drilled to 2818 m in 1956, located southwest of Sylhet 1 It ran into an abnormally pressured sand below 1750 ft and was hurriedly abandoned to avoid any possible blowout.

Sylhet 3 was drilled 300 m north-east of Sylhet 1 in 1957 The hole was drilled to 1675 m but because of mechanical difficulties it was not drilled any further and completed in the intervals above 1338 m

Sylhet 4 was drilled 400 m north-east of Sylhet 1 in 1962. The well blew out at 315 m and was abandoned

Sylhet 5 was drilled as an observation well, 350 m north-west of Sylhet 1 It was drilled to 575 m and tested at 2.5 MMSCF of gas in the middle Tipam Sandstone.

Sylhet 6 was drilled in 1964 about 600 m north-west of Sylhet 1. Drilling continued to 1405 m and was completed in gas bearing sand.

The area was then further explored in the eighties by Petrobangla with the technical assistance from the German Geological Group. Oil was discovered in an upper Bhuban reservoir in Haripur from well Sylhet 7 (Haripur 1) in December 1986. The area was later licensed to Scimitar Oil Co. This operator did not carry out any additional seismic but drilled the well Surma 1 about 600 m of south-west of Haripur 1 As this well did not confirm extension of the pool, the operator plugged back Surma 1 and drilled from that depth an angled hole (Surma 1A). At the level of 200 m subsea, Surma 1A is located 600 m north-west of Haripur 1. As reported by the operator both Surma 1 (the vertical one) and Surma 1A (the deviated one) were dry (Whitmee, 1987).

2.1.2 Structure

Sylhet is located in the central axis of large Surma Basin geosyncline The Sylhet anticline is an arcuate, slightly asymmetrical fold, aligned south-west to north-east. The asymmetry results in a progressive shift of the crystal axis of the anticline towards the south-east with increasing depth

Final well report done by Oil and Mining Services (Whitmee, 1987) depicts that Haripur 1 is located on the south-east shoulder at Tipam level with the crystal axis running through Sylhet 4. At the upper Boka Bil, the crest lies between Sylhet 1 and Haripur 1.

There is a surface expression of fault near Sylhet 4 and 6 but no indication of faulting is recorded in Sylhet 7. Some significant variation in elevations at Tipam level suggests a fault of small through may exist nearby It is also depicted by contour map on top of oil sand designed by Oil & Mining Services (Whitmee, 1987) in Figure 2 1, one of the consultants of Bangladesh Oil, Gas and Mining Corporation (BOGMC) in 1987 But, in this study, a modified map of 1987 is taken from BPI Report no 10 of Khan et al (1991), which shows the latest contour map of Bhuban oil sand in Figure 2 2

Large scale barrier bar sand, a detrital bar at or immediately below the water level at a bay mouth (baymouth bar) or parallel to a shore, exists at tidal ridge deposition of the Boka Bil sands. A noticeable variation in thickness with the overlying and intervening shale beds has been found in this crystal, a plane face figure representing any element or compound of consistent composition Also, the sedimentary facies as seen in Haripur 1 (Sylhet 7) suggest that the gas sands (C to E) are part of a deltaic complex

Figure 2.1: Oil and Mining Services structure contour map of Bhuban oil sand (Boka Bil)

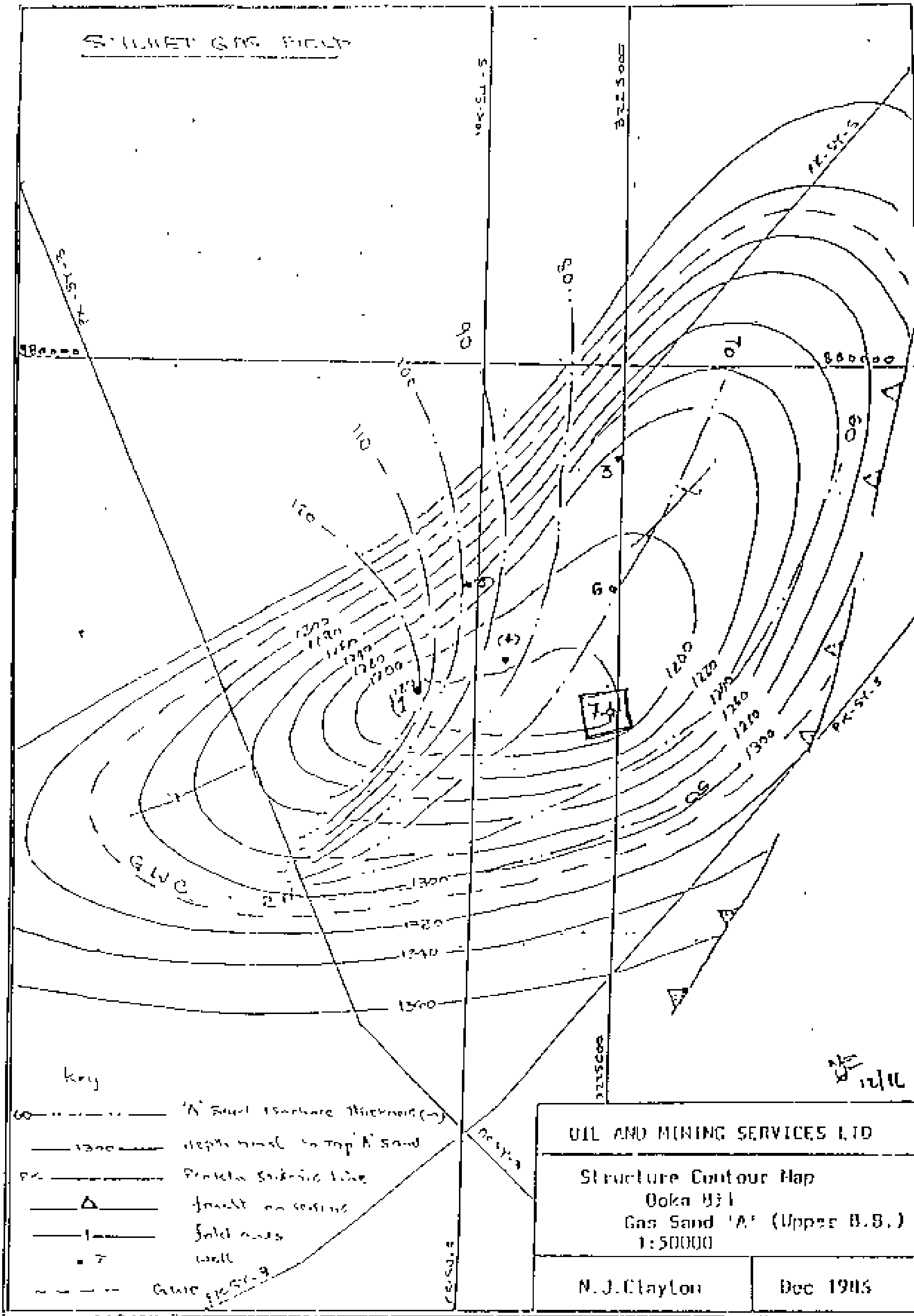
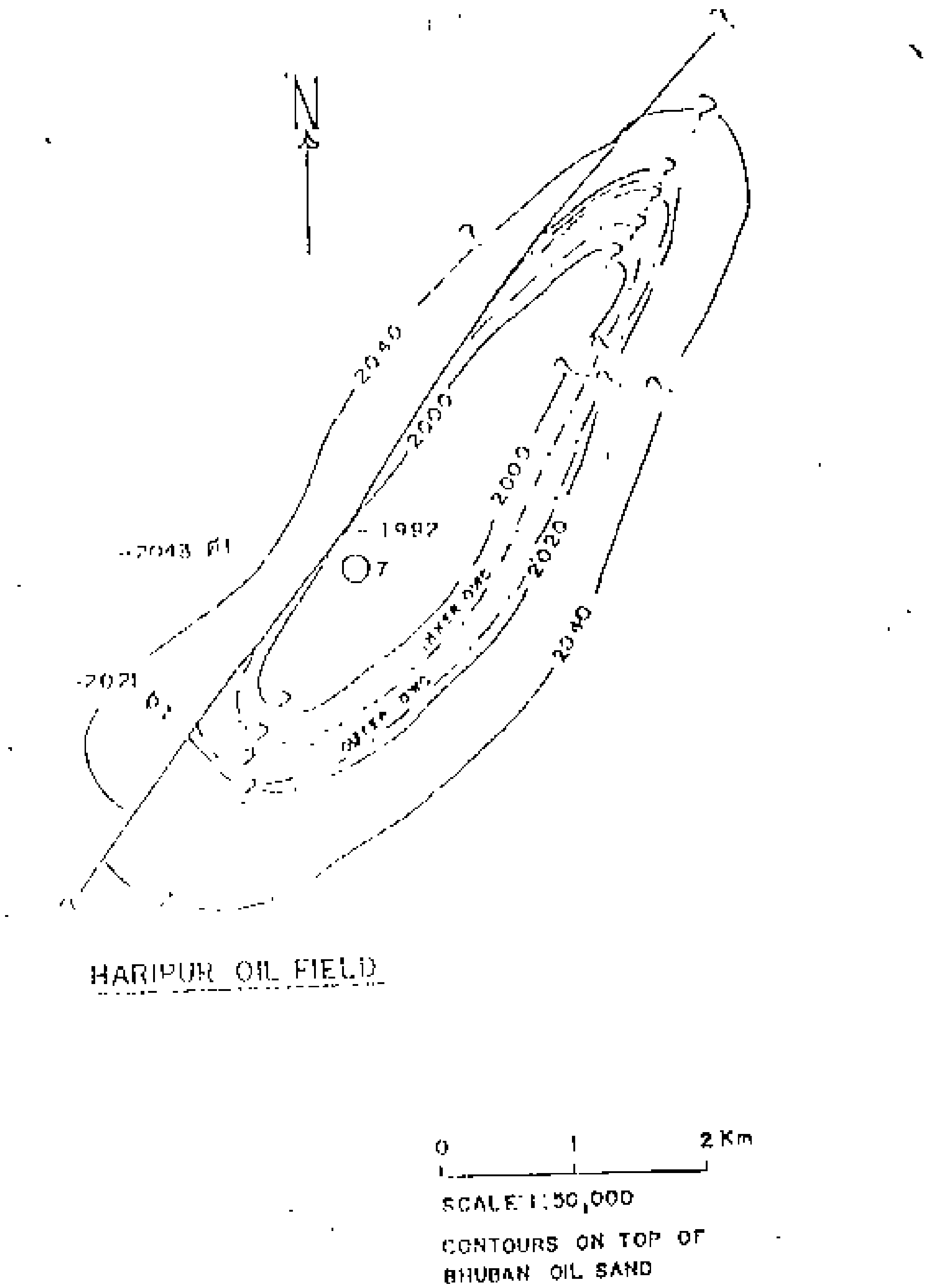


Figure 2 2: Modified BPI map of Bhuban oil sand of BPI report 10 in 1987 (Boka Bil)



2.1.3 Source rock

A sedimentary rock in which petroleum forms is source rock The source rock of entire sequence from the Girujan clays down to the Lower Boka Bil contains finely disseminated carbonaceous material. Both the Upper Boka Bil shale as well as the Lower Boka Bil claystones exhibited finely disseminated wavey carbonaceous laminae. The waxy 28.9 API oil recovered from sands 'D' and 'E' is typically associated with a marginal marine source environment.

2.1.4 Sedimentary sequence with hydrocarbon indications

Tables 2.1, 2.2 and 2.3 below show hydrocarbon zones, well summary and drilling and formation data of Sylhet oil field area.

Table 2.1: Hydrocarbon zones of Haripur 1.

Zone	Net (m)
Tipam Upper	29
Tipam Middle	38
Tipam Lower	15
Boka Bil (Upper)	65.7 (2 meters above well 1 and 1 5 m above well 6)
Boka Bil b (Middle)	11.5
Boka Bil c (Lower)	71 (37 m above well 1)
Boka Bil d (Lower)	-
Boka Bil e (Lower)	-

Source Khan et al. (1991)

Table 2.2: Well data of Haripur 1.

Name of Well	Sylhet 7 (Haripur 1)
Location Latitude (Surface) Longitude	N 24 Deg 58' 36.5 E 92 Deg 02 24 0
Elevation (Rotary Kelly Bushing) RKB Ground level	18.27 M 12 28 M
Total Depth	2065 Meter RKB 475.7 M into the Lower Boka Bil
Spud Date (Ceremonial)	12 September 1986
Days to reach total depth	86 days (7 December 1986)
In Sand	Lower Boka Bil
Deviation Max.	2 degrees
BHT Max	145 degree F
Date of completion	11 January 1987
Days required to test and complete	24.5 days
Status of the Well	Oil Producer

Source: Khan et al. (1991)

Table 2.3. Formation tops of Haripur 1.

Formation	RTKB (m)	BMSL (m)	Thickness (m)
DUPI TILA	Surface	12 (above MSL)	102
TIPAM SERIES	132 0	114	981
Gurujan Clays	132 0	114	63
Upper Tipam	195.0	177	132
Middle Tipam	327.0	309	160.5
Lower Tipam	487.5	469.5	625.2
BOKA BIL SERIES	1113 0	1094 7	952+
UPPER BOKA BIL	1113.0	1094.7	185.5
Upper Marine Shale	1113 0	1094.7	83.8
Top 'A' Sand	1196.8	1178 5	68.7
Lower Shale	1265.5	1247.2	31.0
MIDDLE BOKA BIL	1296.5	1278.2	292 8
Base 'B' Sand (Gas)	1311.0	1292.7	14 5
LOWER BOKA BIL	1589.3	1571.0	475.7+
Upper Sequence	1589.3	1571.0	154.7
Middle Sequence	1744.0	1725.7	130
Lower Sequence	1874.0	1855.7	191
'C' Sand	1774-1957	1855.7-1938.7	83
'D' Sand	1964-1979	1945 7-1960.7	15
'E' Sand	2009.5-2033	1991.2-2014.7	23.5
TOTAL DEPTH	2065.0	2046.7	

Source: Khan et al (1991)

According to the report of Khan et al. (1991) Tipam sandstone series contain 39.3 m of gas and Lower Tipam Sand contains 15 m of gas at the very top of the unit. In Boka Bil series Upper Boka Bil Sand and 'A' contains 65.7 m of gas which is the main sand still being produced by well 3 and well 6. In the upper sequence a significant amount of heavier components (C_7^+) exists over the interval 1630-1645 m. Boka Bil lower sequence contains C, D and E sands which are hydrocarbon bearing 'C' sand contains 71 m of gas bearing sand as determined by sand free test (SFT) which also showed large amount of CO_2 and small amount of H_2O with brown-black waxy oil. Sand D and E at 1982 5 m exhibited slight light brown visible oil staining. SFT samples taken from this sand recovered 28 9 ^{0}API waxy oil as well as gas and formation water with connate water saturation at 2032 m.

2.2 Fluid Composition

Oil and Mining Services (Whitmee, 1987) sampled two sets of pressured gas and oil samples in 1987. Their results yielded a reservoir fluid that would exist in the saturated reservoir. Their study showed an initial solution gas-oil ratio, R_s of 465 SCF/STB at 60^0 F. Formation volume factor, B_o, is 1.224 ft^3/SCF and oil viscosity ranges from 0.832 to 1 568 cp at saturation pressure to atmospheric pressure.

No liquid recovery reported in the production test report of September 1987 Consisting of roughly 90 64% methane, the reservoir gas is classified as a dry gas with 28 9 ^{0}API gravity crude oil (Whitmee, 1987). Oil has high pour point, the temperature at which crude oil will congeal or cease to flow, (75 ^{0}F) and low viscosity due to high percentage of wax about 9.6% (Whitmee, 1987). It also contents little sediments. Table 2.4 shows gas analysis results.

Table 2.4: Reservoir gas analysis results

Gas analysis (core lab)	Percentage
H_2S	0.00
CO_2	0.16
Nitrogen	0.11
Methane	90.67
Ethane	3.58
Propane	1.66
Iso-butane	0.39
n-butane	0.50
Iso-pentane	0.23
n-pentane	0.14
Hexanes	0.24
Heeptanes plus (C_7^+)	2.32
Total	100.00

Source: Khan et al. (1991)

2.3 Reserve Estimation

Volumetric and material balance calculations were done by Oil and Mining Services, Petrobangla and BPI. Initial oil-in-place was estimated using pressure and production data till September 1987. Petrobangla geologists had estimated the stock tank oil originally in place (STOOIP) on volumetric basis to be of the order of 10 million stock tank barrel of oil (MMSTB) (Khan et al., 1991). Again, this has been carried out by Oil and Mining Services (Whitmee, 1987) to recheck Petrobangla figures for the actual estimation of oil reserve. Material balance calculations by Oil and Mining Services show that Haripur is draining a pool with a slightly smaller figure of 8.2 million barrels of STOOIP. Khan et al. (1991) suspect that the reserves could be three or four times larger than assumed in the Oil and Mining Services report Later, Arafin et al. (1991) of BPI suggested that the reservoir has more oil than that of estimated before, however, it would be between 15 93 MMSTB and 21.0 MMSTB. Table 2 5 shows different initial oil-in-place estimates

Table 2.5 Estimated reserves of Haripur oil field.

Method	Oil-in-place reserve (MMSTB)	
	Oil and Mining Services	Others
Volumetric	10.0	10 0 (Petrobangla)
Material balance	8 2	10.1612 and 15.3-21.0 (BPI)
Reservoir limit	8.6	-

Using American Petroleum Institute (API) empirical correlation, the recovery of 19-25% of the oil-in-place may be anticipated depending on the reservoir drive mechanism.

Chapter 3

PROBLEM STATEMENT

Haripur oil field is the only discovered oil field of Petrobangla and this field is not producing any more Production was stopped in June, 1994.

The objective of this study is to analyze the well test data and use that information in simulating the reservoir. It is important to find out actual oil reserve with the aid of simulation as improved version of the structural contour map of BPI (modified from BOGMC map of 1987) is available

The primary objectives of this work are:

1. To conduct the well test analysis and find out necessary reservoir parameters and compare the results with those of the IKM (1993) study
2. To simulate the reservoir and find out the total reserve and determine the reservoir drive mechanism
3. To find out the causes of the production stoppage analyzing the existing documents

Chapter 4

METHODOLOGY OF ANALYSIS

The study is an extension of the work done by IKM in February 1993 which included pressure transient analysis of Haripur oil and gas fields and the reserve estimation study done jointly by Oil and Mining Services (Whitmee, 1987) and Bangladesh Petroleum Institute (BPI) (Khan et al., 1991).

4.1 Pressure Data Analysis

The data was recorded using Amerada pressure gauges due to the non availability of electronic gauge in Bangladesh at that time. Later, the pressure history was recorded using electronic gauge by Intercomp-Kanata Management Ltd. (IKM) in 1993 In this study, only pressure data of IKM (1993) have been used for well test analysis and compared the results with those of IKM

In IKM well test analysis, some basic data like well flow rate and reservoir rock and fluid properties (especially for net pay, porosity, net/gross ratio, etc.) are not available in the report. Therefore for the pressure transient analysis, except pressure gauge recorded data, all other necessary information is taken from Oil and Mining Services and BPI reports Those data are shown in Table 4 1

Table 4.1: Different parameters of Haripur oil field

Parameters	Low	High
Thickness (m)	33.000	37 000
Net/Gross	0 500	0 600
Porosity	0 145	0.150
(1-Sw)	0.500	0.65
Interval (m)	2054.5	2009
Water Saturation (Fraction)	.498	

Source: Arafin et al. (1991) and Whitmee (1987)

Using the above rock and fluid data, pressure survey data of Haripur 1 have been analyzed.

4.2 Reservoir Simulation

Reservoir simulation is a useful tool for understanding the reservoir performance and production forecasting. Earlier reserve estimation and production forecasting were done by Oil and Mining Services (Whitmee, 1987) and BPI (Khan et al , 1991) by hand calculation But no simulation using computer software on Haripur was done either by BPI or by IKM., Arafin et al. (1991) suggested that BPI should perform a Monte Carlo simulation when better seismic data are available. In this study, the simulation has been conducted using a three dimensional compositional model which has features like treatment of variable bubble points and mixing of different PVT regions

Required data for simulation has been shown in Table 4.2 Data have been compiled from BPI report no 10 of Khan et al 1991, BPI report no. 11 of Arafin et al. 1991, study of Whitmee (1987) and Price (1987).

Table 4.2: Fluid PVT properties of Haripur 1.

PVT properties	
Reservoir Pressure	2904 psig
Reservoir Temperature	162 ^{0}F
Separation Temperature	144 ^{0}F
Separation Pressure	75 psig
Z at 2904 psig	0.8530
Gas gravity	0.6826
T_c	377.4279 R
P_c	660 2033 psi
B_g at 2904 psig	0 0051 cuf/scf
B_o at 2904 psig	1 2524 rbbl/stbbl
Pbp	2968 psig
B_o at Bubble point pressure	1.2567
Tank oil gravity solution GOR at 2904 psig	27 6 API

Source: Khan et al (1991), Arafin et al (1991), Whitmee (1987) and Price (1987)

Chapter 5

PRESSURE TRANSIENT ANALYSIS

The application of pressure transient theory through computer assisted techniques allows for the exact compensation for previous production at the source well It is done through calculation of the superposition time function All pressure and production test data was analyzed within the field. Detailed test evaluation was restricted to Lower Boka Bil sand. The information was almost complete for detail review.

5.1 Theory of Pressure Transient Analysis

The differential equation for fluid flow through a porous medium, also known as the diffusivity equation is given by:

$$\frac{\partial^2 p}{\partial r^2}+\frac{1}{r}\frac{\partial p}{\partial r}=\frac{1}{0.0002637}\frac{\phi\mu c_t}{k}\frac{\partial p}{\partial t} \quad \ldots\ldots 5.1.1$$

Matthews' and Russell (1967) presented a derivation of equation 5.1 1 and pointed out the assumptions as: horizontal flow, negligible gravity effects, a homogeneous and isentropic porous medium, a single fluid of small and constant compressibility, and applicability of Darcy's law, and that μ, k, ϕ and c_t and are independent of pressure. As a result of those assumptions, and since the common boundary conditions are linear, equation 5.1 1 is linear and readily solved.

