SAND CONTROL FOR HIGH PERMEABILITY-POROSITY SANDSTONES IN ECUADOR

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1. ABSTRACT

In the Ecuadorian northeast area, sand production has been associated with high porosity. Certain zones where the M-1 Sandstone has porosity above 25 % have experienced a lot of sand production. High rate gravel packs have been successful and more than 27 jobs have been successfully performed. As a rule on new wells with porosity above 25% a gravel pack system is installed on the initial completion.

One important fact is the wellbore cleaning process. On the first jobs, several products were pumped to avoid severe losses to the formation; but due to the high permeability and low reservoir pressure it was not possible to control that. Therefore to minimize production impairment attributed by invasion of contaminants into the gravel pack and formation, a well bore clean out procedure was implemented to remove potentially damaging solids, including filtering all the water to 2 microns.

After the gravel pack, a phosphonic / HF acid treatment is pumped to both clean the gravel from any debris coming on the pumping and placement process and stimulate the producing zone. This treatment has shown excellent results on production and has diminished the effect of the additional restriction created by the gravel pack.

2. INTRODUCTION

In the Ecuadorian northeast area, sand production has been associated with high porosity. Certain zones where the M-1 Sandstone has porosity above 25 % have experienced a lot of sand production. High rate gravel packs have been successful and more than 27 jobs have been successfully performed. As a rule on new wells with porosity above 25% a gravel pack system is installed on the initial completion.

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3. SAND CONTROL FOR HIGH PERMEABILITY-POROSITY SANDSTONES IN ECUADOR

At the moment, more than 27 High Rate Gravel Packs (HRGP) have been performed to control the sand production in the Ecuadorian northeast area.

The designs include the use of a 20/40 gravel for an average sand particle diameter (D50) of 0.196 mm obtained from sieve analysis of formation sand from cores as shown in Figures 1 and 2. The 20/40 size for the gravel is obtained from 6 times the average sand particle diameter (D50), based on the work of Saucier (1974). Continuing on design, a 12 gauge, 4.25" (10.79 cm) O.D. Screen is used for the 7" (17.78 cm) 26-29 #/ft (38.7-43.2 Kg/m) casing when the gravel pack completions have been installed. The screen OD should be selected to provide an annular clearance of 0.75 (1.91 cm) to 1.0 inches (2.54 cm) between the screen OD and casing ID. The gravel pack system for the completion is shown in Figure 3.

With the conditions of the pay zone as illustrated in Table 1, pumping rates average 8 bpm (1272 l/min) with a sand concentration of 2 pounds per gallon (239.6 Kg/m^3) of carrier fluid (ppa). The carrier fluid is treated water with surfactants and clay inhibitors.

Formation	M-1 Sandstone
Porosity	24 – 32 %
Permeability	700 - 5000 mD
API Oil	21 – 24 °
Reservoir Pressure	1800 – 3200 psi (12410 – 22063 KPa)

Table 1. Formation data

The technics of the sand control jobs has been changing since 1999 when the first job was performed. The efforts to minimize the impact on the oil production have been observed on the last jobs. With 27 jobs performed at the date as shown in Figure 4, the results can be evaluated as described in the next paragraphs.

One important improvement is the wellbore Clean-out procedure, where a Non-acid fluid is pumped to pickle both the casing and tubing to clean them from organic and non-organic deposits to minimize production impairment attributed by invasion of contaminants into the gravel pack and formation. Also the water is filtered to 2 microns.

Regarding the succeed of the sand control mechanisms, the produced sand was successfully controlled on all of these jobs as illustrated in the ranges obtained before and after the jobs on Figure 5.

To minimize the production impairment attributed by the additional restriction created by the gravel pack, some techniques could be used as described next:

On the first jobs, several products like viscous non-damaging polymer pills were pumped to avoid severe losses to the formation; but due to the high permeability and low reservoir pressure it was not possible to control that.

FracPack is the best option, because the formation could be stimulated and the oil production could be increased even though exist the restriction created by the gravel pack. This method has a limitation, when the water-oil contact is close to the lower perforation, the fracture could reach this zone and the water cut would increase drastically. The water control technology is now working on these fact and excellent results has been observed even though the water contact is very close. Currently the water control technique is working mostly in low to medium permeability reservoirs. An attempt for FracPack was performed in one of the sand control jobs done here in Ecuador, but as the M-1 Sandstone has high permeability and in most of the cases the water-oil contact is close to the lower perforation, the water cut increased drastically from 80 to 95%, diminishing the oil production.

