Design of Infill Drilling System in Lot X, Central Area, Amazon Forest

Evaluation of oil projects - Capstone

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DEDICATION

To our parents who have always been the reason to go forward.
Infill Drilling in Lot X

APPRECIATION

God for allowing me to follow.
To the engineer Castro Barbaran for his support during the realization of the present project.
SUMMARY

This project evaluates the business opportunity to drill 100 Infill wells in the Central area of Lot X. For the location of each Infill well, three criteria are described in the methodology. Which consists of collecting structural, geological information, the production history and state of each of the wells. Subsequently the areas drained by the existing wells will be done, this will not help to identify areas that have not yet been drained. Finally an infill well will be developed taking into account the EUR and the historical production of the wells nearby.

After determining the location, an economic evaluation is performed with the main indicators: NPV, TIR, and PRI, which take into account tax and royalties. Finally a sensitivity of the NPV is realized with the price of the oil. The results show that Infill drilling is economically viable as long as there is an oil price above 25 US $. 
ABSTRACT

The infill drilling projects have a high successful because the reservoir uncertainty is low thanks to a good characterization of the field.

Infill drilling is a technique that consists of drilling wells within a field that is already development and is being produced by primary or secondary methods. In the case of a heterogeneous field (Lote X), it will allow to recover the reserves that could not be drained by the existing wells due to the low continuity of the formations.

The estimation of incremental oil and gas recovery from infill drilling projects is evidence that reducing well spacing increases recovery factor of a field, which gives us background to evaluate the benefit of improving spacing in developing wells.

The purpose of this work presents a methodology that can be applied to estimate or evaluate infill well project and can be realized an economic evaluation of well infill drilling in Lot X with current oil price.

Recovery of oil that could not be recovered by the current production wells in an economically viable way and without causing great environmental impact.
CONTENT

CHAPTER I ........................................................................................................................................ 7
INTRODUCTION ............................................................................................................................ 7
PROBLEM ........................................................................................................................................ 9
OBJECTIVE .................................................................................................................................... 9
HYPOTHESIS ............................................................................................................................... 10
CHAPTER II ...................................................................................................................................... 11
THEOREICAL FOUNDATION ....................................................................................................... 11
BACKGROUND ............................................................................................................................ 12
CHAPTER III .................................................................................................................................. 23
DESCRIPTION OF THE FIELD ...................................................................................................... 23
CHAPTER IV .................................................................................................................................... 39
METHODOLOGY ............................................................................................................................ 39
RESULTS AND DISCUSSION ........................................................................................................ 61
CONCLUSIONS .............................................................................................................................. 67
REFERENCES ................................................................................................................................... 69
ANNEXES ....................................................................................................................................... 70
CHAPTER I

INTRODUCTION

Infill drilling has now played an important role in the recovery of oil reserves at the distinct stages of life in the field, either because it wants to recover more quickly or because wells that already produce have not been able to drain the oil from certain areas.

Among its main benefits is to improve the lateral continuity of the formations and to have more information of the field. In addition, additional production generates profits without running as much water as when drilling in new areas.

Antecedents of infill drilling project to increase the recovery factor of mature fields have already been made in the world, as well as in South America due to their efficiency by the high knowledge of the deposits as well as an economic advantage compared to the projects Secondary recovery.

Some of these cases are:

The successful results of the Infill drilling have occurred in a wide variety of fields, from fields with primary recovery to fields with tertiary recovery.

Infill perforation is preferably performed in complex and low permeability areas similar to the Northeast.

The main objective of this project was to optimize the production that is being generated by the San Tomé District, by means of two very specific techniques of exploitation, which in combination are considered to give very good results. These techniques are to locate interspaced wells (INFILL DRILLING) in reservoirs that are suitable for this, with the method of exploitation of hollow reduced (SLIM HOLE), which has many economic advantages, and especially in this type of locations.
One of the most important aspects to consider in the planning and development of these reservoirs is the spacing and arrangement between wells, as this involves technical, geological, economic and legal aspects.

Similar cases can be observed in the area of Ozona Canyon Sands a site of tight gas. Where it was estimated to obtain a recovery of reserves of 353MMscf of gas.

Due to the large number of historical cases and antecedents of similar projects, it is necessary to analyze the feasibility of applying similar technologies in the main fields of Peru, for which lot X is an ideal area for the project due to the maturity of the field and Number of wells drilled in the area.
PROBLEM

The Lot X to be found within the Talara basin are fields that have been exploited for more than 50 years, these mature fields being wanted new techniques and technologies to be able to increase the recovery of the field.

Due to the fact that the Talara Basin has undergone an intense tectonic activity which has given rise to a high structural and stratigraphic complexity. Production formations such as Mogollon, Ostrea and others are heterogeneous. This results in layers and areas that have not yet been drained and have recoverable reserves with infill drill holes.

The alternative we propose is the realization of an infill well project in order to increase the recovery factor of Lot X following the methodology subsequently proposed for the optimal selection of wells.

OBJECTIVE

- Increase the recovery factor in the Mogollon formation, Centra area, and improve the lateral continuity of the formation with the drilling of 100 wells Infill. Improve the production of the wells by drilling infill wells applying the methods for their correct selection.
- Increase the productive life of the field and increase the profits of the company.
- Perform a study of the drainage area of each well, to improve the distribution in new analogous fields.
HYPOTHESIS

Through the infill well drilling project an incremental production is generated, achieving an increase in the recovery factor of the reservoir.

A thorough knowledge of the field (correct reservoir characterization, production history, well location, well status, etc.) allows us to perform better engineering studies.

By means of a correct methodology for the selection of infill wells, the results of the project are successfully improved.

In mature fields already known can be realized infill drilling projects due to the extensive knowledge of the fields.

In the price scenarios ranging from 50 $ are viable infill drilling projects, obtaining positive and satisfactory economic indicators.

Infill well drilling generates an increase in the reservoir recovery factor with low operating costs compared to secondary recovery projects.

Link the methodology to reduce spacing between wells in the development of new fields, in order to further optimize the resource and avoid making subsequent expenditures on well infill projects.
CHAPTER II

THEORICAL FOUNDATION

The productive life of a reservoir can be classified into three stages, depending on the energy it has. At the beginning of exploitation, the reservoir has enough energy to produce on its own, however, over time it undergoes a depression of pressure, that is, a loss of energy. To continue the exploitation of the reservoir it is necessary to provide additional energy, either to the well to raise the fluid to the surface, or to the reservoir by means of the injection of some fluid for the maintenance of pressure.

When the energy is applied to the well, there is an artificial production system. In contrast, when the reservoir is supplied with energy, it is called secondary recovery. The improved recovery processes arose from the need to increase the recovery efficiency of hydrocarbons, which by means of conventional and secondary recovery manage to extract between 20 and 50% of the oil contained in the porous volume, which indicates that a large percentage of oil Remains in training. The criterion used to perform the classification of oil recovery methods is that of energy source, using a detailed analysis of the reserves produced from the deposit.

