Journal of Petroleum Research & Studies

Analytical Study to Estimate Re-entry Horizontal Well Productivity of Amara oil Field

Dr. Jalal Abdulwahid R*, Mr. Moaed Hasson D, Ms. Rwaida Abdulmajeed K.**
***Uinversity of Baghdad,**South Oil Company**

Abstract

Amara is situated south east of the city of Missan. The structure of Amara field is approximately about 9 Km long and 5 km width. This field is produced from three producing reservoirs Khasib, Mishrif and Nahr Umar. Most of the wells in this field that are producing from the main pay zone (Nahr Omar) suffer from sand production problem that was led to completely shut-in the wells due to accumulated sands in the wellbore.

The objective of this study is to investigate re-entry horizontal wells as a solution that may lead to minimize the well problems especially that is concern with sand problem, keeping into consideration the increasing wells productivity.

The production of horizontal wells can dramatically be improved by providing a greater contact of reservoir to the wellbore. Horizontal wells may also offer other advantages such as decreasing pressure drop, fluid velocities around the wellbore, minimizing water and gas coning as well as accelerated production. This may be extended to include the elimination of sand production problem from unconsolidated sand formations. Additionally, the design of horizontal wells must also includes the sand screens and/or gravel pack completion.

Due to limited geological and reservoir data of Amara oil field, advance analytical software was used to analyze the production history for two vertical wells AM/2 and AM/3. These wells are completely shut-in due to sand accumulation in the wellbore. The analytical solution converts the vertical well geometry into horizontal well model using same reservoir and fluid characteristics to estimate horizontal wells productivity increment for different pressure drawdowns and stimulation process.

The results showed that well AM/3 has greater response for production increment against the applied reservoir pressure drawdowns and stimulation activity than (well AM/2). This conclusion may led to select (well AM/3) to be much superior than (well AM/2) for eliminating sand control production.

Introduction:

In the last decade, horizontal wells drilling has gained wide acceptance due to the offering a wide range of advantages. The principal application of horizontal wells is to increase the well productivity via increased contact with the reservoir rock. Increasing the area of contact with the reservoir will result in an increase in the productivity index of the well. These facts imply that longer horizontal wells are more productive so that horizontal wells should be drilled as long as possible [1, 2].

In reservoirs with bottom water or gas cap or both, a horizontal well can be strategically placed and produced with much less drawdown resulting in increase of production and ultimate recovery [3]. Moreover, in highly unconsolidated sandstone formations, the production of formation fluids will probably be associated with the production of formation sand. In some situations, small quantities of formation sand can be produced with no significant adverse effects. However, in most cases, sand production leads to reduced productivity and/or excessive maintenance to both down hole and surface equipment [4].

Improvements in technology and operating procedures have resulted in a substantial reduction in costs. Drilling costs are still reported to be 1.3–2 times more than comparable vertical wells [3], such advantages can lead to adapt for drilling horizontal well technology.

Almost all wells drilled in Amara oil field that are producing from the main pay zone (Nahr Omar) suffer from the sand production problem. In addition to the low productivity indices, the pressure history for both of wells AM/2 and AM/3 showed rapid decline in production history as it is shown in Figures (1, 2). Therefore, it is safe to assume the reservoir of weak water drive mechanism and then the selection of horizontal wells may also be a useful choice to increase wells productivity as well as eliminating well problems.

Amara oil Field Description:

The area of Amara oil field is about 9x5 km, this field was discovered in 1993 and first production came in March 2000. The production of field is continuous with exceptions in 2001 and 2003.

The field consists of three reservoirs; the Khasib, Mishrif and Nahr Umr formations. The Khasib is about 80 m thick interval. Mishrif consists of three minor oil-bearing units and water bearing zones. The Nahr Omar is the main oil-bearing unit reaching a thickness from 55 to 70 m [5].

The core permeability of Khasib ranges from 0.1 to 100 md. The Mishrif core permeability is about 0.1 to 1000 md. The permeability of Nahr Omar reservoir ranges from 0.1 to 4000 md [5].

Converting Vertical Wells to Re-entry Horizontal Wells

Estimating horizontal well productivity simulates the production history of the vertical well response using advance analytical software. The vertical well is then converted to horizontal well with anisotropic heterogeneities in reservoir rock and fluids characteristics. The horizontal well can be verified for different lateral section lengths to select the optimum length of horizontal section. This is capable of providing comparable productivity against well lateral length. The lateral section length (L_e) defines the wellbore area open to fluid flow [6].

Because no-flow boundaries are modeled using the method of images, the no-flow boundary has been selected as the best boundary configuration to match the well production history for both wells AM/2 and AM/3. Thus, the results are superposed in time based on the rate history provided [6].

Hence, this reservoir consists of mainly from unconsolidated sandstone, since the hydraulic fracturing may be excluded from the developing scenarios. Thus, only acid stimulation and drilling horizontal well sections are taken into consideration as best scenarios for developing the selected wells.

Results and Discussion:

In spite of the limited geological and reservoir data available for Amara oil field, a primary study using analytical simulation software could be done to evaluate the reservoir response for drilling horizontal well. The wells drilled in this field suffer from sand production liberating from Nahr Omar reservoir which is the main oil bearing interval in this field. Since the reservoir consists mainly from unconsolidated sandstone, the hydraulic fracturing may excluded from the developing scenarios. Thus, only acid stimulation and drilling horizontal well sections are taken into consideration as the reliable scenarios for developing the selected wells.

Analytical study to analyze the production history of wells AM/2 from Dec.2001 to Dec. 2006 and for well AM/3 from April 2000 to Nov.2009 has been made throughout converting them to horizontal wells model using advance software technology [5]. Subsequently, estimating wells productivity increment for different lateral section lengths, pressure drawdowns and stimulation values.

The effect of lateral section lengths on horizontal wells productivity has been verified for different reservoir anisotropy, stimulation activity and declining reservoir pressure drop. Therefore, this could increase oil productivity against lateral section lengths using a wide comparison analysis for the best selection.

The analytical simulation for the production history for well AM/2 showed no effect for formation anisotropy on well productivity. Whereas it could be noticed somewhat a little effect for the formation anisotropy on well AM/3 as shown in figures (3,4) respectively. This may also indicates the weak pressure support provided by the external boundaries.

