DRILLING AND COMPLETIONS BENCHMARKING & BEST PRACTICES

ABSTRACT

To assist companies in pursuing Capital Efficiency, Ziff Energy has expanded into benchmarking the important areas of *Drilling and Completions*, which typically represents more than half of onshore CapEx.

Recently, our firm completed a multi-operator benchmarking and best drilling practices study of South Texas. This study analyzed drilling and completion data for over 400 wells provided by 12 operators representing a total drilling and completion capital investment of greater than one billion dollars ($US). This paper will present some of the findings from this study that should be applicable to other geographic areas including Argentina and other Latin American countries.

Benchmarking can be as intricate as anyone wants this to be, but clearly there are issues regarding data availability, accuracy and usefulness. Benchmark analysis should be an exercise in identifying performance gaps that can be improved upon by changes in practices. Best Practices are more readily collated when multiple operators are willing to share their experience in a particular drilling environment.

Effective drilling programs are critical to E&P companies. This paper will discuss benchmarking and best practices for the well processes: Planning, Execution, Post Well Analysis, and Transfer and Implementation of Lessons Learned. This paper will focus on these topics, benchmarking methodology, and how the application of several of the South Texas findings including best practices will lead to achieving excellence in drilling.

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INTRODUCTION

Ziff Energy Group recently completed a new benchmarking study that evaluates drilling and completion costs and best drilling practices for gas wells in South Texas. Ziff Energy's study analyzes *drilling and completion cost data* for 2001, a period of strong gas drilling activity.

The South Texas Reducing Drilling Costs/Best Practices Project analyzed 418 wells drilled by 12 operators active in the area, including companies of all sizes, Independents and Majors. Drilling operations in Texas Railroad Commission Districts 1, 2, 3, & 4 were analyzed (see Figure 1). The bold font county names represent the counties in which operators provided well information. Participants provided significant input into the study design regarding Peer Group Categories, Cost Classifications, Cost Drivers, and Drilling Practices to be investigated in the *Best Practices* section of the study.

Participants received a detailed *diagnostic on each well* with a confidential, "blinded" well level comparison of their costs within peer groups of 'like kind' wells. Peer groups were based upon factors related to type and difficulty of drilling (pressure conditions, directional vs. vertical, depth, etc.).

Key metrics include $/ft and ft/day. In addition to Drilling Cost Data, Ziff Energy collected data for analysis as *cost drivers* (e.g. trouble incidents, geographic area – such as Lobo, Vicksburg, etc., well depth, whether or not the well is located in environmentally sensitive areas, and detailed drilling time break down).

Ziff Energy also performed an in-depth analysis of *Best Practices*. *"Leader" Drilling Practices* were identified via a survey questionnaire completed by each study participant's drilling operations staff. Ziff Energy's experienced engineers also conducted personal interviews to review with field personnel specific practices that may drive lower drilling costs. Ziff Energy analyzed the correlation of specific practices to strong performance to identify best practices.

Based on the client input, this study's Drilling Practices section focused on three practice areas:

- drilling procedures to avoid difficulties (Theme Topic)
- directional drilling planning and execution
- practices to maximize Rate of Penetration.

A full-day *Drilling Practices Workshop* was held November 20, 2002. At the workshop, drilling staff from participating companies presented innovative practices and those linked to lower drilling costs.

In addition to the above topics the study also produced best practices in the areas of Operations Organization, Performance Monitoring Procedures, Individual Performance Incentives, Operations Management and Well Plan Formulation and Analysis. These topics are less geographically influenced and will have applications for operators in Canada. This paper will focus on these topics and how the application of several of the South Texas best practices will lead to achieving excellence in drilling.

Achieving Excellence in Drilling

When most operators think of achieving excellence in drilling they usually define this in terms of attaining drilling program goals, attaining multi-disciplinary team goals and minimizing unnecessary

costs (AFE goal). With any multi well program the target of excellence continues to be raised to higher standards as an organization gains experience and improves their performance. The learning process cycle time can be of various durations among operators drilling in the same area depending upon their ability to capture lessons learned and implement effective changes to the drilling operation. Maximizing "learning curve" improvements is one part of achieving excellence. Ideally an operator would like to confirm performance improvement on each successive well. Another important part of achieving excellence is reducing performance deviation. As is the case with any repetitive industrial process having a large performance deviation is indicative of opportunities for improvement. If an operator has a large performance deviation and does not have a trend of improving performance they will most likely be noncompetitive and unlikely to profitably remain in business for an extended period.

