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Jeanette Gimre

ABSTRACT

Well completions today are very different from the traditional well completions. Reservoir complexity has increased, making horizontal wells the optimal solution in many reservoir cases, and an increase in the use of multilateral wells. This gives a need for zonal control to make it possible to drain the reservoirs in the most efficient way.

ICDs were developed to reduce the heel-toe effect and increase the horizontal well performance. ICDs respond to the differences in the physics of fluid flow in a reservoir. There has been developed in practice four types of ICDs: orifice/nozzle based (restrictive), helical-channel (frictional), the hybrid design (combination of restrictive, some friction and a tortuous pathway) and the new autonomous ICD (AICD).

An ICV is a downhole flow control valve that is being operated remotely from the surface. The ICV have the possibility to choke or shut the fluid flow. The systems that can control the ICVs can be all hydraulic, all electric, or there can be a combination of the two. The ICV is a part of an intelligent well completion. When the ICV technology was developed it had three goals in mind; to get reliable performance in HP/HT conditions, compatibility with existing downhole control and incremental-positioning systems, and enable a close-loop reservoir optimization. ICVs have the ability to choke the flow, or shut it off completely.

The analysis for the particular well case examined in this thesis showed a clear advantage of using ICVs or ICDs when water has reached the well.

Three different states were examined; early life, mid-life, and late life of the well. In the early stage there was no problem with water production for the well. So when water cut (WC) and produced oil for a conventional well completion was compared with a well completed with ICDs, and a well completed with ICVs, there was no significant difference. When the mid-life case for the well was examined, comparing the conventional well with the well with ICDs, it gave a 21% decrease in WC and 4% increase in produced oil when producing from the well with ICDs. Comparing the conventional well with the well completed with ICVs showed that in the well with ICVs, there would be a 30% decrease in WC, and increased oil production of 4,7%. In the late life case producing from the well with ICDs compared to the conventional well gave a 28% decrease in WC, and a 10% increase in oil production. Producing from the well with ICVs compared to the conventional well, gave a decrease in WC of 39%, and increase in oil production of 14%. When evaluating if ICVs, ICDs or conventional well completion should be used, the reservoir conditions should be well examined to be able to get the best possible result, with the most suitable completion.

ABBREVIATIONS

AFD = Autonomous Flow control Device

AGL – Auto Gas Lift

AICD – Autonomous Inflow Control Device

BHP – Bottom Hole Pressure

ICV = Inflow Control Valve

ICD = Inflow Control Device

GOR = Gas Oil Ratio

HP – High Pressure

HP/HT – High Pressure/High Temperature

HPe – High Permeability

LP – Low Permeability

MP – Medium Permeability

MRM – Multiple Reservoir Management

MTM – Metal-To-Metal

OD – Outside Diameter

OWC – Oil Water Contact

PI – Productivity Index

q_l – liquid production rate

q_o – oil production rate

SAS – Stand Alone sand Screen

Sw = Water saturation

TVD = Total Vertical Depth

WC = Water Cut

1. INTRODUCTION

1.1. Increased well complexity

Well completions today are very different from the traditional well completions. Reservoir complexity has increased, making horizontal wells the optimal solution in many reservoir cases, and an increase in the use of multilateral wells. The increased well/reservoir contact has a number of potential advantages; delayed water or gas breakthrough, increased well productivity, sweep efficiency and drainage area. But there are new challenges related to long, possibly multilateral extreme-reservoir-contact wells.

There are different methods to control zones in a reservoir. Those are with a traditional sliding sleeve, an Inflow Control Device (ICD), or an Inflow Control Valve (ICV). The well will after a while experience a decline period. Then downhole control yields extra value. It allows the field to produce more oil compared to either wellhead control or fixed level control.

1.1.1. Sliding sleeves

Mechanical sliding sleeves have been used for decades for selective zonal shut-off of unwanted water production or excessive GOR (Erlandsen and Omdal, 2008). Sliding sleeves have been proven to be very robust, but there are limitations related to the use of sliding sleeves. Well intervention needs to be done to open or shut the sleeves. The economical aspect related to the well intervention is a large consideration when evaluating the value of sliding sleeves. Choking is not possible with the sleeves, only open or shut. Traditional sliding sleeves have been used as a starting point of the development of the ICVs. The history of the ICVs will be described later in the thesis.

1.1.2. ICD

An ICD is a passive flow restriction mounted on a screen joint to control the fluid-flow path from the reservoir into the flow conduit (Al-Khelaiwi et al. 2010). The principle of the ICD is to restrict the flow rate by creating an additional pressure drop, according the Bernoulli equation. It is the differences in the physics of fluid flow in a reservoir and the ICD flow restriction that gives the ICD its ability to equalize the flow along the well length.

The size of the ICD's restriction is set before or at the time of well completion. Currently it is not possible to change the flow restriction's diameter after installation without intervention. Despite this, ICDs have been installed in hundreds of wells during the last 10 years, and are now considered as a mature well-completion technology (Al-Khelaiwi et al. 2010).

ICDs were first used at the Troll field in the North Sea in 1992 by Norske Hydro. The first patent of the ICD was written by Kristian Brekke.

There are two main reasons for using ICDs:

1) Reduction of Heel-Toe effect

2) Equalize productivity

The Heel-Toe effect is a result of the friction pressure drop causing a variable draw-down along the well (Moen et al. 2008). This results in higher inflow at the heel than at the toe, causing an uneven production. When there is larger production at the heel compared to the toe, there will be early water breakthrough at the heel, leaving the toe unable to produce the remaining oil.

Figure 1 shows an illustration of the flow rate and drawdown without ICDs (left) and with ICDs (right) for a homogeneous reservoir with relatively constant permeability (Halliburton web page). While **Figure 2** shows illustration of the flow rate and drawdown without ICDs (left) and with ICDs (right) for a homogeneous reservoir with varying permeability (Halliburton web page). When there are varying permeability, the ICD pressure drop is varying according to the different permeability. The ICDs reduce the drawdown of high permeability sections and allow more drawdown (inflow) at zones with low permeability.

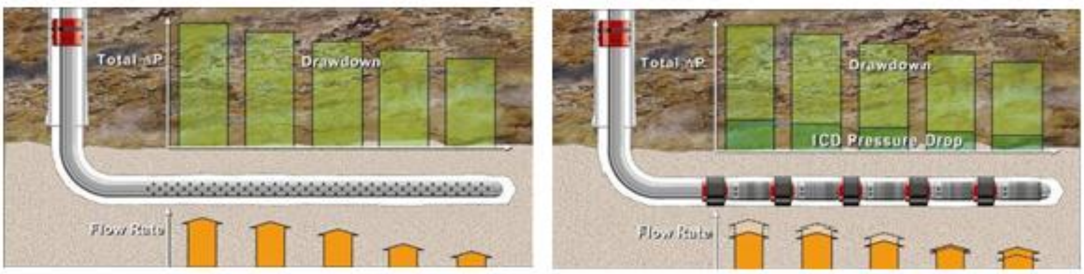

Figure 1: Illustration of the flow rate and drawdown without ICDs (left) and with ICDs (right) for a homogeneous reservoir with relatively constant permeability (Halliburton web page).

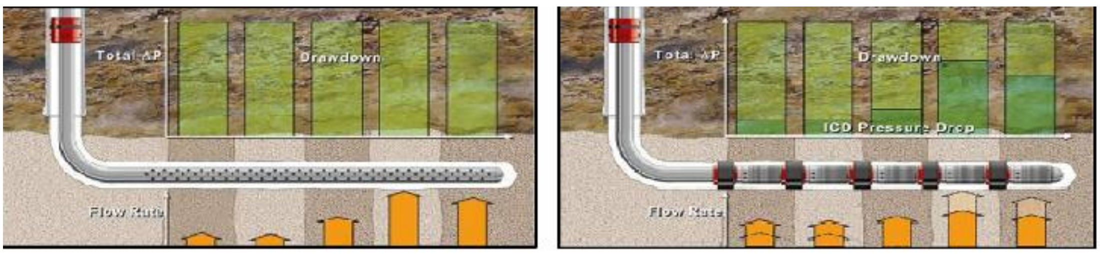

Figure 2: Illustration of the flow rate and drawdown without ICDs (left) and with ICDs (right) for a homogeneous reservoir with varying permeability (Halliburton web page).

If there is an increase in oil viscosity, there will be a decrease in the heel/toe effect. This occurs because the drawdown is proportional to viscosity (Darcy's law) while frictional pressure loss depends only weakly on viscosity for turbulent flow [see the Moody diagram (Moody 1944)] (Al-Khelaiwi et al. 2010).

The ideal case would be to produce the entire water (or gas) – oil contact parallel to the production tubing. Ultimate recovery would take place if the waterfront enters the tubing over the entire length at the depletion stage (Aadnoy and Hareland, 2009). It is important to find the best placement of the ICDs.

The main vendors supplying ICDs are Weatherford, Schlumberger, Baker Hughes and Halliburton.

1.1.3. ICV

An ICV is a downhole flow-control valve that is being operated remotely from the surface by hydraulic, electric or electro-hydraulic actuation system (Al-Khelaiwi et al. 2010). The ICV is a choke with have the ability to choke or completely shut off the fluid flow. The ICV is a key part of an intelligent well completion. Intelligent well completion, and its components, will be explained in further detail in section 1.3.

The ICV design in general ought to achieve the following (Rahman et al., 2012):

- Maintain a pressure balance during the operation to ensure performance integrity.
- Quantifiable flow characteristic.
- Sealing technology must handle all loading and unloading scenarios for the life of the well operations
- Maintain tension and compression integrity of the completion.

There are many different ICV designs, all from simple on/off (flow or no flow), to valves where you can adjust the flow opening in any desired position. The ICVs are used to split the well into two or more sections in order to optimize the production. By making it possible to split the well into different zones, one can obtain a balanced production profile along the entire well completion. ICVs are used in combination with monitoring system to early detect water or gas breakthrough, making choking of the unwanted fluid possible. The ICV system consists of five main components: surface-control equipment, control lines, connectors, gauges to monitor the flow, and the valve itself (Al-Khelaiwi et al. 2010). ICVs may be required to move under conditions of significant pressure loading or unloading (Rahman et al., 2012). This means that because of the operation environment, the ICVs need to be reliable and robust without compromising the ease of intervention.

With production from different zones, with different pore pressure, there may be produced a different amount of oil, gas and water. High pressure zones may then block production from low permeability zones, leading to loss of reserves. There can also be cases where fluid flow from one zone to another. If there is a gas breakthrough in one zone, it may possibly stop production from other zones. When using ICVs, it is possible to avoid these problems when producing from different zones. You can control the water production by shut off that particular zone, and open again if it is registered that the water has withdrawn. By having the ability to monitor and get data in real time, it is possible to have control over the flow rate from the different zones and avoid flow between zones.

To decide the optimal placement of the ICVs, it is very important to have a good understanding of the reservoir geology. The ICVs should be placed in zones that show signs of early water or gas breakthrough.

The main vendors supplying ICVs are Schlumberger, Halliburton and Baker Hughes.

1.1.4. Further study

The rest of the thesis will focus on ICVs and ICDs. The thesis will examine the efficiency of ICDs and ICVs in three different cases; early life, mid-life and late life of a well. The thesis will describe designs of ICVs and ICDs which have been installed in the field. The thesis will not go into details about new designs under development which have not been tested in an actual well.

The study will also look into more details about in what reservoir conditions ICVs and ICDs are used. A comparison of when to use ICVs vs. ICDs will also be done.

ICVs and ICDs can be used both in production wells and injection wells. Injection well places the fluid deep underground into porous rock formations. Injection wells are often used to long term (CO_2) storage, water disposal, mining, preventing salt water intrusion and enhanced oil recovery. Re-injection of for example associate gas from a nearby field can be used to maintain pressure in the well. It can be important to control the injection of the fluid, and that can be done by ICVs or ICDs. ICDs will give an even injection into a reservoir with varying permeability. ICVs have the flexibility to control injection for different zones. With real time data, it is possible to change injection for specific zones if conditions are changing. For an injection well, the purpose of the ICDs and ICVs is to have control of the fluid that is being injected into the reservoir, while for a production well the ICDs and ICVs are controlling the fluid coming into the tube.

In this thesis the focus will be on a production well. There will be carried out a nodal analysis by the use of NETool to see how the ICDs and ICVs work in a producing well. The analysis will examine how the produced fluids change with changing water saturation (Sw). A conventional well completion will be compared with a well completed with ICDs, and a well completed with ICVs. The goal will be to investigate if ICVs or ICDs will have an impact on the produced fluid compared to a conventional well completion.

1.2. What ICVs and ICDs can solve

To manage the reservoir is now less black and white. The extreme-reservoir-contact wells delays water or gas breakthrough and improves the sweep efficiency by reducing the localized drawdown and distributing fluid flux over a greater wellbore length, but it also increases the difficulty of controlling reservoir drainage. When we have a conventional well, the reservoir drainage control because of coning can be managed by closing the wellhead choke. Resulting in an increased cumulative oil production and reduced water production rate at the expense of hydrocarbon production rate (Al-Khelaiwi et al., 2010).

If the production rate gets too high in a well with maximised reservoir contact, there can be a pressure drop around the well, which again can lead to water coning. Water production will most often limit the wells capability to produce oil. It is preferable to avoid water production, so it can be reasonable to choke the flow to get the optimal production.

As one can see from **Figure 3** a conventional producer consists of much less equipment than a smart producer. The smart producer make it possible to control the reservoir in a larger scale than the conventional producer.

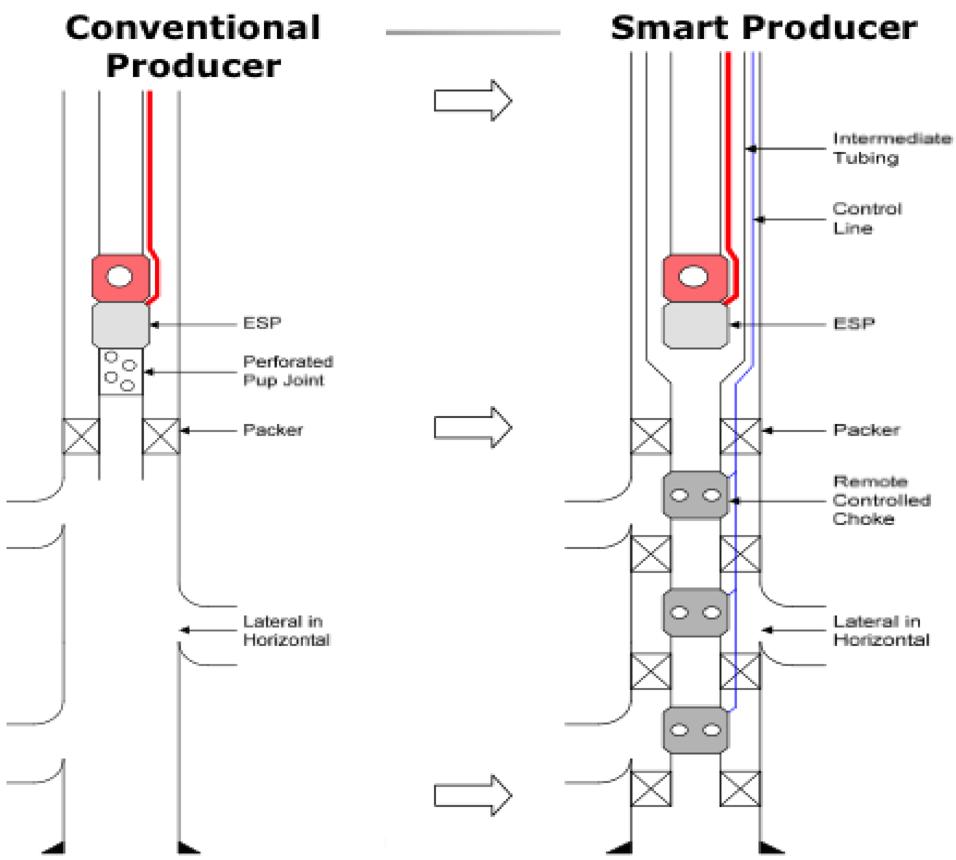

Figure 3: Figure of a conventional producer compared to a smart producer (presented at SPE-ATCE, San-Antonio, 23rd – 24th Sept. 2006)

Premature breakthrough of water or gas occurs because of (Al-Khelaiwi 2010):

1. Reservoir-permeability heterogeneity.
2. Variations in the distance between the wellbore and fluid contacts (e.g. because of multiple fluid contacts, an inclined wellbore, tilted oil/water contact).
3. Variations in reservoir pressure in different regions of the reservoir penetrated by the wellbore.
4. The heel/toe effect that leads to a difference in the specific influx rate between the heel and the toe of the well, especially when the reservoir is homogeneous.

A practical solution to these problems can be done by implement downhole flow control employing ICVs and ICDs.

1.3. Intelligent/smart wells

As the reservoir complexity increases the need for Intelligent Wells are growing.

Intelligent wells have the ability to restrict or exclude production of unwanted fluid (water and/or gas) form the different reservoir zones in a producing well. The distribution of water or gas injection in a well between layers, between compartments, or between reservoirs, can be controlled by intelligent wells (Konopczynski and Ajayi 2007).

The main component an intelligent well consists of is (Shaw, 2011):

- Control and electrical lines – which is the power transmission to the ICV, and transfer the monitored data to the surface (like pressure and temperature).
- Packers – is used to isolate the individual zone along the wellbore.
- Permanent monitoring.
- Interval Control Valves (ICVs) – used to control the incoming fluid.
- A system to control the ICVs – can be hydraulic, electric, or a combination of these two.

In **Figure 4** the placement of the main components are illustrated.

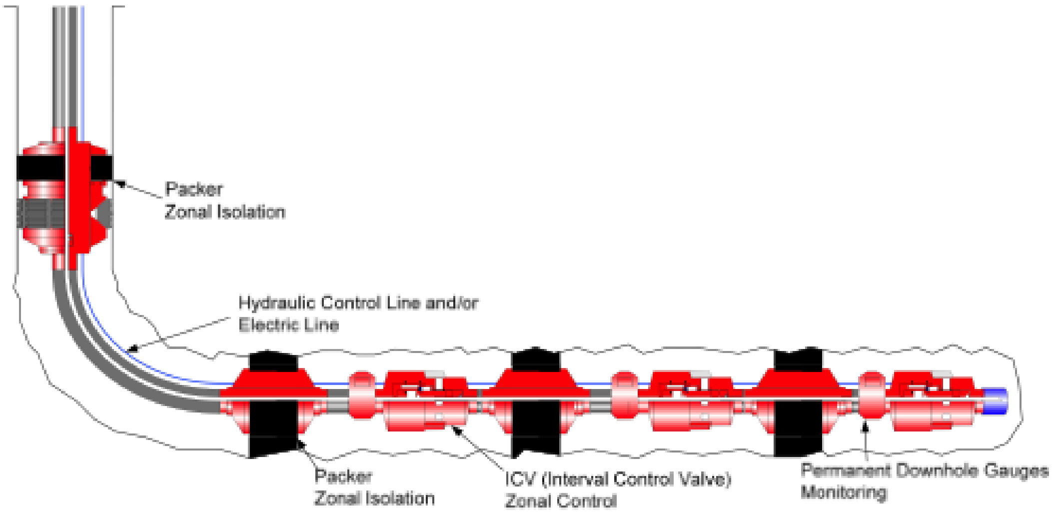

Figure 4: Components of an intelligent completion (Shaw, 2011)

Konopczynski and Ajayi (2007) have described what is essential for fully realize the benefits of intelligent well reservoir management. And that is the three key elements that are shown in **Figure 5.**

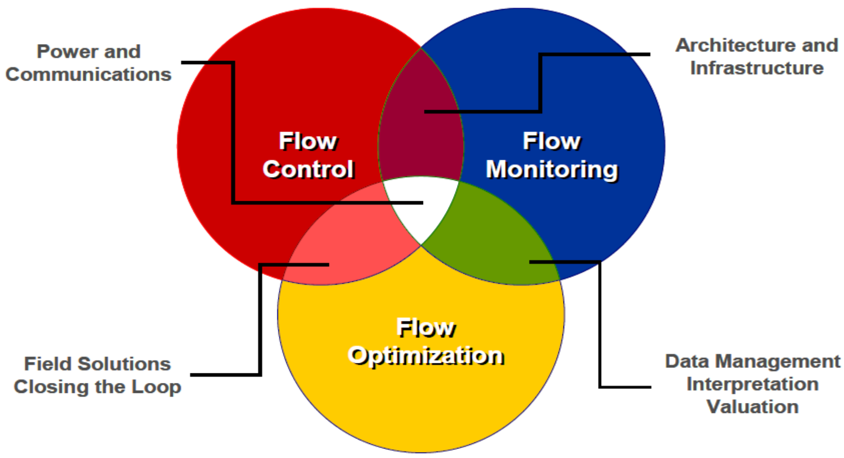

Figure 5: The elements of an intelligent well (Konopczynski and Ajayi 2007).

1. The flow control gives the ability to segment the wellbore into zones or individual flow units. It also gives the ability to control inflow or outflow of fluids in each zone by the use of downhole inflow control valves (ICVs), this can be done without physical intervention.
2. Next there is the flow monitoring, which gives the ability to generate data about key reservoir parameters. Key parameters are for example; temperature, flow, pressure and fluid composition. These parameters are captured in real time at frequencies compatible for analysis and understanding about the well and reservoir performance. The data collected may come from optical or electronic sensors that are located downhole, in close proximity to the reservoir (Konopczynski and Ajayi 2007).
3. Last is the flow optimisation which gives the ability to gather the downhole reservoir parameter data and combine it with other relevant gathering and process production data. It also gives the ability to transmit and store this data, and gives analysis capabilities to generate insight and information about the reservoir performance (Konopczynski and Ajayi 2007). When there has been gathered important information, it is possible to make informed decisions on if it is necessary to modify the well completion architecture. The change in the architecture is done by using the downhole flow control, and undertakes the changes to the settings of the ICV's in a timely manner. Acquisition of data, control and automation capabilities directly associated with the intelligent well hardware, and integrated with the field process control system, is included in flow optimization.

It is widely accepted that an Intelligent Well can provide added value in different areas (Drakeley et al., 2001). The benefits may be one or more of the following:

- Increased recovery.
- Accelerated production profiles
- Reduced well construction costs
- Reduced well intervention frequency and costs -> this also gives an improvement in operational safety
- Increase the Net Present Value of the well

When operators are evaluating if they are to install an intelligent well completion, they evaluate it on the basis of the value offered relative to conventional completion systems. In about 70% of the intelligent well completions, the wells are high-cost critical wells. In these wells, intervention costs are high. Most of the wells where intelligent completion is used are deepwater wells. Installation of intelligent well completion is reducing the need for intervention.

Benefit of intelligent well technology can be achieved when production performance from different completion zones is very different, or when different reservoir fluids are being produced. It can also be smart to use intelligent well when there is production from multiple reservoirs, when commingled production is the main production strategy.

It is important to remember that an intelligent well not always need to be "intelligent" when the goal is to find the best solution on how to produce the well. In some cases a "stupid" well may be the smartest solution.

1.4. Multilateral wells.

A multilateral well is one main well bore with attached lateral well bores, all of which can be communicated with, either individually or by commingling production. The multilateral wells have maximized reservoir contact. ICDs and ICVs provide a range of fluid-flow control options that can increase the reserves and enhance the reservoir sweep efficiency.

There will probably be earlier water breakthrough in one lateral than compared to the other, if the laterals are completed at different vertical depth or in different reservoir facies. If this happen, it will lead to a deterioration of the total well performance. To avoid that, it is possible to combine an ICD completion along the well laterals with installation of ICVs at the mouth of each lateral. The ICVs have as mentioned earlier the ability to remotely adjust the flow contribution. It means that when there is a multilateral well with different depth or facies, the ICVs can remotely adjust each lateral's flow contribution depending on registration of unwanted (gas or water) fluid production (Al-Khelaiwi and Davies 2007).

By doing the study in a multi-zone intelligent well system with the use of variable choking, it is possible to combine the flow performance (pressure drop vs. flow rate) of ICV with the inflow performance of the reservoir for the respective zones. This can greatly contribute in the complex task of nodal analysis and performance optimization of the whole well. **Figure 6** shows a typical example of the ICV flow performance curve for an oil based fluid. In the ICV flow performance curve it is possible to look at the intersection between the given ICV position and oil flow rate, to find the pressure drop across the choke.

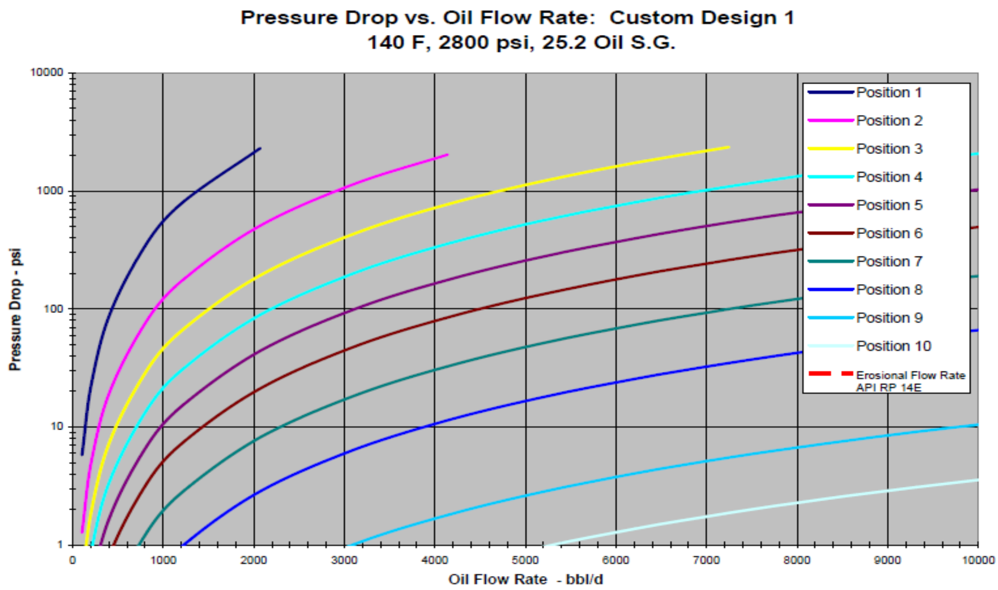

Figure 6: Flow performance of an Interval Control Valve (Konopczynski and Ajayi 2007).

1.5 Field history

1.5.1. Application of Inflow Control Device in the Troll oil field

The Troll Oil field is located in the North Sea 80 km west of the Norwegian west coast. The field is one of the Norwegian continental shelf's largest oil producing field, and consists of a thin oil column only 4-27 meters thick (Henriksen et al., 2006). At first, the thin oil column was not considered economical for development, despite that it was containing a large volume in place. There were many challenges that needed to be solved for the field to be an oil field. **Figure 7** shows a field map over the Troll infrastructure, containing longer horizontal sections than what had been constructed before, and multilateral wells. The construction of the horizontal section, implementation of multilateral well technology and a new sand screen completion has made the field a success.

Figure 7: Field map over the Troll Oil Field infrastructure (Henriksen et al., 2006).

Many technological and operational barriers have been broken during the development of the Troll field (Mikkelsen et al., 2005). There have been installed single 1000 m long horizontal sections. There has also been incorporated construction of a down hole drain system, called a “Starfish” well, which covers more than 13500 m of reservoir section through 5 laterals shown in **Figure 8.**

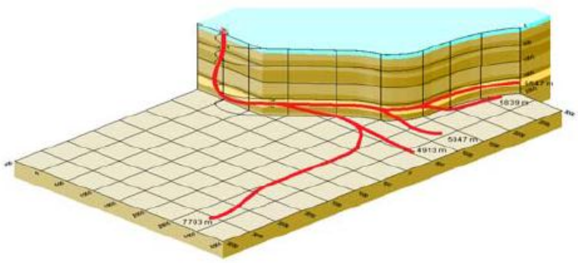

Figure 8: Troll “Starfish” well, covers 13500 m of reservoir section (Henriksen et al., 2006).

One of the main reasons for the success, was Hydros invention and subsequent development of the ICD technology (Brekke and Lien, 1994).

The reservoir section of the Troll field was from the start placed horizontally near the oil water contact to keep maximum distance to the coning potential of the gas cap. The wells penetrated both high and low to medium permeability sands (Henriksen et al., 2006). Since the horizontal reservoir section approached 4000 m, and contained multi-lateral well technology, there was a need for a more robust sand screen design than the one used before.

A shrouded coarse weave premium screen was developed to handle the new requirements associated with the field development. An ICD flow resistance module was incorporated into the premium screen design, and applied in the reservoir completions (Henriksen et al., 2006).

In 1998 there was developed a method to implement ICDs in reservoir simulation. Simulation showed a gain in cumulative oil production by increasing the ICD length, and increased net present value. It also demonstrated how gas break through was delayed with increasing ICD length (Henriksen et al., 2006).

There was done a reservoir simulation model case, which represents a typical Troll well branch, with a 2500 m long horizontal reservoir section (Henriksen et al., 2006). The well is placed 1 m above the OWC. Two simulations was done, one with a conventional well without ICD, and one with ICD. The ICD case gave an increase in oil production on 200 000 Sm^3 oil in 17 years. It also delayed the gas breakthrough by approximately 100 days. When using ICDs, a more uniform drainage can be observed. This leads to a faster growth in GOR, due to the wider spread of the gas coning reaching the well.

In **Figure 9, 10 and 11** the simulation results are shown.

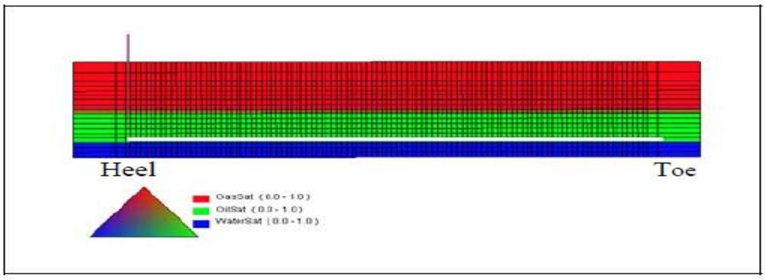

Figure 9: Cross section along the well, showing the oil column at the first time step of the simulation (Henriksen et al., 2006).

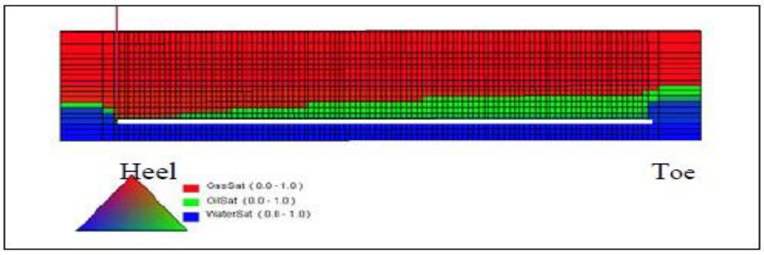

Figure 10: Cross section along the well without ICDs showing the remaining oil at the last time step of the simulation (Henriksen et al., 2006).

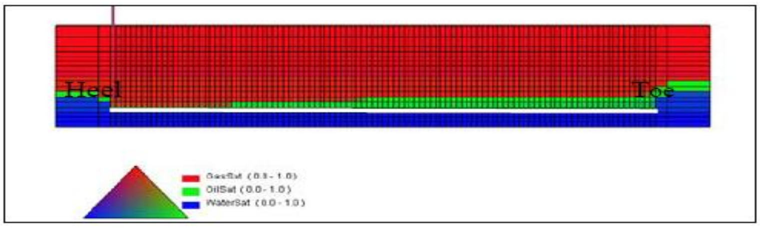

Figure 11: Cross section along the well with ICDs showing the remaining oil at the last time step of the simulation (Henriksen et al., 2006).

The simulation results shows that there are a considerable amount of oil left in the toe of the well when studying the well without ICDs, than compared to the well with ICDs.

Gas breakthrough would have occued almost immediately in a conventional well completion due to the thin oil layer, this is shown form the Troll West Gas Province extended well test (Haug, 1992). By implementing ICDs in the sand control screen completion, the drawdown over the entire horizontal section gave a balanced inflow profile (Henriksen et al., 2006). It was also experienced that the Troll ICD wells was cleaned up more efficiently because of the ICD effect, than compared to the conventional well.

1.5.2. *Application of Intelligent-Well technology with ICV by Indonesian operators*

The case story is about the KE38 field, located in the East Java Basin shown in **Figure 12**, about 50 km off the northern coast of Madura Island, Indonesia.

Figure 12: Kodeco's KE38 field (Youl et al., 2010).

Average water depth in the block is about 190-feet. The reservoir consists of reef-carbonate structures within the Kujung formation (Youl et al., 2010). The field have a relatively large gas-cap supporting the geological structure, which consists of several domes. The oil columns are between 60 and 300 ft, and have an overlying gas cap of 500 ft on average and under-lying water. Gas-oil contact is located at TVD of 4500 to 5000 ft. Porosity of the oil columns ranges from 18 to 26%, and the permeability ranges from 20-100-md. The reservoir has a normal pressure, and the oil is a slightly waxy crude of 35 degrees API (Youl et al., 2010). To make the wells in this field able to produce and maintain a given gas/liquid ratio to have the optimal oil production rate, the wells need artificial lift in the initial stage of the operation.

Conventional gas lift completion has been used to produce field, but there are limitations related to the setting depth of the gas lift mandrel. The mandrel is placed to provide a means of locating gas-lift valves. The position of the gas lift mandrel is very important to achieve efficient operation of the entire system (Schlumberger Oilfield Glossary). When using a conventional gas lift completion, the maximum setting angle is less than 60 degrees. While using an ICV, referred to auto-gas lift (AGL) in this case, gives the possibility to set in a trajectory angle and it can also be set at the deepest point in the wellbore to optimize the oil production (Youl et al., 2010).

AGL takes the advantage of the in-situ energy from either an adjacent gas reservoir or a gas cap to lift the fluid from the oil reservoir (Youl et al., 2010). By using such a system it is possible to avoid large capital expense, operating costs, and reduce the need for well interventions. Conventional gas-lift completion inject gas from the surface into the annulus and produces from the tubing, while in this case the Kujung gas cap is produced into the tubing.

An ICV is installed in this case to control the gas. The ICV is installed between two packers to isolate it in the gas cap (Youl et al., 2010). **Figure 13** shows the ICV used in the case study. The ICV has 11 positions.

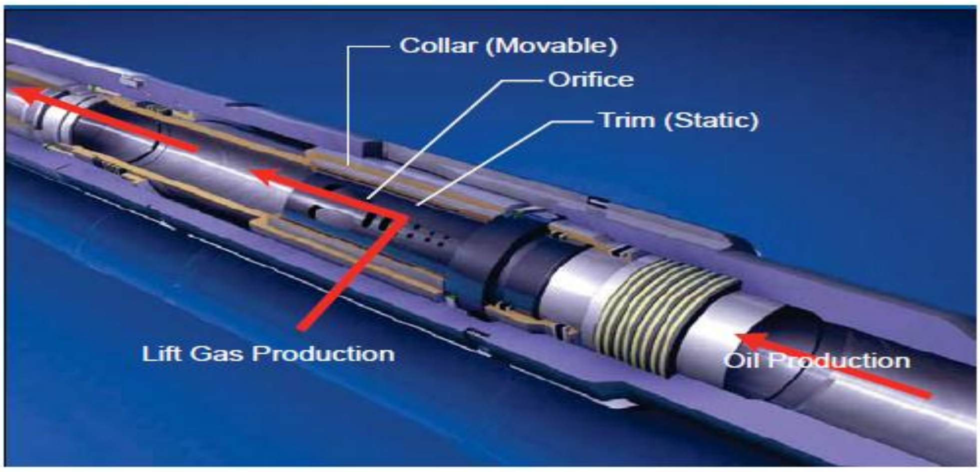

Figure 13: 11-position ICV used in the Kujung Gas Cap (Youl et al., 2010).

To use auto-gas lift it is very important to look at the different uncertainties related to the performance of the well through the entire life. There are different key parameters that need to be considered, and some of those are (Youl et al., 2010):

- Gas Productivity Index (PI)
- Gas reservoir pressure (specifically future depletion)
- Gas zone fluid composition
- Oil zone PI
- Oil reservoir pressure (specifically future depletion)
- Oil zone fluid composition (including water-cut and GOR)

The installation of the ICVs has provided important efficiency in optimizing all phases of the oil production for the gas cap oil reservoir.

2. HISTORICAL DEVELOPMENT

2.1. ICD

The ICD technology was first introduced in Norsk Hydros Troll field in 1992. IDCs were implemented to enhance the horizontal wells performance, and to counteract the heel/toe effect.

The Troll Field is a giant gas field, and is described in detail in section 1.5.1. Originally, the field was developed as a gas field in the “thin-oil-column” region, because production of such thin oil column was considered not possible with the use of conventional wells (Al-Kelaiwi and Davies 2007). Two horizontal wells were drilled with a goal to examine the possibility for economically drainage of the thin oil region. There were conducted long-term tests that indicated that a significant oil production potential existed (Lien et al. 1990; Haug 1992). Tests showed that the well PI was ~ 6000 Sm^3/day/bar, which was very high, 5-10 times higher than expected from a vertical well (Al-Kelaiwi and Davies 2007). Target rate for the well was 3000-5000 Sm^3/day, and with a small pressure drop of only 0.5 – 1.0 bar, it would be possible to produce the well at target rate.

Today, there is a continuously development of new types of ICDs.

2.2. ICV

The ICV technology has arisen as a result of further development of the traditional sliding sleeves. Increased reservoir complexity drove the well completion methods to develop. The need for more efficient methods to drain the reservoir was necessary. The possibility for more efficient production came with the Intelligent Well technology, where the ICVs are an important component.

First generation of the ICVs was a choke that offered only four positions (Williamson et al., 2000). It was only possible to have the valve fully open, closed, and two intermediate choke positions with the four position choke. The size of the flow ports for the intermediate choke positions also had to be selected far enough in advance to allow time for manufacturing of the equipment (Botto et al. 1996). The valve controlled communication between the tubing and annulus by means of a sleeve which axially slides up or down to open and closes the valve (Botto et al. 1996).

The first ICV applications were to allow the controlled, commingled production of multiple reservoirs through a single flow conduit (Akram et al. 2001; Jackson Nielsen et al. 2001; Skilbrei et al. 2003; Lehle and Bilberry 2003; Dolle et al. 2005; Lau et al. 2001; Betancourt et al. 2002; Al-Kasim et al. 2002; Clarke et al. 2006; Jin et al. 2005). The first intelligent completion was installed at Saga's Snorre Tension Leg Platform in the North Sea in August 1997 (Gao et al., 2007).

As the reservoirs became more complex, the need for the next generation ICVs increased. The new-generation ICV can tolerate higher temperature and pressures to cope with the new harsher environments. At the same time, the new-generation ICV have simplified its operation mechanism, debris tolerance and improved inflow performance (Rahman et al., 2012).

Today it is possible to design an ICV with the number of ICV position needed in each particular case.

3. ICD MECHANISM

3.1. Functionality of the ICD

In **Figure 14** a typical ICD tool is shown (Aadnoy and Hareland, 2009).