If μ, k, ϕ and c_t are strong function of pressure, or if varying multiple fluid saturation exists, equation 5.1.1 becomes non-linear and its solution becomes much more complicated.

To solve this equation pseudo-pressure and pseudo-time approach is used. Gas viscosity and density vary significantly with pressure, so the assumptions of equation 5.1.1 are not satisfied for gas systems and the equation does not apply directly to gas flow in porous media. That difficulty is avoided by defining a 'real gas potential' or 'pseudo-pressure' as $m(p) = 2\int_{p_b}^{p} \frac{p}{\mu(p)z(p)}dp$, where p_b is an arbitrary base pressure and $z(p)$ is gas deviation factor at that pressure. In very tight formations the use of $m(p)$ alone is not sufficient to linearize the flow equations because if the large Δp at the beginning of the test, the gas compressibility is changing significantly. In this situation it is also necessary to replace the time with a pseudo function, the 'pseudo-time', usually noted t_{pseudo} and defined as.

$t_{pseudo} = \int_0^t \frac{d\tau}{\mu c_t}$, where τ is time of consideration.

5.1.1 Pressure Drawdown Testing Solution

The first significant transient event at a production well is the initial production period that results in a pressure drawdown at the formation face. Properly run drawdown tests may provide information about formation permeability, skin factor and reservoir volume communicating with the well

The pressure at a well producing at a constant rate in an infinite-acting reservoir is given by (Earlougher, 1977):

$$p_i - p(t,r) = 141.2\frac{qB\mu}{kh}[p_D(t_D, r_D, C_D, geometry, \ldots) + s] \ldots\ldots 5.1.2$$

or,

$$p_i - p_{wf} = 141.2\frac{qB\mu}{kh}[p_D(t_D \ldots) + s] \ldots\ldots 5.1.3$$

where the initial reservoir pressure is p_i. The dimensionless pressure (p_D) at the well ($r_D = 1$) is given by the exponential-integral solution to the flow equation is,

$$p_D(t_D, r_D) = -\frac{1}{2}E_i(\frac{-r_D{}^2}{4t_D}) \approx \frac{1}{2}[\ln(t_D / r_D{}^2) + 0.80907] \ldots\ldots 5.1.4$$

or,

$$p_D = \frac{1}{2}[\ln(t_D) + 0.80907] \ldots\ldots 5.1.5$$

When $t_D / r_D{}^2 > 100$ and after wellbore storage effects have diminished Dimensionless time (t_D) is given by:

$$t_D = \frac{0.0002637kt}{\phi\mu c_t r_w{}^2} \ldots\ldots 5.1.6$$

Equations 5.1.3 through 5.1.6 may be combined and rearranged to a familiar form of the pressure drawdown equation:

$$p_{wf} = p_i - \frac{162.6qB\mu}{kh}[\log t + \log(\frac{k}{\phi\mu c_t r_w{}^2}) - 3.2275 + 0.86859s] \ldots\ldots 5.1.7$$

Equation 5.1.7 describes a straight-line relationship between p_{wf} and $\log t$. By grouping the intercept and slope terms together, it may be written as

$$p_{wf} = m \log t + P_{1hr} \quad \ldots 5.1.8$$

Here, from the semi-log plot, p_{wf} vs $\log t$, slope of the semi-log straight line m is determined by, $m = -\frac{162.6 qB\mu}{kh}$ and the formation permeability k is estimated from $k = -\frac{162.6 qB\mu}{mh}$ and clearly, $\frac{kh}{\mu}$, kh or $\frac{k}{\mu}$ also may be determined.

The skin factor s is determined by,

$$s = 1.1513[\frac{p_{1hr} - p_i}{m} - \log(\frac{k}{\phi \mu c_t r_w^2}) + 3.2275] \quad \ldots 5.1.9$$

5.1.2 Pressure Buildup Testing Solution

Most pressure build up test analysis techniques assume a single well operating at a constant flow rate in an infinite reservoir For any pressure-buildup testing situation, any time after shut-in (Earlougher, 1977)

$$p_{ws} = p_i - \frac{141.2 qB\mu}{kh}\{p_D([t_p + \Delta t]_D) - p_D(\Delta t_D)\} \quad \ldots 5.2.1$$

where p_D is the dimensionless-pressure function, t_p is the equivalent time well was on production or injection before shut-in and Δt_D is as defined by

i.e. $\Delta t_D = \frac{0.0002637 k \Delta t}{\phi \mu c_t r_w^2}$ ... 5.2.2

During the infinite acting time period, after wellbore storage effects have diminished, and assuming that there is no major, induced fracture, then, p_D in equation 5.1.1 may be replaced by the logarithmic approximation to the exponential integral (equation 5.1.4),

$$p_D = \frac{1}{2}(\ln t_D + 0.80907) \quad \text{5.2.3}$$

Equation 5.2.3 applies when $t_D > 100$. By using equation 5.2.2 and equation 5.2.3, equation 5.1.1 may be rewritten as:

$$p_{ws} = p_i - m\log\left(\frac{t_p + \Delta t}{\Delta t}\right) \quad \text{5.2.4}$$

Equation 5.2.4 describes straight line with intercept p_i and slope $-m$, where

$$m = \frac{162.6qB\mu}{kh} \quad \text{5.2.5}$$

which is the same as in the pressure drawdown test.

Average reservoir pressure in an infinite acting reservoir $(p^* = p_i = \overline{p})$ may be estimated by extrapolating the straight-line portion of a Horner plot, $p_{ws}\ vs\ [(t_p + \Delta t)/\Delta t]$ plot which have a straight line section with slope $-m$, for a shut-in well to $[(t_p + \Delta t)/\Delta t] = 1$ Average reservoir pressure of a finite reservoir can be estimated following the method of Miller, Dyes and Hutchinson (MDH) from MDH data plot $(p_{ws}\ vs \log \Delta t)$ when $t_p < t_{pss}$ (Earlougher, 1977)

Equation 5.2.4 indicates that a plot of observed shut-in buttomhole pressure, p_{ws}, $vs \log[(t_p + \Delta t)/\Delta t]$ should have a straight-line portion with slop $-m$ that can be used to estimate reservoir permeability,

$$k = \frac{162.6qB\mu}{mh} \quad \text{5.2.6}$$

Skin may be estimated from the buildup test data and the following pressure immediately before the buildup test

$$s = 1.1513\left[\frac{p_{1hr} - p_{wf}(\Delta t = 0)}{m} - \log\left(\frac{k}{\phi \mu c_t r_w^2}\right) + 3.2275\right] \quad \ldots\ldots 5.2.7$$

Wellbore storage is computed from the slope m as (SAPHIR operating manual V2 20E, 1992):

$$C = \frac{\left[\frac{T_{Match}}{k}\right]}{m \times \left[\frac{P_{Match}}{kh}\right] \times CM \times h} \quad where\, CM = \frac{0.8936}{\phi c_t h r_w^2} \quad \ldots\ldots 5.2.8$$

The equation for different regimes are expressed in a form independent of the fluid type, as a function of $\frac{P_{Match}}{kh}$ and $\frac{T_{Match}}{k}$.

Here, $[\frac{T_{Match}}{k}] = \frac{0.000264}{\phi \mu C_t r_w^2}$ is for in all cases.

And $[\frac{P_{Match}}{kh}]^{p}_{oil} = \frac{1}{141.2qB\mu}$ for single-phase oil and

$[\frac{P_{Match}}{kh}]^{m(p)}_{multiple} = \frac{1}{141.2q}$ for multiphase (SAPHIR operating manual, 1992).

Horner plot is used to find out permeability and skin factor where equivalent time (t_p) is used. Here, $t_p = \frac{24V_p}{q}$, where V_p is the cumulative volume produced since the last pressure equalization and q is the constant rate just before shut in.

5.2 Pressure Test Data

Pressure test data collected by IKM in 1993 are used for creating plots of cartesian or type-curve (simulation), semi-log, log-log (pressure/derivative profile plot), and Horner plot The data from the bottom gauge were chosen as the basis for detailed pressure transient analysis

Appendix 1 shows the IKM (1993) pressure data. Well and reservoir properties were collected from values provided by BPI report of Khan et al. (1991), Arafin et al. (1991) and Oil and Mining Services reports (Whitmee, 1987).

The matching of the test build up data has been considered with a simple model. This model represents the behavior of a well with wellbore storage and skin in a homogeneous, infinite-acting reservoir of infinite lateral extent.

There were three flow periods. The IKM (1993) collected the pressure data for 48.5920 hr at a rate of 155 STB/day then stopped for 71.8580 hr and then again data collected for 17 6170 hours at the rate of 155 STB/day, which had been taken at a depth of 6609 70 feet

In IKM analysis fluid properties were not provided and were calculated from the standing correlations for a 30 ^{0}API degree oil (IKM, 1993). But, here reservoir parameters have been available according to the SAPHIR data requirements. Test type is standard and input test parameters and PVT informations are given below according to Table 5 1.

Table 5 1: Pressure transient analysis input data.

Reservoir parameters	Value	Reservoir parameters	Value
Porosity (ϕ)	0.1475	Formation volume factor (B)	1.2524 ft^3/SCF
Well radius (r_w)	0 292 ft	Total compressibility (c_t)	1.4564E-5
Pay zone (h)	101.68 ft	Viscosity (μ)	1 2 cp.

The temperature of the formation was taken as 162 ^{0}F.

5.3 Transient Analysis and Results

The pressure transient data from all drawdown and build up periods have been accurately examined for the pressure dependent changes in gas viscosity and compressibility factor, all the pressure data have been transformed to pseudo-pressure, by initial functions within the program

The pressure data from both gauges are compared in terms of pressure, pressure and flow rate difference with time. Cartesian (simulation) plot is shown in Figure 5.1, which shows pressure and production profile with time for drawdown and build up periods, which is prepared with the help of pressure gauge data of IKM (1993)

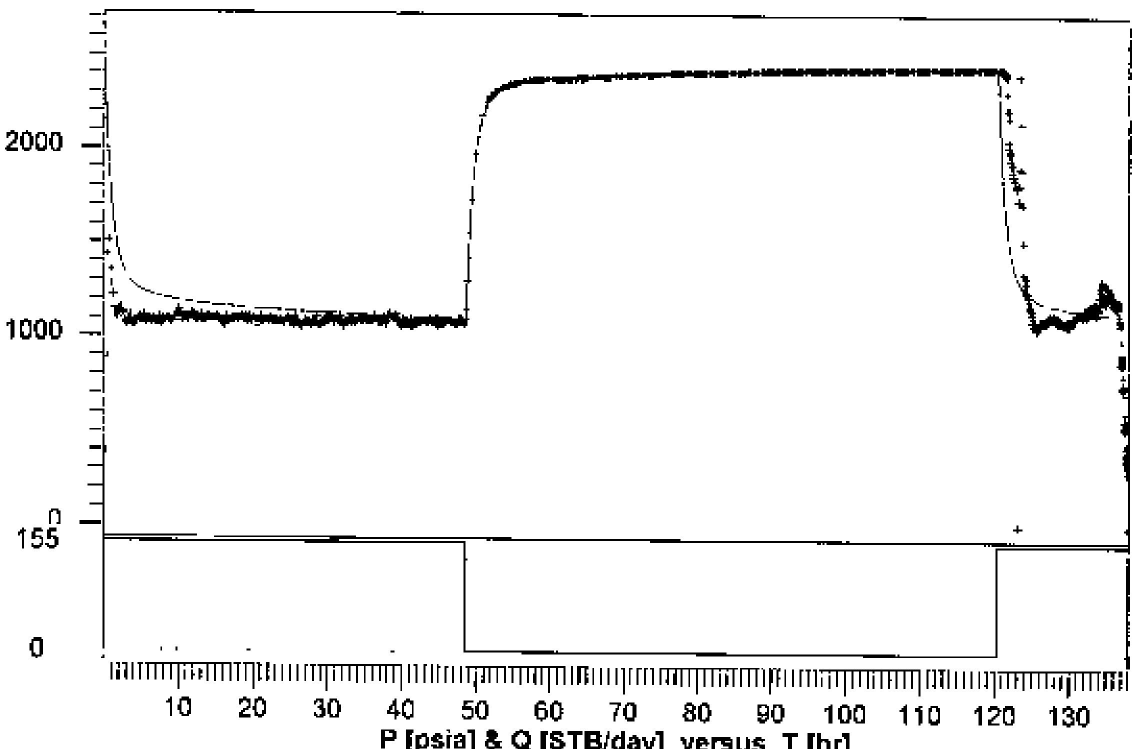
Figure 5.2 is a semi-log plot of pressure vs. superposition time, which have a straight-line section with slope $-m$. Straight line appears after wellbore damage and storage effects have diminished

The log-log pressure/derivative profile of dp and dp' [psia] vs dt [hr] is shown in Figure 5.3. This shows the relationship between pressure and pressure derivative with

Figure 5 1 Simulation (cartesian plot) profile of build up and drawdown test

	Simulation	SYLHET#7

Company	PMRE, BUET	Test	1999 pressure survey
Field	Haripur	Date	30/01/93 - 04/02/93
Well	Haripur 1	Gauge	

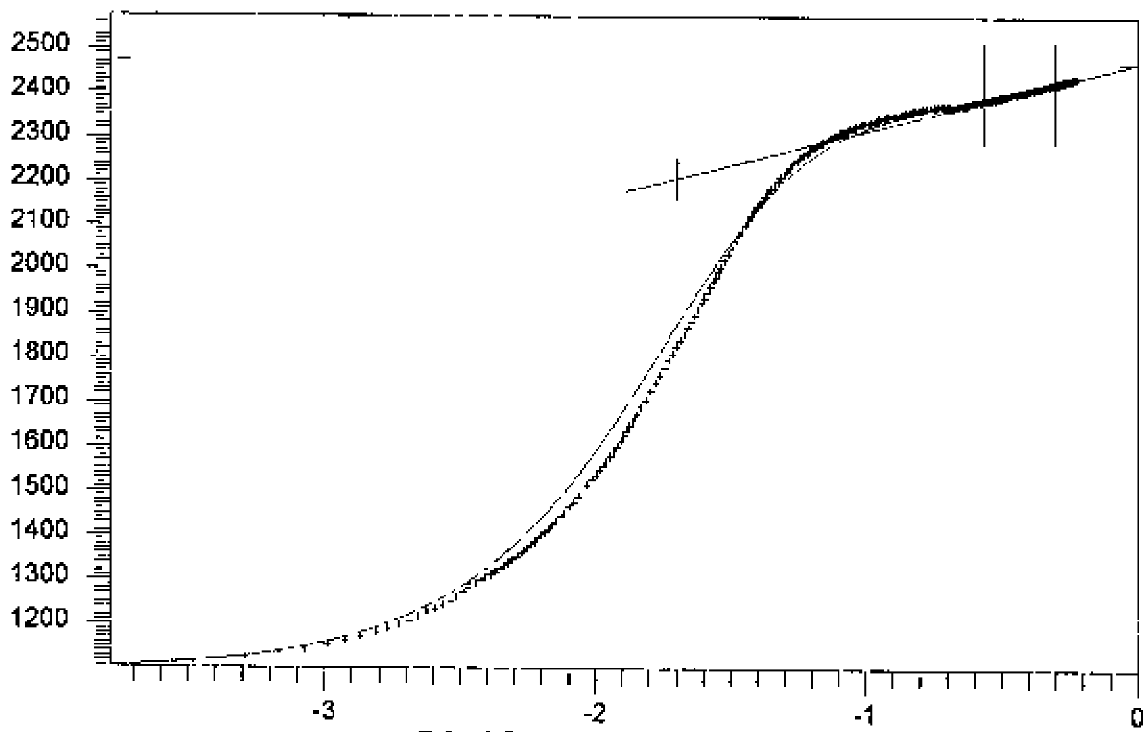


Flow Period #	2	RESERVOIR	Homogeneous
Rate	0 STB/day	BOUNDARY	Infinite
Rate Change	155 STB/day	WELL	Storage & Skin
P at dt=0	1092.3 psia	Storage C	0 00595 STB/psi
Pi	2460.68 psia	Skin factor	6.41
		Delta P Skin	655 917 psia
Time Match	13.3 (hr)-1		
Pressure Match	0.00977 (psia)-1	kh	321 md.ft
		k	3.16 md
		Mobility k/mu	2.63

Figure 5 2: Semi-log plot of Haripur oil field pressure data with early time match

	Semi-Log	SYLHET#7

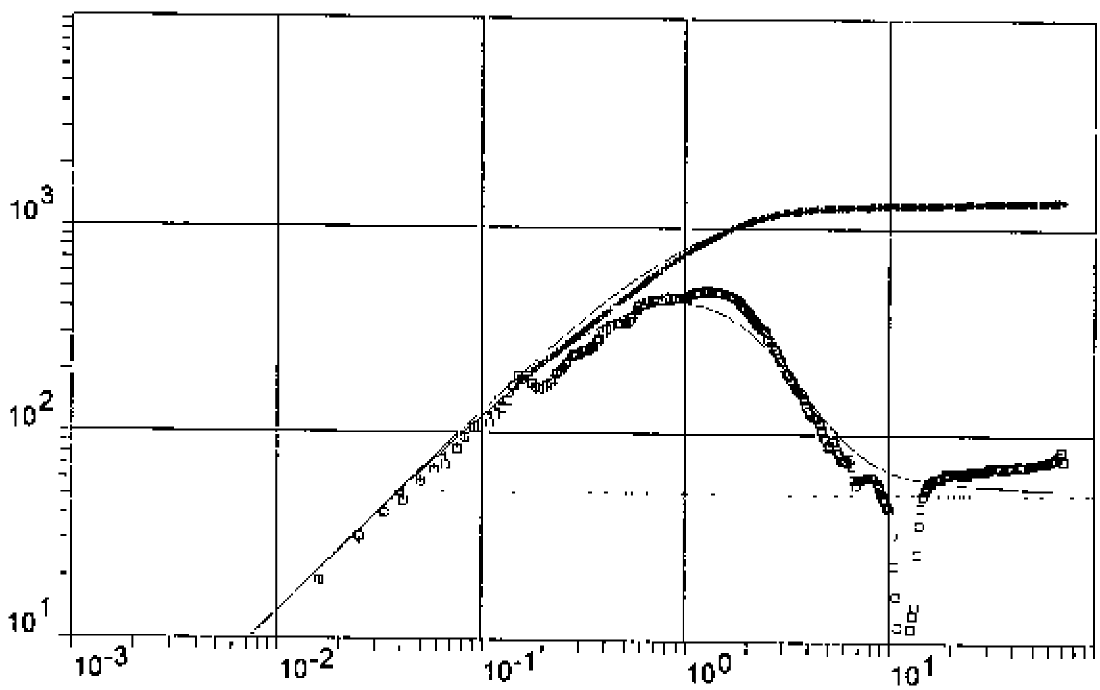
Company	PMRE, BUET	Test	1999 pressure survey
Field	Haripur	Date	30/01/93 - 04/02/93
Well	Haripur 1	Gauge	



Flow Period #	2	RESERVOIR	Homogeneous
Rate	0 STB/day	BOUNDARY	Infinite
Rate Change	155 STB/day	WELL	Storage & Skin
P at dt=0	1092.3 psia	Storage C	0.00595 STB/psi
Pi	2460 68 psia	Skin factor	6.41
		Delta P Skin	655.917 psia
STRAIGHT	LINE		
		kh	321 md.ft
From	18 hr	k	3.16 md
To	47 4 hr	Mobility k/mu	2 63
Slope	155 psia		
Intercept	2467.64 psia		
value at dt=1hr	2204.67 psia		
-> p*	2467.64 psia		
->PMatch	0.00742 (psia)-1		
-> k.h	244 md.ft		
-> k	2.4 md		
-> Skin	3.86		
Time Match	13.3 (hr)-1		
Pressure Match	0.00977 (psia)-1		

Figure 5.3. Pressure and pressure derivative plot on Log-log plane

Log-Log				SYLHET#7
Company	PMRE, BUET	Test	1999 pressure survey	
Field	Haripur	Date	30/01/93 - 04/02/93	
Well	Haripur 1	Gauge		

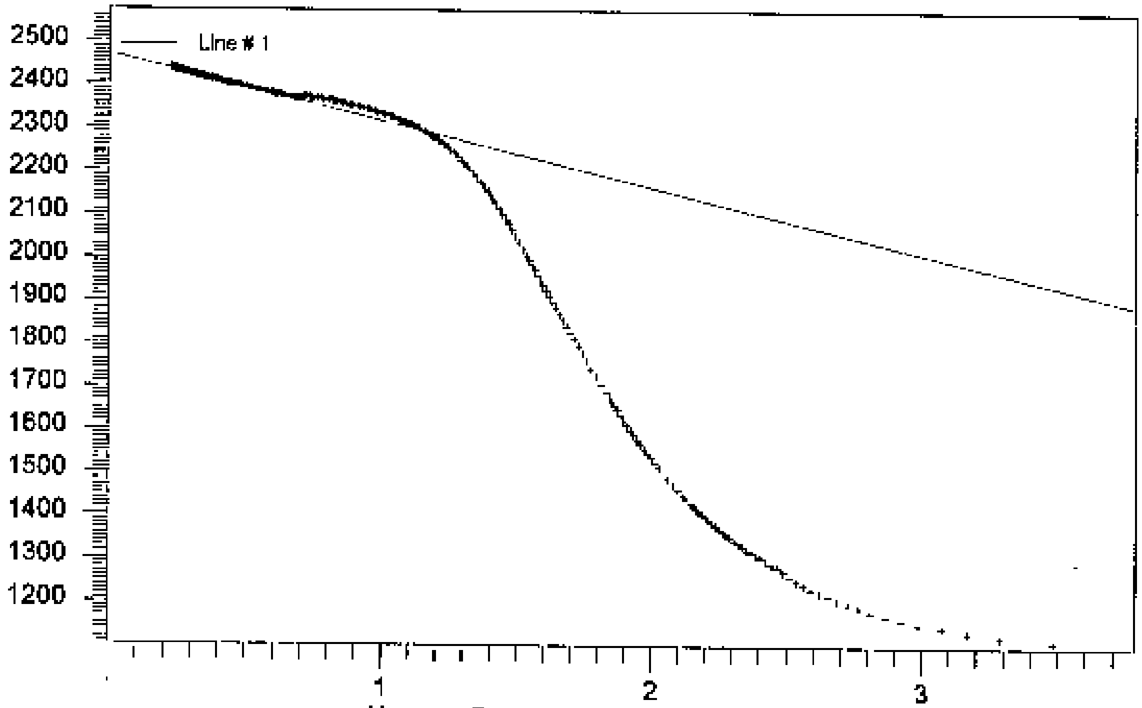


dP & dP' [psia] versus dt [hr]

Flow Period #	2	RESERVOIR	Homogeneous
Rate	0 STB/day	BOUNDARY	Infinite
Rate Change	155 STB/day	WELL	Storage & Skin
P at dt=0	1092 3 psia	Storage C	0.00595 STB/psi
Smoothing	0 1	Skin factor	6 41
Pi	2460.68 psia	Delta P Skin	655 917 psia
Time Match	13 3 (hr)-1	kh	321 md ft
Pressure Match	0.00977 (psia)-1	k	3.16 md
		Mobility k/mu	2.63
		Investig. R	272 ft

Figure 5.4 Horner (flexible) plot with one line match with late time match

	Flexible		SYLHET#7
Company	PMRE, BUET	Test	1999 pressure survey
Field	Haripur	Date	30/01/93 - 04/02/93
Well	Haripur 1	Gauge	



Flow Period #	2
Rate	0 STB/day
Rate Change	155 STB/day
P at dt=0	1092 3 psia
Pi	2460.68 psia
Flexible line #	1
P vs	Log(dt), BU
Slope	-152.944
Intercept	2467 29
kh	248 md ft
k	2.43 md
Skin factor	4

time for the oil bearing sand The unit slope illustrated in the log-log diagnostic plot in Figure 5.3 characterizes the well bore storage dominated flow period. The unit slope line is followed by a transition flow period, which is followed by the infinite-acting, radial-flow period. The infinite-acting, radial-flow period is characterized by a straight line of slope 0.5. Thus, during this period, the derivative plot shows a constant slope of 0 5.