Figure 2 is a Drilling Time Curve for one of the South Texas peer groups. This plot shows one of the South Texas study participant's wells in blue. Note the deviation in days from spud to rig release. While the operator has some of the fastest drilled wells in the peer group they have a range of approximately 15 to 29 days representing a cost reduction opportunity by reducing this deviation. The technical limit curve is comprised of the best drilling time for an interval and the best flat time at each casing seat. The Best of Class well is the one well that comes closest to the Technical Limit curve. This same operator, shown as operator 4 in Figure 3, while having some of the lowest cost per foot wells, also has wells at approximately twice the cost of their best wells. **Reducing deviation is important for overall cost improvements, and to achieve a low F&D.** This is where best practices become important. This also demonstrates why **external** benchmarking is important, as the range of **internal** performance does not always show the potential to improve. Note that operator 7 has a narrow performance range, but their best performance is not as good as the best performance of other operators.

Obstacles to Achieving Excellence

While some companies have the knowledge of best practices they are not effective at implementation, resulting in unnecessary costs. This occurs due to the inability to follow through with a continuous system for each well that includes planning, execution, post well analysis and the transfer coupled with implementation of lessons learned.

Obstacles in the planning phase of a well include inadequate time given for planning prior to the spud date, engineers available and other resource availability such as well site supervisors. Not having adequate involvement of rig supervisors in the planning phase often results in less than optimal "buy-in" from those most directly responsible for executing the plan.

Several obstacles in the execution of the well include lack of experienced personnel, individual motivation and repeated preventable mistakes. Barriers to open communication at the rig site can result due to the organizational hierarchy.

Common reasons given for inadequate Post Well Analysis (PWA) include time and resource availability. Another major contributor to ineffective PWA is timing. The longer the duration between the end of the well and the PWA, the less likely that it will be accomplished and the greater the likelihood loss of important details. Capturing lessons learned as soon as possible is a best practice to be discussed in this paper.

Obstacles to the transfer and implementation of lessons learned include an ineffective means of

transferring, poor communication of reasons for change, and resistance or motivation to change. Some drilling personnel have the attitude that if they are not the originator of an improvement idea then they don't believe there will be any value for them to use. Ego and the "possession of ideas" are obstacles.

Questions operators need to ask themselves are:

- is our team organized to learn quickly?
- is our team organized to rapidly implement change?

System for Excellence

For an operator to quickly improve their position on the learning curve and reduce performance deviation they must have an efficient system encompassing these four processes:

1. Planning
2. Execution
3. Post Well Analysis
4. Transfer and Implementation of Lessons Learned.

The following sections will summarize a few of the many best practices, which greatly influence these processes.

Planning

The best time to commence participation of the entire well team is at the well design and planning stage. As the geoscientists develop the prospect, they should immediately bring in drilling engineers to develop options at an early stage. Once the prospect is clarified and defined, the engineer should plan the well. At some point in the planning process at least one rig supervisor should be involved, and if two or more will work on the well, all should be involved.

The most frequent comment by drilling managers and superintendents relating to positive impacts on drilling performance was additional time for well planning. Secondly, is additional time for rig personnel to be involved with well planning. The common practice is to only concentrate on the rig site supervisor's input at the spud meeting. This does not allow enough time to consider and act on their advice. As one operator commented, "We would get the rig people involved earlier in the planning of each well…as much as six months earlier." Rig personnel now make their buy-in at the pre-spud and that is too late in the process. Rig site supervisors need to "buy-in" to the plan they are responsible for executing. This same operator has confirmed the value of using Field Supervisors in well planning and that superior "buy-in" makes the drilling operation smoother. One reason this isn't done is that Field Supervisors are charged to the AFE, not as overhead. Furthermore operators say they don't have Field Supervisors involved in the planning process due to the required travel time to the office. Field Supervisors do not need to be physically in the office and should be involved via phone calls, faxes, emails, etc.