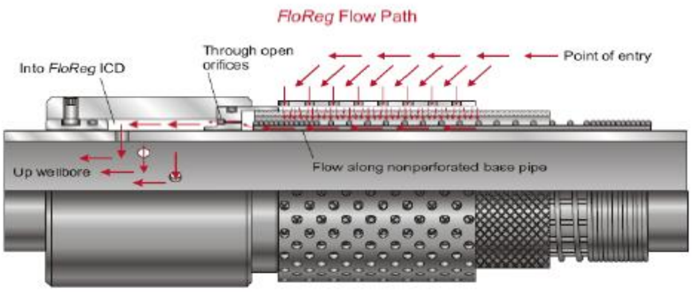

Figure 14: A typical ICD tool (Aadnoy and Hareland, 2009).

The oil comes from the reservoir and then enters the outside of the tool. After entering the tool the oil flows through the screens into a pathway along the base pipe. The oil then flows along the pathway and into a chamber before going through several orifices. When the oil have passed the orifices, it flows through a number of large holes inside the casing (Aadnoy and Hareland, 2009). The orifices are what control the flow.

Looking at the coupled flow model the pressure drop from the reservoir through the ICD and into the base pipe is included. The flow path is coupled in a series of pressure losses, and can be broken into 5 different componets Aadnoy and Hareland, 2009):

- The outside screen
- The conduit below the screen
- The chamber
- The orifices
- The holes through the casing

3.1.1. The outside screen

The slots in the outside screen are a rectangular opening. Analysis done on the actual geometry of the screen gave that 11% of the outside surface is the actual flow area (Aadnoy and Hareland, 2009).

Inflow velocity per meter length is given by:

$$v(m/s) = \frac{q}{A} = \frac{Q(m^3/sek)}{12320x10^{-6}m^2} = 81.17Q$$

The equation for pressure drop between two plates is derived from pressure drop, modelled as a laminar flow between two plates, as defined by Bourgoyne et al. (1986). The final result is:

$$Q = \frac{wh^3}{12\mu}\frac{\Delta P}{L}$$

wh is defined as the effective flow area, and the pressure drop becomes:

$$\Delta P(bar) = \frac{12\mu QL}{Ah^2} = \frac{12\mu(Ns/m^2)Q(m^3/s)1(m)}{12320x10^{-6}(m^2)\{0.25x10^{-3}\}^2(m)^2} = 15.58x10^4\mu Q$$

Where:

μ – Viscosity

Q – Flow rate

3.1.2. *The conduit below the screen*

There are two complexities related to the pressure drop in the conduit below the screen.

First, the axial flow through the nozzles. At any given point the flow is the cumulative flow from the screen openings upstream. This will increase from one end of the conduit to the other (Aadnoy and Hareland, 2009). The second complexity is that the shape of the conduit is a rectangle. To calculate the pressure drop, an equivalent hydraulic radius is defined (Bourgoyne et al. 1986), and the flow equation for a circular hole is used. Each conduit has a size of 0.503 in x 0,202 in. The area of the rods, where the wire is wrapped on, needs to be subtracted. So the effective conduit area is 0.381 in x 0.202 in or 9.7 mm x 5.1 mm.

Then the hydraulic radius is given by:

$$R_H(mm) = \frac{Area}{Wettedperimeter} = \frac{9.7x5.1}{2(9.7+5.1)} = 1.67mm$$

The hydraulic diameter is four times the hydraulic radius, and the laminar pressure drop for a circular pipe is given by:

$$\Delta P = \frac{32\mu v}{d^2}L$$

Using the above equations, the pressure drop becomes:

$$\Delta P(bar) = \frac{32\mu(Ns/m^2)}{\frac{\pi}{4}0.00669^2(m^2)0.00669^2(m^2)}x1(m) = 203000\mu Q$$

Where:

μ – Viscosity

Q – Flow rate

3.1.3. *The chamber*

Before the conduit flow through the nozzles it flows through a chamber. The chamber is relatively large. This means that the velocity is small, making it possible to neglect the pressure drop.

3.1.4. *The nozzles*

Assuming that there is a fully turbulent flow through the nozzles, and with the use of the pressure drop across a nozzle is given by (Bourgoyne et al., 1986):

$$\Delta P(Pa) = \frac{1}{2}\rho v^2 = \frac{\rho Q^2}{2A^2} = \frac{\rho(kg/m^3)Q^2(m^6/s^2)}{2\pi^2 r^4(m^4)}$$

Where:

ρ – Density of oil

Q – Flow rate

r – Nozzle diameter

3.1.5. *The total pressure drop*

By summing the individual pressure drop derived above, the total pressure drop of the system is achieved.

With a minimum nozzle diameter of 1/8 in, giving a radius of 1.59 mm, density of oil assumed to be 0.75 specific gravity, and an oil viscosity of 0.5 cP, the equation for the total pressure drop is:

$$\Delta P(bar) = 779\frac{Q}{L} + 11.5Q + 5.28x10^7\frac{Q^2}{n}$$

Where:

Q – Flow rate

L – Screen length

n – Number of nozzles

3.2. Evaluation of the flow regime

To investigate if the flow regime is turbulent or laminar flow, the value of the Reynolds number is evaluated. Reynolds number is defined as the transition between the phases (Aadnoy and Hareland, 2009). If the value is lower than the Reynolds number, the flow is fully laminar, which means that the pressure drop depends on the viscosity of the fluid. When the value is higher than the Reynolds number, the flow is turbulent, and the pressure drop depends on the fluid density. Reynolds number is defined by the following equation:

$$Re = \frac{vd}{\upsilon} \leq 2320$$

Where:

v – Average flow velocity

d – Pipe diameter

υ – Kinematic viscosity

The kinematic viscosity is defined as:

$$\upsilon = \frac{\mu}{\rho}$$

Where:

μ – Fluid viscosity

ρ – Fluid density

When a system contains a restriction, it is also controlled by the restriction. This means that most of the pressure drop occurs across the restriction (Aadnoy and Hareland, 2009). The flow over the restriction is usually turbulent flow, which means that it is controlled by the fluid density.

3.3. Flow system

The flow through the ICDs is dependent on the pressure drop. From **Figure 15** one can see the flow characteristics for an ICD. The pressure drop is proportional to density and the squared flow rate.

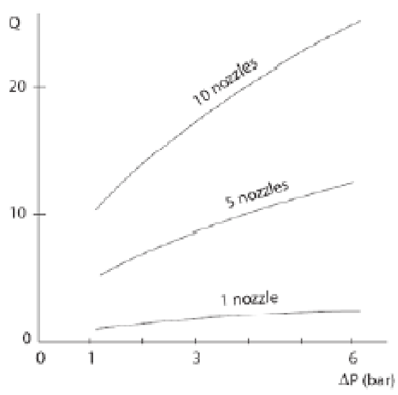

Figure 15: Flow characteristics for an ICD (Aadnoy and Hareland, 2009)

The entire flow system can be defined as follows (Aadnoy and Hareland, 2009):

- Flow comes from the reservoir into the completion system. Usually the flow here is laminar.
- Then it flows through the ICD, where the flow is turbulent.
- Cumulative flow from the toe to the heel of a horizontal well. The flow coming in along the well is laminar at the toe, but often turbulent at the heel.

4. TECHNOLOGY

4.1. ICD design

There has been developed in practice four types of ICDs: orifice/nozzle based (restrictive), helical-channel (frictional), the hybrid design (combination of restrictive, some friction and a tortuous pathway) and the new autonomous ICD (AICD). The different world leading suppliers to the upstream oil and gas industry each have their own patented design.

Normally ICDs are installed in combination with a stand-alone sand screen (SAS), gravel pack or debris filter, depending on the strength of the formation; blank pipe to isolate fractured zones or shale; and with an annular-flow isolation in the form of (external) packers (Al-Khelaiwi et al. 2010).

4.1.1. Channel-type ICD

Channel-type ICD uses surface friction to generate a pressure drop. The pressure drop above the channel ICDs are calculated with the following equations (NETool™ 5000.0.1.0 Technical Manual);

$$\Delta P = H_{total}\rho \ \times v_2$$

$$H_{total} = H_{major} + H_{minor}$$

$$H_{monor} = K_{minor} \times \frac{V_{channel}^2}{2}$$

$$H_{major} = H_f = f \times \left(\frac{L_{channel}}{D_{hydraulic}}\right) \times \left(\frac{V_{channel}^2}{2}\right)$$

$$V_{channel} = \frac{Q_{channel}}{A_{cross-sectionalarea}} = \frac{Q_{ICD}/_{Number\ of\ channels\ in\ parallel}}{A_{cross-sectionalarea}}$$

$$D_{hydraulic} = \frac{4A_{cross-sectionalarea}}{U_{wetted\ perimeter}}$$

Where:

ΔP - Pressure Drop across channel

ρ - Average Fluid Density

v – Fluid Velocity through channel

Q – Fluid flow rate through channel

A – Area of channel

L – Length of channel

K_{minor} – Total minor loss coefficient

f – friction factor

The development of channel-type ICD was done as a modification to the original labyrinth ICD. Channel-type ICD uses a number of helical channels with a preset diameter and length, as shown in **Fig. 16**, to impose a specific deferential pressure at a specified flow rate. When producing the fluid, the fluid flows from the formation through a limited annular space into multiple screen layers mounted on an inner jacket. Then the fluid flows along the solid base pipe of the screens to the ICD chamber where the chosen number of channels impose the desired choking before the fluid passes further onto the inner section of the casing (Al-Khelaiwi and Davies 2007). This can be done either through holes of the preset diameter or a slotted mud filter installed to prevent the kill mud to contaminate the screen during any future well killing operation.

Figure 16: A helical channel-type ICD (Augustine 2002)

The Channel-type ICD is available with five flow resistance ratings, those are: 0.2, 0.4, 0.8, 1.6, and 3.2 bar. These ratings are based on the diameter, length and number of channels incorporated into the device (Augustine 2002). By using this particular ICD, one will experience that the pressure drop occur over a longer interval compared to the nozzle and orific-type ICDs. This advantage will contribute to reduce the possibility of erosion or plugging of the ICD ports. But on the other side, this device depends on friction to create a differential pressure in addition to the acceleration effect.

4.1.2. Orifice or Nozzle-type ICD

In both of orfice and nozzle-type ICD the pressure drop is localized at the orfice or nozzle.

The nozzle-type uses nozzles to create the pressure resistance as pointed out in **Figure 17** (Schlumberger website, 2012)

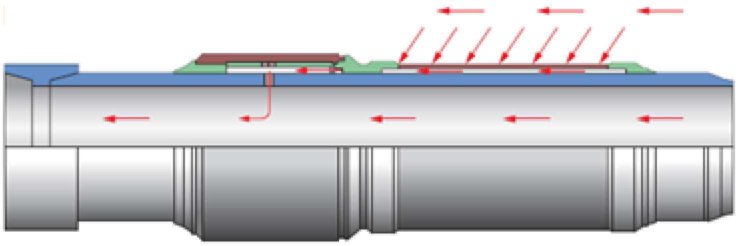

Figure 17: A nozzle-type ICD (Schlumberger website, 2012)

The fluid that is passing through the screen is collected in a chamber where a set of preconfigured nozzles control the fluid flow from the chamber to the inner section of the liner joint. When choosing the number and diameter of the nozzle, one bases the selection on the desired pressure drop across the device at a specific flow rate. The pressure drop is highly dependent on the fluid density and velocity, but less dependent on viscosity when we are constricting the fluid flow to a number of nozzles (Al-Khelaiwi and Davies 2007).

The pressure drop across a nozzle is calculated based on Bernoulli's Equation (NETool™ 5000.0.1.0 Technical Manual):

$$\Delta P = \frac{\rho v^2}{2C^2} = \frac{\rho Q^2}{2A_{valve}^2 C^2} = \frac{8\rho Q^2}{\pi^2 D_{valve}^4 C^2}$$

Where:

ΔP – Pressure drop across orifice

ρ – Average fluid density

V – Fluid velocity through orifice

Q – Fluid flow through orifice

A – Area of orifice

D – Diameter of orifice

C – Flow coefficient

Flow Coefficient relations:

$$C = \frac{C_D}{\sqrt{(1-\beta^4)}} = \frac{1}{\sqrt{K}} \qquad \beta = \frac{D_2}{D_1}$$

C – Flow coefficient

C_D – Discharge coefficient

K – Pressure drop coefficient

The oirfice-type ICD employs multiple orifices to produce the required differential pressure for flow equalization (**Figure 18**).

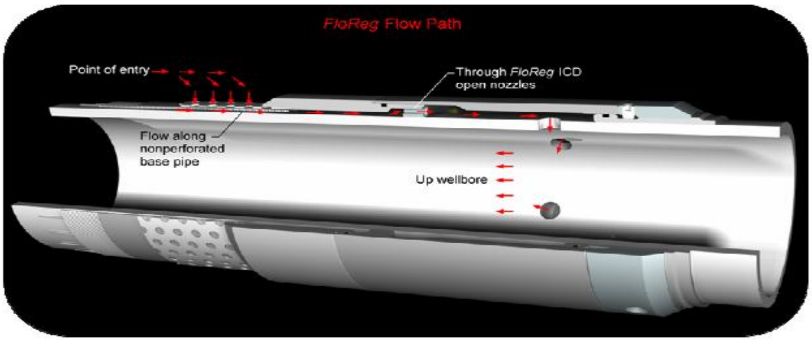

Figure 18: An orifice-type ICD (Jones et al. 2009).

This method forces the fluid from a larger area down through small-diameter ports, this is creating a flow resistance. The change in pressure while flowing is what allows the ICD to function. The orifice-type ICD consists of a number of orifices of known diameter and flow characteristics. The orifices are a part of a jacked installed around the base pipe within the ICD chamber as opposite to the nozzle type ICD (Al-Khelaiwi and Davies 2007). By reducing the numbers of open orifices, the different pressure resistance values are achieved.

Slurry flow testing has indicated that the orifice and nozzle designs are more prone to erosion than helical-channel design (Visosky et al. 2007).

4.1.3. Hybrid ICD design

In the hybrid ICD design a series of flow passages is a maze configuration as can be seen from **Figure 19.**

Figure 19: The hybrid ICD design uses a distributive geometry (Garcia et al. 2009).

The geometry used in the hybrid ICD design is less sensitive to erosion and maintains the plugging-resistance flow area of the helical design (Garcia et al. 2009). The primary pressure drop mechanism is restrictive, but in a distributive configuration. There are incorporated a series of bulkheads in the design. Each of these has one or more slots. In this new adjustable hybrid ICD design it is also incorporated a simple adjustment feature capable of altering the ICD flow resistance immidiately before running in the well. This is incase there is discovered in real-time data collected during drilling that it is indicated that there is a need to change the flow resistance (Garcia et al. 2009).

4.1.4. Autonomous ICD (AICD)

The newest type of ICD development is the autonomous ICD (AICD).

“AICDs should have the possibility to adapt itself according to the phases that enters the wellbore” (Erlendsen and Omdal, 2008).

Autonomous ICDs have the ability to delay water or gas breakthrough by restricting the low viscosity fluid, and favourise the high viscosity fluids. Self choking devices have the ability to give the optimal inflow performance along long horizontal wells. The valve operate without any human intervention, and there is no need for hydraulic or electric power(Mathiesen et al., 2011). The autonomous ICDs are relatively new, so there have not been reported about many installations in the field yet.

There have been developed different types AICDs. Some of them are: Statoil’s RCP, Halliburton’s the EquiFlow AICD, and the BECH Autonomous flow control device (AFD) developed by Hansen Energy Solutions. Statoil’s RCP is the only AICD which is reported as a pilot installed in a field (Mathiesen et al., 2011). There have not been reported about any field installation for the EquiFlow AICD or the BECH AFD, so the details about the design and purpose is outside the scope of this thesis.

- *Statoil’s RCP AICD*

The Statoil’s RCP will delay gas/water breakthrough and reduce the consequences of the breakthrough. The RCP AICD chokes the flow of low-viscosity fluids and allows the viscous fluid (Mathiesen et al., 2011). An example of a well installation is shown in **Figure 20**.

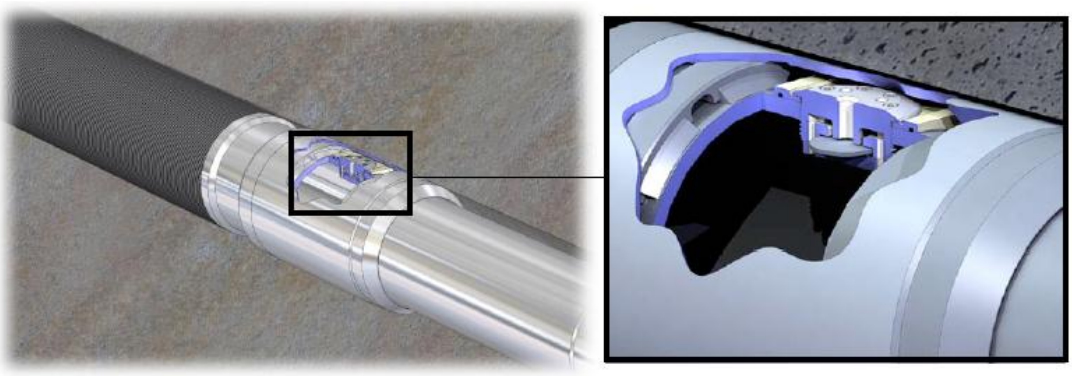

Figure 20: Statoil’s RCP valve connected to the base pipe in a sand screen joint in the well (Mathiesen et al., 2011).

Figure 21 shows a picture of the RCP valve, and the schematic sketch of the RCP is shown in **Figure 22**.

Figure 21: Statoil's RCP valve (Mathiesen et al., 2011).

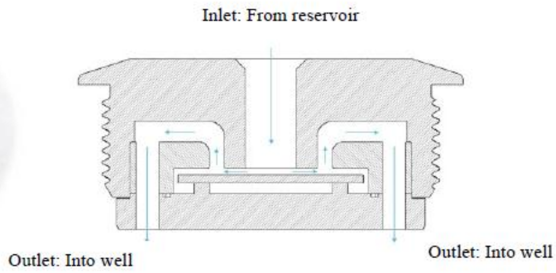

Figure 22: Schematic sketch of the RCP (Mathiesen et al., 2011).

The flow path of the fluid is shown by arrows in **Figure 22**. There is only one moving part in the valve, and that is the free floating disc. The position of the disc is dependent on the flow conditions and fluid properties (Mathiesen et al., 2011). Bernoulli principle gives the basis for the performance of the valve. By neglecting compressible effects and elevation the Bernoulli equation can be expressed as:

$$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2 + \Delta p_{friction\ loss}$$

Where:

p – pressure

v – velocity

Flow rate of low viscosity fluids is restricted by the RCP valve. When the low viscosity fluid force act on the disc, the disc will move towards the inlet and reduce the flow area and the flow. The opposite case will happen when there is a high viscosity fluid flowing through the valve.

4.2. ICV designs

There are different types of ICVs. They can be a ball valve, resemble a traditional sliding sleeve, be offset like a side pocket mandrel or they can have a flapper similar to that of a safety valve (Shaw, 2011). The main thing about all these different valves is that they can be operated from the surface. There are two different functional types of ICVs: on/off and choking ICVs. **Figure 23** shows an example of an ICV designed for deepwater and HP/HT conditions.

Figure 23: ICV designed for deepwater and HP/HT conditions which enables reservoir management by means of the tool's discrete-positioning choke trim and optimal position sensors (SPE.org web site 2008).

ICVs equipped for remote operation require equipment and accessories such as (Al-Khelaiwi et al. 2010) clamps to attach the control lines to the tubing; control lines for hydraulic or electric-power transmission from the surface; feed-through packers to segment and isolate the wellbore; wellhead designed with control-line feed-throughs; and surface readout and control unit.

The first generation ICV design comprised a top sub, upper seat assembly, lower seat assembly (with the valve flow trim), the balanced hydraulic piston, and the bottom subassembly. The top sub houses the hydraulic piston chambers, and it provides a structural integrity. The movement of the upper seat assembly is actuated by a differential pressure application across the hydraulic piston. By that movement, the assembly disengages the upper seat from the lower seat and allow communication between the annulus and the tubing, and allow the fluid to flow. The desired flow characteristics are given by the flow trim, where the flow trim has a flow profile cut into it. When the piston is fully-closed, a locking key mechanism for the upper seat and a reinforced boost piston assembly for the lower seat create a pressure-tight radial line seal that helps maintain sealing capability under high differentials (Rahman et al., 2012). To move the valve in any direction, there is applied a hydraulic pressure through the control lines to either side of the hydraulic piston. After that, the valve can be further opened or return to the closed position by applying the right pressure to the control lines. In **Figure 24** these critical components are illustrated.

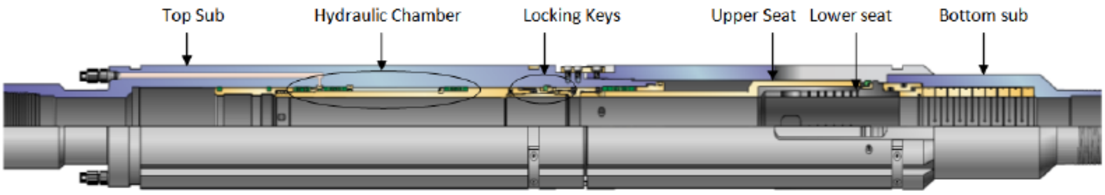

Figure 24: First generation ICV (Rahman et al., 2012)

In the first-generation valves there is a significant difference in the outer diameters (ODs) for the upper and lower seats. This difference is shown in **Figure 25**. That difference has a significant impact on the mandrels ability to be pressure balanced along its length. Upon activation, the metal-to-metal (MTM) sealface is exposed to pressure drops, since the upper seal travels across the outer diameter of the ported flow trim. The MTM seal contact in these valves is a radial line seal, which is vulnerable to debris.

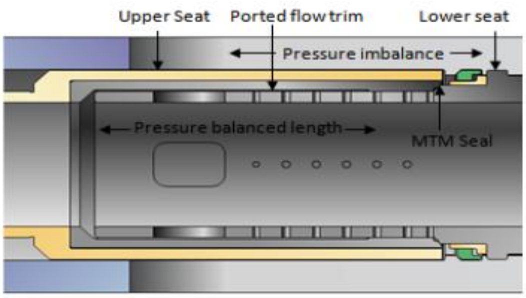

Figure 25: Seal alignment in First-generation valves (Rahman et al., 2012).

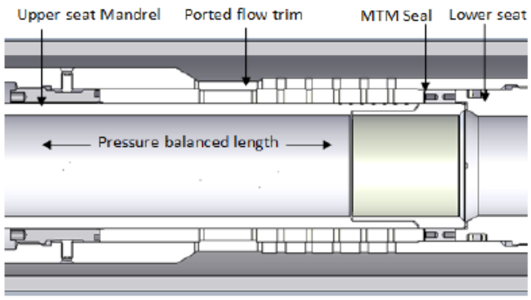

Figure 26: Seal alignment in Second-generation valves (Rahman et al., 2012).

Now in the harsher environments the ICVs need to be operated in, a second-generation ICV is required. The second-generation have a simpler operating mechanism, improved inflow performance and better debris tolerance. The second-generation ICV maintains most components from the first-generation valves. There have been made modifications mainly to the lower seat and the upper seat configuration. The upper seat mandrel travels inside the internal diameter of the ported flow trim as shown in **Figure 26,** and lands in a recess profile beyond the MTM sealface. This gives the design the ability to have constant OD and creates a continuous cylindrical lineation for the lower and upper seat at the point of MTM contact. When there is a constant OD, every opposing forces that may come from the development is minimized. This creates a pressure-balanced mandrel, and eliminates the need for additional mechanical support in maintaining the MTM seal. This means that the valve design do not need a locking key mechanism and the boost-piston assembly which was used in the in the first-generation valves.

The second-generation valve also gives the possibility to change to an appropriate material that easily can improve the pressure rating of the valve without changing the dimensions. In this new-generation design, it is also possible to include a position sensor in the ported housing of the valve, as shown in **Figur 27**. The first-generation ICV was designed without this capability.

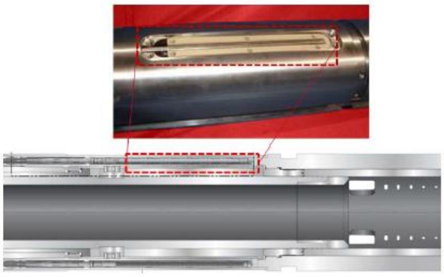

Figure 27: Position-sensor assembly (Rahman et al., 2012).

There is a design challenge with the second-generation ICV, and that is the elastomeric seals inside the hydraulic chamber. At this point the elastomeric seals are qualified to 15,000 psi and 330°F (Rahman et al., 2012). There will be a future focus on improving the ratings for ultra-high pressures and temperature applications. Up to date there has been installed 62 second-generation valves in 22 wells around the globe. All the 62 valves installed are fully functional to date, and there has not been reported any failures of the valves under well operating conditions (Rahman et al., 2012).

4.2.1. Open/close ICV

The on/off ICVs are designed to eliminate or allow communication with a specific zone. They allow selective shut in of specific zones, but do not provide choking capability.

4.2.2. Choking ICV

There can be valves with a limited number of positions. Normally they have up to 10-12 numbers of valve settings. It is also possible to have valves with a larger number of different port sizes than the normal ones. Depending on the need in each particular case, the number of position needed can be implemented. These are called choking ICVs. Typically the ports are very small at the initial position and grow to exceed the tubing flow area in the final positions (Shaw, 2011). Choking ICVs are very often used in comingling production or injection from multiple zones.

4.3. Systems to operate ICV valves

There are different systems to operate ICV valves. They are primarily operated by hydraulic or electrical systems, or they can be operated by a combination of these two. All the systems have advantages and disadvantages that will be explained into further detail below

4.3.1. Hydraulic systems

The direct hydraulic system is the most straight forward of the pure hydraulic systems. **Figure 28** shows a hydraulically actuated ICV. The system uses N+1 hydraulic control lines to control N ICVs. There is an individual hydraulic line which controls each ICV (Shaw, 2011). When there is applied hydraulic pressure to the ICVs, these shift into the next position of the choke (Haaland et al. 2005).

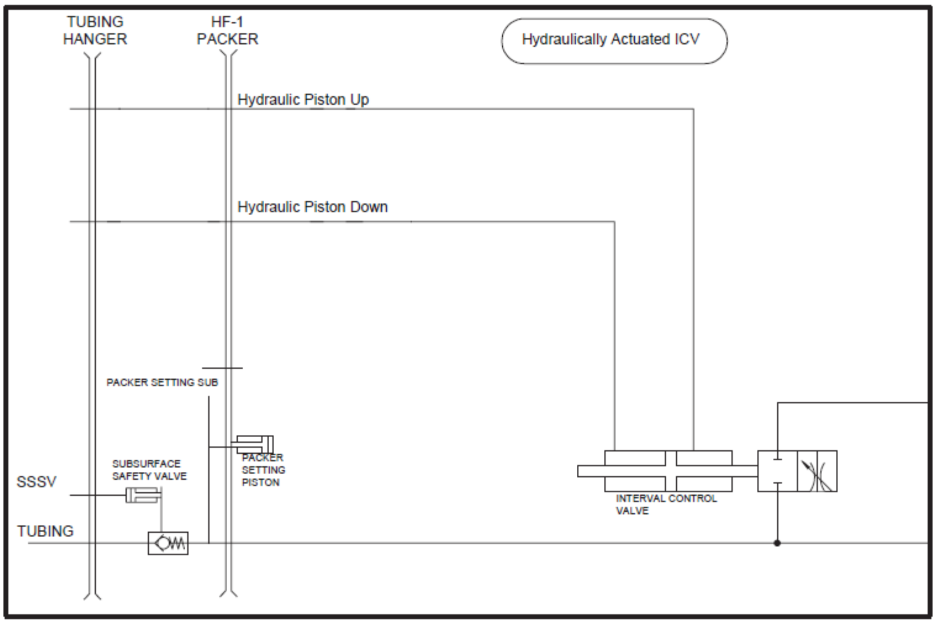

Figure 28: Hydraulically actuated ICV (Jackson and Tips, 2001).

There are different advantages and disadvantages to the direct hydraulic option; these are (Jackson and Tips, 2001):

<u>Advantages:</u>

- With the solenoid system, several single point electrical failures render the valves inoperable without slickline intervention.
- The direct hydraulic system is not dependent on electrical components for actuation. The direct hydraulic system requires at least two electrical failures to prevent actuation.
- The direct hydraulic system is less complex, and thus, can be more cost effective.

<u>Disadvantages:</u>

- Production from more than two independent zones will require additional hydraulic lines, as the system is no longer multiplexed.
- The hydraulic supply to the intelligent completion system is no longer redundant.
- If the subsea pod is used, a direct hydraulic system becomes much more complex than the standard electro/hydraulics module as hydraulic steering would have to be designed to take place in the pod system. While

the intelligent completion equipment would be simpler, the intelligent system would be more complex.

The complexity of the hydraulic systems may vary. But in this thesis the systems to operate the ICVs are not the main aspect, so I will not go into further detail about the hydraulic systems.

4.3.2. Electrical systems

The electrical system uses electrical lines from the surface down to the ICV. Increased complexity of the wells demands less lines downhole to control the valve. This is accomplished by the use of an electrical system. The electronics within the ICV will receive and decode the topset initiated request, and will in turn activate the motor circuits to the valve into the desired position (Drakeley et al. 2001). System controlled by electromechanical means that there will be little force to move the ICV to the desired position. So, the system is sensitive to scale and debris that can block the movement of the ICV position (Shaw, 2011). High temperature has also been a problem for the all electrical systems. High downhole temperature may cause the electric components to fail leading to reliability issues. The system is also quite expensive, making reliability an important factor. Electrical components used today are much more reliable than the first electrical components used. And they are continuously being improved in attempt to satisfy industry demand.

4.3.3. Combination of electro-hydraulic systems

Electric/hydraulic is illustrated in **Figure 29**.

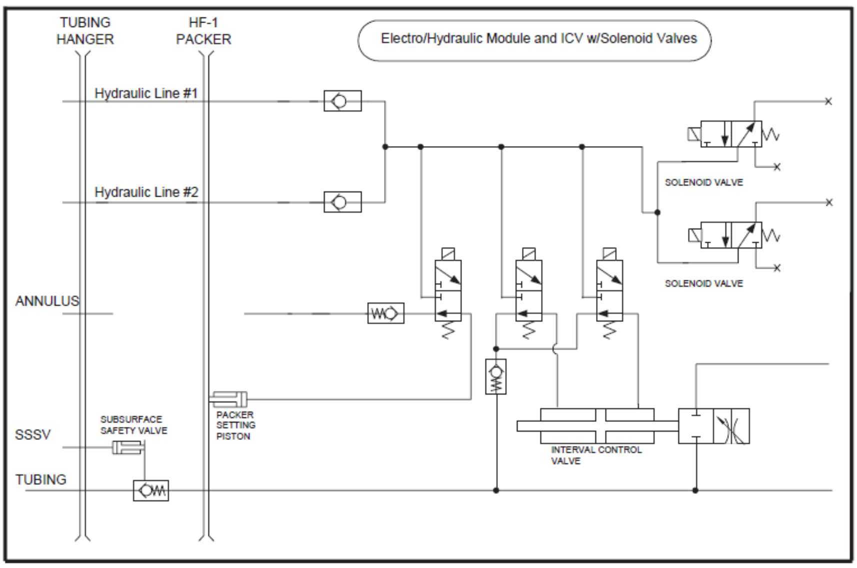

Figure 29: Electro/hydraulic module and ICV w/solenoid valves (Jackson and Tips, 2001)

The system uses an electric liner for multiplexing, and a hydraulic line(s) to provide motive force. The use of hydraulic pressure to move the valves gives a large shifting force, solving the problem which is in the all electrical system. It also gives the system larger debris tolerance, and minimizes the moving parts downhole (Shaw, 2011).

5. SELECTION BETWEEN PASSIVE (ICD) AND ACTIVE INFLOW CONTROL (ICV) COMPLETION

5.1. Framework for comparison of ICV/ICD

The application areas of ICV and ICD technologies now overlap (Gao et. al. 2007). So it can be very useful to do comparative study of ICV and ICD applications to establish a simplified screening tool (**Table 1**). It is possible for reservoir, production and completion engineers to use this screening tool when they are looking for what is the most suitable technology for a specific application.

Aspect		**ICD vs. ICV**
1. Uncertainty in Reservoir Description		**V**
2. More Flexible Development		**V**
3. Number of Controllable Zones		**D**
4. Inner Flow Diameter		**D**
5. Value of Information		**V**
6. Multilateral Wells	Control **of** Lateral	**V**
	Control **within** Lateral	**D**
7. Multiple Reservoir Management		**V**
8. Formation Permeability	High	**D**
	Medium-to-Low	**V**
9. Modelling Tool Availability		**V**
10. Long Term Equipment Reliability		**D**
11. Reservoir Isolation Barrier		**V**
12. Improved Well Clean-Up		**V**
13. Acidizing / Scale Treatment		**V**
14. Equipment Cost		**D**
15. Installation (Risk, Cost and Complexity)		**D**
16. Gas Fields		**V**

Table 1: Comparison of ICV and ICD completions (Al-Khelaiwi et al. 2010)

5.1.1. Uncertainty in reservoir description

There has been used a reservoir-engineering uncertainty-quantification methodology to demonstrate how advanced well completions can reduce the impact of geostatistical uncertainty on the production forecast (Al-Khelaiwi et al. 2010). There has been done a study by Floris et al. (2001) on eight reservoir realizations of the PUNQ-S3 reservoir. The study showed that the results were very dependent on the choice of the base case. If the degree of reservoir uncertainty is low and an optimum well trajectory is employed, an advanced completion often added little or no value. This gives that ICV is preferred when there is uncertainty in reservoir description. Al-Khelaiwi et al. (2010) did research on a well design and completion with a relatively complete knowledge of the reservoir, its geology, fluid contacts and drive mechanism. The result presented in **Figure 30**, shows a conservative estimate of the advanced completion's value.

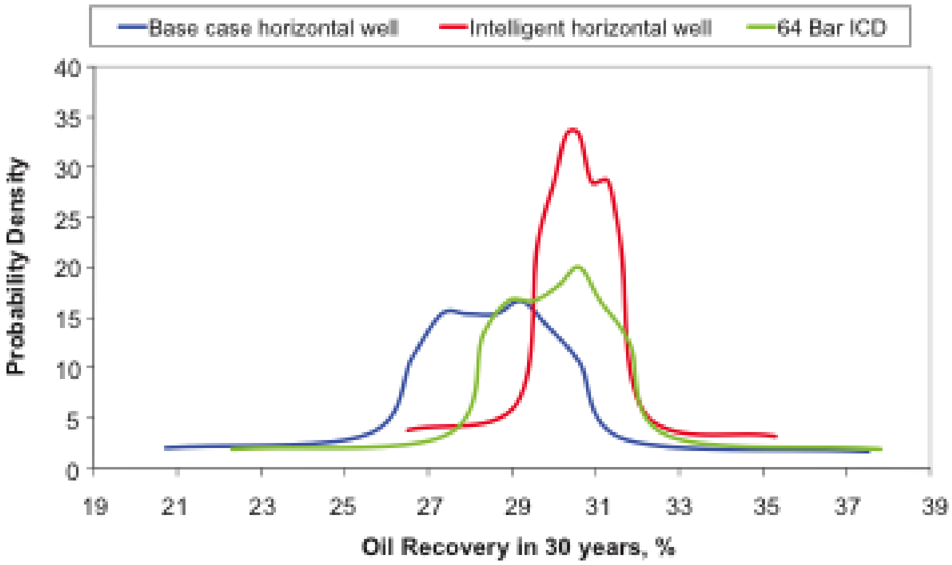

Figure 30: Impact of advanced completion on production forecast (Al-Khelaiwi et al. 2010)

The figure shows that (Al-Khelaiwi et al. 2010):

- ICD technology increased the mean recovery form 28.6 to 30.1% with a small decrease in risk (P10 through P90) form 6.3 to 5.3%.
- ICV technology further increased the mean recovery to 30.6% and reduced the risk compared to the base case by 50%.

5.1.2. More flexible development

When an ICD has been installed, there is no possibility to change the downhole flow path's diameter without intervention. But that can be done for the ICV's flow path diameter. An ICV has more degrees of freedom than an ICD, this allows for more flexible field development strategies to be employed.

<u>Reactive control based on unwanted fluid flows.</u> Compared to an ICV, an ICD's ability to react to unwanted fluids (i.e., gas and water) is limited. The difference becomes even larger when we have a multisetpoint ICV compared to an ICD. The ICVs enable the well to be produced at an optimum water or gas cut by applying the most appropriate (zonal) restrictions that maximize the total oil production with a minimum water or gas cut (Al-Khelaiwi et al. 2010).

<u>Proactive control.</u> An ICD completion employs a proactive control on the fluid displacing oil. But when the device has been installed, it is not possible to modify the restrictions that have been set before installation, at a later point to achieve an optimum oil recovery (Naus et al. 2006, Ebadi and Davies 2006, de Montleau et al. 2006). Here the ICVs, with their continuing flexibility to modify the inflow restriction, has the advantage.

Real-Time Optimization. If one is going to be able to effectively manage the reservoir sweep, it requires continuous adjustment of the production and injection profiles throughout the well's life. During the well's lift, monitoring of downhole and surface data (e.g., pressure, flow rate and temperature) is done continuously. To be able to use these data, one needs to translate this data into information. This information is used to identify if one need to adjust the fluid flow-rate into or out of a specific wellbore section. It may for example be required to frequently adjust the flow-rate, to be able to maintain the required production rate from a thin oil column or from a reservoir with declining pressure (Meum et al. 2008). Here, ICVs have the advantage.

5.1.3. Number of controllable zones

There are practical and economic limitations related to the number of ICVs that can be installed in a well. As a consequence, the zonal flow length controlled by each ICV in horizontal and highly deviated wells, are normally large. The maximum number of ICVs that has been installed in a single completion is six (Al-Khelaiwi et al. 2010). There are various electrical and hybrid electrohydraulic systems that have been developed with the capability of managing many more valves per well. But their operating-temperature limitations and high cost have excluded their widespread acceptance by the market. It will be possible to increase the maximum number of ICV controlled zones that can be installed in each well, if there comes a radical change in the current technology. Then there will be a possibility to develop a very-low-cost, reliable, single-line, electrically activated valve (Saggaf 2008).

On the other side there are no limitations on the number of ICDs which can be installed in a horizontal section. The number of ICDs installed is only limited by the number of packers, cost and/or drag forces limiting the reach of the completion string. For example, Saudi Aramco suggested installing them every 50 to 100 ft (Hembling et al. 2007). When we are in the need of many control intervals in a horizontal well, one would say that ICDs are the preferable choice. This is since an ICD completion potentially can have many more control zones compared to an ICV completion.

5.1.4. Inner flow conduit diameter

One of the main reasons for ICD installation is to reduce the heel/toe effect. When the flow is turbulent, the frictional pressure drop across a length of pipe is inversely proportional to the fifth power of its internal diameter (and to the fourth power when laminar) (Al-Khelaiwi et al. 2010). Since there is this strong dependence on flow–conduit diameter, it makes this parameter an important factor when comparing the production performance of various completion designs, in particular when we have a high-flow-rate well.

