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History Matching, Forecasting & Production Optimization on Norne E-Segment

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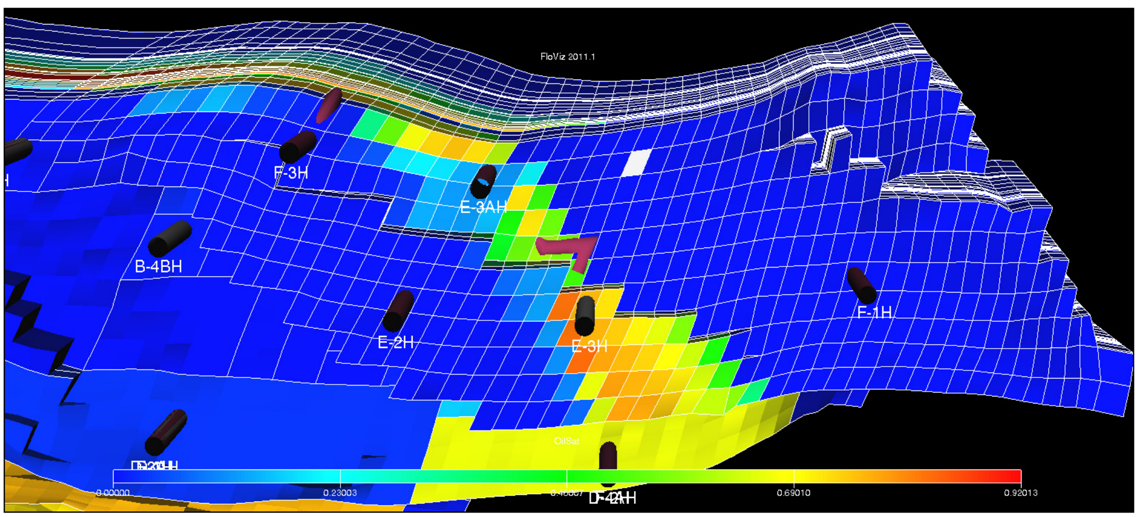

MASTER THESIS

BY

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Trondheim, Norway

July, 2012

DECLARATION

I, Essien Samson Imoh, hereby declare that this Thesis work has been performed in accordance with the regulations of the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. All views expressed in this Thesis work are mine and does not necessarily reflect the views of Statoil and the Norne license partners.

27th July, 2012 ……...

Date **Essien, Samson Imoh**

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My unequivocal gratitude and praise to the Almighty God by whom and through whom all things consist, for the life, grace, favour, strength, wisdom and understanding to come this far in life and continue onwards. All glory be to HIM forever!

DEDICATION

To my darling parents Asuquo and Eno; my beloved siblings Helen, Esther, Udoma, Kufre; my sweetheart Jana Němcová; and my very dear friends, for all their support throughout the years.

I love you all.

ABSTRACT

Reservoir history matching is a tedious and time-consuming exercise, undertaken to reduce the differences in performance between a reservoir simulation model and its historical field performance. To replicate the reservoir's performance, dynamic and static data from the reservoir is required to characterize the reservoir model. This enables it to reproduce a model very close to the historical performance. This Thesis work concentrates mainly on manual history matching carried out on the E-segment of the Norne field. It involves making perturbations to pre-selected sensitive parameters using production and pressure data. A forecast was then performed based on the best match to predict future production and suggest better or improved oil recovery methods for optimized production. Selection of parameters for perturbation was based on thorough sensitivity analysis previously carried out on the same E-segment of Norne in an earlier Project work. The intricacy of manual perturbation would pose a big problem if the region being considered were not small. For the entire Norne field and any other larger field, it would be a lot easier to consider automatic history matching. Transmissibility, porosity, horizontal and vertical permeability proved to be the main parameters of concern as their perturbations significantly affected the outcome of the final match which was a very close match to the observed historical performance. The forecast was done mainly with water injection and clearly showed that increased water injection though increased field pressure, did not necessarily yield more oil production, but rather presented the problem of increased water production at the oil producing wells. Horizontal permeability reduction around the production wells would then be the best bet for optimized oil production.

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NOMENCLATURE

API	American Petroleum Institute
BASE CASE	Norne E-segment data file, base case model
BC	Base case
COMPDAT	Well Completions Specification Data, Eclipse100 Keyword.
E-2H	Production well E-2H
E-3AH	Production well E-3AH
E-3H	Production well E-3H
F-1H	Injection Well F-1H
F-3H	Injection Well F-3H
FGPR	Field Gas Production Rate
Fig.	Figure
FPR	Field Pressure
GOC	Gas Oil Contact
Injec	Injection
INCR	Increased
kg	Kilogramme
km	Kilometre
m	Metres
m^3	Cubic Metres
mD	milli Darcy
MINPV	Minimum Pore Volume
MLT	Multiplied
MULT	Multiplier
MULTZ	Transmissibility Multiplier in Z-direction (downwards)
NTG	Net to Gross ratio
PERMX	Horizontal Permeability in X-direction, Eclipse100 keyword
PERMZ	Vertical Permeability in Z-direction, Eclipse100 keyword
PORO	Porosity Multiplier, Eclipse100 keyword

REDU	Reduced
Sm^3	Standard Cubic Meters
TVD	True Vertical Depth
Wat	Water
WCONPROD	Control Data for Production Wells, Eclipse100 Keyword
WGPR	Well Gas Production Rate
WGPRH	Well Gas Production Rate History
WGPT	Well Gas Production Total
WGPTH	Well Gas Production Total History
WOC	Water Oil Contact
WOPR	Well Oil Production Rate
WOPRH	Well Oil Production Rate History
WOPT	Well Oil Production Total
WOPTH	Well Oil Production Total History
WPI	Well Productivity Index
WPIMULT	Well connection transmissibility factor multiplier, Eclipse100 Keyword (used in the Schedule section)
WWCT	Well Water Cut
WWCTH	Well Water Cut History
WWPR	Well Water Production Rate
WWPRH	Well Water Production Rate History
WWPT	Well Water Production Total
WWPTH	Well Water Production Total History

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1. INTRODUCTION

The complex and somewhat heterogeneous nature of most petroleum reservoirs requires that a great deal of accuracy be taken into consideration when assembling data for building a geological model. If the initial model is built on inaccurate data, there is the likelihood that any further work carried out with or on such a model will also be laden with inaccuracy and errors. There is therefore the need for care, caution and accuracy in obtaining data especially in the business of oil and gas which usually involves a lot of energy, technology, time, financial and man-power investment.

The oil and gas industry like every other sophisticated industry, utilizes several processes, tools and methods to collate data with accuracy and tackle its various challenges in a bid to expend only what is necessary and obtain what is maximally obtainable with reference also to timing. History matching is one of such process employed to match current reservoir geologic model with observed production history with the aim of obtaining an almost exact model for future prediction. Rwechungura et al [23], stated that the economic viability of a petroleum recovery project is greatly influenced by the reservoir production performance under the current and future operating conditions. Therefore evaluation of the past and present reservoir performance and forecast of its future are essential in reservoir management process. The history matching process is being applied to the Norne field with the expectation that researchers will competently utilize the real field data given to produce meaningful results that can be put into operation for better reservoir management. It will also be advantageous if the results from all researchers on this field could be put into a common database for easy access, further research and referencing, with respect to Norne or any other field with similar reservoir properties and characteristics.

This thesis work is concentrated on the E-segment of the Norne field. Manual history matching method was performed using Eclipse100 reservoir simulator, Office and Floviz, all from Schlumberger. Manual history matching involves making perturbations to several pre-selected parameters which are known to affect well performance and productivity. Based on an earlier sensitivity analysis study by Essien[23] on the same E-segment of the Norne field, porosity, transmissibility, horizontal and vertical permeability, amongst others were the main parameters selected to be adjusted to give the best possible match. It is however interesting to note that manual history matching can continue as long as possible, until the very "perfect" match is obtained but that is usually not the case due to time and financial constraints placed on most history matching projects. Another interesting factor is that history matching has no definite solution, hence it can be quite frustrating if the uncertainty in the value of the parameters is very high, raising much doubts on the reliability of the entire matching process.

The Norne field has been in production since November 1997 (Rwechungura et al [22]), therefore an enormous amount of both production and pressure data is available for use in research work. The Centre for Integrated Operations (IO Centre), the Norwegian University of Science and Technology (NTNU), and the Norne Field Operators (Statoil, ENI & Petoro) from the period of 2007 to 2008 made available real data from the Norne field for intensive research. This was classed as a benchmark case for the petroleum industry.

With the provided data and softwares, manual history matching was performed on the E-segment and the scenarios considered were: Gas, oil and water rates and their total production; productivity index; water cut; and field pressure. Perturbation was then performed on the chosen parameters using the Monte Carlo random selection method until the desired near perfect match was obtained. On the whole, a decrease in horizontal permeability and an increase in porosity, transmissibility (WPIMULT), and vertical permeability, gave the best possible match. After obtaining the best matched model (or Final Match), from the manual history matching process, it was used for the forecasting operation.

The forecast was made for an extension period of ten (10) years, from December 2004 to December 2014. Gas injection into the Norne field had been stopped, however a comparison of both simultaneous water and gas injection with only water injection was made for observation purposes. It was clear from the plots obtained that the injected gas had little or no effect on production rates or total production values, affirming the need for it to be stopped. For Improved Oil Recovery (IOR), only water injection was considered and experimented on. Two cases of increased and reduced water injection were run to see their effects on oil and water production rates from the wells. Other IOR methods such as surfactant, polymer and alkaline injection methods were not considered in the forecast since these are complex processes and are very well treated in more detailed works by other researchers.

Though increased water injection increased field pressure it did not yield higher oil production as would have been automatically expected, rather the issue of increased water production and early water breakthrough at the oil production wells was a subject of concern. Horizontal permeability reduction around the grid blocks surrounding the producers was seen to reduce the early water uptake into the oil producing wells.

2. HISTORY MATCHING OVERVIEW

History matching is the process of adjusting the reservoir geological model to match the model from field production data. Reservoir production performance greatly determines the economic feasibility of oil and gas recovery and also the future sustenance of production operations. Thus, for efficient reservoir management, a thorough analysis of past, present and future reservoir performance is required, and history matching is a very handy tool for this.

2.1 Objectives of History Matching

History matching aids in updating the current reservoir model, matching it with past production, and optimized future prediction. Rwechungura et al [23], asserts that the main reason for history matching is not just to match historical data, but to enable the prediction of future performance of the reservoir and thus production optimization with regards to economy and oil and gas recovery by improved or enhanced methods.

According to Olumide[21], the actual geometry of a reservoir is largely unknown, thus productivity forecasts made with such a model would be laden with errors. For this reason the model has to be adjusted by history matching to obtain the suitable model with which prediction of future reservoir performance can be competently carried out.

2.2 Benefits of History Matching

Aside from giving a good match and providing a model for future predictions, history matching process provides some other benefits. Nan Cheng[18], stated that the other benefits of history matching include:

- Model calibration, which helps to improve and validate reservoir description;
- Prediction of future performance with higher degree of confidence;
- Enhancing the understanding of the reservoir; and
- Detecting operational issues during the process of reservoir management.

Olumide[21], adds that history matching improves the quality of the simulation model, helps to locate weakness in available data and provides in-depth understanding of the processes taking place in the reservoir.

2.3 Methods of History Matching

Many methods of history matching have been developed over the years with many researchers trying to find new ways of faster, efficient, accurate and less time-consuming methods. Earliest history matches were performed by trial and error with the hope that manually adjusting the value of some parameters might help give the desired match. Rwechungura et al [23], stated that the quality of such history matching would largely depend on the engineer's experience and the budget allocated for the process. This is due to the fact that petroleum reservoirs are usually very complex and heterogeneous having hundreds of thousands (and in very large reservoirs, millions) of grid blocks in the simulation model required for high resolution evaluation of reservoir parameters. Due to these afore mentioned complexities and the fact that many uncertainties abound in determination of the absolute values and effects of reservoir parameters, manual history matching is not readily considered and is not reliable when the project period is long. For this reason computerized (or automatic) history matching methods have been developed and utilized by many researchers.

However, if the field or segment under consideration is small, accurately delineated, and the reservoir parameters and characteristics well defined as in the case of this study, then manual history matching can be applied with some degree of comfort. Manual history matching basically involves manual perturbation of pre-selected parameters based on sensitivity studies carried out to pre-determine which parameters affect production the most. The Monte Carlo random selection method has been used in many manual history matching projects for parameter selection and combination.

Automatic history matching is based on algorithms written to specifically calculate an objective function and with several iterations to obtain a perfect or a near-perfect match. Basically, It involves the building of a working mathematical model, setting up of an objective function, and applying a minimization algorithm to the defined objective function. According to Rwechungura et al [23], the mathematical model required for the estimation of unknown parameters in history matching consists of two components namely:

- A reservoir simulator to model the flow through porous media, and
- A rock physics model to enable computation of seismic responses.

Olumide[21], states that the objective function is a function of the difference between the observed reservoir performance and the response calculated by the simulation model using the available parameters and can contain many terms representing various constraints.

3. NORNE FIELD/E-SEGMENT OVERVIEW

The pilot project of Norne is the first benchmark cased based on real life data and its purpose is to establish it as a key benchmark for the oil and gas industry (Rwechungura et al [22]). This pilot project was set up by a collaboration between the Centre for Integrated Operations (IO Centre), the Norwegian University of Science and Technology (NTNU), and the Norne Field Operators (Statoil, ENI & Petoro) from 2007 to 2008 (Rwechungura et al [22]). The essence of this benchmark case is to allow researchers evaluate and compare mathematical methods for history matching and closed-loop reservoir management. The first package of Norne data released for different research purposes was released under the name of "E-Segment" (Rwechungura et al [22]).

According to Rwechungura et al [22], the main reasons for establishing the Norne benchmark case is to supply real data rather than synthetic so that the following can be achieved:

- Comparative studies of alternative history matching methods and closed-loop reservoir management;
- Sharing of results, new knowledge and ideas with the Norne field operators and other researchers working on the benchmark case; and
- Publishing of the scientific results for future research and other purposes.

Based on information released from the IO Centre at NTNU[20], The Norne field is located in blocks 6608/10 and 6508/10 on a horst block in the southern part of the Nordland II in the Norwegian Sea. The horst block is approximately 9km by 3km. It was discovered in December 1991. It consists of two separate oil compartments, the Norne main structure (C, D and E segments) and the Northeast segment (G segment). About 98% of oil in place is in the Norne main structure. The total hydrocarbon column (based on well 6608/10-2) is 135m which contains 110m oil and 25m gas in the rocks of Lower and Middle Jurassic age of the Fangst and Båt Group. Approximately 80% of oil is located in the Ile and Tofte formations and gas in the Garn formation.

Development drilling began in August 1996 and oil production started in November 1997, (Rwechungura et al [22]).

3.1 Reservoir simulation model

The publications by Rwechungura et al [22] and by the IO Centre and NTNU [20], give a detailed information concerning the Norne reservoir simulation model. According to the publications, the original high-resolution model is developed based on Geo model 2004. The reservoir is discretized into 46 by 112 by 22 grids and consists of 113344 grid cells of which 44927 are active. The reservoir model is subdivided into four formations from top to base: Garn, Ile, Tofte and Tilje, with the Not formation coming in between the Garn and Ile formations. The model is physically divided into two sections by a shale layer called NOT formation. The upper and lower section consists of 3 and 18 layers respectively, making a total of 22 reservoir sections or zones. The whole Norne reservoir simulation model is in the form of Eclipse100 which is a three phase, three dimensional black oil model. Table 1 below gives a summary of the divisions.

Table 1: Reservoir zonation from Eclipse100 Model (Rwechungura et al [22])

Layer Number	Layer Name	Layer Number	Layer Name
1	Garn 3	12	Tofte 2.2
2	Garn 2	13	Tofte 2.1.3
3	Garn 1	14	Tofte 2.1.2
4	Not	15	Tofte2.1.1
5	Ile 2.2	16	Tofte 1.2.2
6	Ile 2.1.3	17	Tofte 1.2.1
7	Ile 2.1.2	18	Tofte 1.1
8	Ile 2.1.1	19	Tilje 4
9	Ile 1.3	20	Tilje 3
10	Ile 1.2	21	Tilje 2
11	Ile 1.1	22	Tilje 1

The Norne E-segment is separated from the rest of the field by keeping the E-segment part as original grid and coarsening the rest. The E-segment contains 8733 active cells, with block sizes between 80m to 100m in the horizontal direction. In total eight (8) wells have been drilled in the E-segment part. These comprise of one observation, 2 injector and 5 producers (of which 2 are side tracks). This thesis work is based on 2 injectors (F-1H and F-3H), and 3 producers (E-2H, E-3H, E-3AH). Some properties of the oil and gas in the Norne field as given by the IO Centre publication[20] are:

Initial pressure: 273bar at 2639m TVD

Reservoir temperature: 98 °C

Oil density: 859.5 kg/m^3 API= 32.7 Gas density: 0.854 kg/m^3

Water density: 1033 kg/m^3

Oil formation volume factor: 1.32

Gas formation volume factor: 0.0047

Rock wettability: mixed

Pore Compressibility: 4.84×10-5 1/bar at 277 bar

3.2 Development Plan

The reservoir has been produced since November 1997 and as of October 2008 there were 25 wells remaining active which consist of 17 producer wells and 8 injector wells. Some wells are planned to be closed and there is no plan to drill new additional wells. Approximately 80 million Sm^3 of oil has been produced to October 2008, which is nearly 86% of recoverable reserves. It was estimated in December 2007 that the recoverable reserves was 93 million Sm^3 of oil and 11.6 billion Sm^3 of gas. Remaining reserves are estimated to be 13 million Sm^3 of oil and 5.3 billion Sm^3 of gas.

