

The Price Elasticity of U.S. Shale Oil Reserves

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This paper is released to encourage discussion and critical comment. The analysis and conclusions expressed here are those of the authors and not necessarily those of the U.S. Energy Information Administration.

Abstract

We formulated a model of shale oil development that identifies how much of the U.S. resource base is likely to be economically viable at various price levels, and what share of potential drilling sites are likely to be exploited. The analysis is driven by the lognormal variability in productivity of individual wells. We find the volume of reserves to be highly inelastic with respect to price. The overall elasticity of U.S. shale oil reserves appears to lie between 0.3 and 0.5. The elasticity of supply of economically viable drilling sites appears to be roughly double the elasticity of reserves, but still inelastic. A key finding is that the volume of reserves is not proportional to the number of viable drilling sites. In a skewed distribution, relatively few of the highest productivity drilling sites account for the large majority of reserves. The majority of drilling sites have relatively low productivity, and contribute a relatively small portion to the aggregate volume of reserves. When those low productivity sites are cast out due to falling prices, the volume of remaining reserves is little affected. However, variations in the rate of drilling and production are driven by many factors, including price expectations, availability of infrastructure, financing, lease provisions, resource depletion, etc. To forecast the near-term production rate of shale oil, one must incorporate all these factors, how they are changing, and how those changes are expected to impact drilling activity. That is a challenging research problem in itself, and one that must be left to future research.

Keywords: shale oil, price elasticity, drilling productivity, lognormal distribution

JEL Codes: L71, Q31, Q33, Q35, Q41

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Table of Contents

Abstract	i
1. Introduction.....	1
2. Overview.....	2
2.1 Research Objectives	2
2.2 Summary of Findings	3
2.3 Overview of Methodology.....	7
2.4 Data Sources and Validation	8
3. Research Methodology.....	9
3.1 The Individual Well Economic Model.....	9
Model Structure.....	9
Prices.....	10
Costs	10
Income Tax.....	11
Production	11
Application of the Individual Well Model.....	11
3.2 The Distribution of Well Productivity (EUR).....	12
3.3 Combining the Two Models	14
4. Data Sources and Validation.....	16
5. Research Results.....	20
5.1 The Volume of Shale Oil Reserves.....	20
5.2 The Number of Viable Drill Sites	23
5.3 The Distinction Between Average and Median Productivity	26
5.4 Combo Plays are Different	28
5.5 Resilience of Drilled but not Completed Wells (DUCs)	31
5.6 The Impact of Low Prices on Mature Shale Oil Wells.....	34
5.7 Sensitivity of Results to the Coefficient of Variation in Well Productivity	35
6. Limitations of the Study and Suggestions for Further Research	43
References.....	45

Appendices (separate attachments)

- A. Minimum EUR as Function of Price, 2014 & 2016 Cost Scenarios
- B. Minimum EUR as Function of Price, Dynamic Cost Scenario
- C. Reserve Elasticity & Drill Site Elasticity, 2014 & 2016 Cost Scenarios
- D. Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario,
with Alternative Coefficients of Variation
- E. Breakeven Price, by EUR, New Wells vs. DUCs, 2014 Cost Scenario
- F. Tail-End Economics, 2016 Cost Scenario
- G. Notes on the Lognormal Distribution

1. Introduction

The motivation for this analysis is to better understand the impact of changing price levels on the volume of U.S. shale oil reserves. During the course of research, an analytical approach was developed that focuses on the heterogeneity of shale oil resources, both across various shale oil basins and within those basins. It is this heterogeneity that permits certain portions of the shale oil industry to survive under low prices while others do not. This study describes the analytical approach and also the empirical results obtained when real-world data are joined to this framework.

The study is organized as follows. Section 2 provides an overview of the study's objectives, research methods, and principal findings. The methodology is described in detail in Section 3. Data sources and methods of validation are outlined in Section 4. Detailed findings regarding the research questions are reported in Section 5. Limitations of the present study and suggestions for future research are outlined in Section 6. Charts and tables that document all inputs to the research as well as a comprehensive tabulation of all empirical results are attached as appendices.

2. Overview

2.1 Research Objectives

The study attempts to measure how the economic viability of U.S. shale oil supply varies with the price of oil. It is well understood that the volume of economically recoverable shale oil reserves is but a subset of the volume of technically recoverable resources. Our objective is to measure how the size of that subset varies with the price of oil. Reserves represent the potential production only from those wells that are economic to develop and operate. Within any particular shale oil play, the number of such wells is directly influenced by the assumed price level. Cost and well productivity also play an important role in delineating the volume of reserves, and those factors will be addressed too, but the main focus of the study is to measure how the number of viable shale oil drilling locations and the volume of potential production (reserves) varies with the price of oil.

The relationship can be quantified in terms of an elasticity. We define the “price elasticity of reserves” in the conventional way; it represents the percentage increase in the volume of reserves that results from a 1% increase in the price of oil, holding costs and technology constant. A similar definition applies to the number of viable drill sites (which determines the number of wells that could be drilled): the “price elasticity of drill sites” represents the percentage increase in the number of economically viable drilling locations that results from 1% increase in the price of oil. Most of the analysis undertaken in this study is for the purpose of estimating these two elasticities for each of the major shale oil plays in the U.S.

This study also examines the impact of price on the potentially large inventory of drilled but not completed wells (DUCs) that exist in many shale oil basins. The question of economic viability in such cases hinges mainly on the size of the incremental investment that remains to complete the well, and the threshold price required to develop those resources should therefore be lower than for a new well—but how much lower? For each major shale oil play, we provide and compare estimates of the minimum price to develop new wells vs. DUCs, and show how the difference between these two thresholds is affected by the inherent productivity of the well in question.

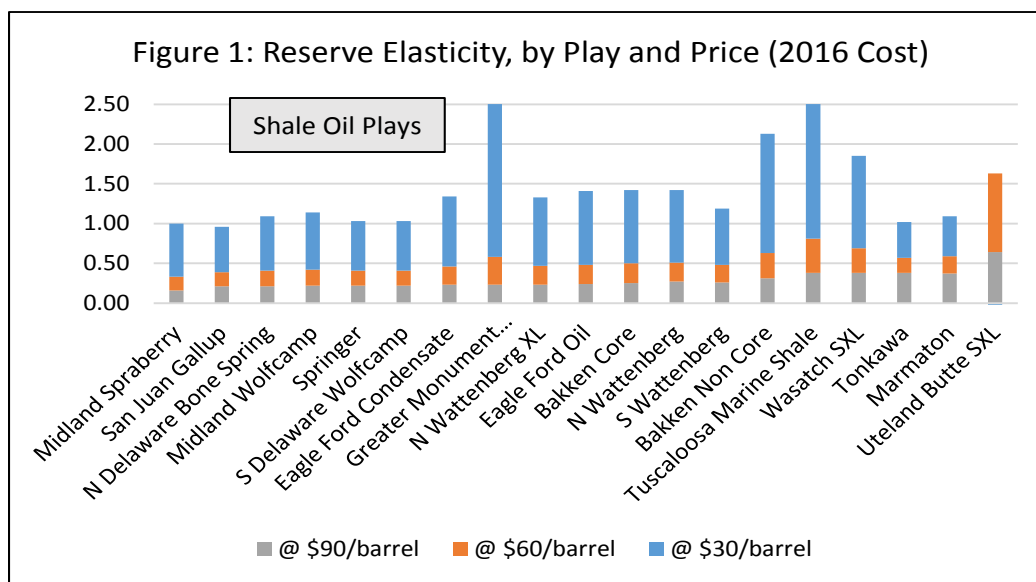
A further objective of the study is to understand how low oil prices affect the continued operation of mature shale oil wells. Would many of the existing and already producing wells be likely to shut down early? If so, how many and how early? And how much potential production would be lost as a result? The analysis reported herein addresses these questions and provides pretty clear answers.

Our final goal, in addition to producing a clear analysis and discussion of the questions posed above, is to provide EIA with a working analytical framework and the associated tools by which this analysis can be updated and expanded as more information becomes available and as new

questions arise in the future. To that end, the complete computer models and full documentation used to produce our results accompany this narrative report.

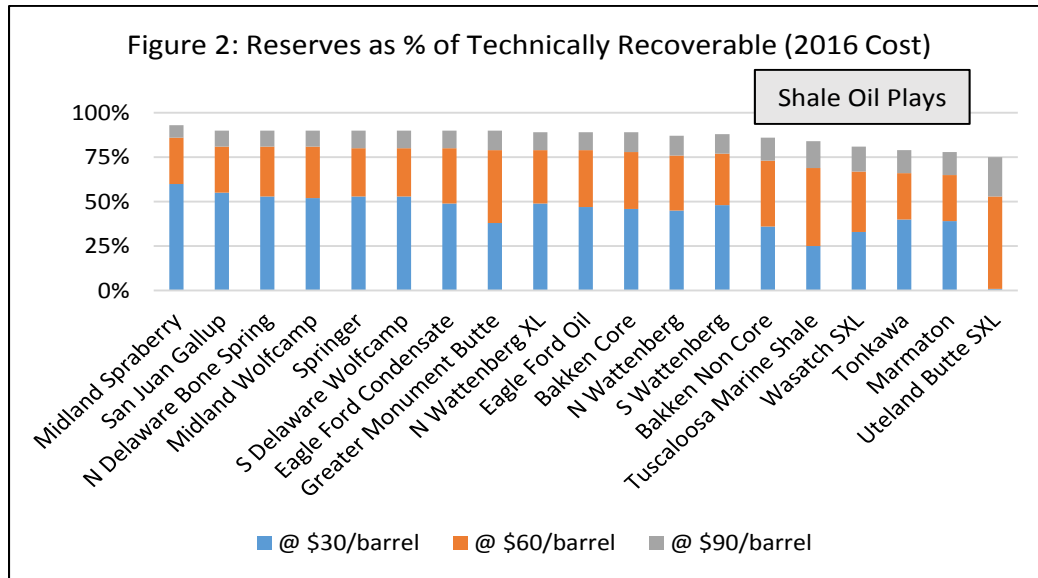
2.2 Summary of Findings

One overriding conclusion that emerges from the analysis is that the volume of reserves in all major U.S. shale oil plays is highly inelastic with respect to price. Any drop in the price of oil, whether from a high starting level or from a relatively low one, tends to diminish the volume of reserves, but only moderately. Results for specific plays vary, but until prices drop below \$60/barrel, a reserve elasticity of 0.5 is typical. This means that when the price of oil falls by 1%, the volume of economically recoverable resource tends to fall by only 0.5%. As price drops beyond \$60, the reserves becomes much less inelastic (approaching or sometimes even exceeding 1.0). The implication is that prices must reach relatively low levels before the volume of reserves begins to shrink in a substantial way. The reasons for this are explained in Section 5.1. The estimated reserve elasticities, calculated at three different price points (\$30, \$60, and \$90), for the shale oil plays are shown in Figure 1.