Acid Stimulation is another method and has been applied with success on all the last jobs. The fluids pumped and the volumes are shown next:

30 gal/ft (372 l/m) Solvent Preflush, 75:25 Diesel : Organic deposits solvent
40 gal/ft (497 l/m) 7.5% Enhanced HCl Acid
50 gal/ft (621 l/m) 1.5% Phosphonic / HF acid
75 gal/ft (931 l/m) 3% Enhanced HCl Acid

This Acid Treatment is pumped right after the Gravel Pack job is performed.

On the next Figures 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15, the results obtained by pumping the acid treatment right after the gravel pack, are compared with those jobs were the acid treatment was not pumped.

4. CONCLUSIONS

1. Excellent results were obtained on sand production control. Total produced sand was reduced from a maximum of 165 PTB (0.47 Kg/m^3) to a maximum of 6 PTB (0.017 Kg/m^3).

2. The Stimulation of the well at the same time the sand control completion system is placed, is the best practice to minimize the additional restriction created by the gravel pack.

3. The clean-out procedure on the casing and tubing before to pump the gravel minimize the production impairment attributed by invasion of contaminants into the gravel pack and formation.

4. Calculated savings obtained for the customer, ranged from USD$2,000 to USD$100,000 per day on the jobs where the acid treatment was pumped after the gravel pack.

5. The best technique for Sand Control operations is the FracPack.

6. If the water-oil contact is close to the lower perforations, a Phosphonic / HF acid treatment can minimize the effect of the additional restriction created by the gravel pack.

5. BIBLIOGRAPHY

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6. FIGURES

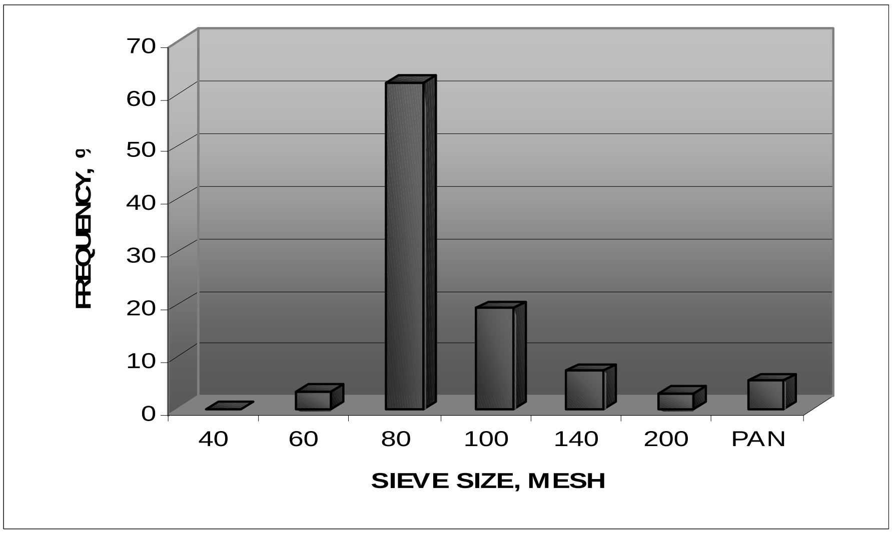


Figure 1. Size Frequency obtained from Sieve Analysis of formation sand from core analysis