3.3 Provided data

The data used for this work was obtained from the Norne E-segment database provided by Statoil and its license partners. The following data were given:

- Reservoir simulation model for the E-segment in Eclipse100 format updated till December 2004;
- Interpreted Faults and Horizons;
- Petro-elastic Model;
- Production, Injection, and Pressure Data;
- Seismic Data;
- Time Depth Conversion; and
- Wells and log Data.

3.4 Parameters of interest for perturbation

The data obtained from measurements in the reservoir are often with some degree of errors, which can be very small and thus negligible if it was thoroughly and accurately done or large with severe unfavourable outcomes if it was wrongly or carelessly taken. Generally, uncertainties abound in all reservoir data, hence the model built from the obtained reservoir data is always questionable. Unlike geologic data, dynamic data such as pressure, production and seismic data are usually changing as production continues, hence they are usually employed in reservoir re-characterization. Being able to match these dynamic data is key to getting a very good match. Several parameters are usually on hand for selection for perturbation in the quest for this good match, but not all have the same effect on rates and pressures. While some have a very noticeable effect when altered, others produce a barely noticeable effect.

Based on an earlier Uncertainty and Sensitivity analysis work carried out on the E-segment of Norne by Essien[8], it was discovered that the parameters that most affected production where net-to-gross ratio, porosity, transmissibility, horizontal and vertical permeability. Hence these parameters where considered foremost for perturbation. Other parameters also considered include fault multipliers, minimum pore volume and fluid contacts. Table 2 gives a summary of the ranges to which the parameters were stretched.

Table 2: Summary of parameter ranges

TESTS	PERMX (mD)	PERMZ (mD)	FAULT MULT	WPIMULT	MULTZ	MINPV (set to)	PORO	WOC (added)
BASE CASE	DEFAULT	DEFAULT	DEFAULT	DEFAULT	DEFAULT	DEFAULT	DEFAULT	DEFAULT
A	0.1	MLT by 10	MTL by 100	5.0	MLT by 1.0	1000 m^3	MLT by 1.25	100m
B	0.01	MLT by 5.0	MTL by 10	2.0	MLT by 0.5	750 m^3	MLT by 1.25	75m
C	0.001	MLT by 0.5	MTL by 0.1	0.5	MLT by 0.1	600 m^3	MLT by 1.25	25m
D	0.0001	MLT by 0.1	MTL by 0.01	0.1	MLT by 0.01	300 m^3	MLT by 1.25	-25m
E	0.00001	MLT by 0.01	MTL by 0.0	0.01	MLT by 0.001	150 m^3	MLT by 1.25	-50m

3.5 Method Used for History Matching the E-segment

The several parameters chosen were altered one after the other in a random Monte Carlo selection method. While one parameter was being altered, all other parameters where held constant using a *Ceteris paribus* format. After altering all the parameters one after the other, the parameters were then combined in many several ways, two at a time, three at a time, and so on, with several ranges chosen for each parameter. Based on several permutations and combinations of parameters, over five hundred (500) simulation runs where made with several adjustments made after each run to test suitability of a particular parameter when its value was altered. Reasonable modification or alteration is required as it would be senseless to allocate an extremely high or low value which is practically impossible to have in real life. Hence perturbations where made with sound judgment and suitable ranges chosen based on obtainable figures from real life field practice. Olumide [21], states it as a challenge and maintains that "un-intelligent" changes should be avoided by identifying key uncertainties and focusing upon them. A combination of Schumberger's Eclipse100, Office and Floviz were used for the history matching process. While the Eclipse100 was used for simulation runs, Floviz was used to view the reservoir in production mode from inception in 1997 up till 2004, and Office was used to make the plots. Hence it was possible using Floviz to observe: the well connections and on which layers they were completed; the oil flow from the wells during production; the oil, gas and water saturation changes during the entire production period of the reservoir; the water flow through the reservoir, and into the wells; the general actions of the injection wells on the producers; the pressure build up and decline as production commenced; and the permeability distribution throughout the reservoir. The use of Floviz also aided in determining which cells to work on, either by increasing or reducing the permeability around a well, and in what direction. Figures 1a, 1b, 2a and 2b give a view of the horizontal and vertical permeabilities as seen using Floviz. Tables 3a and 3b give the summary of the final values used for the selected parameters to build the best matched model.

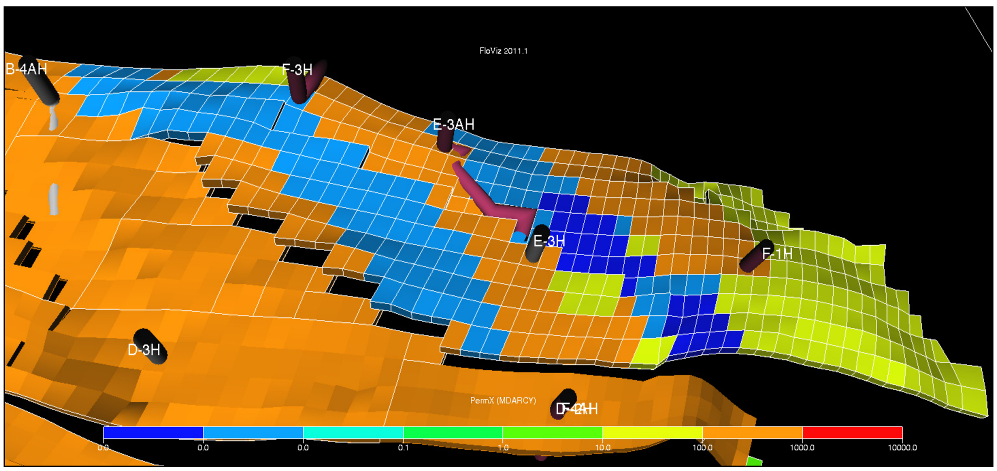

Fig. 1a PERMX for layer 2 showing E-3H & E-3AH Connection

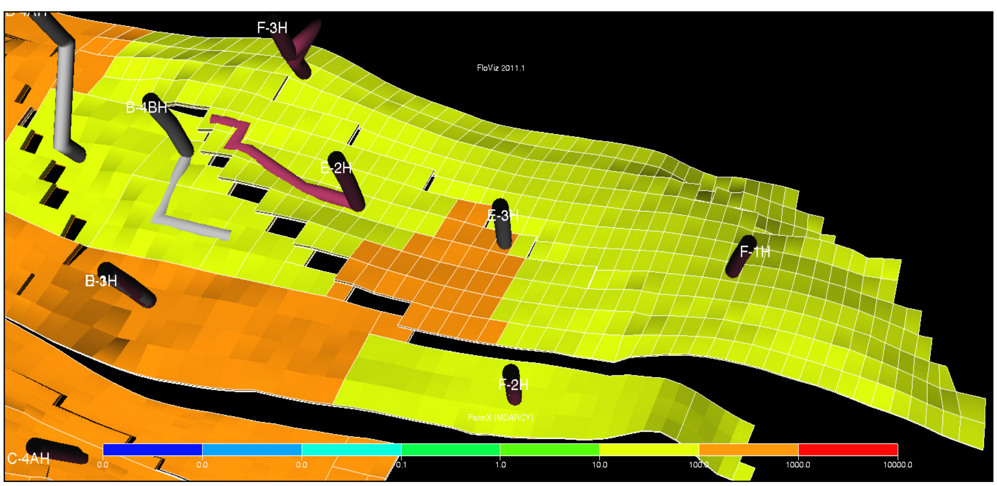

Fig. 1b PERMX for layer 9 showing E-2H Connection

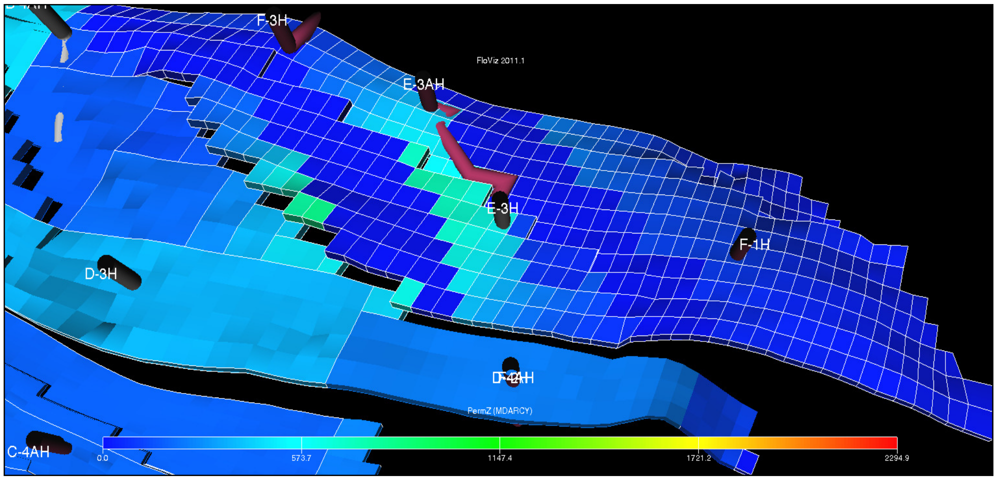

Fig. 2a PERMZ for layer 2 showing E-3H & E-3AH Connection

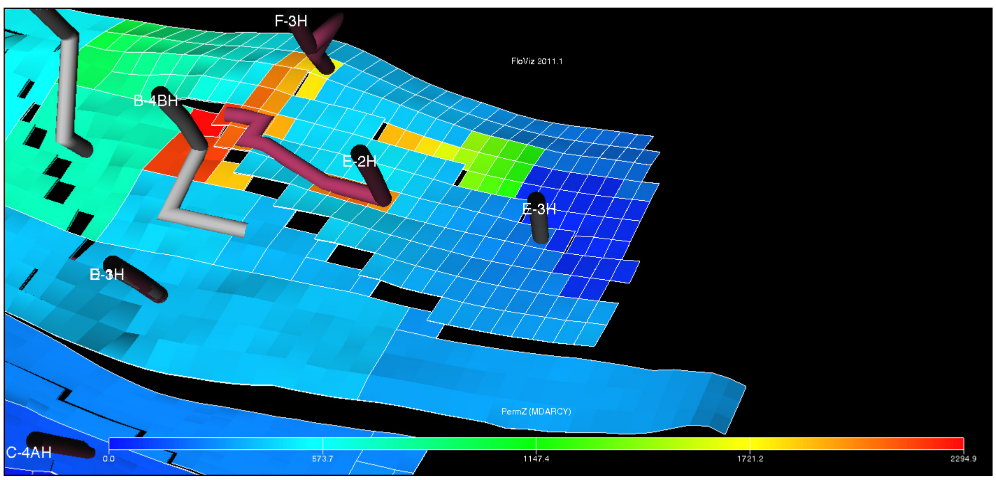

Fig. 2b PERMZ for layer 9 showing E-2H Connection

Table 3a: Summary of Final Parameter Values

TESTS	PERMX MULT E-2H	PERMX MULT E-3AH	PERMX MULT E-3H	PERMZ MULT: E-2H, E-3AH, E-3H	FAULT MULT: E-2H, E-3AH, E-3H
FINAL MATCH	0.2 and 0.4	0.00001	0.25	10.0	DEFAULT

Table 3b: Summary of Final Parameter Values

TESTS	WPIMULT: E-2H, E-3AH, E-3H	MULTZ: E-2H, E-3AH, E-3H	MINPV: E-2H, E-3AH, E-3H	PORO: E-2H, E-3AH, E-3H	WOC & GOC: E-2H, E-3AH, E-3H	NTG
FINAL MATCH	5.0	DEFAULT	DEFAULT	1.25	DEFAULT	DEFAULT

4. HISTORY MATCHING RESULTS AND DISCUSSION

After several simulation runs, a final match was obtained. This final match was tested on the scenarios under consideration namely: Gas, oil and water rates and their total production; productivity index; water cut; and pressure. For most of the tested scenarios, the final match gave a very good match for the gas production rates and production totals as can be seen in figures 3a through to 4c. A very good match was also obtained for the oil production rates as in figures 5a, 5b and 5c. Though the final match gave a good match for total oil production in wells E-2H and E-3H, it did not give so close a match for well E-3AH as figures 6a, 6b and 6c reveal. The most difficult parameter to match using manual history matching (as is the case with other history matching methods) was water cut. Several extra adjustments had to be made to the selected parameters for a good match. After several permeability and porosity alterations, the final match finally tried to fit, as seen in figures 7a, 7b and 7c. The water production rates and total water production was also not easy to match as was the case with water cut. However, the final match gave a good match to the historical data as seen in figures 8a through to 9c. Floviz software was really helpful in helping to locate the cells for which permeability had to be increased or decreased. On the whole, a decrease in horizontal permeability and an increase in porosity, transmissibility (WPIMULT), and vertical permeability gave the best possible match. WPIMULT, multiplies well connection transmissibility factors by a given value. It is usually included after the COMPDAT keyword in the Schedule section of the data file for the specified well. The other parameters for possible perturbation were kept at their default values as shown in tables 3a and 3b, as this was the best value for which they could be used based on the final match. Regretably, pressure could not be matched as there was no tubing head pressure data provided, hence there was no historical data for whcih pressure could be matched, this also affected the bottom hole pressure matching. Figures 3a through to 9c show a comparison between the Base case model and Final match obtained from history matching for all the tested scenarios.