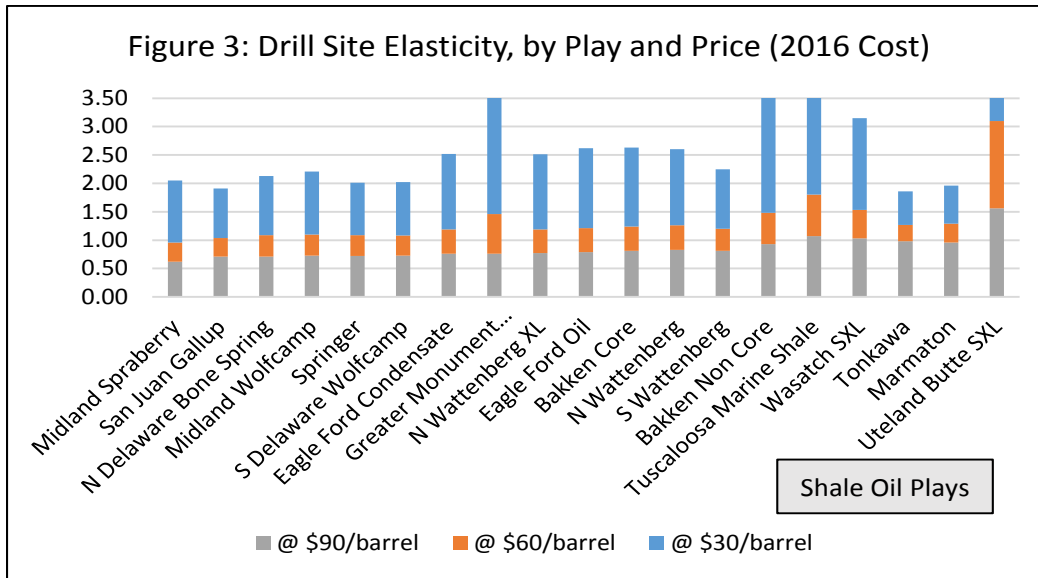
Source: Authors calculation.

Our analysis also shows that at prices close to \$100/barrel, a very high percentage of the technically recoverable resource base is economically viable. Again, this percentage varies among plays, but in the major plays some 80% (or more) of the technically recoverable resources meet this criteria and qualify as reserves if the price were to be \$100/barrel. As the price drops, this percentage also drops, but slowly due to the inelasticity of reserves. Even at prices as low as \$30/barrel, about 50% of the technically recoverable resource found in the major plays remains economically viable. Shown in Figure 2 is the estimated portion of the technically recoverable resource base that counts as reserves, again calculated at the three price points (\$30, \$60, and \$90) in the shale oil plays.

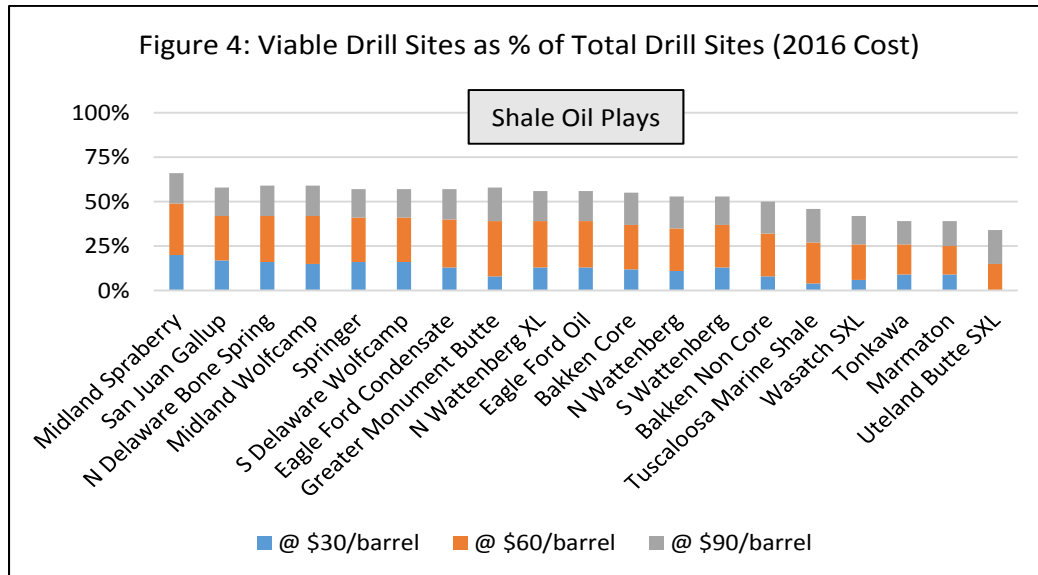


Source: Authors calculation.

Despite the tendencies noted in the previous paragraph, but not inconsistent with them, we find that the number of viable drilling sites is much more elastic than the volume of reserves. With prices at current levels (\cong \$45/barrel), a 1% drop in price is associated with an even greater (>1%) drop in the number of viable drill sites. The marginal drill sites are by definition least productive, so their fate effects a relatively small change in reserves. As the price rises from \$30 to \$60, the number of viable drill sites more than doubles in virtually every play, but the volume of reserves does not increase proportionately. For this reason, it is important to distinguish between the effect of low prices on drilling activity versus the resulting impact on reserve additions. Observed changes in the number of new well permits, drilling rates, and rig counts do not imply equivalent changes in the rate of reserve additions or new production. Figure 3 shows the estimated drill site elasticities at the three price levels (\$30, \$60, \$90) for the shale oil plays. Figure 4 shows the percentage of all potential drill sites within each play that are economically viable at the respective prices.



Source: Authors calculation.



Source: Authors calculation.

The four figures presented so far are predicated on the assumption that upstream costs will remain at 2016 levels regardless of the oil price (the “2016 Cost” scenario). Many observers of the upstream petroleum industry have noted a link between the price of oil and the cost of oil field services and supplies. We refer to this as the “Dynamic Cost” scenario. When such a link is incorporated into the analysis, the response of both reserves and the number of viable drill sites becomes even more inelastic. It turns out, not surprisingly, that declining costs reduce the disincentive created by falling prices, just as rising costs decrease the incentive created by rising prices. This effect is examined in some detail in Sections 5.1 and 5.2.

It is also important to realize that the performance of an “average” well (the arithmetic mean of the entire distribution) in any given play is not representative of the majority of wells in that play. The distribution of well productivity is highly skewed to the right (relatively few highly productive wells exist in combination with many less productive wells), which means that the productivity at the median of the distribution is only about 55% of that of the average well. By definition, half of the drill sites in each play are less productive than the median, while relatively few are more productive than the mean. Any analysis of the potential supply of shale oil that ignores this distinction will not provide an accurate picture of the economic viability of the resource base.

Not all shale oil plays are created equal. Some plays are characterized by high costs, primarily due to greater depth of drilling targets. Some are characterized by low productivity, depending on the nature and properties of the source rock. In some plays, shale oil is produced in conjunction with large quantities of natural gas; in others, not. These differences are reflected in our results and show up in terms of the estimated elasticities, and also in terms of the portion of the technically recoverable resource base that is thought to be economically viable at any given price.

The mixture of fluids (oil/gas/NGL) released from the source rock in a given play has a substantial effect on price elasticity. We distinguish “oil plays” (where production consists primarily of crude oil) from “combo plays” (where associated gas and NGL constitutes more than half of production) and find very different sensitivity to variations in the crude oil price. Indeed, very “gassy” combo plays may exhibit a backward-bending supply curve (negative elasticity), wherein the volume of reserves actually rises when the price of oil moves downward. This stems from the hypothesized link between oil prices and upstream costs. Since oil and gas prices tend to move independently, a sustained reduction in the price of oil may reduce development costs without lowering the price of natural gas. Such a reduction in the price of oil tends to benefit sub-marginal fields located in gassy plays.

Regarding DUCs that presently exist, our findings are exactly as one would expect. Due to the substantial sunk costs that have already been invested to prepare the drill site and drill the vertical portion of the borehole, the price required to bring these wells into production is substantially reduced, by at least 30%-40%, when compared to new wells. The details are presented, play by play, in Section 5.4.

Finally, our findings regarding the impact of low prices on mature wells (those that have already passed through the first three years of rapid decline) are not surprising. Only a negligible portion of the remaining reserves of producing wells are in danger of being shut in due to low prices. Although abandonment might be advanced by several years for some low productivity wells in certain plays, the volume of potential reserves lost is small since these wells produce very little late in their life.

2.3 Overview of Methodology

We take a bottom-up approach that is based on the economic viability of individual shale oil wells under given price, cost and technological assumptions, with particular focus on the impact of variations in well productivity as measured by the expected ultimate recovery from the well (EUR). Economic viability is determined in the usual way, according to a discounted cash flow (DCF) model that projects expenditures and receipts on a monthly basis over the potential life of the each well (assumed to be 30 years). The purpose of the DCF model is to identify the threshold EUR that is economically viable (non-negative NPV) for a given oil price. More to the point, this model is used to determine the variation in the threshold productivity level that is associated with variations in the price level.

Given a specific price level, all wells in a given play that meet the economic threshold contribute to the aggregate volume of reserves. Those wells also contribute to the number of economically viable drill sites. Any increase or decrease in price changes the productivity threshold, and also therefore the estimated volume of reserves and the number of viable drill sites. The elasticity of reserves and the elasticity of drill sites is then calculated by comparing the associated variations in price and quantity.

To implement this approach, it is necessary to know how productivity varies among wells within each play, and to determine what fraction of them are likely to reach any given economic threshold. For this, we draw on results from the U.S. Geological Survey's (USGS) ongoing study of the frequency distribution of individual well EURs in unconventional oil and gas plays in the U.S.¹ Those studies perceive the distribution of EUR to be lognormal, and provide estimates of the population mean and standard deviation of EUR based on the variation across all potential drill sites included within a given play. By linking our EUR threshold analysis to the USGS distributions, we directly obtain estimates of the fraction of all drill sites that are economically viable for a given price. We also obtain the fraction of the technically recoverable resource base that qualifies as reserves.

There is something to be said about the impact of technical change. Several of the USGS studies of well productivity are already several years old. Many are being updated, but the new estimates are not yet available. Given the rapid pace of innovation in the shale oil business, it is reasonable to ask what relevance the earlier studies can have for present purposes. The answer hinges on the nature of technological progress that has occurred during the interim. If it is fair to assume that progress has been neutral, in the sense of affecting low-productivity and high-productivity wells equally, then even the older USGS studies are directly relevant. An example of neutral technical progress would be an innovation that increases the production of all wells within a play, say by 25%. Under that assumption, both the mean and the standard deviation of EUR in the play would increase by the same 25%. But, the ratio of the two (i.e., the

¹ Many such studies been completed and more are underway. We use the estimates presented in "Variability of Distributions of Well-Scale Estimated Ultimate Recovery for Continuous (Unconventional) Oil and Gas Resources in the United States," Open-File Report 2012-1118, U.S. Department of the Interior and U.S. Geological Survey (2012).