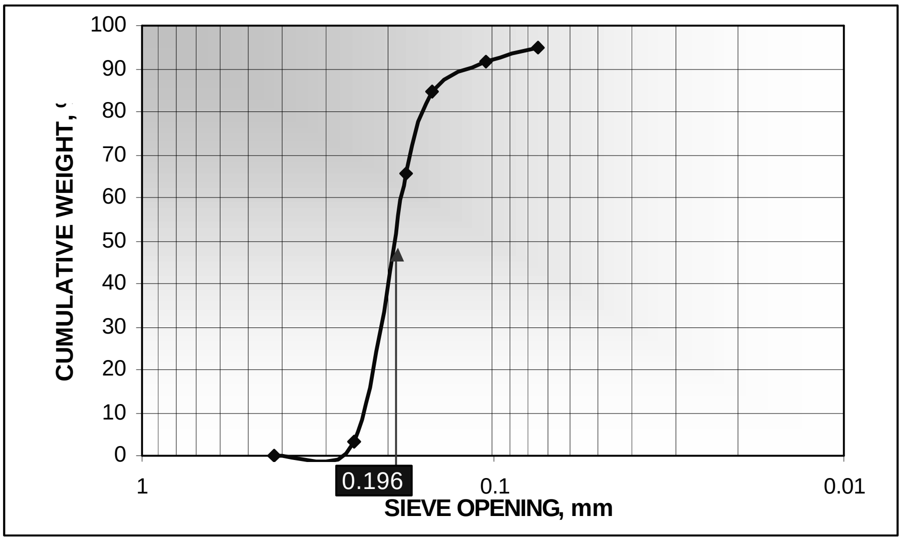


Figure 2. Sieve opening distribution obtained from Sieve Analysis of formation sand from core analysis

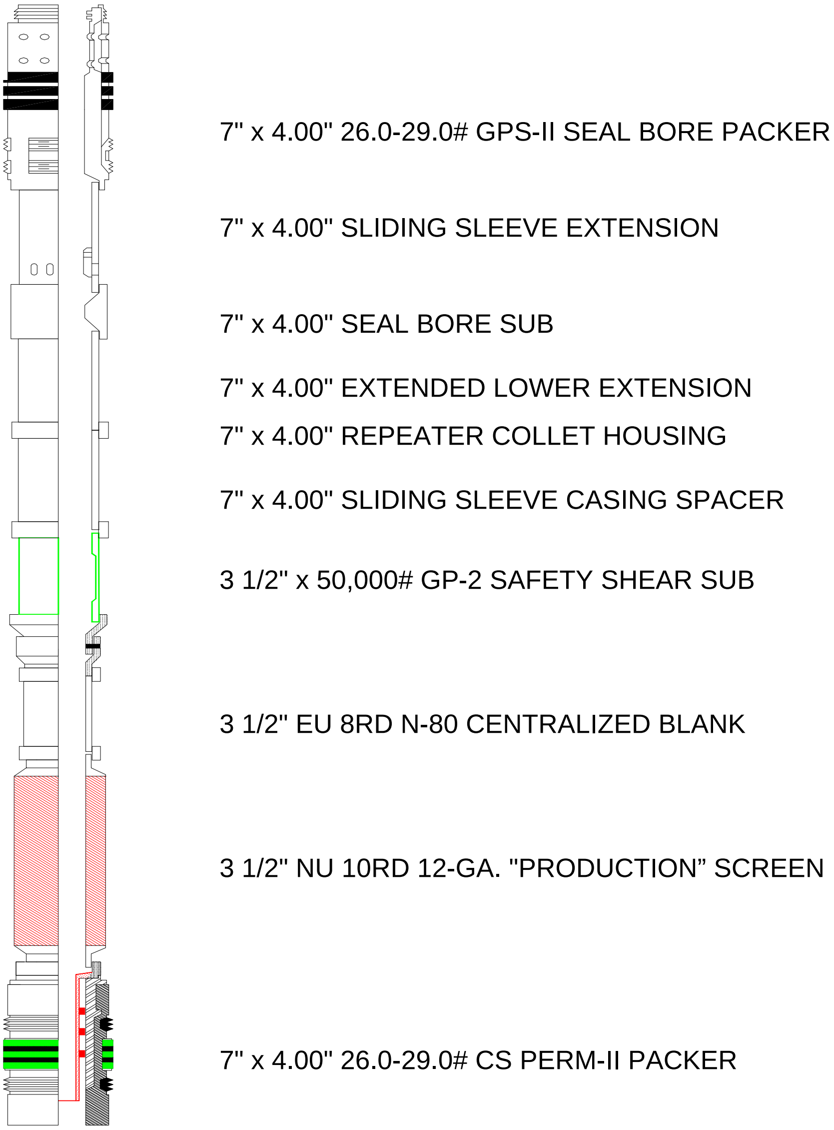


Figure 3. Basic Gravel Pack System used for Sand Control.