4.1 History Match Plots

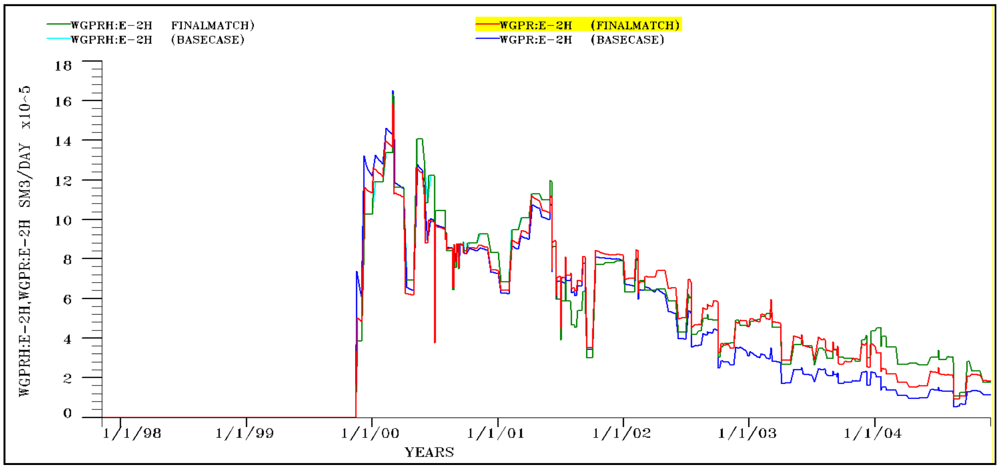

Fig. 3a WGPR & WGPRH, for Well E-2H: FM & BC

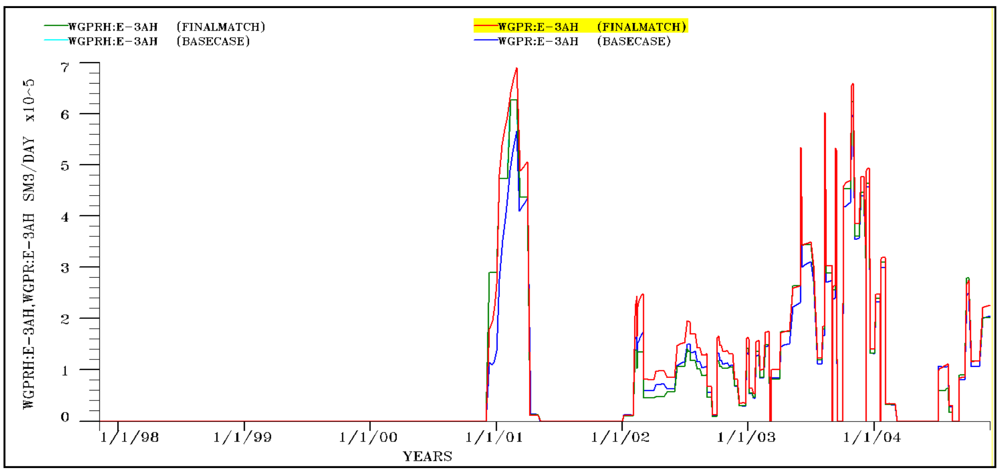

Fig. 3b WGPR & WGPRH, for Well E-3AH: FM & BC

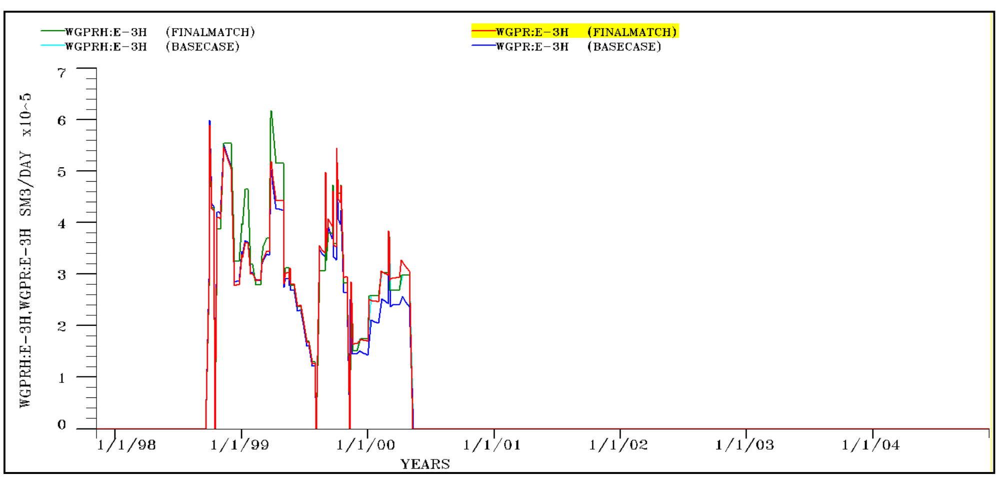

Fig. 3c WGPR & WGPRH, for Well E-3H: FM & BC

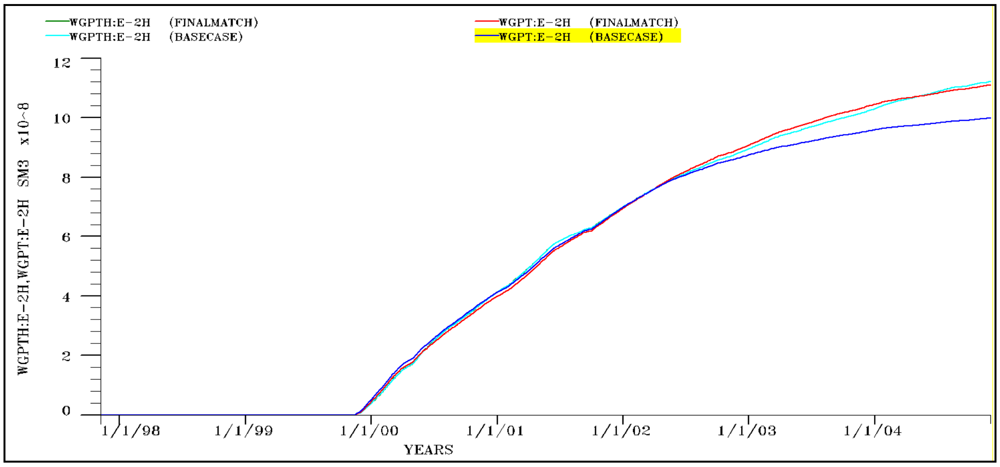

Fig. 4a WGPT & WGPTH, Well E-2H: FM & BC

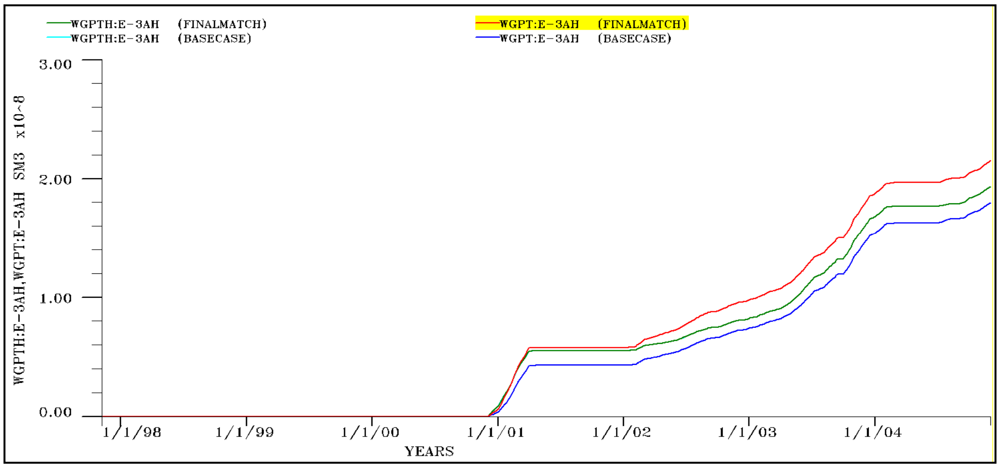

Fig. 4b WGPT & WGPTH, Well E-3AH: FM & BC

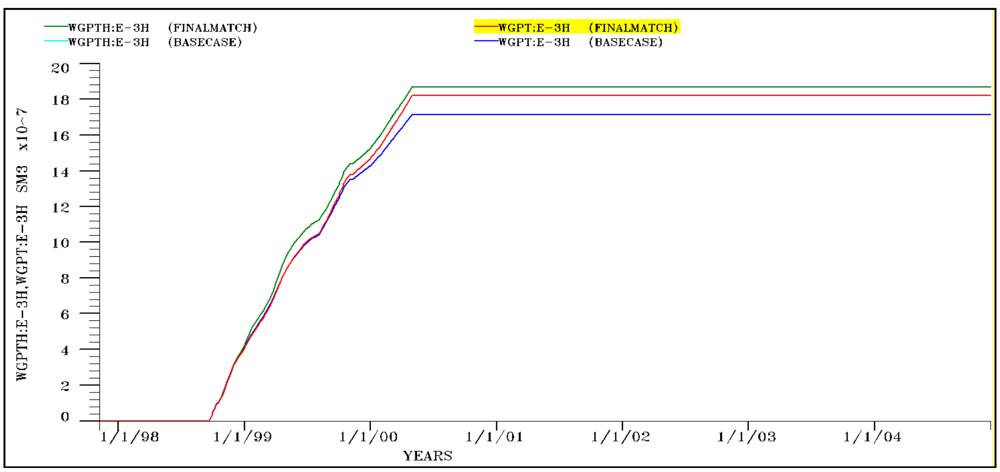

Fig. 4c WGPT & WGPTH, Well E-3H: FM & BC

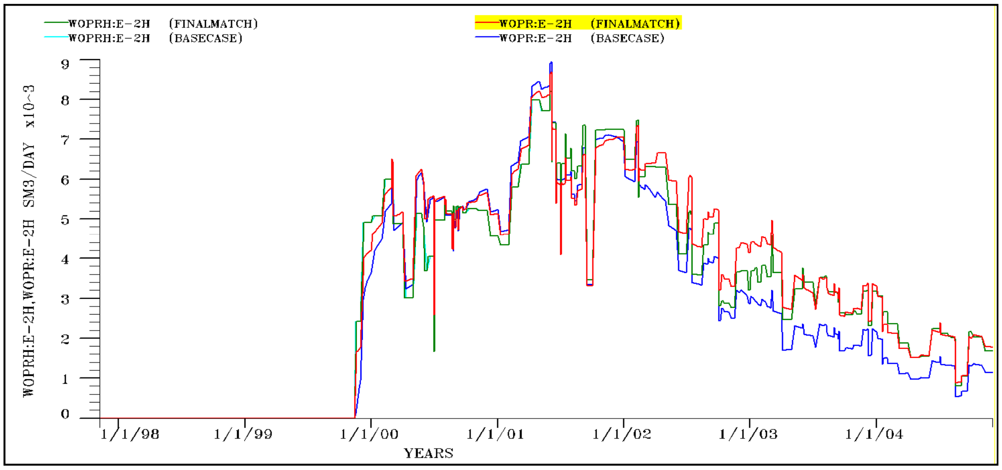

Fig. 5a WOPR & WOPRH, Well E-2H: FM & BC

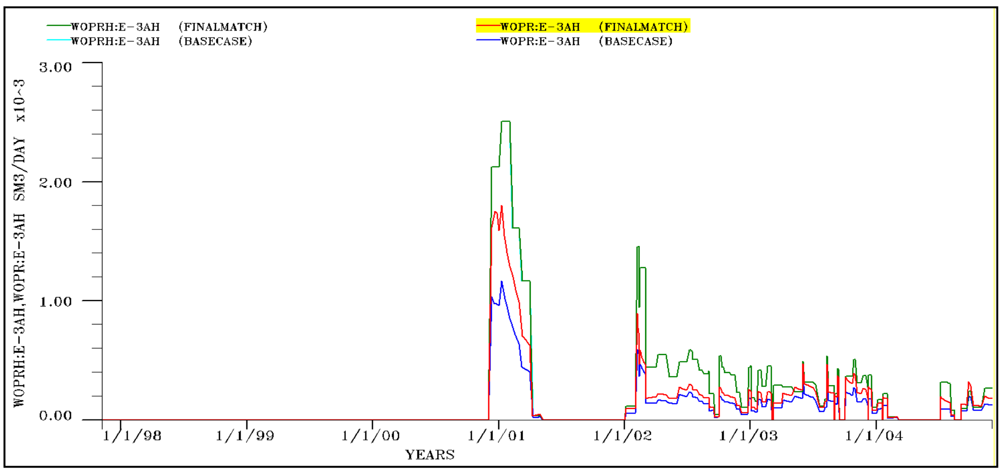

Fig. 5b WOPR & WOPRH, Well E-3AH: FM & BC

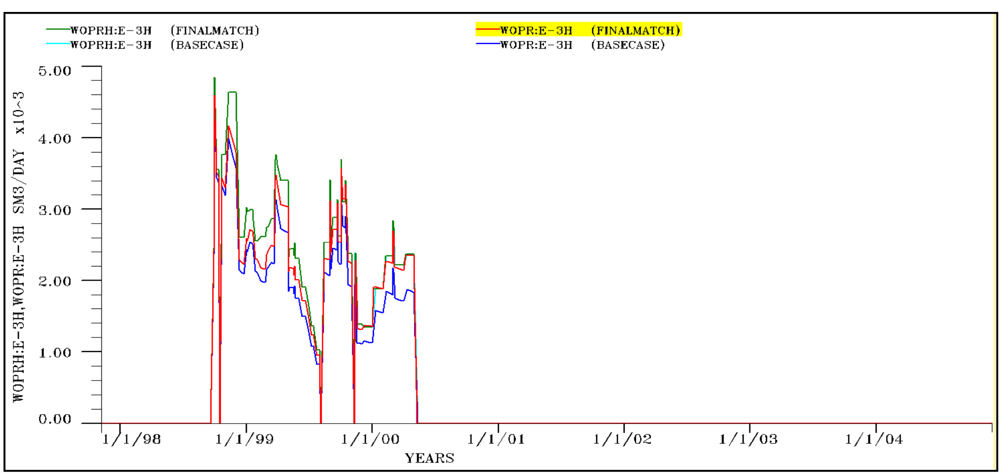

Fig. 5c WOPR & WOPRH, Well E-3H: FM & BC

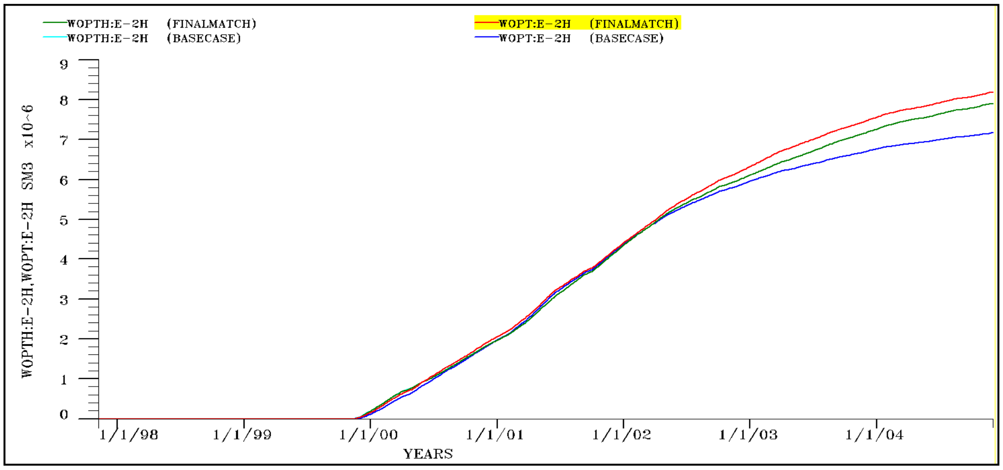

Fig. 6a WOPT & WOPTH, Well E-2H: FM & BC

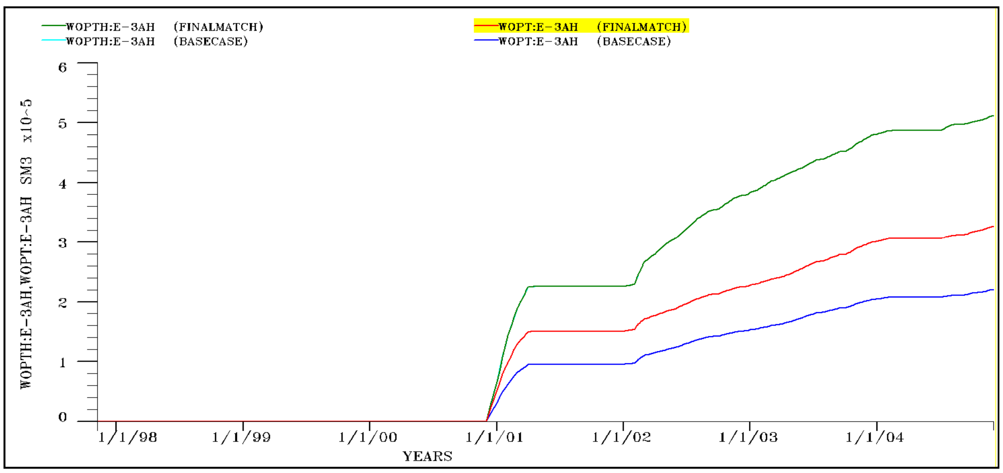

Fig. 6b WOPT & WOPTH, Well E-3AH: FM & BC

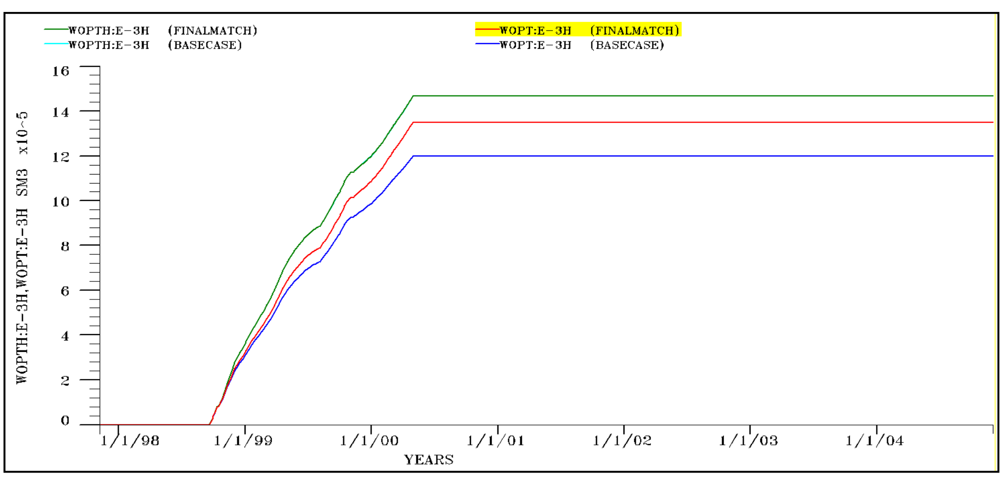

Fig. 6c WOPT & WOPTH, Well E-3H: FM & BC

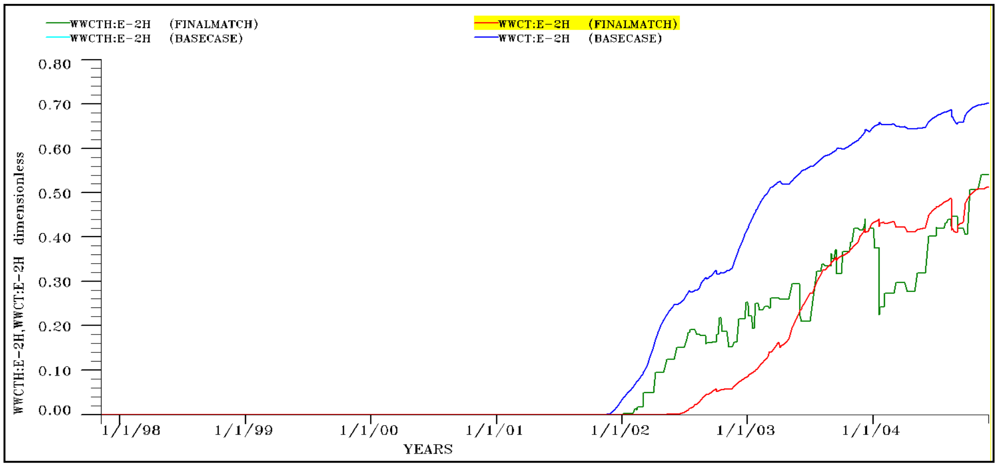

Fig. 7a WWCT & WWCTH, Well E-2H: FM & BC

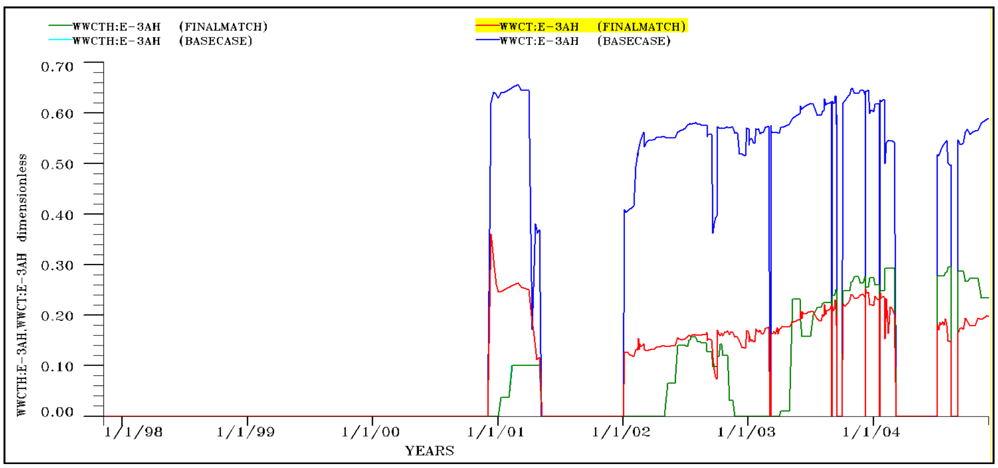

Fig. 7b WWCT & WWCTH, Well E-3AH: FM & BC

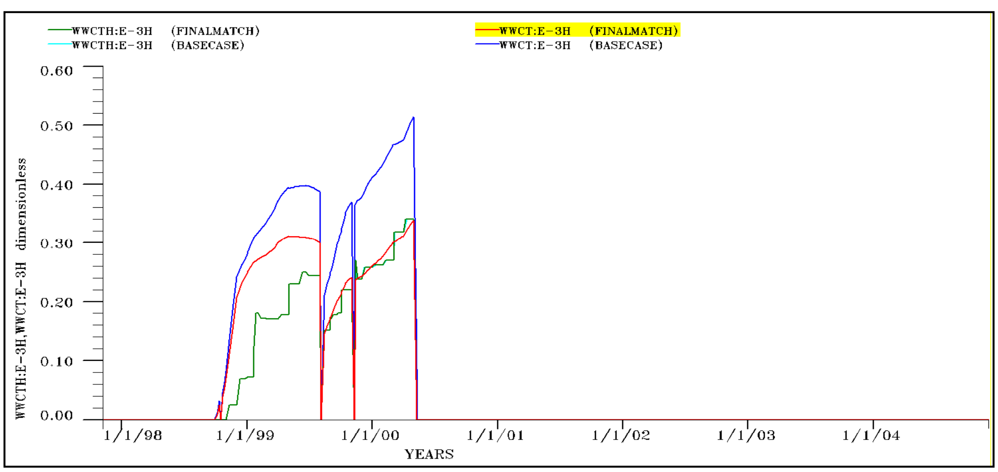

Fig. 7c WWCT & WWCTH, Well E-3H: FM & BC

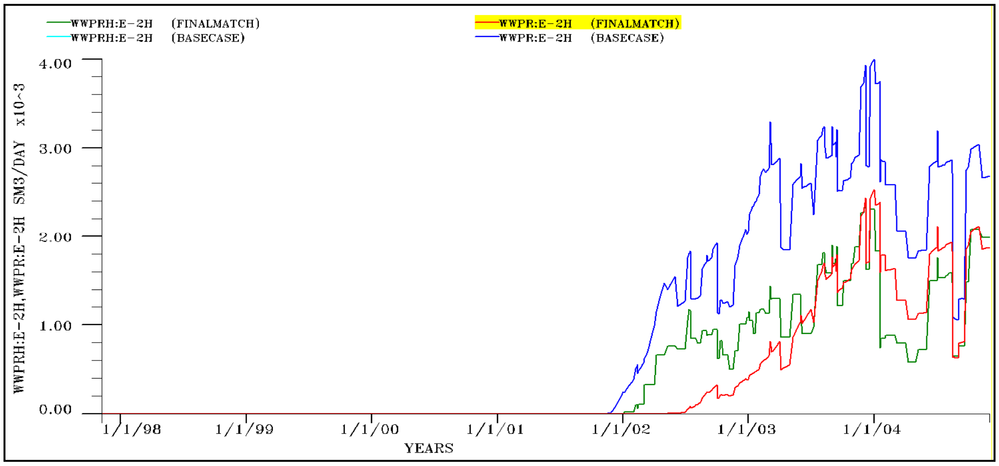

Fig. 8a WWPR & WWPRH, Well E-2H: FM & BC

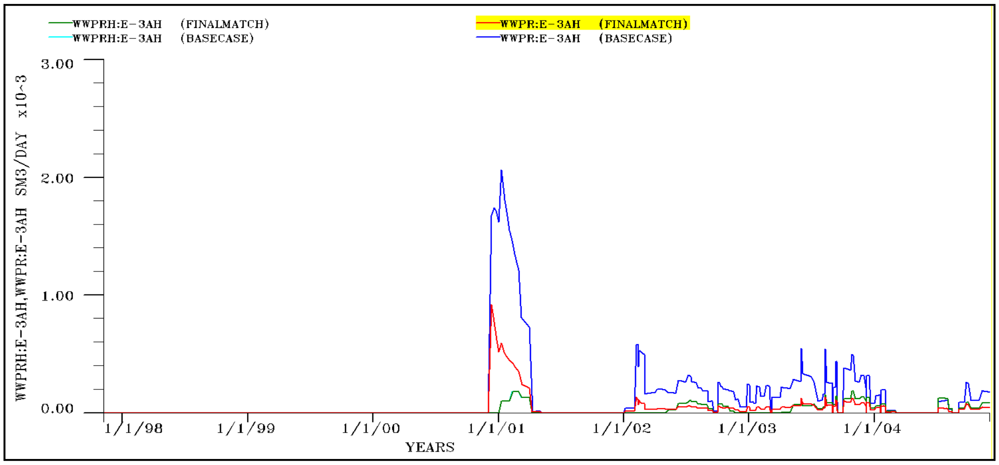

Fig. 8b WWPR & WWPRH, Well E-3AH: FM & BC

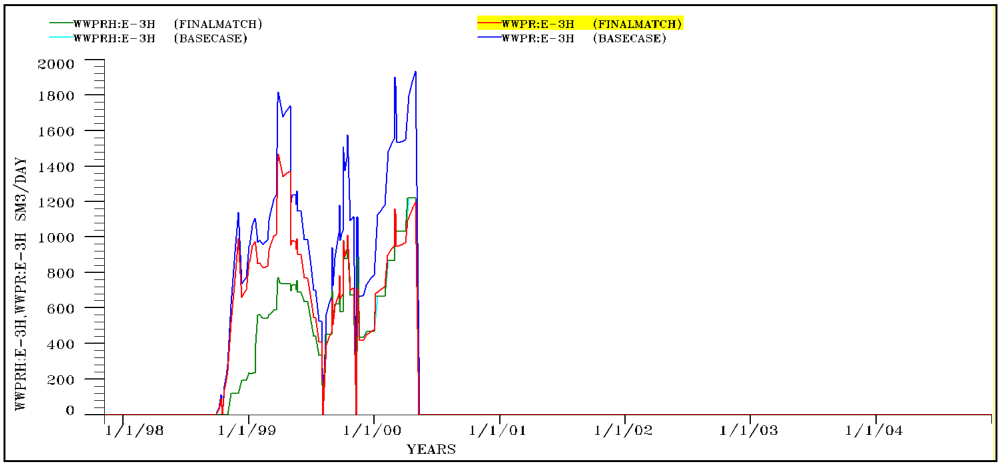

Fig. 8c WWPR & WWPRH, Well E-3H: FM & BC

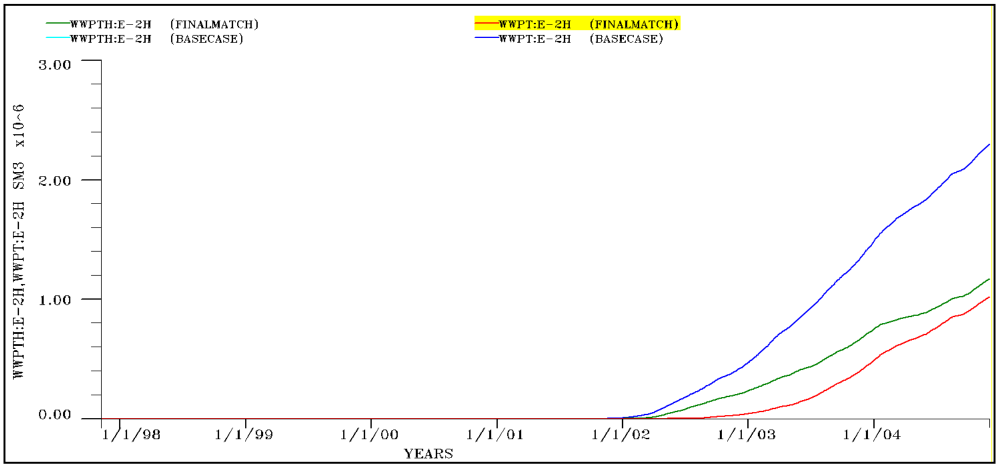

Fig. 9a WWPT & WWPTH, Well E-2H: FM & BC

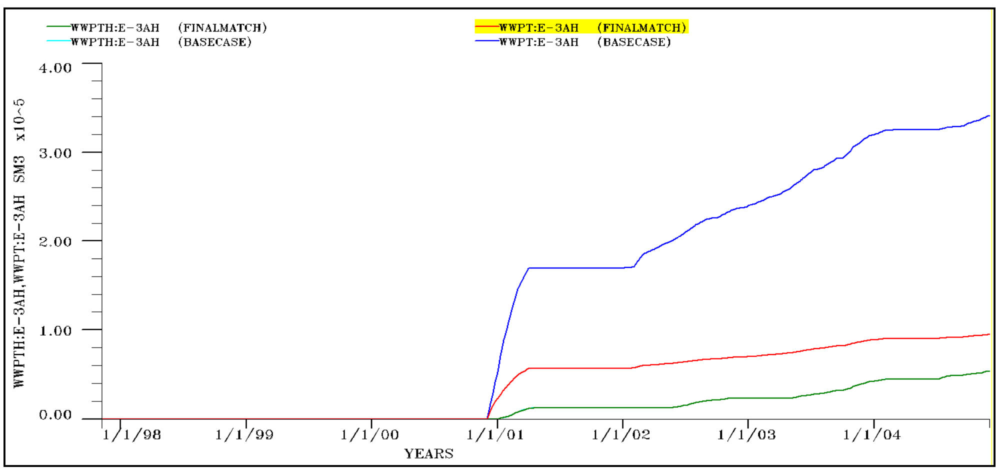

Fig. 9b WWPT & WWPTH, Well E-3AH: FM & BC

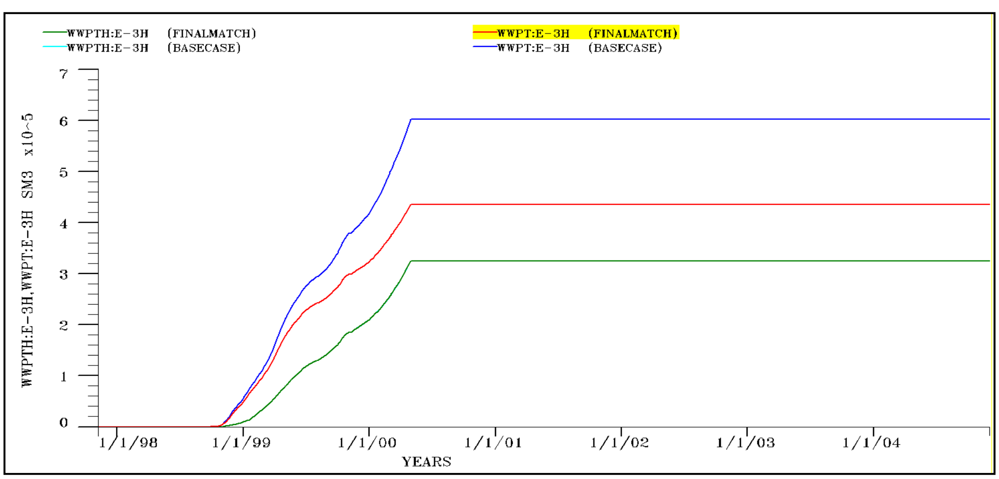

Fig. 9c WWPT & WWPTH, Well E-3H: FM & BC

4.2 Discussion of the results

Even though oil and gas production in the Norne field started in November 1997, the earliest oil and gas production from the E-segment was from well E-3H in September 1998, while well E-2H started oil and gas production in November 1999. As early as November 1998, well E-3H started producing water and by October 2000 it had to be shut in. Well E-3AH was drilled as a side track from well E-3H and it started oil and gas production by December 2000, unfortunately it started water production just a month after in January 2001 and by May 2001, well E-3AH was also shut in, while well E-2H continued to produce oil and gas with no water yet. Well E-3AH was re-opened in February 2002 possibly after some remedial work had been done on it and it started oil and gas production, but water production issues came up again in May 2002, till it was curtailed in November 2002. By April 2003 water production began again in well E-3AH. Well E-2H started producing water in January 2002. From then on till December 2004 which is where the historical data ended, wells E-2H and E-3AH were producing oil, water and some gas.

From the above observation it is clear that water production has been a great issue with the E-segment of Norne, not surprising anyway, since this is usually the case with most offshore fields with a huge underlying aquifer. Oil fields with such huge underlying aquifers have the potential of water encroachment into the production wells immediately oil and gas production begins. Simulation results showed that reducing the horizontal permeability around the grid blocks in between the producers E-2H, E-3H and E-3AH and the water injectors would impede the quick flow of water towards the production wells and thus prevent the early water breakthrough into these wells. Many permeability reduction methods abound and any of them well suited to the environment of the Norne reservoir if applied would go a long way to help solve this water encroachment problem.

Also simulation results showed that increasing the vertical permeability for the production wells would aid in the ease of oil uptake to the surface as should usually be the case. A higher porosity value was used in the Eclipse data file of the final match and it seemed to work quite well as compared to several lower values used or even the actual values given for each grid block in the historical data. This then raises the question of the exact accuracy of the measurement of the reservoir porosity. Though very little can be done to improve on this parameter, it is clear that a higher porosity value than that given for the historical data would be more suiting and certainly more productive.