Figures (5, 6) show the wells response of AM/2 and AM/3 respectively for oil production rate increment against wide range of lateral section lengths and for two different stimulation values (skin factor) for drawdown values of (2600 and 2350 psi) respectively. It can be notice that the production rate for well AM/2 has very little response for the stimulation process and it is limited only for the small lateral section lengths. However, well AM/3 provides the higher liquid production rates against the stimulation process for any lateral section length.

Hence, it may be important to compare the results of horizontal wells productivity that are shown in figures (5, 6) with that obtained by theoretical stimulation process for the vertical wells shown in figure (7). It is noticed that considerable effects for both of lateral section lengths and stimulation process in increasing the wells productivity than that obtained in vertical wells. However, this is well clarified in figure (8) that shows the ratio of productivity indices between horizontal and vertical wells. It can be noticed that both wells AM/2 and AM/3 provide higher productivities than vertical wells as well as the horizontal section length exceeds (250 ft).

Further investigation in figures (5,6, 8) show that optimum selection of lateral section lengths which will provide considerable flow rates for wells AM/2 and AM/3 are range between (1500 and 2000 ft) respectively. As beyond these lengths, the trend of oil production rate showed little increments in oil production via increasing the lateral section lengths. Moreover, this may be attributed for the weak water drive activity supported for the reservoir.

Figures (9, 10) show the production rate response against the applied reservoir pressure drop for different lateral section lengths compared with the base case of vertical well model for wells AM/2 and AM/3. It is demonstrated that well AM/3 provides greater flow rates than well AM/2 at any selective pressure drawdown. However, the selected drawdown values have been taken to maintain well production above the bubble point pressure, so that it can be kept accurate results provided by the analytical simulation.

Figure (11) shows a comparison review for the productivity index increment via lateral section lengths for wells AM/2 and AM/3 respectively. This comparison is based on assumption of (Kr=0.5) and no stimulation or damage effects applied for the wells. This figure obviously indicates that well AM/3 is more sensitive for oil productivity index increment than well AM/2. However, this conclusion should not be conflicted with that obtained in figure (8).

Conclusions:

The production history for both of wells AM/2 and AM/3 showed rapid decline in the production rates affected by both of week drive mechanism and sand accumulation in the wellbores. Therefore, it is important to carry out further advance strategies to develop reservoir production.

Based on the investigation results, it could be concluded that well AM/3 has much greater response for production increment towards the lateral sections lengths of horizontal drilling than well AM/2. This conclusion may lead to select well AM/3 to be much superior than well AM/2 for eliminating sand control production and to be the pilot re-entry horizontal well in this field.

However, eliminating sand production problem in horizontal section must also coupled by using down hole sand screens and/or gravel packs to extend life of the wells. Moreover, producing clean fluids as well as withstanding longley against the sand problem. while declining reservoir pressures at values in which the adhesive forces between the sand particles cannot prevent the movement of sand towards the well.

It is useful to state that the selection of mesh size of sand screens could be determined after getting down hole samples of sands along the entire length of horizontal section. However, the length and diameter of sand screens could be determined after proving the final decision for the best well length selection and optimum production capacity. While, the gravel pack is used to provide extra protection for the sand screens and keep more life for wells to produce clean fluids and to withstand Longley against the sand production problem; Additionally, the gravels has very high permeability than that of reservoir matrix permeability. This leads to neglect pressure drawdowns around the graveled wellbore zone. the effect of gravel pack on horizontal well productivity of AM/2 and AM/3 has been demonstrated for the case of lateral section length of (1500 ft) as shown in figures (12,13) respectively.

Moreover, sand production prediction study will be very useful to provide extensive knowledge for the reservoir and wells conditions. However, this study requires detailed reservoir rock mechanic studies along the entire horizontal well section to determine the stresses forces on the sand formation.

Symbols

AM/2 Well Amara-2

AM/3 Well Amara-3

Kr Vertical to horizontal rock permeability ratio $Kr = \frac{K_v}{K_h}$

Le Horizontal well section length (ft)

NTG Net to gross

S Skin factor

References:

1- M.S. Al-Blehed et.al. “Horizontal wells Find Varied Applications in Saudi Arabia”, Oil and Gas Journal, May-2000.
2- Abdullah M. Al-Qahtani, and Habib Menouar" New Correlations for Optimizing Horizontal Wells Completions", SPE 37768-1997.
3- George Stewart :Well Test Design and Analysis”, Library of Congress Cataloging-in-Publication Data, PennWell Corporation, 2011.
4- Michael J. Economides,” Completion Technology for Unconsolidated Formation”, Rev.2-1995.
5- Reports and Data Provided by Missan Oil Company.
6- FAST Technical Library, “ Rate Transient Analysis-V.4.5” Software Development company, Calgary, Alberta- 2011.