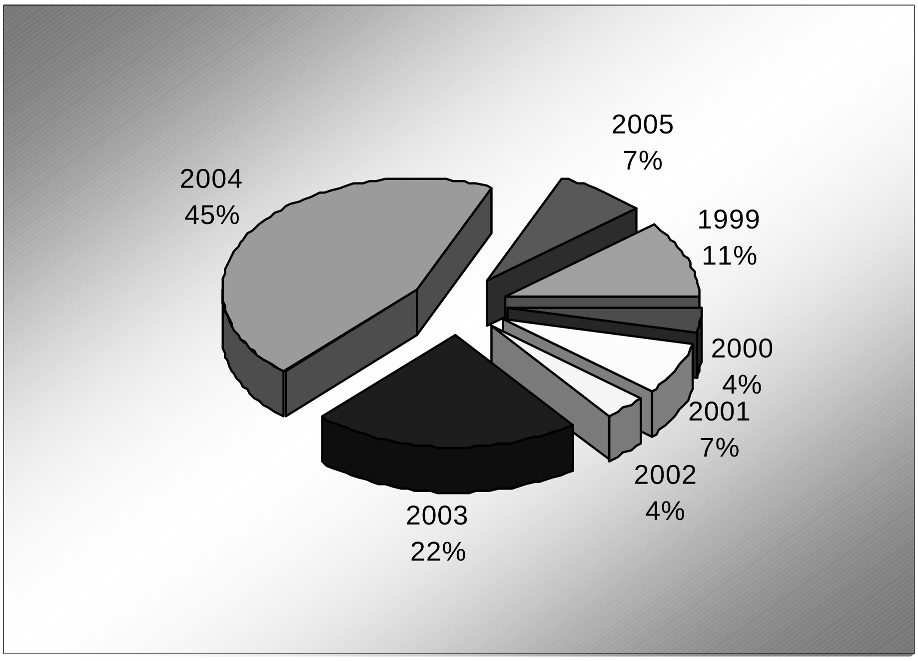
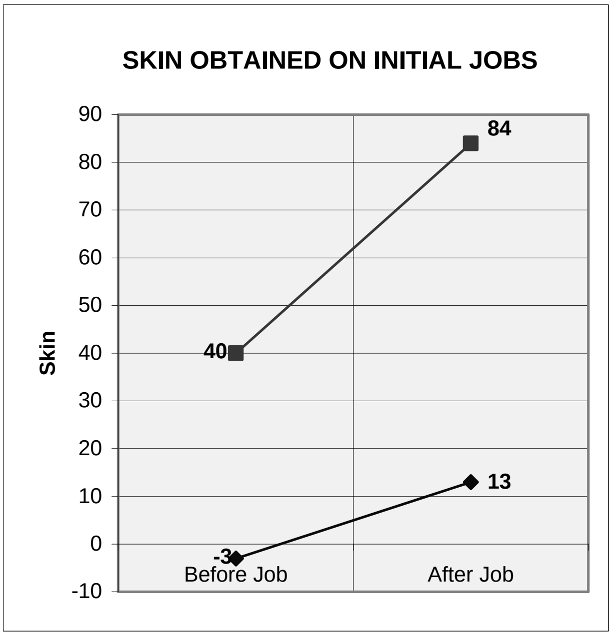


Figure 4. Total Sand Control jobs performed at the date.

Figure 5. Results obtained on Sand Control jobs performed at the date.



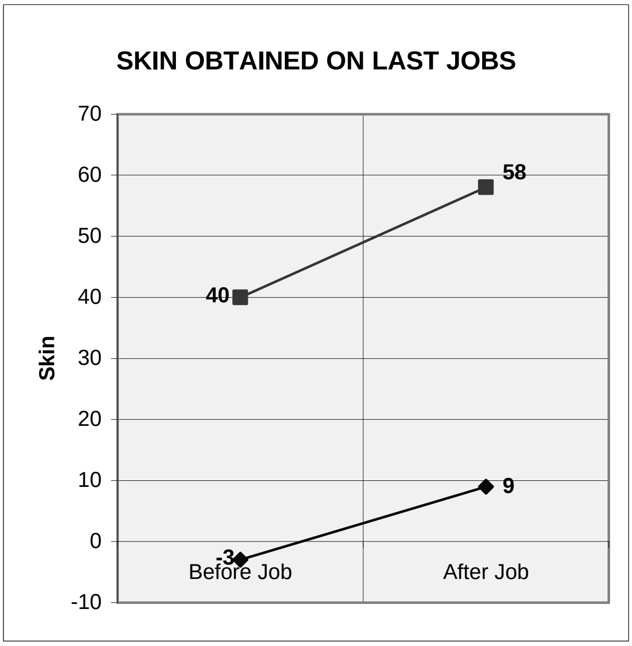


Figure 6. Skin ranges observed before and after the Sand Control jobs on the first treatments.