“coefficient of variation”) would not have changed. Now, it is the coefficient of variation that is crucial to our method, and so long as technical change has been neutral, the previous USGS estimates of that particular parameter are no less informative than current or future ones. Because the assumption of neutral technical progress does not seem unreasonable, and because it admits a larger set of supporting data, we follow that course.

2.4 Data Sources and Validation

The primary data on which our analysis rest come from two sources. Play-specific characteristics of individual wells (capital and operating costs, average EURs, production splits, decline rates, severance taxes and royalties, and price differentials relative to the benchmark West Texas Intermediate (WTI) crude oil price and Henry Hub natural gas price) come from Simmons and Company.² A major advantage of the Simmons data is that it all comes from one source and covers some 34 different shale oil plays. These data were gathered and prepared using consistent methods and any estimates that Simmons may have applied to fill in gaps in the data would have passed through a common filter. Therefore any reported differences among plays are less likely to reflect the type of definitional or pedagogical disparities that could arise when combining micro-level data from different sources. The estimated distributions of well productivity (EUR) all come from the USGS, as mentioned previously.

We have reviewed many additional data sources, including the anecdotal accounts of drilling costs and production rates published in the trade press, the commercially available Drillinginfo and IHS well databases, public records available from the States of North Dakota and Texas, as well as analyst reports produced by various financial institutions. Potentially, the most useful of these would be the Drillinginfo and IHS databases due to their comprehensive nature and detailed contents.

We have reviewed many additional sources of information from the trade press that report isolated statements about average well productivity, the level of and recent decline in drilling costs, as well as threshold price levels for specific shale oil plays. In combination, those reports tend to validate the Simmons input data on which we rely as well as our resulting play-specific estimates of threshold prices for economic viability.

² Simmons & Company International, “U.S. Well Economics,” August, 2015.

3. Research Methodology

The analytical approach may be described as a bottom-up methodology in which the productivity and resulting profitability of the individual wells that potentially contribute to production in a given shale oil play are combined with the estimated frequency distribution of such wells within that play. The volume of reserves within a play is found by aggregating up the reserve potential of all individual wells deemed to be economically viable under a presumed set of specific economic and technological conditions. Any change to the volume of reserves stemming from changes in the economic and technological environment are likewise determined by aggregating effects over the population of individual wells.

3.1 The Individual Well Economic Model

Reserves are distinguished from technically recoverable resources. The latter includes all potential production achievable with existing technology from all drill sites located within the play, whether or not such production is economically viable. The former excludes the production potential of any drill site that is not economically viable. Our measure of economic viability is based on a conventional DCF model applied at the level of the individual well, taking into account the specific characteristics, both physical and economic, of the well in question.

Monthly cash flows are projected over the lifetime of a well and valued in an Excel spreadsheet that includes a detailed accounting of the expenditures and receipts associated with the well's development and operation.

Model Structure

The NPV of a single well is defined as follows:

$$NPV = \sum_{t=1}^T \frac{[P_t^o Q_t^o (1-s^o) + P_t^g Q_t^g (1-s^g) + P_t^l Q_t^l (1-s^l)](1-r) - capex_t - opex_t - tax_t}{(1+i)^{t-1}},$$

where:

- P_t^o = wellhead price of oil during month t (\$/b).
- P_t^g = wellhead price of natural gas during month t (\$/mcf).
- P_t^l = wellhead price of NGL during month t (\$/b).
- Q_t^o = crude oil production during month t (b).
- Q_t^g = natural gas production during month t (mcf).
- Q_t^l = NGL production during month t (b).
- s_t^o = severance tax rate on crude oil (%).

- s_t^g = severance tax rate on natural gas (%).
 r = royalty rate (%).
 i = monthly discount rate (%).
 $capex_t$ = capital expenditures incurred during month t (\$).
 $opex_t$ = operating expenditures incurred during month t (\$).
 tax_t = income tax expenditures incurred during month t (\$).
 T = 360, or whenever net cash flow from production first becomes negative.

Prices

Wellhead prices in the area of each shale oil play are related to market index prices according to fixed differentials that reflect regional premiums and/or discounts relative to the benchmarks.

$$P_t^o = (1 - d^o)WTI_t.$$

$$P_t^g = (1 - d^g)HH_t.$$

$$P_t^l = (1 - d^l)P_t^o.$$

where:

d^o = differential between wellhead price of oil and WTI (%).

d^g = differential between wellhead price of natural gas and HH (%).

d^l = differential between wellhead price of NGL and wellhead price of oil (%).

Costs

Operating costs for a given well are calculated as a constant variable cost per barrel of production (\$/boe), with a minimum of \$2,000 per month. Thus:

$$opex_t = \max[\$2,000, oc \times (Q_t^o + Q_t^l + Q_t^g/6)].$$

where:

oc = fixed unit operating cost (\$/boe).

Capital expenditures reflect the up-front, lump-sum amount required to drill, frack, and complete the well, plus the capital cost of any auxiliary equipment.

Income Tax

Taxable income is based on a simplified treatment of the IRS rules that apply to upstream oil and gas operations. Intangible capital expenditures are expensed immediately and tangible capital expenditures are subject to ten-year, straight-line depreciation. We assume that any tax credit due to a net operating loss may be taken when incurred, which means a monthly net operating loss from the well in question is used to offset taxable income from other sources.

Production

Monthly production flows are modeled using a hybrid-decline model. Distinct (and steep) monthly decline rates are applied to the initial production (IP) rate in each of the first three years, after which production reverts to exponential decline for the remainder of field life at a fixed rate that ensures cumulative production (over 360 months) matches the stated EUR of the well. The hybrid-decline model is calibrated for each shale oil play to reflect a representative “type curve” attributed to that play by industry sources. Representative EURs (which measure well productivity) for each play are also based on industry sources, and include an estimate of the range of variation in well productivity within each play. Production of oil, natural gas, and NGL are assumed to remain in fixed proportions over the life of the well.

Application of the Individual Well Model

The principal purpose of the individual well model, in this project, is to identify for each shale oil play the breakeven EUR that corresponds to a given price and cost level; i.e., the minimum reserve size that is economically viable. Holding cost constant, the threshold productivity level required to ensure economic viability at price P will be denoted EUR_P .

In conjunction with the estimated distribution of EUR within a given play, EUR_P determines the portion of the “technically recoverable resource” within the play that may be counted as “reserves.” Then, by varying the price scenario and noting the indicated change in the volume of reserves in each play, we can calculate the play-specific elasticity of reserves with respect to price.

The scenarios we study involve constant real prices through time. For example, the minimum EUR in a specific play based on \$40 oil is the minimum well productivity required to achieve a non-negative NPV under a constant \$40 price level. Costs are set at levels indicative of the various shale oil plays based on industry sources, and sensitivity of results to various cost scenarios is explored.

It is well known that upstream costs have declined substantially over the past two years in response to the marked reduction in activity caused by the oil price crash. For this reason, we have conducted two sets of parallel analyses, applying in the first case factor prices that prevailed in 2014 (before the crash), and in the second case reducing those costs by 25% to mimic the conditions that exist today. We have also examined a third scenario (“Dynamic Cost”) in which all factor prices are tied by constant elasticity to the prevailing oil price level,

whatever it may be. Thus, if the oil price were to rise by $x\%$, say, we assume in the Dynamic Cost scenario that costs rise simultaneously by $\eta \times x\%$, where η represents the constant elasticity of cost with respect to price.

A rough estimate of η can be obtained by reference to the 25% cost decline. A constant elasticity cost function takes the form:

$$C_t = AP_t^\eta, \quad (1)$$

where C_t and P_t represent the levels of cost and oil price prevailing at time t . We take two observations of the price level: $P_{2014} = \$90$ and $P_{2016} = \$45$ and pair these with the associated cost levels: C_{2014} and $C_{2016} = 0.75 \times C_{2014}$. After substituting these values into Equation (1) and solving for η , the implied elasticity is seen to be 0.415.

Fixed, play-specific, type curves (i.e., decline curves) are adopted throughout, also based on industry sources. This means that the same monthly pattern of production decline applies to all wells in a given play, independent of variations in the EUR of the individual wells. Other input variables that are common to all wells located within a single play include the royalty rate, oil and gas severance tax rates, the differential (if any) between wellhead prices and the reference WTI and gas HH prices, the gas/oil/NGL production mix, drilling and completion costs, and the variable operating cost of the well.

Fixed values of several macroeconomic parameters are applied uniformly across all plays, including the discount rate, the potential life of the well, the income tax rate, and depreciation schedules.

Values of all input parameters used to value wells in each shale oil play included in this study are tabulated in the appendices.

3.2 The Distribution of Well Productivity (EUR)

It is assumed that the variation of EUR across all wells located in a given play follows a lognormal distribution with density $f(EUR|\mu, \sigma)$:

$$f(EUR) = \frac{1}{EUR\sqrt{2\pi\sigma^2}} e^{-\frac{1}{2}\left(\frac{\ln EUR - \mu}{\sigma}\right)^2} \quad \text{for } EUR > 0.$$

It follows that $\ln(EUR)$ follows a normal distribution with mean μ and standard deviation σ . The corresponding moments of the lognormal distribution of EUR are then as follows:³

$$mean = e^{\mu + \sigma^2/2}, \quad (2a)$$

$$stdev = e^{\mu + \sigma^2/2} \times \sqrt{e^{\sigma^2} - 1}, \quad (2b)$$

³ J. Aitchison and J. A. C. Brown, *The Lognormal Distribution*, Cambridge University Press, 1966, p. 9.

$$\text{median} = e^{\mu}, \quad (2c)$$

Further, the coefficient of variation of EUR within the play is calculated as the ratio:

$$\text{coefvar} = \frac{\text{stdev}}{\text{mean}} = \sqrt{e^{\sigma^2} - 1}. \quad (3)$$

Given a set of estimated parameters that describe the variation in well productivity within a play, it is then straightforward to compute the percentage of drilling sites within the play that are economically viable for any given price:

$$\% \text{drillsites} = \int_{x=EUR_p}^{\infty} f(x|\mu, \sigma) = 1 - \Phi\left(\frac{\ln(EUR_p) - \mu}{\sigma}\right),$$

where $\Phi(\cdot)$ represents the standard normal cumulative distribution.

It is possible also to compute the percentage of technically recoverable resources that are economically viable:

$$\% \text{resources} = \frac{\int_{x=EUR_p}^{\infty} x f(x|\mu, \sigma)}{\int_{x=0}^{\infty} x f(x|\mu, \sigma)} = \frac{E[x|x > EUR_p] \times \% \text{drillsites}}{\text{mean}}, \quad (4)$$

which after simplifying can be written as:

$$\% \text{resources} = \Phi\left(\sigma - \frac{\ln(EUR_p) - \mu}{\sigma}\right), \quad (5)$$

where we have used the following fact that is true for any lognormal variate:⁴

$$E[x|x > EUR_p] = E[x] \times \frac{\Phi\left(\sigma - \frac{\ln(EUR_p) - \mu}{\sigma}\right)}{1 - \Phi\left(\frac{\ln(EUR_p) - \mu}{\sigma}\right)}.$$

To perform the calculations indicated in Equations (4) and (5), we need to calibrate the parameters of the lognormal distribution to each specific play. We proceed as follows. First, the *mean* well productivity for a given play is set equal to the average EUR reported by Simmons. These values were reported in August 2015 and we assume they represent the state of technology as of that time. Next, we compute σ by solving Equation (3) using the value of *coefvar* drawn from the USGS studies. As mentioned in Section 2.3, we believe the value of *coefvar* for a given play is determined by nature and is essentially timeless, at least that would be true if technological progress has increased the EUR of all wells within the play by a common percentage. We feel that is a reasonable working assumption. Finally, μ is obtained by solving Equation (2a). The *median* well productivity of the play is then determined by Equation (2c).