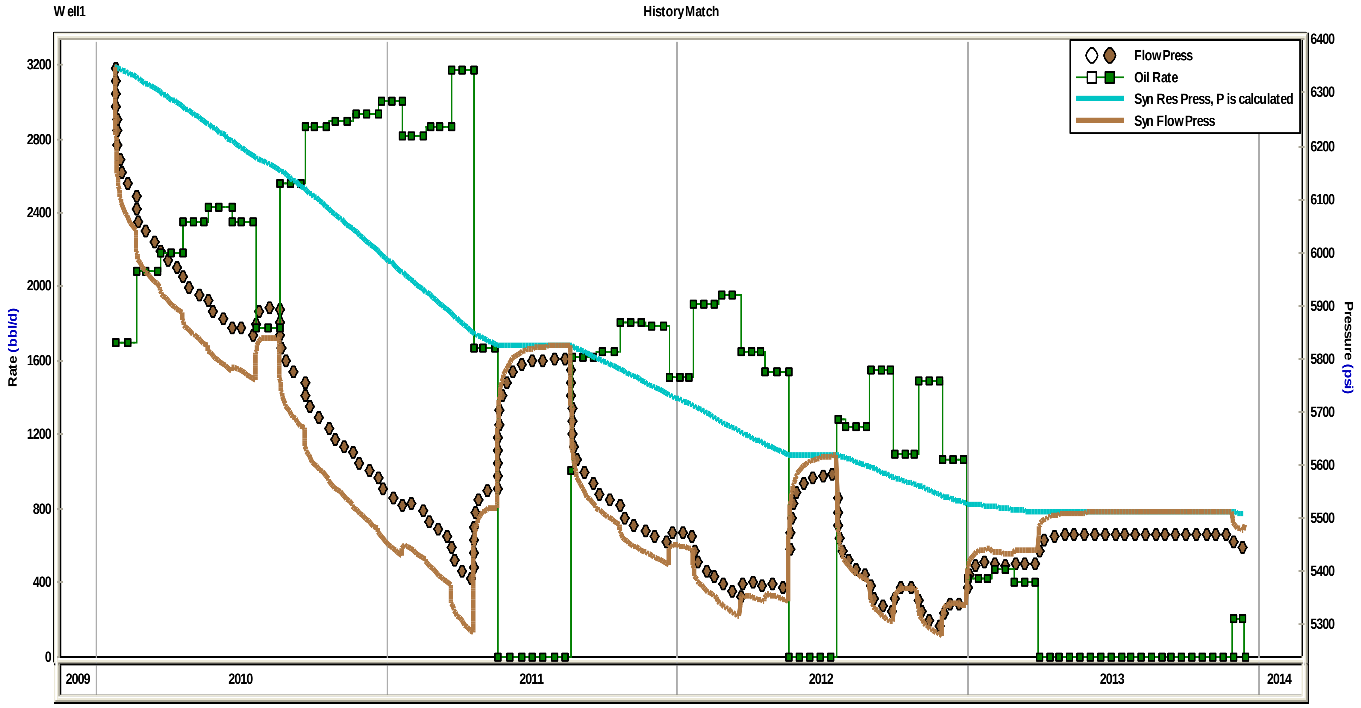

Fig. (1) Analytical simulation of the production history match of well AM/2.

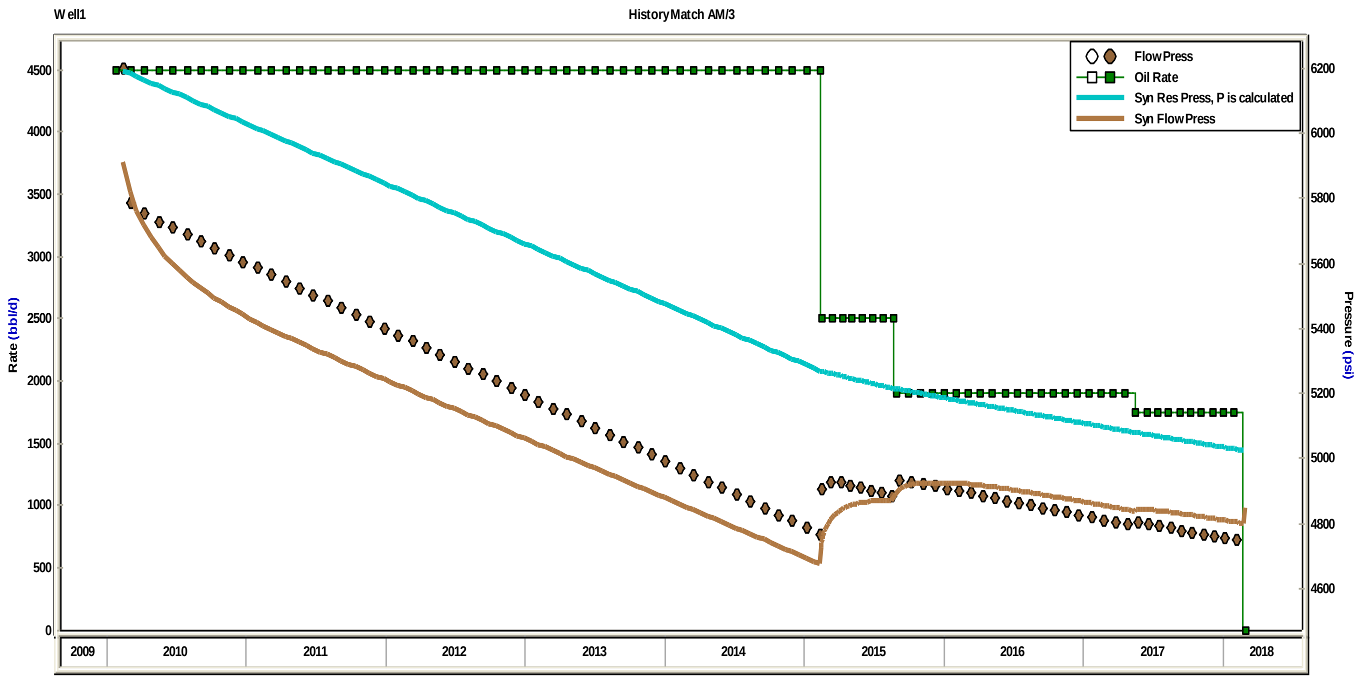

Fig. (2) Analytical simulation of the production history match of well AM/3.