An increase in the well connection transmissibility factor, WPIMULT, also proved to be very advantageous in helping to obtain the final good match. An indication that the wells had good connection with each other and other sections of the reservoir segment. This is a good indication, since it makes it clear that any improved oil recovery method applied on the reservoir is sure to spread round through all the wells with ease if their connectivity is increased by possible available methods.

The closeness of the final match model to the historical model was an indication that the manual history matching method used was quite successful. It also showed that though tedious, history matching can be very challenging, bringing out the best in ones reasoning ability. Making the several perturbations and by combinations and permutations, a fairly good match was obtained, suitable enough for future prediction. So if the field is small, and the reservoir historical data is very accurate, manual history matching method is still a good tool and not obsolete as some may think due to the availability of automatic history matching methods. But for big and complex fields, with relatively large and highly uncertain data, manual history matching is clearly not practicable, if time, energy, man-power and most especially money is of the essence.

5. FORECASTING

Due to the fact that well E-3H was shut and branched off to well E-3AH, the forecast was made for production wells E-2H and E-3AH only.

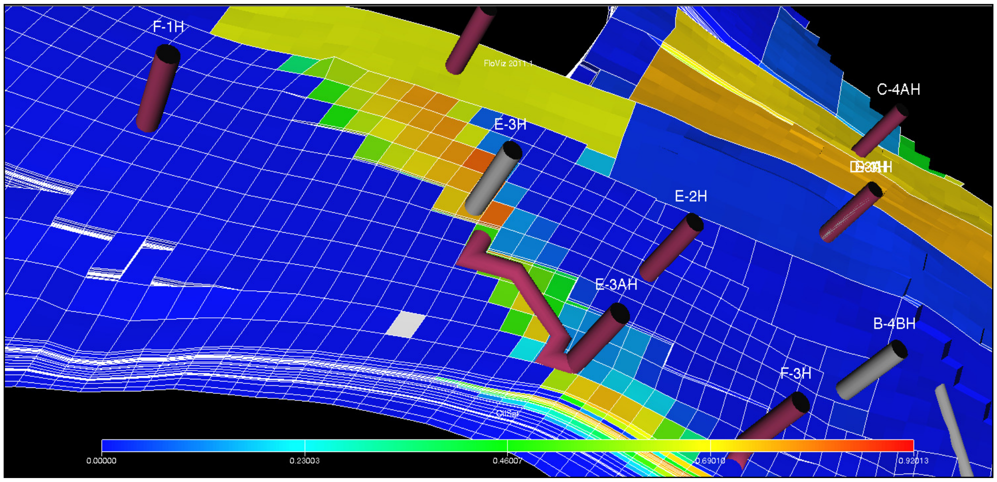

Fig. 10 Branching of well E-3H to well E-3AH

5.1 Discussion of Forecast results

Initially, simultaneous injection of water and gas was being used for pressure maintenance on the entire Norne field. But it was later discovered that there was a sealing NOT shale formation impeding the effect of the gas injection, hence it was stopped and only water injection was being carried out for pressure maintenance. However the forecast was made both for only water injection, and simultaneous water and gas injection. As would be expected, the plots revealed that both curves were almost the same for all scenarios, a true indication that the gas injection was of no effect, hence a waste of money, time and resources if continued.

The forecast was done based on previous historical and production data. The values of water and gas injection rates used in the forecast was that obtained from previous historical data. The assumption being that the same quantity of water and gas injection (if it were to be economical), was still being injected and that all other reservoir fluid properties, parameters, production and pressure data remained the same.

Since the forecast was based on values and rates from historical production, then one would expect the trend to continue as previously obtained by the historical model. This was not necessarily the case. Field pressure somewhat increased, as seen in figure 11. Though this should translate as should be expected into increased oil production rate, it sadly did not. The oil production rates for both wells rather remained constant as seen in figures 12a through to 13b. The total cumulative oil production overtime however increased slightly, as revealed in figures 13a and 13b.

Water cut and water production rates increased during the forecast period, clearly showing that the current water injection rate was rather increasing water intake or flow into the production wells than it was helping them produce oil, thus doing more harm than good. It is obvious that the current water injection rate should be reduced if lesser water production is expected from the oil production wells. If a lower water injection rate can still help maintain reservoir pressure at a reasonably high and efficient productive value, then it should be employed as increased water injection is clearly not the answer as seen from simulation forecast results.

Figures 11 through to 16b show all the plots from the forecast done on the E-segment for oil and water rates, productivity index, water cut and total oil and water production.