The USGS has provided estimates of all these parameters for a miscellaneous set of “assessment units” spread throughout the U.S. Their concept of “assessment unit” is similar to our concept of play—a bed of shale deposits created by common geological events. However, their set of 20 assessment units does not match our set of 34 plays. Some of their assessment

⁴ J. Aitchison and J. A. C. Brown, op. cit., p. 87.

units lie outside the geographical scope of our study, and some of our plays may be composites formed as the combination of several of their units (for example, our two Williston Basin plays are treated as four units by the USGS) while some of their units may be formed as the combination of several of our plays (for example, their single Eagle Ford oil unit is treated as three plays—oil, condensate, and combo—in our study). And some of our more recent plays (for example, all but the Spraberry in the Permian Basin) have yet to be addressed by the USGS.

As a consequence, some judgment must be exercised when extracting and applying the USGS estimates of *coefvar* to our plays. We have followed two courses in this regard. The first is to simply compute the average value of *coefvar* over all of the USGS units and apply it uniformly to all of our plays. The USGS estimates of *coefvar* range between 0.805 and 2.543, averaging 1.475 overall. Variations in *coefvar* within this range do not alter the inherent skewness of the distribution, and it is this skewness that drives many of our results. Having said that, we also pursue a second method, which is to apply to each of our plays an average value of *coefvar* based on the subset of USGS units located in that same basin. We will contrast these two approaches and show that our estimates of the elasticity of reserves and drilling sites are not much affected either way.

3.3 Combining the Two Models

To calculate the elasticity of reserves with respect to price, we account for the relationship between price and breakeven EUR, which moves technically recoverable reserves into or out of the “economic” category as the price rises or falls. The percentage change in economic reserves due to a one percent change in price is what we call the “reserve elasticity.”

The previously described analysis assumes that all wells within a play can be developed at uniform cost, and the reserve elasticity is conditioned on that number. Recognizing that the cost of drilling individual wells varies even within a given play, one might wish to work with the joint distribution of EUR and well cost. Reserves would then be computed by aggregating over the set of all wells with a combination of EUR and well cost (whether higher or lower than average) that are deemed economically viable.

We have not followed that course for three reasons. First, no information on the joint distribution of EUR and well cost is at hand. Second, the range of variation in EUR across wells within each basin swamps the range of variation in cost per well. USGS reports that production from the most productive wells in any given play exceeds that of the least productive wells by a factor of 100:1.⁵ In contrast, the difference between most and least expensive wells in a given play is on the order of 2:1.⁶ Drilling costs are mostly a function of drilling depth, and the relatively uniform depth of shale deposits within each play accounts for the relatively small

⁵ USGS, op. cit., p. 1.

⁶ Reporting on twenty-two U.S. and Canadian shale oil plays, Rodgers see the expense ratio of high cost to low cost for wells within individual plays as ranging between 1.17 to 2.0, with an overall average of 1.45. He estimates the average ratio of greatest to shallowest well depths within those plays as 1.51. See Barry Rodgers, “North American Resource Value—2: North American Tight Oil Play Economics Compared,” *Oil and Gas Journal*, May 6, 2013.

variation in cost per well. Third, any further adjustments we would make to the volume of reserves based on variations in costs would tend to cancel out. Some low-cost wells would be added to our reserve estimate despite having a low EUR, but other high-cost wells would be subtracted in spite of a high EUR. The two adjustments work in opposite directions and their net impact is thought to be of second-order importance. Due to the skewness of the EUR distribution and the nonlinearity of EUR as a function of both price and cost, the opposing forces will not in general exactly cancel out, so our estimated reserve elasticity must be regarded as an approximation that takes best advantage of the available information.

4. Data Sources and Validation

This study encompasses 34 distinct shale plays in the U.S. 19 of these are categorized as “shale oil plays” because oil is the dominant produced fluid (>50%). The remaining 15 are categorized as “combo plays” because in each one oil constitutes less than 50% of production. All major plays that contribute significantly to U.S. shale oil production are included. The individual plays are described in Tables 1 and 2.

Table 1: Oil Plays

Basin	Play	Uniform Coef Var	Specific Coef Var	Well Cost \$mm	EUR mboe	IP Rate boe/d	Oil %	Gas %	NGL %
Anadarko/MidCont	Springer	1.500	1.991	9.0	904	720	68%	16%	17%
Anadarko/MidCont	Marmaton	1.500	1.991	3.1	201	276	55%	25%	20%
Anadarko/MidCont	Tonkawa	1.500	1.991	3.7	249	340	56%	28%	17%
Bakken	Bakken Core	1.500	1.970	7.5	725	851	85%	13%	2%
Bakken	Bakken Non Core	1.500	1.970	6.5	558	655	88%	9%	3%
Denver/Julesburg	N Wattenberg	1.500	1.082	4.0	357	400	71%	20%	10%
Denver/Julesburg	N Wattenberg XL	1.500	1.082	6.6	727	722	67%	21%	13%
Denver/Julesburg	S Wattenberg	1.500	1.082	3.4	395	430	51%	33%	17%
Eagle Ford	Eagle Ford Oil	1.500	1.620	6.0	515	915	71%	15%	14%
Eagle Ford	Eagle Ford Condensate	1.500	1.620	8.0	801	1,367	63%	20%	17%
Other	San Juan Gallup	1.500	1.500	4.2	451	550	65%	18%	18%
Other	Tuscaloosa Marine Shale	1.500	1.500	11.0	683	1,048	92%	8%	0%
Permian	Midland Spraberry	1.500	0.805	6.5	753	825	76%	12%	12%
Permian	N Delaware Bone Spring	1.500	0.805	6.5	676	1,000	60%	20%	20%
Permian	S Delaware Wolfcamp	1.500	0.805	7.8	883	1,100	55%	25%	20%
Permian	Midland Wolfcamp	1.500	0.805	6.5	746	745	60%	19%	21%
Uinta	Greater Monument Butte	1.500	1.500	1.4	188	120	87%	9%	4%
Uinta	Wasatch SXL	1.500	1.500	14.0	1,000	1,444	75%	25%	0%
Uinta	Uteland Butte SXL	1.500	1.500	11.0	700	1,290	75%	25%	0%

Table 2: Combo Plays

Basin	Play	Uniform Coef Var	Specific Coef Var	Well Cost \$mm	EUR mboe	IP Rate boe/d	Oil %	Gas %	NGL %
Anadarko/MidCont	Cana Woodford	1.500	1.991	7.0	1,826	1,606	5%	63%	32%
Anadarko/MidCont	SCOOP Oil	1.500	1.991	9.4	979	762	48%	23%	29%
Anadarko/MidCont	SCOOP Condensate	1.500	1.991	9.6	1,952	1,400	10%	50%	40%
Anadarko/MidCont	STACK	1.500	1.991	8.5	940	826	40%	30%	30%
Anadarko/MidCont	Meramec	1.500	1.991	7.6	1,338	1,425	22%	47%	31%
Anadarko/MidCont	Mississippian	1.500	1.991	2.8	410	409	34%	46%	20%
Anadarko/MidCont	Granite Wash	1.500	1.991	7.5	736	1,340	20%	50%	30%
Anadarko/MidCont	Cleveland	1.500	1.991	2.8	232	400	30%	45%	25%
Appalachia	SW PA Wet Gas	1.500	1.500	5.9	2,933	2485	0	49%	50%
Appalachia	SW PA Super Rich	1.500	1.500	5.9	2,150	1,536	8%	46%	46%
Appalachia	Utica Wet Gas	1.500	1.500	10.3	3,000	3,000	3%	67%	30%
Appalachia	Utica Condensate	1.500	1.500	9.4	1,186	1,186	28%	48%	24%
Eagle Ford	Eagle Ford Combo	1.500	1.620	5.5	898	1,085	21%	45%	34%
Permian	Culberson LL Wolfcamp	1.500	0.805	11.9	1,955	2,450	20%	50%	30%
Permian	S Midland Basin Wolfcamp	1.500	0.805	4.8	500	525	48%	27%	25%

The tables identify the broader sedimentary basin in which each play is located, and provide additional information regarding typical drilling and completion costs (“Well Cost”), the average productivity of all potential drill sites within the play (EUR), the average 30-day initial production rate for those drill sites (IP), as well as the composition of the production stream.

All of these data were provided by Simmons and Company.⁷ The tables also show the estimated coefficient of variation regarding EUR that is attributed to each play, based on the USGS estimates that include both the overall average (labeled as “Uniform Coef Var”) from all USGS assessment units and the basin-specific averages (labeled as “Specific Coef Var”) that serves as an alternative in some of our analysis.

Additional play-specific information provided by Simmons and Company includes the following parameters:

- production decline rates (%)
- operating cost (\$/boe)
- royalty rate (%)
- oil severance tax rate (%)
- natural gas severance tax rate (%)
- oil price differential (%)
- natural gas price differential (%)
- NGL price differential (%)

The specific values of these parameters pertaining to each play are documented in the Appendix A. These values were applied to all potential drill sites within a given play and held fixed throughout our analysis. Finally, a uniform income tax rate of 35% has been applied to the net income of the DCF model, and net cash flows are discounted at the annual rate of 8.5%.

We have attempted to validate the input parameters in various ways. We have, for example, attempted to compare actual IP rates and observed coefficients of variation with the assumed values. The results obtained from the Bakken data are shown in Table 3, which reports on the average 30-day IP rates for all horizontal oil wells drilled in North Dakota, as reported by the North Dakota Industrial Commission.

Table 3: North Dakota, 30-day Initial Production Rates, All Horizontal Oil Wells Spudded in Given Year (b/d)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Average	219	375	619	855	966	968	1,114	1,292	1,180	1,320
Std.Dev.	227	411	649	655	798	777	868	884	784	798
Coef.Var	1.03	1.09	1.05	0.77	0.83	0.80	0.78	0.68	0.66	0.60
Missing Wells	30	28	46	17	42	41	67	92	356	1022
Total Wells	239	287	587	492	1,127	1,478	2,031	2,235	2,597	1,303
Missing %	13%	10%	8%	3%	4%	3%	3%	4%	14%	78%

Source: Authors calculation, data taken from the North Dakota Industrial Commission.

⁷ Simmons & Company International, “U.S. Well Economics,” August, 2015.