Often the ICD completion equipment is run in an open hole with dimensions the same as that of standard sand screen for that hole size. Typically the outside diameter (OD) of the flow conduit is 2 to 3 in smaller than drill-bit diameter **(Table 2).**

ICD completion	sizes			
Hole (bit) size	in.	$5^{7}/_{8}$	$7^{7}/_{8}$	$8^{1}/_{2}$ or $9^{1}/_{2}$
Max. ICD	OD, in.	$7^{1}/_{2}$	$6^{1}/_{2}$	$7^{1}/_{2}$
Flow conduit	OD, in.	$3^{1}/_{2}$	$5^{1}/_{2}$	$6^{5}/_{8}$
	ID, in.	3.0	4.9	5.9

Table 2: ICD completion sizes (Al-Khelaiwi et al. 2010).

On the other side, ICV completions can only be applied in consolidated formation, because an open annulus is required for fluid flow form the reservoir face to the valve. If the annulus collapses, the inflow to the ICV will be severely hampered. Most of the ICV completions that have been installed in cased holes, which reduces the flow-conduit diameter. There are further restrictions on the tubing size because of the need to install control line(s).

The well's PI is the factor which has the greatest influence for the ICD completion design, both the absolute value and its variation as a function of the location along the wellbore; the length of the completion; the target drawdown or production rate; and the in-situ reservoir-fluid properties (density and viscosity) (Al-Khelaiwi et al. 2010). One can estimate the optimum ICD strength [i.e., nozzle diameter or pressure-drop rating (Al-Khelaiwi and Davies 2007)] for each particular well by using "quick look" analytical formulae. Although to be able to do a complete analyse of the completion performance, it is required to use numerical well-modelling software.

The limited size of the diameter of the ICV completion's flow conduit will limit the well's production rate. This is because of its poorer outflow performance. This gives the ICD completion, which has a larger diameter of the flow conduit, an advantage in HP, high-production-rate applications, with comparable borehole sizes.

5.1.5. Value of information

Today it is possible to get real time downhole pressure, temperature and flowrate measures if electronic or fiber-optic-sensing technology is installed (Leskens et al. 2008). It is possible to get these measures for both conventional and advanced (ICD and ICV) completions. The measures can be done both outside the completion (at the sandface) and within the flow conduit. The ICV has the ability for remote-control response. The ICV can be used to get information. It gives the ability to disturb the well inflow (e.g., by closing the valve), and make it possible to identify the zonal productivity. By using an ICV completion it is possible to implement remedial measures, which are very important as real-time production optimization becomes more widespread. On the other side, the only action possible for ICD completions is to change the well's total production rate through preset surface choke. This gives ICV the advantage related to value of information.

5.1.6. Multilateral wells

When an ICV is installed in the main bore of a multilateral well, it has the ability to control the inflow from a lateral. It can balance the flows from multiple laterals or react to changes in particular laterals' performance (Haugen et al. 2006; Abduldayem et al. 2007). With the technology available today, it is not possible to install an ICV within the lateral itself.

It is not possible for ICDs to control lateral total flow rate in the same way as ICVs. But they can offer inflow control along the length of the lateral (Al Qudaihy et al. 2006). ICVs and ICDs offer different flow-control capabilities, which result in both technologies being employed in multilateral wells (Sunbul et al. 2007).

5.1.7. Multiple reservoir management (MRM)

Every day there is a focus on reducing the capital and operational expenditures for field development. That can be done by accessing multiple reservoirs form the same wellbore. It is required allocation of the field's or well's total daily production to a particular zone as well as prevention or reservoir crossflow, both by the national petroleum legislation and good reservoir-engineering practice. One of the greatest concerns where there is a significant difference in reservoir pressure between zones or formations, or when a commingled well is shut in, is reservoir crossflow.

There are several advantages of MRM, these are (Al-Khelaiwi et al. 2010):

- Optimal sequential production (Akram et al. 2001).
- Commingled production through a single wellbore (Jackson Nielsen et al. 2002; Skilbrei et al. 2003; Lehle and Bilberry 2003; Dolle et al. 2005).
- Controlled fluid transfer between layers for sweep improvement or pressure support (Lau et al. 2001).
- In-situ auto gas lift (Betancourt et al. 2002; Al-Kasim et al. 2002; Clarke et al. 2006; Jin et al. 2005).
- Prevention of crossflow between reservoirs during preiods of well shut-in or low production rate. Such crossflow can damage reservoirs because of incompatibility of fluids or changing the fluid-saturation levels of the rock. There may also be a possibility for a loss of reserves to low-pressure reservoirs.

The advantages above have already been achieved in the field (Akram et al. 2001; Jakson Nielsen et al. 2002; Skilbrei et al. 2003; Lehle et al. 2003; Dolle et al. 2005, Lau et al. 2001; Betancourt et al. 2002; Al-Kasim et al. 2002; Clarke et al. 2006; Jin et al. 2005) with ICV completions. The benefits of ICD MRM are still to be confirmed, but there have been made publications from Zaikin et al. (2008). ICD has the capability to limit crossflow under flowing conditions, but have problem with preventing crossflow between reservoirs under shut-in conditions. ICVs provide a greater flexibility to handle changing well and reservoir behavior, which gives it an advantage in MRM compared to ICDs.

5.1.8. Formation permeability

To be able to efficiently manage or balance the distribution of reservoir inflow from a long wellbore section, the pressure drop across the ICD must be greater than or similar to the reservoir drawdown pressure. There have been published ICD applications that show that ICDs mainly have been applied to reservoirs with an average permeability of 1 darcy or greater **(Table 3)**.

PUBLISHED ICD FIELD APPLICATIONS*			
Well Type	Field	Permeability	Challenge
P	Troll	6 D	Gas
P	Grane	7 D	Gas
P	Zuluf	3.5 D	Water
P	Ringhorne	> 1 D	Water and gas
P	Chayvo	> 1 D	Water and gas
P	Etame	1.8 D	Water
P	Emlichheim	1-10 D	Water
P	West Brae	6 D	Water and gas
I	Urd J-1H	0.1-2.5 D	Water
P	Komsomolskoe	21 mD	Water
P	Vankorskoe	10, 150, 550 mD	Water and gas
P	Simsima	> 100 mD	Water
P	Shaybah-257	10-200 mD	Gas

* Zaikin et al. 2008 (41); Salamy et al. 2006 (42); Murison et al. 2006 (45); El-Abd et al. 2008 (64)

Table 3: Published ICD field applications (Al-Khelaiwi et al. 2010).

In these reservoirs the drawdown pressures are typically low, and the flow rates are high, thus the ICDs have the ability to balance inflow efficiently without impacting the productivity significantly. There are some exceptions to this trend in the ICD application:

- ICDs delay gas and water breakthrough by minimizing the dominance of the more-productive intervals in layered, heterogeneous reservoirs (Zaikin et al. 2008).
- ICDs encourage matrix production in fractured reservoirs and minimize production from fractures (El-Abd et al. 2008).
- ICDs can reduce the production of free gas from the gas cap in thin-oil-column reservoirs (Salamy et al. 2006).

When we have low permeability (LP) reservoirs, there will be an extra pressure drop across the ICD, which will reduce the well's PI or injectivity index significantly throughout the whole life of the well. When the permeability of the reservoir decrease the reduction described above will become less acceptable. For effective equalization the ICD must generate a high pressure drop and be robust enough to withstand both the high pressure drop, and possibly, a high flow velocity throughout the well's active life. There will be a reduction in the inflow equalization by any erosion of the ICD restriction that may occur. One can expect erosion to occur at higher permeability zones in heterogeneous formations. This is because of their higher production potential and reduced formation strengths. But with the right equipment design and proper choice of construction materials it is expected that this concern will mitigate.

When one have an ICV application in MP or LP reservoirs it does not require such large reduction in the well's injectivity or productivity. The ICVs are able to operate with static pressure of 690 bar and an unloading pressure of 240 bar (Al-Khelaiwi et al. 2010). On the other side, during long-term operation at pressure differentials greater than 100 bar there may be significant erosion. Use of a two-position ICV (open/close) can reduce the risk of erosion significantly; while one still can achieve near-optimum hydrocarbon recovery in some circumstances (Zandviliet et al. 2007). The reservoir permeability is a very important parameter. The parameter need to be considered both when making the choice between an ICV or ICD completion, and when the selection of the optimum type of ICV or ICD to be installed are done. Impact of reservoir permeability on the choice between ICV and ICD are presented in **Table 4.**

FORMATION-PERMEABILITY ROLE IN THE CHOICE BETWEEN ICV AND ICD			
		ICD	ICV
Prolific reservoirs	Oil producer	Prevents early water and gas breakthrough (+)	Similar to ICD (+) but small tubing size restricts production or injection rate.
	Gas/water injector	Equalizes injection profile (+)	Can be mitigated by drilling larger hole (-)
Medium- and low-permeability reservoirs	Oil producer	Reduces gas-liquid ratio (+) Water cut not reduced (-)	Reduces both GLR and water cut (+)
	Gas/water injector	1. Suitable for gas injection 2. Application for water injection requires larger injection pressure to overcome ICD pressure loss (-) and erosion resistant ICD design (-).	Small tubing size important if injection rate is high (-)

Table 4: Formation permeability role in the choice between ICV and ICD (Al-Khelaiwi et al. 2010).

The result will then be that both ICVs and ICDs are able of equalizing the inflow from heterogeneous reservoirs. But the use of ICD in LP reservoirs reduces the well productivity, which the ICV don't. To make the proper selection between ICVs and ICDs there must simultaneously be done analysis of parameters along with formation permeability. So there should be done analyses of the fluid phases and the productivity variations.

5.1.9. *Modelling tool available*

Most of the current available reservoir simulators such as CMG™, POWERS™, NEXUS-VIP™ and EM^{POWER}™ are able to model downhole-flow-control devices. These devices can act either as ICDs or ICVs (Holmes et al. 1998; Ho-Jeen and Dogru 2009; Wan et al. 2008). All these models divide the wellbore into a number of segments that represent sections of the tubing, annulus and/or flow-control devices. The connection between the segments resemble a "trunk-and-branch" architecture, that means flow from one or more segments always converges to a single segment in the topmost segment (Al-Khelaiwi et al. 2010).

This modelling technique is well suited for modelling ICVs properly, but there is limited suitability for ICD completions. The reason for this is the reservoir simulators inability to model nodes with divergent fluid flow (i.e., splitting the looping flow between the annulus and the ICD). Or the inability to model annular flow that occurs unless annular flow isolation is installed in the annular space between the formation and the ICD at every ICD point, unless the annulus is packed with collapsed formation sand or gravel. The trunk-and-branch modelling is not able to capture the early, post-breakthrough well performance of an ICD completion. The only way we can model the annular flow is by software with algorithms that can emulate splitting and rejoining (or looping) flow paths. Today the software available for this is Eclipse 2008™ and Reveal 7.0™ and network modelling software, NETool™ and GAP™ (Ouyang and Huang 2005; Al-Kelaiwi and Davies, 2007). When using the network modelling software, one need to couple it to a reservoir simulator to be able to capture the complete, dynamic performance of the completion at all the stages of the well's life.

Since there are limitations to the modelling-tool availability to model ICDs, the ICVs have an advantage.

5.1.10. Long-term equipment reliability

When one is going to evaluate the ICD reliability, it can be done in terms of erosion and plugging of the ICD flow restriction. On the other side, the evaluation of ICV reliability is more complex. There are also a large difference in the flow rates that are controlled by ICVs and ICDs. The ICDs are designed to control much lower flow rates compared to the ICVs.

To define ICV reliability it is common to discuss it in terms of the "system" and the "mission" reliability (Matheson et al. 2003; Drakely et al. 2001; Ajayi et al. 2005; Aggrey et al. 2006). As mentioned in the start, the ICV system consists of five main components: surface-control equipment, control lines, connectors, gauges to monitor the flow, and the valve itself. Then again all these different components consist of several subcomponents. Looking at a hydraulically operated ICV, this ICV consists of subcomponents as; a moving sleeve or ball containing the valve-opening trim, a stationary housing and a hydraulic chamber to translate the hydraulic pulses into mechanical movement of the valve (Al-Khelaiwi et al., 2008). If there is a failure to one of the five main components or on one of their subcomponents, it is considered a system failure. On the other side, the ICV is a part of a much larger well or field infrastructure. If external components as a packer or a gravel packer fail, the ICV will be unable to achieve its objective. Such a failure is called a mission failure (Matheson et al. 2003; Drakely et al. 2001; Ajayi et al. 2005). The problem of the ICVs today is still the reliability issue. If one component fails, the system will not work.

One can also apply this concept of mission and system failure to ICD completions. If failure of the ICD's flow restriction is caused by erosion or plugging, it would be considered a system failure, because this is the ICD's main component. There will be a mission failure if there is a failure on a gravel pack, SAS, or annular-flow isolation in conjunction with ICDs.

5 years after the introduction of ICD technology, there were observed the long-term benefits of the ICD completion installed on the Troll –West oil rim. The observation was done by a 4D seismic survey conducted in 2003. It was indicated by the survey that the wells couplet with ICDs was able to maintain excellent equalization of the approaching gas front (Madsen and Abtahi 2005; Bertrand et al. 2005; Jones et al. 2008), despite that the wells had been

producing at critical flow rates with a high gas/oil ratio. If there had been erosion of the helical, channel-type IDCs, it would be expected to result in high gas concentrations, and that would have been detected by the seismic survey. Plugging of ICD can be caused by sand, scale or asphaltene deposition. To reduce the potential of plugging of ICDs caused by sand, it is common to use SAS or gravel packs. When using these completions, one can prevent production of those sand particles that are large enough to plug the ICD's flow restriction. There can also be introduced a minimum flow-restriction diameter into the ICD design process, to minimize the plugging risk if the sand-control measures fail (Al-Khelaiwi et al. 2010). To prevent scaling and asphaltene plugging, it need to be treated with chemicals because it is not possible to hold it back mechanically. There has not been reported any plugging of ICD to date, but screen plugging is a frequently observed problem in sand-control completions (Tronvoll and Sønstebø 1997; Arukhe et al. 2005).

There can be a failure of the ICV to maintain the desired pressure drop caused by erosion of the ICV trim or shroud. The ICV trim design can be modified to minimize such erosion effects (McCasland et al. 2004; Barrilleaux and Boyd 2008; Bussear and Barrilleaux 2004). It is possible to minimize partial or complete plugging of an ICV because of deposition of scale or asphaltene, by regularly cycle through the different valve settings. Detection of inability to adjust the valve to a desired position is a clear sign of ICV system failure. When the industry report ICV-reliability data they are not able to distinguish between failures of the actual valve, or from any other component that make up the actuation system. ICVs actuated hydraulically have a higher reliability than electrically actuated or electrohydraulic ICVs (Ajayi et al. 2005). Statoil have reported a mission-failure rate (including system failures) of 25% on the early systems installed in the Snorre A and B platform (Skarsholt et al. 2005). Later there has been reported a system failure rate of 39% for 36 valves installed in the Snorre B (Kulkarni et al. 2007). On the other side, more-recent ICV installations have given increased ICV system reliability. Shell (de Best and van den Berg 2006) have reported a doubling of number of valves installed between 2003 and 2006. As shown in **Figure 31** there has only been a limited increase in the number of failures.

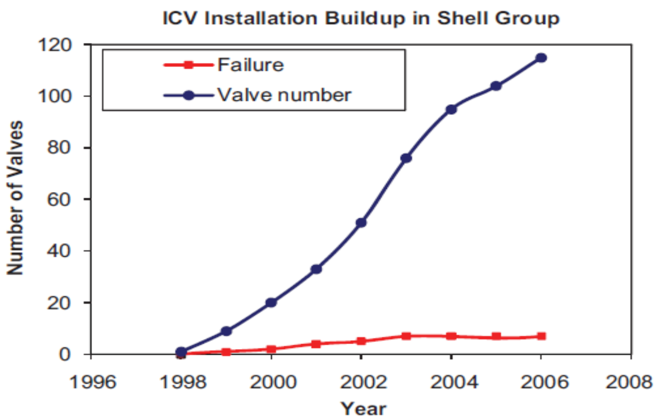

Figure 31: ICV reliability statistics for all-hydraulic systems (de Best and van den Berg 2006).

Despite the improvement of ICV systems in more resent time, the simple design of an ICD with a reduced risk of failure, have an advantage over the more complex ICV. The impact of failure of an ICV valve has much larger impact on the well performance, than compared to failure of a single ICD.

5.1.11. Reservoir isolation barrier

During intervention operations (e.g., for removal of the wellhead) an ICV is accepted as a reservoir-isolation barrier (Stair et al. 2004a), achieving reduced rig time and well intervention costs. Recently, ICDs has been combined with a hydromechanical valve system, giving the ability to isolate the flow path between the screen and the ICD. This can be used to isolate the formation temporarily after the initial completion installation (Coronado et al. 2008). Despite the recent development of ICD combined with a hydromechanical valve, ICV has the advantage for isolating the fluid in the inner tubing string, and provides a two-way, flow isolation barrier (Al-Khelaiwi et al. 2010).

5.1.12. Improved well cleanup

When there is done drilling workover it can cause formation damage, and possibly affect the well performance significantly (Suryanarayana et al. 2007; Ding and Renard 2003; Ding et al. 2002; Ding et al. 2001). Drilling of long horizontal and multilateral wells, crossing heterogeneous, possibly multiple reservoirs often show greater formation damage than conventional wells. This is because the increased exposure time of the drilling and completion fluid in addition to the greater overbalanced pressure often applied during drilling of such wells (Al-Khelaiwi et al. 2010). The increased formation damages, requires more efficiently cleanup processes. The differential pressure between the heel and the toe in a long horizontal well makes it difficult to remove mudcake and invaded-fluid from the toe. Further, the permeability variation along the wellbore will play an important role in the cleanup process. There may be differences in cleanup, which is caused by partial cleaning of the mudcake. ICV has the possibility to control the contribution from a section, and the possibility to open and close individual zones, allowing the application of maximum allowable drawdown per zone. As a result, each zone is being properly cleaned up. The ICV gauges can be used to report the cleanup efficiency of a given zone, before opening a new zone.

The ICDs equalize the inflow contribution, making the LP and HPe sections behave in a similar manner. This helps to “lift off” the filter cake from long wellbore sections, and allow faster flowback of the invaded fluid (Al-Khelaiwi et al. 2010). For the possibility to achieve the “lift off”, must assume that sufficient pressure drop can be generated to lift off the filter cake. When producing the ICD completed wellbore at low flow rates, there may not be provided sufficient cleanup (Raffn et al. 2008). When a high filter-cake-liftoff pressure is required, ICVs have the advantage.

5.1.13. Acidizing/scale treatment

Acid stimulation is a standard treatment for reducing near-wellbore formation damage that has been caused by drilling, completion, injection or production processes (Al-Khelaiwi et al. 2010). The placement of the acid is a key factor in the success of matrix acidizing. However, the placement of the acid becomes more difficult with increased completion length and complexity, and greater permeability variations along the wellbore.

ICVs can contribute to reduce costs (Bellarby et al. 2003; Kavle et al. 2006) by eliminating the need for coiled tubing, and give the ability to stimulate only a single zone or lateral of a multizone completion. Uniform placement of the treatment fluid is achieved from the equalization effect by ICDs. When there is an individual reservoir, ICDs have the advantage in matrix-acidizing treatments compared to ICVs. Even though, the advantage from the ICD is not completely risk free. There might be a possibility for plugging of the ICD flow restriction by debris released by the acid from the tubing wall and carried to the ICD during the treatment. There can also be a problem with spent acid that flows back into the well, carrying formation solids and/or emulsions (Al-Khelaiwi et al. 2010).

Compared to ICDs, ICVs have a much wider range of applications.

5.1.14. Equipment cost

When the choice is done on what advanced-well-completion equipment to install, purchase, installation, and operation costs play a very important role. The cost may vary greatly from well to well, depending on the well location, surface and downhole environments, produced-fluid compositions, and installation risks. An ICV completion is a much more complex system compared to an ICD completion. Since the ICVs and ICDs are not installed only by their self, they are a part of a larger completion; it makes it unreasonable to compare the cost of a single ICD joint with an ICV. Generally it can be assumed that an ICV has higher cost compared to most ICD completions, because of its added functionality. This shows that ICDs have the advantage when one is evaluating equipment cost.

5.1.15. Installation (risk, cost and complexity)

Risks related to the installation of ICV and ICD completions may vary greatly.

Risks of ICD completion include (Al-Khelaiwi et al. 2010):

- Completion string may be stuck before reaching the intended depth. If a variable ICD flow restriction design, packers or blanck pipe is included in the completion design, the risk of stuck string is of particular concern.
- Plugging or damaged screens or ICD flow restriction. One can avoid this risk by using the industry’s standard installation procedures for SAS. Examples of such a procedure are special treatment of the completion fluid and aggressive cleaning of the drilled hole.

- The external packer may fail to set. To solve the packer setting risk it has been used self-energizing, “swell” packers.

Installation of ICVs requires specially trained personnel and dedicated handling procedures to cope with the complex installation process. The valve itself is not a problem to handle; it is the installation of the integrated control and monitoring system which is the challenge. It is a challenging task to mount the valve and gauges at the right locations and clamping the control lines to the tubing string together with the necessary multiple packer feed-throughs and it need to be handled with great care (Al-Khelaiwi et al. 2010). Risks involved with an ICV completion:

- Damage to the ICV system components
- Improper coupling of hydraulic or electric lines. If this should happen, it may lead to complete or partial loss of the ICV monitoring and/or control system data transmission.
- Fishing operation is required to retrieve the tubing string if the isolation packer is set to early.

There should be done a detailed risk analysis before the installation of both ICVs and ICDs. The installation process for ICDs is clearly simpler and more reliable than the installation process for ICVs. This is due to the many factors besides the ICV valve itself that plays an important role.

5.1.16. Gas fields

All the above points are related to comparison of ICVs and ICDs in oil fields. When looking at gas reservoirs, the situation changes as the ICD flow restriction favours liquids to gas due to their high volumetric flow rates (Al-Khelaiwi et al. 2010). So, if there is a gas producing well with water coning or other forms of significant water production issues, ICDs should not be used. The ICD completion would then choke the gas production, and encourage water production, which is not preferable. Applying ICDs to a dry gas field, where the wish is to equalize the inflow from multiple zones with different productivity is no problem. However, before implementing such a completion the existence of isolation barriers between the zones to eliminate gas crossflow between choked zones, and the potential to greater erosion potential of the ICD flow restrictions should for example be examined (Al-Khelaiwi et al. 2008). Overall, ICV is the preferred choice for gas wells.

6. ECONOMICAL CONSIDERATION

Typical intelligent well business drivers are shown in **Figure 32.** The figure show that increased ultimate recovery has the highest relative business value.

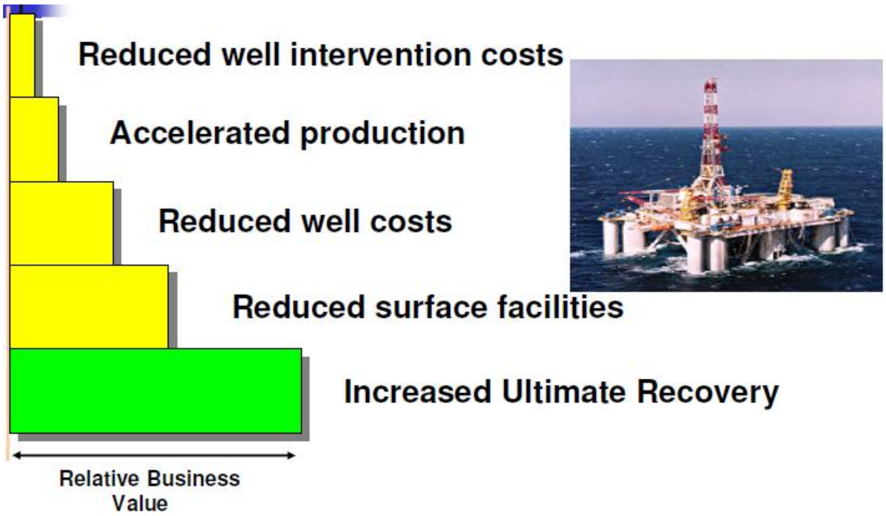

Figure 32: Typical Intelligent Well Business drivers

Increased ultimate recovery is seen as the most important factor from a social perspective. If this should be reached, it would demand a very long time horizon. Most often the industry looks at accelerated production as the most important factor. This is because the industries are interested in creating best possible value now, and drain the reservoir in the best possible way. There are evaluations that need to be done continuously by the industry in how to produce the best possible results.

When evaluating the economical aspect, ICD completions will normally be less expensive compared to ICV completion, as described in section 5.1.14. But when deciding which completion to apply, the whole picture needs to be evaluated. This means that the total reservoir picture needs to be understood to make the best completion choice.

7. ANALSIS METHOD

In this thesis NETool is used to analyse the well behaviour. NETool is a commercially available well completion planning and modelling simulator (Ouyang et al. 2006). NETool models production fluids flowing from the reservoir, through the well completion into a wellbore. By investigating the result from the modelling, it is possible to indicate the best placement of the well, and the best completion for optimal recovery.

When using NETool it is possible to import reservoir properties from for example Eclipse, use values from integrated tables, or manually enter the values. It is possible to examine everything from traditional well completion to more complex reservoirs, allowing computing of multiphase flow from the reservoir through the well completion, into the wellbore and up to the wellhead (Ouyang et al. 2006). Flow from the near wellbore nodes (i.e. reservoir gridblocks) into the well completion is represented by a specified number of nodes. The nodes can be connected in a number of different ways to simulate flow through any completion equipment (ex. ICVs), through the annular space, or through the tubing. By using NETool it is possible to calculate the steady state oil, water and gas production rates, and the production profile along the length of the horizontal wellbore.

There are different completion scenarios available, some of them are openhole, perforated cement liner, blank pipe, slotted liner, wire-wrapped screen and gravel pack. NETool also have the ability to predict the performance of intelligent well completions containing ICDs and ICVs. The ICDs and ICVs can be implemented both in horizontal wells and multilateral wells. When looking at multilateral wells, NETool are able to compute the contribution from each lateral, making it possible to examine what is the best production solution.

The way inflow of oil, water and gas is modeled in NETool (stand-alone version) is based on productivity models. The most basic PI model is: Q = PI × ΔP (NETooleTM Technical Manual). There is created a local Productivity Index ("PI") based on upscaling: PI = M × T, where M = mobility of a fluid phase, and T = transmissibility of the flow geometry and formation.

For a horizontal well, which is discussed in this thesis, the PI model used is The Joshi model (**Figure 33)**.

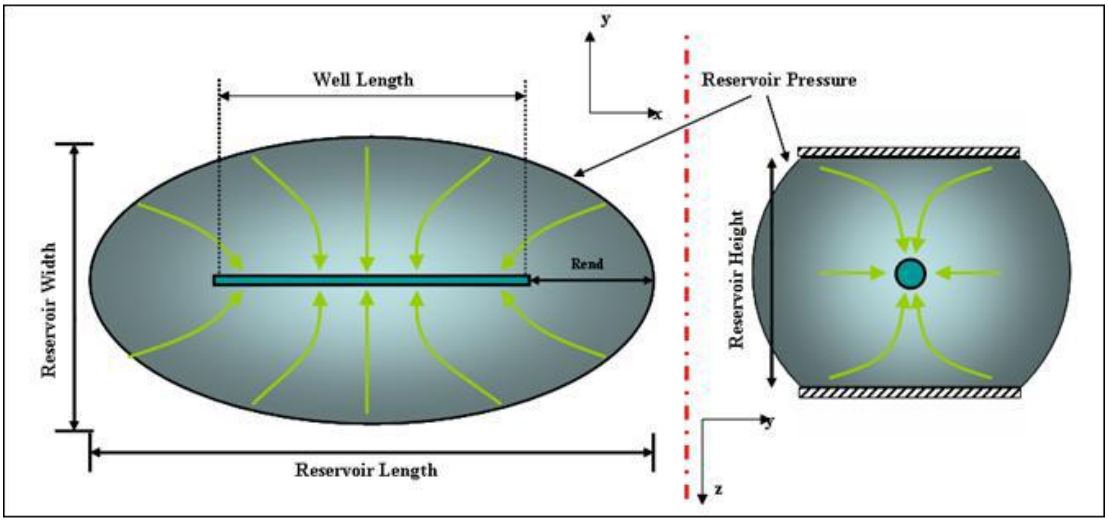

Figure 33: The Joshi PI model for horizontal wells (NETool™ Technical Manual)

The Joshi model is based on a solution where 3D flow problem is subdivided into two 2-D flow problems that then are added. How the problem is divided into two 2D problems is shown in **Figure 33**.

8. NODAL ANALYSIS

8.1. Analysis target

The analysis part will examine the influence ICVs and ICDs will have on the well behaviour. A multilateral well will be the focus of the analysis (see description on what a multilateral well is in section 1.4.). I will examine how the production is by looking at three different scenarios; a conventional well, well with only ICDs, and well with only ICVs. There will be carried out a comparison of the conventional well completion vs. well completion with ICDs, and conventional well completion vs. well completion with ICVs. The analysis will be carried out in NETool. NETool setting used for the entire analysis is shown in appendix **A.1**. The well completion used in NETool for the analysis is shown in appendix **A.2**. In the calculations that are carried out by NETool there are many factors influencing the result; what happens above the production packer will also influence the final results.

8.2. Well case

A graphic illustration of the well trajectory used for the analysis is presented in **Figure 34**. Data for the well trajectory is presented in appendix **A.3**.

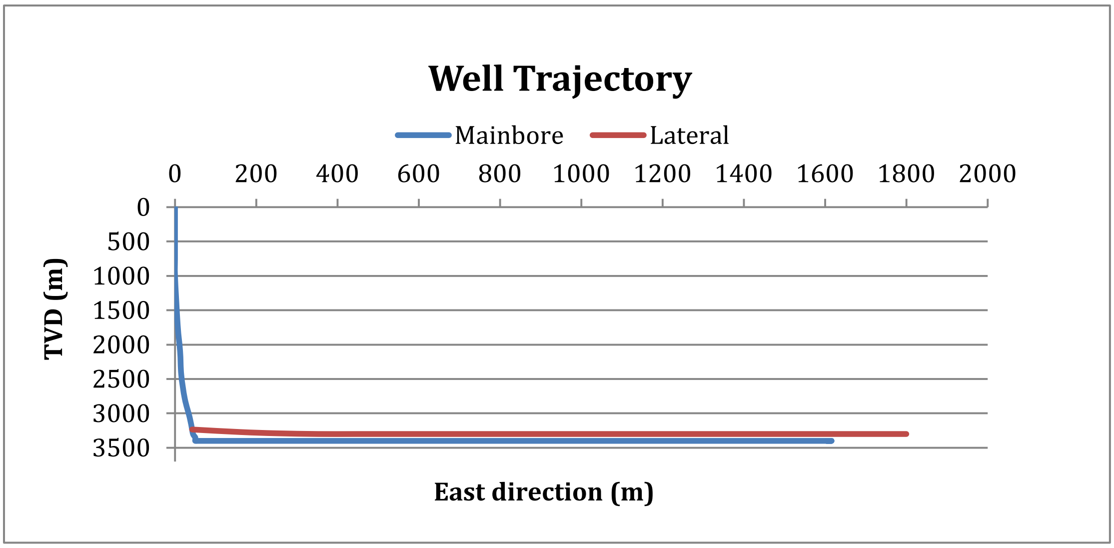

Figure 34: Graphic illustration of the well trajectory analysed in the thesis.

Mainbore has a depth of 3400 meters, and the lateral is placed on 3300 meters depth. This gives a distance between the well in vertical depth of 100 meters.

Figure 35 shows the well path from a birds-eye view. The lateral is not placed right above mainbore. Mainbore has its end point 387 meters north and 1600 meters east. The lateral has its end point 280 meters north and 1800 meters east.

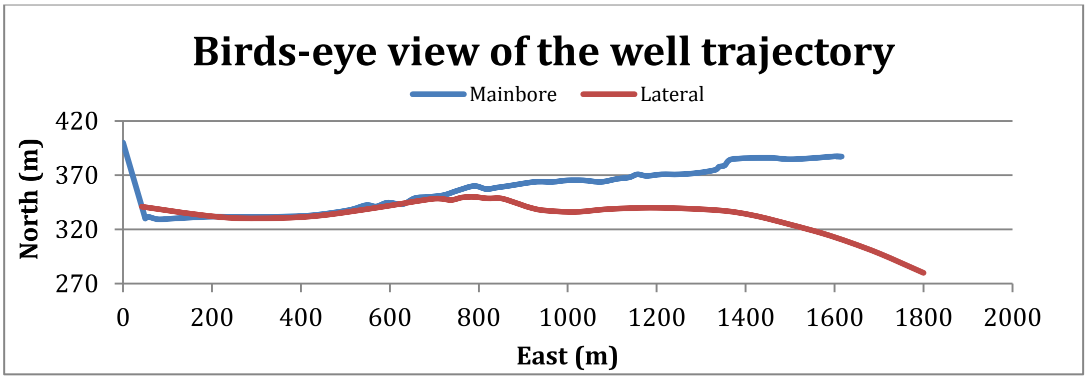

Figure 35: Well trajectory seen from a birds-eye view.

Figure 36 shows an illustration of a typical development for a producing field/well. In the start most of the produced liquid will normally be oil. As the time goes by, more and more water will be produced. Production will stop when it is no longer economical to produce from the field.

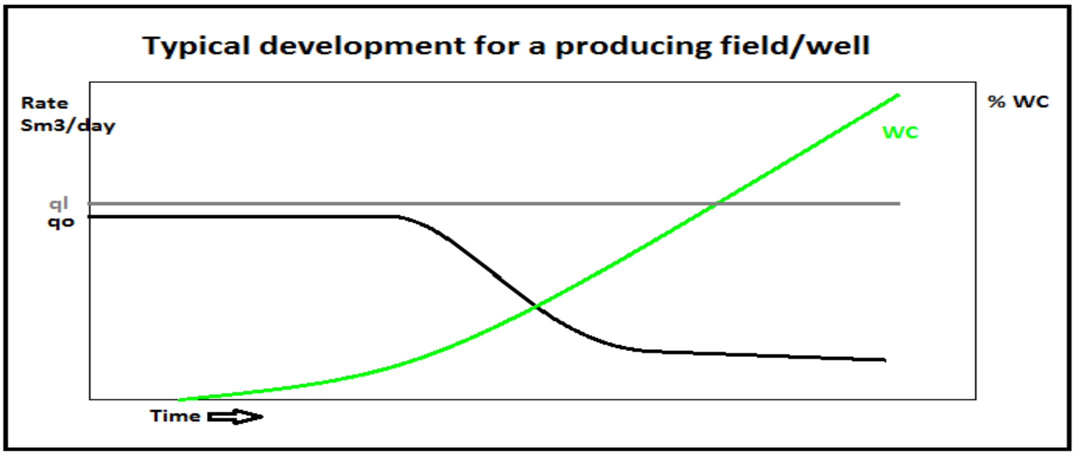

Figure 36: An illustration of a typical development for a producing field/well.

Fig. 37, 38, 39, 40 and 41 illustrates how Sw is changing during the wells life.

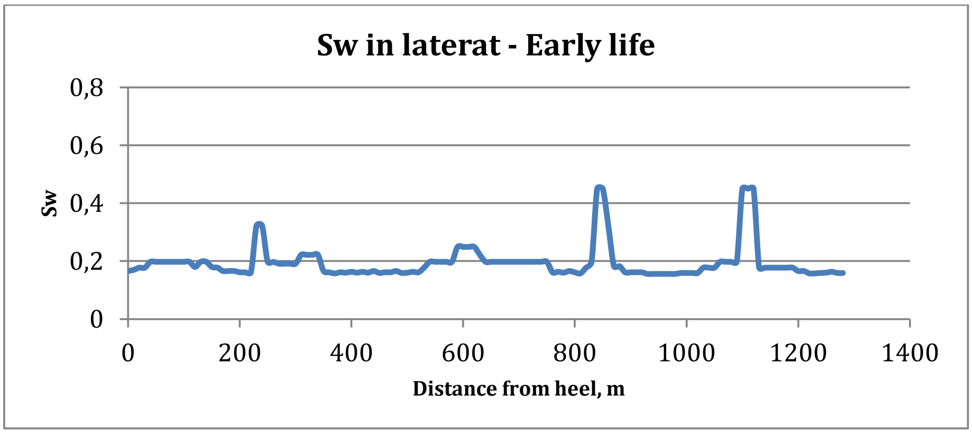

Fig. 37: Sw in the lateral at the early lifetime of the well.

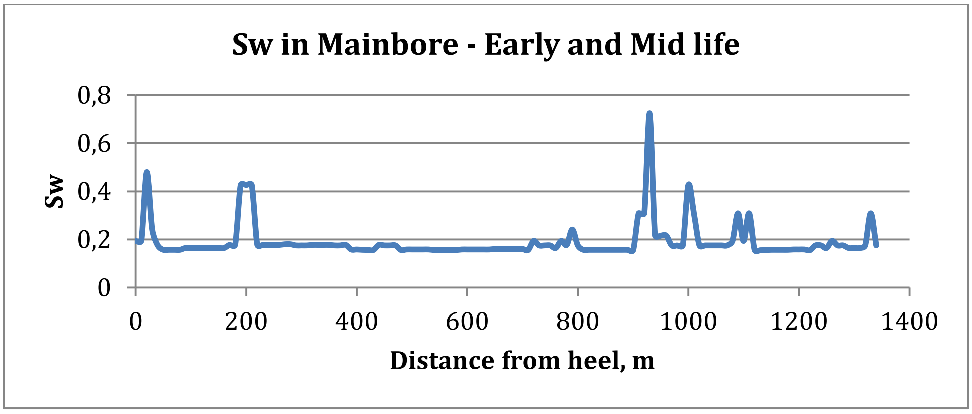

Fig. 38: Sw in mainbore at early and mid-lifetime of the well.

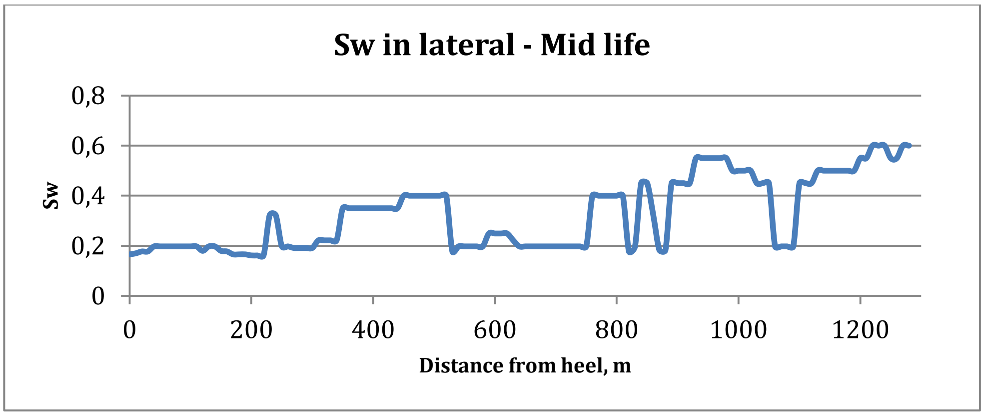

Fig. 39: Sw in the lateral at mid-lifetime of the well.