Execution

The drilling rig is not always a place where communication is easy or encouraged. Many times the individual at the well site is told to do his job and communication is not encouraged, most often due to

the rig hierarchy. The home office provides an order to the rig supervisor, and expects execution right down the chain of command with no opportunity for crew feedback. **If there is no opportunity for personnel to provide suggestions for improvements based on their individual experience, a lost opportunity occurs costing the operator money.** To not capitalize on the best experience available, coupled with the best technology, results in unnecessarily higher cost wells.

Operators should push responsibility down the organizational hierarchy, which should focus on improving communication throughout the rig site and office. This additional individual responsibility should be linked to specific incentive bonuses for defined levels of drilling performance. As several of the South Texas operators commented, the rig crew can make the biggest impact on drilling performance and avoiding trouble time.

Why do motivated rig site personnel result in improved performance? They are closest to the operation and see results first hand. Even if they do not understand the physics of why something occurred, common sense by perceptive operating personnel will solve the problem(s). Also, being closest to the operation, they will observe results of changes sooner than anyone else and, if needed, take corrective action. If rig hands have control over some practice that makes their job easier, they will do a better job. If the proper incentives are given they will work harder and smarter to take home a bigger paycheck. Any individual who has sufficient experience and judgment to make a meaningful contribution should be given the incentives to do so. As one operator stated, “Communication is key to success”.

The South Texas study participants were asked, “When do you employ performance incentives?” 71% said “always” while 29% said “sometimes”. Several of the operators were re-evaluating their performance incentive system and this was because they were not sure if the system they were using was actually making a difference in the overall performance on the well. All of the participants said that they used some type of performance incentive based on a project bonus. None of the operators responding said that they used a performance incentive system that paid field personnel on a monthly or annual bonus. **An incentive program should be enacted whereby innovative and profitable ideas are rewarded accordingly.** Management saw bonus systems that directly rewarded the personnel immediately upon completion of the well as being the most effective. As one operator stated paying the rig personnel through the drilling contractor has administrative costs such that the “hands are not getting the full benefit”.

The following summarizes the most common approach taken for performance incentives by operators. Almost all of the operators using an incentive bonus system require that safety and environment goals must be satisfied first before a performance reward is given. They believe that this provides incentives for the rig personnel to improve both safety and operations. One successful operator includes a “Spot Bonus” for an individual submitting a good idea on cost reduction and also for the crews meeting or exceeding their “Technical Limit” for the well. The bonus program has the added value of retaining personnel during the current well and reducing turnover.

The South Texas Reducing Drilling Costs/Best Practices study reports a number of different methods operators use to provide rig site personnel performance incentives. Operators indicated that the use of performance bonuses had improved drilling time as much as 50%.

Post Well Analysis

A Post Well Report (PWR) is one of the most basic and important means for capturing what

occurred on the well. These reports are of particular value to organizations that have new personnel and want them to become familiar with previous operations. Personnel turnover was a problem for several operators in 2001. Post Well Report documentation completed by individuals directly involved in critical incidents proved to be an effective means for technology/information transfer. This minimized the need for costly review by new personnel of detailed morning and service company reports directed at capturing significant events. Again, operators agreed that they attempted to produce a Post Well Report for every well drilled (71% responding yes to producing a report and 29% sometimes). An opinion expressed by several operators was that producing an "End of Well Report has been difficult due to our undersized staff trying to accomplish this on every well".

Some operators, using DIMS, will use its various report forms to put a Post Well Report together. **A best practice is to have a system to capture knowledge at the well site.** As one operator stated, "We need to get a daily system of capturing improvement suggestions and data." Capturing ideas and suggestions at the well site is valuable. Many times good ideas are not immediately captured and lose some of their important detail if time is allowed to pass. DIMS has a comments section and allows the rig site supervisor to document new ideas or concepts about the well. These can be automatically retrieved in a comments section report, which is very valuable to whoever is writing the Post Well Report. Senior managers should understand that no learning or slow learning due to lost knowledge is very expensive. Why should the same mistake be made twice, when the knowledge gained and paid for in the first experience can be captured and benefit future operations?

A Post Well Report needs to capture more than numerical data. The PWR should include "what went right", "what went wrong" and how do we not repeat practices that were not the most efficient means of overcoming a problem. This knowledge is the **"lessons learned"** and is critical for an operator to be able to improve their learning curve. This is most critical over extended periods when gaps in drilling activity and personnel changes occur.