As we had anticipated, average productivity of Bakken wells has increased dramatically since 2006, with fastest growth in the early years when operators were first learning about the shale. The standard deviation has grown along with the mean, but the coefficient of variation has remained fairly constant, especially if we discount the 2015 data which are mostly incomplete. The observed coefficient of variation has varied between 0.60 and 1.09, and never approached our USGS benchmark estimate of 1.50. The average IP rate averaged 1,180 barrels/day for wells spudded in 2014 (even higher in 2015, but those data are again largely incomplete), which is well above our benchmark rates of 851 barrels/day (Bakken Core) and 655 barrels/day (Bakken non-Core).

These differences are not troubling. Indeed, the discrepancies are exactly in the direction we should expect if the industry has been selective in its choice of drilling sites. If more productive drill sites receive priority, then the set of wells actually drilled is not representative of the entire population of potential drill sites and the observed average would exceed the population mean, which is what we observe. For the same reason, the observed standard deviation would fall below the population standard deviation. The impact on the mean and standard deviation together would in turn reduce the observed coefficient of variation below the population coefficient of variation, which is what we observe in the case of the Bakken Shale. This is admittedly a weak test of the reasonableness of our parameter inputs, but it is a test that we easily could have failed if our input parameters were askew.

We have no reason to believe that the Simmons data or the USGS estimates are biased in any particular direction. We do acknowledge, however, that we are working with estimated values of the input parameters and that it would be useful to pursue further research to verify the accuracy of our assumptions and to update them if new or better information becomes available.

We have also compared our input parameters, as well as our conclusions, with play-specific, industry pronouncements regarding well costs, IP rates, EUR volumes, and break-even prices. This type of comparison finds close correspondence between our inputs and outputs and various quite detailed play-specific reports from operators who are active in the field. A sampling of this literature is listed below. Although these various reports provide at most to anecdotal support, again it is a test that we might have failed.

A Sampling of Relevant Trade Press Reports:

- "Tight Oil Test: U.S. Production Growth Remains Resilient Amid Lower Crude Oil Prices," *IHS Online Pressroom*, November 20, 2014.
- "Price Slump Will Slow, Not Stop, US Oil Growth," *Petroleum Intelligence Weekly*, January 19, 2015.
- "Bakken, Not Beaten," *Oil and Gas Investor*, March 1, 2015.
- "Shale Producers Eye Risky Drilling Ramp-Up," *Petroleum Intelligence Weekly*, April 27, 2015.
- "Permian Perseveres," *Oil and Gas Investor*, May 1, 2015.
- "Well Backlog Won't Halt Fall in US Oil Output," *Petroleum Intelligence Weekly*, May 4, 2015.
- "Optimizing the Eagle Ford," *Oil and Gas Investor*, September 1, 2015.
- "Permian Holds Up Best Among US Shale Plays," *Petroleum Intelligence Weekly*, September 7, 2015.
- "Did OPEC Misjudge Shale Economics?" *Petroleum Intelligence Weekly*, October 5, 2015.
- "Pundits Skeptical Over Fresh Fall in Oil Prices," *Petroleum Intelligence Weekly*, October 12, 2015.
- "Will 2016 Push US Shale Over the Edge?" *Petroleum Intelligence Weekly*, January 11, 2016.
- "Bankruptcies May Spell End for Some Shale Plays," *Petroleum Intelligence Weekly*, February 1, 2016.
- "Break-even model: Cracking the shale enigma," *Bloomberg Intelligence*, February 8, 2016.
- "Continental Thrilled with Trio of Meramec Wells, Keeps Capex at \$920M," *NGI's Shale Daily*, February 26, 2016.
- "Want to Bet on Oil Companies? It's All About the ZIP Code," *Wall Street Journal*, March 27, 2016.
- "Stacked in Oklahoma," *Oil and Gas Investor*, May 1, 2016.
- "US Shale Oil Starts Showing Some Life," *Petroleum Intelligence Weekly*, June 20, 2016.
- "Devon STACK spacing test flows 1,400 boe/d/well," *Oil and Gas Journal*, July 19, 2016.
- "Premium Blend: What's the 'Magic' Oil Price at Which DUCs Could be Completed?," *Oil and Gas Investor* (video interview), July 26, 2016.

5. Research Results

In this section, we discuss the main conclusions that have emerged from the study. The detailed background tables provided in the appendices provide complete documentation of all of our empirical findings. The discussion in this section is organized around seven main issues:

- The impact of low prices on the volume of shale oil reserves.
- The impact of low prices on the number of viable drill sites.
- The distinction between average and median well productivity as it affects economic viability.
- The significance of substantial natural gas resources within the “combo plays” and how their presence affects our results.
- The impact of low prices on the present inventory of drilled but not completed wells (DUCs).
- The impact of low prices on mature shale oil wells that are already in production.
- Robustness of results with respect to the estimated coefficient of variation.

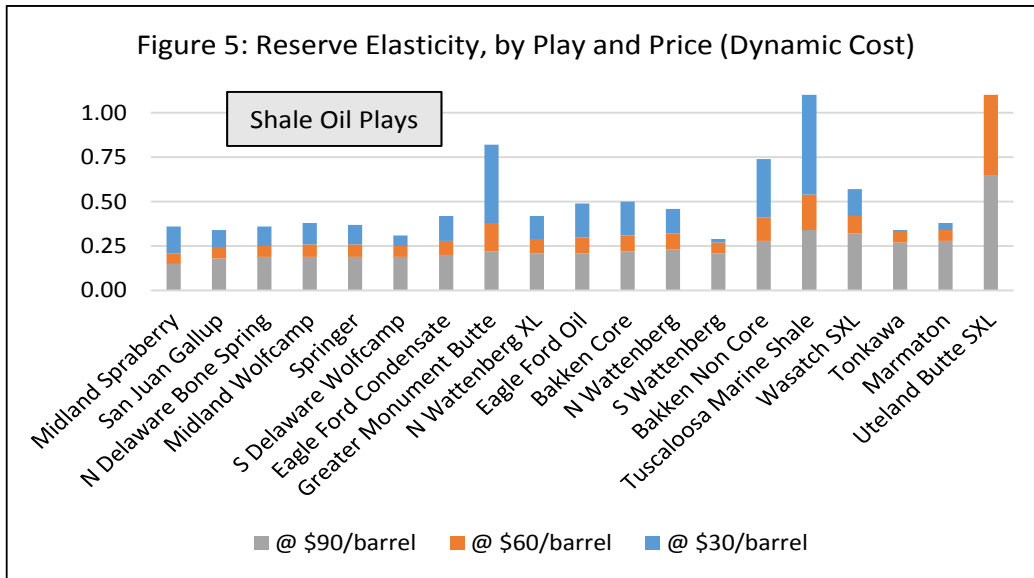
5.1 The Volume of Shale Oil Reserves

(This section pertains only to those plays categorized as “oil plays” on the basis of dominant crude oil production split. The “combo plays” behave quite differently and are discussed separately in Section 5.4).

The price elasticity of reserves varies across all shale oil plays but is generally quite inelastic, which means that the impact of price changes is damped. In almost all plays, the price elasticity is below 0.25 when prices are around \$90.⁸ The elasticity rises a little but remains well below 0.50 as price drops to \$60, and for most plays the elasticity remains below 0.50 as the price drops further to \$30.

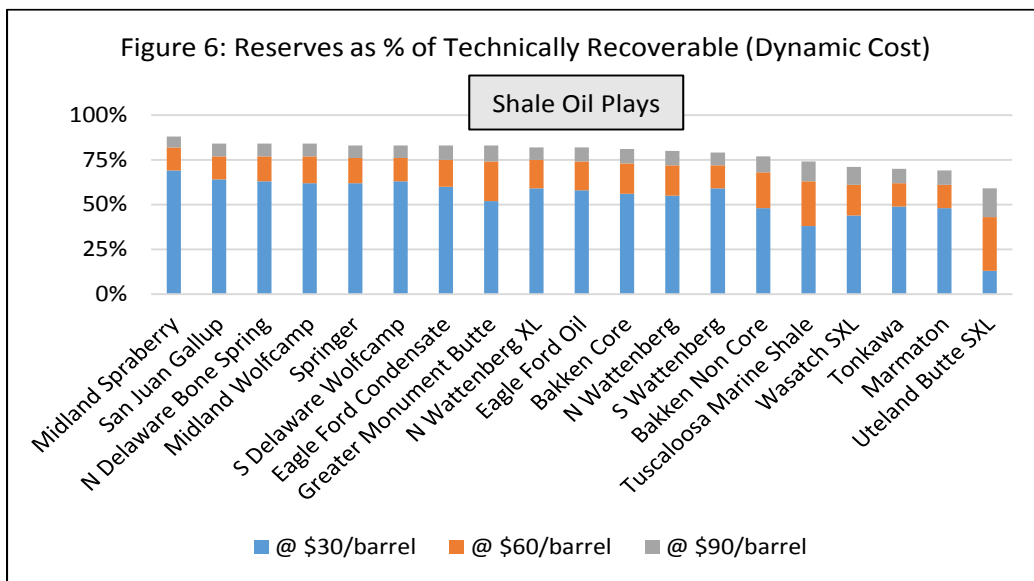
These estimates, shown in Figure 5, reflect the Dynamic Cost scenario, where it is assumed that upstream costs track oil prices with an elasticity of 0.415. More detailed results that cover a finer and broader range of price levels are provided in the appendices. Similar results obtained under the static 2016 Cost scenario were discussed previously in Section 2, and results for the static 2014 Cost scenario are presented in Appendix C. Given the observed tendency for upstream costs to move with oil prices, we feel the Dynamic Cost scenario shown here is the most relevant.

⁸ These figures reflect the arc elasticity calculated by observing the impact of a small change from the stated price level on the volume of reserves.



Source: Authors calculation.

With price at \$90/barrel, the volume of reserves comprises some 80% (or more) of the technically recoverable resource base. This percentage falls as the price drops, of course, but the decrease is modest. In most plays, nearly 75% of the technically recoverable resource remains economic at \$60/barrel, and well above 50% remains economic even at \$30/barrel. The resilience of shale oil reserves reflects the inelasticity discussed in the previous paragraph. Figure 6 plots these results.⁹

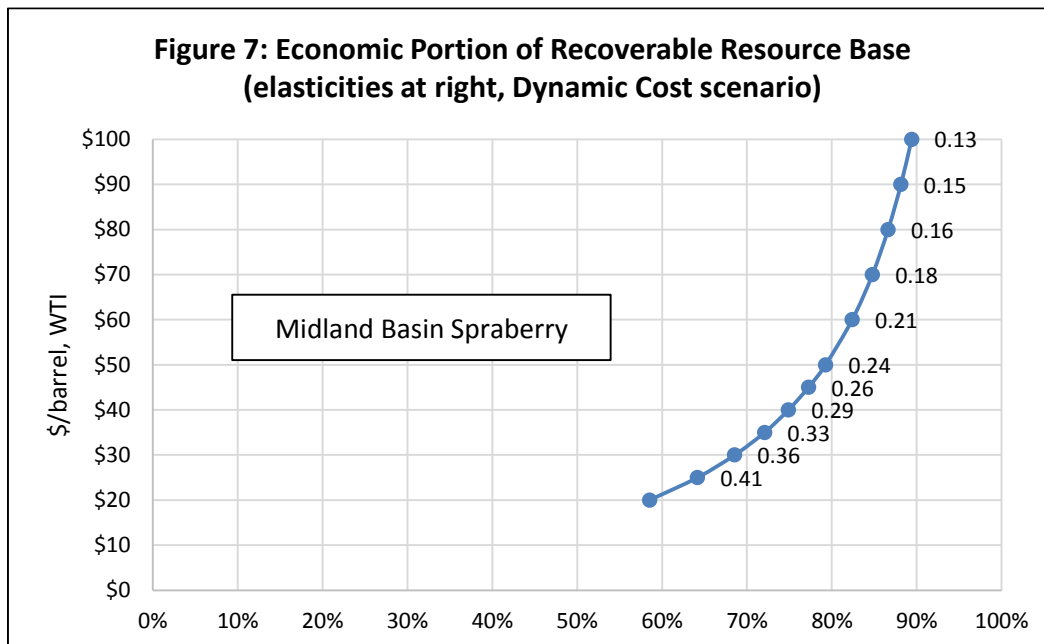


Source: Authors calculation.