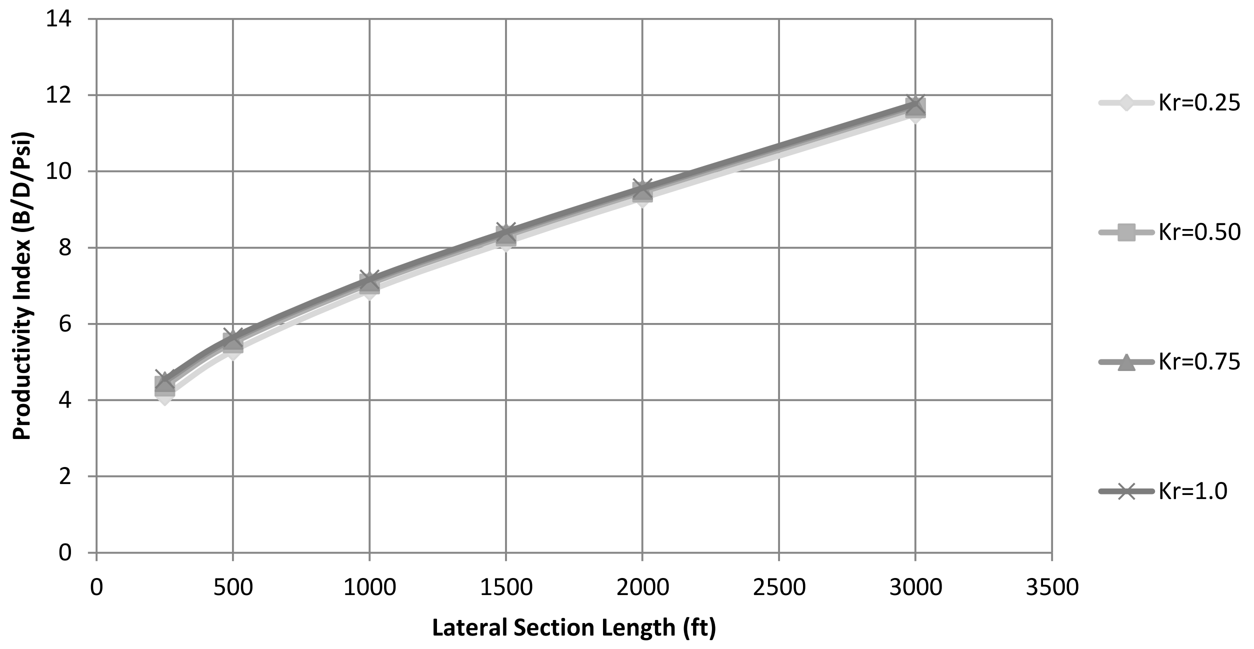

Fig. (3) Prodictivity Index Versus Lateral section Length of Amara Well No.(2)

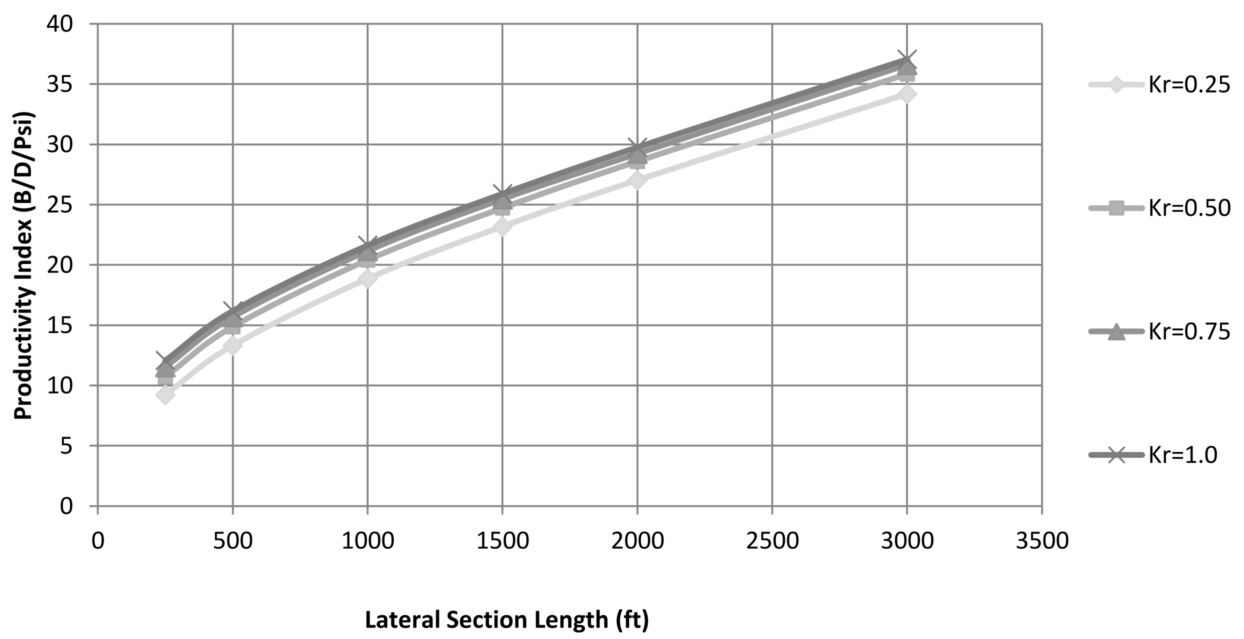

Fig. (4) Productivity Index Versus lateral Section Length of Amara Well No.(3)