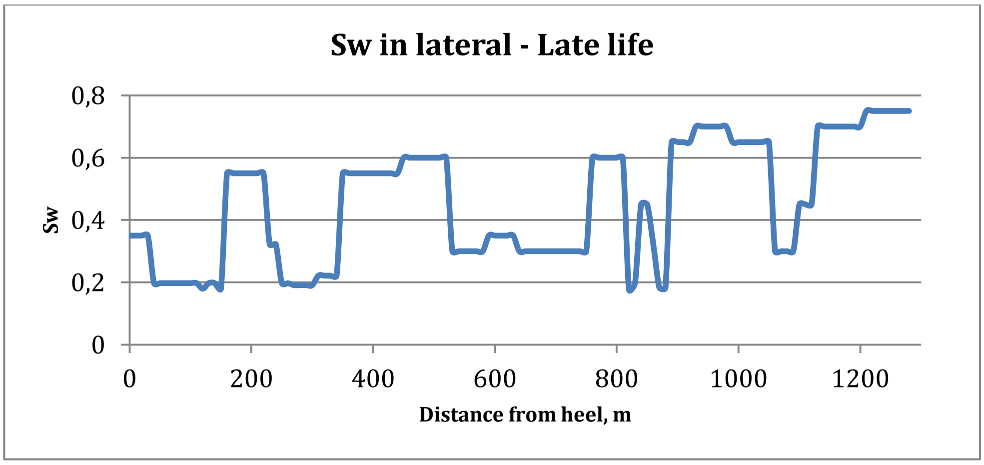

Fig. 40: Sw in the lateral at late lifetime of the well

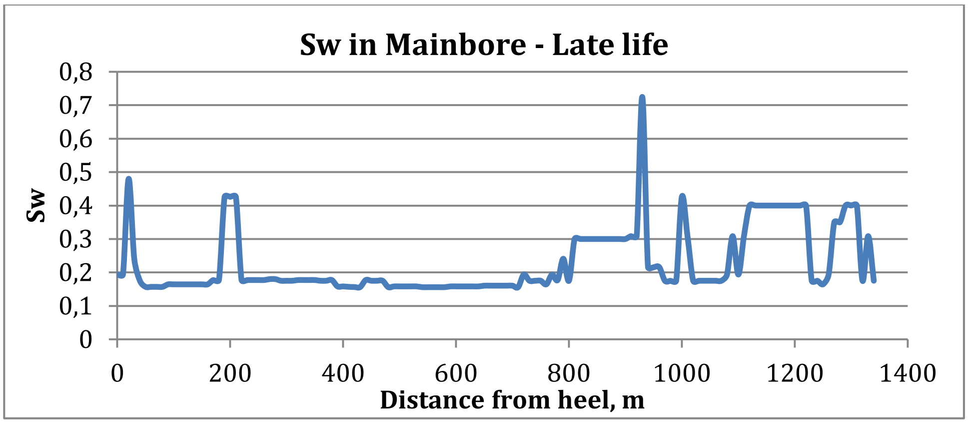

Fig. 41: Sw in mainbore at late lifetime of the well

As seen from the figures above, Sw in the lateral is changing during all of the three stages. Sw in mainbore was the same in early-, and mid-life, but changed a little bit in the late life of the well

In my case I have looked at two different scenarios:

- Have compared a conventional well completion with a well completed with ICDs.

Figure 42 shows an illustration of the conventional well case, and **figure 43** shows the design of the ICD completion.

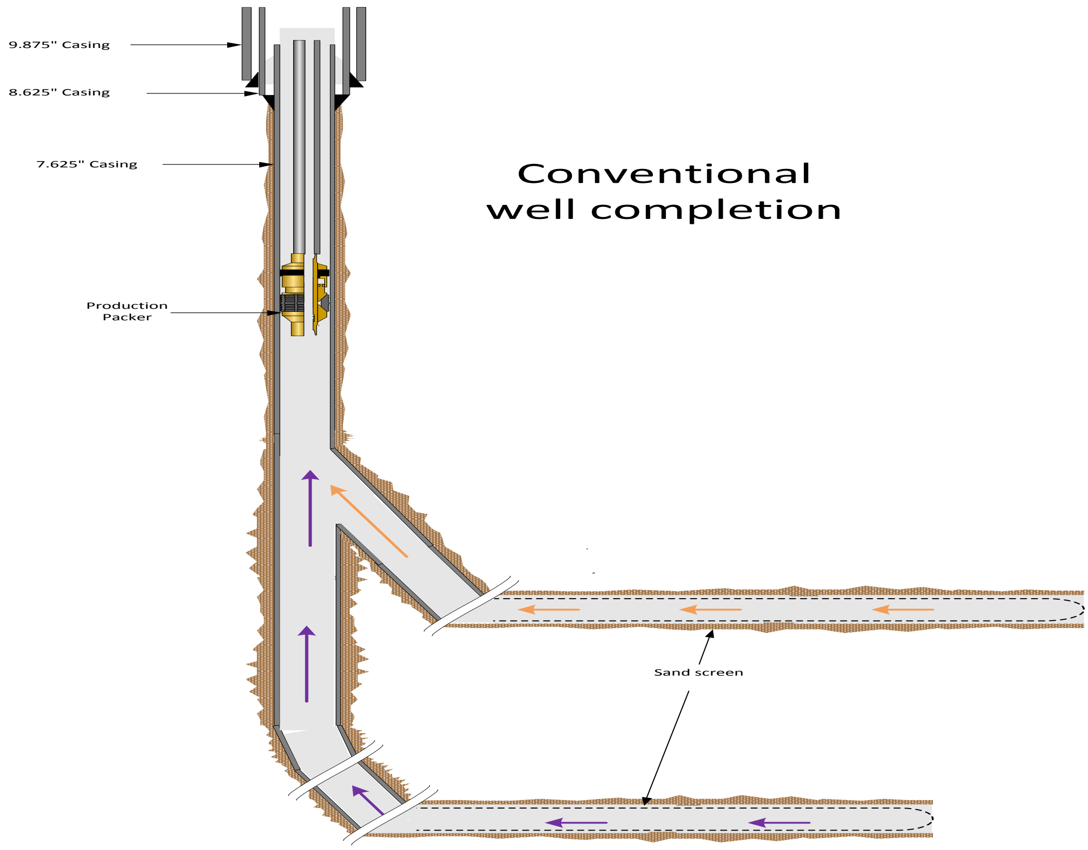

Figure 42: Completion drawing of a conventional well.

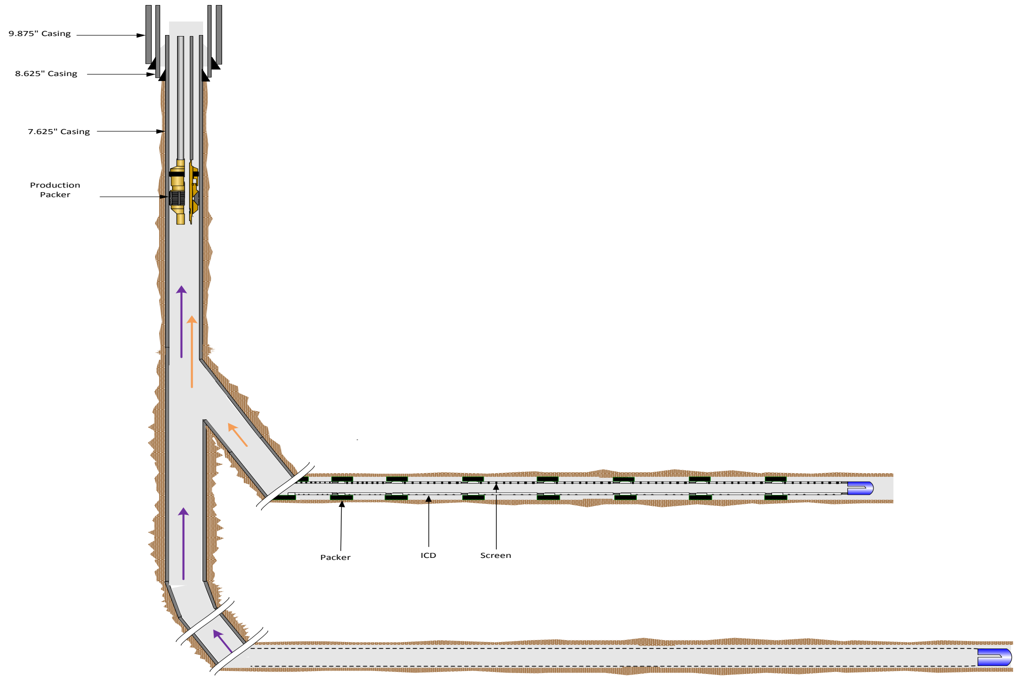

Figure 43: Completion drawing of well with ICDs.

When the pipe size is chosen for the analysis, we need to take into account the dimension of the ICDs with screens. When the screen is mounted on the ICD, the OD gets larger. It is important that the tool fits in the completion.

When doing the analysis with NETool, several ICD configurations and scenarios should be investigated. By investigating different configurations and scenarios the optimal completion solution can be found. It is important to determine the optimal location of the ICD along the particular reservoir, nozzle size, how many nozzles there should be, and to determin if there should be any zonal isolation. NETool is also used to determine how many ICDs that should be in the completion. There will not be any purpose in placing ICDs in a low permeability zone. Then the ICDs would restrain a flow which rather should be produced. This will not be examined in the analysis done in this thesis, since it is outside the scope of the thesis. The target of the analysis is to examine produced fluid in an ICD completion, compared to produced fluid from a conventional well.

To illustrate the effect of ICDs, varying permeability is introduced along the wellbore that have contact with the reservoir. If the permeability had been constant along the reservoir, ICDs would not have made any particular difference. The same permeability has been used in the ICV analysis part. ICDs are only placed in the lateral, because it is assumed that is where the water problem is. It is not necessary to complete mainbore with ICDs, when it is expected to produce mainly oil. If ICDs had been used in both the lateral and mainbore, it would have restrained the oil flow when it was not necessary.

Figure 44 shows a synthetic log of the permeability variations along the horizontal section of mainbore.

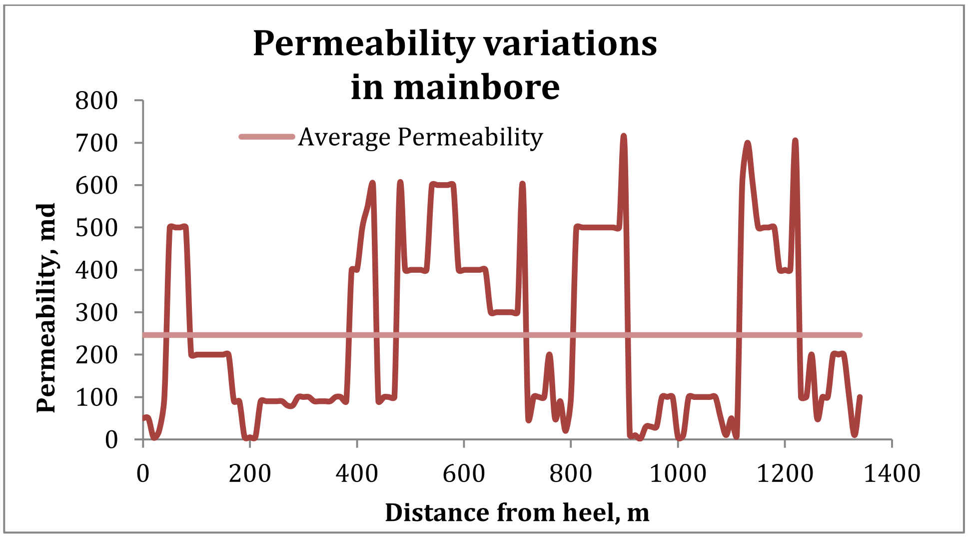

Figure 44: Permeability variations along the horizontal section of mainbore.

In the high permeability zones there is clean sand, and in the zones with low permeability there might be a mixture of clay and sand. There are also points with very low permeability; here we can find tight shale. The fluid will flow more easily through the high permeability zones. And in the low permeability there will be very little fluid flow.

From **Figure 44** we can see that there is a short high permeability zone near the toe, followed by about 200m of low permeability. In the middle we have a relatively large high permeability (sand) zone about 500 – 750m from the toe. From 900 – 1100m there is a tight zone.

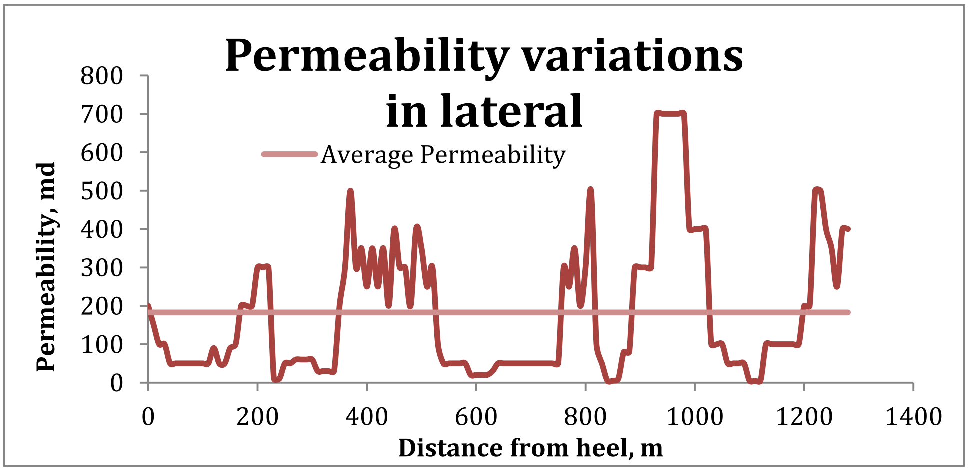

Figure 45: Permeability variation along the horizontal section of the lateral.

In the lateral there is high permeability 300 – 550m, 750-850m and 900- 1050m from the toe (**Figure 45**). Permeability and Sw data are found in appendix **A.4**, and are the same for the analysis with the conventional well completion, completion with ICDs and completion with ICVs.

- Will also compare a conventional well completion with a well completed with ICVs. Have used the same well trajectory and water permeability settings as for the first case. Have looked at a case where we are in early life; mid-life; and late life to illustrate how the optimal positioning of the valve may change. The design of the ICV completion is shown in **Figure 46**.

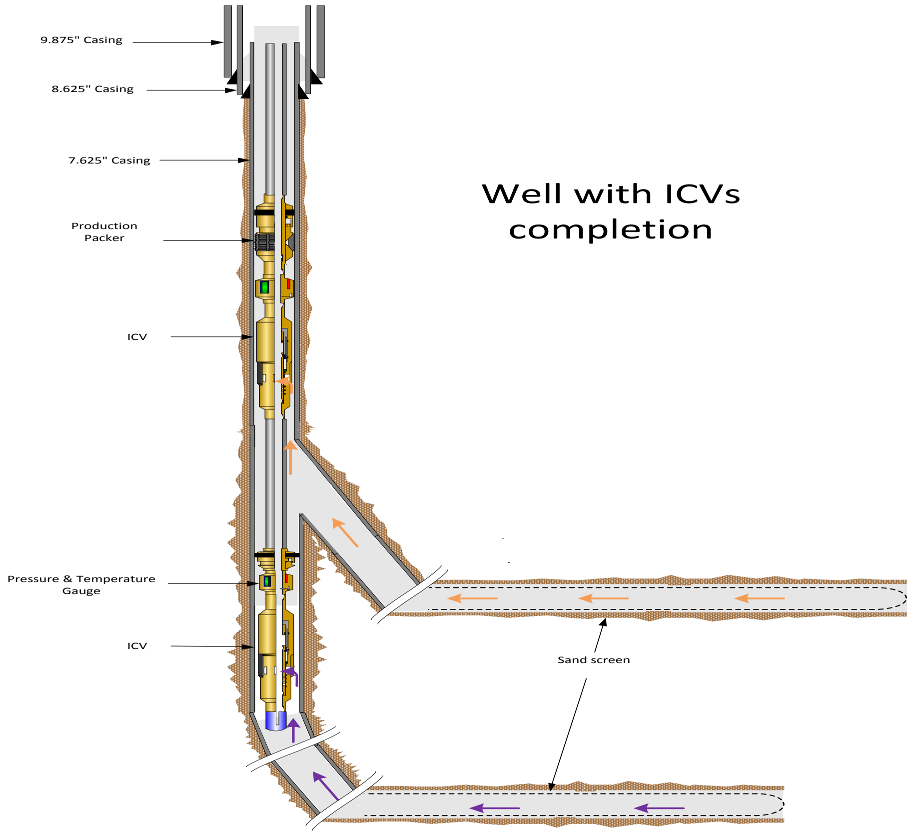

Figure 46: Completion drawing of well with ICVs.

8.3. Cv value

The Cv value describes the flow characteristics in units USG/min/psi$^{0.5}$. **Figure 47** shows the Cv value specifications used for the ICV analysis in this thesis. Flow rate and the Cv are related. The relationship is given by:

$$Q = Cv \cdot \sqrt{\frac{P_1 - P_2}{R}}$$

Where:

Q – Flow rate in gpm

R – Specific gravity at upstream conditions (density of liquid at flowing temperature to density of water at 15.6°C (60°F))

P_1 – Upstream absolute static pressure to measured two nominal pipe diameters upstream of valve fitting

P_2 – Downstream absolute static pressure six nominal pipe diameters downstream of valve fitting.

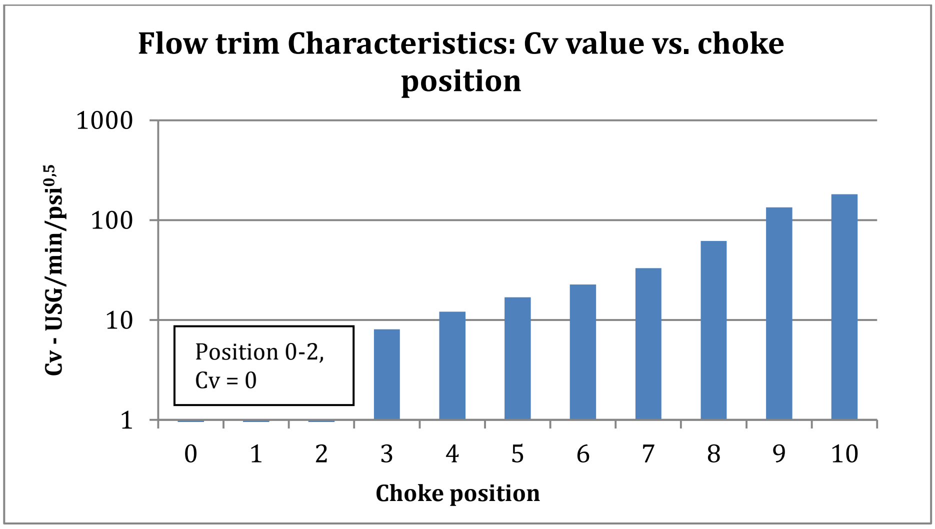

Figure 47: Cv value plotted against choke position.

From **Figure 47** we can see that when the ICV is in position 0, 1 or 2, the Cv value is 0. This means that for all those three positions, the valve is closed. In position 3-10 the valve is open.

The choke trim design is important because of:

- Control of water or gas influx
- Distribution of water or gas injection
- Commingling of reservoirs

When there is control of these factors, it is possible to achieve improved reserve recovery and accelerated production. To be able to customise the flow trim Cv design, it is important to do an analysis of the reservoir performance.

9. DISCUSSION OF RESULTS

9.1. Permeability combined with water saturation

In section 8 Sw and permeability for the analysis done in the thesis have been presented. By combining permeability and Sw, it is illustrated how Sw is changing as a result of the permeability variations. Illustration of Sw and permeability combined is shown in F**igure 48, 49, 50, 51 and 52.**

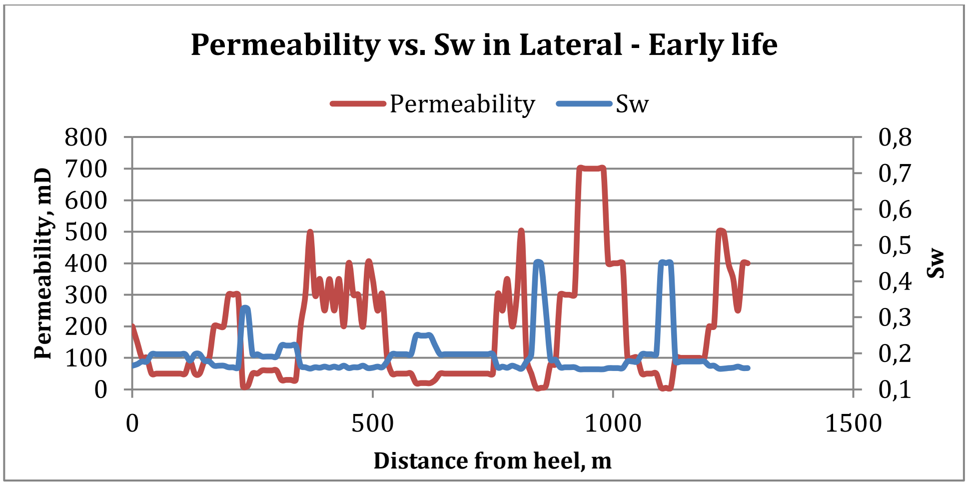

Figure 48: Permeability and Sw relation in the lateral - Early life of the well.

Figure 48 shows permeability and Sw relation in early life of the well. In this case there is low Sw in the high permeability areas, and high Sw in the low permeability areas.

When we compare Sw for mid-life (**Figure 39**) and permeability (**Figure 45**) in the lateral, we can see that there is a water front that has reached the lateral. This means that the water is coming in from the top, east of mainbore. **Figure 49** shows that there is high Sw in the high permeability zones.

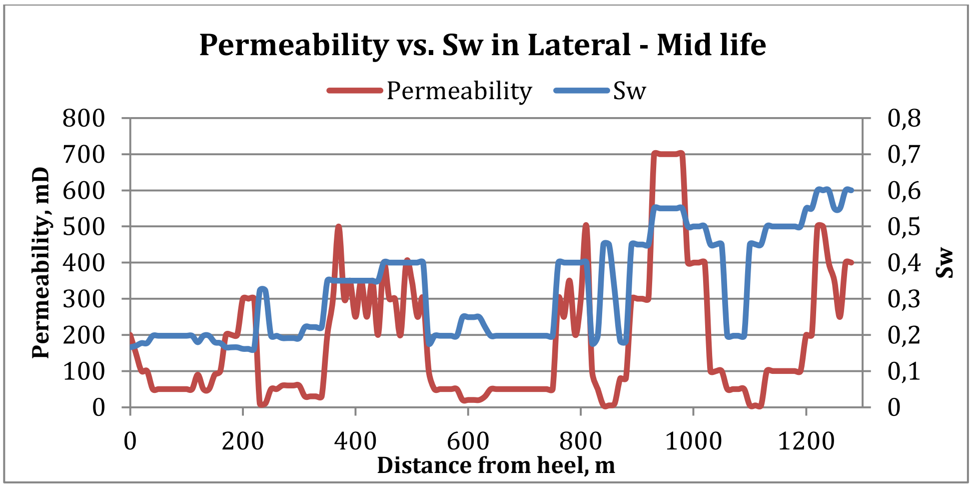

Figure 49: Permeability and Sw relation in lateral – Mid-life of the well.

Another observation is that Sw is highest in the toe, decreasing towards the heel. The reason for that is that the water reaches the toe first, and is working its way towards the heel.

In **Figure 50** permeability is plotted and compared with Sw for mainbore. In mainbore Sw is the same for the early and mid-life of the case being analyzed; with low Sw in the high permeability zones, and vice versa.

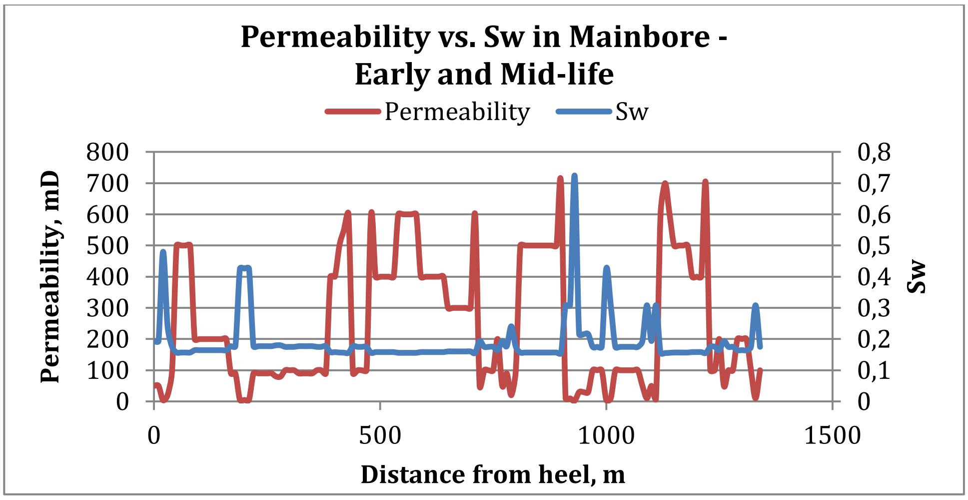

Figure 50: Permeability and Sw relation in mainbore – Early and Mid-life of the well.

In **Figure 51**, late life Sw in the lateral has increased. This means that the lateral is probably producing a lot of water, and little oil. Something should be done to restrain the water production coming from the lateral.

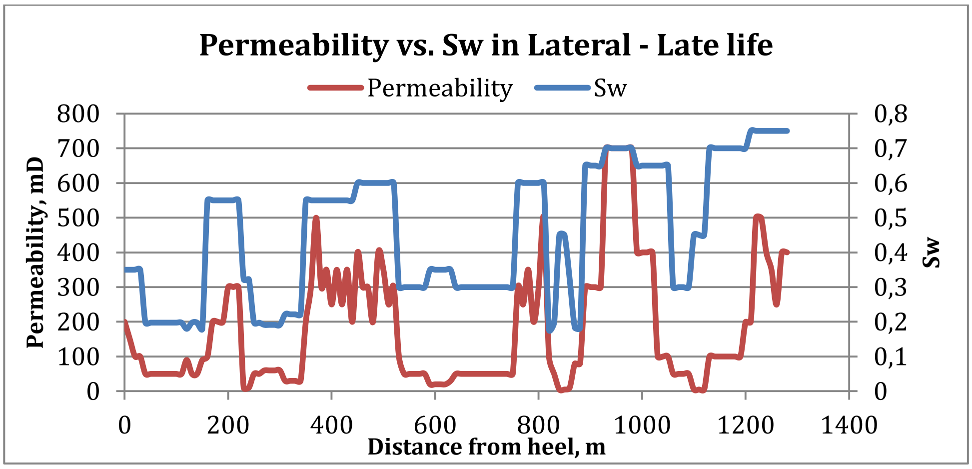

Figure 51: Permeability and Sw relation in lateral – Late life of the well

Sw in mainbore has not changed very much during the different stages. There is some increase in Sw in the mid-toe region (**Figure 52**).

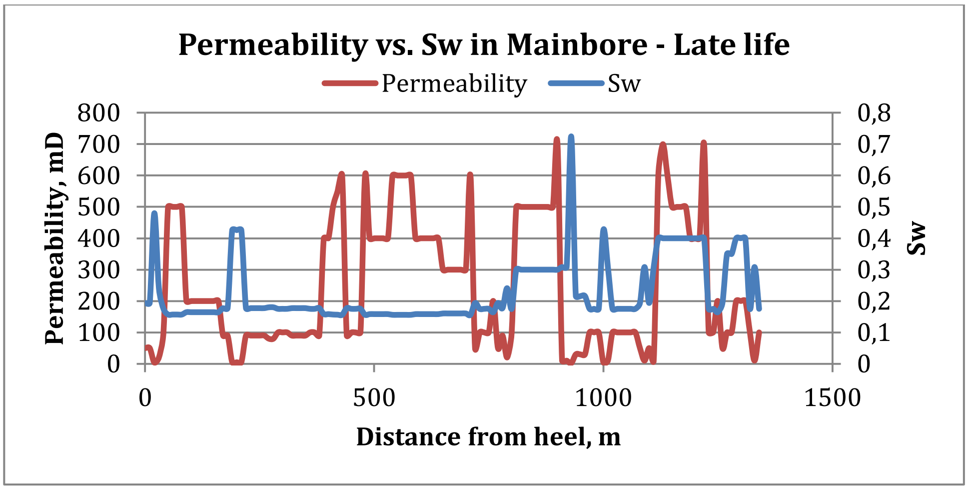

Figure 52: Permeability and Sw relation in mainbore – Late-life of the well

Water production from mainbore will not be a big problem compared to the water coming from the lateral.

9.2. Well with ICDs

When doing the analysis with NETool there need to be set a *target* for analysis. The target can be for example:

- Flowing BH pressure
- Tubing Head pressure
- Total Downhole rate, or
- Total liquid rate

In the analysis the lateral is completed with ICDs to illustrate the effect ICDs can have on oil, water and total production in the three different cases; early life, mid-life and late life of the well. In this thesis Total liquid rate is used as a target.

Total liquid rate is set to be 1000 Sm^3/day, which means that all the solutions from NETool gives a total liquid rate of 1000 Sm^3/day. The difference will be in how much of the liquid is oil and how much is water for the different cases. To be able to get out 1000 Sm^3/day in the different cases, the BHP needs to be regulated either up or down to allow the wanted fluid to be produced.

9.3.1 ICD Early life

The data from the comparison of the conventional well completion against well completed with ICDs are found in appendix **A.5**. Figure **53a** shows liquid, oil and water rate contribution from the lateral for the conventional well, and for the well with ICDs in the lateral.

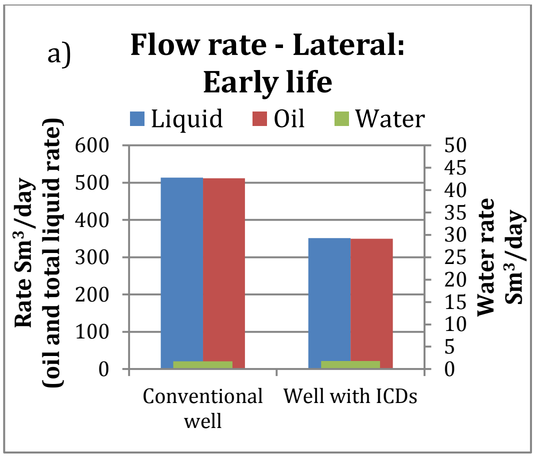

Figure 53a: Flow rate from lateral for a conventional well and well with ICDs

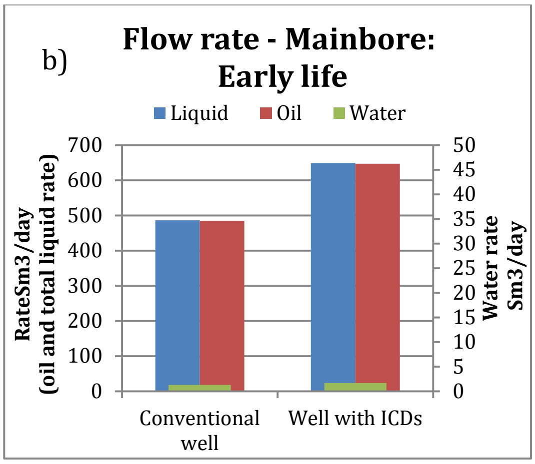

Fig. 53b: Flow rate from mainbore for a conventional well and well with ICDs

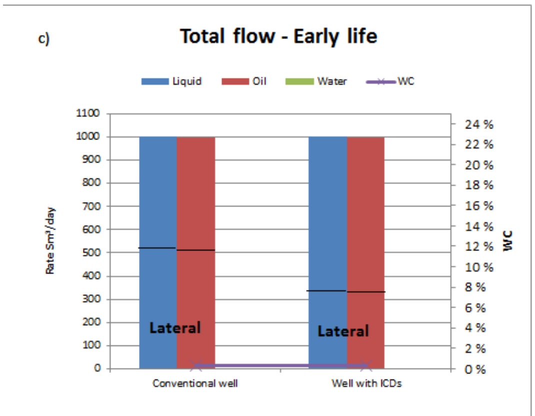

Figure 53c: Total flow from mainbore and lateral for the conventional well and well with ICDs early life.

The figure shows that total liquid rate is higher in the lateral when producing from the conventional well compared to production with ICDs. This is because the ICDs restrict the flow into the lateral, giving mainbore the ability to produce more liquid. Water production is very low for both the conventional well and the well with ICDs in the early life of the well.

When we look at flow rate in mainbore (**Figure 53b)**, we see that the total flow rate is larger when producing from the well with ICDs (648 Sm^3/day) compared to the conventional well (485,5 Sm^3/day). When producing from the conventional well we have an oil rate of 484,5 Sm^3/day, and by producing from the well with ICDs we will get an oil rate of 646,5 Sm^3/day.

Almost all fluid produced in mainbore is oil, the same case as for production from the lateral.

In **Figure 53c)** the total flow from both lateral and mainbore are displayed. Total liquid rate is 1000 Sm^3/day for both the conventional well case and the well with ICDs. This is because as mentioned earlier, that the target of the analysis is set to total liquid rate = 1000 Sm^3/day.

The difference from the well cases is that oil and liquid contribution from the lateral is higher in the conventional well than in the well with ICDs. In this case there is not any problem with water production. This means, as shown from **Figure 53c**, that there will be no difference if we decide to complete the well with or without ICDs.

9.3.2. ICD Mid-life

Figure 54a shows liquid, oil and water rate contribution from the lateral for the conventional well, and for the well with ICDs in the lateral.

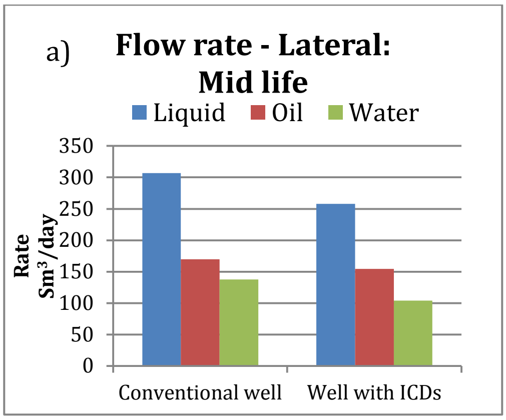

Figure 54a: Flow rate from lateral for a conventional well and well with ICDs

The figure shows that total liquid rate is higher in the lateral when producing from the conventional well compared to production with ICDs. In the mid-lift water is produced. When producing from a conventional well, water rate from the lateral is 137,5 Sm^3/day. Production from a well with ICDs gives water production of 103,5 Sm^3/day. This means that the lateral is producing at a relatively high WC.

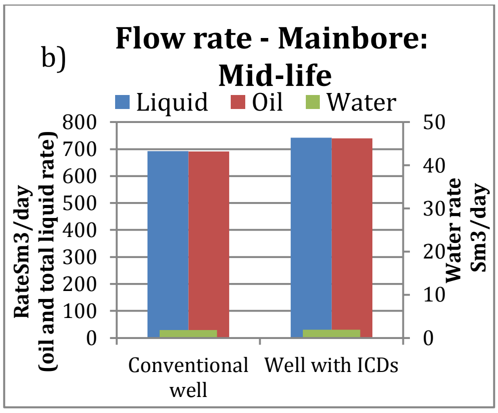

Fig. 54: Flow rate from mainbore for a conventional well and well with ICDs – mid-life case.

When we look at flow rate in mainbore (**Figure 54b)**, we see that the total flow rate is larger when producing from the well with ICDs (742 Sm^3/day) compared to the conventional well (693 Sm^3/day). When producing from the conventional well we have an oil rate of 691 Sm^3/day, and by producing from the well with ICDs we will get an oil rate of 740 Sm^3/day.

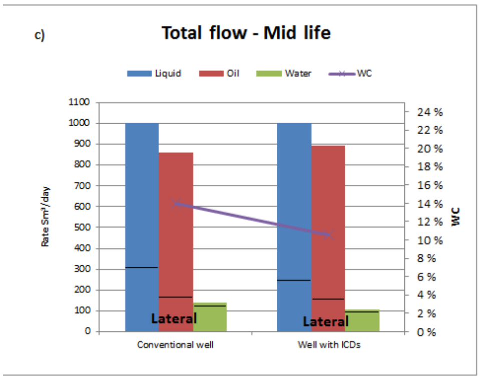

Figure 54c: Total flow from mainbore and lateral for the conventional well and well with ICDs – mid-life case.

In **Figure 54c** the total flow from both lateral and mainbore are displayed. We can see that it is the lateral who contributes with almost all the water that is produced in this case.

The figure shows that by completing the lateral with ICDs, the oil rate is increased from 860 Sm^3/day to 894 Sm^3/day, giving an increase in total oil rate of 4%. Water rate is decreased from 139 Sm^3/day to 106 Sm^3/day. This means that WC is decreased by 21%.

The ICDs play an important role in this case by restricting the flow contribution from the lateral.

9.3.3. ICD Late life

Figure 55a shows liquid, oil and water rate contribution from the lateral for the conventional well, and for the well with ICDs in the lateral for the late life well case.

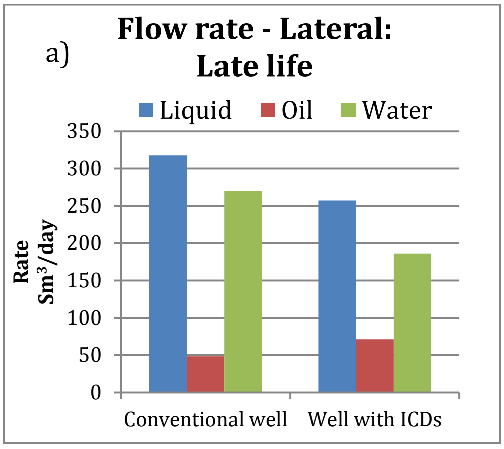

Figure 55a: Flow rate from lateral for a conventional well and well with ICDs

In this case water is the dominating fluid being produced. Also here total fluid produced in the lateral is lower when we produce from the well with ICDs compared to production form the conventional well. When we produce from the well with ICDs, oil rate is increased to 71 Sm^3/day, compared to 48 Sm^3/day when producing from the conventional well.

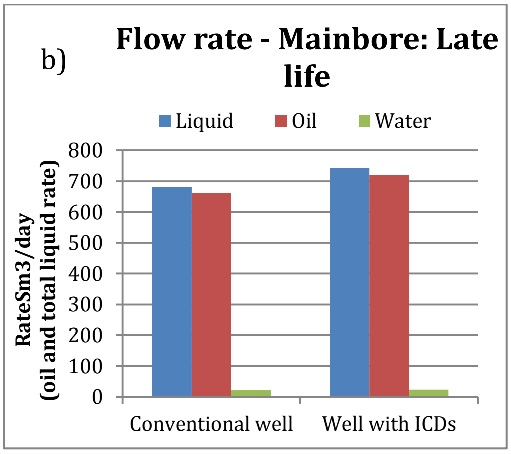

Fig. 55b: Flow rate from mainbore for a conventional well and well with ICDs

When we look at flow rate in mainbore (**Figure 55b)**, we see that the total flow rate is larger when producing from the well with ICDs (743 Sm^3/day) compared to the conventional well (682 Sm^3/day). When producing from the conventional well we have an oil rate of 661 Sm^3/day, and by producing from the well with ICDs we will get an oil rate of 720 Sm^3/day.