Figure 1.- Enhanced Recovery Diagram
BACKGROUND

The successful results of the Infill drilling have occurred in a wide variety of fields, from fields with primary recovery to fields with tertiary recovery.

Infill perforation is preferably performed in complex and low permeability areas similar to the Northeast.

Quantification of the potential for Infill drilling and well recompletion in existing basins is often a challenge, due to the high variability in rock quality, well spacing, well completion practices, and the large number of wells. Wells involved. Often an operator has multiple Infill well candidates to choose from in a particular campaign.

The most accurate way to determine the Infill potential is to carry out a complete evaluation of the reservoir, including the preparation of a geological model of the study area, estimation of the distribution of the static properties of the reservoir such as porosity and permeability, Construction and calibration of a reservoir simulation model, so that a reservoir model can be obtained to predict future production and reserves of the potential locations of Infill wells. In the history adjustment process, the reservoir simulation model has to be adjusted to obtain a simulated response of the production similar to the production response observed in the field.

Conventional reservoir simulation studies may be the most accurate way to determine potential infill in a field, but they have the disadvantage that they require a lot of time to complete the study and are costly. This is important to be considered in studies where there are a large number of potential candidates for Infill locations, low permeability reservoirs where they can be among tens to hundreds of Infill candidates.

The Infill drilling we will perform in Lot X as a study area will be a drilling technique in already developed fields and that we are already applying primary and secondary recovery methods for an improvement in production
is why we will comment on the primary recovery and secondary with some cases of these.

Below are some case studies of fields.

- Cases with Primary Recovery

It results from the use of the natural energy sources present in the reservoirs for the displacement of the oil towards the producing wells.

The efficiency of the displacement of the oil in the primary recovery stage depends on the properties of the rock-fluid system and the thrust mechanisms that exist in the oil field. These mechanisms are:

1. Expansion of dissolved gas,

2. Gravitational forces,

3. Hydraulic thrust, and

4. Expelling force due to compaction of poorly consolidated reservoir rocks (Expansion of rock and fluids).

These mechanisms in the reservoir can act simultaneously or sequentially, depending on the composition and the properties of the deposit. A common aspect in all mechanisms of primary recovery is the fact that for them to act there must be a reduction of pressure in the reservoir; for this reason, when at some point in the life of a reservoir a fluid injection process is initiated which maintains totally or partially according to the degree of pressure maintenance, a primary mechanism for a secondary or additional recovery, based mainly on the immiscible displacement of the fluid in the reservoir by the injected fluid.

The Raja field, located south of Sumatra, produced from 1940 to 1976 from 36 wells with a spacing of 80 acres. Between 1976 and 1978, 6 new wells were drilled, increasing production from 300 to 3500 BPD.
The geology of this zone is quite complicated, with production of several limolites and sands along a thickness of 1500 ft. The type of channels is meander and is in the whole structure.

The Infill drilling project in the Raja field had an increase of more than 10 times in production due to an improvement in lateral continuity. Figure 1 shows the performance of this project.

Figure 2: Raja Field Production after Infill Drilling


- Cases with Secondary Recovering.

In the secondary recovery a fluid is injected into the reservoir to provide the necessary energy to produce, the main objective is to maintain an adequate pressure, at this stage the properties of the rock-fluid system are not altered.

The general mechanism of secondary oil recovery is the displacement of hydrocarbons to the producing wells and is due to the difference in pressure between the reservoir and the pressure of the producing wells. Secondary recovery may consist of maintaining pressure or an oil sweep by injecting water and / or gas into a well arrangement, well-scale operations are not considered to be improved recovery processes. Decay of reservoir pressure during primary recovery can be partially restored by injecting gas into the reservoir. Gas injection methods can be subdivided into three categories: (a)
Pressure restoration, (b) Pressure maintenance, and (c) Gas management, depending on the path chosen, gas is injected into the reservoir.

In the unit of Dollarhide, pertaining to a field where water injection takes place. By 1980, 44 Infill wells were drilled, producing more than 2.65 million barrels of crude oil. These wells produce more than 80% of the 2000 BPD produced by the field. The field declination curve analysis shows total crude oil production and crude oil production with 40-acre spacing.

This graph indicates that no interference has occurred yet due to the increase in the number of wells. The average final output for Infill wells is 125,000 barrels of oil per well at the end of the decline curve.

**Figure 3: Production of the Dollarhide Unit**


Results: only results have been reported for 11 Infill drilling projects in fields with secondary recovery, covering 1323 wells. The total increase in production of these projects was 142 million barrels for an average of 107,100 bbl / well. Table 1 and 2 shows a detailed summary of these 11 projects.
From tables 1 and 2 it can be observed that the recovery increase on average is 5%, by analogy for the case of sandstone deposit, the percentage increase would also be 5%.

### Table 1: Summary of Infill projects

<table>
<thead>
<tr>
<th></th>
<th>Means San Andre</th>
<th>Fullerton Clearfork</th>
<th>Robertson Clearfork</th>
<th>IAB Meniel Penn</th>
<th>Hewitt Hoxbar</th>
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<td><strong>Roca</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Profundidad, ft</td>
<td>4000</td>
<td>7000</td>
<td>6500</td>
<td>5800</td>
<td>2000 to 3000</td>
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<tr>
<td>Espesor Bruto, ft</td>
<td>300</td>
<td>600</td>
<td>1400</td>
<td></td>
<td></td>
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<tr>
<td>Espesor Neto, ft</td>
<td>92</td>
<td>92</td>
<td>200 to 300</td>
<td>45</td>
<td>100 to 700</td>
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<tr>
<td>Porosidad, %</td>
<td>9</td>
<td>10</td>
<td>6.3</td>
<td>7</td>
<td>21</td>
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<tr>
<td>Permeabilidad, md</td>
<td>20</td>
<td>3</td>
<td>0.65</td>
<td>27</td>
<td>184</td>
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<td>Agua intersticial, %</td>
<td>29</td>
<td>22</td>
<td>30</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>Aceite Residual, %</td>
<td>36</td>
<td>28</td>
<td>24</td>
<td></td>
<td></td>
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<tr>
<td>Temperatura, °F</td>
<td>100</td>
<td>117</td>
<td>117</td>
<td>134</td>
<td>96</td>
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<tr>
<td>Coeficiente Dykstra-Parson</td>
<td>—</td>
<td>0.83</td>
<td>—</td>
<td></td>
<td>0.73</td>
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<tr>
<td><strong>Fluido</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravedad, °API</td>
<td>29</td>
<td>42</td>
<td>32</td>
<td>44</td>
<td>35</td>
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<tr>
<td>FVF</td>
<td>1.04</td>
<td>1.62</td>
<td>1.25</td>
<td>1.86</td>
<td>1.13</td>
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<td>Presión de Saturación, psi</td>
<td>310</td>
<td>2370</td>
<td>1700</td>
<td>2525</td>
<td>905</td>
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<tr>
<td>Viscosidad del aceite, cp</td>
<td>6</td>
<td>0.75</td>
<td>1.2</td>
<td>0.2</td>
<td>8.7</td>
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<tr>
<td>Viscosidad del agua, cp</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
<td>0.5</td>
<td>0.95</td>
</tr>
<tr>
<td>Relación de viscosidad</td>
<td>7.5</td>
<td>1.25</td>
<td>2.0</td>
<td>0.4</td>
<td>0.2</td>
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<td><strong>Proyectos Infill</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Número de pozos</td>
<td>141</td>
<td>16</td>
<td>254</td>
<td>138</td>
<td>17</td>
</tr>
<tr>
<td>Áreas por pozo</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>16</td>
<td>40</td>
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<tr>
<td>Corte de agua</td>
<td></td>
<td>—</td>
<td>—</td>
<td></td>
<td>96 to 97</td>
</tr>
<tr>
<td>Incremento de crudo, 10^6 bbl</td>
<td>15.4</td>
<td>1.2</td>
<td>24.6</td>
<td>10.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Incremento por pozo, 10^3 bbl</td>
<td>109</td>
<td>75</td>
<td>97</td>
<td>78</td>
<td>100</td>
</tr>
<tr>
<td>Incremento por pozo por acre, bbl/acre</td>
<td>5450</td>
<td>7500</td>
<td>4650</td>
<td>4330</td>
<td>2500</td>
</tr>
<tr>
<td>Incremento del recobro, %OOIP</td>
<td>5 a 8</td>
<td>2 a 5</td>
<td>3 a 4</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>
Infill Drilling is a technique that consists of drilling wells within a field that is already under development and is being produced by primary or secondary methods. Infill drilling accelerates production for the case of a homogenous deposit, but will not increase reserves. In the case of a heterogeneous deposit, it will allow to recover the reserves that could not be drained by the existing wells due to the low continuity of the formations.