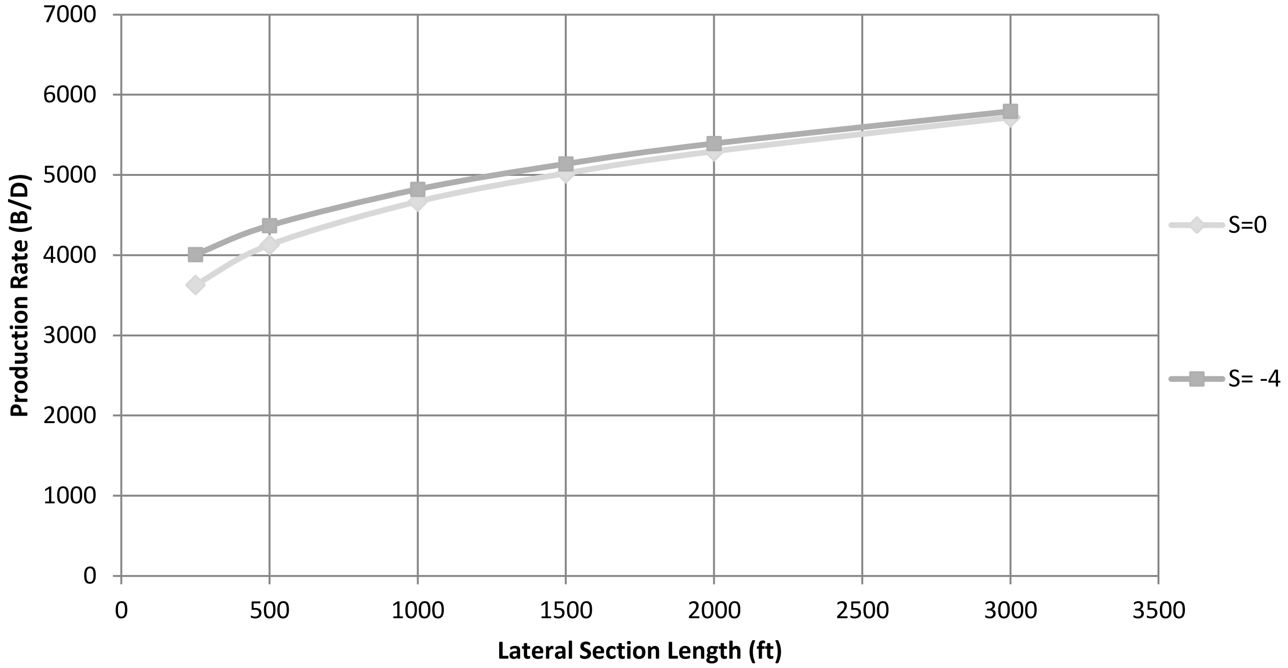

Fig. (5) Stimulation Activity for Horizontal Well AM/2

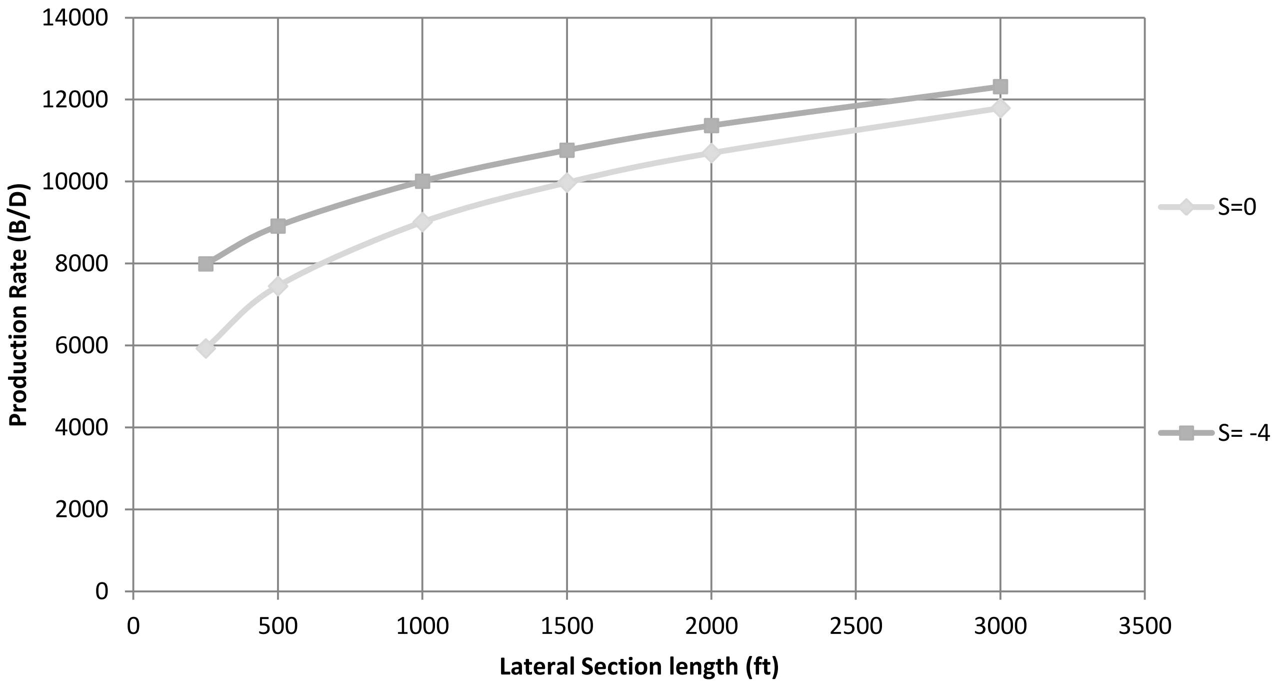

Fig.(6) Stimulation Activity for Horizontal Well AM/3

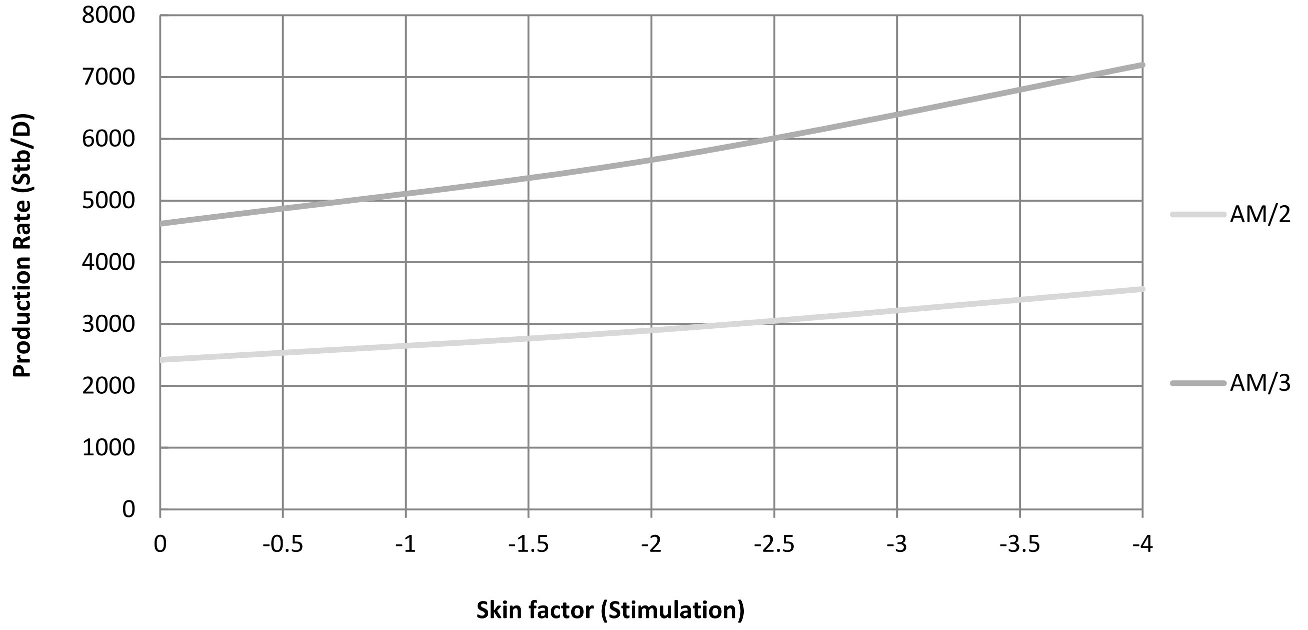

Fig. (7) Estimated production rate versus stimulation factor for vertical wells AM/2 & AM/3