Figure 7. Skin ranges observed before and after the Sand Control jobs on the treatments where the acid was pumped. **

** Most of the last jobs were performed on new well completions

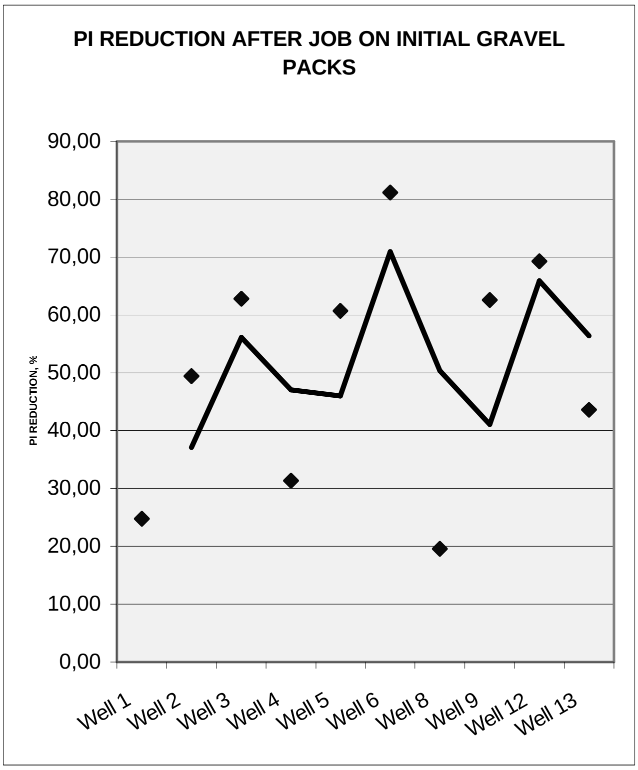


Figure 8. PI reduction observed after job on initial Sand Control jobs

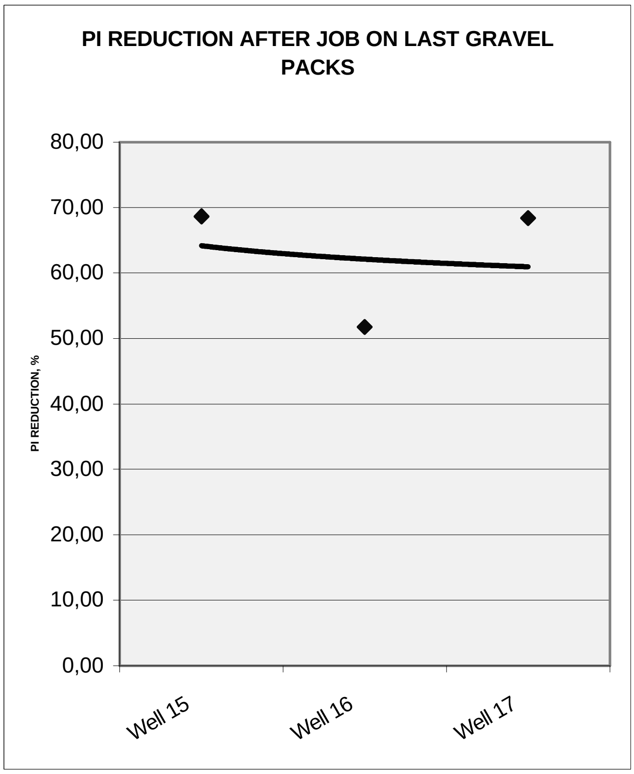


Figure 9. PI reduction observed after job on last Sand Control jobs where acid was pumped. **