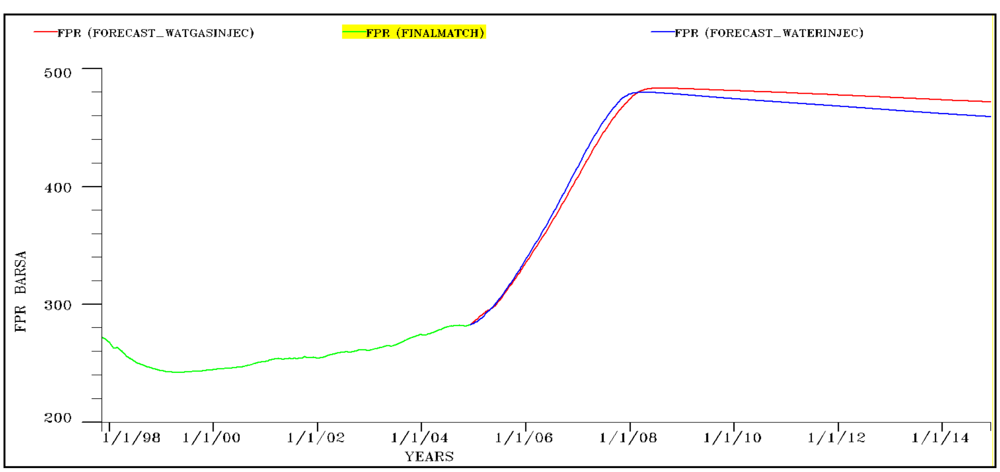

Fig. 11 FPR, for Wat&Gas Injec, FM & Wat Injec

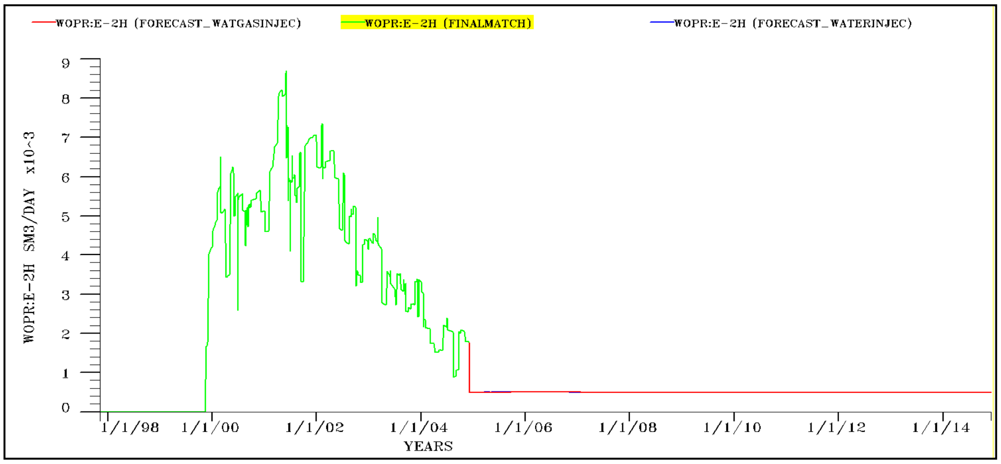

Fig. 12a WOPR, E-2H: Wat&Gas Injec, FM & Wat Injec

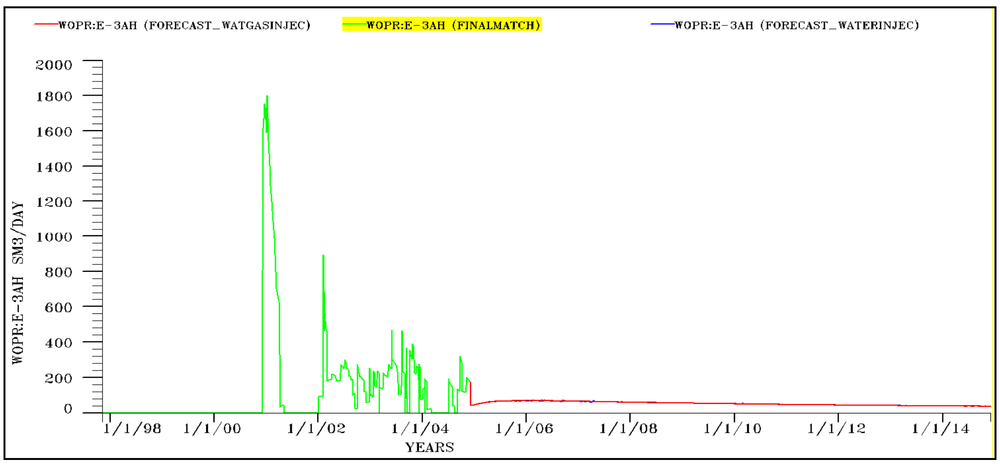

Fig. 12b WOPR, E-3AH: Wat&Gas Injec, FM & Wat Injec

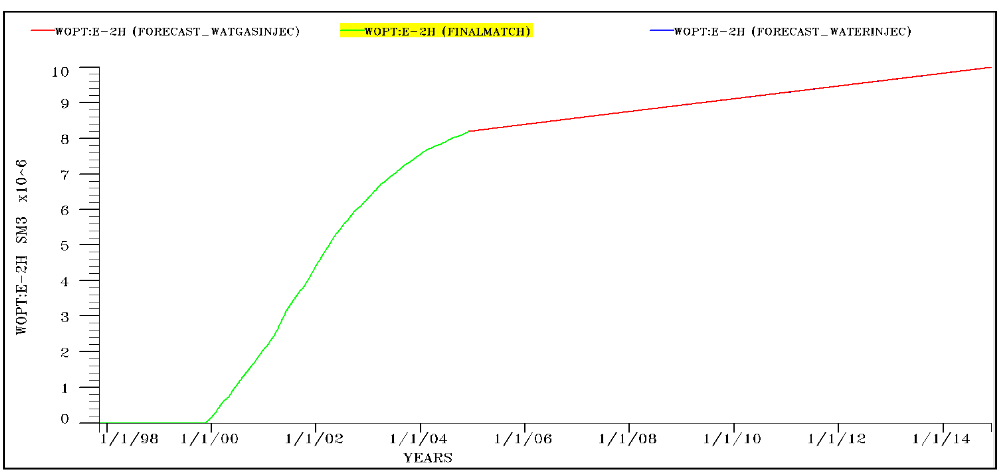

Fig. 13a WOPT, E-2H: Wat&Gas Injec, FM & Wat Injec

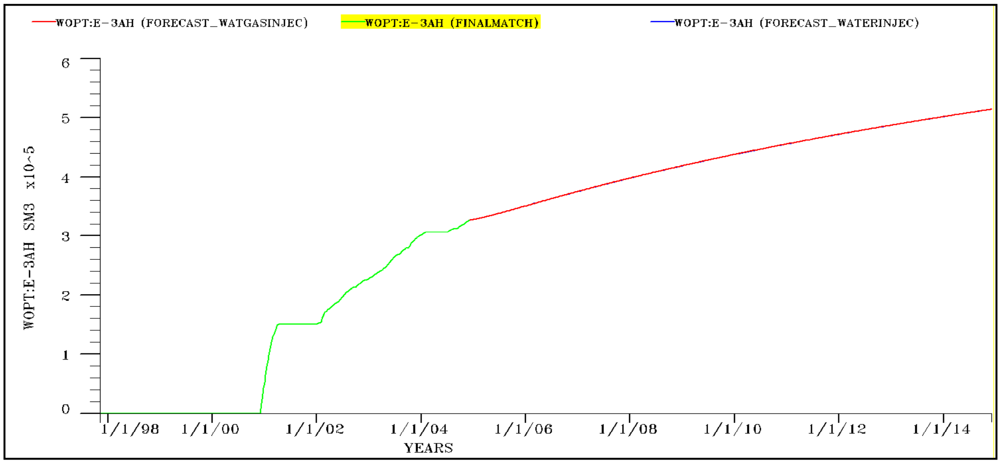

Fig. 13b WOPT, E-3AH: Wat&Gas Injec, FM & Wat Injec

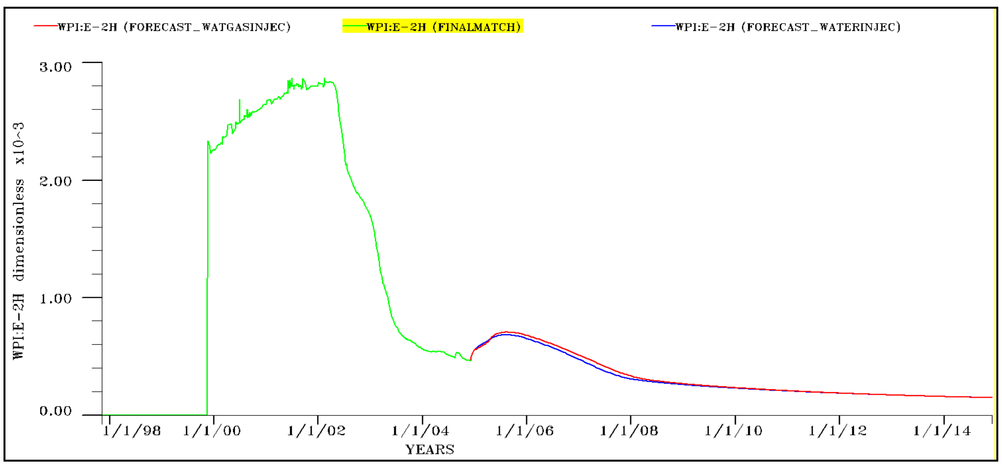

Fig. 14a WPI, E-2H: Wat&Gas Injec, FM & Wat Injec

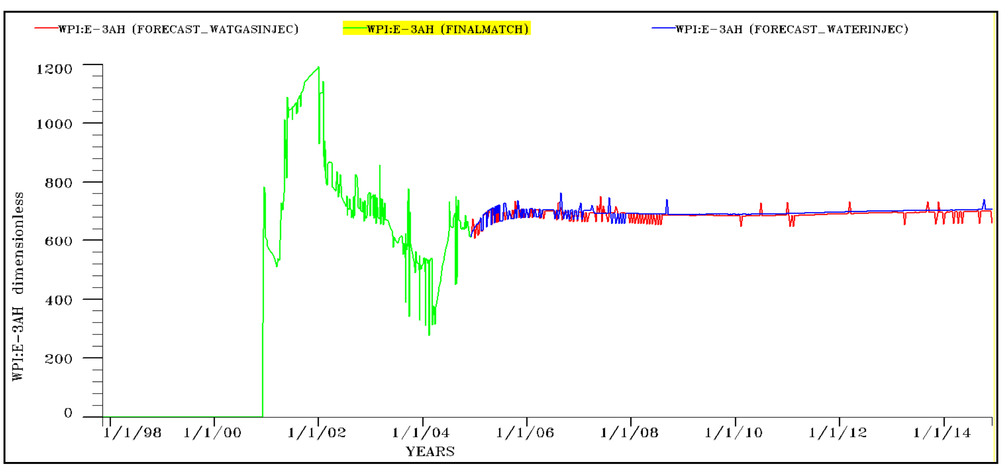

Fig. 14b WPI, E-3AH: Wat&Gas Injec, FM & Wat Injec

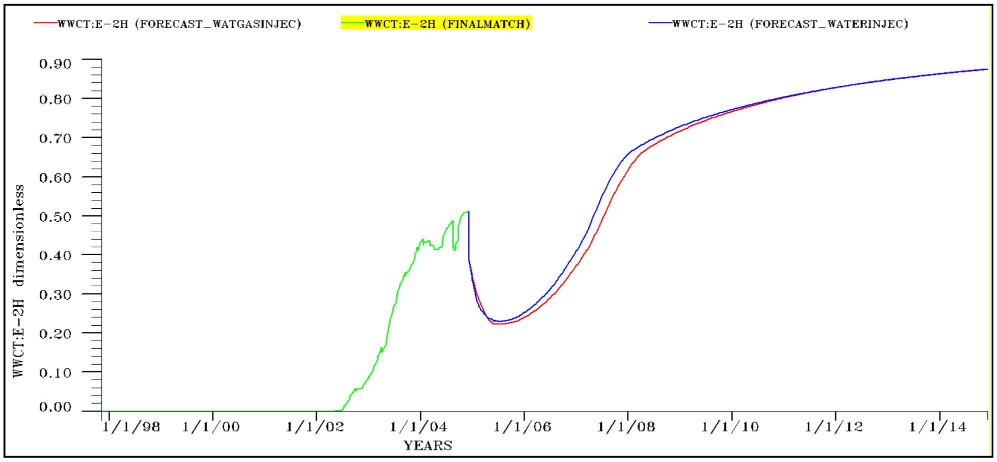

Fig. 15a WWCT, E-2H: Wat&Gas Injec, FM & Wat Injec

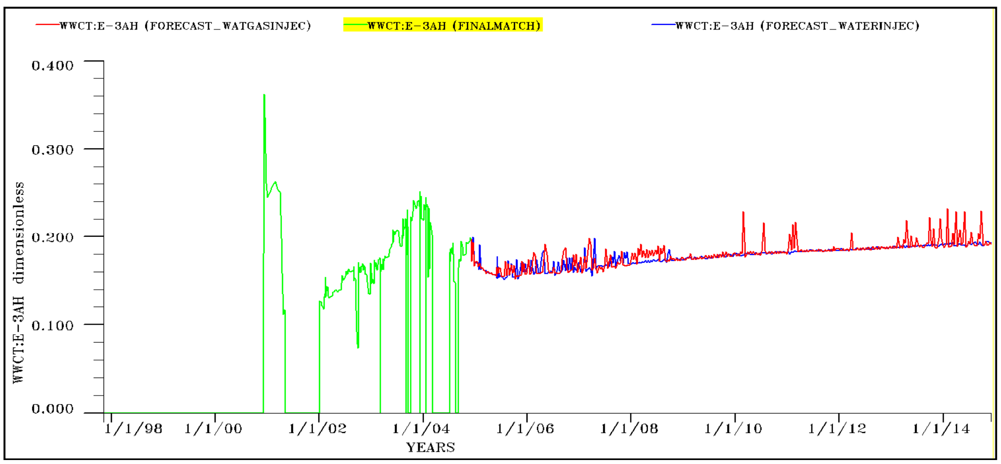

Fig. 15b WWCT, E-3AH: Wat&Gas Injec, FM & Wat Injec

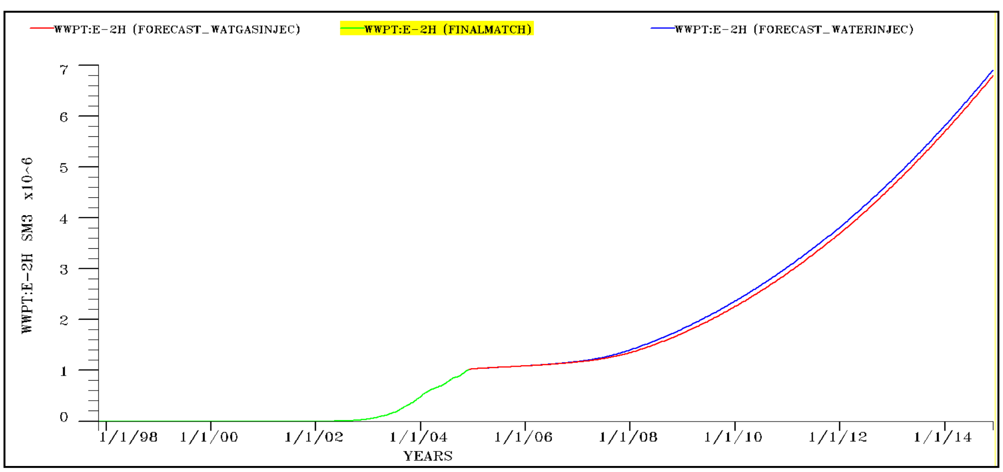

Fig. 16a WWPT, E-2H: Wat&Gas Injec, FM & Wat Injec

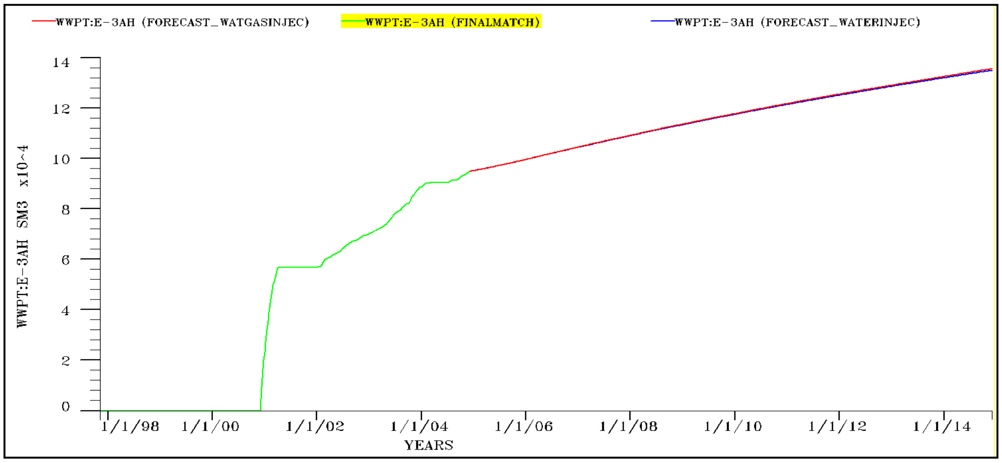

Fig. 16b WWPT, E-3AH: Wat&Gas Injec, FM & Wat Injec

5.2 Limitations and Assumptions to Forecasting

For the purpose of forecasting, several assumptions had to be made, these were:

- The injection rates for the injectors had to be based on the previous values obtained from historical data;
- This meant that the forecast result would show a continuously repeating or constant pattern as seen in the forecast plots;
- The Tubing Head Pressure value was not given so it was assumed to be zero, and under such conditions the Vertical Flow Performance (VFP) table value under the WCONPROD keyword in the Schedule section was set to zero.

6. RECOMMENDATIONS FOR OPTIMIZATION/IOR OPERATIONS

For optimized production from the E-segment, experiments suggest that water injection would help maintain the current pressure rate. Surprisingly, increased water injection, though it helps in increasing reservoir pressure, is not the answer to increased oil production rate as can been seen in figures 17, 18a and 18b. Oil production rates for both producers remained fairly the same, despite the increased water injection, though the overall total oil production increased slightly as seen in figures 19a and 19b. The WPI plots, figures 20a and 20b, showed that a reduced water injection process was more favourable. Reduced water injection also yielded a lower water cut value for both wells, figures 21a and 21b.

The E-segment and Norne field as whole has an issue of water encroachment resulting in easy water inflow into the production wells, hence an increased water injection rate would only aggravate the already lingering water issue and lead to increased water production from the supposedly oil producing wells especially as seen in figure 22a. Since the reservoir is already water flooded a reduced water injection rate that is able to maintain reservoir pressure at the current pressure value is desirable. This would aid in delaying and reducing the increased water production at the producing wells.