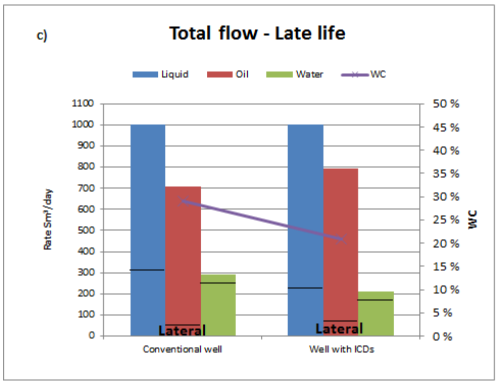

Figure 55c: Total flow from mainbore and the lateral for the conventional well and well with ICDs – mid-life case.

When we add mainbore flow rate and lateral flow rate, we get the total flow rates for the late well case (**Figure 55c**). The figure shows that by completing the lateral with ICDs, the oil rate is increased from 709 Sm^3/day to 791 Sm^3/day, giving an increase in total oil rate of 10%. Water rate is decreased from 291 Sm^3/day to 209 Sm^3/day. This means that WC is decreased by 28%.

9.3. Well with ICVs

There has been done analysis of the impact from ICVs in three different cases; early life, mid-life and late life. The results have then been compared to a well with a conventional well completion under the same conditions as for the ICV analysis. The data from the NETool analysis for the different cases, and valve settings are shown in appendix **A.6**.

The target of the NETool analysis is still total liquid rate = 1000 Sm^3/day. This means that BHP needs to be regulated to allow the target rate to be produced in the different cases. For example when ICVs are used it is possible to set the valve in ex. 10 different position. Position 0, 1 and 2 do not allow any flow, position 3 a little flow, while the valve is fully open in position 10. If the ICV valve position is ex. 3 BHP need to be lower than if the valve is in position 5, since the flow is restrained.

So, during the analysis BHP are different, but the total liquid rate are the same.

9.3.1. Early life

Figure 56 shows the results of the study of well with ICVs and a conventional well in the early stage. Results show that in this stage of the wells life, there are no significant difference between producing from a conventional well and a well with ICDs. The oilrate coming from the lateral in a conventional well is almost the same as the oilrate coming from the well with ICVs. WC are approximately the same for the two cases compared.

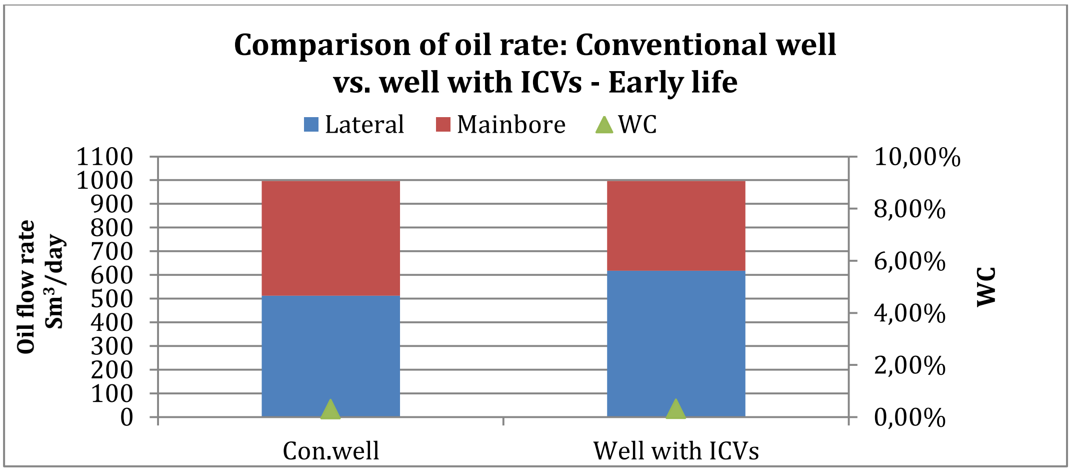

Figure 56: Comparison of estimated oil flow rate and WC for a conventional well, and estimated oil flow rate and WC for a well with ICVs in the early stage of the well.

In the early stage of the wells life there is no problem with water production in this case. This means that there is no need for the ICVs to choke or stop production from one of the zones. That will change during the wells life as we can see from **Figures 48-52** where we have water coming in during the wells life.

In this early life case for the well, the flexibility of the ICV is illustrated (**Figure 57**). The figure shows how it is possible to control flow contribution from mainbore and lateral. Since both ICVs are fully open in the optimal case, where we have largest oil flow rate, the flow contribution from mainbore and the lateral are well illustrated.

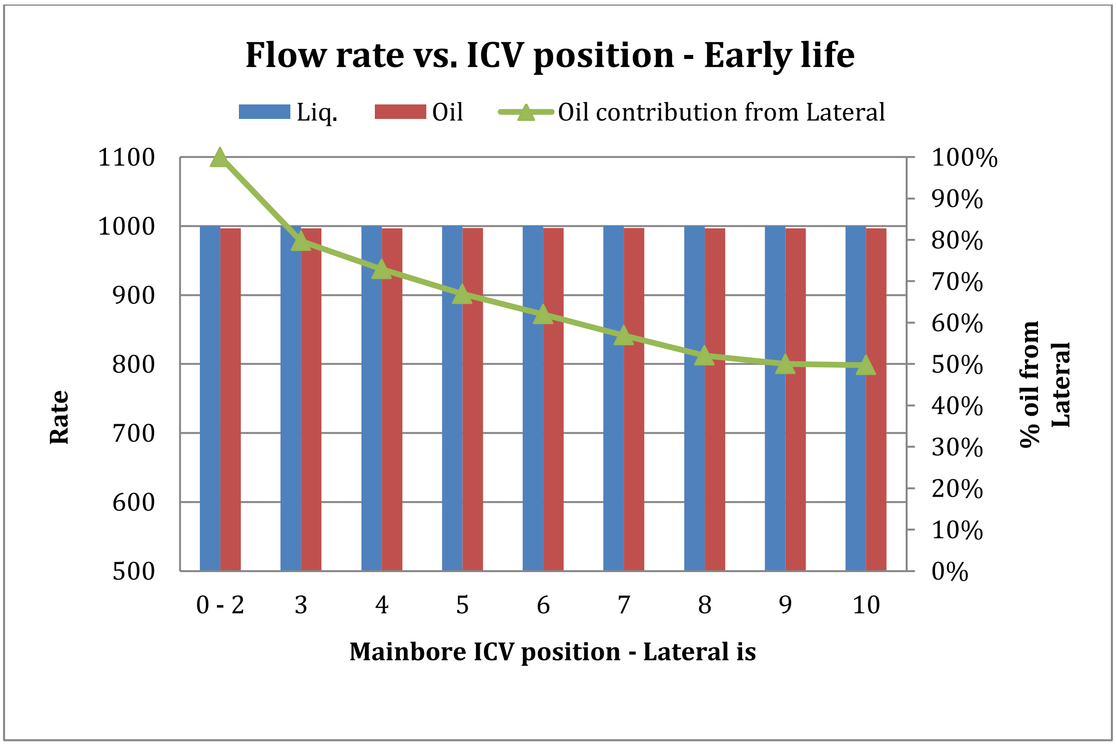

Figure 57: Flow rate vs. ICV position – Early life. The ICV controlling flow from the lateral is fully open, while the ICV controlling mainbore is changed from position 0 up to position 10.

Figure 57 shows how the oil flow rate is approximately constant as we regulate the opening position of the ICV controlling flow from mainbore. In this early case, the lateral ICV is in position 10 (fully open). Only mainboer ICV position is changed. When mainbore is shut off (position 0-2) 100% of the oil rate is coming from the lateral. By changing the mainbore ICV position, oil rate from the lateral is decreasing. At the end, when both ICVs are fully open, there is a 50/50 contribution of oil from mainbore and the lateral.

9.3.2. Mid-life

When the mid-life well case is evaluated, we can see from **Figure 49** that water has reached the lateral. This means that the lateral is producing at a high WC, and something should be done to restrict the production from the lateral.

Analysis of the different ICV positions controlling maninbore and the lateral has been done. The best solution is to produce with the ICV controlling production from the lateral in position 4, and have the ICV controlling mainbore fully open (position 10). **Figure 58** shows the result of the analysis done on a conventional well compared with a well with ICVs.

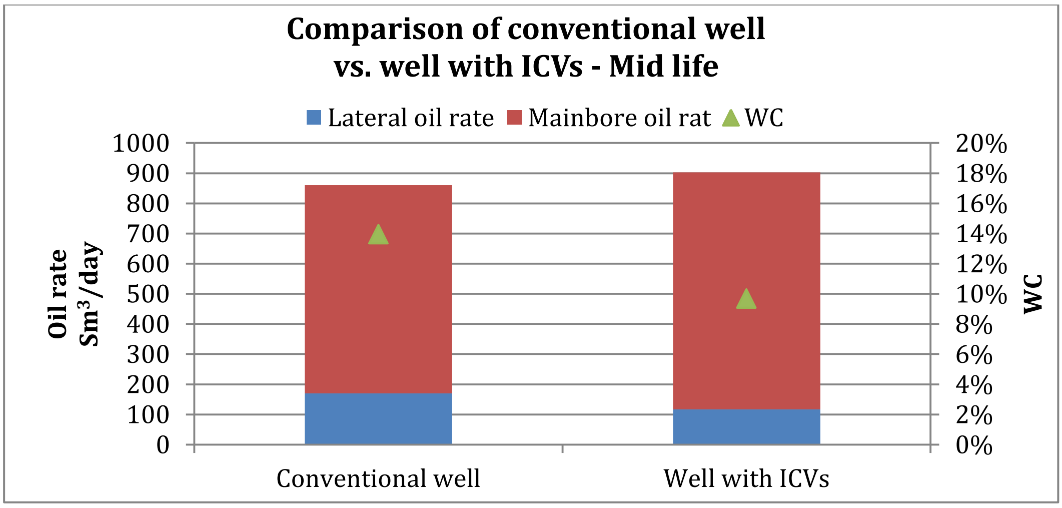

Figure 58: Comparison of estimated oil flow rate and WC for a conventional well, and estimated oil flow rate and WC for a well with ICVs in Mid-life of the well.

Total oil flow rate for the conventional well case is 860.5 Sm^3/day, and total oil flow rate is increased to 903 Sm^3/day in the ICV case. This means that there is a 4.7% increase in total oil flow rate when comparing the conventional well case with a well with ICVs. If a conventional well completion had been used, the water rate would have been 139 Sm^3/day. By completing the well with ICVs the water rate is decreased to 97 Sm^3/day, which means that WC is reduced by 30%. This makes it clear that it is very important with zonal control.

It would have been possible to shut flow from the lateral completely to reduce WC even more, but it is assumed that one would wish to drain as much oil as reasonable from the lateral. The ICV controlling the lateral is set in position 4 instead of position 3, which would have given a little bit lower WC. This is because with the lateral ICV in position 4 it is possible to get 18% more oil from the lateral.

Another reason for not wanting to close the flow from the lateral completely is that on a later point of the wells life, it may not be possible to get out the remaining reserves in the lateral. If mainbore is drained too much before the lateral is reopened, there may not be enough support from the reservoir to get the fluid to the surface, or it may not be economic to produce from the well.

In **Figure 59** flow rate is plotted against ICV position. The ICV controlling mainbore is the variable, while the ICV controlling the lateral is set at position 4.

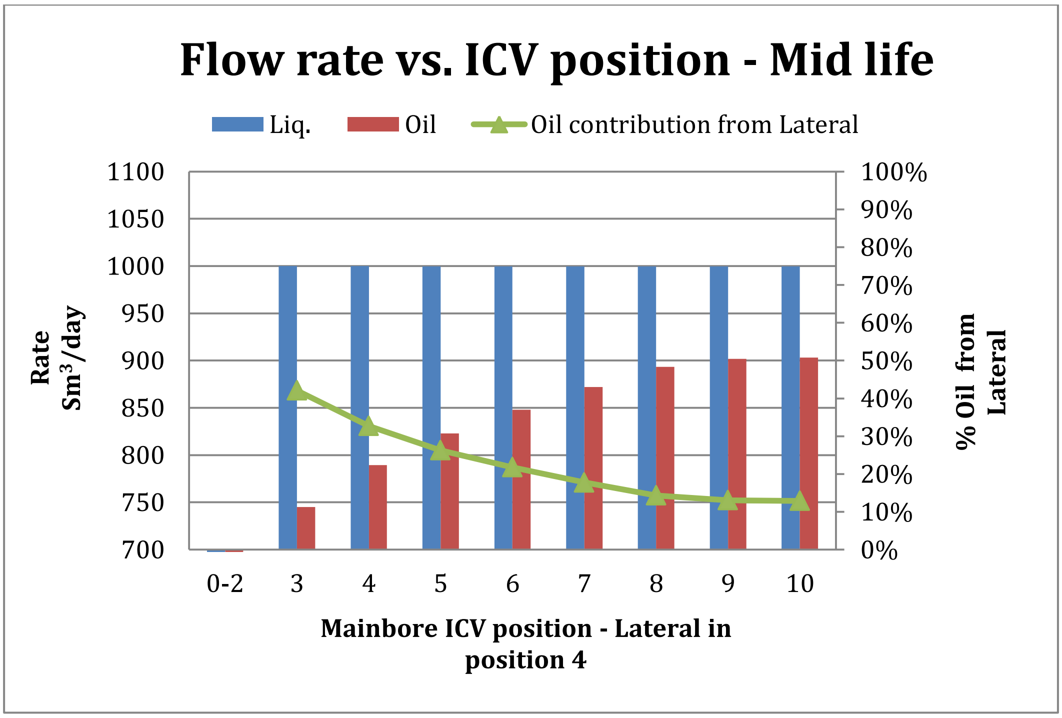

Figure 59: Flow rate vs. ICV position – Mid-life. The ICV controlling flow from the lateral is in position 4, while the ICV controlling mainbore is changed from position 0 up to position 10.

Also here we can see that by opening the ICV controlling mainbore, oil contribution from the lateral is decreasing. Since the ICV controlling flow from the lateral is set in position 4, oil contribution from the lateral do not get higher than 42% of the total oil flow. By allowing more flow from mainbore, the total oil rate increases.

9.3.3. Late-life

A late well case has been evaluated. **Figure 51 and 52** shows permeability and Sw for the late well case. There is higher Sw in the lateral in the late case than compared to the mid-life case. Water has also reached the toe in manibore. Since Sw has increased in the lateral, flow from the lateral should still be restricted. If the lateral were to produce without any restriction, total WC for the well would be high and the water would cause a lower oil flow rate.

Analysis of the different ICV positions controlling maninbore and the lateral has been done. The best solution is to produce with the ICV controlling production from the lateral in position 3, and have the ICV controlling mainbore fully open (position 10). **Figure 60** shows the result of the analysis done on a conventional well compared with a well with ICVs.

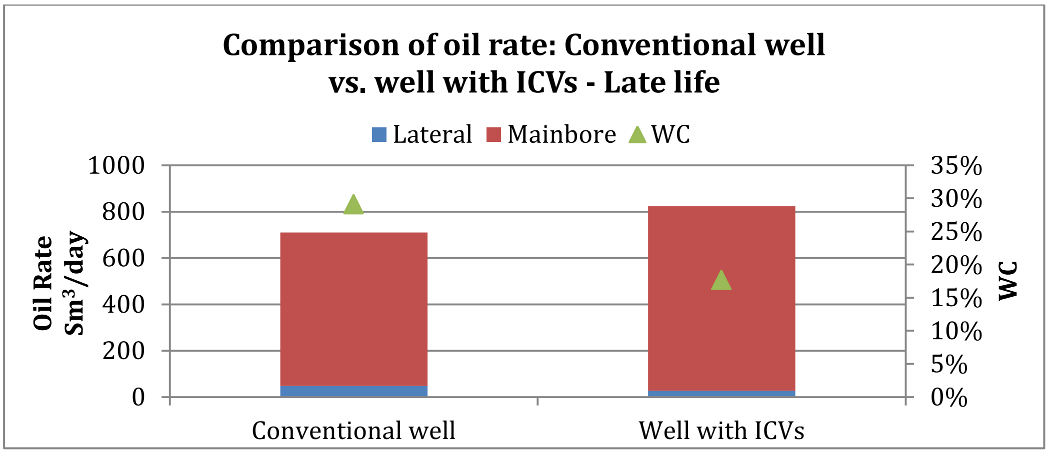

Figure 60: Comparison of estimated oil flow rate and WC for a conventional well, and estimated oil flow rate and WC for a well with ICVs in late-life of the well.

Total oil flow rate for the conventional well case is 709 Sm^3/day, while total oil flow rate for the well with ICVs is 823 Sm^3/day. This means that there is a 14% increase in total oil flow rate when comparing the conventional well case with the well with ICVs. If a conventional well completion had been used, the water rate would have been 290 Sm^3/day. By completing the well with ICVs water rate can be decreased to 176 Sm^3/day, which means that WC is reduced by 39%. Also in this case it is important to have control with the different zones.

It would have been possible to shut flow from the lateral completely to reduce WC even more, but it is assumed that one would wish to drain as much oil as economically reasonable from the lateral. In this case the ICV controlling the lateral is set in position 3 instead of position 4. By using position 3, the total oil flow rate is 4% higher than if we were to use position 4.

As mentioned in the mid-life case, it can be a good idea to not shut off the lateral completely.

In **Figure 61** flow rate is plotted against ICV position. The ICV controlling mainbore is the variable, while the ICV controlling the lateral is set at position 3.

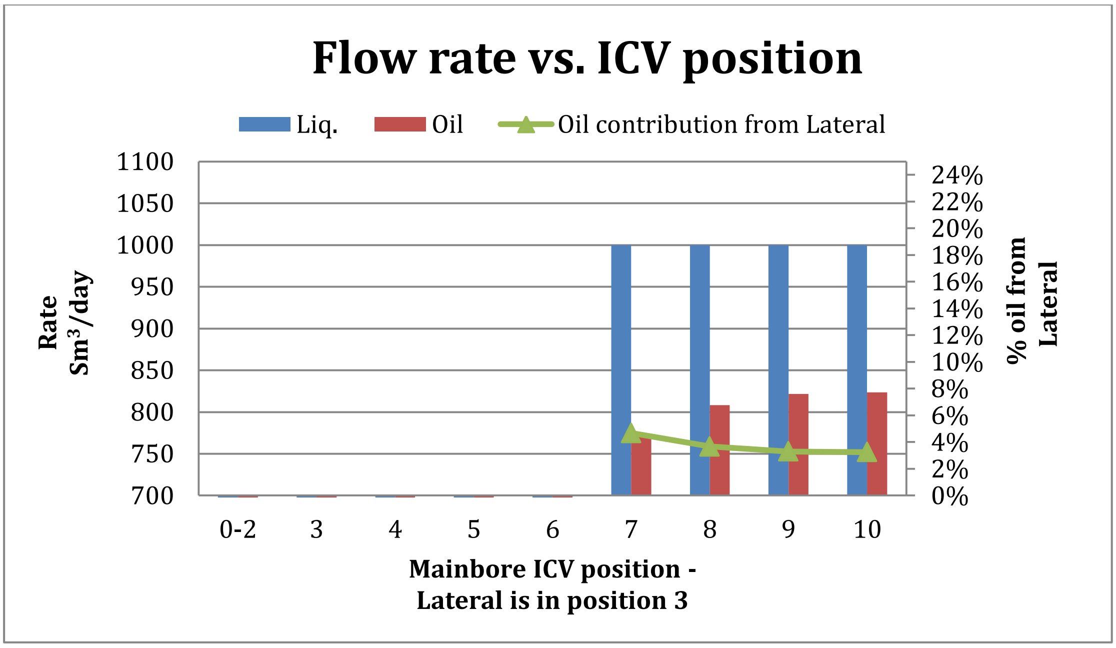

Figure 61: Flow rate vs. ICV position – Late life. The ICV controlling flow from the lateral is in position 3, while the ICV controlling mainbore is changed from position 0 up to position 10.

Also here we can see that by opening the ICV controlling mainbore, oil contribution from the lateral is decreasing. Since the ICV controlling flow from the lateral is set in position 3, oil contribution from the lateral do not get higher than 5% of the total oil flow. By allowing more flow from mainbore, the total oil rate increases.

Often the best solution is to install a variable ICV instead of an on/off valve in the well. Reservoir properties may be unpredictable, and there may be a need to produce more or less from a specific zone. Flexibility can be an advantage in many cases.

10. CONCLUSION

The area of use for ICVs and ICDs are quite different. All the ICDs follow Bernoulli principle, while the ICVs have the possibility to choke or close the flow from the reservoir. For multilateral wells ICVs can control and balance inflow from the different laterals, or react to changes in a particular lateral. ICVs will then have the possibility to choke or close the flow from the particular lateral depending on the case. ICDs do not have the possibility to control lateral flow in the same way as the ICVs. But the ICDs can be applied to minimise variable productivity effect or heel-toe effect within the lateral based on the natural contribution of each lateral, or the required contribution using ICVs. Today, ICVs are not possible to install within the lateral.

Reduced capital and operational expenditures for field development is a main concern today. Multiple reservoirs management is an important task. The different reservoirs accessed from the same wellbore may have very different reservoir pressure between zones or formations. ICVs then provide greater flexibility to handle the changing well and reservoir behaviour. By connecting different formations the production can be accelerated by commingling, and tubing performance can be maximized.

The efficiency of ICV and ICD systems are very dependent on the reservoir conditions. If there is a reservoir with long horizontal wells with relatively constant reservoir conditions, IDCs would do a good enough job. But if there are multiple reservoir accessed, where the reservoir conditions can vary a lot, ICVs will give the best control.

Both the ICV and ICD technology is continuously being improved. For the ICVs the complexity is that the control systems and gauges need to be reliable and become more robust. So for the service providers, it is important to develop a technical solution that can reduce the costs and improve the reliability of the system. The ICDs under development are working on reducing the water flow, and by that favouring the oil flow. The ICDs are very robust.

The case examined in this thesis is one concrete case. The results from the analysis carried out with NETool, show a clear advantage in using ICDs or ICVs when there is varying permeability and Sw. By completing this particular well with ICVs or ICDs it is possible to reduce WC and increase oil rate, compared to production from a conventional well. The well completed with ICVs gave lower WC and higher oil rate compared to the well completed with ICD. Since the case analysed is very concrete, it is not possible to draw a general conclusion based on these results.

The reservoir conditions and well behaviour should be well analysed. A thorough analysis of the field is important for the operator to have the ability to make the right choice in how to complete and produce the well. Sometimes the best solution can be a simple completion, and other times more advanced completions are the smartest choice, it all depends on the field we are planning to produce from.

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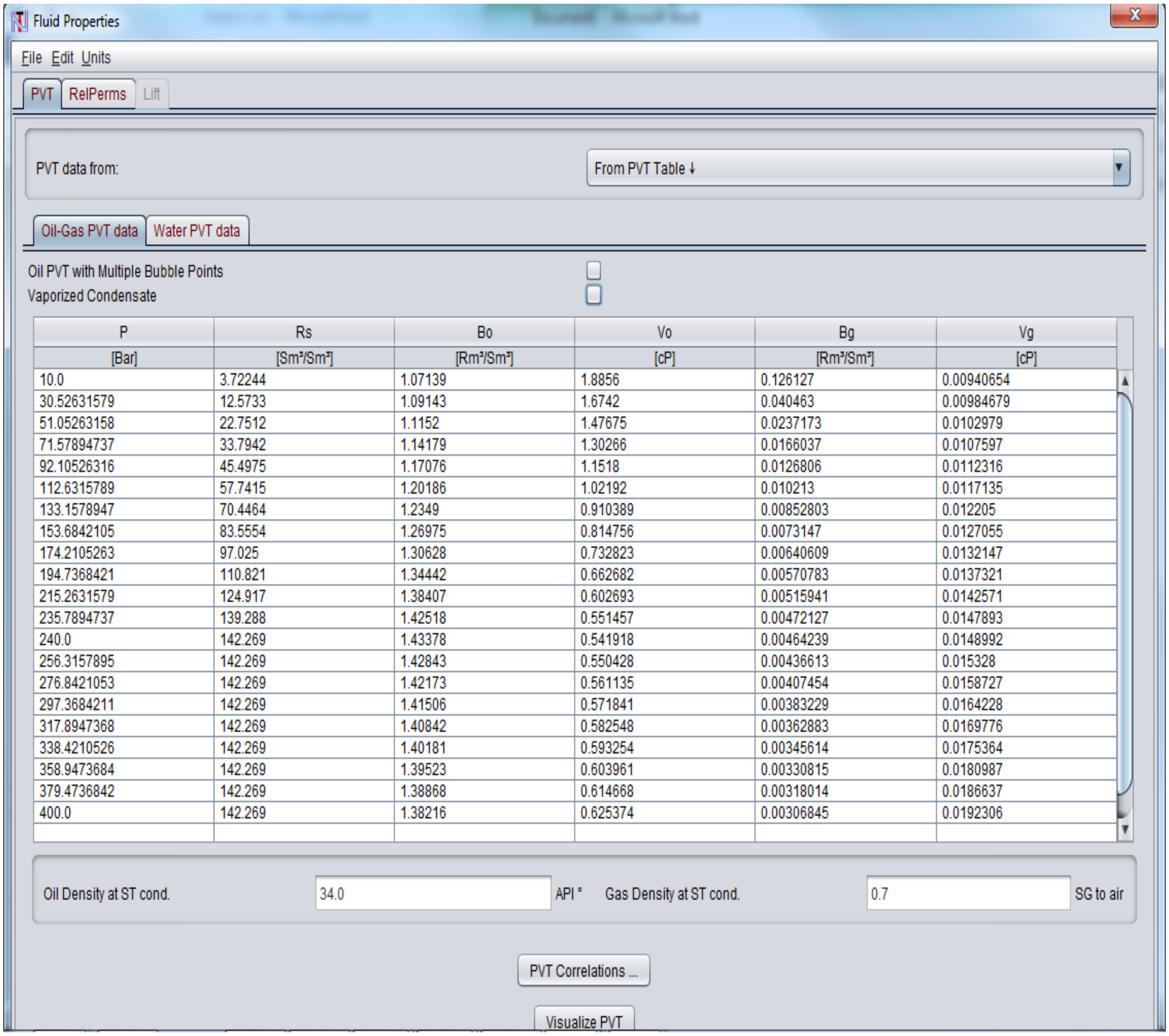
APPENDIXES

A.1: NETool settings used in the whole analysis:



P [Bar]	Rs [Sm³/Sm³]	Bo [Rm³/Sm³]	Vo [cP]	Bg [Rm³/Sm³]	Vg [cP]
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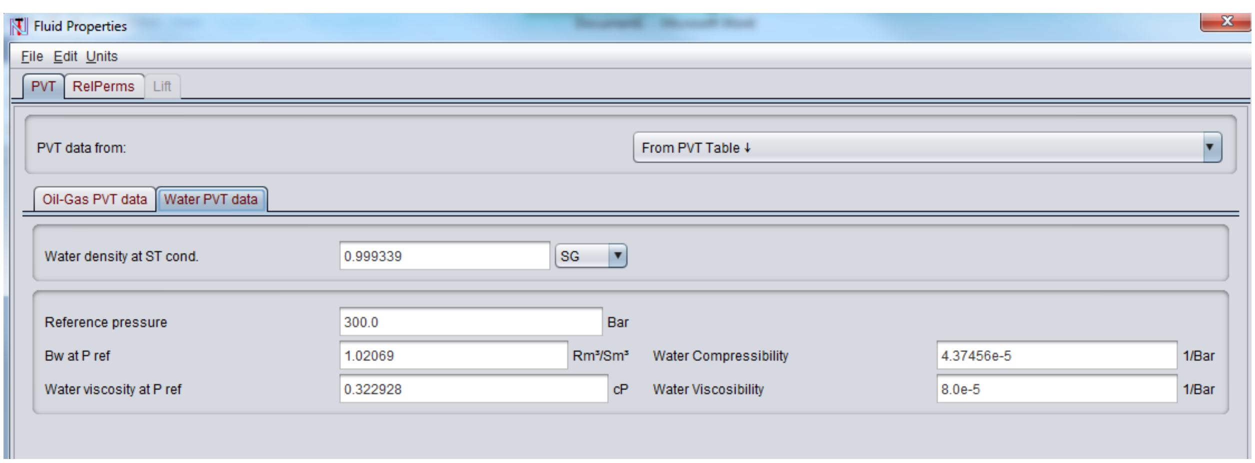
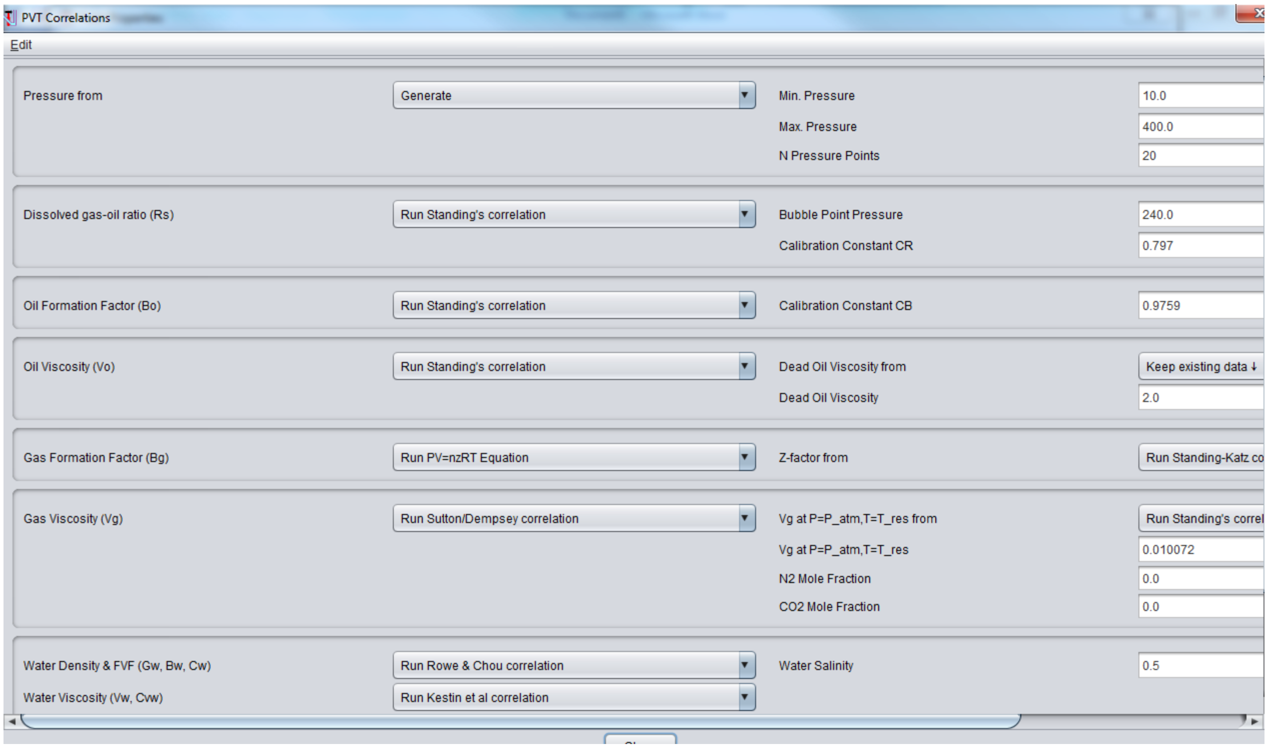
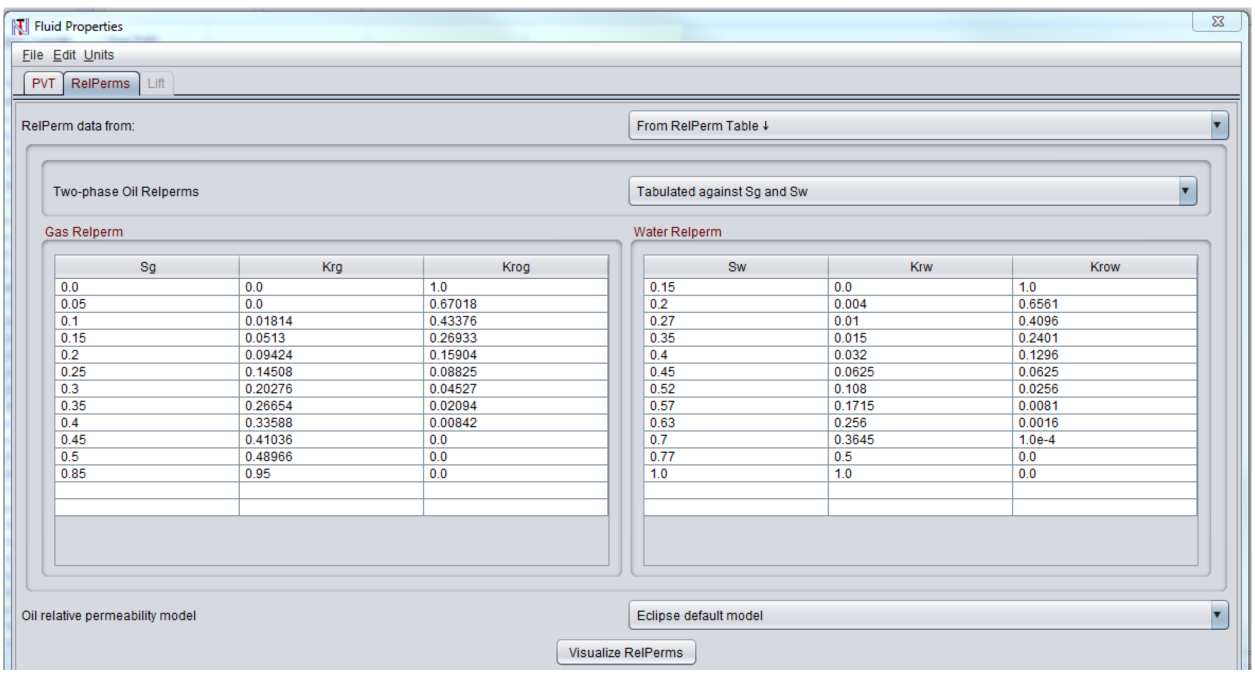
30.52631579	12.5733	1.09143	1.6742	0.040463	0.00984679
51.05263158	22.7512	1.1152	1.47675	0.0237173	0.0102979
71.57894737	33.7942	1.14179	1.30266	0.0166037	0.0107597
92.10526316	45.4975	1.17076	1.1518	0.0126806	0.0112316
112.6315789	57.7415	1.20186	1.02192	0.010213	0.0117135
133.1578947	70.4464	1.2349	0.910389	0.00852803	0.012205
153.6842105	83.5554	1.26975	0.814756	0.0073147	0.0127055
174.2105263	97.025	1.30628	0.732823	0.00640609	0.0132147
194.7368421	110.821	1.34442	0.662682	0.00570783	0.0137321
215.2631579	124.917	1.38407	0.602693	0.00515941	0.0142571
235.7894737	139.288	1.42518	0.551457	0.00472127	0.0147893
240.0	142.269	1.43378	0.541918	0.00464239	0.0148992
256.3157895	142.269	1.42843	0.550428	0.00436613	0.015328
276.8421053	142.269	1.42173	0.561135	0.00407454	0.0158727
297.3684211	142.269	1.41506	0.571841	0.00383229	0.0164228
317.8947368	142.269	1.40842	0.582548	0.00362883	0.0169776
338.4210526	142.269	1.40181	0.593254	0.00345614	0.0175364
358.9473684	142.269	1.39523	0.603961	0.00330815	0.0180987
379.4736842	142.269	1.38868	0.614668	0.00318014	0.0186637
400.0	142.269	1.38216	0.625374	0.00306845	0.0192306