To continue the analysis, a generalized Horner diagnostic plot for the build-up period, p_{ws} vs $\log[(t_p + \Delta t)/\Delta t]$ is set out in Figure 5 4, providing insights into the test behavior. After dissipation of wellbore storage and skin effect, the pressure at the gauge level actually declines with time before re-establishing a build up period. The Horner straight line during the later stages of the build-up match is shown in this figure.

From all the above curve analysis reservoir properties are found. In this regard, the log-log plot uses early time pressure data whereas Horner plot uses late time pressure data. Thus, slope of semi-log is 155 psia/cycle and that of Horner is −152 944 psia/cycle. The main test results are provided in Table 5.2.

Table 5.2: Pressure transient analysis results of Haripur oil field'

Parameters	Result	
	Type curve	Build up
Initial pressure (p_i), psia	2460.68	2460.68
Reservoir Capacity (kh), md.ft	321	248
Permeability (k), md	3.16	2 43
Wellbore Storage Coefficient, STB/psi	0 00595	0 00595
Mobility (k/μ), psia	2 63	2 63
Skin Factor (s)	6 41	4.00
Time match, 1/hr	13.3	-
Pressure match, 1/psia	0.00977	0.00742
Pressure (p) at $dt = 0$, psia	1092.3	1092.3

The important results to note about the analysis are the average reservoir permeability, 2.43 md and apparent skin factor, +4.00. The absolute magnitude of each variable is highly dependent on the slope of the straight line. While the results are indicative of the measured transient behavior, a minute suppression of the pressure build up through thermal transients could result in higher calculated permeability than that exists in the reservoir.

The initial reservoir pressure of the sand was determined in this study is 2460 68 psia. The IKM found the initial average reservoir pressure 2468.922 psia But Oil and Mining Services (Whitmee,1987) found it around 2927 psia.

5.4 Comparison of Results of SAPHIR with those of IKM Analysis

Reservoir rock and fluid data used in this study have been taken mostly from BPI (1991) and Oil and Mining Services (Whitmee, 1987), whereas in IKM (1993) study most of those data was assumed. So there is a variation in data as well in results A comparison of results is shown in Table 5 3.

Table 5.3 Comparison of results in Pressure transient analysis with IKM.

Properties	SAPHIR			IKM workbench
	Semi-Log	Type-curve (Simulation)	Horner	
Reservoir	Homogeneous	Homogeneous	Homogeneous	Homogeneous
Boundary	Infinite	Infinite	Infinite	Infinite
Well	Storage & skin	Storage & skin	Storage & skin	Storage & skin
C (STB/psi)	0 00595	0.00595	–	0.006564
p_i (psia)	2460 68	2460 68	2460.68	2468.922
r_i (ft)	–	186	–	161
kh (md.ft)	244	321	248	251
Skin (s)	3.86	6.41	4.0	4.1
k (md)	2.4	3.16	2 43	2.19

The estimated permeabilities from the study are 2.4 md, 3.16 md and 2.43 md using semi-log, type-curve and build-up analysis, respectively. The permeability estimated by IKM (1991) was 2.19 md Similarly the skin factors estimated from this study are 3.86, 6 41 and 4.0 using semi-log, type-curve and Horner analysis, respectively. IKM (1991) study found the skin as 4.1. It can be observed that the semi-log and Horner analysis results compare very well with the IKM results, whereas, the type-curve results of this study are slightly higher. This has happened probably due to some noise in the pressure transient data.

Chapter 6

SIMULATION STUDIES

The reservoir sands of Haripur oil field have been simulated using historical data and thereafter production forecasts through gas cap possibility have been made. An implicit compositional model has been used to simulate the reservoir. Compositional simulators can model performance of volatile oil and gas condensate reservoirs in which phase compositions vary widely with pressure. The confidence level of the forecasts depends heavily on the accuracy of the geological data as well as the fluids and reservoir properties.

6.1 EXODUS Simulator

Numerical reservoir simulator EXODUS (V 4.00, 1997) is a general purpose compositional model for simulating black oil, gas or gas condensate, and volatile oil reservoirs. The compositional formulation of the model accurately represents the phase behavior for the treatment of variable points of PVT regions, tracer tracking and differentiation of injected and in place fluids The transfer of any component between the oil, gas and water phases is calculated using equilibrium ratios. In this model black oil data are internally converted to compositional models.

The program can simulate problems in one, two or three dimensions using either rectangular (x-y-z) or cylindrical (r-Ø-z) coordinates, with any combination of oil, gas or water phases, and characterizing the reservoir fluid into one or more components.

Interblock mass transfer is represented by Darcy's law with relative permeability, capillary pressure and gravity effects. The reservoir description capability includes naturally fractured and communicating faulted reservoirs Dual porosity/dual permeability reservoirs may be simulated. The model also allows special connection of non-neighboring grid cells for unconventional problems Wells can be vertical, deviated or horizontal. Multiphase correlations are fully coupled to provide pressure losses in the tubing

Simulator has non-linear regression parameter built into it whereby the program user may find the best values of porosity, permeability, relative permeability that will match observed field history. This is commonly known as automatic history matching This feature is of great value in reducing the time required to obtain a history match.

6.2 Mathematical Basis for Implicit Compositional Model

The simulation model is a fully implicit, three dimensional, multi-component model for simulating isothermal processes. The finite difference formulation is a block centered approximation to the partial differential equations. In addition to five and nine point finite difference approximations, the model allows the linking of any pair of grid cells for mass transfer.

In finite difference formulation a partial differential equation is converted to a finite difference equation using the Taylor series expansion. The reservoir is discretized to a number of blocks and each block is represented by a finite difference equation The boundary conditions are also converted to a corresponding finite difference equation. These result in a set of algebraic equations, which is then solved using a suitable scheme.

Mathematical formulation used in the model is briefly discussed below:

Any component can exist in any phase and we assume there are N phases and N_C components

Component balance, i = 1, 2 .. .. N_C

$$\sum_{n=1}^{N} \nabla\left[T \frac{k_{rn}\rho_n X_{in}}{\mu_n}(\Delta P + \Delta P_{cn} - \gamma_n \Delta z)\right] = \frac{V}{\Delta t}\partial\left(\phi \sum_{n=1}^{N} \rho_n S_n X_{in}\right) + q_i \quad \text{...... .. ..6.1.1}$$

where the terms are : T = transmissibility; k_r = relative permeability; ΔP = pressure drop, ΔP_c= capillary pressure drop, γ = specific gravity; V= volume; Δt= length of timestep, ρ = density; q_i = production rate

The interface mass transfer is handled by means of K values. Thus for each pair of phases, e.g , oil and gas :

$$y_i = K_{go} X_i \quad \text{.... . ... .6.1.2}$$

where y_i is the mole fraction of component, i, in the gas phase, K_{go} is the interface mass transfer coefficient for the component i, X_i is the mole fraction of component, i, in the oil phase.

Phase constraint equations, one for each phase, ensure that the mole fractions sum to 1.

$$\sum_{i=1}^{N_c} X_{in} = 1.0 \qquad 6.1.3$$

A saturation constraint equation :

$\sum_{n=1}^{N_c} S_n = 1.0$, completes the equation set

6.3 Model Configuration and Reservoir Grid Description

Partial differential equations that describe fluid flow in reservoirs are solved numerically, by discretising the differential equations with difference equations. To use difference equations, a reservoir is treated as if it is composed of discrete volume elements and changes in conditions within each volume element are computed over each of many discrete time intervals. Reservoir volume elements are termed as gridblocks.

The net isopach maps used in the model were prepared and modified from BOGMC map of 1987 (Khan et al , 1990).

A three-dimensional 25×7×5-grid is shown in Figure 6 1 and grid-model of the contour map with a net pay zone of 2020-2040 m used for simulation and production forecast as shown in Figure 6 2.

Well locations are selected from perforation intervals of wellbore diagram provided by IKM (1993). The interval is between 6628 and 6670 ft as shown in Appendix 2.

Figure 6.1. Model grid system with 25×7×5 grid used in Lower Boka Bil Sand

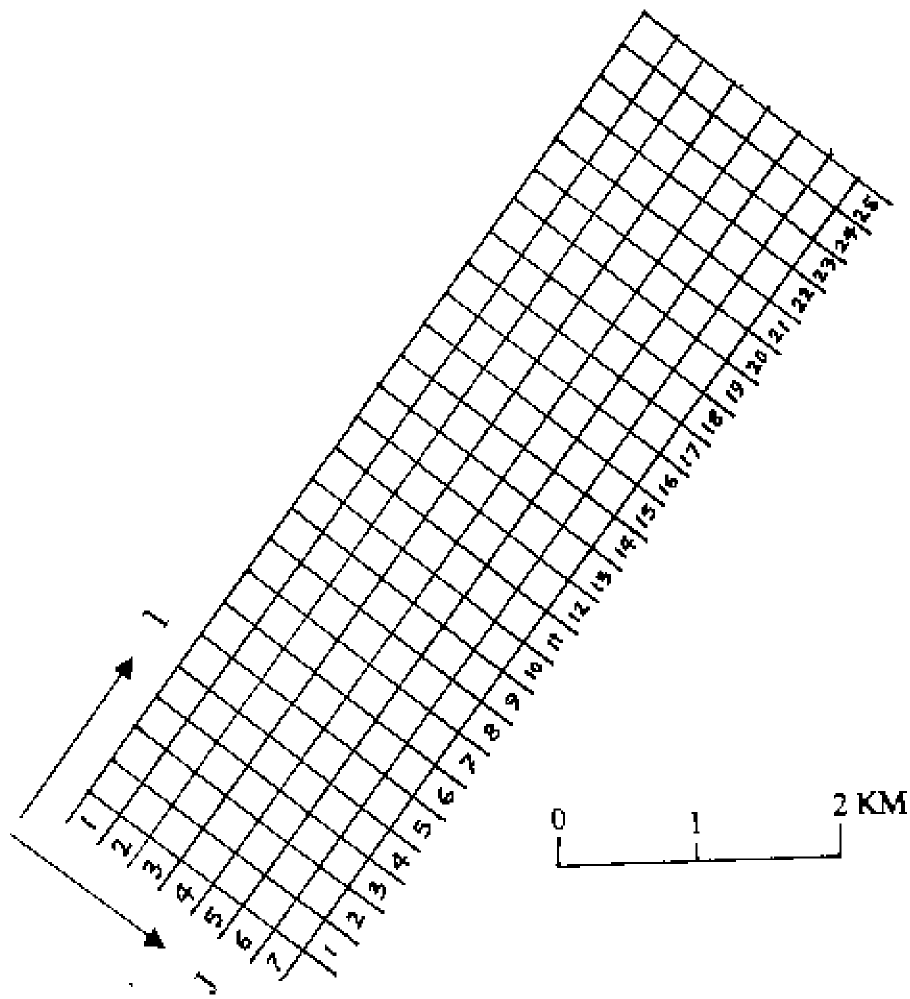


Figure 6.2: Net pay isopach map of Lower Boka Bil Sand with grid

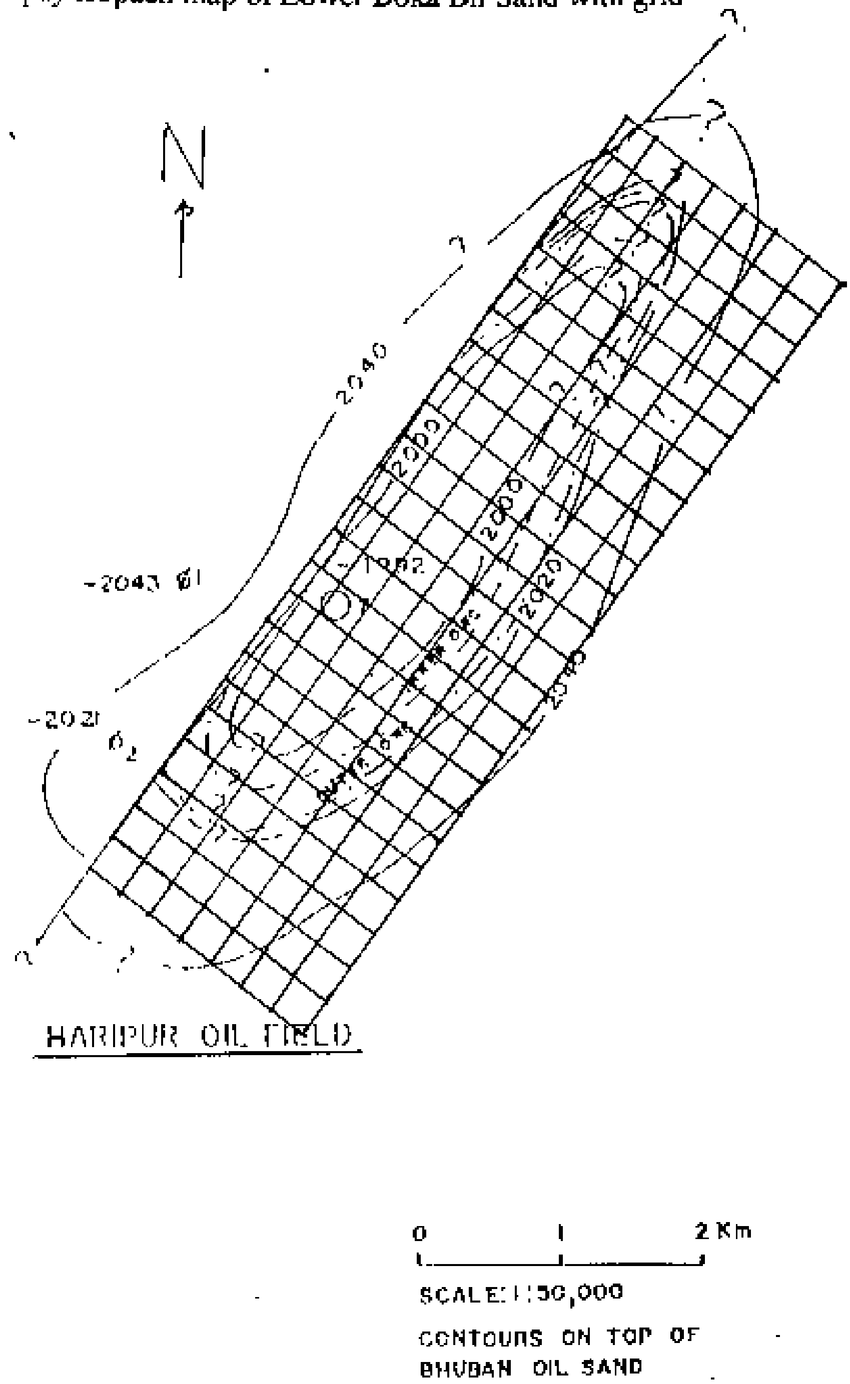


Fig-1 (Modified From BOGMC Map of 1987)
B P I Report No:10

6.4 Simulation Input Parameters

Most of the input parameters used in this study are taken from the previous studies conducted by BPI (Khan, 1991). The rock and fluid properties have been assumed uniform throughout the model. The necessary input data for the simulation study have been compiled from geological and geophysical study (Whitmee, 1987), core-analysis (Price, 1987), well-log analysis, well-test results compiled by BPI (Khan et al., 1991 and Arafin et al , 1991), IKM (1993) and from this pressure transient analysis. SGFL provided the production data of Haripur 1. All data are given according to simulation procedure.

Table 6 1 shows differential vaporization at reservoir pressure, which is used to prepare different input data, required by the simulator.

Table 6.1 Differential vaporization at various reservoir pressure.

Pressure psig	Solution Gas/Oil Ratio	Relative Total Volume	Oil Density gm/cc	Deviation Factor Z	Gas Formation Volume Factor	Oil viscosity (cp)	Calculated Gas Viscosity (cp)
2913	465	1.224	0.7784			0.832	
2350	376	1.192	0.7860	0.881	0.00653	0.889	0.0175
1800	289	1.160	0.7980	0.889	0.00858	0.978	0.0160
1250	203	1.128	0.8104	0.910	0.01261	1.105	0.0147
700	118	1.097	0.8234	0.943	0.02311	1.269	0.0136
240	46	1.068	0.8367	0.976	0 06707	1 661	0 0128
0	0	1.044	0.8458			1 568	

Gravity of Residual Oil =28.5 ^{0} API @ 60 ^{0}F

Source Khan et al (1991)

6.4.1 PVT properties

Reservoir fluid properties have been taken from BPI report (Khan et al., 1991) which is given below in Table 6.2. Other properties like specific gravity of gas in surface condition is taken as 0.83, stock tank oil density as 55.0 lb/cuft and bubble point pressure as 2913.73 psia and the surface water density is taken as 63.022 lb/cuft from BPI report 10 (Khan et al., 1991)

Table 6.2 PVT properties at different pressure.

B_o rb/stb	R_s SCF/STB	B_g rcf/scf	μ_o cp	μ_g cp	B_w rb/stb	μ_w cp
1 0936	47	0.0466	3.7959	0.0129	1.01302	0 444
1.1048	75	0.0294	3 2300	0.0132	1.01118	0.444
1.1164	105	0.0212	2.8056	0.0135	1.01059	0.444
1.1283	136	0 0165	2 4784	0.0139	1 00937	0.444
1.1404	167	0.0134	2.2197	0.0143	1.00815	0 444
1 1527	198	0.0112	2.0105	0.0148	1.00694	0.444
1 1652	230	0.0097	1.8382	0.0153	1.00572	0 444
1 1779	263	0.0085	1.6940	0.0159	1.00450	0 444
1.1906	296	0.0076	1.5716	0 0165	1.00329	0.444
1.2035	329	0.0068	1.4666	0.0172	1.00207	0.444
1.2166	362	0.0063	1.3754	0.0179	1.00000	0.444
1.2297	396	0 0058	1.2956	0.0186	1.00000	0.444
1.2429	430	0 0054	1 2251	0.0193	1 00000	0.444
1.2524	454	0.0051	0.8320	0.0200	1 00000	0 444
1 2500	460	0 0049	1 1100	0 0201	1 00000	0.444
1.2444	465	0 0047	1.1603	0.0203	1.00000	0 444
1.2435	483	0 0045	1.1700	0.0205	1.00000	0 444

Source: Khan et al. (1991), Arafin et al., (1991) and Whitmee (1987)

6.4.2 Relative permeability and Capillary pressure

Irreducible water saturation and residual gas saturation are taken to be 0.22 and 0.3, respectively (Whitmee, 1987). Capillary pressure and relative permeability data are not available and these values have been calculated using Honarpour correlations. So Honarpour correlation (EXODUS V 4 00, 1997) was used to prepare a saturation function data which is shown in Table 6.3A and 6.3B. Assuming lithology and wettability as sandstone and conglomerate water-wet, respectively. Other properties have been taken as connate water saturation (s_{wc}) is 0 2, residual oil-water saturation (s_{orw}) is 0.25, connate gas saturation (s_{gc}) is 0 1, residual gas-oil saturation (s_{org}) is 0.2, residual gas permeability [$k_{rg}(s_{org})$] as 1.0 and absolute rock permeability k (air) is 614 md. Using these data water saturation (s_w), liquid saturation (s_l), residual water permeability (k_{rw}) and residual gas permeability (krg) have been obtained Parameter for regression analysis of the K_{rw} table value (p_{ar} k_{rw}) and parameter for regression analysis of the k_{row} table value (p_{ar} k_{row}) is zero. Also, parameter for regression analysis of the k_{rg} table value (p_{ar} k_{rw}) and parameter for regression analysis of the k_{rog} table value (p_{ar} k_{row}) is zero.