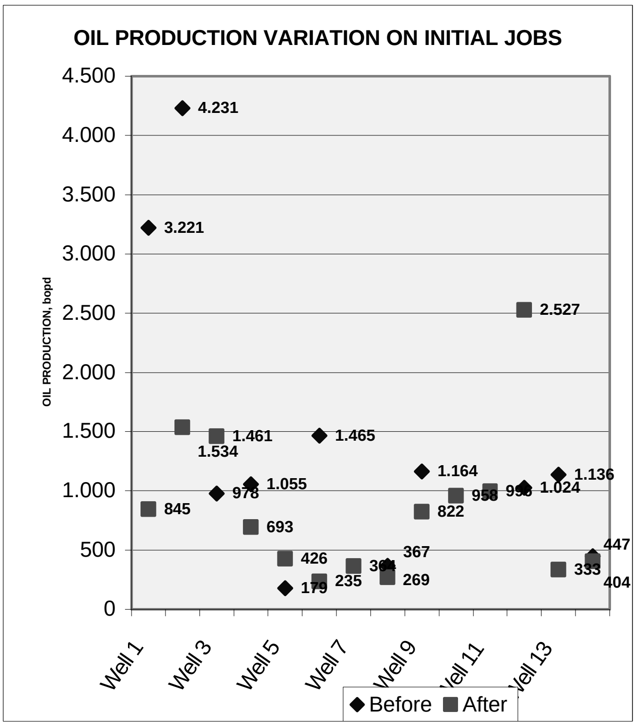


Figure 10. Oil production variation observed on initial Sand Control jobs.

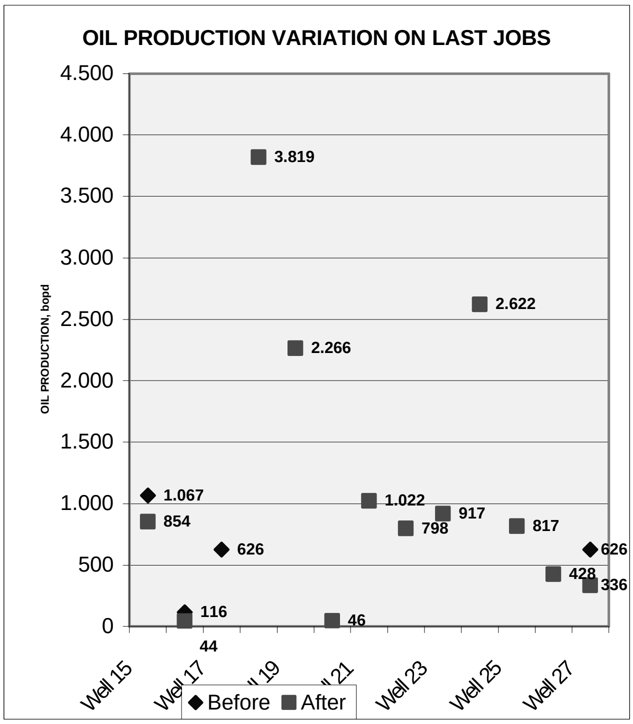


Figure 11. Oil production variation observed on last Sand Control jobs where acid was pumped. **

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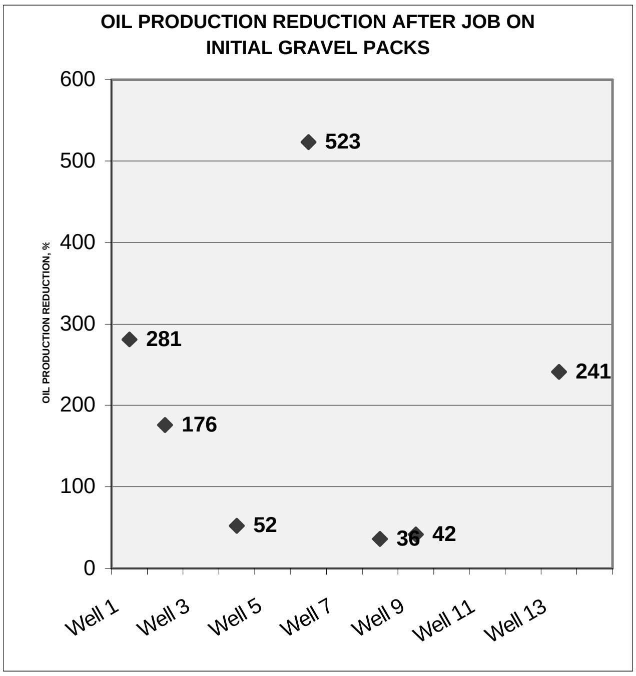