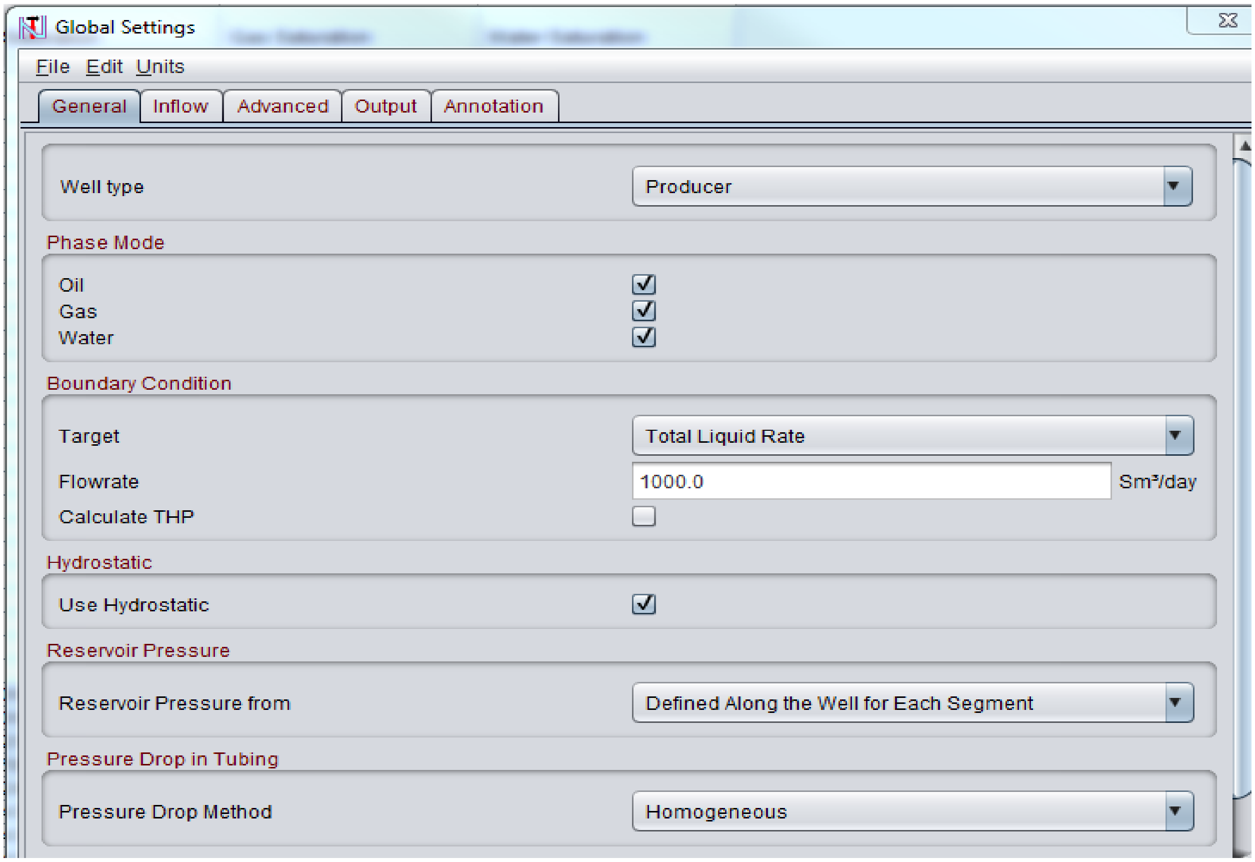


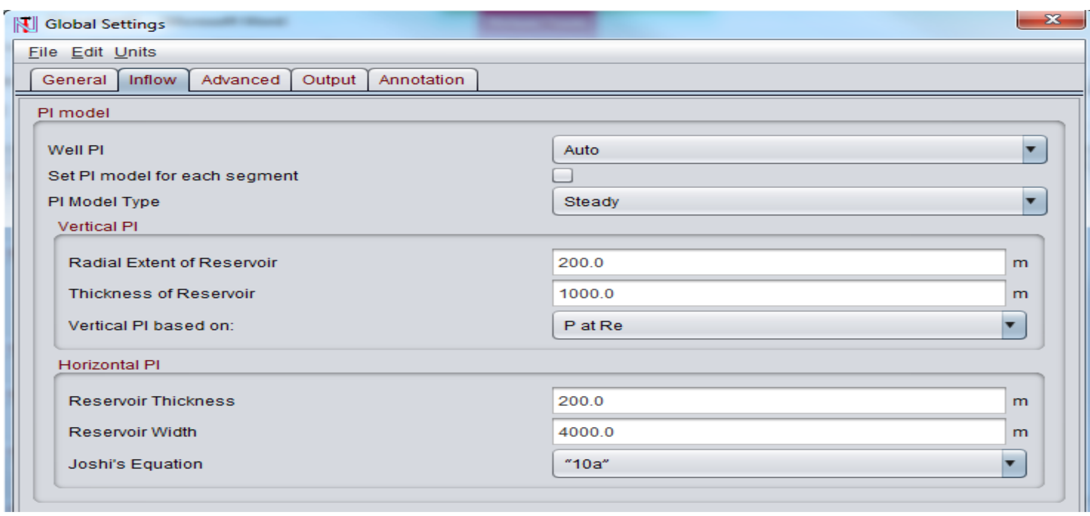
Gas Relperm

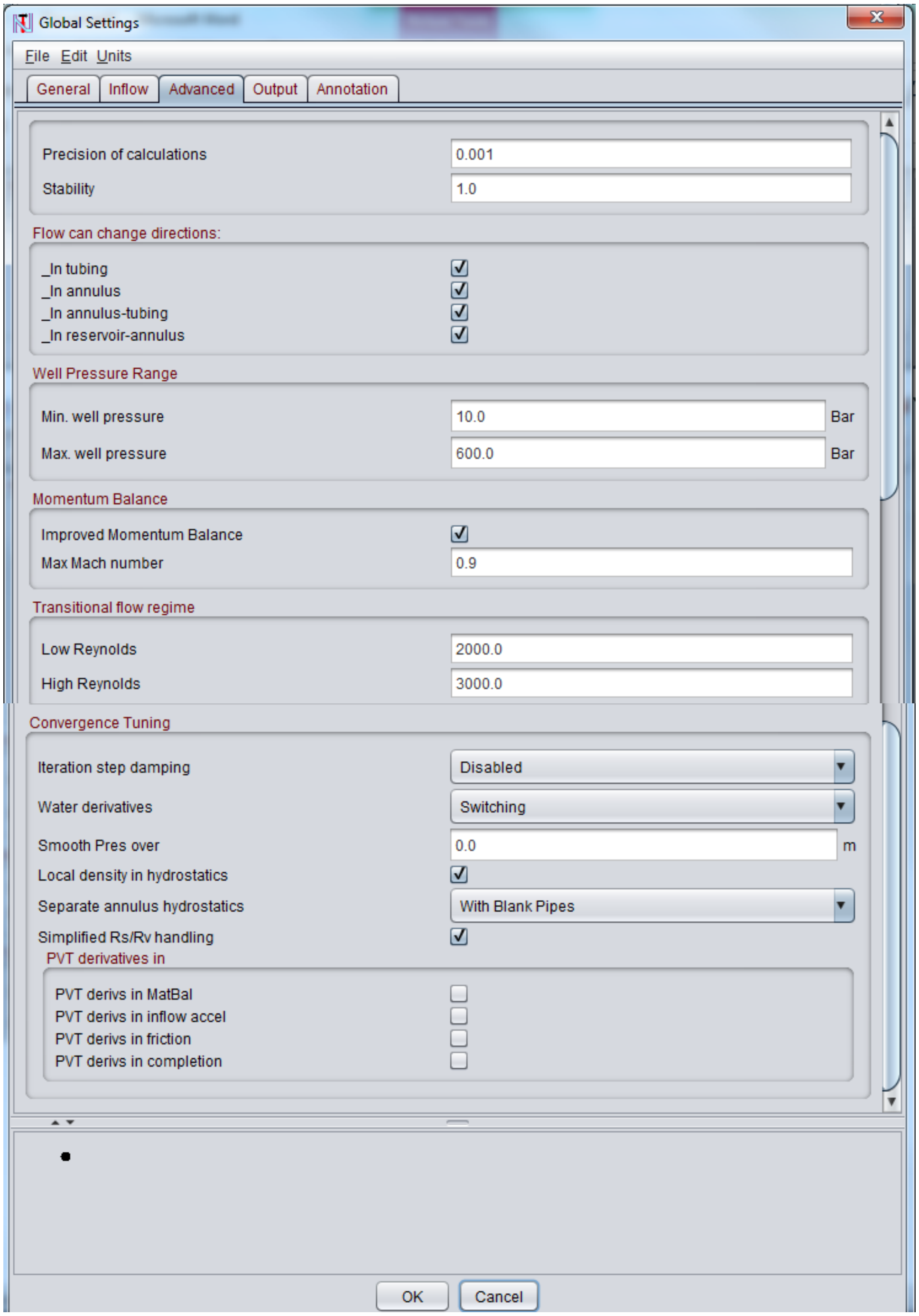
Sg	Krg	Krog
0.0	0.0	1.0
0.05	0.0	0.67018
0.1	0.01814	0.43376
0.15	0.0513	0.26933
0.2	0.09424	0.15904
0.25	0.14508	0.08825
0.3	0.20276	0.04527
0.35	0.26654	0.02094
0.4	0.33588	0.00842
0.45	0.41036	0.0
0.5	0.48966	0.0
0.85	0.95	0.0

Water Relperm

Sw	Krw	Krow
0.15	0.0	1.0
0.2	0.004	0.6561
0.27	0.01	0.4096
0.35	0.015	0.2401
0.4	0.032	0.1296
0.45	0.0625	0.0625
0.52	0.108	0.0256
0.57	0.1715	0.0081
0.63	0.256	0.0016
0.7	0.3645	1.0e-4
0.77	0.5	0.0
1.0	1.0	0.0


Global Settings
File Edit Units
General
Inflow
Advanced
Output
Annotation
Well type
Producer
Phase Mode
Oil
Gas
Water
Boundary Condition
Target
Total Liquid Rate
Flowrate
1000.0
Sm³/day
Calculate THP
Hydrostatic
Use Hydrostatic
Reservoir Pressure
Reservoir Pressure from
Defined Along the Well for Each Segment
Pressure Drop in Tubing
Pressure Drop Method
Homogeneous


Global Settings
File Edit Units
General
Inflow
Advanced
Output
Annotation
PI model
Well PI
Auto
Set PI model for each segment
PI Model Type
Steady
Vertical PI
Radial Extent of Reservoir
200.0
m
Thickness of Reservoir
1000.0
m
Vertical PI based on:
P at Re
Horizontal PI
Reservoir Thickness
200.0
m
Reservoir Width
4000.0
m
Joshi's Equation
"10a"


Global Settings
File Edit Units
General
Inflow
Advanced
Output
Annotation
Precision of calculations
0.001
Stability
1.0
Flow can change directions:
_In tubing
_In annulus
_In annulus-tubing
_In reservoir-annulus
Well Pressure Range
Min. well pressure
10.0
Bar
Max. well pressure
600.0
Bar
Momentum Balance
Improved Momentum Balance
Max Mach number
0.9
Transitional flow regime
Low Reynolds
2000.0
High Reynolds
3000.0
Convergence Tuning
Iteration step damping
Disabled
Water derivatives
Switching
Smooth Pres over
0.0
m
Local density in hydrostatics
Separate annulus hydrostatics
With Blank Pipes
Simplified Rs/Rv handling
PVT derivatives in
PVT derivs in MatBal
PVT derivs in inflow accel
PVT derivs in friction
PVT derivs in completion
OK
Cancel

A.2: Well completion in NETool

Mainbore: Completion in ICD and Conventional cases:

Seg #	Segment Top MD [m]	Segment Length [m]	Lateral Connection	Casing/Liner	Sand Control	Inflow Control	Stinger	Tubing	Well Hole Size [in]	Liner OD [in]	Liner ID [in]	Sand Control OD [in]	Sand Control ID [in]	Inflow Control OD [in]	Inflow Control ID [in]
1	0	20		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	8,63			3,5	2,9
2	20	180		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
3	200	180		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
4	380	120		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
5	500	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
6	600	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
7	700	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
8	800	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
9	900	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
10	1000	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
11	1100	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
12	1200	50		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	8,63			3,5	2,9
13	1250	4		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	8,63			3,5	2,9
14	1254	50		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	7,63			3,5	2,9
15	1304	200		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
16	1504	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
17	1604	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
18	1704	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
19	1804	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
20	1904	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
21	2004	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
22	2104	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
23	2204	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
24	2304	50		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
25	2354	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
26	2374	4		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	7,63			3,5	2,9
27	2378	70		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	6,5			3,5	2,9
28	2448	70		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
29	2518	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
30	2538	34		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
31	2572	10		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
32	2582	48		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
33	2630	4		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
34	2634	4		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
35	2638	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
36	2738	12		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
37	2750	350		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
38	3100	116		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
39	3216	4		Blank Pipe	-	Packer	-	Open	12,6	7,63	6,5			6,5	2,9
40	3220	4		Blank Pipe	-	ICV	-	Open	12,6	7,63	6,5			5,85	2,75
41	3224	6		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
42	3230	6,303		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
42	3236,303	0	To Annulus [Inflow Control]					Open	12,6					3,5	2,9
43	3236,303	49,997		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
44	3286,3	13,7		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
45	3300	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
46	3320	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
47	3340	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
48	3360	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
49	3380	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
50	3400	36,3		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
51	3436,3	4		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
52	3440,3	4		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
53	3444,3	25		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
54	3469,3	29		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
55	3498,3	11,7		Cemented B.P.	-	Packer	-	Open	12,6	12,6	6,5			6,5	2,9
56	3510	4		Cemented B.P.	Packer	-	-	Open	12,6	12,6	6,5	6,5	4,778		
57	3514	16		-	Screen	-	-	Open	12,6			5,5	4,778		
58	3530	10		-	Screen	-	-	Open	12,6			5,5	4,778		
59	3540	10		-	Screen	-	-	Open	12,6			5,5	4,778		
60	3550	10		-	Screen	-	-	Open	12,6			5,5	4,778		
61	3560	10		-	Screen	-	-	Open	12,6			5,5	4,778		
62	3570	4		-	Screen	-	-	Open	12,6			5,5	4,778		
63	3574	16		-	Screen	-	-	Open	12,6			5,5	4,778		
64	3590	10		-	Screen	-	-	Open	12,6			5,5	4,778		
65	3600	10		-	Screen	-	-	Open	12,6			5,5	4,778		
66	3610	10		-	Screen	-	-	Open	12,6			5,5	4,778		
67	3620	10		-	Screen	-	-	Open	12,6			5,5	4,778		
68	3630	10		-	Screen	-	-	Open	12,6			5,5	4,778		
69	3640	10		-	Screen	-	-	Open	12,6			5,5	4,778		
70	3650	10		-	Screen	-	-	Open	12,6			5,5	4,778		
71	3660	10		-	Screen	-	-	Open	12,6			5,5	4,778		
72	3670	10		-	Screen	-	-	Open	12,6			5,5	4,778		
73	3680	4		-	Screen	-	-	Open	12,6			5,5	4,778		
74	3684	16		-	Screen	-	-	Open	12,6			5,5	4,778		
75	3700	10		-	Screen	-	-	Open	12,6			5,5	4,778		
76	3710	10		-	Screen	-	-	Open	12,6			5,5	4,778		
77	3720	10		-	Screen	-	-	Open	12,6			5,5	4,778		
78	3730	10		-	Screen	-	-	Open	12,6			5,5	4,778		
79	3740	4		-	Screen	-	-	Open	12,6			5,5	4,778		
80	3744	16		-	Screen	-	-	Open	12,6			5,5	4,778		
81	3760	10		-	Screen	-	-	Open	12,6			5,5	4,778		
82	3770	10		-	Screen	-	-	Open	12,6			5,5	4,778		
83	3780	10		-	Screen	-	-	Open	12,6			5,5	4,778		
84	3790	10		-	Screen	-	-	Open	12,6			5,5	4,778		
85	3800	10		-	Screen	-	-	Open	12,6			5,5	4,778		
86	3810	10		-	Screen	-	-	Open	12,6			5,5	4,778		
87	3820	10		-	Screen	-	-	Open	12,6			5,5	4,778		
88	3830	10		-	Screen	-	-	Open	12,6			5,5	4,778		
89	3840	10		-	Screen	-	-	Open	12,6			5,5	4,778		
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95	3894	16		-	Screen	-	-	Open	12,6			5,5	4,778		
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99	3934	16		-	Screen	-	-	Open	12,6			5,5	4,778		
100	3950	4		-	Screen	-	-	Open	12,6			5,5	4,778		

101	3954	16		-	Screen	-	-	Open	12,6			5,5	4,778
102	3970	10		-	Screen	-	-	Open	12,6			5,5	4,778
103	3980	10		-	Screen	-	-	Open	12,6			5,5	4,778
104	3990	10		-	Screen	-	-	Open	12,6			5,5	4,778
105	4000	4		-	Screen	-	-	Open	12,6			5,5	4,778
106	4004	16		-	Screen	-	-	Open	12,6			5,5	4,778
107	4020	10		-	Screen	-	-	Open	12,6			5,5	4,778
108	4030	10		-	Screen	-	-	Open	12,6			5,5	4,778
109	4040	10		-	Screen	-	-	Open	12,6			5,5	4,778
110	4050	10		-	Screen	-	-	Open	12,6			5,5	4,778
111	4060	10		-	Screen	-	-	Open	12,6			5,5	4,778
112	4070	10		-	Screen	-	-	Open	12,6			5,5	4,778
113	4080	10		-	Screen	-	-	Open	12,6			5,5	4,778
114	4090	10		-	Screen	-	-	Open	12,6			5,5	4,778
115	4100	10		-	Screen	-	-	Open	12,6			5,5	4,778
116	4110	10		-	Screen	-	-	Open	12,6			5,5	4,778
117	4120	10		-	Screen	-	-	Open	12,6			5,5	4,778
118	4130	10		-	Screen	-	-	Open	12,6			5,5	4,778
119	4140	10		-	Screen	-	-	Open	12,6			5,5	4,778
120	4150	10		-	Screen	-	-	Open	12,6			5,5	4,778
121	4160	10		-	Screen	-	-	Open	12,6			5,5	4,778
122	4170	10		-	Screen	-	-	Open	12,6			5,5	4,778
123	4180	10		-	Screen	-	-	Open	12,6			5,5	4,778
124	4190	10		-	Screen	-	-	Open	12,6			5,5	4,778
125	4200	10		-	Screen	-	-	Open	12,6			5,5	4,778
126	4210	10		-	Screen	-	-	Open	12,6			5,5	4,778
127	4220	10		-	Screen	-	-	Open	12,6			5,5	4,778
128	4230	4		-	Screen	-	-	Open	12,6			5,5	4,778
129	4234	16		-	Screen	-	-	Open	12,6			5,5	4,778
130	4250	10		-	Screen	-	-	Open	12,6			5,5	4,778
131	4260	10		-	Screen	-	-	Open	12,6			5,5	4,778
132	4270	10		-	Screen	-	-	Open	12,6			5,5	4,778
133	4280	4		-	Screen	-	-	Open	12,6			5,5	4,778
134	4284	16		-	Screen	-	-	Open	12,6			5,5	4,778
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137	4320	10		-	Screen	-	-	Open	12,6			5,5	4,778
138	4330	4		-	Screen	-	-	Open	12,6			5,5	4,778
139	4334	16		-	Screen	-	-	Open	12,6			5,5	4,778
140	4350	10		-	Screen	-	-	Open	12,6			5,5	4,778
141	4360	10		-	Screen	-	-	Open	12,6			5,5	4,778
142	4370	10		-	Screen	-	-	Open	12,6			5,5	4,778
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145	4400	10		-	Screen	-	-	Open	12,6			5,5	4,778
146	4410	10		-	Screen	-	-	Open	12,6			5,5	4,778
147	4420	4		-	Screen	-	-	Open	12,6			5,5	4,778
148	4424	16		-	Screen	-	-	Open	12,6			5,5	4,778
149	4440	10		-	Screen	-	-	Open	12,6			5,5	4,778
150	4450	10		-	Screen	-	-	Open	12,6			5,5	4,778
151	4460	10		-	Screen	-	-	Open	12,6			5,5	4,778
152	4470	10		-	Screen	-	-	Open	12,6			5,5	4,778
153	4480	10		-	Screen	-	-	Open	12,6			5,5	4,778
154	4490	4		-	Screen	-	-	Open	12,6			5,5	4,778
155	4494	16		-	Screen	-	-	Open	12,6			5,5	4,778
156	4510	4		-	Screen	-	-	Open	12,6			5,5	4,778
157	4514	16		-	Screen	-	-	Open	12,6			5,5	4,778
158	4530	10		-	Screen	-	-	Open	12,6			5,5	4,778
159	4540	4		-	Screen	-	-	Open	12,6			5,5	4,778
160	4544	16		-	Screen	-	-	Open	12,6			5,5	4,778
161	4560	10		-	Screen	-	-	Open	12,6			5,5	4,778
162	4570	10		-	Screen	-	-	Open	12,6			5,5	4,778
163	4580	10		-	Screen	-	-	Open	12,6			5,5	4,778
164	4590	4		-	Screen	-	-	Open	12,6			5,5	4,778
165	4594	16		-	Screen	-	-	Open	12,6			5,5	4,778
166	4610	10		-	Screen	-	-	Open	12,6			5,5	4,778
167	4620	10		-	Screen	-	-	Open	12,6			5,5	4,778
168	4630	10		-	Screen	-	-	Open	12,6			5,5	4,778
169	4640	4		-	Screen	-	-	Open	12,6			5,5	4,778
170	4644	16		-	Screen	-	-	Open	12,6			5,5	4,778
171	4660	10		-	Screen	-	-	Open	12,6			5,5	4,778
172	4670	10		-	Screen	-	-	Open	12,6			5,5	4,778
173	4680	10		-	Screen	-	-	Open	12,6			5,5	4,778
174	4690	10		-	Screen	-	-	Open	12,6			5,5	4,778
175	4700	10		-	Screen	-	-	Open	12,6			5,5	4,778
176	4710	10		-	Screen	-	-	Open	12,6			5,5	4,778
177	4720	10		-	Screen	-	-	Open	12,6			5,5	4,778
178	4730	10		-	Screen	-	-	Open	12,6			5,5	4,778
179	4740	4		-	Screen	-	-	Open	12,6			5,5	4,778
180	4744	16		-	Screen	-	-	Open	12,6			5,5	4,778
181	4760	20		-	Screen	-	-	Open	12,6			5,5	4,778
182	4780	10		-	Screen	-	-	Open	12,6			5,5	4,778
183	4790	10		-	Screen	-	-	Open	12,6			5,5	4,778
184	4800	10		-	Screen	-	-	Open	12,6			5,5	4,778
185	4810	4		-	Screen	-	-	Open	12,6			5,5	4,778
186	4814	16		-	Screen	-	-	Open	12,6			5,5	4,778
187	4830	4		-	Screen	-	-	Open	12,6			5,5	4,778
188	4834	16		-	Screen	-	-	Open	12,6			5,5	4,778
189	4850	5		-	Screen	-	-	Plug	12,6			5,5	4,778
TOE	4855												

Lateral: Completion conventional case and ICV cases

Seg #	Segment Top MD	Segment Length	Casing/Liner	Sand Control	Inflow Control	Stinger	Tubing	Well Hole Size	Liner OD	Liner ID	Sand Control OD	Sand Control ID
	[m]	[m]						[in]	[in]	[in]	[in]	[in]
1	3236,303	99,997	Blank Pipe	-	-	-	Open	8,5	7,63	6,5		
2	3336,3	100	Blank Pipe	-	-	-	Open	8,5	7,63	6,5		
3	3436,3	100	Blank Pipe	-	-	-	Open	8,5	7,63	6,5		
4	3536,3	4	Cemented B.P.	-	-	-	Open	8,5	8,5	6,5		
5	3540,3	10	Cemented B.P.	-	-	-	Open	8,5	8,5	6,5		
6	3550,3	9,7	Cemented B.P.	-	-	-	Open	8,5	8,5	6,5		
7	3560	4	Cemented B.P.	Packer	-	-	Open	8,5	8,5	6,5	6,5	4,778
8	3564	16	-	Screen	-	-	Open	8,5			5,5	4,778
9	3580	10	-	Screen	-	-	Open	8,5			5,5	4,778
10	3590	10	-	Screen	-	-	Open	8,5			5,5	4,778
11	3600	4	-	Screen	-	-	Open	8,5			5,5	4,778
12	3604	16	-	Screen	-	-	Open	8,5			5,5	4,778
13	3620	10	-	Screen	-	-	Open	8,5			5,5	4,778
14	3630	10	-	Screen	-	-	Open	8,5			5,5	4,778
15	3640	10	-	Screen	-	-	Open	8,5			5,5	4,778
16	3650	10	-	Screen	-	-	Open	8,5			5,5	4,778
17	3660	10	-	Screen	-	-	Open	8,5			5,5	4,778
18	3670	10	-	Screen	-	-	Open	8,5			5,5	4,778
19	3680	10	-	Screen	-	-	Open	8,5			5,5	4,778
20	3690	10	-	Screen	-	-	Open	8,5			5,5	4,778
21	3700	10	-	Screen	-	-	Open	8,5			5,5	4,778
22	3710	10	-	Screen	-	-	Open	8,5			5,5	4,778
23	3720	10	-	Screen	-	-	Open	8,5			5,5	4,778
24	3730	4	-	Screen	-	-	Open	8,5			5,5	4,778
25	3734	16	-	Screen	-	-	Open	8,5			5,5	4,778
26	3750	10	-	Screen	-	-	Open	8,5			5,5	4,778
27	3760	10	-	Screen	-	-	Open	8,5			5,5	4,778
28	3770	10	-	Screen	-	-	Open	8,5			5,5	4,778
29	3780	10	-	Screen	-	-	Open	8,5			5,5	4,778
30	3790	4	-	Screen	-	-	Open	8,5			5,5	4,778
31	3794	16	-	Screen	-	-	Open	8,5			5,5	4,778
32	3810	10	-	Screen	-	-	Open	8,5			5,5	4,778
33	3820	10	-	Screen	-	-	Open	8,5			5,5	4,778
34	3830	10	-	Screen	-	-	Open	8,5			5,5	4,778
35	3840	10	-	Screen	-	-	Open	8,5			5,5	4,778
36	3850	10	-	Screen	-	-	Open	8,5			5,5	4,778
37	3860	10	-	Screen	-	-	Open	8,5			5,5	4,778
38	3870	10	-	Screen	-	-	Open	8,5			5,5	4,778
39	3880	10	-	Screen	-	-	Open	8,5			5,5	4,778
40	3890	10	-	Screen	-	-	Open	8,5			5,5	4,778
41	3900	10	-	Screen	-	-	Open	8,5			5,5	4,778
42	3910	10	-	Screen	-	-	Open	8,5			5,5	4,778
43	3920	4	-	Screen	-	-	Open	8,5			5,5	4,778
44	3924	16	-	Screen	-	-	Open	8,5			5,5	4,778
45	3940	10	-	Screen	-	-	Open	8,5			5,5	4,778
46	3950	10	-	Screen	-	-	Open	8,5			5,5	4,778
47	3960	10	-	Screen	-	-	Open	8,5			5,5	4,778
48	3970	10	-	Screen	-	-	Open	8,5			5,5	4,778
49	3980	10	-	Screen	-	-	Open	8,5			5,5	4,778
50	3990	10	-	Screen	-	-	Open	8,5			5,5	4,778
51	4000	10	-	Screen	-	-	Open	8,5			5,5	4,778
52	4010	10	-	Screen	-	-	Open	8,5			5,5	4,778
53	4020	10	-	Screen	-	-	Open	8,5			5,5	4,778
54	4030	10	-	Screen	-	-	Open	8,5			5,5	4,778
55	4040	10	-	Screen	-	-	Open	8,5			5,5	4,778
56	4050	10	-	Screen	-	-	Open	8,5			5,5	4,778
57	4060	10	-	Screen	-	-	Open	8,5			5,5	4,778
58	4070	10	-	Screen	-	-	Open	8,5			5,5	4,778
59	4080	10	-	Screen	-	-	Open	8,5			5,5	4,778
60	4090	4	-	Screen	-	-	Open	8,5			5,5	4,778
61	4094	16	-	Screen	-	-	Open	8,5			5,5	4,778
62	4110	10	-	Screen	-	-	Open	8,5			5,5	4,778
63	4120	10	-	Screen	-	-	Open	8,5			5,5	4,778
64	4130	10	-	Screen	-	-	Open	8,5			5,5	4,778
65	4140	10	-	Screen	-	-	Open	8,5			5,5	4,778
66	4150	10	-	Screen	-	-	Open	8,5			5,5	4,778
67	4160	10	-	Screen	-	-	Open	8,5			5,5	4,778
68	4170	10	-	Screen	-	-	Open	8,5			5,5	4,778
69	4180	10	-	Screen	-	-	Open	8,5			5,5	4,778
70	4190	10	-	Screen	-	-	Open	8,5			5,5	4,778

71	4200	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
72	4210	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
73	4220	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
74	4230	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
75	4240	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
76	4250	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
77	4260	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
78	4270	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
79	4280	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
80	4290	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
81	4300	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
82	4310	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
83	4320	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
84	4330	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
85	4334	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
86	4344	16	-	**Screen**	-	-	Open	8,5			5,5	4,778
87	4360	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
88	4370	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
89	4380	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
90	4384	16	-	**Screen**	-	-	Open	8,5			5,5	4,778
91	4400	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
92	4410	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
93	4420	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
94	4430	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
95	4440	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
96	4450	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
97	4460	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
98	4464	16	-	**Screen**	-	-	Open	8,5			5,5	4,778
99	4480	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
100	4490	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
101	4500	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
102	4510	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
103	4520	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
104	4530	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
105	4540	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
106	4550	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
107	4560	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
108	4564	16	-	**Screen**	-	-	Open	8,5			5,5	4,778
109	4580	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
110	4590	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
111	4594	16	-	**Screen**	-	-	Open	8,5			5,5	4,778
112	4610	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
113	4620	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
114	4624	16	-	**Screen**	-	-	Open	8,5			5,5	4,778
115	4640	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
116	4650	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
117	4660	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
118	4670	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
119	4680	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
120	4690	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
121	4700	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
122	4704	16	-	**Screen**	-	-	Open	8,5			5,5	4,778
123	4720	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
124	4730	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
125	4740	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
126	4750	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
127	4760	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
128	4770	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
129	4774	4	-	**Screen**	-	-	Open	8,5			5,5	4,778
130	4778	32	-	**Screen**	-	-	Open	8,5			5,5	4,778
131	4810	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
132	4820	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
133	4830	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
134	4840	10	-	**Screen**	-	-	Open	8,5			5,5	4,778
135	4850	10	-	**Screen**	-	-	**Plug**	8,5			5,5	4,778
TOE	4860											

Lateral: Completion ICD cases

N parallel Nozzles - 2
Nozzle diameter (mm) – 2
Nozzle coefficient – 0.790569
Connected to reservoir – from 3564

Seg #	Segment Top MD [m]	Segment Length [m]	Casing/Liner	Sand Control	Inflow Control	Stinger	Tubing	Well Hole Size [in]	Liner OD [in]	Liner ID [in]	Inflow Control OD [in]	Inflow Control ID [in]
1	3236,303	99,997	Blank Pipe	-	-	-	Open	8,5	7,63	6,5		
2	3336,3	100	Blank Pipe	-	-	-	Open	8,5	7,63	6,5		
3	3436,3	100	Blank Pipe	-	-	-	Open	8,5	7,63	6,5		
4	3536,3	4	Cemented B.P.	-	-	-	Open	8,5	8,5	6,5		
5	3540,3	10	Cemented B.P.	-	-	-	Open	8,5	8,5	6,5		
6	3550,3	9,7	Cemented B.P.	-	-	-	Open	8,5	8,5	6,5		
7	3560	4	Cemented B.P.	-	Packer	-	Open	8,5	8,5	6,5	6,5	4,778
8	3564	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
9	3580	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
10	3590	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
11	3600	4	-	-	Packer	-	Open	8,5			8,5	4,778
12	3604	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
13	3620	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
14	3630	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
15	3640	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
16	3650	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
17	3660	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
18	3670	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
19	3680	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
20	3690	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
21	3700	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
22	3710	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
23	3720	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
24	3730	4	-	-	Packer	-	Open	8,5			8,5	4,778
25	3734	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
26	3750	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
27	3760	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
28	3770	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
29	3780	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
30	3790	4	-	-	Packer	-	Open	8,5			8,5	4,778
31	3794	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
32	3810	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
33	3820	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
34	3830	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
35	3840	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
36	3850	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
37	3860	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
38	3870	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
39	3880	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
40	3890	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
41	3900	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
42	3910	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
43	3920	4	-	-	Packer	-	Open	8,5			8,5	4,778
44	3924	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
45	3940	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
46	3950	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
47	3960	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
48	3970	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
49	3980	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
50	3990	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
51	4000	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
52	4010	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
53	4020	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
54	4030	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
55	4040	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
56	4050	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
57	4060	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
58	4070	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
59	4080	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
60	4090	4	-	-	Packer	-	Open	8,5			8,5	4,778
61	4094	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
62	4110	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
63	4120	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
64	4130	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
65	4140	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
66	4150	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
67	4160	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
68	4170	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
69	4180	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
70	4190	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778

71	4200	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
72	4210	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
73	4220	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
74	4230	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
75	4240	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
76	4250	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
77	4260	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
78	4270	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
79	4280	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
80	4290	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
81	4300	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
82	4310	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
83	4320	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
84	4330	4	-	-	Packer	-	Open	8,5			8,5	4,778
85	4334	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
86	4344	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
87	4360	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
88	4370	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
89	4380	4	-	-	Packer	-	Open	8,5			8,5	4,778
90	4384	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
91	4400	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
92	4410	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
93	4420	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
94	4430	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
95	4440	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
96	4450	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
97	4460	4	-	-	Packer	-	Open	8,5			8,5	4,778
98	4464	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
99	4480	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
100	4490	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
101	4500	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
102	4510	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
103	4520	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
104	4530	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
105	4540	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
106	4550	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
107	4560	4	-	-	Packer	-	Open	8,5			8,5	4,778
108	4564	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
109	4580	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
110	4590	4	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
111	4594	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
112	4610	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
113	4620	4	-	-	Packer	-	Open	8,5			8,5	4,778
114	4624	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
115	4640	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
116	4650	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
117	4660	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
118	4670	10	-	-	Packer	-	Open	8,5			8,5	4,778
119	4680	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
120	4690	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
121	4700	4	-	-	Packer	-	Open	8,5			8,5	4,778
122	4704	16	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
123	4720	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
124	4730	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
125	4740	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
126	4750	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
127	4760	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
128	4770	4	-	-	Packer	-	Open	8,5			8,5	4,778
129	4774	4	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
130	4778	32	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
131	4810	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
132	4820	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
133	4830	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
134	4840	10	-	-	Nozzle ICD	-	Open	8,5			5,5	4,778
135	4850	10	-	-	Nozzle ICD	-	Plug	8,5			5,5	4,778
TOE	4860											

<u>ICV ana. With ICV to stop flow from laterat or mainbore</u>:

Mainbore (where the ICVs are placed):

Seg #	Segment Top MD [m]	Segment Length [m]	Lateral Connection	Casing/Liner	Sand Control	Inflow Control	Stinger	Tubing	Well Hole Size [in]	Liner OD [in]	Liner ID [in]	Sand Control OD [in]	Sand Control ID [in]	Inflow Control OD [in]	Inflow Control ID [in]
1	0	20		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	8,63			3,5	2,9
2	20	180		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
3	200	180		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
4	380	120		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
5	500	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
6	600	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
7	700	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
8	800	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
9	900	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
10	1000	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
11	1100	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	9,88	8,63			3,5	2,9
12	1200	50		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	8,63			3,5	2,9
13	1250	4		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	8,63			3,5	2,9
14	1254	50		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	7,63			3,5	2,9
15	1304	200		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
16	1504	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
17	1604	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
18	1704	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
19	1804	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
20	1904	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
21	2004	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
22	2104	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
23	2204	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
24	2304	50		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
25	2354	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	8,63	7,63			3,5	2,9
26	2374	4		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	7,63			3,5	2,9
27	2378	70		Cemented B.P.	-	Blank Pipe	-	Open	12,6	12,6	6,5			3,5	2,9
28	2448	70		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
29	2518	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
30	2538	34		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
31	2572	10		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
32	2582	48		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
33	2630	4		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
34	2634	4		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
35	2638	100		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
36	2738	12		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
37	2750	350		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
38	3100	116		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
39	3216	4		Blank Pipe	-	Packer	-	Open	12,6	7,63	6,5			6,5	2,9
40	3220	4		Blank Pipe	-	ICV	-	Open	12,6	7,63	6,5			5,85	2,75
41	3224	6		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
42	3230	6,303		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
42	3236,303	0	To Annulus [Inflow Control]					Open	12,6					3,5	2,9
43	3236,303	49,997		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
44	3286,3	13,7		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
45	3300	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
46	3320	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
47	3340	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
48	3360	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
49	3380	20		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
50	3400	36,3		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
51	3436,3	4		Blank Pipe	-	Packer	-	Open	12,6	7,63	6,5			6,5	2,9
52	3440,3	4		Blank Pipe	-	ICV	-	Open	12,6	7,63	6,5			5,85	2,75
53	3444,3	25		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
54	3469,3	29		Blank Pipe	-	Blank Pipe	-	Open	12,6	7,63	6,5			3,5	2,9
55	3498,3	4		Cemented B.P.	-	Packer	-	Open	12,6	12,6	6,5			6,5	2,9
56	3502,3	4		Cemented B.P.	Packer	-	-	Open	12,6	12,6	6,5	6,5	4,778		
57	3506,3	23,7		-	Screen	-	-	Open	12,6			5,5	4,778		
58	3530	10		-	Screen	-	-	Open	12,6			5,5	4,778		
59	3540	10		-	Screen	-	-	Open	12,6			5,5	4,778		
60	3550	10		-	Screen	-	-	Open	12,6			5,5	4,778		

61	3560	10	-	Screen	-	-	Open	12,6	5,5	4,778
62	3570	4	-	Screen	-	-	Open	12,6	5,5	4,778
63	3574	16	-	Screen	-	-	Open	12,6	5,5	4,778
64	3590	10	-	Screen	-	-	Open	12,6	5,5	4,778
65	3600	10	-	Screen	-	-	Open	12,6	5,5	4,778
66	3610	10	-	Screen	-	-	Open	12,6	5,5	4,778
67	3620	10	-	Screen	-	-	Open	12,6	5,5	4,778
68	3630	10	-	Screen	-	-	Open	12,6	5,5	4,778
69	3640	10	-	Screen	-	-	Open	12,6	5,5	4,778
70	3650	10	-	Screen	-	-	Open	12,6	5,5	4,778
71	3660	10	-	Screen	-	-	Open	12,6	5,5	4,778
72	3670	10	-	Screen	-	-	Open	12,6	5,5	4,778
73	3680	4	-	Screen	-	-	Open	12,6	5,5	4,778
74	3684	16	-	Screen	-	-	Open	12,6	5,5	4,778
75	3700	10	-	Screen	-	-	Open	12,6	5,5	4,778
76	3710	10	-	Screen	-	-	Open	12,6	5,5	4,778
77	3720	10	-	Screen	-	-	Open	12,6	5,5	4,778
78	3730	10	-	Screen	-	-	Open	12,6	5,5	4,778
79	3740	4	-	Screen	-	-	Open	12,6	5,5	4,778
80	3744	16	-	Screen	-	-	Open	12,6	5,5	4,778
81	3760	10	-	Screen	-	-	Open	12,6	5,5	4,778
82	3770	10	-	Screen	-	-	Open	12,6	5,5	4,778
83	3780	10	-	Screen	-	-	Open	12,6	5,5	4,778
84	3790	10	-	Screen	-	-	Open	12,6	5,5	4,778
85	3800	10	-	Screen	-	-	Open	12,6	5,5	4,778
86	3810	10	-	Screen	-	-	Open	12,6	5,5	4,778
87	3820	10	-	Screen	-	-	Open	12,6	5,5	4,778
88	3830	10	-	Screen	-	-	Open	12,6	5,5	4,778
89	3840	10	-	Screen	-	-	Open	12,6	5,5	4,778
90	3850	10	-	Screen	-	-	Open	12,6	5,5	4,778
91	3860	10	-	Screen	-	-	Open	12,6	5,5	4,778
92	3870	10	-	Screen	-	-	Open	12,6	5,5	4,778
93	3880	10	-	Screen	-	-	Open	12,6	5,5	4,778
94	3890	4	-	Screen	-	-	Open	12,6	5,5	4,778
95	3894	16	-	Screen	-	-	Open	12,6	5,5	4,778
96	3910	10	-	Screen	-	-	Open	12,6	5,5	4,778
97	3920	10	-	Screen	-	-	Open	12,6	5,5	4,778
98	3930	4	-	Screen	-	-	Open	12,6	5,5	4,778
99	3934	16	-	Screen	-	-	Open	12,6	5,5	4,778
100	3950	4	-	Screen	-	-	Open	12,6	5,5	4,778
101	3954	16	-	Screen	-	-	Open	12,6	5,5	4,778
102	3970	10	-	Screen	-	-	Open	12,6	5,5	4,778
103	3980	10	-	Screen	-	-	Open	12,6	5,5	4,778
104	3990	10	-	Screen	-	-	Open	12,6	5,5	4,778
105	4000	4	-	Screen	-	-	Open	12,6	5,5	4,778
106	4004	16	-	Screen	-	-	Open	12,6	5,5	4,778
107	4020	10	-	Screen	-	-	Open	12,6	5,5	4,778
108	4030	10	-	Screen	-	-	Open	12,6	5,5	4,778
109	4040	10	-	Screen	-	-	Open	12,6	5,5	4,778
110	4050	10	-	Screen	-	-	Open	12,6	5,5	4,778
111	4060	10	-	Screen	-	-	Open	12,6	5,5	4,778
112	4070	10	-	Screen	-	-	Open	12,6	5,5	4,778
113	4080	10	-	Screen	-	-	Open	12,6	5,5	4,778
114	4090	10	-	Screen	-	-	Open	12,6	5,5	4,778
115	4100	10	-	Screen	-	-	Open	12,6	5,5	4,778
116	4110	10	-	Screen	-	-	Open	12,6	5,5	4,778
117	4120	10	-	Screen	-	-	Open	12,6	5,5	4,778
118	4130	10	-	Screen	-	-	Open	12,6	5,5	4,778
119	4140	10	-	Screen	-	-	Open	12,6	5,5	4,778
120	4150	10	-	Screen	-	-	Open	12,6	5,5	4,778
121	4160	10	-	Screen	-	-	Open	12,6	5,5	4,778
122	4170	10	-	Screen	-	-	Open	12,6	5,5	4,778
123	4180	10	-	Screen	-	-	Open	12,6	5,5	4,778
124	4190	10	-	Screen	-	-	Open	12,6	5,5	4,778
125	4200	10	-	Screen	-	-	Open	12,6	5,5	4,778
126	4210	10	-	Screen	-	-	Open	12,6	5,5	4,778
127	4220	10	-	Screen	-	-	Open	12,6	5,5	4,778
128	4230	4	-	Screen	-	-	Open	12,6	5,5	4,778
129	4234	16	-	Screen	-	-	Open	12,6	5,5	4,778
130	4250	10	-	Screen	-	-	Open	12,6	5,5	4,778