Table 6.3A: Saturation function data

s_w	k_{rw}	k_{row}	p_{cw} (psia)	p_{ar} k_{rw}	p_{ar} k_{row}
0 20000	0	1	7	0	0
0 24231	0.00287	0.71602	4	0	0
0.28462	0.00596	0.54974	3	0	0
0.32692	0 00941	0.41661	2.5	0	0
0 36923	0 01341	0.31166	2	0	0
0.41154	0.01819	0.23026	1.5	0	0
0.45385	0.02408	0.16817	1	0	0
0.49615	0.03143	0.12152	0.5	0	0
0 53846	0.04072	0.08683	0.25	0	0
0.58077	0.05246	0 06103	0	0	0
0.62308	0.06727	0 04145	0	0	0
0 66538	0.08585	0.02586	0	0	0
0 70769	0 10899	0.01247	0	0	0
0.75	0 13756	0	0	0	0
1	0 47719	0	0	0	0

Table 6.3B: Saturation function data.

s_l	k_{rg}	k_{rog}	p_{cg} (psia)	p_{ar} k_{rg}	p_{ar} k_{rog}
0.2	0.77992	0	3 9	0	0
0 4	0 36416	0	3.5	0	0
0.425	0.32191	0.00001	3	0	0
0 45	0.28184	0 00007	2.5	0	0
0.475	0 24392	0.00021	2	0	0
0.5	0.20817	0.00054	1.5	0	0
0.525	0.17458	0 00116	1	0	0
0.55	0.14315	0.00225	0.5	0	0
0.575	0.11389	0 00404	0.2	0	0
0 6	0.08679	0.00683	0	0	0
0.625	0.06185	0.01102	0	0	0
0.65	0.03907	0 0171	0	0	0
0 675	0 01845	0.02568	0	0	0
0.7	0	0.03753	0	0	0
1	0	1	0	0	0

6.4.3 Reservoir parameters

Thickness of the different layers of the sands is obtained from the net isopach map and BPI Report no. 10 (Khan et al., 1991). Dead oil viscosity and bubble point viscosity have been taken as 5 3444 cp and 1.1603 cp, respectively. Average thickness, well diameter, porosity, skin factor, permeability and initial pressure values have been obtained from the well completion reports compiled by Arafin et al. (1991), Whitmee (1987) and pressure transient analysis results These values are shown in Table 4.1 and Table 6.4.

Table 6.4: Reservoir input parameters.

Parameter	Value				
	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
I and J Grid distance (ft)	863.55				
Net thickness (ft)	4.10	4.92	4.92	5.74	5.74
Gross thickness (ft)	16.40	19.68	19.68	22.96	22.96
Top depth (ft)	6589.52	6605.92	6625.60	6645.28	6691.20
X, Y and Z permeability (k)	88.5				
Initial datum pressure (psi)	2460.68				
Initial saturation pressure (psi)	2927.73				
Rock compressibility, 1/psi	0.00000923				
Initial water saturation	0.25				
Initial gas saturation	0.20				

Source: Khan et al. (1991), Arafin et al. (1991) and Whitmee (1987)

6.5 Reservoir Scenarios

Non-availability of tabulated actual production data caused a great problem for comparison of simulation model output but the annual production reports of Sylhet Gas Field Limited (SGFL) have been taken into consideration.

A detailed graphical data are provided in Appendix 3.

In this simulation study two reservoir scenarios are considered.

Case I. Reservoir with a gas cap

Case II: Reservoir without a gas cap

6.5.1 Case I: Reservoir with a gas cap

Reservoir contour map of the Lower Boka Bil is divided into 25×7×5 layers for simulation. Input data are given according to the data requirement of the simulator Since gas cap is considered, gas-oil contact should be situated above the pay zone of Lower Boka Bil and it is assumed at 6601.00 ft according to Whitmee (1987). The water-oil contact, highest level where water saturation is 100 percent, has been considered at the depth of 6700.00 ft (Khan et al., 1991).

Khan et al of BPI (1991) assumed that no gas cap initially existed in the oil bearing zone but a gas cap may develop later in the production history. Arafin et al. from BPI (1991) have a suspicion that the oil reserves of Haripur 1 is possible having gas in Sylhet 1, Sylhet 2 and Sylhet 3. Also from the production scenario high gas-oil ratio (GOR) indicates presence of a gas cap This GOR indicated that oil flow would correspondingly decrease as the gas flow increases, which is a normal function of relative permeabilities.

From the results obtained from simulation run, on the 17th of July, 1994 oil rate was about 88 bbl/day with high GOR of 2740.168 SCF/STB and cumulative water production of 0 03 MMBBL. But the cumulative oil production was only 0.296 MMSTB. This is quite low as the reserve of STOOIP found by volumetric / material balance analysis conducted by BPI and Oil and Mining Services, which is not less than 8 0 STOOIP. From the latest production report total oil withdrawal from the pool was 0.63 MMSTB on the 14th of July, 1994 So simulation results is much lower than the actual production.

Production rate obtained from this model is quite different from the actual production data available. Actual oil production is much higher than that of model output of Case I

Comparison of result is shown in Figure 6 3, 6.4 and 6.5 with actual oil, gas and GOR production, respectively

Figure 6 3: Comparison of Case I oil production results with the actual oil production

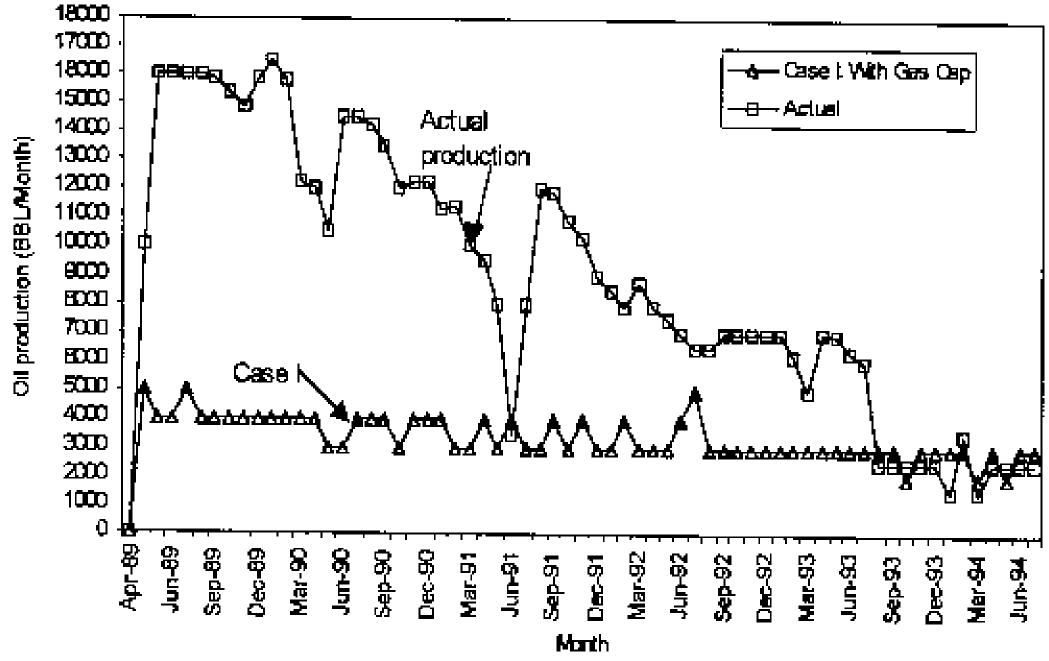


Figure 6.4: Comparison of Case I gas production results with the actual gas production

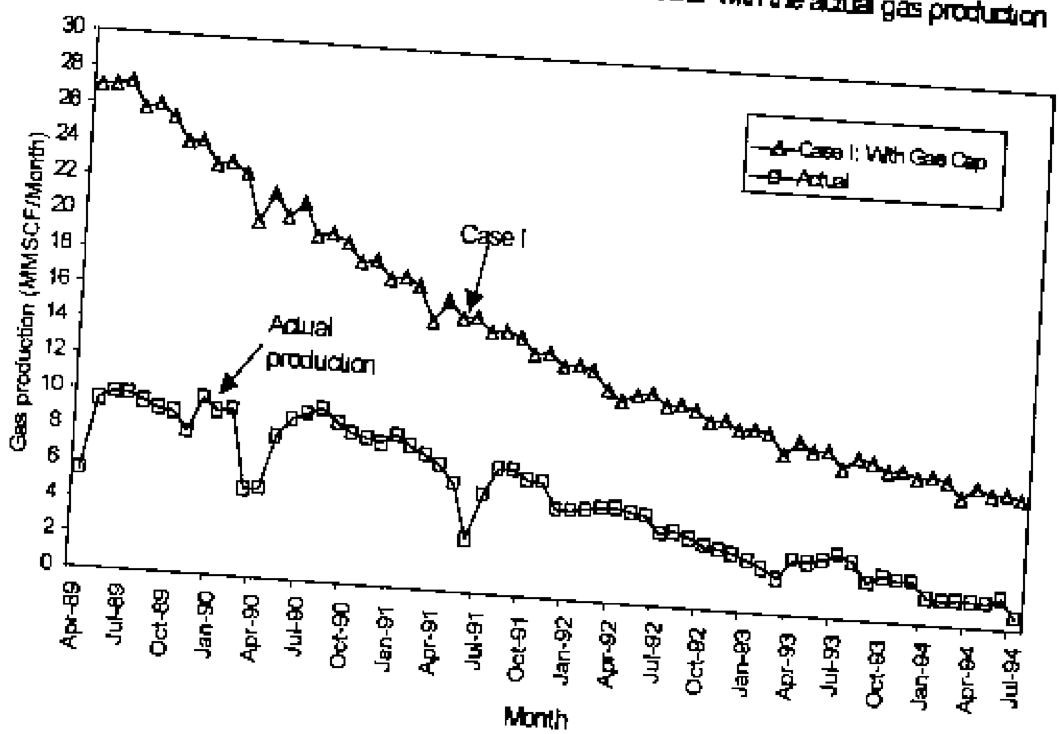
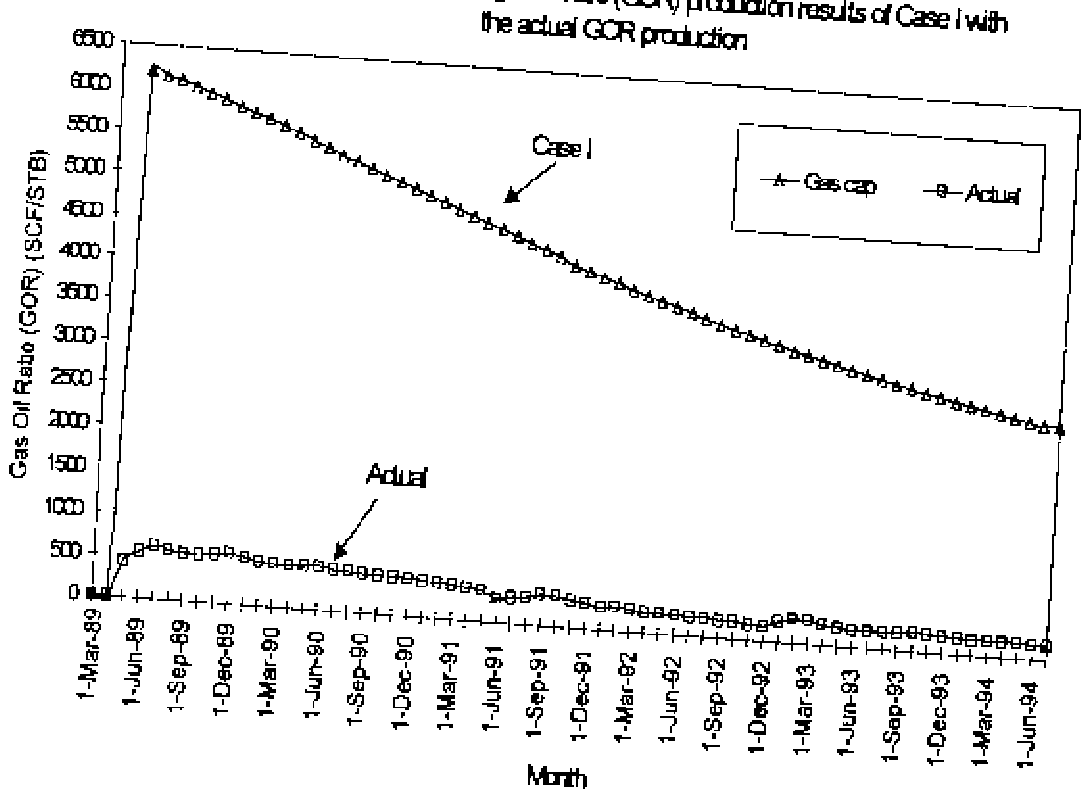


Figure 6.5. Comparison of gas oil ratio (GOR) production results of Case I with the actual GOR production



In Figure 6.3, actual oil production is very much higher than that of Case I. But at the end of August 1993, it fairly the same as the actual oil production rate.

In case of Figure 6.4, actual gas production rate shows much lower than that of model output of Case I.

On the contrary, GOR production will be very much higher in this case than that of actual and this has been shown in Figure 6.5.

Detailed results are provided in Appendix 4.

It is to be mentioned that the Case I simulation results have not matched with the actual field history. Simulation results predict that the oil-in-place of Haripur oil field is 21 2 MMBBL

6.5.2 Case II: Reservoir with no gas cap

BPI material balance calculations were done assuming no water influx and no gas cap for the oil pool. In Case II simulation the same assumptions, i e., no water influx and no gas cap have been considered

Input dates were kept the same as those of Case I. There is no indication of gas cap in Lower Boka Bil as predicted by Arafin et al of BPI (1991). So gas water contact has been assumed at 6700.00 ft The gas-oil contact is considered at 6585.00 and water oil contacts is considered at the same level as that considered in Case I.

This case shows higher cumulative production of oil than that of Case I. On the 17th of July, 1994 the oil rate was 221.97 bbl/day with a lower rate of GOR 323.518 SCF/STB. Lower GOR may result due to absence of gas cap. Cumulative water production is also considerably low, which is 0.03 MMBBL. Cumulative Oil production is 0 635 MMSTB Average gas rate is 0.072 MMCF/D. But oil and gas recovery is only 2 567% and 1 558% respectively. Which are very low with respect to the oil-in-place obtained from the material balance study conducted by BPI (Khan et al. 1991)

From actual cumulative production of June 1991 total oil production was about 0.387 MMSTB and at that time gas production was 491.57 MMSCF (Khan et al 1991). In this study on 17th of June, 1991, the cumulative oil and gas productions were 0.373 MMSTB and 127.41 MMSCF, respectively. Although the oil production is comparable, gas production predicted by this model is much lower. This indicates that there may be some gas cap or increased gas saturation towards the top of the formation.

Figure 6.6: Comparison of Case II oil production results with the actual oil production

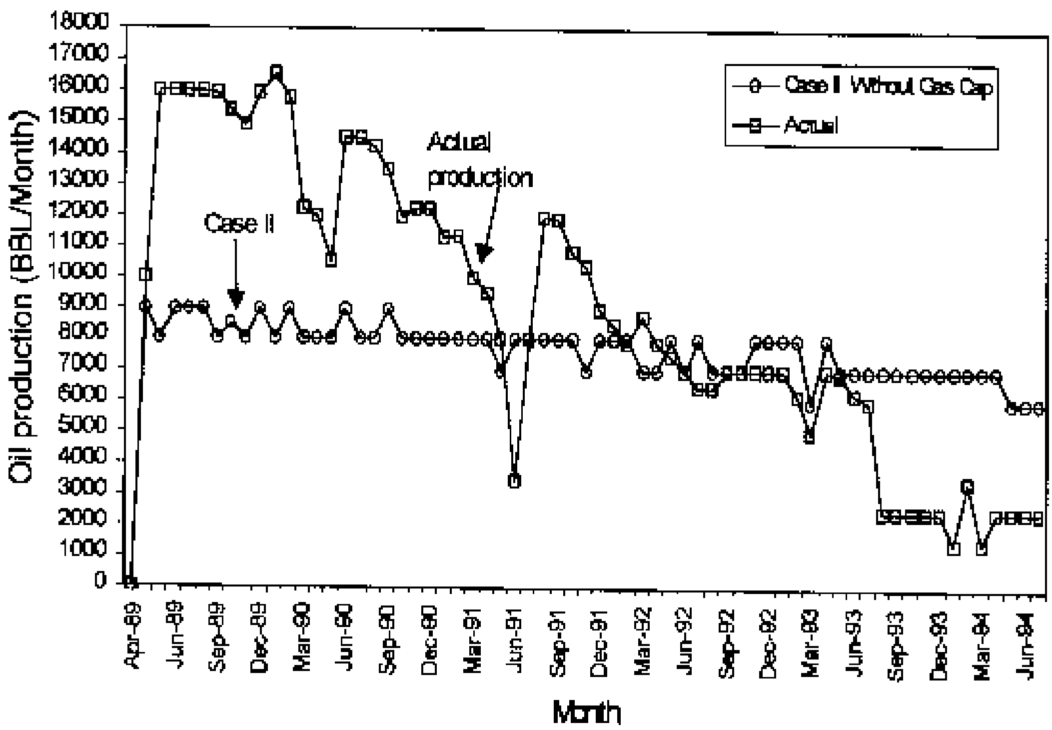


Figure 6.7: Comparison of Case II gas production results with the actual gas production

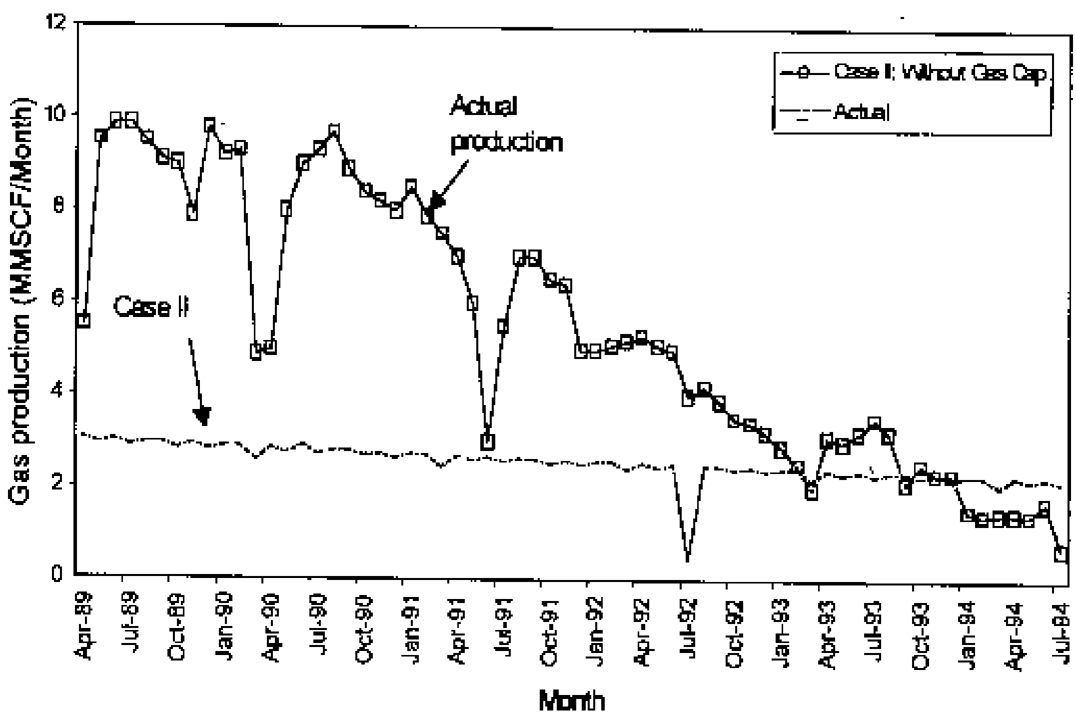
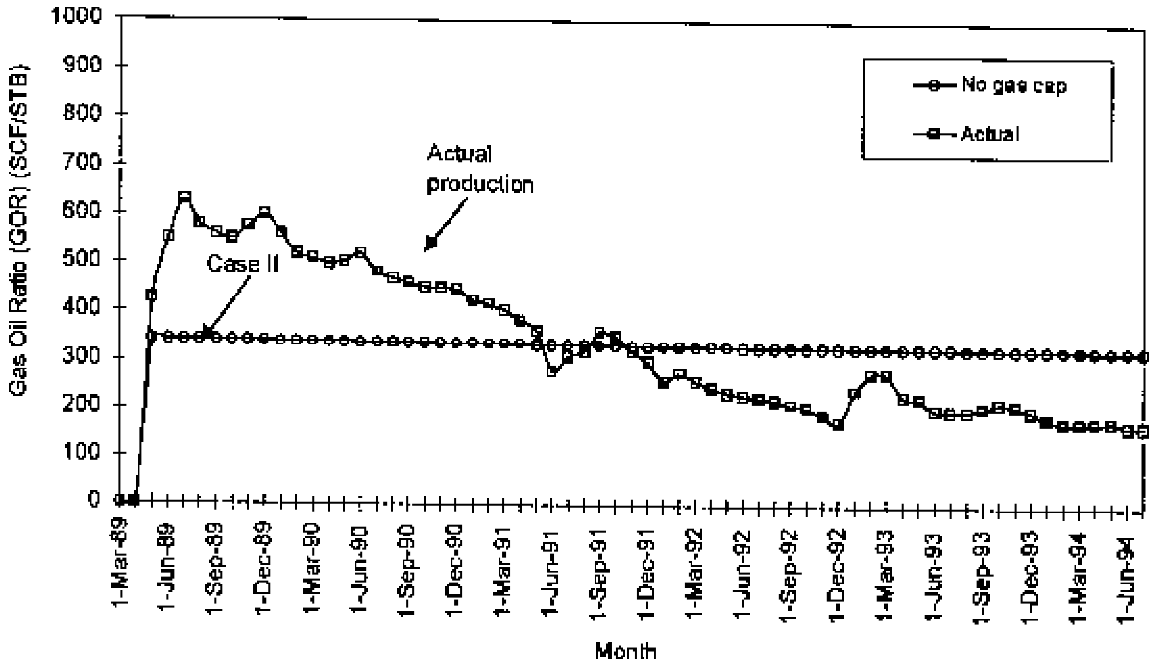


Figure 6.8: Comparison of gas oil ratio (GOR) production resultsof Case II with the actual GOR production



Production rate found in this model is similar to the actual production of Haripur 1. Initially actual oil production was higher than that of model output of Case II. Figures 6.6, 6.7 and 6.8 show the comparison of results of oil, gas and GOR production, respectively.

From the early 1992 to mid 1993, the actual oil production and model output were the same. Later on the model output of Case II become higher than the actual production which is shown in Figure 6.6

From mid 1993 in Figure 6.7, gas production results of Case II matches with the actual production of the well.