⁹ These results are based on the Dynamic Cost scenario. Results based on the 2014 Cost and 2016 Cost scenarios are provided in Appendix C.

The percentages shown in Figure 6 are much higher than typical recovery rates found in conventional oil plays, but the two things differ in kind. In the case of a conventional oil reservoir, the “recovery factor” measures ultimate production against the entire volume of resource in place. Here we are measuring ultimate production only against that portion of the resource in place that is deemed technically recoverable given current technological methods. In all of our plays, the portion of shale oil in place that is currently technically recoverable is itself quite small, perhaps as low as 5% in some cases.¹⁰

For each play, our results regarding reserve elasticity and “recovery rate” can be combined into a single graph that represents the “supply curve” of shale oil reserves in that play, as illustrated by Figure 7 for the Midland Basin Spraberry play.¹¹ Nearly 90% of the technically recoverable resource base located the Spraberry is economic at \$100/barrel, given current technology. And nearly 60% of that resource base remains economic even with prices as low as \$20/barrel.



Source: Authors calculation.

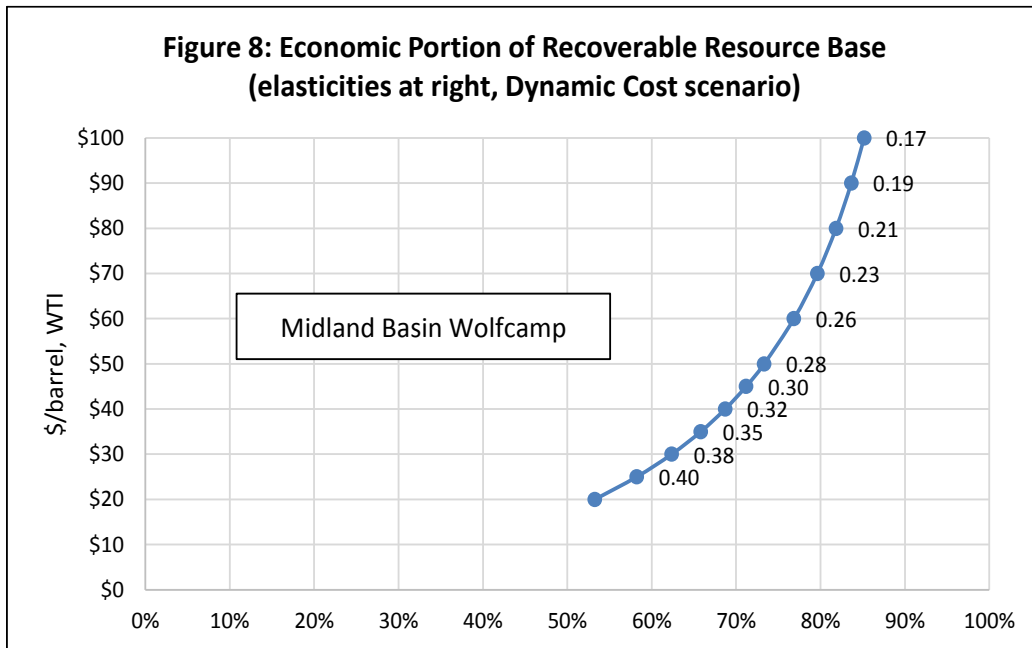
This type of supply curve can easily be transformed to provide absolute reserve volumes once an estimate of the technically recoverable resource base is obtained. For example, if the volume of technically recoverable shale oil in the Midland Basin Spraberry and Wolfcamp plays amounts to 75 billion barrels, as has been suggested,¹² then the estimated volume of shale oil

¹⁰ For example, Simmons estimates the technically recoverable resources in the Bakken Shale comprise only 4% of the oil in place. See “E&P Basin Tear Sheets,” Simmons & Company International, August 22, 2014.

¹¹ This figure reflects the Dynamic Cost scenario. Similar charts based on the other cost scenarios, and for all plays, are provided in Appendix C.

¹² This estimate of technically recoverable reserves is from Pioneer CEO Scott Sheffield, as published by *Oil and Gas Investor* magazine in May 2015.

reserves contained in these two plays (which are similar economically) at \$20 would be approximately 42 billion barrels, but would rise to roughly 54 billion barrels at \$40 dollars, and rise to 65 billion barrels at \$100/barrel. The estimate of 42 billion reserves at \$20 is calculated by averaging the recovery factors of both plays (53% and 59%) and multiplying by 75 billion barrels, etc. For comparison to Spraberry, the Wolfcamp supply curve is shown in Figure 8.

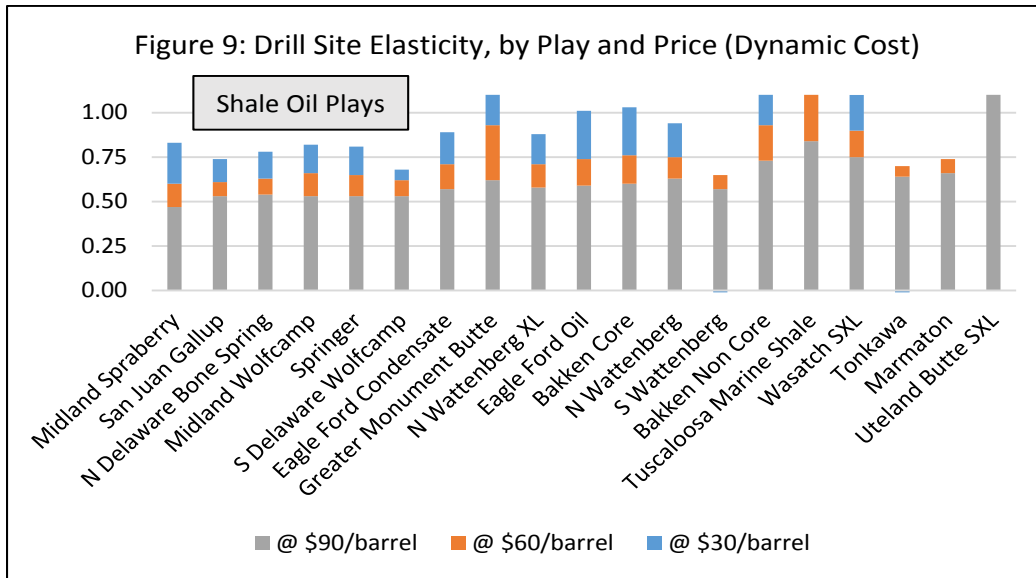


Source: Authors calculation.

5.2 The Number of Viable Drill Sites

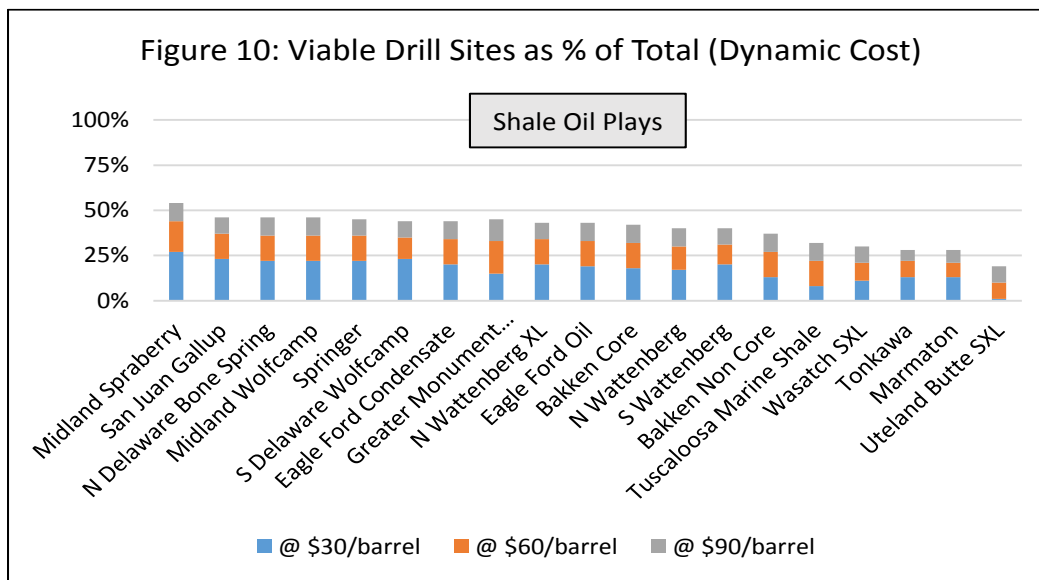
The skewness of the lognormal distribution of EUR means there are a disproportionate number of low productivity drilling sites in any given shale oil play. This fact largely explains the much higher elasticity of drill sites with respect to price. Any reduction in price affects the marginal (low productivity) drill sites, and because these comprise a fairly large percentage of all drill sites, a large fraction are lost to low prices. Moreover, as the price falls successively lower, bringing the marginal EUR into the dense part of the distribution, the number of sites vulnerable to a further decline in prices increases. The outcome: a less inelastic response overall than in the case of reserves. In every shale oil play we consider, the elasticity of drill sites is at least twice the elasticity of reserves.

This is evident in Figure 9, which plots the elasticity of drill sites measured at the three price benchmarks (\$30, \$60, and \$90). The chart is based on the Dynamic Cost scenario. Comparable results based on the other cost scenarios are provided in Appendix C. In few of the plays, however, does the elasticity of drill sites ever exceed unity, except at very low prices at which no sites remain viable. This inelastic response means that the reduction in the number of economically viable drill sites is generally smaller than the percentage reduction in price that brings it about.