131	4260	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
132	4270	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
133	4280	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
134	4284	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
135	4300	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
136	4310	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
137	4320	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
138	4330	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
139	4334	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
140	4350	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
141	4360	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
142	4370	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
143	4380	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
144	4390	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
145	4400	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
146	4410	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
147	4420	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
148	4424	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
149	4440	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
150	4450	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
151	4460	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
152	4470	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
153	4480	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
154	4490	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
155	4494	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
156	4510	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
157	4514	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
158	4530	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
159	4540	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
160	4544	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
161	4560	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
162	4570	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
163	4580	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
164	4590	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
165	4594	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
166	4610	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
167	4620	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
168	4630	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
169	4640	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
170	4644	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
171	4660	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
172	4670	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
173	4680	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
174	4690	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
175	4700	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
176	4710	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
177	4720	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
178	4730	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
179	4740	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
180	4744	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
181	4760	20		-	**Screen**	-	-	Open	12,6			5,5	4,778		
182	4780	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
183	4790	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
184	4800	10		-	**Screen**	-	-	Open	12,6			5,5	4,778		
185	4810	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
186	4814	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
187	4830	4		-	**Screen**	-	-	Open	12,6			5,5	4,778		
188	4834	16		-	**Screen**	-	-	Open	12,6			5,5	4,778		
189	4850	5		-	**Screen**	-	-	**Plug**	12,6			5,5	4,778		
TOE	4855														

A.3: Well Trajectory

Mainbore		
East	North	TVD
0	400	0
0	400	50
0	400	500
0	400	750
0	400	1000
6,65	390,69	1715,49
12,63	382,31	2095,07
15,46	378,35	2440,14
24,11	366,24	2785,21
36,27	349,22	3061,27
42,16	340,98	3234,6
44,54	337,65	3302,82
50	330	3440,85
50	330	3441,78
50	330	3480
50	330,45	3500
56,17	331,72	3500
79,15	329,35	3500
112,34	330,07	3500
191,49	331,72	3500
262,98	331,72	3500
337,02	331,72	3500
421,28	332,9	3500
505,53	337,63	3500
546,38	342,37	3500
569,36	341,18	3500
594,89	344,73	3500
628,58	343,31	3500
656,41	348,89	3500
687,33	350	3500
721,35	351,68	3500
752,27	355,86	3500
789,37	360,05	3500
816,77	357,26	3500
841,03	358,65	3500
865,3	360,05	3500
925,96	363,86	3500
965,39	363,86	3500
998,75	365,24	3500
1035,15	365,24	3500
1074,58	363,86	3500
1110,98	366,63	3500
1138,28	368,01	3500
1156,47	370,78	3500
1177,71	369,4	3500
1211,07	370,78	3500
1250,5	370,78	3500
1292,96	372,17	3500
1331,92	374,94	3500
1340	377,7	3500
1353,24	379,09	3500
1368,47	384,69	3500
1450	386,04	3500
1500	384,69	3500
1560	386,04	3500
1600	387,39	3500
1600	390,73	3500
1600	390,09	3500
1600	391,44	3500

Lateral		
East	North	TVD
42,16	340,98	3234,6
160,32	334,08	3271,57
249,6	330,54	3289,52
352,34	330,54	3300
445,99	332,9	3300
569,36	340	3300
698,5	348,28	3300
736,76	347,1	3300
762,27	349,46	3300
789,47	350,01	3300
819,8	348,63	3300
850,13	348,63	3300
883,5	344,48	3300
913,83	340,32	3300
947,19	337,55	3300
1016,95	336,17	3300
1093,85	338,82	3300
1200	340	3300
1339,3	337,63	3300
1417,77	332,9	3300
1499,39	324,62	3300
1573,36	316,34	3300
1634,57	308,06	3300
1703,44	297,41	3300
1800	280	3300

A.4: Permeability and water saturation

Permeability and water saturation: **Mainbore:**

Distance form heel	MD	Perm. mD	Av. Perm.	Sw Early	Sw Mid	Sw late
0	3520	50	246,1926	0,193734	0,193734	0,193734
10	3530	50	246,1926	0,193734	0,193734	0,193734
20	3540	4	246,1926	0,479877	0,479877	0,479877
30	3550	20	246,1926	0,241028	0,241028	0,241028
40	3560	100	246,1926	0,175119	0,175119	0,175119
50	3570	500	246,1926	0,156931	0,156931	0,156931
60	3580	500	246,1926	0,156931	0,156931	0,156931
70	3590	500	246,1926	0,156931	0,156931	0,156931
80	3600	500	246,1926	0,156931	0,156931	0,156931
90	3610	200	246,1926	0,164427	0,164427	0,164427
100	3620	200	246,1926	0,164427	0,164427	0,164427
110	3630	200	246,1926	0,164427	0,164427	0,164427
120	3640	200	246,1926	0,164427	0,164427	0,164427
130	3650	200	246,1926	0,164427	0,164427	0,164427
140	3660	200	246,1926	0,164427	0,164427	0,164427
150	3670	200	246,1926	0,164427	0,164427	0,164427
160	3680	200	246,1926	0,164427	0,164427	0,164427
170	3690	90	246,1926	0,177328	0,177328	0,177328
180	3700	90	246,1926	0,177328	0,177328	0,177328
190	3710	5	246,1926	0,425946	0,425946	0,425946
200	3720	5	246,1926	0,425946	0,425946	0,425946
210	3730	5	246,1926	0,425946	0,425946	0,425946
220	3740	90	246,1926	0,177328	0,177328	0,177328
230	3750	90	246,1926	0,177328	0,177328	0,177328
240	3760	90	246,1926	0,177328	0,177328	0,177328
250	3770	90	246,1926	0,177328	0,177328	0,177328
260	3780	90	246,1926	0,177328	0,177328	0,177328
270	3790	80	246,1926	0,180028	0,180028	0,180028
280	3800	80	246,1926	0,180028	0,180028	0,180028
290	3810	100	246,1926	0,175119	0,175119	0,175119
300	3820	100	246,1926	0,175119	0,175119	0,175119
310	3830	100	246,1926	0,175119	0,175119	0,175119
320	3840	90	246,1926	0,177328	0,177328	0,177328
330	3850	90	246,1926	0,177328	0,177328	0,177328
340	3860	90	246,1926	0,177328	0,177328	0,177328
350	3870	90	246,1926	0,177328	0,177328	0,177328
360	3880	100	246,1926	0,175119	0,175119	0,175119
370	3890	100	246,1926	0,175119	0,175119	0,175119
380	3900	90	246,1926	0,177328	0,177328	0,177328
390	3910	400	246,1926	0,158286	0,158286	0,158286
400	3920	400	246,1926	0,158286	0,158286	0,158286
410	3930	500	246,1926	0,156931	0,156931	0,156931
420	3940	550	246,1926	0,156423	0,156423	0,156423
430	3950	600	246,1926	0,155991	0,155991	0,155991
440	3960	90	246,1926	0,177328	0,177328	0,177328
450	3970	100	246,1926	0,175119	0,175119	0,175119
460	3980	100	246,1926	0,175119	0,175119	0,175119
470	3990	100	246,1926	0,175119	0,175119	0,175119
480	4000	600	246,1926	0,155991	0,155991	0,155991
490	4010	400	246,1926	0,158286	0,158286	0,158286
500	4020	400	246,1926	0,158286	0,158286	0,158286
510	4030	400	246,1926	0,158286	0,158286	0,158286
520	4040	400	246,1926	0,158286	0,158286	0,158286
530	4050	400	246,1926	0,158286	0,158286	0,158286
540	4060	600	246,1926	0,155991	0,155991	0,155991
550	4070	600	246,1926	0,155991	0,155991	0,155991
560	4080	600	246,1926	0,155991	0,155991	0,155991
570	4090	600	246,1926	0,155991	0,155991	0,155991
580	4100	600	246,1926	0,155991	0,155991	0,155991
590	4110	400	246,1926	0,158286	0,158286	0,158286
600	4120	400	246,1926	0,158286	0,158286	0,158286
610	4130	400	246,1926	0,158286	0,158286	0,158286

620	4140	400	246,1926	0,158286	0,158286	0,158286
630	4150	400	246,1926	0,158286	0,158286	0,158286
640	4160	400	246,1926	0,158286	0,158286	0,158286
650	4170	300	246,1926	0,16043	0,16043	0,16043
660	4180	300	246,1926	0,16043	0,16043	0,16043
670	4190	300	246,1926	0,16043	0,16043	0,16043
680	4200	300	246,1926	0,16043	0,16043	0,16043
690	4210	300	246,1926	0,16043	0,16043	0,16043
700	4220	300	246,1926	0,16043	0,16043	0,16043
710	4230	600	246,1926	0,155991	0,155991	0,155991
720	4240	50	246,1926	0,193734	0,193734	0,193734
730	4250	100	246,1926	0,175119	0,175119	0,175119
740	4260	100	246,1926	0,175119	0,175119	0,175119
750	4270	100	246,1926	0,175119	0,175119	0,175119
760	4280	200	246,1926	0,164427	0,164427	0,164427
770	4290	50	246,1926	0,193734	0,193734	0,193734
780	4300	90	246,1926	0,177328	0,177328	0,177328
790	4310	20	246,1926	0,241028	0,241028	0,241028
800	4320	100	246,1926	0,175119	0,175119	0,175119
810	4330	500	246,1926	0,156931	0,156931	0,3
820	4340	500	246,1926	0,156931	0,156931	0,3
830	4350	500	246,1926	0,156931	0,156931	0,3
840	4360	500	246,1926	0,156931	0,156931	0,3
850	4370	500	246,1926	0,156931	0,156931	0,3
860	4380	500	246,1926	0,156931	0,156931	0,3
870	4390	500	246,1926	0,156931	0,156931	0,3
880	4400	500	246,1926	0,156931	0,156931	0,3
890	4410	500	246,1926	0,156931	0,156931	0,3
900	4420	700	246,1926	0,155296	0,155296	0,3
910	4430	10	246,1926	0,308489	0,308489	0,308489
920	4440	10	246,1926	0,308489	0,308489	0,308489
930	4450	2	246,1926	0,724349	0,724349	0,724349
940	4460	30	246,1926	0,215812	0,215812	0,215812
950	4470	30	246,1926	0,215812	0,215812	0,215812
960	4480	30	246,1926	0,215812	0,215812	0,215812
970	4490	100	246,1926	0,175119	0,175119	0,175119
980	4500	100	246,1926	0,175119	0,175119	0,175119
990	4510	100	246,1926	0,175119	0,175119	0,175119
1000	4520	5	246,1926	0,425946	0,425946	0,425946
1010	4530	10	246,1926	0,308489	0,308489	0,308489
1020	4540	100	246,1926	0,175119	0,175119	0,175119
1030	4550	100	246,1926	0,175119	0,175119	0,175119
1040	4560	100	246,1926	0,175119	0,175119	0,175119
1050	4570	100	246,1926	0,175119	0,175119	0,175119
1060	4580	100	246,1926	0,175119	0,175119	0,175119
1070	4590	100	246,1926	0,175119	0,175119	0,175119
1080	4600	50	246,1926	0,193734	0,193734	0,193734
1090	4610	10	246,1926	0,308489	0,308489	0,308489
1100	4620	50	246,1926	0,193734	0,193734	0,193734
1110	4630	10	246,1926	0,308489	0,308489	0,308489
1120	4640	600	246,1926	0,155991	0,155991	0,4
1130	4650	700	246,1926	0,155296	0,155296	0,4
1140	4660	600	246,1926	0,155991	0,155991	0,4
1150	4670	500	246,1926	0,156931	0,156931	0,4
1160	4680	500	246,1926	0,156931	0,156931	0,4
1170	4690	500	246,1926	0,156931	0,156931	0,4
1180	4700	500	246,1926	0,156931	0,156931	0,4
1190	4710	400	246,1926	0,158286	0,158286	0,4
1200	4720	400	246,1926	0,158286	0,158286	0,4
1210	4730	400	246,1926	0,158286	0,158286	0,4
1220	4740	700	246,1926	0,155296	0,155296	0,4
1230	4750	100	246,1926	0,175119	0,175119	0,175119
1240	4760	100	246,1926	0,175119	0,175119	0,175119
1250	4770	200	246,1926	0,164427	0,164427	0,164427
1260	4780	50	246,1926	0,193734	0,193734	0,193734
1270	4790	100	246,1926	0,175119	0,175119	0,35
1280	4800	100	246,1926	0,175119	0,175119	0,35
1290	4810	200	246,1926	0,164427	0,164427	0,4
1300	4820	200	246,1926	0,164427	0,164427	0,4
1310	4830	200	246,1926	0,164427	0,164427	0,4
1320	4840	100	246,1926	0,175119	0,175119	0,175119
1330	4850	10	246,1926	0,308489	0,308489	0,308489
1340	4860	100	246,1926	0,175119	0,175119	0,175119

Permeability and water saturation: **Lateral:**

Lateral							
Distance from heel	MD	Perm. Md	Av. Perm.	Sw- ICD case	Sw Early	Sw Mid	Sw ICV late
0	3570	200	182,6744186	0,650000	0,165695747	0,165695747	0,35
10	3580	150	182,6744186	0,600000	0,169757545	0,169757545	0,35
20	3590	100	182,6744186	0,550000	0,177327883	0,177327883	0,35
30	3600	100	182,6744186	0,550000	0,177327883	0,177327883	0,35
40	3610	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
50	3620	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
60	3630	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
70	3640	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
80	3650	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
90	3660	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
100	3670	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
110	3680	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
120	3690	90	182,6744186	0,179731	0,179731169	0,179731169	0,17973117
130	3700	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
140	3710	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
150	3720	90	182,6744186	0,179731	0,179731169	0,179731169	0,17973117
160	3730	100	182,6744186	0,600000	0,177327883	0,177327883	0,4
170	3740	200	182,6744186	0,650000	0,165695747	0,165695747	0,4
180	3750	200	182,6744186	0,650000	0,165695747	0,165695747	0,4
190	3760	200	182,6744186	0,650000	0,165695747	0,165695747	0,4
200	3770	300	182,6744186	0,750000	0,16134773	0,16134773	0,4
210	3780	300	182,6744186	0,750000	0,16134773	0,16134773	0,4
220	3790	300	182,6744186	0,750000	0,16134773	0,16134773	0,4
230	3800	10	182,6744186	0,322427	0,322427286	0,322427286	0,32242729
240	3810	10	182,6744186	0,322427	0,322427286	0,322427286	0,32242729
250	3820	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
260	3830	50	182,6744186	0,197581	0,197580608	0,197580608	0,19758061
270	3840	60	182,6744186	0,191123	0,191123019	0,191123019	0,19112302
280	3850	60	182,6744186	0,191123	0,191123019	0,191123019	0,19112302
290	3860	60	182,6744186	0,191123	0,191123019	0,191123019	0,19112302
300	3870	60	182,6744186	0,191123	0,191123019	0,191123019	0,19112302
310	3880	30	182,6744186	0,221599	0,221599335	0,221599335	0,22159933
320	3890	30	182,6744186	0,221599	0,221599335	0,221599335	0,22159933
330	3900	30	182,6744186	0,221599	0,221599335	0,221599335	0,22159933
340	3910	30	182,6744186	0,221599	0,221599335	0,221599335	0,22159933
350	3920	200	182,6744186	0,600000	0,165695747	0,35	0,45
360	3930	300	182,6744186	0,650000	0,16134773	0,35	0,45
370	3940	500	182,6744186	0,750000	0,157541018	0,35	0,45
380	3950	300	182,6744186	0,750000	0,16134773	0,35	0,45
390	3960	350	182,6744186	0,750000	0,160031169	0,35	0,45
400	3970	250	182,6744186	0,750000	0,163129675	0,35	0,45
410	3980	350	182,6744186	0,750000	0,160031169	0,35	0,45
420	3990	250	182,6744186	0,750000	0,163129675	0,35	0,45
430	4000	350	182,6744186	0,750000	0,160031169	0,35	0,45
440	4010	200	182,6744186	0,600000	0,165695747	0,35	0,45
450	4020	400	182,6744186	0,700000	0,15901484	0,4	0,5
460	4030	300	182,6744186	0,700000	0,16134773	0,4	0,5
470	4040	300	182,6744186	0,700000	0,16134773	0,4	0,5
480	4050	200	182,6744186	0,650000	0,165695747	0,4	0,5
490	4060	400	182,6744186	0,750000	0,15901484	0,4	0,5
500	4070	350	182,6744186	0,700000	0,160031169	0,4	0,5
510	4080	250	182,6744186	0,700000	0,163129675	0,4	0,5
520	4090	300	182,6744186	0,700000	0,16134773	0,4	0,5
530	4100	100	182,6744186	0,177328	0,177327883	0,177327883	0,3
540	4110	50	182,6744186	0,197581	0,197580608	0,197580608	0,3
550	4120	50	182,6744186	0,197581	0,197580608	0,197580608	0,3
560	4130	50	182,6744186	0,197581	0,197580608	0,197580608	0,3
570	4140	50	182,6744186	0,197581	0,197580608	0,197580608	0,3
580	4150	50	182,6744186	0,197581	0,197580608	0,197580608	0,3
590	4160	20	182,6744186	0,249033	0,24903347	0,24903347	0,35
600	4170	20	182,6744186	0,249033	0,24903347	0,24903347	0,35
610	4180	20	182,6744186	0,249033	0,24903347	0,24903347	0,35

620	4190	20	182,6744186	0,249033	0,24903347	0,24903347
630	4200	30	182,6744186	0,221599	0,221599335	0,221599335
640	4210	50	182,6744186	0,197581	0,197580608	0,197580608
650	4220	50	182,6744186	0,197581	0,197580608	0,197580608
660	4230	50	182,6744186	0,197581	0,197580608	0,197580608
670	4240	50	182,6744186	0,197581	0,197580608	0,197580608
680	4250	50	182,6744186	0,197581	0,197580608	0,197580608
690	4260	50	182,6744186	0,197581	0,197580608	0,197580608
700	4270	50	182,6744186	0,197581	0,197580608	0,197580608
710	4280	50	182,6744186	0,197581	0,197580608	0,197580608
720	4290	50	182,6744186	0,197581	0,197580608	0,197580608
730	4300	50	182,6744186	0,197581	0,197580608	0,197580608
740	4310	50	182,6744186	0,197581	0,197580608	0,197580608
750	4320	50	182,6744186	0,197581	0,197580608	0,197580608
760	4330	300	182,6744186	0,700000	0,16134773	0,4
770	4340	250	182,6744186	0,700000	0,163129675	0,4
780	4350	350	182,6744186	0,700000	0,160031169	0,4
790	4360	200	182,6744186	0,700000	0,165695747	0,4
800	4370	300	182,6744186	0,700000	0,16134773	0,4
810	4380	500	182,6744186	0,700000	0,157541018	0,4
820	4390	100	182,6744186	0,177328	0,177327883	0,177327883
830	4400	50	182,6744186	0,197581	0,197580608	0,197580608
840	4410	5	182,6744186	0,450213	0,450213342	0,450213342
850	4420	5	182,6744186	0,450213	0,450213342	0,450213342
860	4430	10	182,6744186	0,322427	0,322427286	0,322427286
870	4440	80	182,6744186	0,182669	0,182668862	0,182668862
880	4450	80	182,6744186	0,182669	0,182668862	0,182668862
890	4460	300	182,6744186	0,650000	0,16134773	0,45
900	4470	300	182,6744186	0,650000	0,16134773	0,45
910	4480	300	182,6744186	0,650000	0,16134773	0,45
920	4490	300	182,6744186	0,650000	0,16134773	0,45
930	4500	700	182,6744186	0,750000	0,155761394	0,55
940	4510	700	182,6744186	0,750000	0,155761394	0,55
950	4520	700	182,6744186	0,750000	0,155761394	0,55
960	4530	700	182,6744186	0,750000	0,155761394	0,55
970	4540	700	182,6744186	0,750000	0,155761394	0,55
980	4550	700	182,6744186	0,750000	0,155761394	0,55
990	4560	400	182,6744186	0,650000	0,15901484	0,5
1000	4570	400	182,6744186	0,159015	0,15901484	0,5
1010	4580	400	182,6744186	0,159015	0,15901484	0,5
1020	4590	400	182,6744186	0,159015	0,15901484	0,5
1030	4600	100	182,6744186	0,177328	0,177327883	0,45
1040	4610	100	182,6744186	0,177328	0,177327883	0,45
1050	4620	100	182,6744186	0,177328	0,177327883	0,45
1060	4630	50	182,6744186	0,197581	0,197580608	0,197580608
1070	4640	50	182,6744186	0,197581	0,197580608	0,197580608
1080	4650	50	182,6744186	0,197581	0,197580608	0,197580608
1090	4660	50	182,6744186	0,197581	0,197580608	0,197580608
1100	4670	5	182,6744186	0,450213	0,450213342	0,450213342
1110	4680	5	182,6744186	0,450213	0,450213342	0,450213342
1120	4690	5	182,6744186	0,450213	0,450213342	0,450213342
1130	4700	100	182,6744186	0,177328	0,177327883	0,5
1140	4710	100	182,6744186	0,177328	0,177327883	0,5
1150	4720	100	182,6744186	0,177328	0,177327883	0,5
1160	4730	100	182,6744186	0,177328	0,177327883	0,5
1170	4740	100	182,6744186	0,177328	0,177327883	0,5
1180	4750	100	182,6744186	0,177328	0,177327883	0,5
1190	4760	100	182,6744186	0,177328	0,177327883	0,5
1200	4770	200	182,6744186	0,165696	0,165695747	0,55
1210	4780	200	182,6744186	0,165696	0,165695747	0,55
1220	4790	500	182,6744186	0,157541	0,157541018	0,6
1230	4800	500	182,6744186	0,157541	0,157541018	0,6
1240	4810	400	182,6744186	0,159015	0,15901484	0,6
1250	4820	350	182,6744186	0,160031	0,160031169	0,55
1260	4830	250	182,6744186	0,163130	0,163129675	0,55
1270	4840	400	182,6744186	0,159015	0,15901484	0,6
1280	4850	400	182,6744186	0,159015	0,15901484	0,6

A.5: ICD results:

				Oil rate [Sm³/d]	Gas rate [MMSm³/d]	Water rate [Sm³/d]	GOR [Sm³/Sm³]	WCUT [%]	LGR [Sm³/Sm³]	Q res. total [Rm³/d]	BHP [Bar]
ICD case1		Tot	Oil+Gas+Wat	996,229	0,14177	3,50561	142,307	0,350654	0,0070518	4606,52	42,5515
		Lateral		349,679	0,0497485	1,81515	142,269	0,516411	0,00706542	501,102	258,353
		Mainbore		646,55	0,0920215	1,69046					
ICD case2		Tot	Oil+Gas+Wat	894,238	0,12775	105,616	142,859	10,5631	0,00782666	4652,57	38,4764
		Lateral		154,316	0,0219544	103,681	142,269	40,1868	0,0117515	326,364	**257,9**
		Mainbore		739,922	0,1057956	1,935					
ICD case3		Tot	Oil+Gas+Wat	790,665	0,112996	209,175	142,912	20,9208	0,00884848	4741,85	33,8463
		Lateral		70,9428	0,010093	186,238	142,269	72,4152	0,0254812	291,752	**257,464**
		Mainbore		719,7222	0,102903	22,937					
Conventional-Case 1		Tot	Oil+Gas+Wat	996,764	0,142255	3,03179	142,717	0,303241	0,00702819	4557,5	43,2031
		Lateral		512,359	0,0728928	1,76905	142,269	0,344088	0,00705321	733,175	259,206
		Mainbore		484,405	0,0693622	1,26274					
Conventional-Case 2		Tot	Oil+Gas+Wat	860,521	0,122821	139,371	142,729	13,9386	0,00814104	4632,87	37,3567
		Lateral		169,562	0,0241234	137,571	142,269	44,7919	0,0127317	382,771	258,175
		Mainbore		690,959	0,0986976	1,8					
Conventional-Case 3		Tot	Oil+Gas+Wat	709,388	0,100646	290,668	141,877	29,0652	0,00993639	4775,89	30,3175
		Lateral		48,2008	0,00685748	269,578	142,269	84,832	0,0463405	344,487	257,881
		Mainbore		661,1872	0,09378852	21,09					

Case 1 = early life

Case 2 = mid-life

Case 3 = late life

A.6: ICV – analysis.

Case 1 – Early life)

Pres,l = 265													
Pres, m = 272													
Target: Total Liquid Rate: 1000													
						Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. total	BHP
Conventional				Tot	Oil+Gas+Wat	996,764	0,142255	3,03179	142,717	0,303241	0,00702819	4557,5	43,2031
				Lateral		512,359	0,0728928	1,76905	142,269	0,344088	0,00705321	733,175	259,206
				Mainbore		484,405	0,0693622	1,26274	0,448	-0,04085	-2,502E-05	3824,325	
	Lateral	Mainbore											
ICV position	10	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. total	BHP
				Tot	Oil+Gas+Wat	996,446	0,142118	3,44668	142,625	0,344705	0,00703565	4654,93	42,1629
				Lateral	Oil+Gas+Wat	996,553	0,141779	3,44668	142,269	0,344668	0,00705325	1426,51	257,807
				Mainbore	Oil+Gas+Wat	-0,107	0,000339	0					
	10	1		same as above since 1 is closed									
						0	0	0	0	0	0	0	
	10	2		lik den oppfor									
	10	3		Tot	Oil+Gas+Wat	996,504	0,142507	3,27467	143,007	0,327539	0,00701564	4617,75	42,6517
				Lateral	Oil+Gas+Wat	794,303	0,113005	2,74539	142,269	0,344444	0,00705323	1136,84	258,4
				Mainbore	Oil+Gas+Wat	202,201	0,029502	0,52928					
	10	4		Tot	Oil+Gas+Wat	996,511	0,142617	3,21704	143,116	0,321791	0,0070099	4603,55	42,8296
				Lateral	Oil+Gas+Wat	726,398	0,103344	2,5101	142,269	0,344364	0,00705323	1039,61	258,596
				Mainbore	Oil+Gas+Wat	270,113	0,039273	0,70694					
	10	5		Tot	Oil+Gas+Wat	997,102	0,140947	3,16708	141,356	0,316623	0,00709679	4553,66	42,8614
				Lateral	Oil+Gas+Wat	667,369	0,0949459	2,30564	142,269	0,344293	0,00705322	955,088	258,766
				Mainbore	Oil+Gas+Wat	329,733	0,0460011	0,86144					
	10	6		Tot	Oil+Gas+Wat	997,203	0,140762	3,12577	141,157	0,312474	0,00710653	4538,3	42,9685
				Lateral	Oil+Gas+Wat	618,508	0,0879945	2,13645	142,269	0,344231	0,00705322	885,134	258,905
				Mainbore	Oil+Gas+Wat	378,695	0,0527675	0,98932					
	10	7		Tot	Oil+Gas+Wat	997,067	0,141344	3,08286	141,76	0,30824	0,007076	4543,15	43,0883
				Lateral	Oil+Gas+Wat	567,679	0,0807631	1,96049	142,269	0,344164	0,00705321	812,366	259,05
				Mainbore	Oil+Gas+Wat	429,388	0,0605809	1,12237					
	10	8		Tot	Oil+Gas+Wat	996,758	0,142481	3,04159	142,944	0,30422	0,00701708	4558,92	43,2557
				Lateral	Oil+Gas+Wat	518,691	0,0737936	1,79096	142,269	0,344097	0,00705321	742,239	259,188
				Mainbore	Oil+Gas+Wat	478,067	0,0686874	1,25063					
	10	9		Tot	Oil+Gas+Wat	996,778	0,14247	3,02467	142,93	0,302527	0,00701764	4554,48	43,2995
				Lateral	Oil+Gas+Wat	498,623	0,0709385	1,72152	142,269	0,344068	0,00705321	713,512	259,244
				Mainbore	Oil+Gas+Wat	498,155	0,0715315	1,30315					
	10	10		Tot	Oil+Gas+Wat	996,781	0,142469	3,02236	142,929	0,302296	0,0070177	4553,92	43,305
				Lateral	Oil+Gas+Wat	495,882	0,0705487	1,71204	142,269	0,344064	0,00705321	709,59	259,252
				Mainbore	Oil+Gas+Wat	500,899	0,0719203	1,31032					

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	9	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat	996,446	0,14212	3,44668	142,627	0,344705	0,00703557	4660,85	42,1039
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	4		Tot	Oil+Gas+Wat	996,552	0,142502	3,21504	142,995	0,321579	0,00701582	4603,59	42,7959
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	5		Tot	Oil+Gas+Wat	997,04	0,14115	3,1649	141,569	0,316425	0,00708613	4561,02	42,8438
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	6		Tot	Oil+Gas+Wat	997,097	0,141109	3,12349	141,52	0,31228	0,00708829	4549,19	42,9557
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	7		Tot	Oil+Gas+Wat	996,757	0,14168	3,0799	142,141	0,308041	0,00705703	4541,52	43,2046
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	8		Tot	Oil+Gas+Wat	996,775	0,142436	3,03928	142,896	0,303985	0,00701941	4558,97	43,2419
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	9		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	10		Tot	Oil+Gas+Wat	996,795	0,142434	3,02009	142,892	0,302065	0,00701947	4554,13	43,2927
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	8	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat	996,442	0,142137	3,44668	142,645	0,344706	0,00703468	4708,97	41,6323
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	3		Tot	Oil+Gas+Wat	997,002	0,140931	3,26051	141,354	0,325965	0,00709755	4609,38	42,2808
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	4		Tot	Oil+Gas+Wat	997,082	0,140883	3,2003	141,296	0,319939	0,00710007	4587,76	42,4885
				Lateral	Oil+Gas+Wat	706,62	0,10053	2,44159	142,269	0,344341	0,00705323	1011,29	258,653
				Mainbore	Oil+Gas+Wat	290,462	0,040353	0,75871	-0,973	-0,0244	4,684E-05	3576,47	-216,165
	8	5		Tot	Oil+Gas+Wat	996,921	0,141496	3,14876	141,933	0,314854	0,00706785	4578,89	42,759
				Lateral	Oil+Gas+Wat	645,785	0,0918751	2,2309	142,269	0,344266	0,00705322	924,186	258,828
				Mainbore	Oil+Gas+Wat	351,136	0,0496209	0,91786					
	8	6		Tot	Oil+Gas+Wat	997,007	0,14127	3,10664	141,694	0,310629	0,00707945	4558,21	42,9087
				Lateral	Oil+Gas+Wat	596,06	0,0848009	2,05874	142,269	0,344202	0,00705322	852,997	258,969
				Mainbore	Oil+Gas+Wat	400,947	0,0564691	1,0479					
	8	7		Tot	Oil+Gas+Wat	997,21	0,14088	3,06358	141,275	0,306274	0,00710016	4538,7	42,9991
				Lateral	Oil+Gas+Wat	544,917	0,0775248	1,88172	142,269	0,344133	0,00705321	779,781	259,114
				Mainbore	Oil+Gas+Wat	452,293	0,0633552	1,18186					
	8	8		Tot	Oil+Gas+Wat	997,434	0,140371	3,02253	140,732	0,302115	0,00712722	4516,39	43,0847
				Lateral	Oil+Gas+Wat	496,169	0,0705895	1,71303	142,269	0,344064	0,00705321	710	259,251
				Mainbore	Oil+Gas+Wat	501,265	0,0697815	1,3095	-1,537	-0,04195	7,401E-05	3806,39	-216,166
	8	9		Tot	Oil+Gas+Wat	996,897	0,141788	3,00555	142,23	0,300584	0,00705209	4554,59	43,0962
				Lateral	Oil+Gas+Wat	476,348	0,0677696	1,64446	142,269	0,344035	0,0070532	681,628	259,307
				Mainbore	Oil+Gas+Wat	520,549	0,0740184	1,36109					
	8	10		Tot	Oil+Gas+Wat	996,893	0,141796	3,00326	142,238	0,300357	0,00705167	4554,26	43,1019
				Lateral	Oil+Gas+Wat	473,648	0,0673854	1,63512	142,269	0,344031	0,0070532	677,763	259,315
				Mainbore	Oil+Gas+Wat	523,245	0,0744106	1,36814					

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	7	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat	996,43	0,142194	3,44668	142,703	0,344711	0,00703178	4872,35	40,1097
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	3		Tot	Oil+Gas+Wat	996,832	0,141364	3,22851	141,813	0,322831	0,00707435	4697,91	41,5197
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	4		Tot	Oil+Gas+Wat	996,914	0,141293	3,16308	141,731	0,316284	0,00707802	4656,24	41,911
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	5		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	6		Tot	Oil+Gas+Wat	997,039	0,141228	3,06591	141,647	0,306559	0,00708151	4600,99	42,4508
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	7		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	8		Tot	Oil+Gas+Wat	997,128	0,141224	2,9825	141,63	0,298217	0,00708175	4560,24	42,8715
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	9		Tot	Oil+Gas+Wat	997,155	0,141211	2,96643	141,614	0,296607	0,00708244	4552,48	42,9494
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	10		Tot	Oil+Gas+Wat	997,159	0,14121	2,96425	141,613	0,296389	0,00708252	4551,42	42,9601
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						[Sm^3/d]	[MMSm^3/d]	[Sm^3/d]	[Sm^3/Sm^3]	[%]	[Sm^3/Sm^3]	[Rm^3/d]	[Bar]
	Lateral	Mainbore											
ICV position	6	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat	996,409	0,142302	3,44668	142,815	0,344718	0,00702628	5161,79	37,6816
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	4		Tot	Oil+Gas+Wat	996,742	0,142091	3,12249	142,556	0,312291	0,00703678	4743,1	41,2855
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	5		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	6		Tot	Oil+Gas+Wat	996,81	0,142148	3,02304	142,603	0,302355	0,00703373	4659,15	42,126
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	7		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	8		Tot	Oil+Gas+Wat	996,887	0,142145	2,9418	142,589	0,29423	0,00703388	4600,86	42,7177
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	9		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	10		Tot	Oil+Gas+Wat	996,904	0,142146	2,92447	142,588	0,292498	0,00703381	4589,71	42,8334
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	5	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat	996,318	0,142538	3,44649	143,065	0,34473	0,00701402	5701,48	33,895
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	3		Tot	Oil+Gas+Wat	996,674	0,142086	3,15362	142,56	0,315417	0,00703676	4946,61	39,4171
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	4		Tot	Oil+Gas+Wat	996,697	0,142121	3,07992	142,592	0,30806	0,0070347	4830,1	40,4727
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	5		Tot	Oil+Gas+Wat	996,722	0,142131	3,02294	142,598	0,302371	0,00703399	4753	41,2
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	6		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	7		Tot	Oil+Gas+Wat	996,792	0,142176	2,93895	142,634	0,293974	0,00703163	4658,54	42,1387
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	8		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	9		Tot	Oil+Gas+Wat	996,828	0,142183	2,88799	142,635	0,288881	0,00703121	4610,59	42,6271
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	10		Tot	Oil+Gas+Wat	996,83	0,142184	2,88608	142,636	0,28869	0,00703116	4608,94	42,6444
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	4	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat	996,583	0,141594	3,44668	142,079	0,344657	0,00706267	7474,73	25,0854
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	3		Tot	Oil+Gas+Wat	996,79	0,142236	3,0998	142,694	0,310015	0,00702978	5176,13	37,5499
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	4		Tot	Oil+Gas+Wat	996,852	0,142276	3,0236	142,725	0,302398	0,00702771	4960,35	39,3488
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	5		Tot	Oil+Gas+Wat	996,854	0,142312	2,96714	142,761	0,296767	0,00702556	4844,19	40,3958
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	6		Tot	Oil+Gas+Wat	996,848	0,142266	2,9259	142,716	0,292656	0,00702749	4764,85	41,1248
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	7		Tot	Oil+Gas+Wat	996,975	0,142299	2,8879	142,731	0,288829	0,00702647	4690,24	41,8601
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	8		Tot	Oil+Gas+Wat	997	0,14233	2,85461	142,758	0,285502	0,00702491	4642,68	42,3446
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	9		Tot	Oil+Gas+Wat	997,011	0,142333	2,84186	142,76	0,284228	0,00702473	4625,85	42,5167
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	10		Tot	Oil+Gas+Wat	997,013	0,142333	2,84016	142,759	0,284057	0,00702476	4623,63	42,5392
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	3	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. tot	BHP
	No solu.			Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	3		Tot	Oil+Gas+Wat	996,832	0,142417	3,0237	142,87	0,302414	0,00702062	5647,36	34,2146
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	4		Tot	Oil+Gas+Wat	996,87	0,142457	2,94809	142,904	0,294863	0,00701841	5208,29	37,352
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	5		Tot	Oil+Gas+Wat	996,938	0,142415	2,89543	142,853	0,289591	0,00702055	4964,29	39,3512
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	6		Tot	Oil+Gas+Wat	996,964	0,142436	2,8586	142,869	0,285911	0,00701947	4838,91	40,4789
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	7		Tot	Oil+Gas+Wat	996,992	0,142439	2,82538	142,869	0,282589	0,00701928	4744,35	41,371
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	8		Tot	Oil+Gas+Wat	997,007	0,142486	2,79735	142,914	0,279789	0,00701685	4678,23	42,0322
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	9		Tot	Oil+Gas+Wat	997,019	0,14248	2,78681	142,906	0,278736	0,00701717	4655,35	42,2594
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	10		Tot	Oil+Gas+Wat	997,021	0,142478	2,78541	142,903	0,278595	0,00701728	4652,37	42,2888
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	0	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat								
		STENGT		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	3		Tot	Oil+Gas+Wat								
		For lavt BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	4		Tot	Oil+Gas+Wat	997,475	0,141338	2,60829	141,696	0,260807	0,00707581	7727,07	24,1455
	TOO LOW BHP			Lateral	Oil+Gas+Wat	0	0	0	NaN	NaN	NaN	8.64e-009	260,603
				Mainbore	Oil+Gas+Wat	997,475	0,141338	2,60829	#VALUE!	#VALUE!	#VALUE!	#VALUE!	-236,458
	0	5		Tot	Oil+Gas+Wat	997,218	0,141791	2,60778	142,186	0,260824	0,00705142	5805	33,0788
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	6		Tot	Oil+Gas+Wat	996,939	0,143545	2,60828	143,985	0,260946	0,00696331	5302,11	36,9031
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	7		Tot	Oil+Gas+Wat	996,971	0,143267	2,60824	143,702	0,260933	0,00697704	4992,47	39,3321
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	8		Tot	Oil+Gas+Wat	996,993	0,143125	2,60823	143,557	0,260927	0,00698412	4818,89	40,8531
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	9		Tot	Oil+Gas+Wat	997	0,143084	2,60822	143,515	0,260925	0,00698615	4767,92	41,324
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	10		Tot	Oil+Gas+Wat	997	0,143081	2,60822	143,511	0,260925	0,00698633	4761,68	41,3829
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