Lot X is a heterogeneous field with little continuity due to the large number of failures, which makes it a good prospect for the implementation of this method.

The heterogeneity and discontinuity between strata are specific characteristics of the reservoir which diminish their productive potential. They can be attenuated with the application of the Infill drilling technique,
reducing the spacing by drilling wells which will be reflected in an increase in connectivity between producers.

A cross-section of the formation can be seen in Figure 3, showing the discontinuity and heterogeneity of the deposit. By means of the drilling of an Infill well, the production is accelerated since it produces from strata 1, 2, 3, 5, 6; which are produced by wells 1 and 2. The biggest contribution of the Infill well is the increase of the reserves when putting to produce the sand 4, a sand that because of the nature of the deposit (heterogeneous) had not been found.

**Figure 4: Improvement of discontinuity through infill drilling**

![Diagram](source-url)


By improving the lateral connectivity by drilling an Infill well between two wells, a new zone opens between them, resulting in an increase in the recovery.

The factors that contribute to the increase of recovery after drilling are as follows:

- Improvement in the sandy sweep.
- Improvement in injection disequilibrium due to sandal heterogeneity.
- Improvement in vertical sweep.
Infill Drilling in Lot X

- Improvement in lateral continuity between zones.
- Reduction of the economic limit.

The acceleration in production, due to the infill drilling, generates great economic benefits if well programmed, since it allows to reach one of the objectives more persecuted by the companies that is the obtaining of profits in the shortest possible time. In addition, with the acceleration of production, operating costs (OPEX) are reduced because they occur in a shorter time.

Many factors should be considered for the selection of an Infill drilling project, some of these are:

- Remaining reserves.
- Heterogeneity of the reservoir.
- Spacing of Wells.
- Crude price.

Some of the characteristics of the deposit may be useful to evaluate the applicability of the technique of infill drilling. Based on positive results, obtained from several projects made in mature fields around the world, certain ranges have been established for the properties of the deposit.

These values guide the choice of viable fields for the implementation of an Infill well drilling program, for which it is necessary to develop an integrated reservoir model.

- Depth, 4300 to 7000 ft
- Net thickness, 12 to 500 ft
- Permeability, 0.7 to 27 mD
- Porosity, 7 to 19%
- Water saturation, 20 to 45%

These ranges correspond to experimental values, but fields with values outside the ranges will not necessarily be discarded as potential candidates for the implementation of an Infill well drilling program.
Currently Infill drilling is considered a very important technique in the industry, which must be taken into account in mature fields, due to the great demand for oil and the few discoveries of new deposits and good amount of reserves.

**Drilling Infill Vs Tertiary Recovery**

In some studies carried out by researchers, it has been proposed that Infill perforation is a more effective technique in the recovery of crude oil than the tertiary recovery, EOR, using chemicals such as carbon dioxide, surfactants, polymers or inert gases. Some opinions say that the tertiary recovery is a very expensive technique, its development is very slow and of questionable utility. A statement made by A.F. Van Everdingen indicates that tertiary recovery methods should be discarded and field cleared for an infill drilling with water injection with a well spacing of 20 acres or less.

**Infill drilling or tertiary recovery?**

The question in most reservoirs should not be whether to do Infill or EOR drilling projects, but when to apply each one. One proposal, the most used one, is to drill Infill for several years and then apply EOR methods. This has certain advantages over using both at the same time. The advantages are:

1. Less expenses (no costs for chemicals or gas compression)
2. Drilling programs will not be delayed by the purchase of chemicals or the construction of injection plants.
3. Eventually the tertiary recovery projects would have a much smaller spacing and better injection patterns.

However, there are some disadvantages to this type of proposal:

1. The amount of oil still present in the reservoir would be much lower, especially in areas where Infill wells are located. When the tertiary
recovery process is carried out the oil saturation will be minimal, making the oil recovery insignificant; therefore the process will be inefficient when the oil saturation approaches the criticism. EOR programs show better results when they start at an early stage of water injection not when the injection takes a long time to be applied to the reservoir.

2. Drilling programs are not designed for optimum performance of the tertiary recovery processes.

3. Infill drilling could produce less oil than required to keep the program viable, and then be able to apply EOR.

Another proposal is to not do infill drilling and conduct a tertiary recovery program at existing spacing, 40 to 160 acres. The main advantage of this method is the savings in additional costs due to the drilling of the Infill wells. In the case of a uniform reservoir with a high permeability and CO2 injection, greater spacing would also be an advantage because the short circuit effect on the injection would be reduced. The main disadvantage is the waiting time between the investment, the injection of the chemicals and the beginning of the crude production. Another disadvantage is the loss of reserves that may still be located in areas not drained by the injection of chemicals.

A different alternative is to perform Infill drilling and EOR methods at the same time. This alternative has many advantages:

1. Total reserves of crude oil will be higher.

2. The combined reserves of the infill and tertiary recovery can be recovered in a much shorter time.

3. Well costs are shared.

4. Increased crude saturation at the time of tertiary recovery.
5. There will be production in a shorter time.

6. Well patterns can be adapted for both infill drilling and EOR methods.

This alternative is really advantageous for the injection of chemicals such as micelles, polymers and silicates due to the new wells that can be designed to allow a better distribution of the injected chemicals.
CHAPTER III

DESCRIPTION OF THE FIELD

1.1 Basin and Lot X Location

The Talara Basin is located in the Northwest part of Peru at 1,250 Km from the city of Lima. Its extension is 15,000 km² of which one third is onshore.