GOR production fairly matches with that of actual in Figure 6.8

But model output does not match properly throughout the whole production period This might have happened due to wax solidification in the tubing, which the simulator is unable to model properly

Detailed results are provided in Appendix 5.

It is to be mentioned that the Case II simulation results have not matched with the actual field history In this case simulation results predict that the oil-in-place of Haripur oil field is 24 7 MMBBL.

6.6 Comparison of Results for the Cases I and II

Results of Case I and Case II have been analyzed. Case I has shown that reservoir will produce very high GOR, gas production and considerably very low oil production where as Case II shows lower values for GOR, gas production and produce high oil production At the end of simulation date (16th of December, 1994), GOR, cumulative gas production and cumulative oil production of Case I are 2580.444 SCF/STB, 1362.709 MMCF and 0.309 MMSTB, respectively and those for Case II are 322.492 SCF/STB, 223.926 MMCF and 0.668 MMSTB, respectively. Water production for Case II is almost the same as that of Case I. Excessive GOR with high gas production for Case I is due to gas cap consideration Case II shows an oil production, which is very close to that of actual trend. Comparisons of results of two cases are shown in Figures 6 9, 6.10, 6.11 and 6.12 of oil, gas, GOR and water production, respectively.

Figure 6.9: Cumulative oil production with time for Case I and Case II

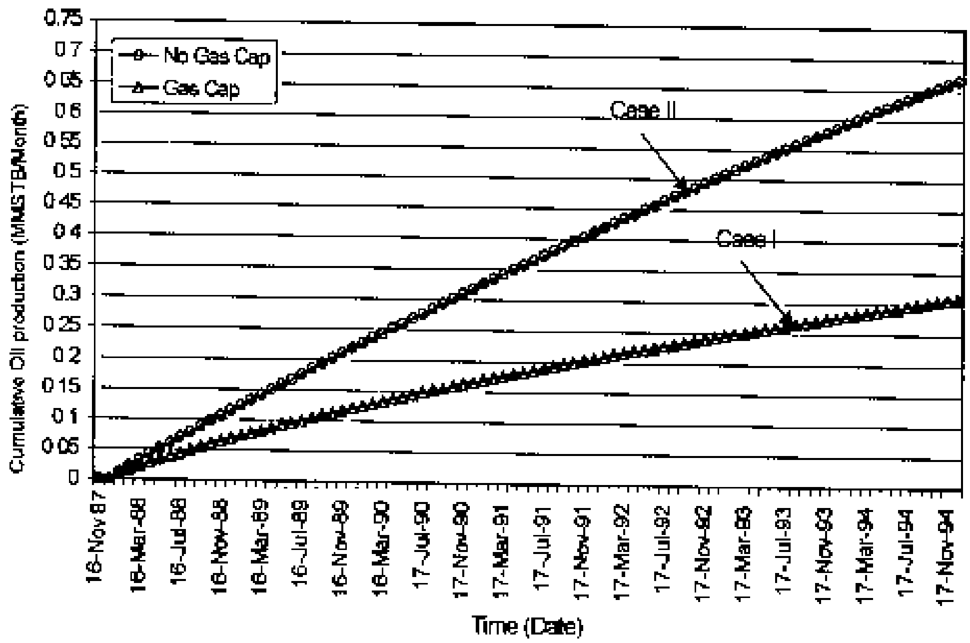


Figure 6.10. Cumulative Gas production with time for Case I and Case II

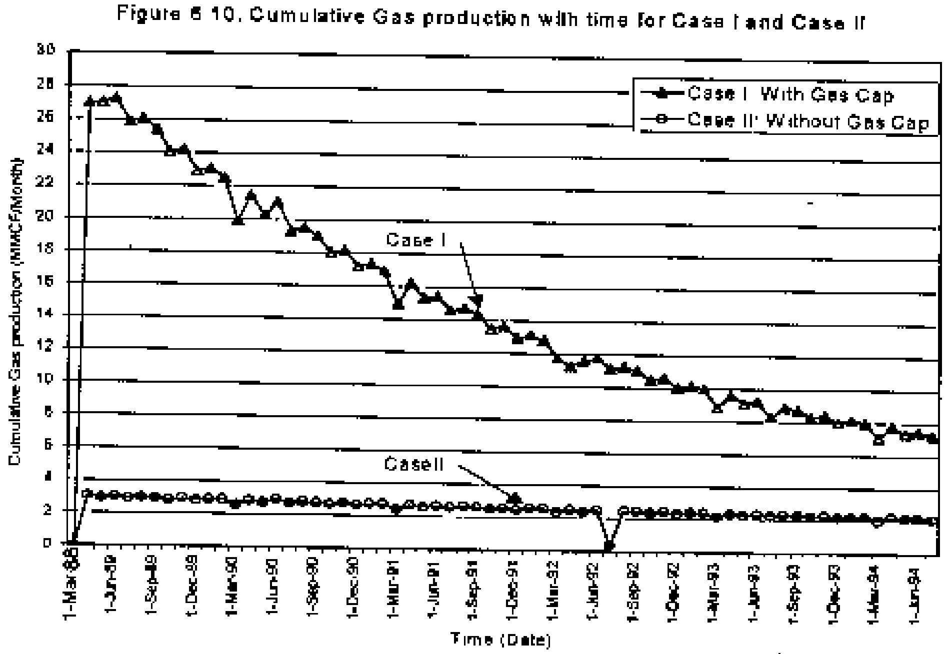


Figure 6 11: Cumulative gas oil ratio (GOR) with time for Case I and Case II

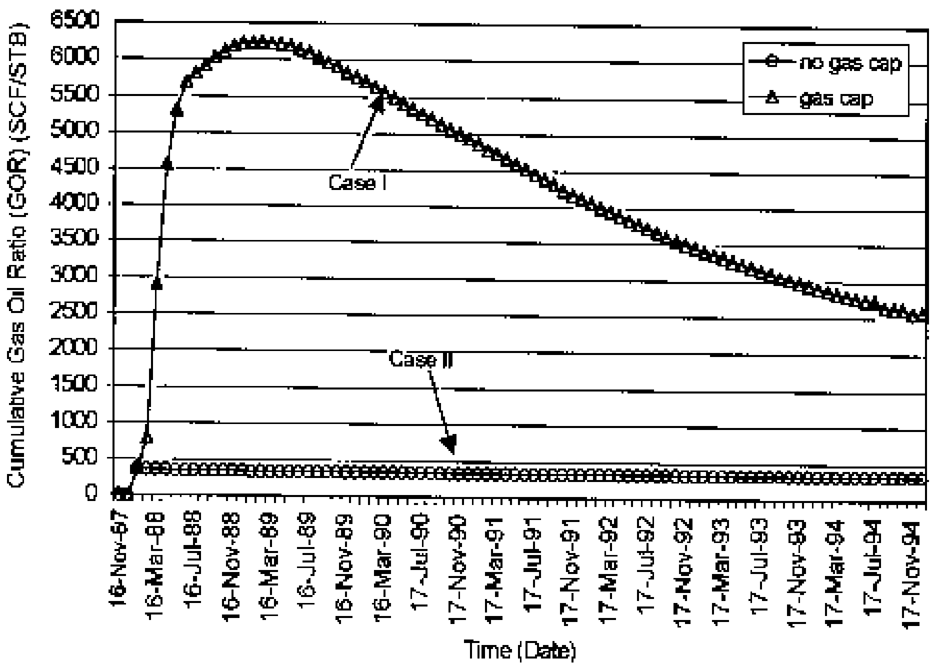
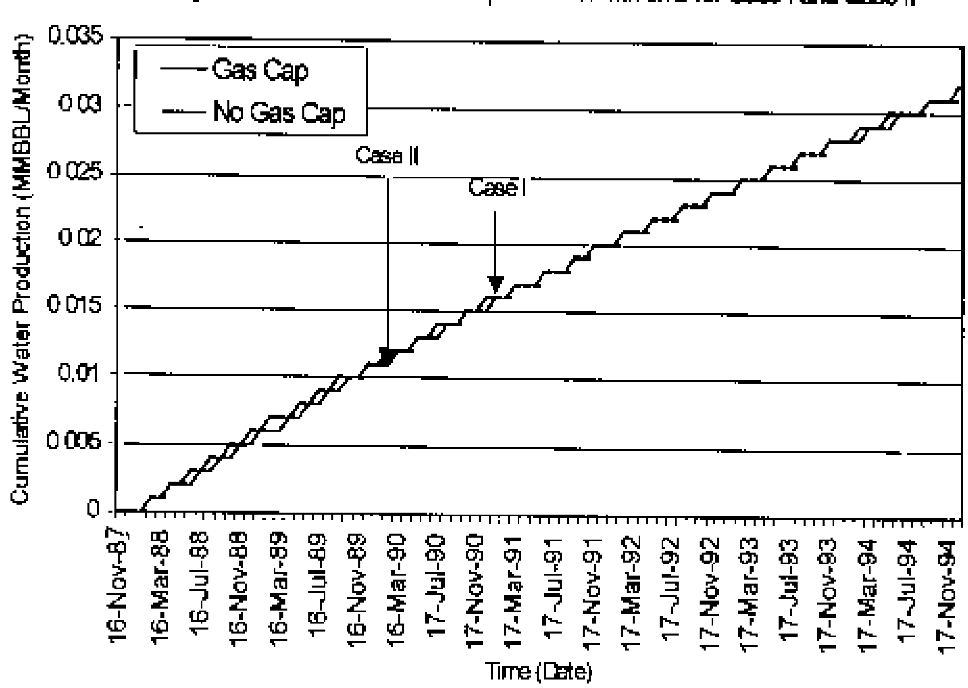


Figure 6.12: Cumulative Water production with time for Case I and Case II



6.7 Comparison of Results with the Actual Production Data

Results are shown in tabular form below. Here results of Case I and Case II have been obtained from the simulation results are compared with the actual production data.

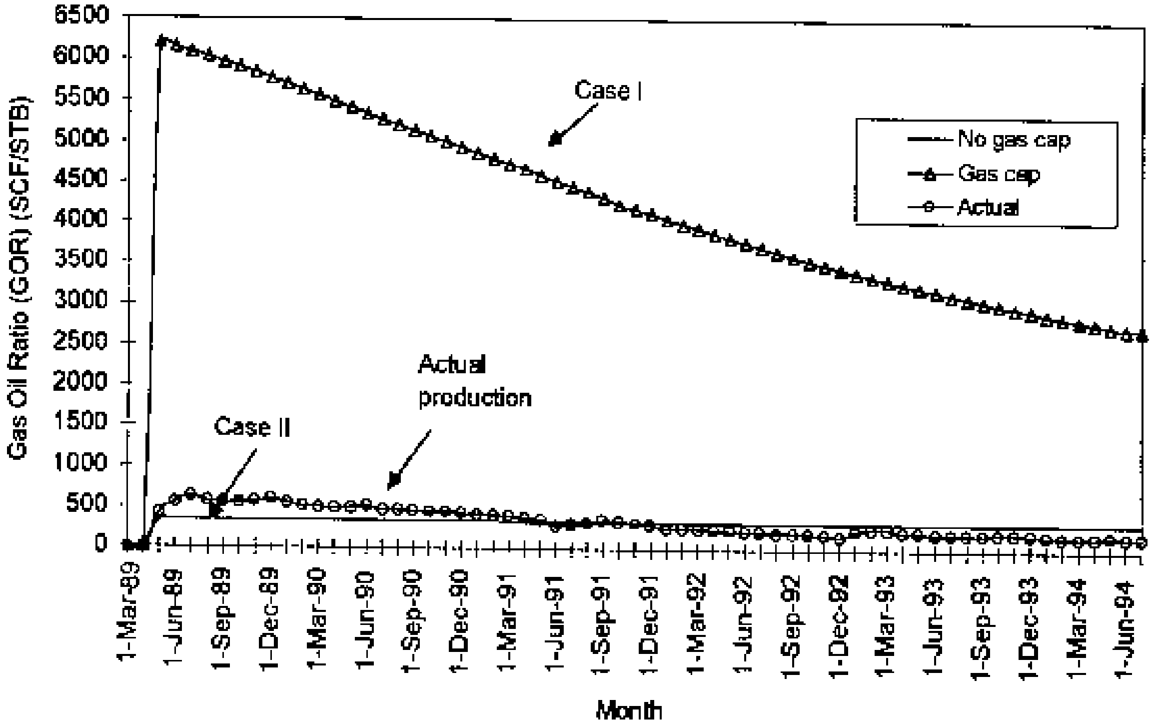
Table 6.5: Comparison of results with actual production data.

Date		Case I	Case II	Actual
6/91	Cumulative oil production (MMBBL)	0.19	0.373	0.3873
	Cumulative gas production (MMSCF)	959.77	127.41	491.57
	Cumulative GOR production (SCF/STB)	4465 28	332.243	-
	Cumulative water production (MMBBL)	0.018	0.018	-
7/94	Cumulative oil production (MMBBL)	0.296	0.635	0.6369
	Cumulative gas production (MMSCF)	1328.254	213.161	891.57
	Cumulative GOR production (SCF/STB)	2740.168	323.518	-
	Cumulative water production (MMBBL)	0.03	0 03	-

For both cases, simulation have been conducted assuming the last production date was the 16th of December, 1994, as local experts abandoned the oil field on the 14th of July of that year as production cost, wax build up inside tubing and other operating difficulties caused production not viable.

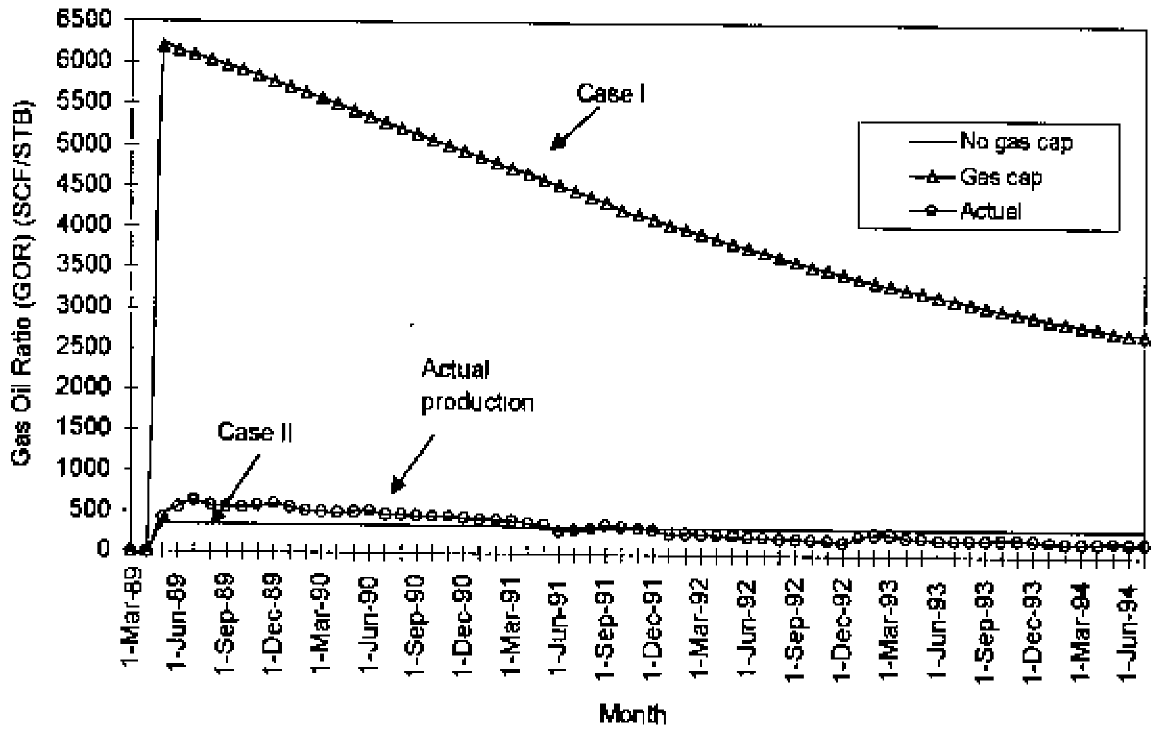
Comparison of results of the two models and the actual production are shown in figure 6.13, 6 14 and 6 15, respectively.

Figure 6.15: Comparison of results of the two cases with the actual GOR production



In both cases, the simulated production profile did not match with the actual field history In Case II scenario the total production is very close to the actual oil production but results of Case I differ significantly. It may be concluded that the gas cap in the initial stage of production was not present. Thus Case II is more reliable in predicting the oil-in-place of Haripur oil field Reserve estimate of Haripur oil field is likely to be 24.7 MMSTB.

Figure 6.15: Comparison of results of the two cases with the actual GOR production



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Chapter 7

ANALYSIS OF PRODUCTION STOPPAGE

To find out the causes of the production stoppage, available different reports, papers and documents have been analyzed. These analyses have done taking into consideration the source rock and fluid properties data, oil sample results, presence of any drive mechanism and finally the production scenarios. The following articles have summarized the analysis.

7.1 Source Rock and Presence of Wax

The sedimentary facies seen in Haripur 1, suggested the sands C to E to be a part of deltaic complex This in turn further complicates any interpretation of the sand units distribution and maximum structural elevation The entire source structure contains finely disseminated carbonaceous material. As Assam produces Tipam oil and gas, it is just possible that heavier fractions may exist in the Tipam of Sylhet downdip. Also the final additional interest is a bright spot on line park-tila Sylhet (PK-SY-3) downflank in the Tipam rocks approximately 2.5-km north-west of Haripur 1 (Whitmee, 1987). This may be a significant accumulation of hydrocarbons that is trapped in a pinch-out. Evidently the carbonaceous-carbonate environment of the Lower Boka Bil mixed with marginal marine facies is suitable for generation of waxy oil.

Core Lab results indicated that, the PVT results were consistent with standard industry correlation with the exception of viscosity (0.832 cp at bubble point pressure and maximum of 1.568 cp at atmospheric pressure), which was considerably lower than the correlations This is probably due to the effect of the wax. From the compositional analysis of the separator products it is seen that the crude oil was typical with no unpleasant surprises except a high pour point of 75 ^{0}F, due to high wax content of 9.6% (Whitmee, 1987). So waxy 28.9 ^{0}API oil with heavier hydrocarbon was present in oil bearing sands of Haripur.

7.2 Oil Sample Assay

The results indicate that this black, medium API crude oil is essentially of naptheno-aromatic composition (hydrogen saturated, six carbon atoms) and of moderate pour point and wax content. Paraffins, straight chain hydrocarbon molecules that contain saturated carbon hydrogen bonds, only make up about one third (33.33%) of the total composition (light volume, LV%). The oil is not biodegraded and is of low sulfur and nitrogen contents. So Tipam oil is containing heavier hydrocarbons.

7.3 Reservoir Drive Mechanism

Four years after production started, in 1991, the volumetric and material balance calculations checked whether the pool behavior was matching with the depletion drive predictions. History matching of BPI study (Khan et al., 1991) indicated that there was a fairly strong water influx from the aquifer. BPI study confirmed a partial or full pressure maintenance due to an active water drive and predicted that the primary recovery would be much higher than for solution gas drives. All the Upper Assam fields in India have a fairly active water drive (primary recovery more than 65% of STOOIP). On the contrary, because of high structural position of Haripur oil field it will always be likely to have a high GOR problem, especially if a gas cap forms (Khan et al., 1991).

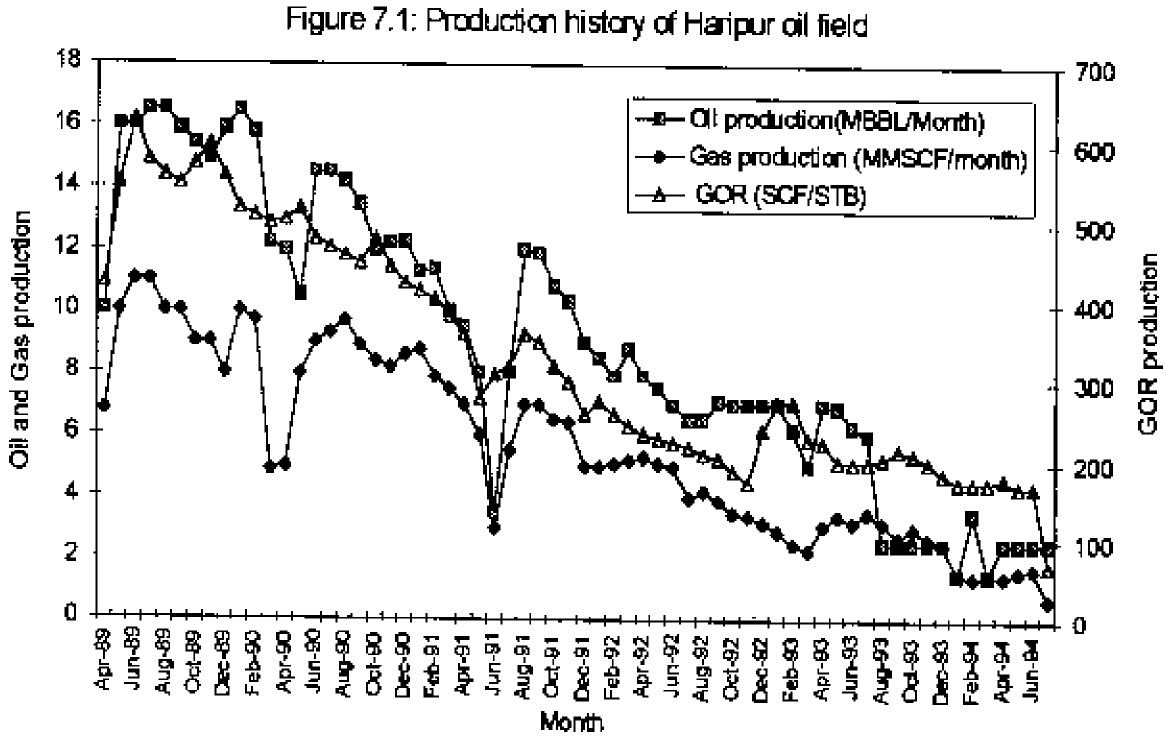
So, BPI study predicted that primary recovery from Haripur pool could be between 50% to 60% of the oil-in-place This primary recovery was earlier predicted by Oil and Mining Services, considering solution gas drive, of the order of 20.75% for oil and 83 2% for gas (Khan et al., 1991)

Simulation results of Case I show high GOR, with a low recovery. Case II shows lower GOR with an optimum production that matches with the actual production data So it may be asserted that well has an active water drive, which was also indicated in BPI (Khan et al., 1991) study.