Case 2 – Mid-life)

Target: Total Liquid Rate: 1000 Sm3/day													
					Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. total	BHP
Conventional well (non ICV)				Tot	Oil+Gas+Wat	860,521	0,122821	139,371	142,729	13,9386	0,008141	4632,87	37,3567
				Lateral		169,562	0,024123	137,571	142,269	44,7919	0,012732	382,771	258,175
				Mainbore		690,959	0,098698	1,8	0,46	-30,8533	-0,00459	4250,099	
	Lateral	Mainbore											
ICV position	10	0			Phase mode								
				Tot	Oil+Gas+Wat	553,719	0,078494	446,315	141,758	44,63	0,01274	5664,13	19,6752
				Lateral	Oil+Gas+Wat	553,684	0,078772	446,316	142,269	44,6316	0,012695	1247,73	254,165
				Mainbore	Oil+Gas+Wat	0,035	-0,00028	-0,001					
	10	1		Lik som for 0									
	10	2		lik den oppfor									
	10	3		Tot	Oil+Gas+Wat	684,678	0,097965	315,222	143,082	31,5254	0,010207	5026,59	27,8632
				Lateral	Oil+Gas+Wat	389,226	0,055375	314,449	142,269	44,6867	0,012708	877,595	255,893
				Mainbore	Oil+Gas+Wat	295,452	0,04259	0,773	0,813				
	10	4		Tot	Oil+Gas+Wat	727,873	0,104186	271,996	143,138	27,2032	0,009597	4910,16	30,3159
				Lateral	Oil+Gas+Wat	335,129	0,047678	270,969	142,269	44,7072	0,012712	755,782	256,458
				Mainbore	Oil+Gas+Wat	392,744	0,056508	1,027	0,869				
	10	5		Tot	Oil+Gas+Wat	764,987	0,109496	234,856	143,135	23,4893	0,009131	4818,24	32,3453
				Lateral	Oil+Gas+Wat	288,7	0,041073	233,612	142,269	44,7265	0,012717	651,212	256,941
				Mainbore	Oil+Gas+Wat	476,287	0,068423	1,244	0,866				
	10	6		Tot	Oil+Gas+Wat	795,333	0,113902	204,487	143,213	20,4524	0,008778	4757,56	33,9627
				Lateral	Oil+Gas+Wat	250,769	0,035677	203,063	142,269	44,7441	0,012721	565,763	257,335
				Mainbore	Oil+Gas+Wat	544,564	0,078225	1,424	0,944				
	10	7		Tot	Oil+Gas+Wat	826,513	0,118287	173,318	143,116	17,3347	0,008453	4700,67	35,577
				Lateral	Oil+Gas+Wat	211,873	0,030143	171,709	142,269	44,7646	0,012725	478,124	257,738
				Mainbore	Oil+Gas+Wat	614,64	0,088144	1,609	0,847				
	10	8		Tot	Oil+Gas+Wat	856,074	0,122442	143,761	143,027	14,3785	0,008166	4655	37,0647
				Lateral	Oil+Gas+Wat	175,023	0,0249	141,979	142,269	44,788	0,012731	395,079	258,119
				Mainbore	Oil+Gas+Wat	681,051	0,097542	1,782	0,758				
	10	9		Tot	Oil+Gas+Wat	868,018	0,124147	131,81	143,023	13,1833	0,008054	4639,22	37,656
				Lateral	Oil+Gas+Wat	160,133	0,022782	129,958	142,269	44,7991	0,012733	361,519	258,272
				Mainbore	Oil+Gas+Wat	707,885	0,101365	1,852	0,754				
	10	10		Tot	Oil+Gas+Wat	869,63	0,124401	130,185	143,05	13,0209	0,008037	4638	37,7346
				Lateral	Oil+Gas+Wat	158,11	0,022494	128,325	142,269	44,8007	0,012734	356,958	258,293
				Mainbore	Oil+Gas+Wat	711,52	0,101907	1,86	0,781				

						[Sm^3/d]	[MMSm^3/(	[Sm^3/d]	[Sm^3/Sm^3]	[%]	[Sm^3/Sm^3]	[Rm^3/d]	[Bar]
	Lateral	Mainbore											
ICV position	9	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. total	BHP
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	3		Tot	Oil+Gas+Wat	685,089	0,098024	314,811	143,083	31,4843	0,010201	5029,04	27,863
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	4		Tot	Oil+Gas+Wat	728,308	0,10425	271,561	143,14	27,1597	0,009591	4911,6	30,3225
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	5		Tot	Oil+Gas+Wat	765,406	0,10956	234,438	143,14	23,4475	0,009126	4819,18	32,355
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	6		Tot	Oil+Gas+Wat	795,722	0,113945	204,105	143,197	20,414	0,008775	4757,56	33,9736
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	7		Tot	Oil+Gas+Wat	826,849	0,118309	172,989	143,084	17,3017	0,008451	4700,17	35,5863
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	8		Tot	Oil+Gas+Wat	856,338	0,122485	143,495	143,034	14,3519	0,008163	4655,31	37,0735
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	9		Tot	Oil+Gas+Wat	868,244	0,124203	131,572	143,051	13,1596	0,00805	4640,06	37,6637
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	10		Tot	Oil+Gas+Wat	869,865	0,12443	129,952	143,045	12,9976	0,008035	4637,81	37,7438
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						[Sm^3/d]	[MMSm^3/(	[Sm^3/d]	[Sm^3/Sm^3]	[%]	[Sm^3/Sm^3]	[Rm^3/d]	[Bar]
	Lateral	Mainbore											
ICV position	8	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat	553,72	0,078476	446,315	141,725	44,6299	0,012743	5776,46	19,2264
		TOO LOW BHP											
				Lateral	Oil+Gas+Wat	553,684	0,078772	446,316	142,269	44,6316	0,012695	1247,73	254,165
				Mainbore	Oil+Gas+Wat	0,036	-0,0003	-0,001	-0,544	-0,0017	4,83E-05	4528,73	
	8	3		Tot	Oil+Gas+Wat	688,259	0,098481	311,642	143,087	31,1673	0,010153	5048,26	27,8589
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	4		Tot	Oil+Gas+Wat	731,656	0,104743	268,21	143,159	26,8246	0,009546	4922,89	30,3709
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	5		Tot	Oil+Gas+Wat	768,629	0,110051	231,218	143,179	23,1253	0,009085	4825,97	32,4319
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	6		Tot	Oil+Gas+Wat	798,689	0,1143	201,158	143,11	20,1189	0,008748	4758,82	34,0549
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	7		Tot	Oil+Gas+Wat	829,392	0,118636	170,455	143,04	17,0481	0,008428	4701,27	35,662
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	8		Tot	Oil+Gas+Wat	858,383	0,122781	141,447	143,038	14,1471	0,008143	4656,74	37,1387
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	9		Tot	Oil+Gas+Wat	870,102	0,124404	129,739	142,977	12,976	0,008037	4638,93	37,7256
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	10		Tot	Oil+Gas+Wat	871,692	0,12463	128,149	142,974	12,8169	0,008022	4636,78	37,8046
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						[Sm^3/d]	[MMSm^3/(	[Sm^3/d]	[Sm^3/Sm^3	[%]	[Sm^3/Sm^3	[Rm^3/d]	[Bar]
	Lateral	Mainbore											
ICV position	7	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
		TOO LOW BHP		Tot	Oil+Gas+Wat	553,724	0,078416	446,314	141,615	44,6297	0,012753	6133,48	17,9233
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	3		Tot	Oil+Gas+Wat	697,331	0,099776	302,572	143,082	30,2601	0,010022	5107,07	27,8195
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	4		Tot	Oil+Gas+Wat	741,178	0,106089	258,693	143,135	25,8726	0,009425	4954,6	30,4946
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	5		Tot	Oil+Gas+Wat	777,769	0,111251	222,099	143,038	22,2128	0,008988	4841,01	32,6259
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	6		Tot	Oil+Gas+Wat	807,044	0,115394	192,822	142,983	19,2848	0,008665	4767,54	34,2672
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	7		Tot	Oil+Gas+Wat	836,592	0,119577	163,273	142,933	16,3295	0,008362	4705,5	35,8703
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	8		Tot	Oil+Gas+Wat	864,258	0,123479	135,61	142,873	13,5628	0,008097	4656,04	37,3253
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	9		Tot	Oil+Gas+Wat	875,368	0,125073	124,495	142,881	12,4512	0,007994	4639,24	37,8969
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	10		Tot	Oil+Gas+Wat	876,875	0,125292	122,987	142,885	12,3004	0,00798	4637,14	37,9738
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								

						Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
						$[Sm^3/d]$	$[MMSm^3/($	$[Sm^3/d]$	$[Sm^3/Sm^3]$	[%]	$[Sm^3/Sm^3]$	$[Rm^3/d]$	[Bar]
	Lateral	Mainbore											
ICV position	6	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
		TOO LOW BHP		Tot	Oil+Gas+Wat	553,718	0,078307	446,304	141,421	44,6294	0,012771	6844,37	15,7835
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	3		Tot	Oil+Gas+Wat	709,112	0,101484	290,787	143,114	29,0816	0,009853	5194,22	27,7104
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	6	4		Tot	Oil+Gas+Wat	753,385	0,10777	246,486	143,048	24,6518	0,009278	4998,32	30,6173
				Lateral	Oil+Gas+Wat	303,233	0,043141	245,31	142,269	44,7202	0,012715	683,946	256,79
				Mainbore	Oil+Gas+Wat	450,152	0,064629	1,176					
	6	5		Tot	Oil+Gas+Wat	789,375	0,112858	210,485	142,971	21,0515	0,008859	4884,52	32,7088
				Lateral	Oil+Gas+Wat	258,26	0,036742	209,098	142,269	44,7404	0,01272	582,64	257,257
				Mainbore	Oil+Gas+Wat	531,115	0,076116	1,387					
	6	6		Tot	Oil+Gas+Wat	817,641	0,116844	182,226	142,903	18,225	0,008557	4781,78	34,5265
				Lateral	Oil+Gas+Wat	222,989	0,031724	180,672	142,269	44,7584	0,012724	503,171	257,623
				Mainbore	Oil+Gas+Wat	594,652	0,08512	1,554					
	6	7		Tot	Oil+Gas+Wat	845,732	0,120851	154,12	142,895	15,4143	0,008273	4729,59	35,9957
				Lateral	Oil+Gas+Wat	187,938	0,026738	152,401	142,269	44,7792	0,012729	424,186	257,985
				Mainbore	Oil+Gas+Wat	657,794	0,094113	1,719					
	6	8		Tot	Oil+Gas+Wat	871,739	0,124579	128,116	142,908	12,8134	0,008026	4662,37	37,5578
				Lateral	Oil+Gas+Wat	155,531	0,022127	126,242	142,269	44,8028	0,012734	351,145	258,32
				Mainbore	Oil+Gas+Wat	716,208	0,102452	1,874					
	6	9		Tot	Oil+Gas+Wat	882,112	0,126112	117,73	142,966	11,7749	0,007928	4645,83	38,1119
				Lateral	Oil+Gas+Wat	142,595	0,020287	115,795	142,269	44,814	0,012737	321,988	258,453
				Mainbore	Oil+Gas+Wat	739,517	0,105825	1,935					
	6	10		Tot	Oil+Gas+Wat	883,518	0,126315	116,323	142,968	11,6341	0,007915	4643,53	38,1862
				Lateral	Oil+Gas+Wat	140,843	0,020038	114,38	142,269	44,8156	0,012737	318,037	258,471
				Mainbore	Oil+Gas+Wat	742,675	0,106277	1,943					

						[Sm^3/d]	[$MMSm^3/$	[Sm^3/d]	[Sm^3/Sm^3	[%]	[Sm^3/Sm^3	[Rm^3/d]	[Bar]
	Lateral	Mainbore											
ICV position	5	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	3		Tot	Oil+Gas+Wat	723,26	0,103578	276,625	143,21	27,6657	0,009653	5316,5	27,4904
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	4		Tot	Oil+Gas+Wat	767,756	0,11009	232,08	143,391	23,2118	0,009082	5090,57	30,5751
				Lateral	Oil+Gas+Wat	285,222	0,040578	230,812	142,269	44,728	0,012717	643,378	256,977
				Mainbore	Oil+Gas+Wat	482,534	0,069512	1,268					
	5	5		Tot	Oil+Gas+Wat	802,887	0,11516	196,91	143,432	19,695	0,008682	4930,44	32,9572
				Lateral	Oil+Gas+Wat	241,306	0,03433	195,437	142,269	44,7488	0,012722	544,442	257,433
				Mainbore	Oil+Gas+Wat	561,581	0,08083	1,473					
	5	6		Tot	Oil+Gas+Wat	829,901	0,118893	169,876	143,262	16,9914	0,008409	4830,11	34,6704
				Lateral	Oil+Gas+Wat	207,586	0,029533	168,251	142,269	44,7671	0,012726	468,463	257,782
				Mainbore	Oil+Gas+Wat	622,315	0,08936	1,625					
	5	7		Tot	Oil+Gas+Wat	856,396	0,122429	143,441	142,959	14,3464	0,008167	4727,81	36,4225
				Lateral	Oil+Gas+Wat	174,627	0,024844	141,659	142,269	44,7883	0,012731	394,187	258,123
				Mainbore	Oil+Gas+Wat	681,769	0,097585	1,782					
	5	8		Tot	Oil+Gas+Wat	880,522	0,125907	119,309	142,991	11,9329	0,007941	4671,41	37,8256
				Lateral	Oil+Gas+Wat	144,562	0,020567	117,384	142,269	44,8122	0,012736	326,42	258,432
				Mainbore	Oil+Gas+Wat	735,96	0,10534	1,925					
	5	9		Tot	Oil+Gas+Wat	890,079	0,127317	109,741	143,04	10,9761	0,007853	4652,9	38,3643
				Lateral	Oil+Gas+Wat	132,649	0,018872	107,759	142,269	44,8235	0,012739	299,565	258,555
				Mainbore	Oil+Gas+Wat	757,43	0,108445	1,982					
	5	10		Tot	Oil+Gas+Wat	891,373	0,127498	108,447	143,036	10,8467	0,007842	4650,21	38,4366
				Lateral	Oil+Gas+Wat	131,038	0,018643	106,458	142,269	44,8252	0,012739	295,934	258,572
				Mainbore	Oil+Gas+Wat	760,335	0,108855	1,989					

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	4	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. total	BHP
		Too low BHP		Tot	Oil+Gas+Wat	997,475	0,141338	2,60829	141,696	0,260807	0,00707581	7727,07	24,1455
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	3		Tot	Oil+Gas+Wat	745,064	0,106689	254,758	143,194	25,4803	0,00937139	5536,75	26,9654
				Lateral	Oil+Gas+Wat	313,591	0,0446143	253,644	142,269	44,7159	0,0127142	707,275	256,682
				Mainbore	Oil+Gas+Wat	431,473	0,0620747	1,114					
	4	4		Tot	Oil+Gas+Wat	789,277	0,113862	210,386	144,261	21,0457	0,00877958	5222,5	30,633
				Lateral	Oil+Gas+Wat	258,131	0,036724	208,994	142,269	44,7405	0,0127199	582,349	257,259
				Mainbore	Oil+Gas+Wat	531,146	0,077138	1,392					
	4	5		Tot	Oil+Gas+Wat	823,042	0,117733	176,747	143,046	17,6784	0,00849203	4958,91	33,3801
				Lateral	Oil+Gas+Wat	216,165	0,0307536	175,17	142,269	44,7622	0,0127249	487,796	257,693
				Mainbore	Oil+Gas+Wat	606,877	0,0869794	1,577					
	4	6		Tot	Oil+Gas+Wat	848,118	0,121376	151,673	143,112	15,1704	0,00823715	4842,56	35,1989
				Lateral	Oil+Gas+Wat	184,892	0,0263043	149,943	142,269	44,7812	0,0127293	417,32	258,017
				Mainbore	Oil+Gas+Wat	663,226	0,0950717	1,73					
	4	7		Tot	Oil+Gas+Wat	872,106	0,124621	127,707	142,897	12,7731	0,00802282	4745,25	36,8368
				Lateral	Oil+Gas+Wat	155,03	0,0220559	125,838	142,269	44,8032	0,0127343	350,016	258,325
				Mainbore	Oil+Gas+Wat	717,076	0,1025651	1,869					
	4	8		Tot	Oil+Gas+Wat	893,537	0,127803	106,254	143,031	10,6276	0,0078229	4682,78	38,2172
				Lateral	Oil+Gas+Wat	128,312	0,0182548	104,255	142,269	44,828	0,0127401	289,789	258,6
				Mainbore	Oil+Gas+Wat	765,225	0,1095482	1,999					
	4	9		Tot	Oil+Gas+Wat	901,951	0,128992	97,8412	143,014	9,78615	0,00775082	4659,81	38,7373
				Lateral	Oil+Gas+Wat	117,84	0,016765	95,7926	142,269	44,8398	0,0127428	266,181	258,707
				Mainbore	Oil+Gas+Wat	784,111	0,112227	2,0486					
	4	10		Tot	Oil+Gas+Wat	903,086	0,129154	96,707	143,014	9,6727	0,00774111	4656,9	38,8064
				Lateral	Oil+Gas+Wat	116,429	0,0165642	94,6517	142,269	44,8415	0,0127432	262,998	258,722
				Mainbore	Oil+Gas+Wat	786,657	0,1125898	2,0553					

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	3	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat								
		TOO LOW BHP											
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	3		Tot	Oil+Gas+Wat	779,022	0,11069	220,973	142,089	22,0974	0,00903417	5962,92	25,6292
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	3	4		Tot	Oil+Gas+Wat	821,573	0,117872	178,112	143,471	17,8168	0,00848114	5372,5	30,6011
				Lateral	Oil+Gas+Wat	217,879	0,0309974	176,552	142,269	44,7612	0,0127246	491,657	257,676
				Mainbore	Oil+Gas+Wat	603,694	0,0868746	1,56					
	3	5		Tot	Oil+Gas+Wat	852,237	0,122208	147,478	143,397	14,752	0,00818041	5066,25	33,6883
				Lateral	Oil+Gas+Wat	179,667	0,0255611	145,727	142,269	44,7848	0,0127301	405,547	258,071
				Mainbore	Oil+Gas+Wat	672,57	0,0966469	1,751					
	3	6		Tot	Oil+Gas+Wat	874,184	0,125277	125,535	143,307	12,5571	0,0079801	4903,62	35,6886
				Lateral	Oil+Gas+Wat	152,326	0,0216712	123,654	142,269	44,8055	0,0127348	343,921	258,353
				Mainbore	Oil+Gas+Wat	721,858	0,1036058	1,881					
	3	7		Tot	Oil+Gas+Wat	894,504	0,128138	105,223	143,251	10,5251	0,00780193	4786,42	37,3868
				Lateral	Oil+Gas+Wat	127,03	0,0180725	103,22	142,269	44,8294	0,0127404	286,899	258,613
				Mainbore	Oil+Gas+Wat	767,474	0,1100655	2,003					
	3	8		Tot	Oil+Gas+Wat	912,222	0,130598	87,5135	143,165	8,75367	0,00765505	4703,86	38,7506
				Lateral	Oil+Gas+Wat	104,992	0,0149371	85,4057	142,269	44,8565	0,0127466	237,212	258,839
				Mainbore	Oil+Gas+Wat	807,23	0,1156609	2,1078					
	3	9		Tot	Oil+Gas+Wat	919,062	0,131546	80,677	143,131	8,06981	0,0075999	4676,47	39,2482
				Lateral	Oil+Gas+Wat	96,4875	0,0137272	78,5288	142,269	44,8694	0,0127496	218,037	258,926
				Mainbore	Oil+Gas+Wat	822,5745	0,1178188	2,1482					
	3	10		Tot	Oil+Gas+Wat	919,98	0,131674	79,7595	143,127	7,97803	0,00759254	4672,99	39,3137
				Lateral	Oil+Gas+Wat	95,3463	0,0135648	77,6059	142,269	44,8713	0,0127501	215,463	258,938
				Mainbore	Oil+Gas+Wat	824,6337	0,1181092	2,1536					

						[Sm^3/d]	[MMSm^3/(	[Sm^3/d]	[Sm^3/Sm^3]	[%]	[Sm^3/Sm^3]	[Rm^3/d]	[Bar]
	Lateral	Mainbore											
ICV position	0	0			Phase mo	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat								
		NO SOLU											
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	3		Tot	Oil+Gas+Wat								
		NO SOLU											
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	4		Tot	Oil+Gas+V	997,475	0,141338	2,60829	141,696	0,260807	0,007076	7727,07	24,1455
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	5		Tot	Oil+Gas+V	997,218	0,141791	2,60778	142,186	0,260824	0,007051	5805	33,0788
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	6		Tot	Oil+Gas+V	996,939	0,143545	2,60828	143,985	0,260946	0,006963	5302,11	36,9031
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	7		Tot	Oil+Gas+V	996,971	0,143267	2,60824	143,702	0,260933	0,006977	4992,47	39,3321
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	8		Tot	Oil+Gas+V	996,993	0,143125	2,60823	143,557	0,260927	0,006984	4818,89	40,8531
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	9		Tot	Oil+Gas+V	997	0,143084	2,60822	143,515	0,260925	0,006986	4767,92	41,324
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	10		Tot	Oil+Gas+V	997	0,143081	2,60822	143,511	0,260925	0,006986	4761,68	41,3829
				Lateral	Oil+Gas+V	0	0	0	NaN	NaN	NaN	8.64e-009	260,379
				Mainbore	Oil+Gas+V	997	0,143081	2,60822	#VALUE!				

Case 3 – Late life)

Case 3)													
Pres,l = 265													
Pres, m = 272													
Target: Total Liquid Rate: 1000 Sm3/day						[Sm³/d]	[MMSm³/(	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
					Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. total	BHP
Conventional well (non ICV)				Tot	Oil+Gas+Wat	709,388	0,100646	290,668	141,877	29,0652	0,009936	4775,89	30,3175
				Lateral		48,2008	0,006857	269,578	142,269	84,832	0,046341	344,487	257,881
				Mainbore		661,1872	0,093789	21,09					
	Lateral	Mainbore											
ICV position	10	0			Phase mode								
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0	0	0	0	0	
	10	1		Lik som for 0									
	10	2		lik den oppfor									
	10	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	10	4		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0	0	0	0	0	
	10	5		Tot	Oil+Gas+Wat								
Since we allready have too low BHP, this will continue to be too low when we restrain further the				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	10	6		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	10	7		Tot	Oil+Gas+Wat	642,939	0,092142	356,824	143,314	35,6908	0,01085	4935,33	26,8972
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	642,939	0,092142	356,824	143,314	35,6908	0,01085	4935,33	
	10	8		Tot	Oil+Gas+Wat	700,529	0,100393	299,241	143,31	29,931	0,009959	4818,27	29,9596
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	700,529	0,100393	299,241	143,31	29,931	0,009959	4818,27	
	10	9		Tot	Oil+Gas+Wat	724,285	0,103779	275,477	143,285	27,5543	0,009634	4776,35	31,1643
				Lateral	Oil+Gas+Wat	45,3641	0,006454	253,851	142,269	84,839	0,046362	324,353	257,953
				Mainbore	Oil+Gas+Wat	678,9209	0,097325	21,626	1,016	-57,2847	-0,03673	4451,997	
	10	10		Tot	Oil+Gas+Wat	727,541	0,104239	272,224	143,276	27,2288	0,009591	4770,75	31,3269
				Lateral	Oil+Gas+Wat	44,7551	0,006367	250,474	142,269	84,8406	0,046367	320,029	257,968
				Mainbore	Oil+Gas+Wat	682,7859	0,097872	21,75	1,007	-57,6118	-0,03678	4450,721	

						[Sm^3/d]	[MMSm^3/(	[Sm^3/d]	[Sm^3/Sm^3]	[%]	[Sm^3/Sm^3]	[Rm^3/d]	[Bar]
	Lateral	Mainbore											
ICV position	9	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. total	BHP
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0	0				
	9	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	4		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0	0				
	9	5		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	6		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	7		Tot	Oil+Gas+Wat	643,562	0,092225	356,179	143,304	35,6272	0,01084	4933,82	26,9292
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	8		Tot	Oil+Gas+Wat	701,045	0,10043	298,724	143,257	29,8793	0,009955	4816,56	29,9814
			TOO LOW	Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	9	9		Tot	Oil+Gas+Wat	724,746	0,103812	275,016	143,239	27,5082	0,009631	4774,83	31,1834
				Lateral	Oil+Gas+Wat	45,2782	0,006442	253,375	142,269	84,8392	0,046363	323,743	257,955
				Mainbore	Oil+Gas+Wat	679,4678	0,09737	21,641	0,97				
	9	10		Tot	Oil+Gas+Wat	727,995	0,104272	271,771	143,231	27,1835	0,009588	4769,27	31,3456
				Lateral	Oil+Gas+Wat	44,6707	0,006355	250,006	142,269	84,8408	0,046367	319,43	257,971
				Mainbore	Oil+Gas+Wat	683,3243	0,097917	21,765	0,962				

Since we allready have too low BHP, this will continue to be too low when we restrain further the flow from mainbore

						[Sm^3/d]	[$MMSm^3$/(	[Sm^3/d]	[Sm^3/Sm^3]	[%]	[Sm^3/Sm^3]	[Rm^3/d]	[Bar]
	Lateral	Mainbore											
ICV position	8	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0					
	8	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	4		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0					
	8	5		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	6		Tot	Oil+Gas+Wat	590,29	0,083749	409,712	141,877	40,9711	0,011941	5078,92	23,768
			TOO LOW BHP	Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	8	7		Tot	Oil+Gas+Wat	648,444	0,092806	351,266	143,121	35,1368	0,010772	4923,67	27,1504
			TOO LOW BHP	Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	648,444	0,092806	351,266					
	8	8		Tot	Oil+Gas+Wat	705,033	0,10082	294,753	143	29,4816	0,009917	4808,1	30,1473
				Lateral	Oil+Gas+Wat	48,975	0,006968	273,869	142,269	84,8301	0,046335	349,98	257,861
				Mainbore	Oil+Gas+Wat	656,058	0,093852	20,884					
	8	9		Tot	Oil+Gas+Wat	728,307	0,10414	271,469	142,99	27,153	0,0096	4766,17	31,33
				Lateral	Oil+Gas+Wat	44,6156	0,006347	249,701	142,269	84,8409	0,046368	319,039	257,972
				Mainbore	Oil+Gas+Wat	683,6914	0,097793	21,768					
	8	10		Tot	Oil+Gas+Wat	731,494	0,104595	268,283	142,989	26,8343	0,009559	4760,82	31,4899
				Lateral	Oil+Gas+Wat	44,0193	0,006263	246,393	142,269	84,8425	0,046373	314,805	257,987
				Mainbore	Oil+Gas+Wat	687,4747	0,098332	21,89					

Since we allready have too low BHP, this will continue to be too low when we restrain further the flow from mainbore

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	7	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0					
	7	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	4		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	5		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0					
	7	6		Tot	Oil+Gas+Wat	605,873	0,088	393,769	145,245	39,391	0,0113596	5158,46	24,4779
			TOO LOW BHP	Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	7		Tot	Oil+Gas+Wat	662,219	0,0957364	337,475	144,569	33,7578	0,0104421	4966,07	27,6834
			TOO LOW BHP	Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	7	8		Tot	Oil+Gas+Wat	716,186	0,10324	283,502	144,152	28,359	0,00968319	4842,79	30,5566
				Lateral	Oil+Gas+Wat	46,8635	0,00666723	262,165	142,269	84,8352	0,0463504	334,996	257,915
				Mainbore	Oil+Gas+Wat	669,3225	0,09657277	21,337					
	7	9		Tot	Oil+Gas+Wat	738,301	0,106303	261,391	143,983	26,1472	0,0094042	4797,25	31,6836
				Lateral	Oil+Gas+Wat	42,7259	0,00607856	239,218	142,269	84,8459	0,0463832	305,62	258,02
				Mainbore	Oil+Gas+Wat	695,5751	0,10022444	22,173					
	7	10		Tot	Oil+Gas+Wat	741,324	0,10672	258,369	143,959	25,8448	0,0093674	4791,49	31,8355
				Lateral	Oil+Gas+Wat	42,1606	0,00599815	236,081	142,269	84,8475	0,046388	301,605	258,034
				Mainbore	Oil+Gas+Wat	699,1634	0,10072185	22,288					

Since we allready have too low BHP, this will continue to be too low when we restrain further the flow from mainbore

					[Sm³/d]	[MMSm³/(	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore										
ICV position	6	0		Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
			Tot	Oil+Gas+Wat								
			Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat								
	6	3	Tot	Oil+Gas+Wat								
			Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat								
	6	4	Tot	Oil+Gas+Wat								
			Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat	0	0	0					
	6	5	Tot	Oil+Gas+Wat								
			Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat								
	6	6	Tot	Oil+Gas+Wat								
	Since we allready have too low BHP, this will continue to be too low when we restrain further the flow from		Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat	0	0	0					
	6	7	Tot	Oil+Gas+Wat	679,855	0,098128	319,902	144,337	31,9979	0,010188	4948,32	28,4423
		TOO LOW BHP	Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat	679,855	0,098128	319,902					
	6	8	Tot	Oil+Gas+Wat	730,654	0,105204	269,089	143,986	26,9158	0,009503	4828,5	31,1687
			Lateral	Oil+Gas+Wat	44,1638	0,006283	247,195	142,269	84,8421	0,046371	315,831	257,983
			Mainbore	Oil+Gas+Wat	686,4902	0,098921	21,894					
	6	9	Tot	Oil+Gas+Wat	751,333	0,10806	248,418	143,824	24,848	0,009252	4785,27	32,2315
			Lateral	Oil+Gas+Wat	40,2976	0,005733	225,742	142,269	84,8528	0,046404	288,372	258,082
			Mainbore	Oil+Gas+Wat	711,0354	0,102327	22,676					
	6	10	Tot	Oil+Gas+Wat	754,155	0,10845	245,598	143,803	24,5659	0,009219	4779,84	32,3745
			Lateral	Oil+Gas+Wat	39,7704	0,005658	222,816	142,269	84,8543	0,046409	284,626	258,095
			Mainbore	Oil+Gas+Wat	714,3846	0,102792	22,782					

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	5	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	4		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat	0	0	0					
	5	5		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	6		Tot	Oil+Gas+Wat	649,65	0,0940594	350,105	144,785	35,0191	0,010629	5107,19	26,3534
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	7		Tot	Oil+Gas+Wat	700,329	0,101027	299,435	144,256	29,9506	0,00989602	4937,91	29,2916
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	5	8		Tot	Oil+Gas+Wat	747,544	0,107597	252,198	143,934	25,2263	0,00929153	4818,94	31,861
				Lateral	Oil+Gas+Wat	41,0042	0,00583363	229,664	142,269	84,8508	0,0463979	293,392	258,064
				Mainbore	Oil+Gas+Wat	706,5398	0,10176337	22,534					
	5	9		Tot	Oil+Gas+Wat	766,608	0,110227	233,141	143,785	23,32	0,00906994	4777,86	32,8545
				Lateral	Oil+Gas+Wat	37,442	0,00532684	209,888	142,269	84,8615	0,0464308	268,081	258,154
				Mainbore	Oil+Gas+Wat	729,166	0,10490016	23,253					
	5	10		Tot	Oil+Gas+Wat	769,203	0,110585	230,547	143,766	23,0605	0,00904056	4772,68	32,9879
				Lateral	Oil+Gas+Wat	36,9574	0,00525789	207,196	142,269	84,863	0,0464356	264,636	258,167
				Mainbore	Oil+Gas+Wat	732,2456	0,10532711	23,351					

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	4	0			Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. total	BHP
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	4		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	5		Tot	Oil+Gas+Wat	636,718	0,0925477	363,028	145,351	36,312	0,0108025	5338,06	24,6559
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	6		Tot	Oil+Gas+Wat	684,241	0,0990389	315,501	144,743	31,5583	0,0100944	5096,9	27,7153
		TOO LOW BHP		Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	4	7		Tot	Oil+Gas+Wat	730,356	0,105393	269,362	144,303	26,9438	0,00948565	4933,33	30,4823
				Lateral	Oil+Gas+Wat	44,2145	0,00629035	247,476	142,269	84,842	0,046371	316,191	257,982
				Mainbore	Oil+Gas+Wat	686,1415	0,09910265	21,886					
	4	8		Tot	Oil+Gas+Wat	772,456	0,111194	227,255	143,949	22,7321	0,00899069	4811,91	32,848
				Lateral	Oil+Gas+Wat	36,3425	0,00517042	203,781	142,269	84,8651	0,0464418	260,266	258,182
				Mainbore	Oil+Gas+Wat	736,1135	0,10602358	23,474					
	4	9		Tot	Oil+Gas+Wat	789,241	0,113501	210,475	143,81	21,0535	0,00880799	4772,63	33,7501
				Lateral	Oil+Gas+Wat	33,2088	0,00472458	186,368	142,269	84,876	0,0464754	237,984	258,262
				Mainbore	Oil+Gas+Wat	756,0322	0,10877642	24,107					
	4	10		Tot	Oil+Gas+Wat	791,518	0,113814	208,199	143,792	20,8258	0,00878376	4767,67	33,8708
				Lateral	Oil+Gas+Wat	32,7838	0,00466412	184,006	142,269	84,8776	0,0464803	234,962	258,273
				Mainbore	Oil+Gas+Wat	758,7342	0,10914988	24,193					

					$[Sm^3/d]$	[MMSm³/	$[Sm^3/d]$	[Sm³/Sm³	[%]	[Sm³/Sm³	$[Rm^3/d]$	[Bar]
	Lateral	Mainbore										
ICV position	3	0		Phase mode	Oil rate	Gas rate	Water rat	GOR	WCUT	LGR	Q res. tota	BHP
			Tot	Oil+Gas+Wat								
			Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat								
	3	3	Tot	Oil+Gas+Wat								
			Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat								
	3	4	Tot	Oil+Gas+Wat								
			Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat								
	3	5	Tot	Oil+Gas+Wat	691,972	0,100574	307,739	145,345	30,7828	0,00994	5359,29	26,5267
		TOO LOW BHP	Lateral	Oil+Gas+Wat								
			Mainbore	Oil+Gas+Wat								
	3	6	Tot	Oil+Gas+Wat	733,886	0,106229	265,814	144,749	26,5894	0,009411	5109,22	29,494
		TOO LOW BHP	Lateral	Oil+Gas+Wat	43,55	0,006196	243,79	142,269	84,8437	0,046376	311,472	257,999
			Mainbore	Oil+Gas+Wat	690,336	0,100033	22,024					
	3	7	Tot	Oil+Gas+Wat	773,205	0,111593	226,468	144,325	22,6542	0,008958	4931,62	32,0659
			Lateral	Oil+Gas+Wat	36,1948	0,005149	202,96	142,269	84,8655	0,046443	259,216	258,186
			Mainbore	Oil+Gas+Wat	737,0102	0,106444	23,508					
	3	8	Tot	Oil+Gas+Wat	808,101	0,116349	191,579	143,978	19,164	0,008592	4810,6	34,1892
			Lateral	Oil+Gas+Wat	29,6815	0,004223	166,757	142,269	84,8902	0,046519	212,893	258,351
			Mainbore	Oil+Gas+Wat	778,4195	0,112126	24,822					
	3	9	Tot	Oil+Gas+Wat	821,77	0,118217	177,913	143,856	17,797	0,008456	4771,98	34,9799
			Lateral	Oil+Gas+Wat	27,1325	0,00386	152,576	142,269	84,902	0,046555	194,753	258,416
			Mainbore	Oil+Gas+Wat	794,6375	0,114357	25,337					
	3	10	Tot	Oil+Gas+Wat	823,613	0,118467	176,069	143,838	17,6125	0,008438	4767,04	35,0848
			Lateral	Oil+Gas+Wat	26,7886	0,003811	150,662	142,269	84,9037	0,046561	192,304	258,424
			Mainbore	Oil+Gas+Wat	796,8244	0,114656	25,407					

						[Sm³/d]	[MMSm³/d]	[Sm³/d]	[Sm³/Sm³]	[%]	[Sm³/Sm³]	[Rm³/d]	[Bar]
	Lateral	Mainbore											
ICV position	0	0			Phase mode	Oil rate	Gas rate	Water rate	GOR	WCUT	LGR	Q res. tota	BHP
				Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat								
				Mainbore	Oil+Gas+Wat								
	0	3		Tot	Oil+Gas+Wat								
				Lateral	Oil+Gas+Wat	0	0	0					
				Mainbore	Oil+Gas+Wat	0	0	0					
	0	4		Tot	Oil+Gas+Wat	969,202	0,137286	30,8832	141,648	3,08806	0,0072847	7967,53	22,7193
		TOO LOW BHP		Lateral	Oil+Gas+Wat	0	0	0					
				Mainbore	Oil+Gas+Wat	969,202	0,137286	30,8832					
	0	5		Tot	Oil+Gas+Wat	969,182	0,137578	30,8833	141,953	3,08813	0,00726905	5913,48	31,5799
				Lateral	Oil+Gas+Wat	0	0	0					
				Mainbore	Oil+Gas+Wat	969,182	0,137578	30,8833					
	0	6		Tot	Oil+Gas+Wat	968,674	0,139631	30,8836	144,147	3,08973	0,00715857	5382,89	35,441
				Lateral	Oil+Gas+Wat	0	0	0					
				Mainbore	Oil+Gas+Wat	968,674	0,139631	30,8836					
	0	7		Tot	Oil+Gas+Wat	968,702	0,139326	30,8829	143,828	3,08957	0,00717442	5058,1	37,8483
				Lateral	Oil+Gas+Wat	0	0	0					
				Mainbore	Oil+Gas+Wat	968,702	0,139326	30,8829					
	0	8		Tot	Oil+Gas+Wat	968,722	0,139166	30,8826	143,659	3,08948	0,00718285	4876,72	39,3541
				Lateral	Oil+Gas+Wat	0	0	0					
				Mainbore	Oil+Gas+Wat	968,722	0,139166	30,8826					
	0	9		Tot	Oil+Gas+Wat	968,729	0,139121	30,8826	143,612	3,08946	0,00718518	4823,64	39,8201
				Lateral	Oil+Gas+Wat	0	0	0					
				Mainbore	Oil+Gas+Wat	968,729	0,139121	30,8826					
	0	10		Tot	Oil+Gas+Wat	968,73	0,139116	30,8826	143,606	3,08946	0,00718548	4817,09	39,8783
				Lateral	Oil+Gas+Wat	0	0	0					
				Mainbore	Oil+Gas+Wat	968,73	0,139116	30,8826					