It is defined as an Antearco Basin, bounded by the north with the structural rise of Zorritos, by the east with the rising of the mountain range of Los Amotapes, by the west with the zone of subduction of the Pacific and the South American Plate.

Due to its geographical position, it is a basin that is characterized by a stratigraphic-structural complexity that makes reservoirs strongly shared. It has a filling of 24,000 feet of sedimentary rocks ranging from the Paleozoic to the Pliocene, being characterized by being a multi-reservoir basin, being the main reservoirs in the Eocene period: Basal Salina, San Cristobal, Mogollon, Ostrea, Echino, Arenas Talara. These reservoirs may be duplicated and tripled due to the numerous inverse faults existing, mainly in the coastal area.

The Talara Basin is a basin that covers approximately 67 million acres along the west coast of South America, where the width of the Peruvian coastal zone is about 130 km. Grossling (1976) mentions that potential prospective areas for oil and gas are 1,000,000 km² in the onshore area and about 24,000 km² in the offshore area, which includes the Cretaceous-Tertiary oil system and the Cretaceous-Paleogene basin. The exploitation of oil and gas in mature fields and marginal fields of northwest Peruvian-Filomeno Marcelo Alto mori.

Production in northwestern Peru comes mainly from Talara's onshore and offshore basins and to a lesser extent from the onshore basin of Tumbes. The Talara Basin is of the fore arc type. The intense tectonic activity to which it has
Infill Drilling in Lot X

been subjected has given rise to a high structural complexity, where a high stratigraphic complexity is also observed.

Lot X is currently a unit managed by the China oil company in 2024. Lot X is located in the district of Lobitos, Alto and los Organos, in the Talara basin, Piura department. It covers an area of 46,952 hectares.

Figure 5: Location of Lot X on the map of Peru.
Figure 6: Location and distribution of Lot X

Source: Adapted from the map of lots in the northwest, PERUPETRO.

1.2 History of the basin and field

Drilling in La Cuneca Talara started at the end of the 19th century. In the middle of the twentieth century the active companies were several. IPC acquired the Lima Concession from the Lobitos oil company in the 1950s. The oil company of Peru SA takes control of the upstream and downstream chain in the northwestern Peru. Petroperu abandoned the upstream business in the 1990s.

As of September 2015, it produced more than 2.7 million barrels. The lot has been licensed since 1994, and was initially operated by the Argentine company Perez (1996). In 2004, the concession was obtained by Petrobras Energia. In November of this year it happened to be operated by CNPC. The license in lot X will last until May 2024.
Grosso, Marchal and Daudt (2005) mention that the basement, productive of the area, is composed of a series of Paleozoic rocks metamorphosed in different degrees. On this base can be developed both Tertiary units and Cretaceous units. No Triassic or Jurassic deposits have been identified. The total thickness of the sedimentary column is about 12,500 feet. Tertiary sedimentation is represented by a predominantly continental (fluvial) to transitional (delta / shallow) filling that culminates with an abrupt subsidence in the middle Eocene (Figure 8). This regional tectonic event causes the establishment of deep water conditions where high frequency turbiditic systems represent the most prospective hydrocarbon plays.

**Figure 7: Geological ages of their formations.**
### Table 3: Companies operating in the Northwest Peruvian

<table>
<thead>
<tr>
<th>COMPANÍA OPERADORA</th>
<th>LOTE</th>
<th>CUENCA</th>
<th>FECHA DE SUSCRIP.</th>
<th>Área del Lote / ha</th>
<th>Área Efectiva de trabajo / ha</th>
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<td>GMP S. A.</td>
<td>I</td>
<td>TALARA</td>
<td>27.12.1991</td>
<td>6,943,250</td>
<td>339.00</td>
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<td>PETROLERA MONTERRICO S. A.</td>
<td>II</td>
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<td>05.01.1996</td>
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<td>46,552,342</td>
<td>2,252.00</td>
</tr>
<tr>
<td>OLYMPIC PERU INC</td>
<td>XII</td>
<td>SECHURA</td>
<td>30.05.1998</td>
<td>283,357,845</td>
<td>29.00</td>
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<tr>
<td>PETROLERA MONTERRICO S. A.</td>
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<td>25.03.1998</td>
<td>9,999,772</td>
<td>10.00</td>
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<tr>
<td>PETROLERA MONTERRICO S. A.</td>
<td>XX</td>
<td>TALARA</td>
<td>19.01.2006</td>
<td>6,124,267</td>
<td>131.00</td>
</tr>
</tbody>
</table>

**Source:** adapted from the batch map of PERUPETRO, June 2016

### Figure 8: Main characteristics of the ETANESTE area

**Area:** 95 Km²  
**Area con sismica:** 71 Km²  
**Total pozos:** 1832  
**Primer pozo perforado EA122 (1/6/1925) Central**  
**Pozos activos:** 923  
**Pozos Inactivos:** 918  
**Producción de petróleo:** 4312 BOPD  
**Prod. Acum.: 163 MMbbls (40% del Acum. del Lote X)**  
**Proyectos de RS en ejecución:**  
1. Laguna-Verdua  
2. Central-Echinocymus  
3. Somotillo-Proyecto Echinocymus  

**Source:** PETROBRAS, as of 2007
1.3 Stratigraphy Sequence

Stratigraphy has been carried out by different companies and research institutions. The Talara basin distributes its sedimentary units as shown in the figure below.

Based on the analysis of seismic data, wells, aerogravimetry and gravity, the creation of the Talara Basin in the Paleocene and Eocene age resulted from two events (1) subduction of the Nazca Plate under the South American ridge and ) Depositional events related to transtensional and extensional tectonics (Raez Lurquin, 1999). Normal faulting is an important aspect of the structural style of the Talara basin, as well as low angle faults and large transcurrent vertical faults (Zúñiga-Rivero et al., 1998b). Bianchi (2002) mapping faults in the offshore area (Campo Litoral), where it is observed that the big faults have a north-south orientation. Seismic and subsurface data indicate that the faulting is more intense on the east side (onshore) and decreases towards the sea (Zúñiga-Rivero et al., 1998a). The following graph shows the complex failure in a north-south cross-section. The movement of the faults during the time of deposition and erosion resulted in formations of varying thickness across the Basin.