7.4 Production Scenarios

From the production scenarios, it is anticipated that some of the production decline was due to the wax deposition in the tubing. The wax would cause a restriction to oil flow and a corresponding pressure drop at the wellhead. The GOR would also increase due to increased gas mobility. Figure 7 1 shows the actual production scenarios.

It should be noted that the wax was not totally responsible for the decline in production rate. A solution gas drive can also cause a high GOR to occur. From the analysis of Oil and Mining Services (Whitmee, 1987), with the data available at that time, they have seen that an increase in GOR is reasonable and reasonably matches the performance of the well to date. No gas cap is required to explain the GOR behavior of Haripur 1.



If other drive mechanisms come into play, the primary oil and gas recovery forecast of Oil and Mining Services (Whitmee, 1987) will not hold, especially if any water is produced due to a water drive mechanism. As can be seen, the GOR will steadily increase with time with a corresponding decrease in the oil rate.

Again, based on the Gearhart ULTRA Interpretation (Whitmee, 1987), no gas cap was seen from the production oil reservoir unit. Production history also supported that no gas cap existed at that time. The oil bearing sand has no gas cap and, thus, only water drive exists.

Chapter 8

DISCUSSION

Pressure transient analysis and simulation results are discussed separately below For pressure transient analysis model output is compared with that of IKM results. Reservoir simulation has been conducted and obtained production results are compared with the actual production data of Haripur oil field

8.1 Pressure Transient Analysis

In this study values of different useful rock and fluid properties of Haripur 1 well are obtained from several reports and papers. But most of the values are taken from BPI Report 10 (Khan et al , 1991) which is the compilation of different papers.

In well test interpretation, the pressure data are taken from IKM pressure gauge data (pressure survey, 1993) and values of other rock and fluid properties are taken from BPI Report (1991). But the analysis results compare well with different studies. In the IKM analysis, the initial pressure is 2468.922 psia, permeability 2.19 md, skin factor 4.10, and the wellbore storage coefficient 0 006564 bbl/psi. Both in this study, the reservoir pressure is found as 2460.68 psia, permeability as 2.4 md, skin factor as 4 0, and the wellbore storage as 0.00595 bbl/psi. These variation of results may have occurred because the input data taken in this study in case of porosity (ϕ), pay zone (h), formation volume factor (B), total compressibility (c_t) and viscosity (μ) are different from those used in the IKM study. In the IKM analysis these values are mostly assumed arbitrarily.

8.2 Reservoir Simulation Analysis

In this study two cases have been analyzed. All the necessary data are not available for reservoir simulation. Assumptions were made to carry out the study where data was not available.

8.2.1 Case I: Reservoir with gas cap

Here cumulative production and other results (Appendix 4) differ from the actual production data On the 17th of July, 1994, cumulative production of oil for Case I shows as 0 296 MMBBL. Actual production up to the 14th of July, 1994 was 0.6369 MMBBL. Because of the gas cap, the gas production and GOR were much higher than the actual values. Saturation functions like water relative permeability (k_{rw}), oil relative permeability and gas relative permeability (k_{rg}), etc used in simulation were taken from Honarpour correlations, which might affect the production forecasting. Oil in Haripur 1 well is very waxy which has caused low production rate and cumulative oil production This study may not have properly simulated the wax buildup phenomena in the tubing, which actually restricted the oil flow from the reservoir.

8.2.2 Case II: Reservoir with no gas cap

In this case simulated result (Appendix 5) showed a total production of 0.635 MMSTB whereas the actual production was 0.637 MMSTB. This result is very close. However, the difference occurs due to some inaccuracies in the assumed data. But it is obvious that there was no gas cap present initially. From the production test report (Whitmee, 1987), the waxy oil itself reduces the oil production rate through the 3.5 inch tubing. It should be mentioned that Haripur 1 was originally conceived as a crystal gas well for gas production from shallower zones.

Case II simulation seems to be more reliable as the production status predicted by the simulation is equal to the actual production status. Thus reserve estimate of Haripur oil field is likely to be 24 7 MMSTB

8.3 Future Recovery

Production of Haripur well stopped due to wax buildup in the tubing. Wax build up occurs in the tubing year round, which clogs the tubing inside diameter, reducing the production creating flow restriction. So in future, thermal or non-thermal heavy oil recovery methods may be used for further production of oil.

According to Selby et al (1989), thermal method is suitable for thick (>10m), low depth (1000 m) formation having low permeability (k) and oil saturation (S_o) In case of Haripur oil field, the well has 35 m payzone at a depth of 2020 m with 2.4 md permeability and moderate water saturation. The oil has a very high wax content. Thus any type of thermal or non-thermal heavier oil recovery method may be applied for future production. As the oil is waxy and viscous, thermal method such as cyclic steam stimulation will be more appropriate for the future production. Thermal method may augment the oil recovery at least 50% as Tipam oil of Upper Assam fields in India have a primary recovery of 65% (Khan et al , 1991)

Chapter 9

CONCLUSIONS

In this study pressure transient analysis and reservoir simulation of the Haripur oil field have been conducted. Pressure transient analysis results have almost matched with the same analysis done by IKM in 1993 Here, the same pressure data are used and analyzed with latest available reservoir rock and fluid properties. In reservoir simulation, two cases have been considered Case I considers a gas cap and Case II considers no gas cap in the oil bearing sand. Latest available data are used for the study In Case II simulated productions are close to the actual production scenarios. Inspite of some non-availability of data, the study has been conducted satisfactorily. Based on the study, the conclusions are outlined below.

1. Pressure transient analysis results give reservoir characteristics, which are very close to those of IKM analysis. Analysis shows significant skin factor that represents a damage. One reason of the formation damage may be due to the mud filtrate invasion and the drilling process. This damage causes additional pressure drop during production at a given rate.

2. The pressure transient analysis results are considered reasonable for the purpose of quantitative reservoir engineering analysis So these results would be useful for a better simulation study.

3 From the reservoir simulation it has been established that initially there was no gas cap present in the reservoir. In Case II (which considers no gas cap) simulation total oil production is very close to the actual production status and it predicts the oil-in-place of Haripur oil field to be 24.73 MMSTB.

4. In the literature it has been identified that the drastic production decline was mainly due to the wax buildup on the tubing. The wax with high specific gravity would cause a restriction to flow. As this is the case, after scraping the tubing, the oil rate would increase to the previous rate of approximately 320 bopd, on a 16/64 ths chock without an increase in GOR.

5. Production stopped on the 14th of July, 1994, but the material balance and simulation study show that the reservoir contains more oil It might be in the form of heavier hydrocarbons as reservoir source rocks indicated.

6 According to the BPI study, structural position of Haripur 1 makes it disadvantageous as a long-term primary production under gas cap drive Gas injection, which is a pressure maintenance method, will be difficult to apply Any gas will migrate to the crest of the oil structure where the well is situated. However, Haripur 1 itself is in an ideal location as a gas injection well for future production.

Chapter 10

RECOMMENDATIONS

In this study pressure transient analysis and reservoir simulation have been conducted and thus, reservoir parameters have been estimated and future production scenarios have been studied. It is shown that still huge amount of recoverable reserve present in the formation Analyzing all obtained reservoir parameters and simulation results this study recommends that:

1. PVT samples should be collected and studied extensively to understand the reservoir fluid characteristics. However, due to the present tubing condition, it may be difficult to obtain representative samples from this well.

2. Further investigation is necessary to ascertain the actual initial reservoir pressure as IKM found 2468.92 psia and this study shows 2460.68 psia whereas Oil and Mining Services found it as 2927 00 psia.

3 This study agrees with that of the Oil and Mining Services that a well completion study should be undertaken to ascertain the optimum tubing size in future oil wells. Proper design of the tubing system is very important for producing the oil with high wax content.

4 Haripur well contains heavier hydrocarbon with high percentage of wax Increasing temperature around wellbore by using cyclic steam stimulation / injection method should be considered to overcome the flow problem for future production.

5. A fresh field development scheme should be taken through careful evaluation, appraisal and exploitation of the Haripur oil field to maximize economic recovery from the field

NOMENCLATURE

B	:	Formation volume factor, rft^3 / sft^3
B_o	:	Oil formation volume factor, rft^3 / sft^3
B_g	:	Gas formation volume factor, rft^3 / sft^3
B_w		Water formation volume factor, rft^3/sft^3
c_t		Total compressibility, 1/ psi
GOR	:	Gas-oil ratio
h	:	Pay zone, ft
k	:	Layer(XY), ft or permeability, md.
k_{rg}	:	Gas relative permeability
k_{rw}	:	Water relative permeability, md
$k_{ro}w$	:	Oil relative permeability in presence of water, md
p_{cw}	:	Water-oil capillary pressure, psia
p_{ar} k_{rw}	:	Parameter for regression analysis of the Krw table value
p_{ar} k_{row}	:	Parameter for regression analysis of the Krow table value
p_{cg}	:	Gas-oil capillary pressure, psia
p_{ar} k_{rg}	:	Parameter for regression analysis of the Krg table value
p_{ar} k_{rog}	:	Parameter for regression analysis of the Krog table value
p_{wf}	:	Flowing bottom-hole pressure, psi
p_i	:	Initial pressure, psi
p^*	:	Apparent reservoir pressure, pressure obtained from semi-log plot, psi
$\overline{p}$	:	Average reservoir pressure, psi
p_{ws}	:	Shut-in bottom hole pressure, psi
p_{1hr}	:	Pressure straight-line portion of semi-log plot 1 hour after beginning a transient test, psi
R_s	:	Solution gas-oil ratio, sft^3/rft^3
R	:	Radial distance, ft
r_i	:	Radius of investigation, ft

r_w		Wellbore radius, ft
r_D	:	Dimensionless radial distance
s_w	:	Water saturation, fraction
Δt	:	Shut in time, hours
μ_o	:	Oil viscosity, cp
μ_g	:	Gas viscosity, cp
ϕ	:	Porosity, fraction
μ_w	:	Water viscosity, cp

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Appendices

APPENDIX 1

IKM (1993) Pressure Data (History Listing) of Sylhet 7

History Listings			SYLHET#7
Company	PMRE, BUET	Formation interval	6589.52 ft - 6668.24
Field	Haripur	Perforated interval	6628 ft - 6670 ft
Well	Haripur 1		
Test	1999 pressure survey		
Date	30/01/93 - 04/02/93		
Gauge			
Depth	6609.70 ft		

Date	Time	Pressure psia	Date	Time	Pressure psia	Date	Time	Pressure psia
31/01/92	00:00 00	0 00	31/01/92	08:48:00	1074 30	31/01/92	17 50:31	1092.40
	00 03 00	0 00		09.05.31	1062 60		18:07:58	1091.60
	00:20 31	933.900		09 22 58	1086 10		18 25:29	1098 10
	00 37.58	1427 60		09:40:30	1115.70		18:43 01	1104 50
	00 55:30	1260.70		09:58 01	1140.50		19 00 28	1078 60
	01:13,01	1183 30		10:15:28	1103 60		19:17 59	1086 70
	01:30 28	1131 70		10:33 00	1062 50		19 35 31	1075 30
	01:47.59	1097 10		10.50:31	1085 00		19 52.58	1090.90
	02 05:31	1125.60		11 07 58	1078 50		20:10:29	1075 40
	02 22 58	1109.50		11 25.30	1092 00		20.28:01	1069.50
	02 40 29	1076.30		11:43 01	1101.90		20:45:28	1090.20
	02 58 01	1045 00		12:00:28	1101 20		21:02:59	1079.10
	03 15 28	1062 90		12:18:00	1084 10		21:20:31	1072.90
	03.32:59	1091.30		12:35.31	1089 50		21 37 58	1079.00
	03 50 31	1077 40		12 52.58	1077 20		21:55:29	1076 90
	04 07 58	1070 10		13:10.30	1075 00		22:13:01	1082 60
	04 25 30	1081 60		13 28:01	1072 60		22:30.28	1076.10
	04 43 01	1077.00		13 45 28	1091 10		22 47 59	1074.00
	05 00:28	1066.90		14 03 00	1092 10		23 05 31	1071.80
	05 18 00	1091 60		14.20:31	1089 50		23:22:58	1082.40
	05:35 31	1073 70		14:37 58	1083 30		23 40 29	1061.20
	05 52 58	1083 10		14 55 30	1089.60		23 58 01	1048.90
	06:10 30	1076 10		15 13 01	1097.60	01/02/92	00 15 28	1084.10
	06 28 01	1096.70		15 30 28	1084.20		00 32 59	1088 50
	06:45 28	1080 20		15 48 00	1080 70		00 50:31	1075 20
	07 03:00	1079.00		16:05 31	1062 60		01:07:58	1068.80
	07:20 31	1075 80		16 22.58	1084.90		01 25:29	1072.50
	07:37 58	1054 50		16:40:29	1070 40		01:43:01	1066 40
	07 55 30	1089 00		16 58.01	1086 90		02:00 28	1048.50
	08 13 01	1078 20		17:15 28	1086 90		02.17:59	1063 20
	08:30:28	1081.00		17.32:59	1077.30		02.35 31	1058.90

History Listings

SYLHET#7

Company	PMRE, BUET	Formation interval	6589.52 ft - 6668.24
Field	Haripur	Perforated interval	6628 ft - 6670 ft
Well	Haripur 1		
Test	1999 pressure survey		
Date	30/01/93 - 04/02/93		
Gauge			
Depth	6609.70 ft		

Date	Time	Pressure psia	Date	Time	Pressure psia	Date	Time	Pressure psia
01/02/92	02 52:58	1062.30	01/02/92	11 55 29	1080 70	01/02/92	20:58:01	1078 50
	03 10 29	1062 80		12:13.01	1103.40		21:15:28	1059.20
	03 28 01	1088 80		12 30 28	1095 00		21.32.59	1065 30
	03:45 28	1056.00		12.47:59	1092 50		21 50 31	1054 40
	04 02 59	1084 70		13.05 31	1070 70		22 07 58	1062 60
	04 20:31	1091 00		13:22 58	1071.80		22:25 29	1073 40
	04 37.58	1049 80		13:40 29	1063.00		22:43 01	1098 60
	04 55 29	1064 40		13 58.01	1083 80		23.00:28	1076.70
	05 13 01	1074 20		14 15.28	1108.00		23.17:59	1088 10
	05:30.28	1061.70		14:32 59	1087.30		23 35 31	1096.70
	05.47:59	1071.50		14:50 31	1086.70		23:52 58	1087.80
	06 05 31	1079.70		15.07:58	1112 40	02/02/92	00:10.29	1064.50
	06 22 58	1091.40		15:25 29	1056 90		00 28:01	1094.90
	06 40 29	1077.70		15 43.01	1064 40		00 45 28	1279.50
	06 58 01	1089 10		16.00.28	1076.30		01 04:58	1533 30
	07 15 28	1089 30		16:17.59	1070.80		01:40 01	1858 60
	07.32:59	1086.30		16:35:31	1066 60		02 15 00	2061.60
	07 50 31	1051 00		16 52.58	1071.30		02:49 58	2178.50
	08:07 58	1067.50		17 10 29	1048 60		03 25:01	2244 30
	08 25.29	1066.50		17:28 01	1098 70		04 00 00	2278.90
	08 43 01	1080 70		17 45 28	1068 40		04 34:58	2301 80
	09 00 28	1078 30		18 02:59	1060.40		05 10 01	2316.00
	09 17 59	1068.90		18 20 31	1076.40		05 45 00	2328 20
	09 35 31	1081.10		18 37.58	1077 30		06:19 58	2333.60
	09 52 58	1073 50		18:55 29	1078.50		06 55:01	2342 60
	10:10 29	1082 00		19 13:01	1074 90		07 30:00	2347 20
	10 28 01	1081 80		19:30:28	1088 70		08.04:58	2350.50
	10 45:28	1075 80		19:47:59	1076.40		08:40 01	2355.30
	11 02 59	1074 90		20:05:31	1078 00		09 15 00	2359 20
	11 20 31	1090 50		20:22 58	1073 90		09 49 58	2361 80
	11:37:58	1074.10		20.40 29	1053.50		10:25:01	2364 20

History Listings	SYLHET#7

Company	PMRE, BUET	Formation interval	6589 52 ft - 6668.24
Field	Haripur	Perforated interval	6628 ft - 6670 ft
Well	Haripur 1		
Test	1999 pressure survey		
Date	30/01/93 - 04/02/93		
Gauge			
Depth	6609.70 ft		

Date	Time	Pressure psia	Date	Time	Pressure psia	Date	Time	Pressure psia
02/02/92	11:00 00	2366 30	03/02/92	05 04 58	2400 00	03/02/92	23.10 01	2419 80
	11:34:58	2368 20		05 40 01	2401 40		23:45 00	2420 50
	12 10:01	2369 70		06 15 00	2402 20	04/02/92	00:19:58	2421 00
	12:45 00	2366 60		06 49 58	2403 00		00 55:01	2421 30
	13 19 58	2366.10		07 25 01	2403 80		01 30 00	2421 60
	13.55:01	2367.00		08 00:00	2404.40		02 04:58	2422 00
	14:30 00	2368 70		08 34:58	2405.40		02 40 01	2422 50
	15 04 58	2370 20		09:10 01	2405 90		03:15:00	2422.90
	15 40 01	2372 00		09:45.00	2406 70		03.49:58	2423.30
	16 15.00	2373 70		10.19 58	2407.50		04:25 01	2423 60
	16 49.58	2375 40		10.55 01	2407.90		05:00 00	2424.10
	17.25 01	2377 00		11.30:00	2408 80		05:34 58	2424.50
	18.00 00	2378 60		12.04:58	2409 40		06:10:01	2424.80
	18 34 58	2380 00		12 40 01	2410.20		06 45 00	2425 30
	19:10.01	2381 40		13 15:00	2410.70		07:19 58	2425.60
	19 45 00	2382 80		13:49 58	2411.40		07 55 01	2425.90
	20 19 58	2384.10		14 25 01	2412 00		08:30.00	2426 20
	20 55 01	2385.50		15.00 00	2412.60		09.04:58	2426.50
	21 30 00	2386.80		15:34:58	2413.20		09:40:01	2426.80
	22.04 58	2388 00		16 10 01	2413 80		10 15 00	2427 10
	22 40 01	2389 20		16 45.00	2414 30		10 49 58	2427 50
	23 15 00	2390 50		17.19 58	2414 90		11:25.01	2427.90
	23:49.58	2391.80		17:55:01	2415 40		12 00 00	'2428.30
03/02/92	00:25 01	2392.90		18.30.00	2415 90		12 34 58	2428.60
	01 00 00	2393 90		19 04:58	2416 40		13:10:01	2428.90
	01:34 58	2394 80		19 40 01	2417 00		13 45:00	2429.20
	02 10.01	2395 80		20.15 00	2417.40		14:19:58	2429 50
	02 45 00	2396 50		20 49 58	2417.90		14 55 01	2429 80
	03:19 58	2397 40		21 25 01	2418 40		15 30 00	2430 10
	03 55 01	2398 20		22 00 00	2418.90		16 04 58	2430.50
	04 30 00	2399.10		22:34:58	2419 40		16 40 01	2430 70

	History Listings	SYLHET#7

Company	PMRE, BUET	Formation interval	6589 52 ft - 6668.24
Field	Haripur	Perforated interval	6628 ft - 6670 ft
Well	Haripur 1		
Test	1999 pressure survey.		
Date	30/01/93 - 04/02/93		
Gauge			
Depth	6609 70 ft		

Date	Time	Pressure psia	Date	Time	Pressure psia	Date	Time	Pressure psia
04/02/92	17 15 00	2431 00	05/02/92	01 53:34	2217.50	05/02/92	04 08:16	1323.70
	17.49 58	2431 40		01 56:31	2029.00		04.16:58	1291 20
	18 25 01	2431.60		01 59 23	1995.60		04.25 44	1242 90
	19:00 00	2431 90		02:02:20	1990 80		04:34 29	1203.80
	19.34.58	2432.30		02 06 13	1991.20		04:43:15	1167 50
	20.10:01	2432.40		02 08:09	1991 70		04:52.01	1147.60
	20 45:00	2432.80		02 11:05	1980 90		05:00 46	1121.60
	21 19 58	2433 10		02 13:58	1933 10		05:09:28	1077 10
	21 55 01	2433 30		02.16 55	1926 80		05 18:14	1072 40
	22 30 00	2433 60		02:19 51	1927.10		05 26 59	1071.20
	23 04.58	2434 00		02.22 44	1927.60		05:35 45	1051.30
	23 40 01	2434 20		02 25 40	1912 20		05:44:31	1053 60
05/02/92	00 15 00	2434 40		02 28 33	1863 80		05 53:16	1075.30
	00:49 58	2433.90		02 31 30	1863 00		06 01 58	1088.80
	01:04 01	2427 10		02:34:26	1863.80		06:10 44	1085.00
	01 06.53	2427.10		02:37 19	1864.50		06 19 29	1087.60
	01.09.50	2427.10		02 40 15	1839 20		06 28 15	1093.30
	01.12 43	2417 80		02:43 08	1820.10		06 37 01	1092 00
	01:15 39	2417 70		02:46:04	1821.10		06 45 46	1087 90
	01:18 35	2417.80		02 49 01	1821.80		06:54 28	1090 40
	01:21:26	2417.90		02 51:53	1804 40		07:03.14	1102.60
	01 24 25	2408 00		02:54:50	1799.70		07:11:59	1113.60
	01:27 21	2408 00		02.57:43	1801 60		07:20 45	1121 50
	01 30:14	2408.00		03.00:39	1804 00		07 29:31	1113 90
	01 33 10	2398 00		03:07:01	0 40000		07 38 16	1131 80
	01 36.03	2398.10		03.15 46	1792.20		07 46 58	1121 00
	01:39 00	2398.00		03 24 28	2287 00		07 55 44	1119 80
	01.41 56	2398 10		03 33:14	2198 30		08:04:29	1120 50
	01:44 49	2217 10		03 41 59	1736 30		08 13 15	1105.40
	01:47 45	2217 20		03 50.45	1355.60		08 22:01	1124.60
	01:50 38	2217 40		03:59 31	1273 40		08 30 43	1087.70