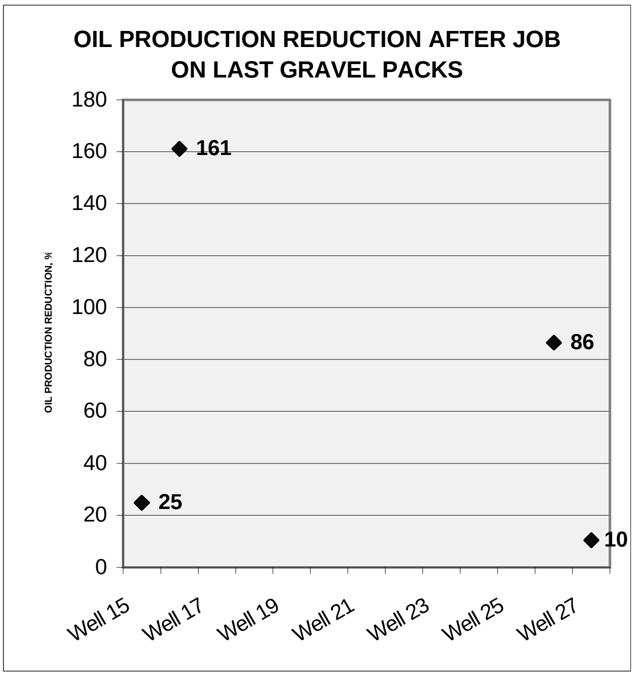
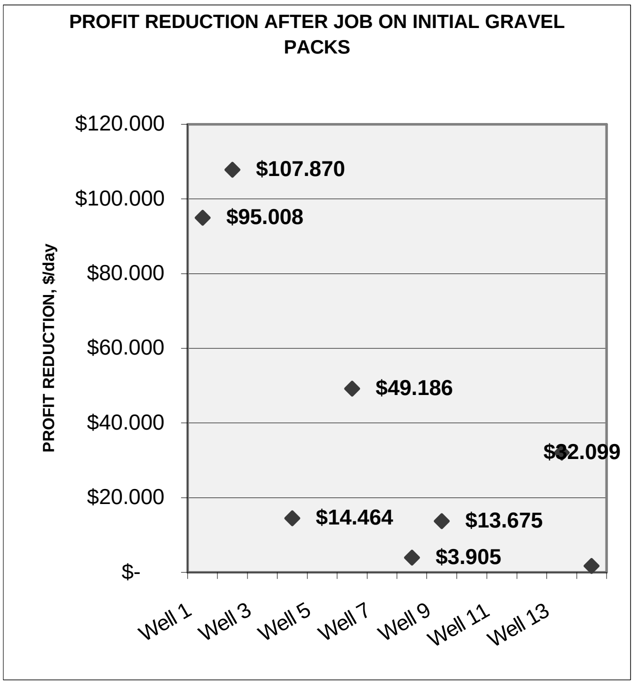


Figure 12. Oil production reduction observed on initial Sand Control jobs.

Figure 13. Oil production reduction observed on last Sand Control jobs where acid was pumped. **



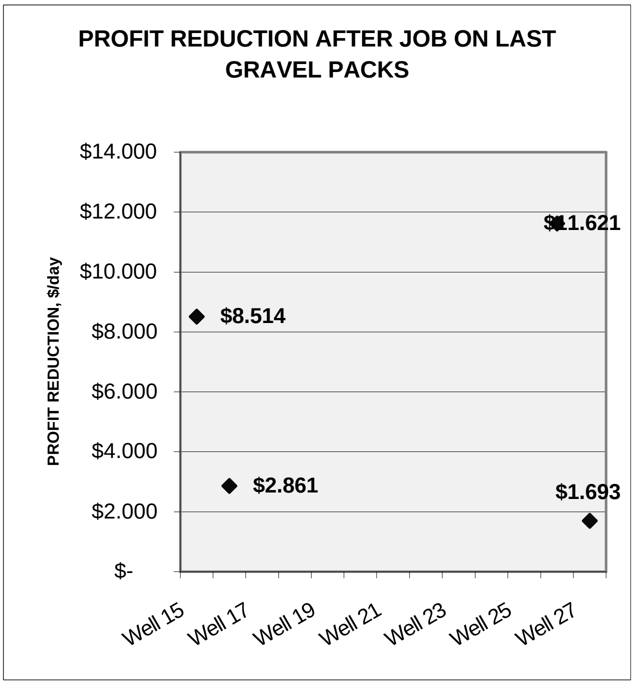


Figure 14. Profit reduction calculated on initial Sand Control jobs.

Figure 15. Profit reduction calculated on last Sand Control jobs where acid was pumped. **

Reference price for oil: $36/bbl

** Most of the last jobs were performed on new well completions