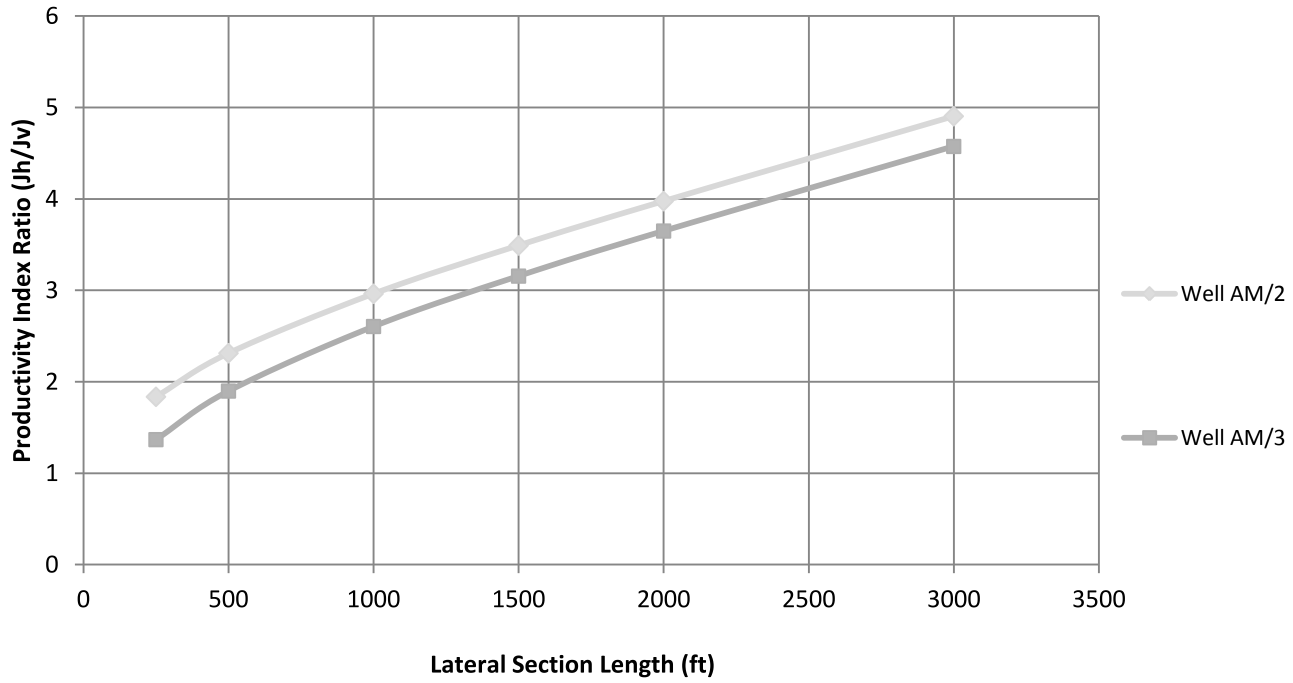

Fig. (8) Productivity Index Ratio (Jh/Jv) against Lateral Section Lengths for Wells AM/2 & AM/3

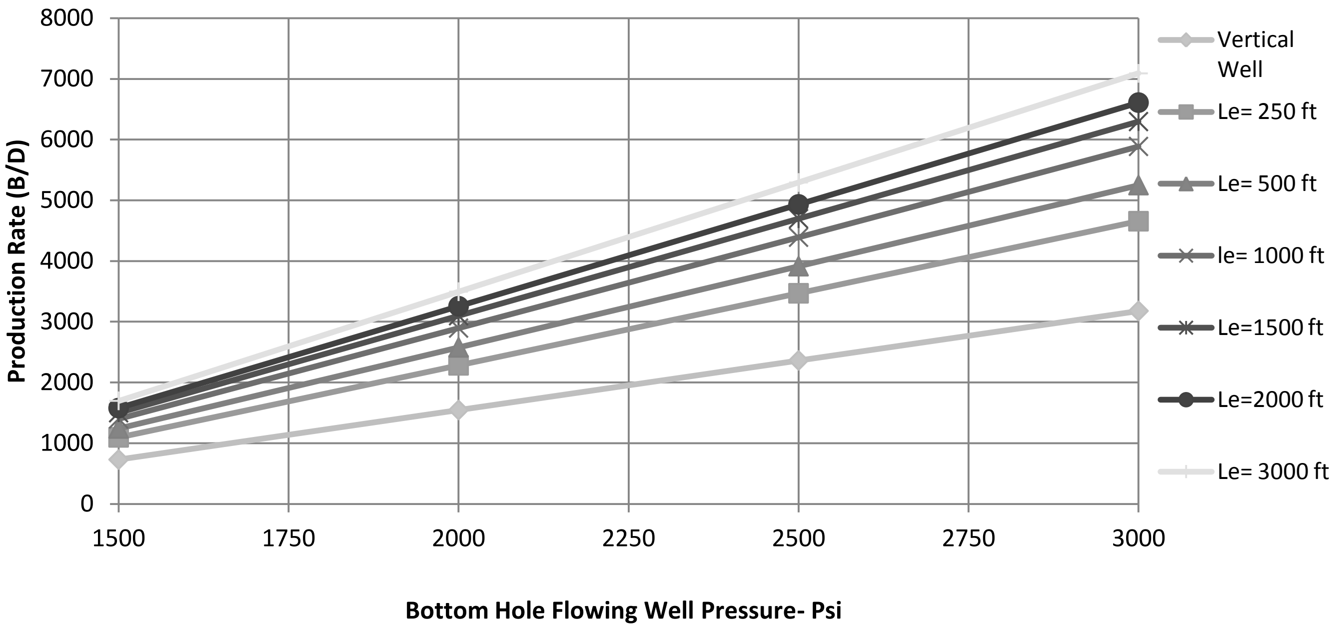

Fig. (9) Production Rate Increment against Reservoir Pressure Drawdown for Various Lateral Section Lengths (Well AM/2)