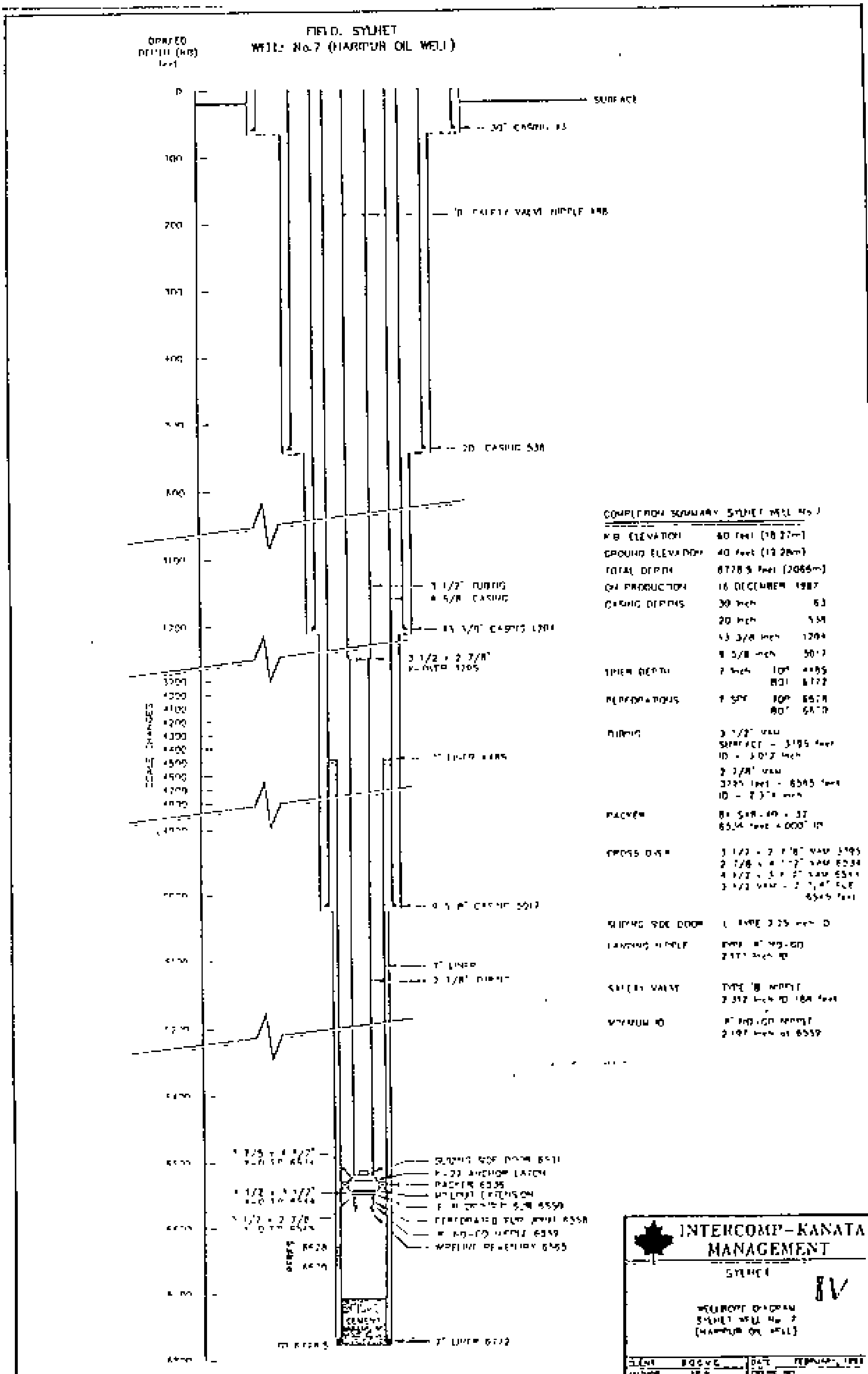
	History Listings	SYLHET#7

Company	PMRE, BUET	Formation interval	6589 52 ft - 6668.24
Field	Haripur	Perforated interval	6628 ft - 6670 ft
Well	Haripur 1		
Test	1999 pressure survey		
Date	30/01/93 - 04/02/93		
Gauge			
Depth	6609.70 ft		

Date	Time	Pressure psia	Date	Time	Pressure psia	Date	Time	Pressure psia
05/02/92	08 39.28	1097.50	05/02/92	13 10 44	1174 50	05/02/92	16·35:23	1191 20
	08:48'14	1087.40		13.19:29	1187 20		16 38 20	1207.50
	08 56 59	1087 00		13.28:15	1181.40		16 41 13	1199 80
	09 05 45	1089 30		13·37.01	1162 90		16:44 09	1103.90
	09 14 31	1075 90		13 45'43	1135.90		16 47 06	1090.80
	09.23 13	1102.50		13 54 28	1168 30		16 49:58	1098 70
	09 31:58	1062.10		14 03 14	1199.10		16 52:55	1102 50
	09 40 44	1069 40		14:11'59	1259.10		16.55 51	1000 30
	09·49 29	1072 20		14 20:45	1287 60		16'58 44	869.800
	09:58.15	1074.70		14.29'31	1291.80		17:01:40	886 200
	10 07:01	1086.10		14.38'13	1205.00		17:04:33	903 000
	10 15 43	1099.00		14 46:58	1226.70		17 07:30	914 000
	10 24 28	1102 00		14 55 44	1192.20		17 10.26	847 700
	10.33 14	1104 10		15:04·29	1246 60		17.13'18	731 700
	10 41 59	1116 00		15:13 15	1289.20		17 16 15	740 700
	10 50 45	1121 40		15 22.01	1261 70		17.19 08	751.800
	10 59'31	1122 00		15 30 43	1243 90		17 22 04	760.600
	11:08'13	1134 10		15 39:28	1211.90		17'25 01	869.100
	11:16'58	1126.10		15 48.14	1190.80		17:27'53	525 600
	11:25 44	1143 30		15 56 59	1203.60		17 30'50	546 800
	11:34.29	1134.10		16 03 21	1207.10		17.33'43	565.000
	11:43.15	1135 30		16 06:14	1217.60		17.36:39	553 900
	11 52 01	1144 40		16 09 10	1192 50		17.39 36	367.200
	12·00·43	1146 90		16 12.03	1209.10		17.42:28	361 100
	12 09 28	1154 10		16 15:00	1189 00		17·45·25	424 400
	12'18 14	1132 30		16:17.56	1170.00		17'48 21	430 000
	12 26 59	1126 30		16·20:49	1205.20		17 51 14	332.000
	12:35 45	1148 70		16:23·45	1189 20		17:54:10	299.300
	12 44 31	1164 30		16 26 38	1176.50		17 57 03	328 500
	12 53 13	1162 30		16:29 34	1166.70		18 00 00	0 00
	13 01 58	1159 60		16 32 31	1166 80			

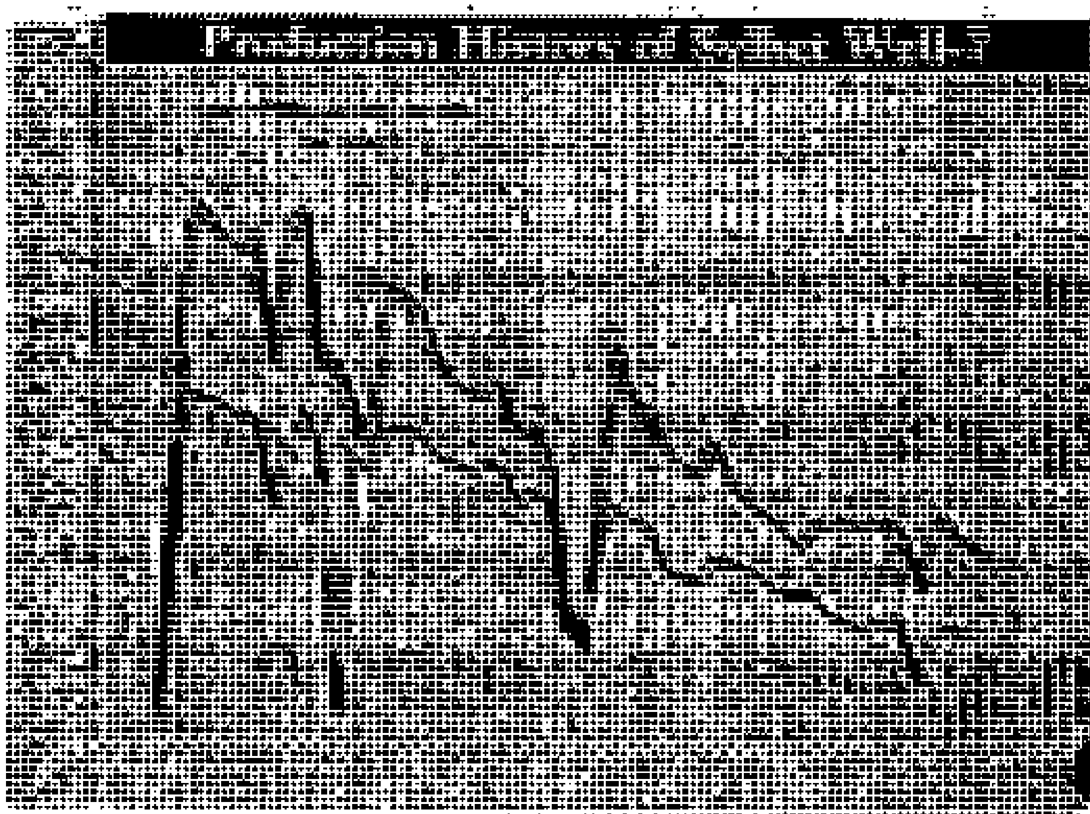
APPENDIX 2

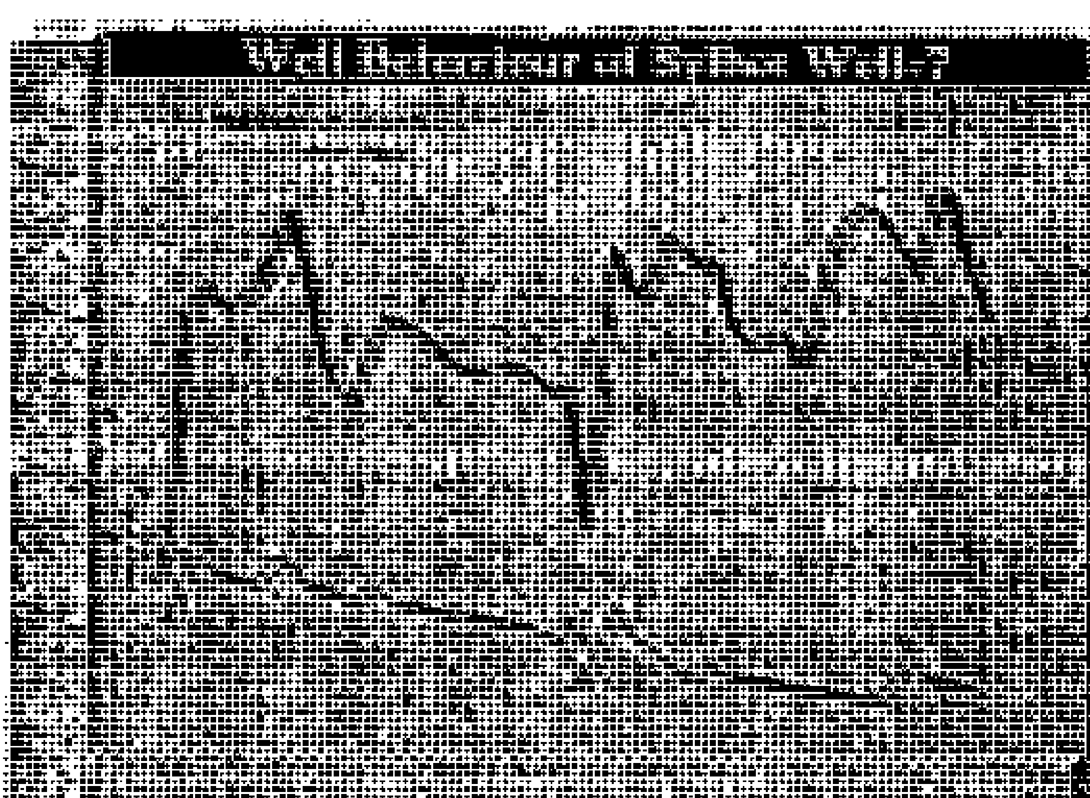
Wellbore Diagram of Sylhet 7

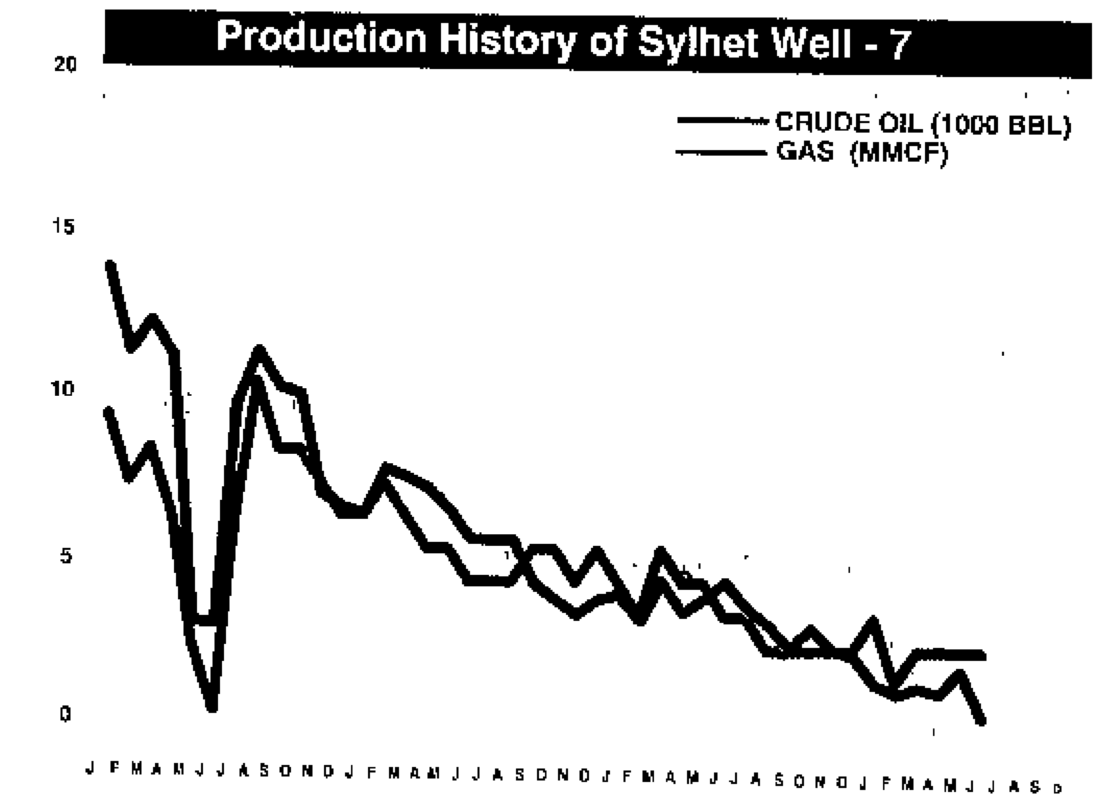


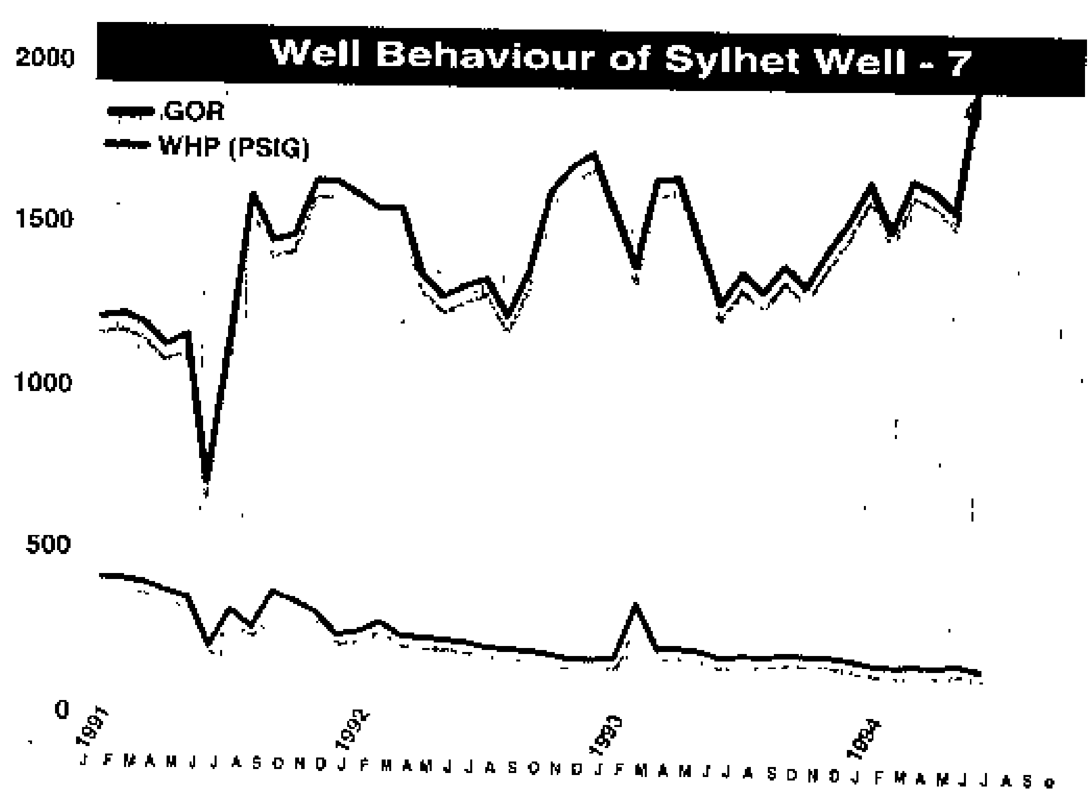
APPENDIX 3

Production History of Sylhet 7






Production History of Sylhet Well - 7
CRUDE OIL (1000 BBL)
GAS (MMCF)
20
15
10
5
0
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O


Well Behaviour of Sylhet Well - 7
GOR
WHP (PSIG)
2000
1500
1000
500
0
1991
1992
1993
1994
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O

APPENDIX 4

Results of Model Case I Using Reservoir With Gas Cap

Calender Date	Region	Average press. psia	Oil in place BBLS	Gas in place BBLS	Water in Place BBLS	Oil Rate BBLS/D	Gas Rate MMCF/D	Water Rate BBLS/D
16-Dec-87	1	2477.808	2.12E+07	1.63E+07	1.16E+07	0	0	0

Date	Time	Current gas	Current Oil	Current Water	GOR	CUM Gas	CUM Oil	CUM Water	OIL REC	Gas REC	AVG Oil	AVG Gas
	Days	Rate(MMCF/D)	Rate (STB/D)	Rate (BBL/D)	SCF/STB	PROD (MMCF)	PROD (MMSTB)	PROD (MMBBLS)	%	%	Rate (STB/D)	Rate (MMCF/D)
16-Jan-88	31	0.106	285.49	14.1	372.885	3.532	0.009	0	0.045	0.022	304.74	0.114
16-Feb-88	62	0.187	235.55	15.32	792.54	9.319	0.017	0.001	0.079	0.057	235.55	0.187
16-Mar-88	91	0.604	207.66	15.72	2907.068	26.826	0.023	0.001	0.107	0.164	207.66	0.604
16-Apr-88	122	0.859	187.89	15.95	4569.887	53.443	0.029	0.002	0.135	0.327	187.89	0.859
16-May-88	152	0.95	178.6	16.05	5317.021	81.932	0.034	0.002	0.16	0.502	178.6	0.95
16-Jun-88	183	0.987	173.34	16.02	5695.336	112.536	0.039	0.003	0.185	0.689	173.34	0.987
16-Jul-88	213	0.988	169.73	15.92	5821.622	142.179	0.044	0.003	0.209	0.871	169.73	0.988
16-Aug-88	244	0.989	166.83	15.8	5928.111	172.838	0.05	0.004	0.234	1.059	166.83	0.989
16-Sep-88	275	0.989	164.12	15.66	6027.633	203.504	0.055	0.004	0.258	1.247	164.12	0.989
16-Oct-88	305	0.988	161.53	15.51	6114.809	233.137	0.06	0.005	0.281	1.428	161.53	0.988
16-Nov-88	336	0.984	158.93	15.34	6188.942	263.629	0.064	0.005	0.304	1.615	158.93	0.984
16-Dec-88	366	0.975	156.51	15.16	6226.829	292.865	0.069	0.006	0.326	1.794	156.51	0.975
16-Jan-89	397	0.961	154.03	14.99	6236.497	322.644	0.074	0.006	0.348	1.976	154.03	0.961
16-Feb-89	428	0.947	151.75	14.81	6238.877	351.993	0.079	0.007	0.371	2.156	151.75	0.947
16-Mar-89	456	0.932	149.71	14.66	6225.177	378.088	0.083	0.007	0.39	2.316	149.71	0.932
16-Apr-89	487	0.918	147.59	14.5	6216.863	406.532	0.087	0.007	0.412	2.49	147.59	0.918
16-May-89	517	0.902	145.54	14.36	6197.936	433.593	0.092	0.008	0.432	2.656	145.54	0.902
16-Jun-89	548	0.88	143.28	14.2	6144.684	460.885	0.096	0.008	0.453	2.823	143.28	0.88
16-Jul-89	578	0.862	141.32	14.07	6098.615	488.741	0.1	0.009	0.473	2.982	141.32	0.862
16-Aug-89	609	0.841	139.32	13.93	6039.188	512.824	0.105	0.009	0.494	3.142	139.32	0.841
16-Sep-89	640	0.819	137.31	13.8	5966.138	538.221	0.109	0.01	0.514	3.297	137.31	0.819
16-Oct-89	670	0.802	135.58	13.68	5917.252	562.288	0.113	0.01	0.533	3.445	135.58	0.802
16-Nov-89	701	0.781	133.73	13.55	5841.269	586.503	0.117	0.01	0.552	3.593	133.73	0.781
16-Dec-89	731	0.763	132.08	13.44	5776.035	609.391	0.121	0.011	0.571	3.733	132.09	0.763
16-Jan-90	762	0.745	130.47	13.33	5712.634	632.498	0.125	0.011	0.59	3.875	130.47	0.745
16-Feb-90	793	0.727	128.87	13.22	5638.633	655.022	0.129	0.012	0.609	4.013	128.87	0.727
16-Mar-90	821	0.71	127.46	13.12	5569.409	674.899	0.133	0.012	0.626	4.134	127.46	0.71
16-Apr-90	852	0.693	126	13.02	5498.854	696.377	0.137	0.012	0.644	4.266	126	0.693
16-May-90	882	0.676	124.6	12.92	5426.778	716.663	0.14	0.013	0.662	4.39	124.6	0.676
17-Jun-90	914	0.659	123.17	12.82	5348.446	737.743	0.144	0.013	0.68	4.519	123.17	0.659
17-Jul-90	944	0.644	121.9	12.74	5284.092	757.068	0.148	0.014	0.698	4.638	121.9	0.644