**Figure 6: Map of Failure of Talara basin**
In the Talara basin, the tectonic movements originated during the Paleozoic (Higley, 2004) established the geological framework that influenced the subsequent structural and depository patterns (Zúñiga-Rivero et al., 1998b). The position, shape, and size of offshore basins including the Talara basin are controlled by early Cretaceous tectonic activity, and involved Paleozoic and Mesozoic strata; which affected the region and divided it into a series of limited sedimentation areas. The Talara basin originated by tectonic activity in the Paleogene. The stratigraphic sequence of the Talara basin is mainly Eocene, which has a thickness of more than 8,500 m, which overlies more than 1,500 m of the Paleocene and a thickness of approximately 2,045 m of the Cretaceous (Zúñiga Rivero et al.-1998b). Figure 5 shows the stratigraphic sequence of the Basin.

**Figure 9: Stratigraphic column and description lithology, Lot X**

![Stratigraphic column and description lithology, Lot X](Source: PETROBRAS)
Figure 10: Stratigraphic column and description of Merina deposit, Lot X

Source: PETROBRAS
Figure 11: Stratigraphic column and description lithology of Merina-Mogollón deposit, Lot X

Source: PETROBRAS
Figure 12: Stratigraphic column and description lithology of the Tuna reservoir, Lot X

Source: PETROBRAS
Infill Drilling in Lot X

Figure 13: Stratigraphic column and lithology description, Lot X

Yacimiento La Tuna - Mogollón

Litología

- Ars. Cal. No compact; porosa
- Ars. fn/md.porosa, inter lut/lim.
- Lut. marrón, suave, smectita
- Ars. fn/md.porosa, inter lut/lim.
- Lut. marrón, suave, smectita
- Lut. marrón, suave, smectita
- Ars/Am/Cong. Czo. Fr/mad/gso, friab, poro-perm.
- Lut/Lim. Gis mod. sve. Inter Dolomita
- Ars. Fm/med muy calabarea (frag conchas)
- Lut. Intero Lim. Duras, abrasivas
- Ars. Mfn/mad. Calo. duras
- Ars/Am. Medigso/mgsograv. Heterog, compact
- Ars/Am/Cong. Gso/grava. Compact, fisurado

Comentarios

- Perdidas de circulación
- Entrada de agua y gas
- Derrumbes y puentes
- Litología abrasiva
- Derrumbes y puentes
- Perdidas de circulación
- Entrada de gas
- Baja tasa de penetración
- Litología abrasiva

Source: PETROBRAS
Infill Drilling in Lot X

Figure 14: Stratigraphic column and lithology description, Lot X

Yacimiento Carrizo - Intermedios

Litología

<table>
<thead>
<tr>
<th>Comentarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perdidas de circulación</td>
</tr>
<tr>
<td>Demnbres y puentes</td>
</tr>
<tr>
<td>Entrada de agua y gas</td>
</tr>
<tr>
<td>Demnbres y puentes</td>
</tr>
<tr>
<td>Litología abrasiva</td>
</tr>
<tr>
<td>Perdidas de circulación</td>
</tr>
<tr>
<td>Demnbres y puentes</td>
</tr>
</tbody>
</table>

Source: PETROBRAS
Grosso, Marchal and Daudt (2005) mention that the basement, productive of the area, is composed of a series of Paleozoic rocks metamorphosed in
Infill Drilling in Lot X

different degrees. On this base can be developed both Tertiary units and Cretaceous units. No Triassic or Jurassic deposits have been identified. The total thickness of the sedimentary column is about 12,500 feet. Tertiary sedimentation is represented by a predominantly continental (fluvial) to transitional (delta / shallow) filling that culminates with an abrupt subsidence in the middle Eocene (Figure 8). This regional tectonic event causes the establishment of deep water conditions where high frequency turbiditic systems represent the most prospective hydrocarbon plays.

Figure 16: Latex producing formations

Source: Undergraduate thesis by Rodríguez Peralta, UNI.

According to Figure 8, the Mogollon formation of the Central area has its cap at 5000 ft and a base at 3800 ft. Its net sand sand reaches 100 to 200 feet. With an effective porosity of 3 to 5%, permeability of 0.01 to 0.1 md and a saturation
of water of 55 to 60%. Taking into account the current permeability value, it will be necessary to perform a hydraulic fracturing of the production formation. It also has 24 wells for the Mogollón formation to 2007. A project of the year 2008 I drill about 85 development wells in the Central zone.

Figure 17: Lot X formations and their main characteristics in the Central area

Source: PETROBRAS, 2007
Table 4: Original oil in situ of the formations

<table>
<thead>
<tr>
<th>Formación</th>
<th>OOIP (MMbbls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verdun</td>
<td>10</td>
</tr>
<tr>
<td>Brechas</td>
<td>103</td>
</tr>
<tr>
<td>Helico</td>
<td>252</td>
</tr>
<tr>
<td>Echino</td>
<td>366</td>
</tr>
<tr>
<td>Ostrea</td>
<td>429</td>
</tr>
<tr>
<td>Mogollon</td>
<td>998</td>
</tr>
<tr>
<td>Amotape</td>
<td>41</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2199</strong></td>
</tr>
</tbody>
</table>

Source: PETROBRAS
CHAPTER IV

METHODOLOGY

Technical and commercial analyzes can support the drilling of additional producing wells to reduce spacing beyond that used within the initial development plan, subject to government regulations (if such approvals are required). Infill perforations can have a combined effect of increasing recovery efficiency and speeding up production. Only incremental recovery can be considered as additional reserves; this additional recovery may require a new distribution of production between individual wells with different entitlements of interest.

To be successful in an Infill drilling project it is necessary to have a map and study where the best alternatives are selected to achieve the expected objectives of the project.

For this reason, a methodology will be designed for existing mature fields and especially for Lot X.

Taking into account the main parameters in the selection of infill drilling projects such as the location and evolution of the prospectus, we will choose to carry out a study of lot X with the sufficient information that has the field.

It is extremely important to know that the design methodology of Infill wells is known to know the location, characteristics and properties for the production of undrained oil, which is still left in the field and through this project can gain a recovery incremental of the field.

The project will be followed by evaluating the productive sands layer by layer, so that an infill well that crossed different sands obtain the best results.

In the processes of the location of the areas projected for Infill drilling, it is of the utmost importance to have a good characterization of the field where the project will be carried out. For them, it is necessary to have the necessary
Infill Drilling in Lot X

geological and structural information to help us to know the geometry of the reservoir, its limits, faults, contact water oil, location of the wells drilled in the area.

It is also necessary to know the quality of the reservoir, that is, to know its petrophysical characteristics (porosity, permeabilities, capillary pressure) and the rock-fluid properties that will help us to understand the field drainage mechanisms (irreducible saturations and current reservoir saturations).

To all this, it is also necessary to know for the application of the methodology the history of distribution of the field production, in order to identify the sands that have contributed the most production, low sands containing oil remaining in them, as well as areas not drained because they are outside the reach of the drainage radius.

Because this lot has a large number of wells drilled we must know the condition of each of them, i.e., if they are producing wells know the production volumes and their production history, if they are inactive wells know the reasons why it is not producing (low production, need workover work, etc.) and if abandoned wells know the reason for abandonment (well problems, high water cut, etc.).