Another possible solution to this water problem would be to reduce the horizontal permeability of the grid blocks in between the injectors and the producers, limiting the easy and quick flow of water from the injectors into the producers. For ease of oil flow through the wells to the top, vertical permeability increase would certainly assure that.

Figures 17 through to 22b, show all the plots made to improve oil recovery on wells E-2H and E-3AH by experimenting both with increased and reduced water injection into the Norne E-segment.

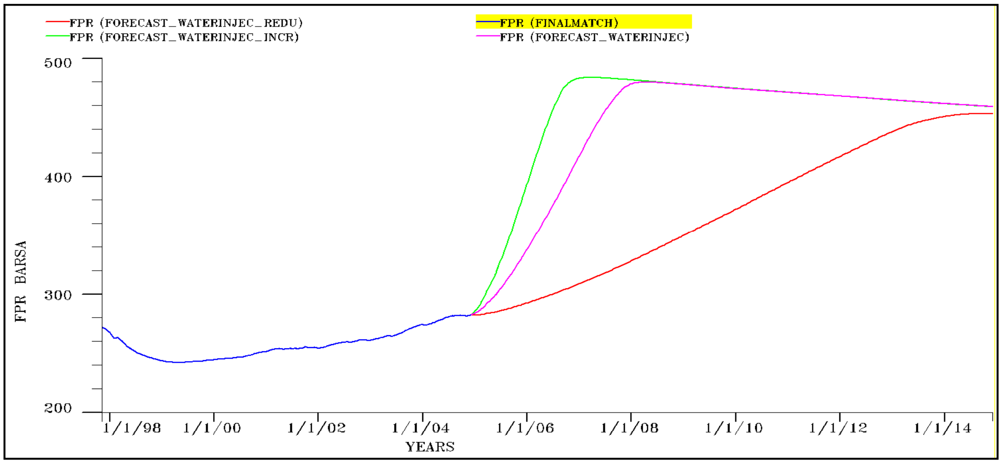

Fig. 17 FPR, for Wat Injec REDU & INCR, FM & Wat Injec

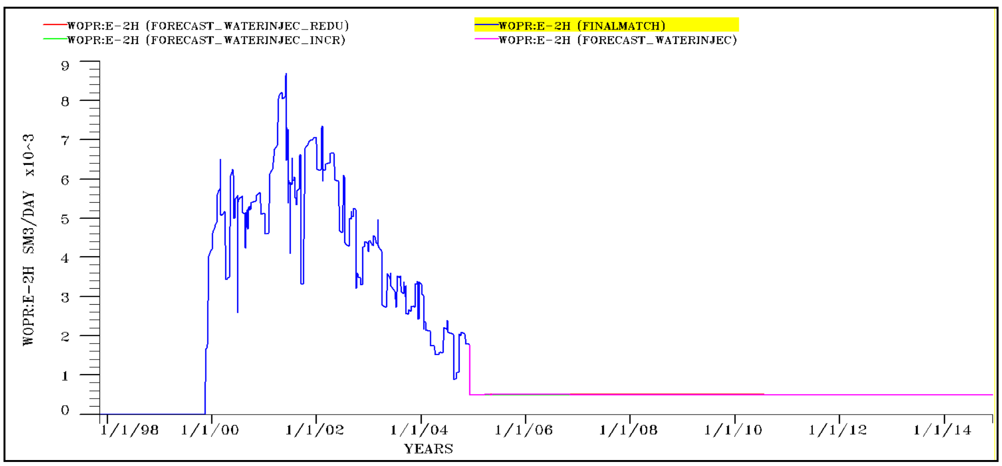

Fig. 18a WOPR, E-2H for Wat Injec REDU & INCR, FM & Wat Injec

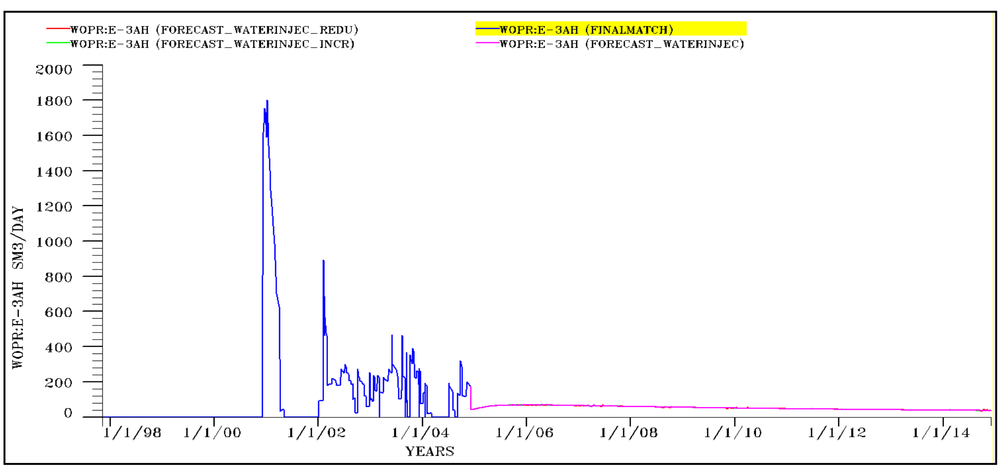

Fig. 18b WOPR, E-3AH for Wat Injec REDU & INCR, FM & Wat Injec

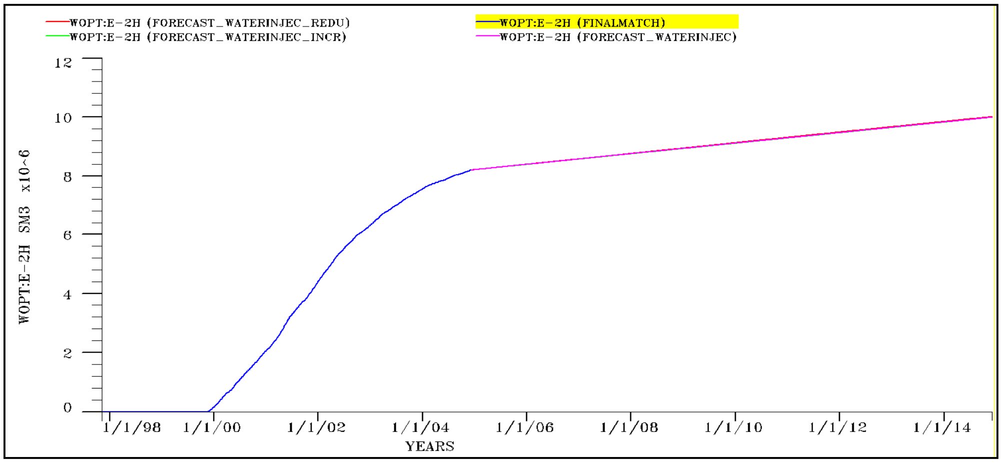

Fig. 19a WOPT, E-2H for Wat Injec REDU & INCR, FM & Wat Injec

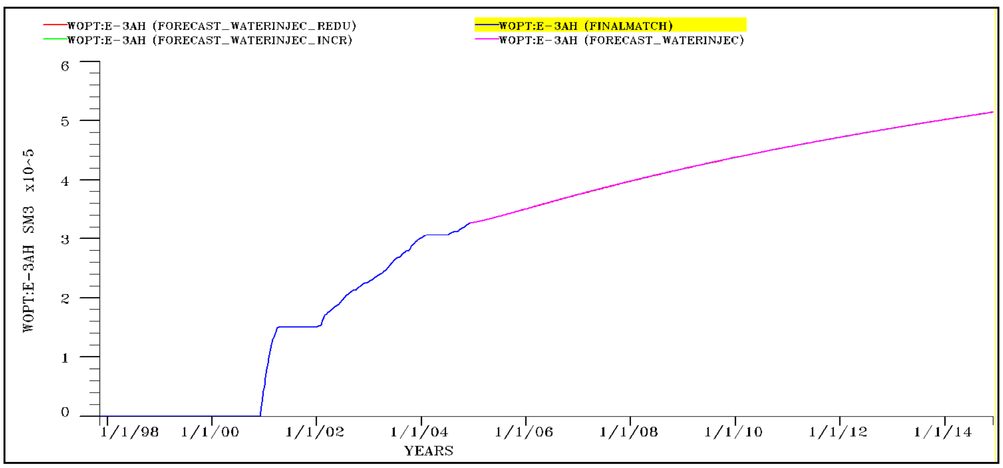

Fig. 19b WOPT, E-3AH for Wat Injec REDU & INCR, FM & Wat Injec

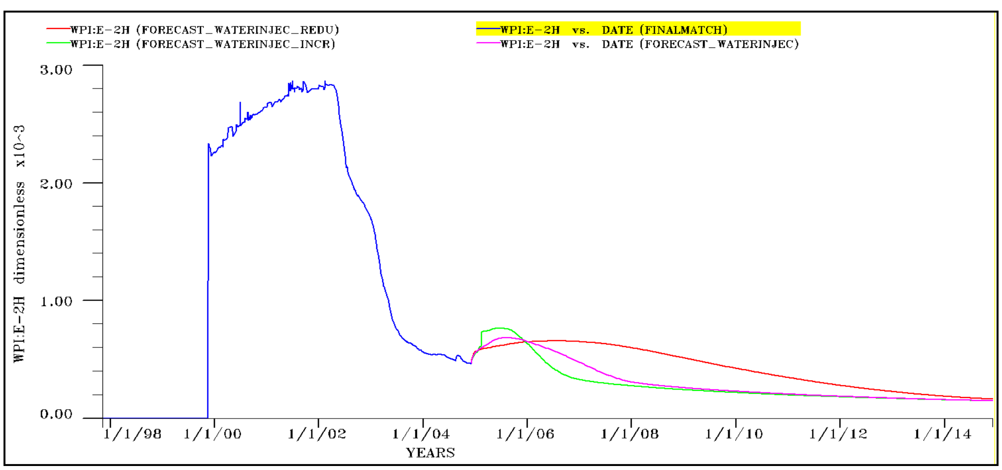

Fig. 20a WPI, E-2H for Wat Injec REDU & INCR, FM & Wat Injec

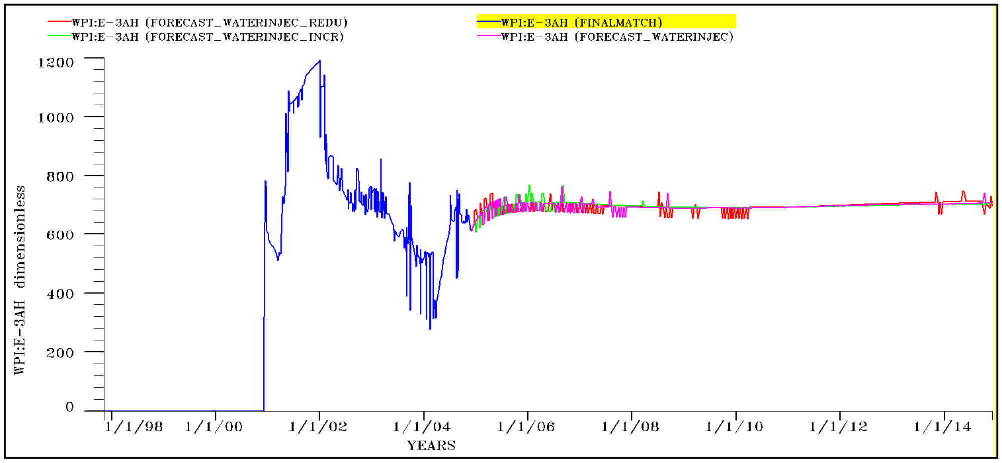

Fig. 20b WPI, E-3AH for Wat Injec REDU & INCR, FM & Wat Injec

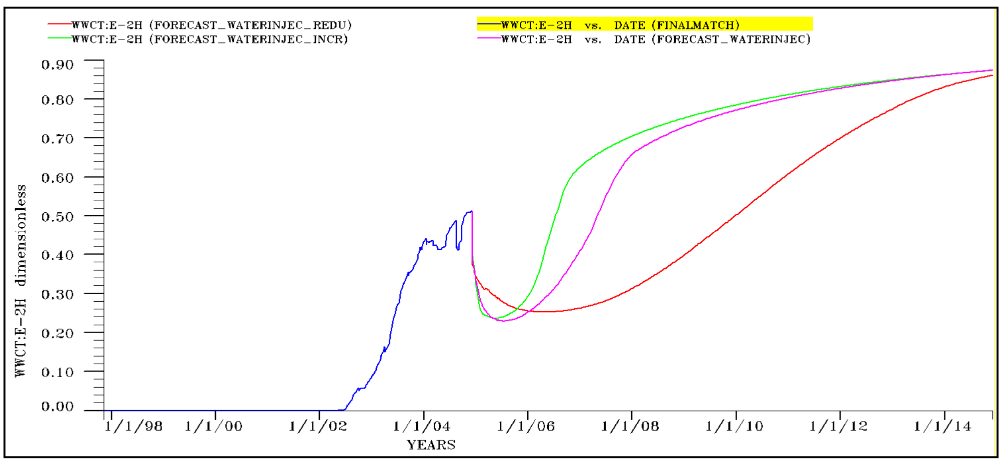

Fig. 21a WWCT, E-2H for Wat Injec REDU & INCR, FM & Wat Injec

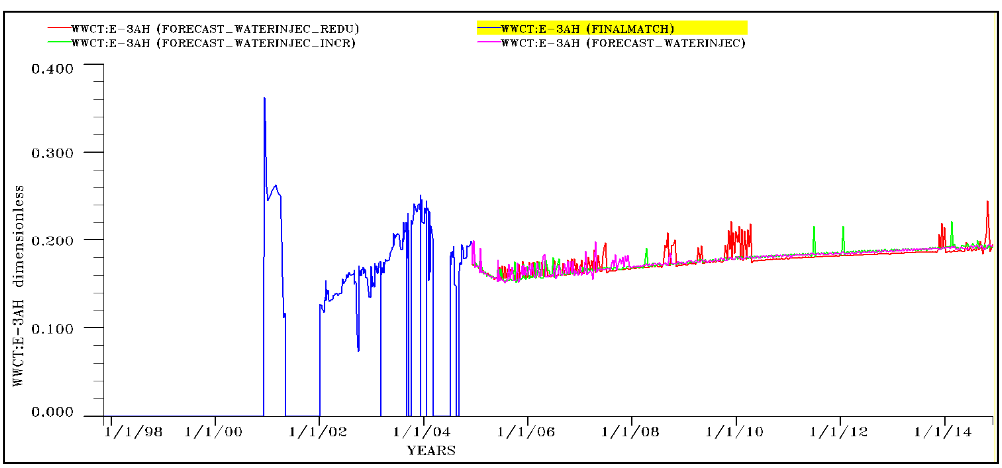

Fig. 21b WWCT, E-3AH for Wat Injec REDU & INCR, FM & Wat Injec

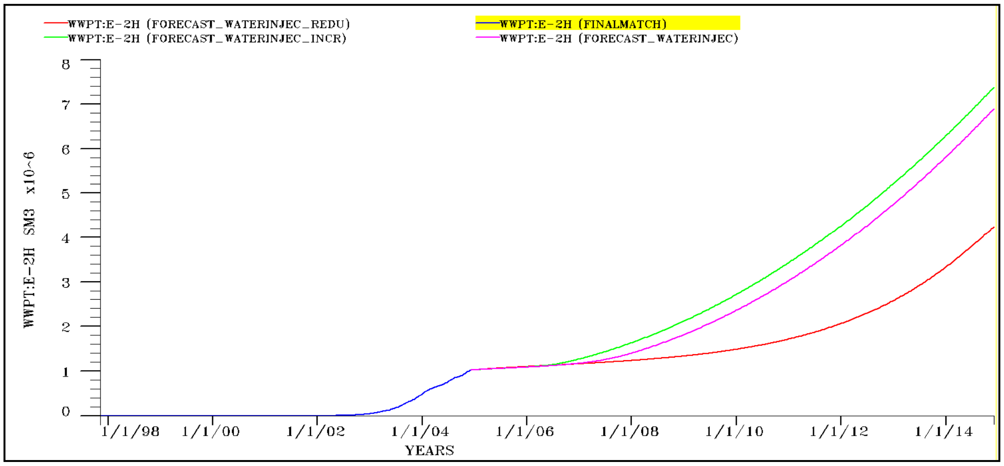

Fig. 22a WWPT, E-2H for Wat Injec REDU & INCR, FM & Wat Injec

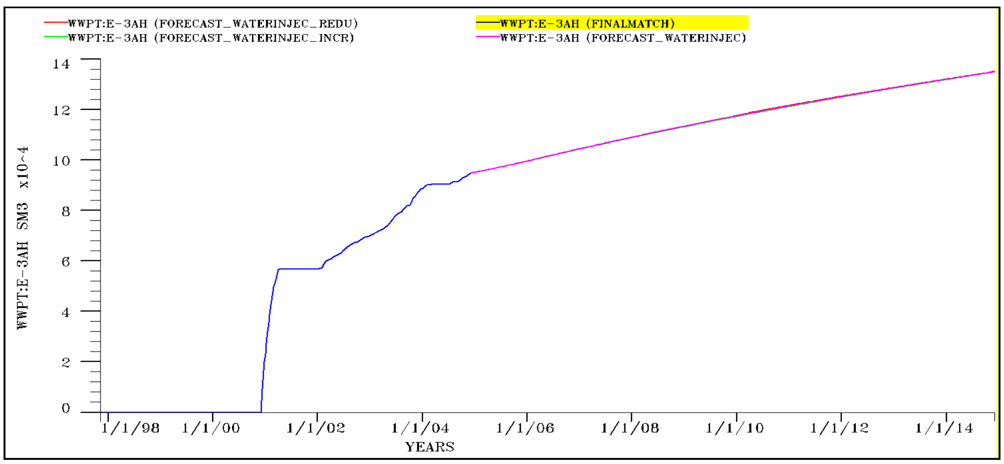

Fig. 22b WWPT, E-3AH for Wat Injec REDU & INCR, FM & Wat Injec

7. CONCLUSION

Manual history matching though very tedious and time-consuming, can be very helpful in understanding the contributive effects of several reservoir parameters to oil and gas productivity. For the E-segment of Norne, porosity, transmissibility multipliers, horizontal and vertical permeability proved to be the key factors shaping the nature of the segment. The perturbation of these parameters to obtain the desired or near perfect match is not as easy as it sounds and should be performed with sound judgment and practical values. The ten (10) year forecast showed that if the reservoir production conditions as at December 2004 still prevail, then we would really need to reduce water injection and focus on horizontal permeability reduction on the grid blocks in between the water injectors and the oil producers. This is one of the many production optimization strategies that can be adopted for improved oil recovery. The E-segment and Norne field as a whole is underlain by a huge aquifer, therefore increasing water injection would mean only one thing, and that is increasing water production from the oil producers rather than oil production.