Lessons learned should be documented as soon as possible and ideally while the well is being drilled to prevent individuals from forgetting details, particularly on long wells. In addition, capturing lessons learned at the well site allows the timely gathering of crucial improvement ideas, a critical task before the *transfer and implementation of lessons learned*. Participants' response to the question "Does the Post Well Report summarize "lessons learned"?" was 57% yes and 43% sometimes. Again operators stated this is something they would like to see done on every well, but personnel resources were not always available to accomplish this task. As one operator stated, "There was no further review unless there was a significant incident on the well."

Transfer and Implementation of Lessons Learned

The consensus among the participants was that a best practice is to **have the same individuals who plan the well to be involved in the post-well analysis**. Individuals who plan a well understand the detailed reasoning developed and therefore will be able to shed greater light on improvement opportunities in the post well report. Being involved first hand in post analysis allows a better understanding of the specific problems encountered and the lessons learned. They also have the advantage of being able to use this knowledge in a timely fashion as opposed to information transfer from another source and documented by someone else. Quicker for the next well plan than if the information is transferred to them from another source, documented by someone else. The goal is to be able to reduce the cycle time to analyze, document and implement the experience gained from each well for a given well program. When operators were not able to have the same personnel involved in both the planning and post well analysis they indicated that this was due to lack of resources.

The following table summarizes the responses from participants who were asked, "How is this knowledge transferred to all relevant personnel in the area?"

Methods for Transferring Knowledge	Yes	No
Personnel meeting of all participants in the project	43%	57%
Printed documentation	100%	0%
Website (intranet) documentation	71%	29%
Emailing documentation to all project employees	43%	57%
Individual review between employee and supervisor	57%	43%
Documentation stored at office for employees interested in reviewing	100%	0%

The knowledge that is captured in a PWR is of no use unless it is transferred to the relevant personnel to use on future operations. Printed documentation appears to be the standard of all operators, but has the disadvantage of not being easily accessible by personnel in remote locations. The other disadvantage is that hard copies often get lost or misplaced. As one drilling manager commented, "All the previous studies we had of problems are gone. Got thrown in the garbage during moves". A system that is website based is becoming more common with 71% of operators saying they used "Website (intranet) documentation". The advantage of this system is that personnel can remotely access knowledge and hard copies of reports as primary method for transferring knowledge. A website (intranet) administrator is responsible for maintaining the security of all documentation.

Cooperation Among Operators

Most operators understand that there are few breakthrough practices for improving drilling performance. To achieve consistent improvement, operators must learn ways of performing many tasks better. Participation in Ziff Energy Group's multi-client South Texas study provides the needed best practices, but in several cases the operators must change to be able to fully exploit these practices. When drilling performance is variable, finding the most effective approaches for reducing this variability, and developing best practices that organizations can implement is a key benefit to joint operator sharing of knowledge. The goal of operator participation in such a drilling study is to improve the internal rates of return from their drilling projects.

There are many obstacles to achieving excellence in drilling. A common problem in the industry is for an operator to capture the experience that has been gained through their employees. Even if operators wanted to identify best practices, they can be hindered by the general lack of good, detailed operational records and consistent completion of Post Well Analysis. Morning reports usually do not sufficiently describe every detailed practice required to repeat successful operations. This key information is lost with personnel turnover and is also scattered among the service companies. Operators who have an extended break in drilling operations in a particular area can lose much of the performance improvement they made due to the loss of valuable knowledge. Therefore, for any single operator to stay abreast of best practices means that a systematic multi-operator approach to catalog best practices in an area will most likely yield benefits for all.

An individual operator will encounter great difficulty collecting and analyzing all of the detailed drilling information required to identify best practices without the consent of other operators. Publicly available data is not sufficiently complete or accurate to thoroughly understand the reasons for success or failure, and is therefore not sufficient to determine all best practices. No single operator typically drills enough wells to know all of the best practices for an area. While many operators conduct systematic studies of their own drilling practices in an area, it is not possible for them to benefit from the valuable experience of other operators without a cooperative effort.