The drainage radius of a well shows us the influence it has on the reservoir showing its limits of extraction, although theoretically a single well could drain an entire reservoir this would suppose an ideal model of constant properties that allows the free flow of fluid in addition of a geological model that does not present limits to the flow (sealing faults, discordance, etc.) and would still take a long time to exhaust the present reserves.

It is because the ideal drainage radius of a well has been studied in order to optimize the production of a field, this depends very much on the quality of the reservoir and the depositional environment, as well as the type of well.

In the study of the field our drainage radius represents an image of a circular area that represents the area of the reservoir that contributes to the well.
The drainage radius does not help to visually identify, through the bubble map, areas that have not been drained so far, which helps us to identify prospective areas for infill drilling.

The drainage radius concept will be implemented in our case using the bubble map method and will be our first criterion to identify and select prospective areas for our infill drilling project.

For the first identification we will calculate the radius of drainage of each of the wells of the field and define each according to the production unit. Once the calculations have been made, they are drawn on the map, a map is made for each production unit to better analyze the drainage areas.

To calculate the radius of drainage there are two ways of calculating it.

If the reservoir is subject to hydraulic thrust.

\[ N_p = \frac{7758 \times A \times h \times \phi \times (1 - S_w - S_{or})}{B_{oi}} \]

Solving the equation is obtained:

\[ r_{ev} = \frac{43560 \times N_p \times B_{oi}}{\sqrt{7758 \times \pi \times h \times \phi \times (1 - S_w - S_{or})}} \text{ (ft)} \]

If it is a volumetric deposit:

\[ N_p = 7758 \times A \times h \times \phi \times \left[ \frac{1 - S_w}{B_{oi}} - \frac{1 - S_w - S_g}{B_o} \right] \text{ (STB)} \]

Solving the drainage radius:

\[ r_{ev} = \frac{43560 \times N_p}{\sqrt{7758 \times \pi \times h \times \phi \times \left[ \frac{1 - S_w}{B_{oi}} - \frac{1 - S_w - S_g}{B_o} \right]}} \text{ (ft)} \]
Where:

Np  Produced Oil (STB)
A   Drained Area (Ft²)
H   Net Thickness (Ft)
Ø   Porosity (%)
Sw  Water saturation (%)
Sg  Gas saturation (%)
Sor Saturation of residual oil (%)
Bo  Oil formation factor (RB / STB) current conditions
Boi Oil formation factor (RB / STB) initial conditions

The steps to follow to perform the assessment of the creation of Infill wells are followed by an engineering, optimization and economic criterion for them will take into account some criteria, which would contribute to improve the selection.

- The areas to be chosen must be outside the influence of neighboring wells, ie they must be outside the drainage area of other wells.
- The areas must have a significant size to make the project viable, its size should be similar or similar to the current field spacing.
- The wells must be above the water-oil contact and have a substantial net productive sand for its viability.
- It should be a consideration that the wells infill in project should not be found near to abandoned or inactive wells (wells that were abandoned due to low production or high water cut, etc.)

It is the most used method for calculating and estimating reserves. Due to its easy application. The estimation of reserves using declination curves is based on the analysis of the graph of oil production (oil produced vs. Time). When these variables have been plotted using data of the production history that is
possessed, the behavior of the production curve is extrapolated and the forecast of production and remaining reserves is obtained.

When analyzing the extrapolated declination curves, it is necessary to verify that the information being used from the well is not being affected by the deposition of paraffins or asphaltenes, sandblasting, isolation of zones, mechanical damage to the well and the conformation of gas or water.

Mathematical Fundamentation:

Generally there are three types of production decline curves which are governed by the following equation:

Figure 18: Decline curves.

Source: Paris de Ferrer m. Injection of water and gas in oil fields.
Infill Drilling in Lot X

\[
\frac{D}{Dt} = \left(\frac{q}{q_t}\right)^n
\]

Where:

- Exponential \((n = 0)\)
- Harmonica \((n = 1)\)
- Hyperbolic \((0 < n < 1)\)

**Exponential Declination**

The exponential decline consists of the decline of production to constant percentage and this is due to the mathematical expression or exponential equation that defines it, basically it is also the relationship that exists between the expenses of production and the production itself in a specific period of time.

On the other hand, in this graph of hydrocarbon production versus time for a given well, an extrapolation can be made to the future so as to be able to know about future production costs. In this way knowing such expenses, it is very probable to determine the net production or the reservation of a determined deposit.

\[
q(t) = q_o \times exp[-b(t - t_o)]
\]

Where:

- \(Qt\) Production over time
- \(Qo\) Initial production where decline begins
- \(B\) Ratio of continuous production \(Dq / Dt = -b \times Q\)
- \(T\) Time to know production
- \(To\) Decline start time
Hyperbolic Declination

This decline is due to the result of all natural and induced thrust mechanisms leading to a decrease in reservoir pressure and this in turn is related to the changes generated by the expansion of lightly compressible oil.

The equation used in this case is as follows:

\[ q = \frac{q_o}{1 + \frac{b_o t}{a}} \]

Harmonic Declination

There are times when production can be managed primarily by gravitational segregation, in which case the rate of decline (D) is directly proportional to the expenditure (q). Harmonic declination is a particular case of hyperbolic decline, in this case the value of the declining constant (b) is equal to 1. The above equations are similar to those of hyperbolic declination only if the term b is assumed to be 1, the final equation of this type of decline falls:

\[ q = \frac{q_o}{1 + b_o t} \]

\[ b = \frac{b_o}{1 + b_o t} \]

1.4 Location of current wells

The fields of the Northeast Peruvian are developed that is why it is necessary to perform an analysis to see the possibility of realizing infill drillings. One way to determine is by performing a collection of well information and following a clear and necessary methodology for its correct location.
Infill Drilling in Lot X

Methodology for the location of Wells Infill.

Obtain the map of the field and data of faults and limits.

Obtain field production information. If you are active, inactive or abandoned and say its possible causes.

Analyze historical production data. Identify the possible causes of inactive wells.

Do you have information?

Show production drain spokes. Define zones that are not outside of these radios.

Identify areas where drainage is not being performed to make possible infill perforations.

Do we know the drainage radius?
Infill Drilling in Lot X

Verify on the map that the potential Infill wells located in these prospective areas are outside the influence of the drainage radii of existing neighboring wells.

Obtain the 10-year EUR value by means of approximations of declination curves per sand from each well.

To know the ranges of the properties of the deposit. Giving more guarantees to wider areas for the application of Infill drilling.

Is there any influence of the EUR drainage radius on prospective areas?

Do you have the data?

Take test data and make correlations.

Discard prospective areas, because in the future the neighboring wells could be draining these areas.

Evaluate the prospective areas and average the results obtained for each of the evaluated areas.

For each sand, the most feasible prospective areas will be selected to drill an Infill well.

END
Lot X began its productive development in the year 1910, which means that the area has been exploited for almost 100 years and has produced around 450 million barrels of oil and has drilled more than 4900 wells and are currently active less than half of them. The following figure shows black holes wells that are already being produced.