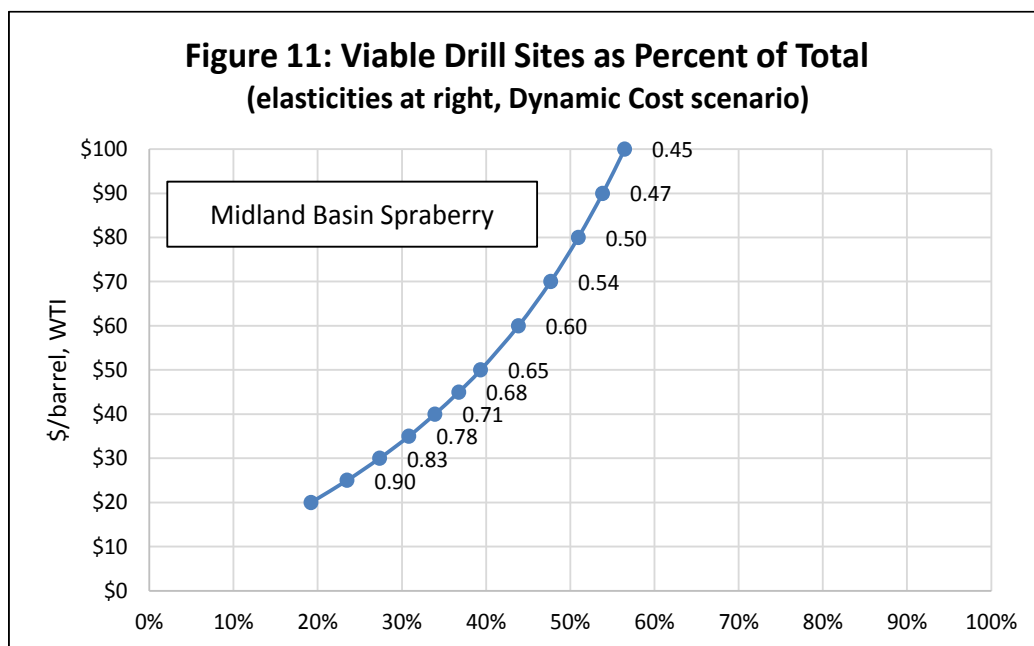
Source: Authors calculation.

It is notable that in nearly all plays the fraction of potential wells sites that are economically viable is less than 50%, even if the price is \$100/barrel. This is shown in Figure 10, and is but another reflection of the skewed shape of the distribution of well productivity. It means that very many additional, low-productivity sites would become viable if prices exceed \$100, and that at current and historical prices only a small portion of the available sites have so far factored in to the shale oil boom. On the other hand, the potential contribution of these additional wells to reserves is quite small; their large number does not make up for their low productivity (see Figure 6). Of course, continued technological progress could increase the size of their potential reserves.



Source: Authors calculation.

As we saw previously, elasticity and percentage viable of well sites can be brought together in one chart that traces the supply curve of drill sites in any given play, as shown in Figure 11 below for the Midland Basin Spraberry. The full set of these curves covering all plays is provided in Appendix D. And, as in the case of reserves, this figure can be transformed into a supply curve of the absolute number of viable drill sites if the total number of potential sites is known. One way to proceed would be to figure the geographic extent (in acres) of the play and divide by the typical well spacing factor. For example, Simmons and Company (2014) reports the combined area of the Cana Woodford, SCOOP, and STACK plays in the Anadarko Basin to be 688 square miles (440,320 acres), with average spacing of 160 acres/well. Based on those dimensions, there should be roughly 2,750 potential drill sites within those plays.



Source: Authors calculation.

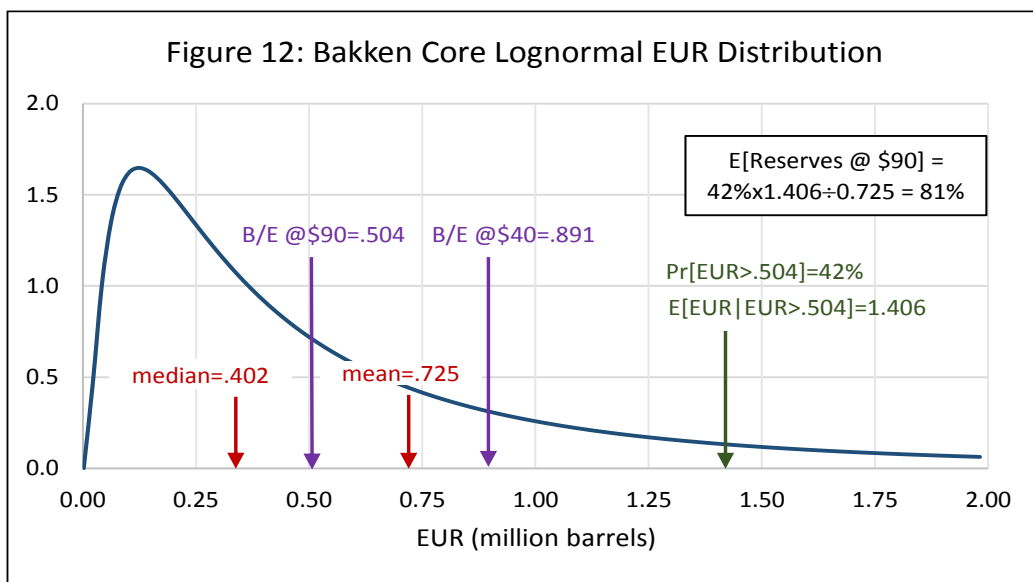
5.3 The Distinction Between Average and Median Productivity

One important property of the lognormal distribution is that the statistical mean, or average, is actually atypical. The percentage of wells that match or exceed the average level of productivity may be quite small, and the number that fall short may be quite large. The median marks the point that divides the distribution of drill sites into two equal parts. And in the lognormal distribution, the median always falls below the mean, and becomes relatively smaller as the coefficient of variation increases.

The relationship between mean and median is illustrated in Figure 12, which reflects the Bakken Core play. We show both the mean and median of the estimated distribution of EUR. In this case, the median is 402,000 barrels whereas the mean is 725,000 barrels. The

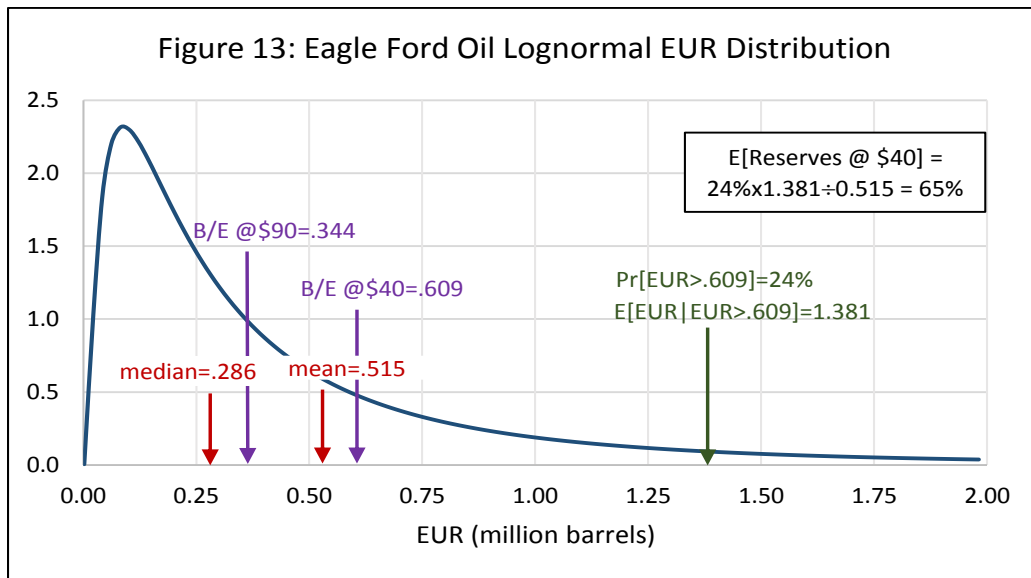
importance of the distinction has to do with their differential ability to withstand low price. We have superimposed on this distribution the minimum EUR associated with prices of both \$90 and \$40/barrel. Viability requires an EUR of at least 891,000 barrels in the \$40 case, but only 504,000 barrels in the \$90 case. The average well surpasses the \$90 hurdle, but not the \$40 hurdle. The median well falls short of both.

If not the average well, what percentage of wells in the Bakken Core do surpass the \$90 hurdle? The answer is found by integrating under the curve to the right of the cutoff, which corresponds to our variable *%drillsites*, as defined in Section 3.2. In this case, the answer turns out to be 42%. But since those wells are all high productivity, they comprise a relatively large portion of the total volume of technically recoverable reserves—the area to the right of the cutoff weighted by the productivity of wells in that region (which corresponds to our variable *%resources*, as defined in Equation 5). In the case of the Bakken Core, those 42% of all drill sites contribute 81% of the technically recoverable resource base.



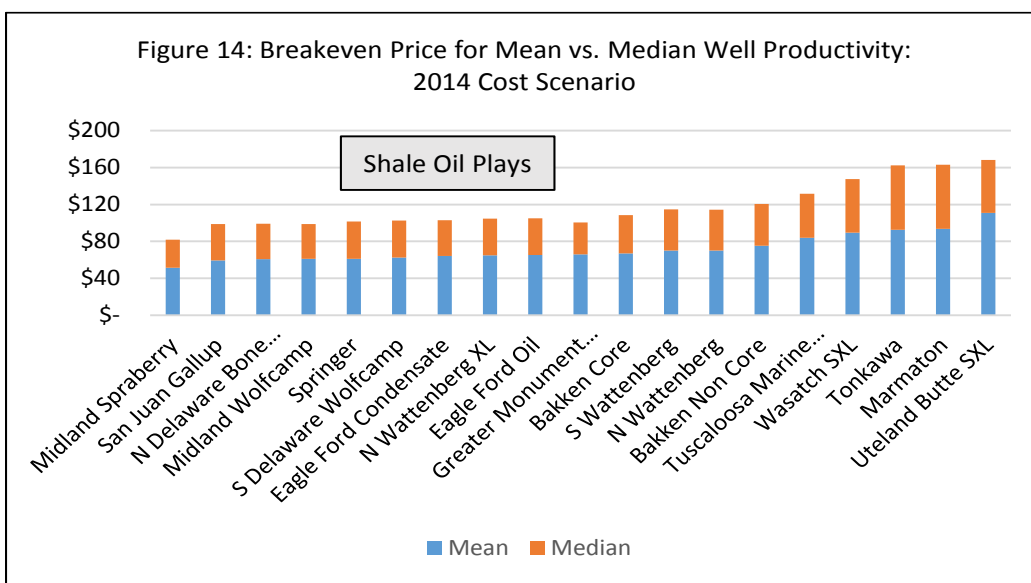
Source: Authors calculation.

For comparison, the analogous diagram showing the estimated lognormal distribution of well productivity in the Eagle Ford Oil play appears below in Figure 13. As indicated in the figure, only 24% of all potential drill sites surpass the \$40/barrel hurdle, but those relatively few sites comprise 65% of the technically recoverable resource base.



Source: Authors calculation.