CONCLUSIONS

Operators who achieve excellence in drilling are organized not only to capture best practices, but also to effectively transfer and implement best practices. When best practices are not used, unnecessary costs are incurred. The cost difference between operators in the United States who implement best drilling practices versus average drilling practices is approximately 22%. The South Texas Reducing Drilling Cost/Best Practices project had a range of 5% to 56% depending upon the specific peer group and determined the overall study area average is 33%. Performance improvements are achieved as an operator improves their learning curve. The operator must have an efficient system for:

1. Planning
2. Execution
3. Post Well Analysis
4. Transfer and Implementation of Lessons Learned.

As an operator drills more wells in a particular well program, the cycle time for these processes should be reduced as the operator's learning curve improves.

Figure 1 South Texas Map of Study Area

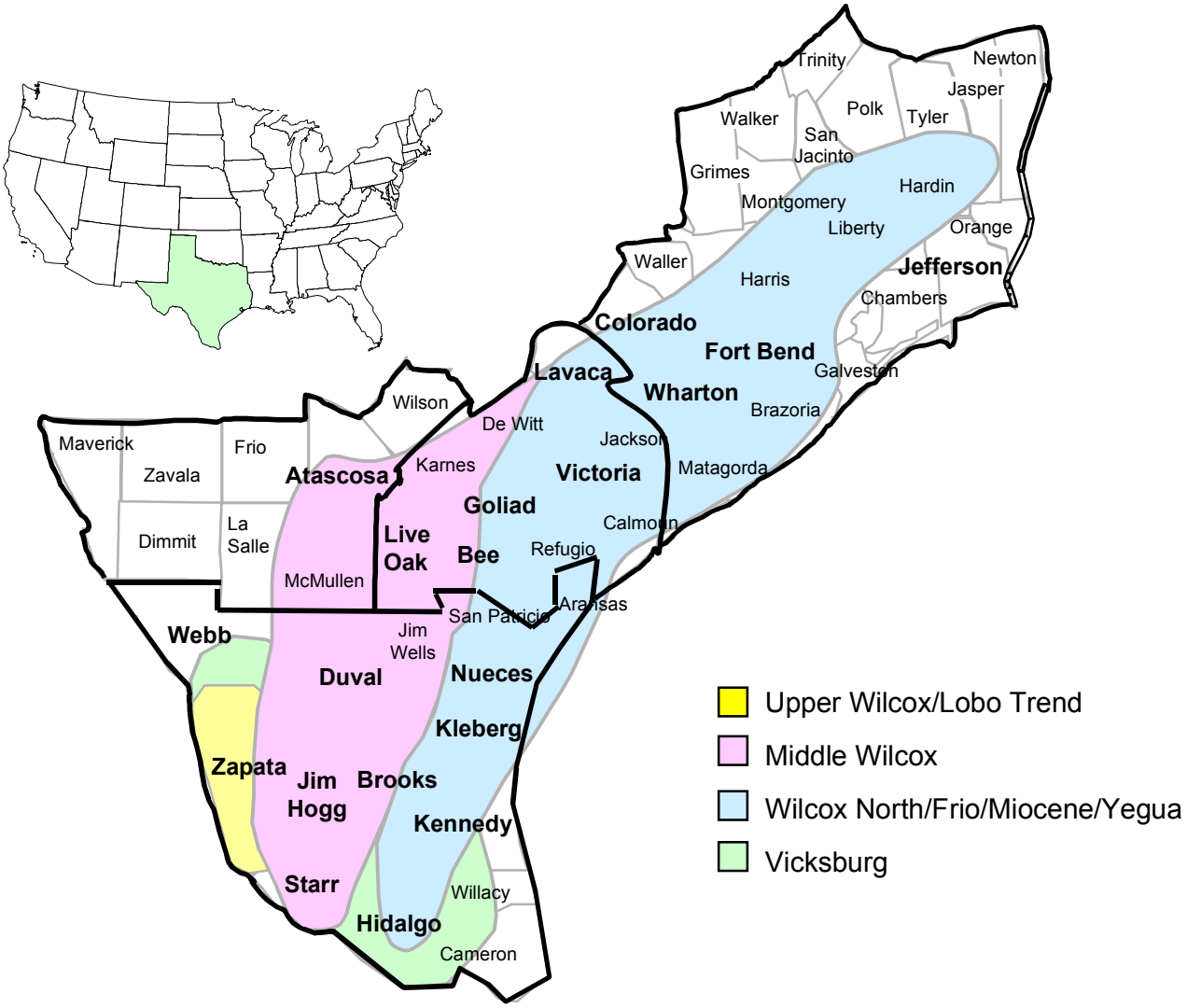

Figure 2 Drilling Time Curve

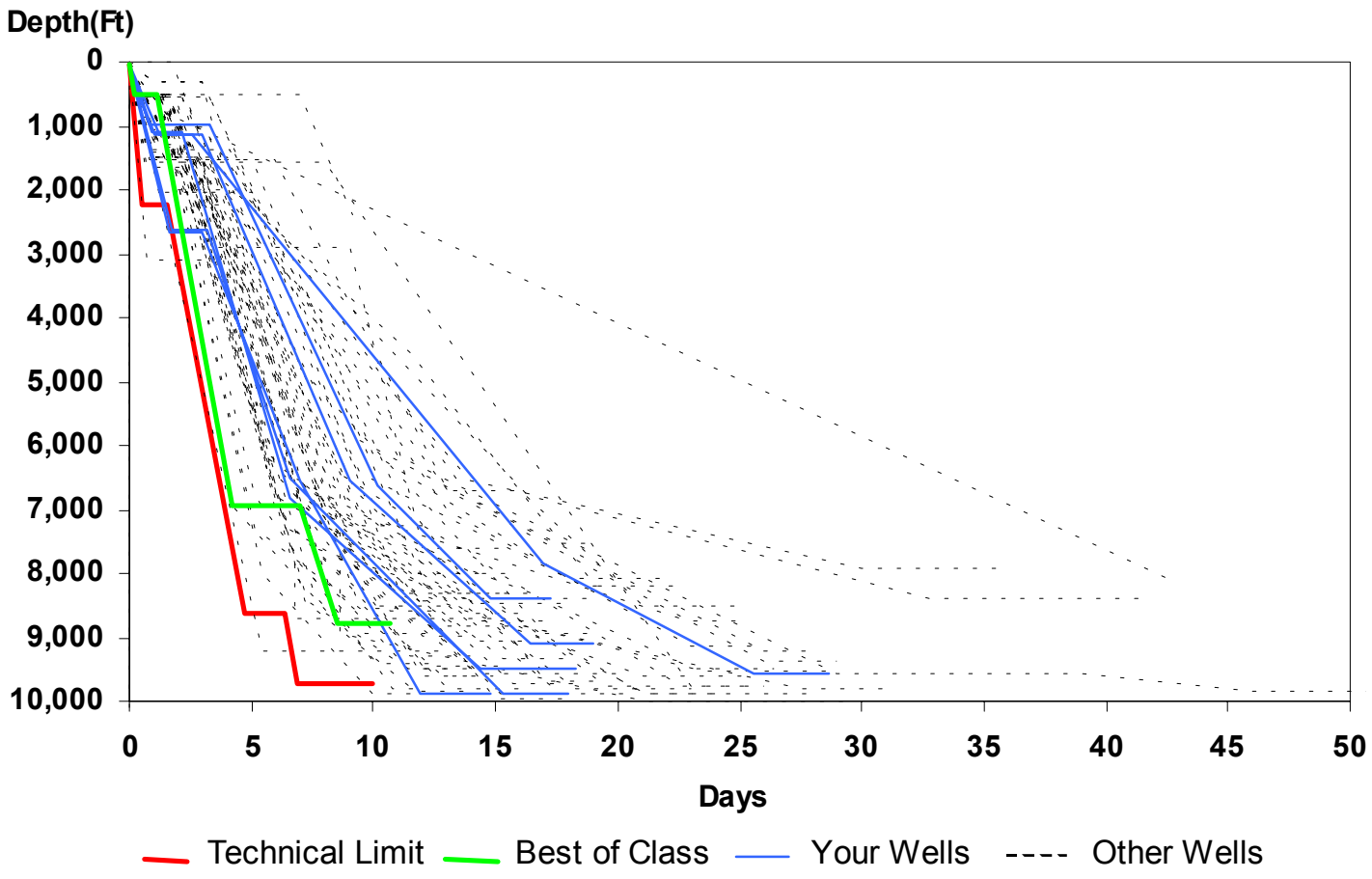

Figure 3 Operator Comparison – Drilling Cost by Operator