**Figure 19: Distribution of wells in Lot X, Central area, to 2009**

Source: PETROBRAS
Infill Drilling in Lot X

Figure 20: Distribution of wells in Lot X, Intermediate secondary projects La tuna, at 2009

Source: PETROBRAS

Figure 21: Distribution of wells in Lot X, Drilling inFill La Tuna, to 2009

Source: PETROBRAS
Figure 22: Distribution of wells in Lot X, Drilling Infill intermediate Merina Central area, to 2009

Source: PETROBRAS

Figure 23: Distribution of wells in Lot X, Drilling development Merina Central area, to 2009

Source: PETROBRAS
Figure 24: Distribution of wells in Lot X, Development mogollón carrizo, to 2009

Source: PETROBRAS

Figure 25: Distribution of wells in Lot X, Perforacion development mogollon merina east.

Source: PETROBRAS
Figure 26: Distribution of wells in Lot X, Perforation intermediate development Carrizo.

Source: PETROBRAS

1.5 Oil reserves

The Mogollón formation has an original oil in place (POIS) of 998 MMSTB.
Figure 27: h.phi.So map of the Mogollón formation

Source: PETROBRAS


1.6 Location for perforations

For the identification and selection of the prospective areas it should be taken into account that this is done in part under the criterion of the evaluator and evidently following certain guidelines or criteria which are mentioned below:

- Prospective areas should be outside the influence of drainage radii from neighboring wells.
- The area must be significant, thus avoiding interference from future drainage.
- They should not be located near abandoned wells for low production, dry, high water production and High GOR.

It should be remembered that the selection criteria of areas cited are proposed by Rodríguez and Bernal in their undergraduate thesis and are a possible guide to identify prospective areas in the way that is believed to be the most convenient for this case.

To locate the possible areas, first a bubble map will be constructed, which will indicate the drainage radius of the current producing wells. An easy way is to calculate this radius based on its accumulated production with the following formula:

\[
r_{ev} = \sqrt{\frac{43560 \times N_p}{7758 \times h \times \pi \times \phi \times \left[ \frac{1 - S_w}{B_o} \times \frac{1 - S_w - S_g}{B_o} \right] (ft)}}
\]

With this data the bubble map is constructed in order to observe the potential areas of drilling. The bottom figure is just a reference to a bubble map.
After choosing the potential areas, we then make sure that these areas are of significant size.

Finally, it will be necessary to classify the current wells in the field as follows:
Table 5: Classification of well status.

<table>
<thead>
<tr>
<th>STATUS</th>
<th>CAUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>Causes not reported.</td>
</tr>
<tr>
<td>Inactive</td>
<td>Removal of surface unit, string or other mechanical part. Low production.</td>
</tr>
<tr>
<td>Abandoned</td>
<td>Dry</td>
</tr>
<tr>
<td></td>
<td>High water production.</td>
</tr>
<tr>
<td></td>
<td>High Oil Gas Ratio</td>
</tr>
<tr>
<td></td>
<td>Mechanical problems (collapses and fish).</td>
</tr>
</tbody>
</table>

Once the condition of each well is identified, the penultimate filter is performed, which indicates that the infill drilling should not be near wells with high water cut, GOR, or low production.

**Figure 30: Potential Locations for Infill (Red)**

---

Evaluation of the prospective areas

After filtering the areas that are likely to interfere with the production of neighboring wells, the process enters a fourth and final stage in which areas are rated, in a range of 1 to 5 (5 being the best rating), with Regarding
different parameters or characteristics of the deposit that must be taken into account to consider which of these areas in each of the sands are the ones that are most likely to be good oil producers.

Each of the parameters used to evaluate the prospective areas of each sand, shown below, should be scaled from 1 to 5 by assigning value ranges for each property to each scale number.

This allocation is made particularly to each sand and depends on how the values of this property behave throughout the entire reservoir, these variations along the reservoir are much easier to perceive if the variable is plotted on a grid map which shows its sandy behavior through all the sand, this is done knowing the values of these properties in the different existing wells and applying geostatistical methods to extrapolate this data to areas where the information is not possessed.

To be a little clearer and try to understand perfectly the procedure to be carried out will exemplify the weighting of a variable in a given arena:

We want to weight the variable "cumulative production (Np)" to be able to evaluate the prospective areas of certain sand. The first thing to do is to know the production data accumulated at the time of each of the completions of this arena, having these values are plotted on a grid map using the geostatistical method of your choice. Analyzing the map, the variable range is established, which for this example will be between 20000 and 300000 barrels of crude, and also in which values is the highest concentration of data, which make up a sub-range where the Average accumulated production of the sand, this sub-range will be set to a value of 3. Based on the already weighted sub-range and considering that the greater the accumulated production the better the prospective areas can be, the other sub-ranges of the variable, the weighting of the variable being as follows:
Table 6. Weighting of a variable.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sub-range</th>
<th>Weighing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative production Np</td>
<td>Less than 215000</td>
<td>1</td>
</tr>
<tr>
<td>(bbls)</td>
<td>215000-235000</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>235000-265000</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>265000-285000</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Greater than 285000</td>
<td>5</td>
</tr>
</tbody>
</table>

Source. The authors, based on CEC production histories.

Taking the weighting scales of these variables, we must proceed to evaluate each of the areas with respect to each variable, obtaining the values of the properties of each area of grid maps (Grid Maps). The final weight of each area will be the average of the grades obtained from the evaluation of each of the variables in each area.

To facilitate the processing of data within the process of evaluation of the prospective areas it is advisable to make a selection matrix using a spreadsheet, specifying the sand to be evaluated, the prospective area, the properties to be evaluated, the calculated average value for each area with their respective rating and the total score of each arena. Next, we propose a model of selection matrix that is recommended for the evaluation of the prospective areas:

In the event that the information required for the weighting and qualification of the prospective areas is not available, this information must be obtained through tests, registers, analysis of hearts, correlations and other tests that are considered necessary to obtain the required data.

After evaluating all the processes and obtaining the average score for each prospective area, obtained through the weighting of ranges should proceed to analyze the areas and identify the best score of each sand. The areas with the highest score are those that have the highest probability of success at the time of drilling an Infill well, and also because of the selection process...
are the areas that provide the greatest security that there is no interference with the production of the Neighboring wells.

Selecting the most feasible prospective areas to drill an Infill well, which are the ones that after averaging all the values obtain the highest score, we proceed to finally suggest the location of the Infill well that can be for the best prospective area of each sand or for the same area that presents good results in several arenas.

The analysis for the selection of the point to be drilled must be carried out with great care, as this may depend on the success of drilling an Infill well in the selected area. After the selection of the point to be drilled is made, the coordinates must be clearly specified in order to be able to locate this point in the field.