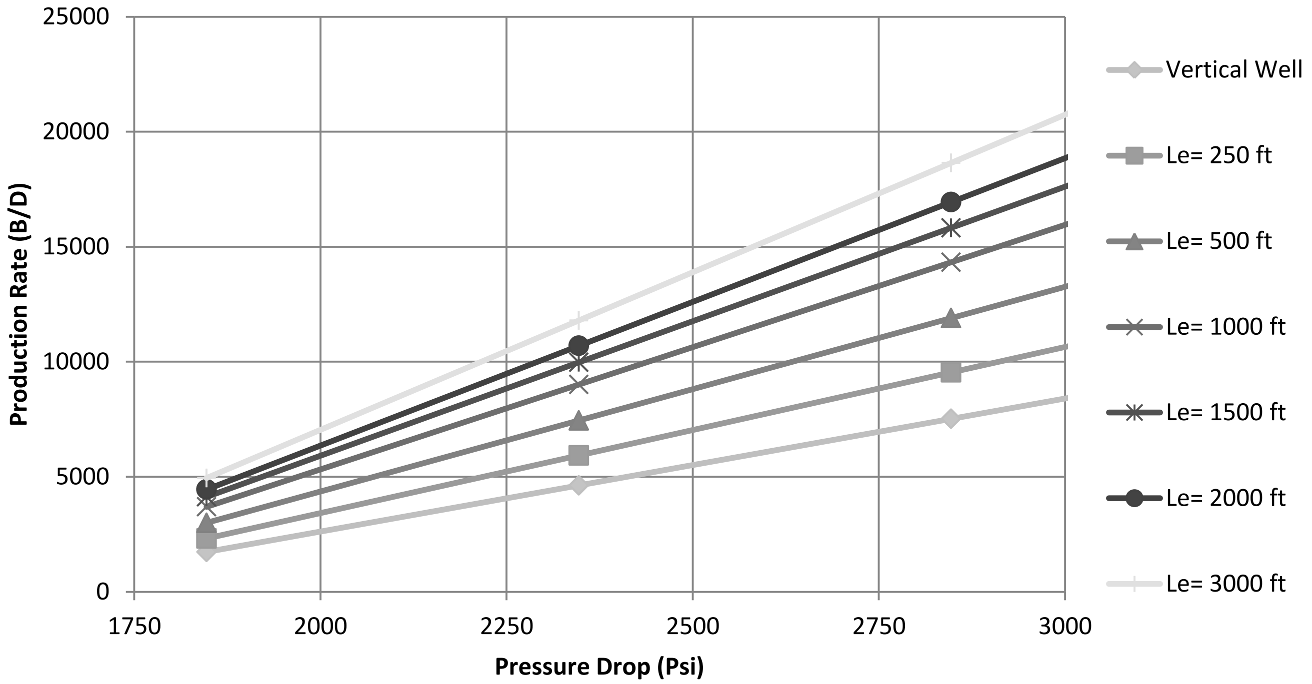

Fig. (10) Production Rate Increment Against Reservoir Pressure Drawdown for Various Lateral Section Lengths (Well AM/3)

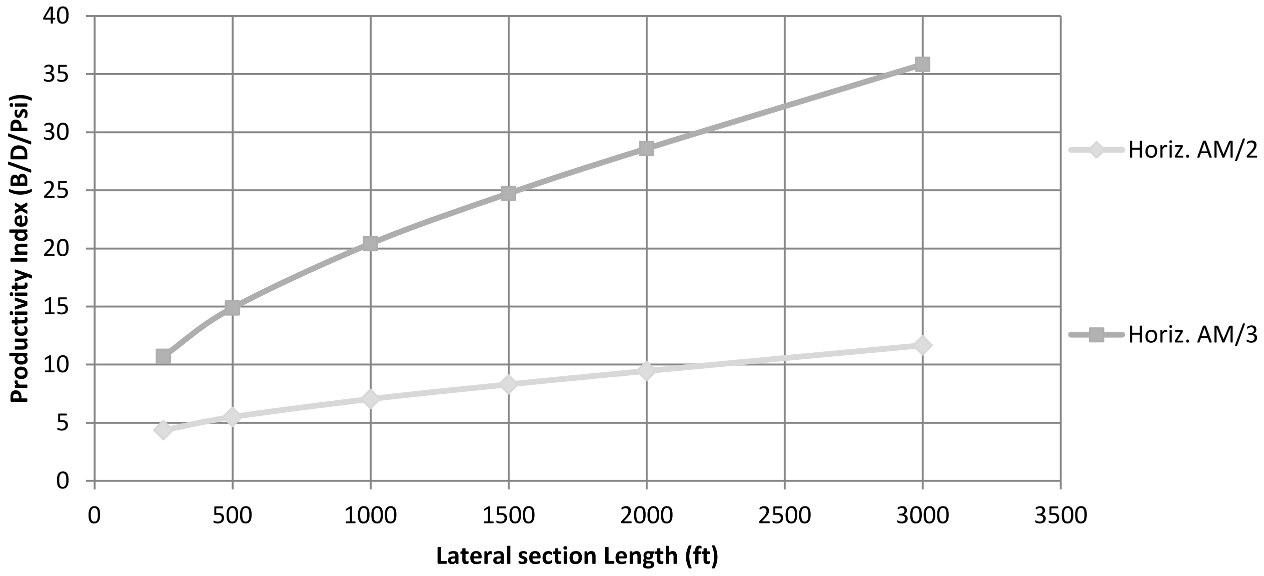

Fig. (11) Productivity Index Varition with Lateral Section Length for Wells AM/2 and AM/3