Date	Time	Current gas	Current Oil	Current Water	GOR	CUM Gas	CUM Oil	CUM Water	OIL REC	Gas REC	AVG Oil	AVG Gas
	Days	Rate(MMCF/D)	Rate (STB/D)	Rate (BBL/D)	SCF/STB	PROD (MMCF)	PROD (MMSTB)	PROD (MMBBLS)	%	%	Rate (STB/D)	Rate (MMCF/D)
17-Aug-90	975	0.629	120.61	12.65	5216.262	776.571	0.152	0.014	0.715	4.757	120.61	0.629
17-Sep-90	1006	0.614	119.33	12.56	5145.212	795.605	0.155	0.014	0.733	4.874	119.33	0.614
17-Oct-90	1036	0.6	118.16	12.48	5078.987	813.609	0.159	0.015	0.749	4.984	118.16	0.6
17-Nov-90	1067	0.586	116.98	12.39	5012.073	831.785	0.163	0.015	0.767	5.095	116.98	0.586
17-Dec-90	1097	0.573	115.87	12.32	4944.071	848.971	0.166	0.016	0.783	5.201	115.87	0.573
17-Jan-91	1128	0.56	114.76	12.24	4875.235	866.315	0.17	0.016	0.8	5.307	114.76	0.559
17-Feb-91	1159	0.546	113.7	12.17	4805.934	883.254	0.173	0.016	0.816	5.411	113.7	0.546
17-Mar-91	1187	0.535	112.76	12.1	4741.772	898.225	0.176	0.017	0.831	5.502	112.76	0.535
17-Apr-91	1218	0.523	111.77	12.03	4675.865	914.426	0.18	0.017	0.847	5.602	111.77	0.523
17-May-91	1248	0.51	110.81	11.97	4606.128	929.738	0.183	0.017	0.863	5.695	110.81	0.51
17-Jun-91	1279	0.498	109.85	11.9	4533.657	945.177	0.187	0.018	0.879	5.79	109.85	0.498
17-Jul-91	1309	0.487	108.97	11.84	4465.285	959.774	0.19	0.018	0.895	5.879	108.97	0.487
17-Aug-91	1340	0.475	108.08	11.78	4394.894	974.499	0.193	0.018	0.91	5.97	108.08	0.475
17-Sep-91	1371	0.464	107.22	11.72	4328.045	988.884	0.197	0.019	0.926	6.058	107.22	0.464
17-Oct-91	1401	0.45	106.32	11.66	4234.362	1002.39	0.2	0.019	0.941	6.141	106.32	0.45
17-Nov-91	1432	0.441	105.55	11.61	4177.053	1016.057	0.203	0.02	0.957	6.224	105.55	0.441
17-Dec-91	1462	0.432	104.82	11.55	4125.042	1029.029	0.206	0.02	0.971	6.304	104.82	0.432
17-Jan-92	1493	0.423	104.06	11.5	4063.198	1042.136	0.209	0.02	0.987	6.384	104.06	0.423
17-Feb-92	1524	0.414	103.32	11.45	4003.419	1054.959	0.213	0.021	1.002	6.463	103.32	0.414
17-Mar-92	1553	0.405	102.65	11.41	3947.162	1066.709	0.216	0.021	1.016	6.535	102.65	0.405
17-Apr-92	1584	0.396	101.94	11.36	3887.362	1078.993	0.219	0.021	1.031	6.61	101.94	0.396
17-May-92	1614	0.388	101.27	11.32	3829.7	1090.628	0.222	0.022	1.045	6.681	101.27	0.388
17-Jun-92	1645	0.38	100.6	11.28	3773.54	1102.396	0.225	0.022	1.06	6.753	100.6	0.38
17-Jul-92	1675	0.372	99.96	11.23	3718.206	1113.548	0.228	0.022	1.074	6.821	99.96	0.372
17-Aug-92	1706	0.364	99.31	11.19	3661.915	1124.819	0.231	0.023	1.088	6.891	99.31	0.364
17-Sep-92	1737	0.356	98.68	11.15	3605.73	1135.849	0.234	0.023	1.103	6.958	98.68	0.356
17-Oct-92	1767	0.349	98.08	11.11	3554.936	1146.309	0.237	0.023	1.116	7.022	98.08	0.349
17-Nov-92	1798	0.342	97.48	11.08	3503.415	1156.896	0.24	0.024	1.131	7.087	97.48	0.342
17-Dec-92	1828	0.335	96.91	11.04	3455.49	1166.942	0.243	0.024	1.144	7.149	96.91	0.335
17-Jan-93	1859	0.328	96.33	11	3406.645	1177.115	0.246	0.024	1.158	7.211	96.33	0.328
17-Feb-93	1890	0.322	95.77	10.97	3358.878	1187.086	0.249	0.025	1.172	7.272	95.77	0.322
17-Mar-93	1918	0.316	95.28	10.93	3317.612	1195.937	0.251	0.025	1.185	7.326	95.28	0.316
17-Apr-93	1949	0.31	94.73	10.9	3272.035	1205.545	0.254	0.025	1.199	7.385	94.73	0.31
17-May-93	1979	0.304	94.22	10.87	3228.178	1214.67	0.257	0.026	1.212	7.441	94.22	0.304
17-Jun-93	2010	0.298	93.69	10.83	3184.124	1223.918	0.26	0.026	1.226	7.498	93.69	0.298
17-Jul-93	2040	0.293	93.2	10.8	3142.607	1232.705	0.263	0.026	1.239	7.551	93.2	0.293
17-Aug-93	2071	0.287	92.7	10.77	3100.093	1241.614	0.266	0.027	1.253	7.606	92.7	0.287
17-Sep-93	2102	0.282	92.21	10.74	3059.291	1250.359	0.269	0.027	1.266	7.66	92.21	0.282
17-Oct-93	2132	0.277	91.75	10.71	3022.031	1258.677	0.271	0.027	1.279	7.711	91.75	0.277

Date	Time Days	Current gas Rate(MMCF/D)	Current Oil Rate (STB/D)	Current Water Rate (BBL/D)	GOR SCF/STB	CUM Gas PROD (MMCF)	CUM Oil PROD (MMSTB)	CUM Water PROD (MMBBLS)	OIL REC %	Gas REC %	AVG Oil Rate (STB/D)	AVG Gas Rate (MMCF/D)
17-Nov-93	2163	0.272	91.27	10.67	2982.757	1267 116	0.274	0 028	1 292	7 762	91.27	0.272
17-Dec-93	2193	0 268	90 82	10 64	2946.956	1275 146	0 277	0 028	1 305	7.811	90 82	0.268
17-Jan-94	2224	0 263	90 36	10 61	2909.449	1283.295	0.28	0 028	1 318	7.861	90 36	0 263
17-Feb-94	2255	0 258	89.91	10.58	2872 843	1291 303	0.283	0.029	1.332	7 91	89 91	0 258
17-Mar-94	2283	0 254	89.52	10.56	2840.978	1298 424	0.285	0 029	1.343	7 954	89 52	0 254
17-Apr-94	2314	0 25	89.07	10 53	2803.699	1306 166	0.288	0 029	1 356	8 001	89.07	0.25
17-May-94	2344	0 246	88 66	10.5	2770.007	1313 533	0 29	0 03	1 369	8 047	88 66	0 246
17-Jun-94	2375	0 241	88 24	10 47	2736 765	1321.02	0.293	0.03	1 382	8.092	88.24	0.242
17-Jul-94	2405	0 241	88	10 45	2740 168	1328 254	0.296	0 03	1 394	8.137	88	0.241
17-Aug-94	2436	0.232	87.39	10 42	2653.139	1335 442	0.299	0 03	1.407	8 181	87 4	0 232
17-Sep-94	2467	0 229	87.02	10 39	2634.425	1342 549	0 301	0.031	1 42	8 224	87.02	0.229
17-Oct-94	2497	0 229	86 79	10.37	2638.691	1349 415	0 304	0 031	1.432	8 266	86 79	0 229
17-Nov-94	2528	0 221	86.25	10 34	2563 47	1356.268	0 307	0 031	1 445	8.308	86 25	0 221
16-Dec-94	2557	0 222	86.07	10.32	2580 444	1362 709	0.309	0.032	1 456	8.348	86 07	0 222

APPENDIX 5

Results of Model Case II Using Reservoir With No Gas Cap

Calender Date	Region	Average press. psia	Oil in place BBLS	Gas in place BBLS	Water in Place BBLS	Oil Rate BBLS/D	Gas Rate MMCF/D	Water Rate BBLS/D
16-Dec-87	1	2477 808	2 47E+07	1 37E+07	1.16E+07	0	0	0

Date	Time Days	Current gas Rate(MMCF/D)	Current Oil Rate (STB/D)	Current Water Rate (BBL/D)	GOR SCF/STB	CUM Gas PROD (MMCF)	CUM Oil PROD (MMSTB)	CUM Water PROD (MMBBLS)	OIL REC %	Gas REC %	AVG Oil Rate (STB/D)	AVG Gas Rate (MMCF/D)
16-Jan-88	31	0 131	363 66	11 66	361.274	4 322	0.012	0	0 048	0.032	381.72	0.139
16-Feb-88	62	0.121	339 23	12 27	356.183	8.068	0 022	0.001	0 09	0.059	339 23	0.121
16-Mar-88	91	0.116	326 93	12 85	353 462	11 419	0.032	0 001	0.129	0 083	326.93	0 116
16-Apr-88	122	0 112	319 46	13.37	351.925	14 904	0 042	0 002	0 169	0 109	319.46	0 112
16-May-88	152	0.11	312 6	13.76	350 378	18 19	0 051	0 002	0.207	0 133	312 6	0.11
16-Jun-88	183	0.107	307.87	14.18	349.074	21 521	0 061	0 002	0 245	0 157	307 87	0 107
16-Jul-88	213	0.106	304 02	14 49	347.97	24 695	0.07	0 003	0 282	0 18	304.02	0.106
16-Aug-88	244	0.104	300.82	14 73	347 008	27.931	0.079	0.003	0 32	0 204	300 82	0.104
16-Sep-88	275	0 103	298.07	14.9	346 146	31 129	0 088	0 004	0 357	0.227	298.07	0 103
16-Oct-88	305	0 102	295.74	15 02	345.379	34 194	0 097	0.004	0.393	0 25	295.74	0 102
16-Nov-88	336	0.101	293 69	15.09	344 671	37,332	0 106	0.005	0.43	0 273	293 69	0 101
16-Dec-88	366	0 1	291.93	15 13	344.039	40 345	0.115	0 005	0 465	0.295	291 93	0 1
16-Jan-89	397	0 1	290 3	15 14	343 432	43.435	0.124	0.006	0 502	0.317	290 3	0.1
16-Feb-89	428	0.099	289 48	15 14	343 074	46 514	0.133	0.006	0.538	0 34	289 48	0.099
16-Mar-89	456	0 099	288.45	15.11	342.634	49 281	0.141	0 006	0 571	0.36	288.45	0 099
16-Apr-89	487	0 098	287 33	15.06	342 139	52.329	0 15	0 007	0.607	0 382	287.33	0.098
16-May-89	517	0.098	286 14	15	341.628	55 262	0 159	0 007	0 641	0 404	288 14	0 098
16-Jun-89	548	0 097	284.95	14.92	341.125	58 275	0.167	0 008	0 677	0 426	284.95	0 097
16-Jul-89	578	0.097	283.76	14 83	340 64	61.175	0.176	0.008	0 712	0.447	283 76	0.097
16-Aug-89	609	0.096	282.58	14 73	340 167	64.154	0.185	0.009	0.747	0 469	282 58	0.096
16-Sep-89	640	0 096	281.41	14 62	339 709	67.118	0.193	0.009	0 782	0.491	281.41	0 096
16-Oct-89	670	0 095	280.25	14.5	339 272	69 97	0.202	0.01	0.816	0 511	280 25	0 095
16-Nov-89	701	0 095	279 11	14.38	338 848	72 902	0 211	0 01	0.851	0 533	279.11	0.095
16-Dec-89	731	0 094	277 97	14 26	338.441	75.724	0.219	0.011	0.885	0.553	277 97	0 094
16-Jan-90	762	0 094	276.83	14 13	338 043	78 625	0.227	0 011	0.92	0.575	276 83	0.094
16-Feb-90	793	0.093	275.68	14	337 654	81.511	0 236	0 011	0 954	0.596	275.68	0.093
16-Mar-90	821	0.093	274.58	13.88	337.293	84.104	0.244	0.012	0.985	0 615	274.58	0 093
16-Apr-90	852	0 092	273.46	13.75	336.934	86 961	0 252	0.012	1.02	0 636	273.46	0.092
16-May-90	882	0 092	272.34	13 63	336.583	89 711	0.26	0 013	1 053	0.656	272 34	0 092
17-Jun-90	914	0 091	271 2	13 5	336.23	92 629	0 269	0 013	1 088	0.677	271.2	0.091
17-Jul-90	944	0.091	270 1	13 39	335 887	95.35	0 277	0.013	1.121	0 697	270 1	0.091

Date	Time	Current gas	Current Oil	Current Water	GOR	CUM Gas	CUM Oil	CUM Water	OIL REC	Gas REC	AVG Oil	AVG Gas
	Days	Rate(MMCF/D)	Rate (STB/D)	Rate (BBL/D)	SCF/STB	PROD (MMCF)	PROD (MMSTB)	PROD (MMBBLS)	%	%	Rate (STB/D)	Rate (MMCF/D)
17-Aug-90	975	0.09	269	13.27	335.55	98.148	0.285	0.014	1.154	0.717	269	0.09
17-Sep-90	1006	0.09	267.89	13.16	335.217	100.932	0.294	0.014	1.188	0.738	267.89	0.09
17-Oct-90	1036	0.089	266.8	13.05	334.895	103.613	0.302	0.015	1.22	0.757	266.8	0.089
17-Nov-90	1067	0.089	265.71	12.95	334.577	106.369	0.31	0.015	1.254	0.777	265.71	0.089
17-Dec-90	1097	0.088	264.63	12.84	334.268	109.022	0.318	0.015	1.286	0.797	264.63	0.088
17-Jan-91	1128	0.088	263.55	12.74	333.961	111.751	0.326	0.016	1.319	0.817	263.54	0.088
17-Feb-91	1159	0.086	262.46	12.64	333.657	114.465	0.334	0.016	1.352	0.837	262.46	0.086
17-Mar-91	1187	0.087	261.42	12.55	333.372	116.906	0.342	0.017	1.381	0.854	261.43	0.087
17-Apr-91	1218	0.087	260.38	12.45	333.087	119.594	0.35	0.017	1.414	0.874	260.38	0.087
17-May-91	1248	0.086	259.33	12.36	332.803	122.184	0.357	0.017	1.445	0.893	259.33	0.086
17-Jun-91	1279	0.086	258.28	12.26	332.52	124.846	0.365	0.018	1.478	0.912	258.28	0.086
17-Jul-91	1309	0.085	257.23	12.17	332.243	127.41	0.373	0.018	1.509	0.931	257.23	0.085
17-Aug-91	1340	0.085	256.18	12.08	331.967	130.046	0.381	0.018	1.541	0.95	256.18	0.085
17-Sep-91	1371	0.085	255.13	11.99	331.693	132.669	0.389	0.019	1.573	0.97	255.13	0.085
17-Oct-91	1401	0.084	254.13	11.91	331.435	135.196	0.397	0.019	1.604	0.988	254.13	0.084
17-Nov-91	1432	0.084	253.1	11.83	331.17	137.795	0.404	0.02	1.636	1.007	253.1	0.084
17-Dec-91	1462	0.083	252.09	11.75	330.911	140.297	0.412	0.02	1.666	1.025	252.09	0.083
17-Jan-92	1493	0.083	251.11	11.67	330.663	142.871	0.42	0.02	1.698	1.044	251.11	0.083
17-Feb-92	1524	0.083	250.1	11.59	330.406	145.433	0.428	0.021	1.729	1.063	250.1	0.083
17-Mar-92	1553	0.082	249.13	11.51	330.161	147.818	0.435	0.021	1.758	1.08	249.13	0.082
17-Apr-92	1584	0.082	248.16	11.44	329.917	150.356	0.442	0.021	1.789	1.099	248.16	0.082
17-May-92	1614	0.081	247.13	11.36	329.653	152.8	0.45	0.022	1.819	1.117	247.13	0.081
17-Jun-92	1645	0.081	246.11	11.29	329.395	155.313	0.457	0.022	1.85	1.135	246.11	0.081
17-Jul-92	1675	0.081	245.1	11.22	329.143	157.734	0.465	0.022	1.88	1.153	245.11	0.081
17-Aug-92	1706	0.08	244.1	11.15	328.893	160.222	0.472	0.023	1.91	1.171	244.1	0.08
17-Sep-92	1737	0.08	243.05	11.08	328.626	162.698	0.48	0.023	1.941	1.189	243.05	0.08
17-Oct-92	1767	0.079	242.02	11.01	328.366	165.083	0.487	0.023	1.97	1.206	242.02	0.079
17-Nov-92	1798	0.079	241	10.95	328.111	167.534	0.495	0.024	2.001	1.224	241	0.079
17-Dec-92	1828	0.079	239.98	10.88	327.859	169.894	0.502	0.024	2.03	1.242	239.98	0.079
17-Jan-93	1859	0.078	238.97	10.82	327.609	172.321	0.509	0.024	2.06	1.259	238.97	0.078
17-Feb-93	1890	0.078	237.96	10.76	327.358	174.736	0.517	0.025	2.089	1.277	237.96	0.078
17-Mar-93	1918	0.078	237.01	10.7	327.123	176.907	0.523	0.025	2.116	1.293	237	0.078
17-Apr-93	1949	0.077	236.05	10.64	326.891	179.299	0.531	0.025	2.146	1.31	236.05	0.077
17-May-93	1979	0.077	235.07	10.58	326.654	181.603	0.538	0.026	2.174	1.327	235.07	0.077
17-Jun-93	2010	0.076	234.1	10.53	326.418	183.971	0.545	0.026	2.204	1.344	234.1	0.076
17-Jul-93	2040	0.076	233.14	10.47	326.186	186.253	0.552	0.026	2.232	1.361	233.14	0.076
17-Aug-93	2071	0.076	232.17	10.41	325.952	188.599	0.559	0.027	2.261	1.378	232.17	0.076
17-Sep-93	2102	0.075	231.2	10.36	325.715	190.933	0.566	0.027	2.29	1.395	231.2	0.075
17-Oct-93	2132	0.075	230.24	10.3	325.484	193.181	0.573	0.027	2.318	1.412	230.24	0.075

Date	Time	Current gas	Current Oil	Current Water	GOR	CUM Gas	CUM Oil	CUM Water	OIL REC	Gas REC	AVG Oil rate	AVG Gas
	Days	Rate(MMCF/D)	Rate (STB/D)	Rate (BBL/D)	SCF/STB	PROD (MMCF)	PROD (MMSTB)	PROD (MMBBLS)	%	%	Rate (STB/D)	Rate (MMCF/D)
17-Nov-93	2163	0.075	229 29	10.25	325 256	195.493	0 58	0 028	2.347	1 429	229.29	0 075
17-Dec-93	2193	0.074	228 35	10 2	325.03	197.72	0 587	0 028	2 374	1.445	228.35	0 074
17-Jan-94	2224	0 074	227 41	10 15	324 805	200.01	0 594	0 028	2 403	1.462	227 42	0 074
17-Feb-94	2255	0 074	226.47	10.1	324 58	202.289	0 601	0 028	2.431	1 478	226 47	0.074
17-Mar-94	2283	0.073	225.58	10.05	324.366	204 337	0 608	0 029	2 457	1.493	225 58	0.073
17-Apr-94	2314	0 073	224 69	10	324.159	206 595	0 615	0 029	2.485	1.51	224 69	0 073
17-May-94	2344	0.072	223 78	9 95	323 943	208.77	0 621	0.029	2 512	1.526	223.78	0 072
17-Jun-94	2375	0 072	222.87	9.91	323.729	211.007	0 628	0 03	2.54	1.542	222 87	0 072
17-Jul-94	2405	0.072	221.97	9.86	323 518	213 161	0.635	0 03	2 567	1.556	221 97	0 072
17-Aug-94	2436	0.071	221 08	9 81	323.309	215 377	0 642	0 03	2.595	1 574	221.07	0 071
17-Sep-94	2467	0.071	220 17	9.77	323 098	217 582	0.648	0 031	2 622	1.59	220.17	0 071
17-Oct-94	2497	0 071	219.29	9 72	322.893	219 706	0 655	0.031	2 649	1.606	219 29	0 071
17-Nov-94	2528	0.07	218 42	9.68	322 69	221 891	0.662	0 031	2 676	1 622	218 42	0 07
16-Dec-94	2557	0.07	217 56	9.64	322 492	223.926	0 666	0 031	2.702	1 636	217 56	0 07