1.7 Infill drilling and completion

- 3 wells drilled every month
- Location: central area
- Geological objectives: Mogollón
- Depth 4500ft
- It has the following characteristics:

Depth: 4500 feet  
Gross: 126-51 bfpd  
Maximum GOR: 1502-1352

The resulting design of the Mechanical Pumping system:

Tubing 2 3/8 "(4500 ft. Wells)  
D type rods  
Bottom pumps: 1.25 "or 1.5"
RESULTS AND DISCUSSION

1.8 Production forecast for typical well

The forecast was made based on the production date of neighboring wells. In Figure 31 it can be seen that the decline of production is very rapid, one year after the drilling production will fall below half.

Figure 31: Infill well curve in the central area

Figure 31 shows that after the third year there will be a notable production of gas, a percentage of which can be sold.

Figure 32 was constructed taking into account that 3 wells are drilled per month. This shows that oil production is high during the first four years.
1.9 Economic evaluation

In order to carry out the economic evaluation, it is first necessary to determine the investment in well drilling, completion and start-up.

As an average for the work, the cost of drilling, completing and putting into production of 1 MMUS $ was considered, being the average cost of putting into production an infill well in the Talara basin.

In a general framework it was considered that the drilling of 100 wells with a frequency of 3 wells will be carried out every month.

An international market scenario of 60 $ barrel of oil and 4 $ MMBTU was estimated for the economic analysis.

According to the Peruvian Peruvian regulations, the income tax of 30% and royalties on the sale of liquids were considered 20%

It was estimated based on estimates of nearby areas operating costs was considered $ 15 per barrel produced.

Finally, cash flow is calculated for 15 years based on production with an opportunity cost of 15%. For production, it was taken into account that 36
wells were drilled the first year, another 36 the second and the last 24 the third year. The table shows the positive result for this project, with a capital recovery in two years.

If the price is maintained at US $ 60 we would have a project NPV of US $ 71 million with an opportunity cost of 15% the internal rate of return of the project was calculated at 28%.

<table>
<thead>
<tr>
<th>GENERAL PARAMETERS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL PRICE</td>
<td>60</td>
</tr>
<tr>
<td>GAS PRICE</td>
<td>4</td>
</tr>
<tr>
<td>OPEX</td>
<td>15</td>
</tr>
<tr>
<td>TAX</td>
<td>30%</td>
</tr>
<tr>
<td>ROYALTY</td>
<td>20%</td>
</tr>
<tr>
<td>DISCOUNT RATE</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table of General Parameters
# Infill Drilling in Lot X

## Project Cash Flow

<table>
<thead>
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64
## Infill Drilling in Lot X

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Total: 1,028,251,000.00
Infill Drilling in Lot X

GRAPHIC VNA VS TIR

![Graph showing VAN vs TIR relationship]

PROJECT SUMMARY

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CONCLUSIONS

✓ Taking into account the current state of the field, reservoir properties, recovery factor and reserves; The infill drilling is shown as a great option to increase the production of Lot X

✓ Economically, the Infill well drilling project in Lot X, central area, is viable. It has an investment recovery of almost two years and a NPV of 32 MMUS $.

✓ Infil drilling avoids huge drilling and exploration drilling costs in new areas.
RECOMMENDATIONS

✓ To estimate the incremental increase and success of the Infill drilling project it is advisable to choose an appropriate methodology with the data of the field that is possessed.

✓ Simulation prediction methods are more accurate and have a high percentage of reliability with good field characterization.
REFERENCES


3. RODRÍGUEZ, BERNAL: Methodology for the infill well drilling in a mature field with fluvial deposition environment. Application field Colorado. Undergraduate thesis. Industrial University of Santander.


ANNEXES

Engineering design:
- The Talara Basin (Lot X), being an area that has undergone an intense tectonic activity and being an area that has heterogenous formations, has caused that many zones of appreciable oil saturation have not been produced.
- Lot X being a developing field that is being produced by primary and secondary methods. The option to perform Infill drilling will allow to recover the reserves that could not be drained by the existing wells due to the low continuity of the formations.

PROBLEM SOLVING:
- Areas in northwestern Peru have reduced their oil productivity, which is why we plan to drill Infill wells to raise productivity.
- We could use other techniques of improved recovery but because of being more expensive, we decided to realize the Infill Drilling thus avoiding expenses by chemical and compression of the gas.

Application of Science:
- The location of the Infill Wells was made taking into account the prospective area according to the drainage radius of the neighboring wells.

\[
r_{ev} = \frac{43560N_p}{7758h\pi \phi \left( \frac{1 - S_w}{B_{oi}} - \frac{1 - S_w - S_g}{B_o} \right)} (ft)
\]

- Which should not be affected by well drainage radii that are already producing in the field. This in order to avoid a production of two wells of a certain zone.
Experimentation and Testing / Modern Engineering Practice:

- The application of these perforations were made according to the approximate data that are made for workover work.
- We proceeded to carry out an analysis to determine the degree of feasibility of our project, if it were to be carried out.
- From the beginning of the project we based on the scientific method, generating a problem, which was to decrease the productivity of the heterogeneous formations of Lot X, and in turn devise a possible hypothesis. With this, we proceeded to perform an experimental method based on real data.

Project management:

- As every project must have a scheme or a structure as we will do the work based on the three big criteria: cost, scope, time.
- The way of carrying out the project was detailed through a timetable detailing the dates of deliveries of advances, meetings, etc.
- The specifications of what was sought through this project were detailed in the scope in which were the objectives and goals that we had to fulfill. This would help us compare the real-time advance with the reach to see if we are on the right track.
- All expenditures by the team were detailed in the budget, which included things like research expenses, virtual downloads, computers, physical materials.

Environmental Awareness and Social Responsibility:

- Take social responsibility to all communities adjacent to the areas where we will drill infill wells to safeguard their natural areas and lifestyles.
- The constant realization of environmental talks and the awareness by the nature that is used to carry out the works, will be the priorities to achieve objectives in common between company and population.
Continuous learning:

- Investigating infill drilling as a way to better oil recovery was an unknown technique on the part of the team. With the decision to perform these drilling, we reached a greater research and increase of knowledge of this new type of technologies.

- The constant participation in oil congresses and seminars in our country are fundamental to learn more knowledge and techniques that are developed in the oil industry.

Knowledge of Contemporary Issues:

- Always be up to date on oil price variations to see if our project is viable for its realization.

- New technological trends such as Infill drilling were taken into account for the realization of this project.

Ethical and Professional Responsibility:

- Dates established for the delivery of reports, research and project progress were established each time we had meetings between team members.

- The data and information abstracts have been clarified and recorded in each part of this report as respect for intellectual property.

Communication:

- The way in which we stayed in contact between the team members and the engineers who were our academic support was through a correct communication technology via the Internet and telephone calls.

- The contribution of the members with more mastery of the North American language was fundamental for obtaining and interpreting more information for this project.
Teamwork and Emotional Intelligence:

- Continued assistance among all team members was critical to the project. Meeting always from time to time to share ideas and make decisions about the actions to be performed.
- The differences of opinions and the selection of actions to be taken were balanced by a group leader who always tried to encourage motivation and mutual respect.
Infill Drilling in Lot X