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APPENDIX

(A) Cut portion of Eclipse100 FINALMATCH Data file showing altered parameters.

```
---------------------------------------------------------------------------
-- Ny model July 2004 build by marsp/oddhu (Edited by SAMSON ESSIEN, July 2012)
-- New grid with sloping faults based on geomodel xxx
--
--
INCLUDE
 './INCLUDE/PETRO/PORO_0704.prop' /

MULTIPLY
  PORO  1.25  1 46  1 112  1 22 /
/

--Sam; E-2H water reduction
MULTIPLY
  PERMX 0.2  7   7   55  57  8  8  /
  PERMX 0.2  8   8   55  57  8  8  /
  PERMX 0.2  8   8   66  69  8  8  /
  PERMX 0.2  9   9   55  56  8  8  /
  PERMX 0.2  9   9   62  69  8  8  /
  PERMX 0.2  10  10  52  57  8  8  /
  PERMX 0.2  10  10  67  69  8  8  /
  PERMX 0.2  11  11  52  56  8  8  /
  PERMX 0.2  12  12  52  56  8  8  /
  PERMX 0.2  12  12  61  64  8  8  /
  PERMX 0.4  7   7   55  57  9  9  /
  PERMX 0.4  8   8   55  57  9  9  /
  PERMX 0.4  8   8   66  69  9  9  /
  PERMX 0.4  9   9   55  56  9  9  /
  PERMX 0.4  9   9   62  69  9  9  /
  PERMX 0.4  10  10  52  57  9  9  /
  PERMX 0.4  10  10  67  69  9  9  /
  PERMX 0.4  11  11  52  56  9  9  /
  PERMX 0.4  12  12  52  56  9  9  /
  PERMX 0.4  12  12  61  64  9  9  /
/

--Sam; E-3AH water reduction
MULTIPLY
  PERMX 0.00001  6   6   45  48  1  1  /
  PERMX 0.00001  6   6   64  70  1  1  /
  PERMX 0.00001  7   7   46  57  1  1  /
  PERMX 0.00001  7   7   67  71  1  1  /
  PERMX 0.00001  8   8   47  58  1  1  /
```

```
 PERMX 0.00001  8   8   67  73  1  1  /
 PERMX 0.00001  9   9   50  61  1  1  /
 PERMX 0.00001  9   9   68  74  1  1  /
 PERMX 0.00001  10  10  58  65  1  1  /
 PERMX 0.00001  10  10  71  77  1  1  /
 PERMX 0.00001  11  11  59  66  1  1  /
 PERMX 0.00001  11  11  71  77  1  1  /
 PERMX 0.00001  12  12  62  68  1  1  /
 PERMX 0.00001  12  12  74  79  1  1  /
 PERMX 0.00001  13  13  63  69  1  1  /
 PERMX 0.00001  13  13  78  83  1  1  /
 PERMX 0.00001  14  14  65  70  1  1  /
 PERMX 0.00001  14  14  79  83  1  1  /
 PERMX 0.00001  15  15  66  71  1  1  /
 PERMX 0.00001  15  15  80  84  1  1  /
 PERMX 0.00001  16  16  71  72  1  1  /
 PERMX 0.00001  16  16  82  85  1  1  /
 PERMX 0.00001  6   6   45  48  2  2  /
 PERMX 0.00001  6   6   64  70  2  2  /
 PERMX 0.00001  7   7   46  57  2  2  /
 PERMX 0.00001  7   7   67  71  2  2  /
 PERMX 0.00001  8   8   47  58  2  2  /
 PERMX 0.00001  8   8   67  73  2  2  /
 PERMX 0.00001  9   9   50  61  2  2  /
 PERMX 0.00001  9   9   68  74  2  2  /
 PERMX 0.00001  10  10  58  65  2  2  /
 PERMX 0.00001  10  10  71  77  2  2  /
 PERMX 0.00001  11  11  59  66  2  2  /
 PERMX 0.00001  11  11  71  77  2  2  /
 PERMX 0.00001  12  12  62  68  2  2  /
 PERMX 0.00001  12  12  74  79  2  2  /
 PERMX 0.00001  13  13  63  69  2  2  /
 PERMX 0.00001  13  13  78  83  2  2  /
 PERMX 0.00001  14  14  65  70  2  2  /
 PERMX 0.00001  14  14  79  83  2  2  /
 PERMX 0.00001  15  15  66  71  2  2  /
 PERMX 0.00001  15  15  80  84  2  2  /
 PERMX 0.00001  16  16  71  72  2  2  /
 PERMX 0.00001  16  16  82  85  2  2  /
/

--Sam;E-3H water reduction
MULTIPLY
 PERMX 0.25  9   9   70  74  2  22  /
 PERMX 0.25  10  10  70  76  2  22  /
 PERMX 0.25  11  11  71  79  2  22  /
 PERMX 0.25  12  12  73  79  2  22  /
 PERMX 0.25  13  13  74  78  2  22  /
 PERMX 0.25  14  14  75  77  2  22  /
```

```
/

COPY
  PERMX PERMY /
  PERMX PERMZ /
/

-- Permz reduction is based on input from PSK
-- based on same kv/kh factor
-- ******************************************
-- CHECK! (esp. Ile & Tofte)
-- ******************************************
MULTIPLY
  'PERMZ' 10.0   6   6   45   48   1   1  /
  'PERMZ' 10.0   6   6   64   70   1   1  /
  'PERMZ' 10.0   7   7   46   57   1   1  /
  'PERMZ' 10.0   7   7   67   71   1   1  /
  'PERMZ' 10.0   8   8   47   58   1   1  /
  'PERMZ' 10.0   8   8   67   73   1   1  /
  'PERMZ' 10.0   9   9   50   61   1   1  /
  'PERMZ' 10.0   9   9   68   74   1   1  /
  'PERMZ' 10.0   10  10  58   65   1   1  /
  'PERMZ' 10.0   10  10  71   77   1   1  /
  'PERMZ' 10.0   11  11  59   66   1   1  /
  'PERMZ' 10.0   11  11  71   77   1   1  /
  'PERMZ' 10.0   12  12  62   68   1   1  /
  'PERMZ' 10.0   12  12  74   79   1   1  /
  'PERMZ' 10.0   13  13  63   69   1   1  /
  'PERMZ' 10.0   13  13  78   83   1   1  /
  'PERMZ' 10.0   14  14  65   70   1   1  /
  'PERMZ' 10.0   14  14  79   83   1   1  /
  'PERMZ' 10.0   15  15  66   71   1   1  /
  'PERMZ' 10.0   15  15  80   84   1   1  /
  'PERMZ' 10.0   16  16  71   72   1   1  /
  'PERMZ' 10.0   16  16  82   85   1   1  /
  'PERMZ' 10.0   6   6   45   48   2   2  /
  'PERMZ' 10.0   6   6   64   70   2   2  /
  'PERMZ' 10.0   7   7   46   57   2   2  /
  'PERMZ' 10.0   7   7   67   71   2   2  /
  'PERMZ' 10.0   8   8   47   58   2   2  /
  'PERMZ' 10.0   8   8   67   73   2   2  /
  'PERMZ' 10.0   9   9   50   61   2   2  /
  'PERMZ' 10.0   9   9   68   74   2   2  /
  'PERMZ' 10.0   10  10  58   65   2   2  /
  'PERMZ' 10.0   10  10  71   77   2   2  /
  'PERMZ' 10.0   11  11  59   66   2   2  /
  'PERMZ' 10.0   11  11  71   77   2   2  /
  'PERMZ' 10.0   12  12  62   68   2   2  /
  'PERMZ' 10.0   12  12  74   79   2   2  /
```

```
  'PERMZ' 10.0   13  13  63   69   2   2  /
  'PERMZ' 10.0   13  13  78   83   2   2  /
  'PERMZ' 10.0   14  14  65   70   2   2  /
  'PERMZ' 10.0   14  14  79   83   2   2  /
  'PERMZ' 10.0   15  15  66   71   2   2  /
  'PERMZ' 10.0   15  15  80   84   2   2  /
  'PERMZ' 10.0   16  16  71   72   2   2  /
  'PERMZ' 10.0   16  16  82   85   2   2  /
  'PERMZ'  0.25   1   46  1    112  3   3  /
  'PERMZ'  0.0    1   46  1    112  4   4  /   Not        (inactive anyway)
  'PERMZ'  0.13   1   46  1    112  5   5  /
  'PERMZ'  0.13   1   46  1    112  6   6  /
  'PERMZ'  0.13   1   46  1    112  7   7  /
  'PERMZ' 10.0   7   7   55   57   8   8  /
  'PERMZ' 10.0   8   8   55   57   8   8  /
  'PERMZ' 10.0   8   8   66   69   8   8  /
  'PERMZ' 10.0   9   9   55   56   8   8  /
  'PERMZ' 10.0   9   9   62   69   8   8  /
  'PERMZ' 10.0   10  10  52   57   8   8  /
  'PERMZ' 10.0   10  10  67   69   8   8  /
  'PERMZ' 10.0   11  11  52   56   8   8  /
  'PERMZ' 10.0   12  12  52   56   8   8  /
  'PERMZ' 10.0   12  12  61   64   8   8  /
  'PERMZ' 10.0   7   7   55   57   9   9  /
  'PERMZ' 10.0   8   8   55   57   9   9  /
  'PERMZ' 10.0   8   8   66   69   9   9  /
  'PERMZ' 10.0   9   9   55   56   9   9  /
  'PERMZ' 10.0   9   9   62   69   9   9  /
  'PERMZ' 10.0   10  10  52   57   9   9  /
  'PERMZ' 10.0   10  10  67   69   9   9  /
  'PERMZ' 10.0   11  11  52   56   9   9  /
  'PERMZ' 10.0   12  12  52   56   9   9  /
  'PERMZ' 10.0   12  12  61   64   9   9  /
  'PERMZ' 0.07   1   46  1    112  10  10 /    Ile 1.2
  'PERMZ' 0.19   1   46  1    112  11  11 /    Ile 1.1
  'PERMZ' 0.13   1   46  1    112  12  12 /    Tofte 2.2
  'PERMZ' 0.64   1   46  1    112  13  13 /    Tofte 2.1.3
  'PERMZ' 0.64   1   46  1    112  14  14 /    Tofte 2.1.2
  'PERMZ' 0.64   1   46  1    112  15  15 /    Tofte 2.1.1
  'PERMZ' 0.64   1   46  1    112  16  16 /    Tofte 1.2.2
  'PERMZ' 0.64   1   46  1    112  17  17 /    Tofte 1.2.1
  'PERMZ' 0.016  1   46  1    112  18  18 /   Tofte 1.1
  'PERMZ' 0.004  1   46  1    112  19  19 /   Tilje 4
  'PERMZ' 0.004  1   46  1    112  20  20 /   Tilje 3
  'PERMZ' 1.0    1   46  1    112  21  21 /    Tilje 2
  'PERMZ' 1.0    1   46  1    112  22  22 /    Tilje 1
/
--
-- History and prediction --
```

```
--
INCLUDE
 './INCLUDE/BC0407_2004_FINALMATCH.SCH' /

END
---------------------------------------------------------------------------------------------------------------
```

(B) Cut portion of Schedule section in Eclipse100 INCLUDE file showing the forecast segment

```
--
-- 2582.000000 days from start of simulation ( 6 'NOV' 1997 )

DATES
 1 'DEC' 2004 /
/

-- SAM. Start of FORECAST  (Water Injection)

WELSPECS
'E-2H'   'MANI-E2'   13   67  1*      'OIL'  2*     'STOP'  4* /
/

COMPDAT
-- WELL      I   J    K1  K2         Sat.       CF      DIAM       KH SKIN ND       DIR   Ro
    'E-2H'   12   64    8    8    'OPEN'  1*     3.579     0.216   288.070  2*       'Y'     8.059 /
    'E-2H'   12   63    8    8    'OPEN'  1*    30.255     0.216   2436.132  2*       'Y'     8.072 /
    'E-2H'   12   62    8    8    'OPEN'  1*    19.754     0.216   1591.188  2*       'Y'     8.085 /
    'E-2H'   12   61    9    9    'OPEN'  1*    40.653     0.216   3160.979  2*       'Y'     6.960 /
    'E-2H'   11   57    9    9    'OPEN'  1*   154.351     0.216  11915.254  2*      'Y'     6.755 /
    'E-2H'   11   56    9    9    'OPEN'  1*    37.252     0.216   2883.094  2*       'Y'     6.827 /
    'E-2H'   10   56    9    9    'OPEN'  1*    53.777     0.216   4191.415  2*       'Y'     7.030 /
    'E-2H'   10   55    9    9    'OPEN'  1*   162.617     0.216  12678.107  2*      'Y'     7.038 /
    'E-2H'   10   54    9    9    'OPEN'  1*    30.378     0.216   2387.271  2*       'Y'     7.278 /
/

-- ADDED BY SAMSON

WPIMULT
    E-2H    5.0  /
/

WELSPECS
 'E-3AH'   'MANI-E1'    7   64  1*      'OIL'  2*     'STOP'  4* /
/

COMPDAT
-- WELL      I   J    K1  K2         Sat.       CF      DIAM       KH SKIN ND       DIR   Ro
   'E-3AH'    7   65    2    2    'OPEN'  1*    14.740     0.216   1070.479  2*       'Y'     5.287 /
```

```
  'E-3AH'   7  66   2   2    'OPEN'  1*    33.983     0.216   2467.537  2*       'Y'     5.284 /
  'E-3AH'   8  66   2   2    'OPEN'  1*    26.299     0.216   1919.028  2*       'Y'     5.386 /
  'E-3AH'  10  69   1   1    'OPEN'  1*    53.632     0.216   4407.631  2*       'Y'     8.824 /
  'E-3AH'  10  70   1   1    'OPEN'  1*   273.486     0.216  22423.428  2*       'Y'     8.734 /
  'E-3AH'  10  71   1   1    'OPEN'  1*    16.622     0.216   1357.625  2*       'Y'     8.587 /
  'E-3AH'  11  71   1   1    'OPEN'  1*    63.822     0.216   5300.814  2*       'Y'     9.247 /
/

-- ADDED BY SAMSON

WPIMULT
    E-3AH    5.0  /
/

WCONPROD
 'E-2H' 'OPEN'  'ORAT' 10000 10000 50000 2* 100 0.0 0 /
 'E-3AH' 'OPEN' 'ORAT' 10000 10000 50000 2* 100 0.0 0 /
/

GRUPTREE
  'INJE'     'FIELD'  /
  'PROD'     'FIELD'  /
  'MANI-B2'    'PROD'  /
  'MANI-B1'    'PROD'  /
  'MANI-D1'    'PROD'  /
  'MANI-D2'    'PROD'  /
  'MANI-E1'    'PROD'  /
  'MANI-E2'    'PROD'  /
  'MANI-K1'    'MANI-B1'  /
  'MANI-K2'    'MANI-D2'  /
  'MANI-C'     'INJE'  /
  'MANI-F'     'INJE'  /
  'WI-GSEG'    'INJE'  /
  'B1-DUMMY'    'MANI-B1'  /
  'D2-DUMMY'    'MANI-D2'  /
/

GRUPNET
   'FIELD'    20.000  5* /
    'PROD'    20.000  5* /
  'MANI-B2'  1*    8  1*       'NO'  2* /
  'MANI-B1'  1*    8  1*       'NO'  2* /
  'MANI-K1'  1* 9999  4* /
 'B1-DUMMY'  1* 9999  4* /
  'MANI-D1'  1*    8  1*       'NO'  2* /
  'MANI-D2'  1*    8  1*       'NO'  2* /
  'MANI-K2'  1* 9999  4* /
 'D2-DUMMY'  1* 9999  4* /
  'MANI-E1'  1*    9  1*       'NO'  2* /
```

```
 'MANI-E2'  1*    9  4* /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   9260.852  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   1157.603  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'  11884.032  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   1654.426  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   7183.810  1* 600 3*  /
/

-- 31.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'JAN' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   8699.281  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   3156.042  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'  13641.597  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   3276.842  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   7069.271  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 2 2 2 0 1 1 0 1 1 0 0 /


-- 62.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'FEB' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   8379.568  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'  10325.321  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'  14649.800  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   3472.086  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   7507.896  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 /


-- 90.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
```

```
 1 'MAR' 2005 /
/

WCONINJE
    'C-2H'    'WATER'  1*     'RATE'   8788.852  1* 600 3*  /
    'C-4H'    'WATER'  1*     'RATE'  11198.881  1* 600 3*  /
    'F-1H'    'WATER'  1*     'RATE'  15233.403  1* 600 3*  /
    'F-2H'    'WATER'  1*     'RATE'   3600.965  1* 600 3*  /
    'F-3H'    'WATER'  1*     'RATE'   7894.813  1* 600 3*  /
/

-- 121.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'APR' 2005 /
/

WCONINJE
    'C-2H'    'WATER'  1*     'RATE'   8979.270  1* 600 3*  /
    'C-4H'    'WATER'  1*     'RATE'   6451.143  1* 600 3*  /
    'F-1H'    'WATER'  1*     'RATE'  14139.213  1* 600 3*  /
    'F-2H'    'WATER'  1*     'RATE'   3250.343  1* 600 3*  /
    'F-3H'    'WATER'  1*     'RATE'   7005.187  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 2 2 2 0 1 1 0 1 1 0 0 /


-- 151.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'MAY' 2005 /
/

WCONINJE
    'C-2H'    'WATER'  1*     'RATE'   9401.403  1* 600 3*  /
    'C-4H'    'WATER'  1*     'RATE'   8563.603  1* 600 3*  /
    'F-1H'    'WATER'  1*     'RATE'  14787.120  1* 600 3*  /
    'F-2H'    'WATER'  1*     'RATE'   3461.913  1* 600 3*  /
    'F-3H'    'WATER'  1*     'RATE'   7387.740  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 /


-- 181.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
```

```
 31 'MAY' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   7020.300  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'  11859.500  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'  12876.600  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   2947.900  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   6182.900  1* 600 3*  /
/

-- 182.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'JUN' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   8527.080  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'  13857.420  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'  15492.380  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   3634.380  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   7759.600  1* 600 3*  /
/

-- 187.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 6 'JUN' 2005 /
/

DATES
 1 'DEC' 2005 /
/

DATES
 1 'DEC' 2006 /
/

DATES
 1 'DEC' 2007 /
/

DATES
 1 'DEC' 2008 /
/

DATES
 1 'DEC' 2009 /
/
```

```
DATES
 1 'DEC' 2010 /
/

DATES
 1 'DEC' 2011 /
/

DATES
 1 'DEC' 2012 /
/

DATES
 1 'DEC' 2013 /
/

DATES
 1 'DEC' 2014 /
/

-- END OF SIMULATION
----------------------------------------------------------------------------------------------------------
```