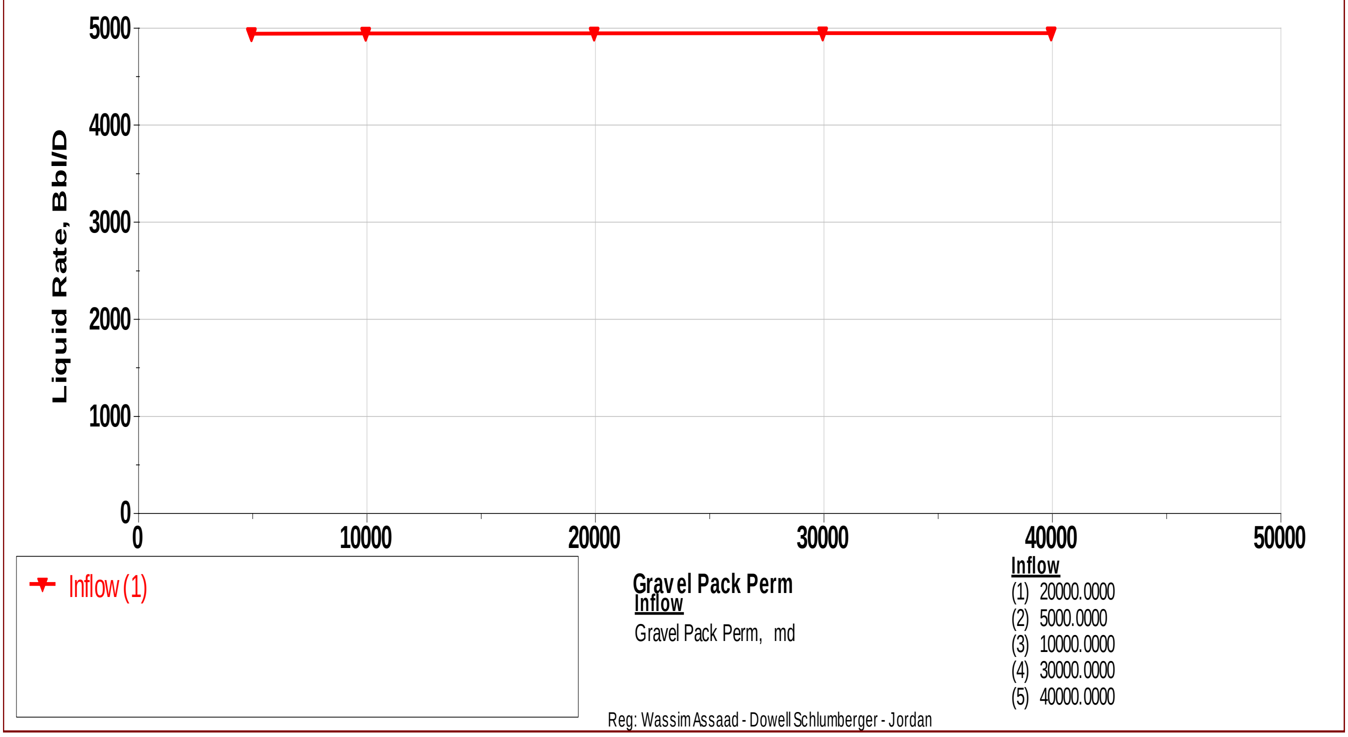

Fig. (12) Effect of gravel pack on horizontal well productivity of AM/2

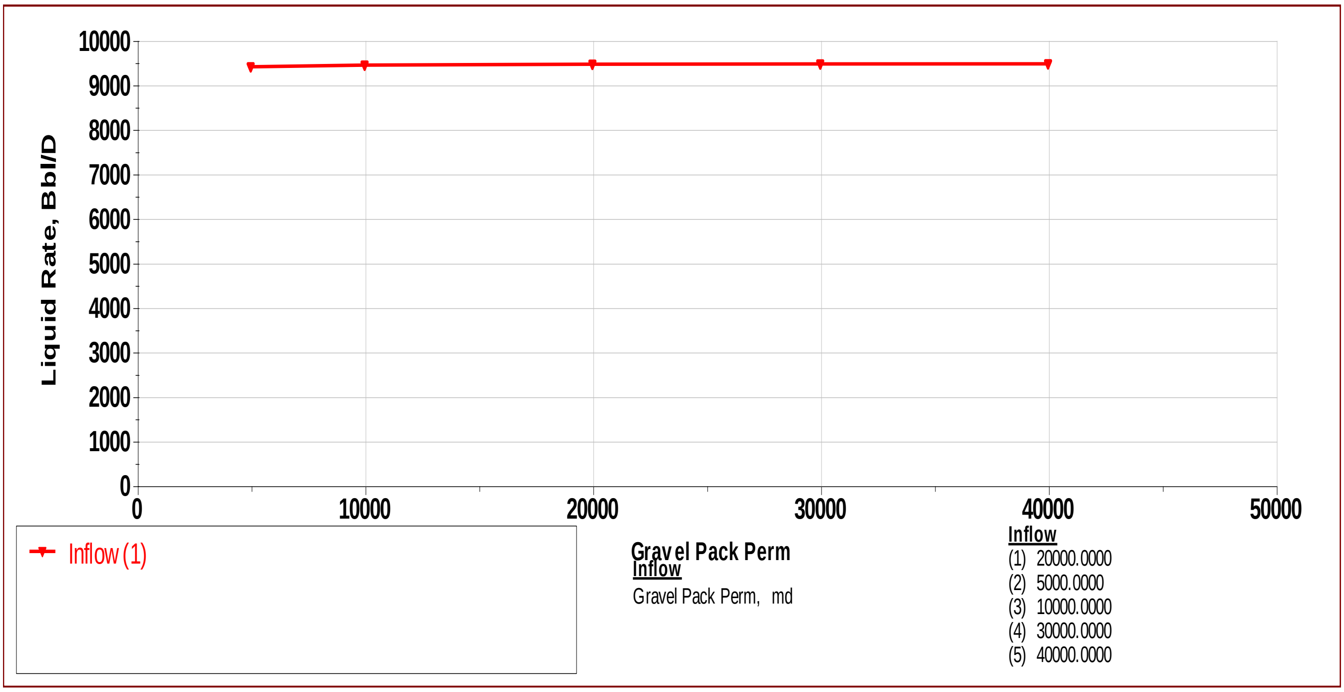

Fig. (13) Effect of gravel pack on horizontal well productivity of AM/3