(C) Cut portion of Schedule section in Eclipse100 INCLUDE file showing the forecast segment for Increased Water Injection

```
-- 2582.000000 days from start of simulation ( 6 'NOV' 1997 )

DATES
 1 'DEC' 2004 /
/

-- SAM. Start of FORECAST (for Increased Water Injection)

WELSPECS
'E-2H'   'MANI-E2'   13   67  1*      'OIL'  2*     'STOP'  4* /
/

COMPDAT
-- WELL       I   J    K1  K2          Sat.       CF      DIAM       KH SKIN ND       DIR   Ro
   'E-2H'  12  64   8   8    'OPEN'  1*     3.579     0.216   288.070  2*       'Y'    8.059 /
   'E-2H'  12  63   8   8    'OPEN'  1*    30.255     0.216  2436.132  2*       'Y'    8.072 /
   'E-2H'  12  62   8   8    'OPEN'  1*    19.754     0.216  1591.188  2*       'Y'    8.085 /
   'E-2H'  12  61   9   9    'OPEN'  1*    40.653     0.216  3160.979  2*       'Y'    6.960 /
   'E-2H'  11  57   9   9    'OPEN'  1*   154.351     0.216 11915.254  2*       'Y'    6.755
/
   'E-2H'  11  56   9   9    'OPEN'  1*    37.252     0.216  2883.094  2*       'Y'    6.827 /
   'E-2H'  10  56   9   9    'OPEN'  1*    53.777     0.216  4191.415  2*       'Y'    7.030 /
```

```
  'E-2H'  10  55   9   9    'OPEN'  1*   162.617    0.216  12678.107  2*      'Y'    7.038
/
  'E-2H'  10  54   9   9    'OPEN'  1*   30.378    0.216   2387.271  2*      'Y'    7.278 /
/

-- ADDED BY SAMSON

WPIMULT
   E-2H   5.0  /
/

WELSPECS
 'E-3AH'  'MANI-E1'   7  64  1*     'OIL'  2*    'STOP'  4* /
/

COMPDAT
-- WELL     I   J   K1  K2        Sat.      CF     DIAM      KH SKIN ND      DIR   Ro
  'E-3AH'   7  65   2   2    'OPEN'  1*   14.740    0.216  1070.479  2*      'Y'    5.287 /
  'E-3AH'   7  66   2   2    'OPEN'  1*   33.983    0.216  2467.537  2*      'Y'    5.284 /
  'E-3AH'   8  66   2   2    'OPEN'  1*   26.299    0.216  1919.028  2*      'Y'    5.386 /
  'E-3AH'  10   69   1   1    'OPEN'  1*   53.632    0.216   4407.631  2*      'Y'    8.824
/
  'E-3AH'   10   70    1    1      'OPEN'   1*    273.486     0.216   22423.428  2*        'Y'
8.734 /
  'E-3AH'  10   71   1   1    'OPEN'  1*   16.622    0.216   1357.625  2*      'Y'    8.587
/
  'E-3AH'  11   71   1   1    'OPEN'  1*   63.822    0.216   5300.814  2*      'Y'    9.247
/
/

-- ADDED BY SAMSON

WPIMULT
   E-3AH   5.0  /
/

WCONPROD
 'E-2H' 'OPEN'  'ORAT' 10000 10000 50000 2* 100 0.0 0 /
 'E-3AH' 'OPEN' 'ORAT' 10000 10000 50000 2* 100 0.0 0 /
/

GRUPTREE
  'INJE'    'FIELD'  /
  'PROD'    'FIELD'  /
  'MANI-B2'    'PROD'  /
  'MANI-B1'    'PROD'  /
  'MANI-D1'    'PROD'  /
  'MANI-D2'    'PROD'  /
  'MANI-E1'    'PROD'  /
```

```
  'MANI-E2'    'PROD'  /
  'MANI-K1'    'MANI-B1'  /
  'MANI-K2'    'MANI-D2'  /
  'MANI-C'    'INJE'  /
  'MANI-F'    'INJE'  /
  'WI-GSEG'    'INJE'  /
  'B1-DUMMY'    'MANI-B1'  /
  'D2-DUMMY'    'MANI-D2'  /
/

GRUPNET
   'FIELD'    20.000  5* /
   'PROD'    20.000  5* /
 'MANI-B2'  1*   8  1*      'NO'  2* /
 'MANI-B1'  1*   8  1*      'NO'  2* /
 'MANI-K1'  1* 9999  4* /
'B1-DUMMY'  1* 9999  4* /
 'MANI-D1'  1*   8  1*      'NO'  2* /
 'MANI-D2'  1*   8  1*      'NO'  2* /
 'MANI-K2'  1* 9999  4* /
'D2-DUMMY'  1* 9999  4* /
 'MANI-E1'  1*   9  1*      'NO'  2* /
 'MANI-E2'  1*   9  4* /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   13260.852  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   1957.603  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   16884.032  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   3254.426  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   11183.810  1* 600 3*  /
/

-- 31.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'JAN' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   12699.281  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   5156.042  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   18641.597  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   5276.842  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   11069.271  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 2 2 2 0 1 1 0 1 1 0 0 /
```

```
-- 62.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'FEB' 2005 /
/

WCONINJE
   'C-2H'   'WATER'  1*    'RATE'   12379.568  1* 600 3*  /
   'C-4H'   'WATER'  1*    'RATE'   15325.321  1* 600 3*  /
   'F-1H'   'WATER'  1*    'RATE'   21649.800  1* 600 3*  /
   'F-2H'   'WATER'  1*    'RATE'   5472.086  1* 600 3*  /
   'F-3H'   'WATER'  1*    'RATE'   11507.896  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 /


-- 90.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'MAR' 2005 /
/

WCONINJE
   'C-2H'   'WATER'  1*    'RATE'   12788.852  1* 600 3*  /
   'C-4H'   'WATER'  1*    'RATE'   17198.881  1* 600 3*  /
   'F-1H'   'WATER'  1*    'RATE'   22233.403  1* 600 3*  /
   'F-2H'   'WATER'  1*    'RATE'   5600.965  1* 600 3*  /
   'F-3H'   'WATER'  1*    'RATE'   11894.813  1* 600 3*  /
/

-- 121.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'APR' 2005 /
/

WCONINJE
   'C-2H'   'WATER'  1*    'RATE'   12979.270  1* 600 3*  /
   'C-4H'   'WATER'  1*    'RATE'   9451.143  1* 600 3*  /
   'F-1H'   'WATER'  1*    'RATE'   21139.213  1* 600 3*  /
   'F-2H'   'WATER'  1*    'RATE'   5250.343  1* 600 3*  /
   'F-3H'   'WATER'  1*    'RATE'   11005.187  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 2 2 2 0 1 1 0 1 1 0 0 /
```

```
-- 151.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'MAY' 2005 /
/

WCONINJE
    'C-2H'    'WATER'  1*     'RATE'   13401.403  1* 600 3*  /
    'C-4H'    'WATER'  1*     'RATE'   12563.603  1* 600 3*  /
    'F-1H'    'WATER'  1*     'RATE'   21787.120  1* 600 3*  /
    'F-2H'    'WATER'  1*     'RATE'   5461.913  1* 600 3*  /
    'F-3H'    'WATER'  1*     'RATE'   11387.740  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 /


-- 181.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 31 'MAY' 2005 /
/

WCONINJE
    'C-2H'    'WATER'  1*     'RATE'   11020.300  1* 600 3*  /
    'C-4H'    'WATER'  1*     'RATE'   171859.500  1* 600 3*  /
    'F-1H'    'WATER'  1*     'RATE'   18876.600  1* 600 3*  /
    'F-2H'    'WATER'  1*     'RATE'   5947.900  1* 600 3*  /
    'F-3H'    'WATER'  1*     'RATE'   9182.900  1* 600 3*  /
/

-- 182.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'JUN' 2005 /
/

WCONINJE
    'C-2H'    'WATER'  1*     'RATE'   12527.080  1* 600 3*  /
    'C-4H'    'WATER'  1*     'RATE'   18857.420  1* 600 3*  /
    'F-1H'    'WATER'  1*     'RATE'   22492.380  1* 600 3*  /
    'F-2H'    'WATER'  1*     'RATE'   6634.380  1* 600 3*  /
    'F-3H'    'WATER'  1*     'RATE'   11759.600  1* 600 3*  /
/

-- 187.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 6 'JUN' 2005 /
```

```
/

DATES
 1 'DEC' 2005 /
/

DATES
 1 'DEC' 2006 /
/

DATES
 1 'DEC' 2007 /
/

DATES
 1 'DEC' 2008 /
/

DATES
 1 'DEC' 2009 /
/

DATES
 1 'DEC' 2010 /
/

DATES
 1 'DEC' 2011 /
/

DATES
 1 'DEC' 2012 /
/

DATES
 1 'DEC' 2013 /
/

DATES
 1 'DEC' 2014 /
/

-- END OF SIMULATION
---------------------------------------------------------------------------------------------------------------
```

(D) Cut portion of Schedule section in Eclipse100 INCLUDE file showing the forecast segment for Reduced Water Injection

```
-- 2582.000000 days from start of simulation ( 6 'NOV' 1997 )

DATES
 1 'DEC' 2004 /
/

-- SAM. Start of FORECAST (for Reduced Water Injection)

WELSPECS
'E-2H'   'MANI-E2'   13   67  1*      'OIL'  2*      'STOP'  4* /
/

COMPDAT
-- WELL      I    J    K1  K2         Sat.       CF      DIAM       KH SKIN ND       DIR   Ro
   'E-2H'   12   64    8    8    'OPEN'  1*     3.579     0.216    288.070  2*       'Y'     8.059 /
   'E-2H'   12   63    8    8    'OPEN'  1*    30.255     0.216   2436.132  2*       'Y'     8.072 /
   'E-2H'   12   62    8    8    'OPEN'  1*    19.754     0.216   1591.188  2*       'Y'     8.085 /
   'E-2H'   12   61    9    9    'OPEN'  1*    40.653     0.216   3160.979  2*       'Y'     6.960 /
   'E-2H'   11   57    9    9    'OPEN'  1*   154.351     0.216  11915.254  2*       'Y'     6.755
/
   'E-2H'   11   56    9    9    'OPEN'  1*    37.252     0.216   2883.094  2*       'Y'     6.827 /
   'E-2H'   10   56    9    9    'OPEN'  1*    53.777     0.216   4191.415  2*       'Y'     7.030 /
   'E-2H'   10   55    9    9    'OPEN'  1*   162.617     0.216  12678.107  2*       'Y'     7.038
/
   'E-2H'   10   54    9    9    'OPEN'  1*    30.378     0.216   2387.271  2*       'Y'     7.278 /
/

-- ADDED BY SAMSON

WPIMULT
    E-2H    5.0  /
/

WELSPECS
 'E-3AH'   'MANI-E1'    7   64  1*      'OIL'  2*     'STOP'  4* /
/

COMPDAT
-- WELL      I    J    K1  K2         Sat.       CF      DIAM       KH SKIN ND       DIR   Ro
  'E-3AH'   7   65    2    2    'OPEN'  1*    14.740     0.216   1070.479  2*       'Y'     5.287 /
  'E-3AH'   7   66    2    2    'OPEN'  1*    33.983     0.216   2467.537  2*       'Y'     5.284 /
  'E-3AH'   8   66    2    2    'OPEN'  1*    26.299     0.216   1919.028  2*       'Y'     5.386 /
  'E-3AH'   10   69    1    1    'OPEN'  1*    53.632     0.216   4407.631  2*       'Y'     8.824
/
  'E-3AH'   10    70     1     1       'OPEN'   1*     273.486      0.216   22423.428   2*         'Y'
8.734 /
  'E-3AH'   10   71    1    1    'OPEN'  1*    16.622     0.216   1357.625  2*       'Y'     8.587
/
```

```
  'E-3AH'   11   71    1    1     'OPEN'  1*     63.822     0.216   5300.814  2*        'Y'      9.247
/
/

-- ADDED BY SAMSON

WPIMULT
    E-3AH    5.0  /
/

WCONPROD
 'E-2H' 'OPEN'  'ORAT' 10000 10000 50000 2* 100 0.0 0 /
 'E-3AH' 'OPEN' 'ORAT' 10000 10000 50000 2* 100 0.0 0 /
/

GRUPTREE
  'INJE'     'FIELD'  /
  'PROD'     'FIELD'  /
  'MANI-B2'    'PROD'  /
  'MANI-B1'    'PROD'  /
  'MANI-D1'    'PROD'  /
  'MANI-D2'    'PROD'  /
  'MANI-E1'    'PROD'  /
  'MANI-E2'    'PROD'  /
  'MANI-K1'    'MANI-B1'  /
  'MANI-K2'    'MANI-D2'  /
  'MANI-C'     'INJE'  /
  'MANI-F'     'INJE'  /
  'WI-GSEG'    'INJE'  /
  'B1-DUMMY'    'MANI-B1'  /
  'D2-DUMMY'    'MANI-D2'  /
/

GRUPNET
   'FIELD'    20.000  5* /
    'PROD'    20.000  5* /
  'MANI-B2'  1*    8  1*       'NO'  2* /
  'MANI-B1'  1*    8  1*       'NO'  2* /
  'MANI-K1'  1* 9999  4* /
 'B1-DUMMY'  1* 9999  4* /
  'MANI-D1'  1*    8  1*       'NO'  2* /
  'MANI-D2'  1*    8  1*       'NO'  2* /
  'MANI-K2'  1* 9999  4* /
 'D2-DUMMY'  1* 9999  4* /
  'MANI-E1'  1*    9  1*       'NO'  2* /
  'MANI-E2'  1*    9  4* /
/

WCONINJE
```

```
   'C-2H'    'WATER'  1*     'RATE'   4260.852  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   657.603  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   6884.032  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   854.426  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   4183.810  1* 600 3*  /
/

-- 31.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'JAN' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   4699.281  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   1156.042  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   6641.597  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   1676.842  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   4069.271  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 2 2 2 0 1 1 0 1 1 0 0 /


-- 62.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'FEB' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   4379.568  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   5325.321  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   7649.800  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   1772.086  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   4007.896  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 /


-- 90.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'MAR' 2005 /
/

WCONINJE
```

```
   'C-2H'    'WATER'  1*     'RATE'   4788.852  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   6198.881  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   7233.403  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   1800.965  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   4894.813  1* 600 3*  /
/

-- 121.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'APR' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   4979.270  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   3451.143  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   7139.213  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   1650.343  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   4005.187  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 2 2 2 0 1 1 0 1 1 0 0 /


-- 151.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'MAY' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   4401.403  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   4563.603  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   7787.120  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   1761.913  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   4387.740  1* 600 3*  /
/

RPTSCHED
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 /


-- 181.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 31 'MAY' 2005 /
/

WCONINJE
```

```
   'C-2H'    'WATER'  1*     'RATE'   4020.300  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   6859.500  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   6876.600  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   1547.900  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   3182.900  1* 600 3*  /
/

-- 182.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 1 'JUN' 2005 /
/

WCONINJE
   'C-2H'    'WATER'  1*     'RATE'   4527.080  1* 600 3*  /
   'C-4H'    'WATER'  1*     'RATE'   6857.420  1* 600 3*  /
   'F-1H'    'WATER'  1*     'RATE'   8492.380  1* 600 3*  /
   'F-2H'    'WATER'  1*     'RATE'   1834.380  1* 600 3*  /
   'F-3H'    'WATER'  1*     'RATE'   4759.600  1* 600 3*  /
/

-- 187.000000 days from start of Forecast ( 1 'DEC' 2004 )
DATES
 6 'JUN' 2005 /
/

DATES
 1 'DEC' 2005 /
/

DATES
 1 'DEC' 2006 /
/

DATES
 1 'DEC' 2007 /
/

DATES
 1 'DEC' 2008 /
/

DATES
 1 'DEC' 2009 /
/

DATES
 1 'DEC' 2010 /
/
```

```
DATES
 1 'DEC' 2011 /
/

DATES
 1 'DEC' 2012 /
/

DATES
 1 'DEC' 2013 /
/

DATES
 1 'DEC' 2014 /
/

-- END OF SIMULATION

------------------------------------------------------------------------------------------------------------
```