Another way to measure the difference between the average and median drill site is to calculate the breakeven price required to develop each of them without losing money. We have made this calculation, using the Individual Well Economic Model applied to the estimated mean and median EUR level within each shale oil play included in the study. The results appear in Figure 14. The blue bar represents breakeven price for a well of average (mean) productivity in a given play, whereas the orange bar represents the higher breakeven price for a well of median (typical) productivity. As can be seen, “typical” drill sites require much higher prices than “average” drill sites. For this reason, focusing exclusively on the “average” drilling results in a particular shale oil play will be misleading.

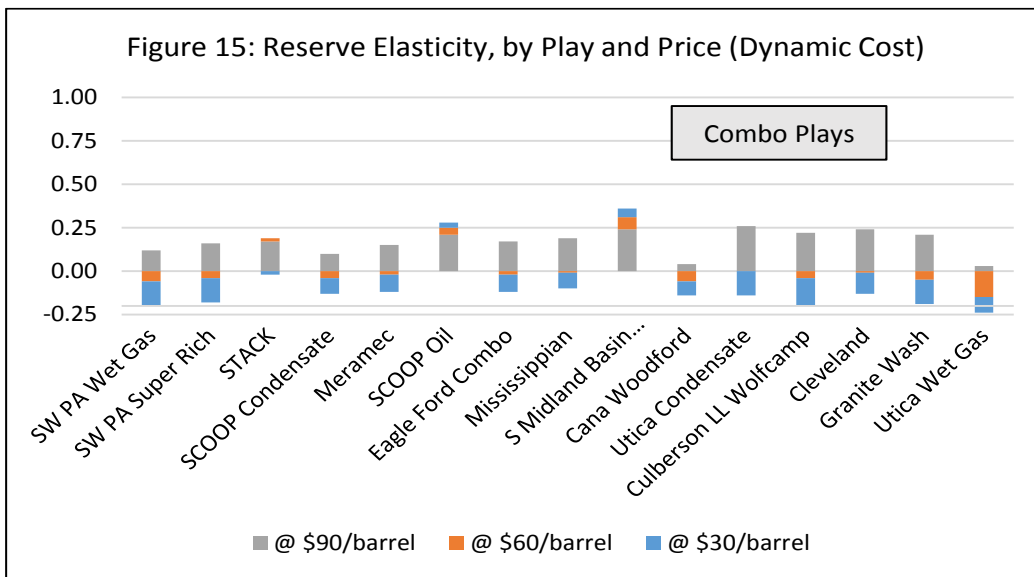


Source: Authors calculation.

5.4 Combo Plays are Different

The combo plays included in our study are gas-prone, with natural gas plus NGLs comprising between 52% and 100% of the technically recoverable resource base in the various plays. Accordingly, economic viability of the combo plays is determined less by oil prices than by gas prices and this reduces the elasticity of both reserves and drill sites with respect to the price of oil. That elasticity is reduced even further, however, by the dynamic link between oil prices and upstream costs. As oil prices fall, so do upstream costs in the combo plays, which increases their net cash flow holding all else equal. If a play is sufficiently gassy, the induced cost savings may outweigh the lost revenue, which creates the effect of a “backward bending” supply curve (negative elasticity). Both of these forces (low oil composition and dynamic costs) appear to play a major role in the supply of shale oil reserves from the combo plays, as illustrated in the following charts.

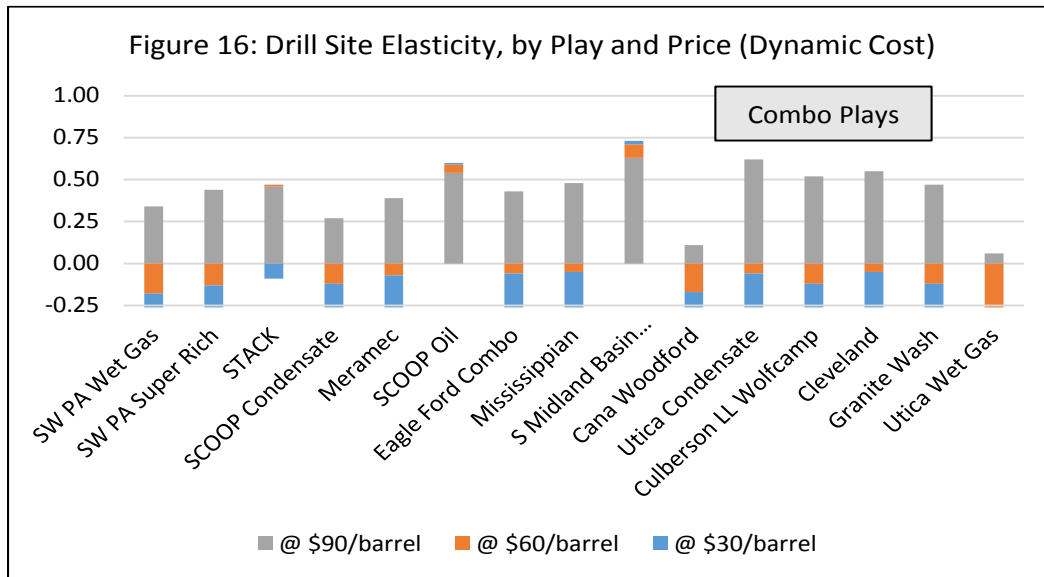
Figure 15 displays the elasticity of reserves in the various combo plays. In none of these plays does the elasticity exceed 0.25 when the price is \$90/barrel. As the price declines, the reserve elasticity actually declines (become more inelastic) due to the linkage to costs—the opposite of what happens in oil plays. At prices at \$60/barrel or below, the elasticity in many of these plays is already negative: Lower oil prices beget larger reserves. It should be understood that reserves are measured in terms of barrels of oil equivalent, with each six thousand cubic feet (mcf) of natural gas converted to one barrel of oil. But, both components of reserves (gas and liquid) increase when a marginal drill site is made economic by a cost reduction.



Source: Authors calculation.

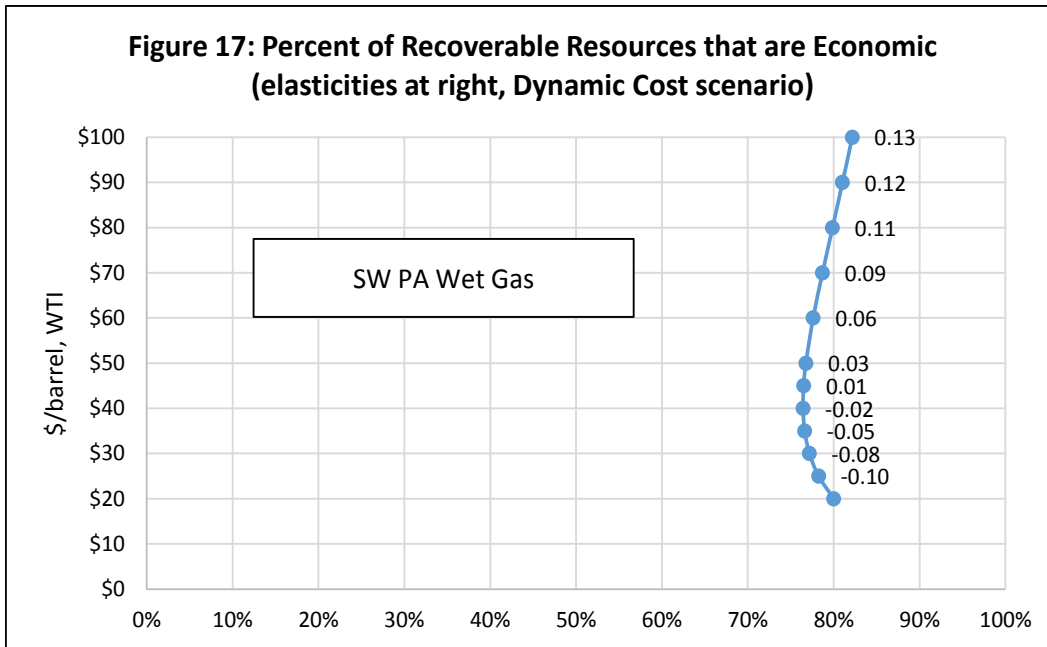
The elasticity of drill sites follows a similar pattern, as shown in Figure 16. Similar to the oil plays, the supply of drill sites in the combo plays is more elastic than is the supply of reserves (but still inelastic overall). This is most evident at the \$90 price level, where many of the drill

site elasticities approach or exceed 0.50. The cause is the same as in the oil plays: a preponderance of low-productivity sites that contribute little to reserves even if economically viable, and subtract little from reserves when they are not. But, due to the dynamic cost linkage, the elasticity falls with the price of oil. At the point where the elasticity becomes negative, the supply curve of drill sites begins to bend backward: lower oil prices beget a larger number of viable combo drill sites.

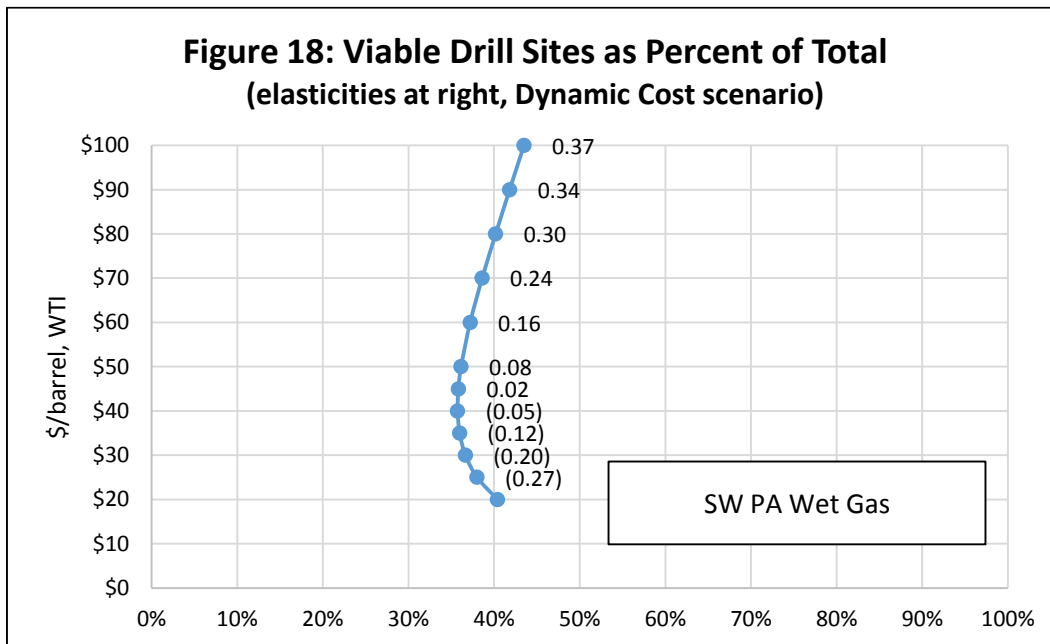


Source: Authors calculation

The backward bending supply curves of reserves and drill sites for the SW PA Wet Gas play are illustrated in Figures 17 and 18. This is an extreme example of the phenomenon due to the fact that this particular play is comprised entirely of natural gas and NGL.

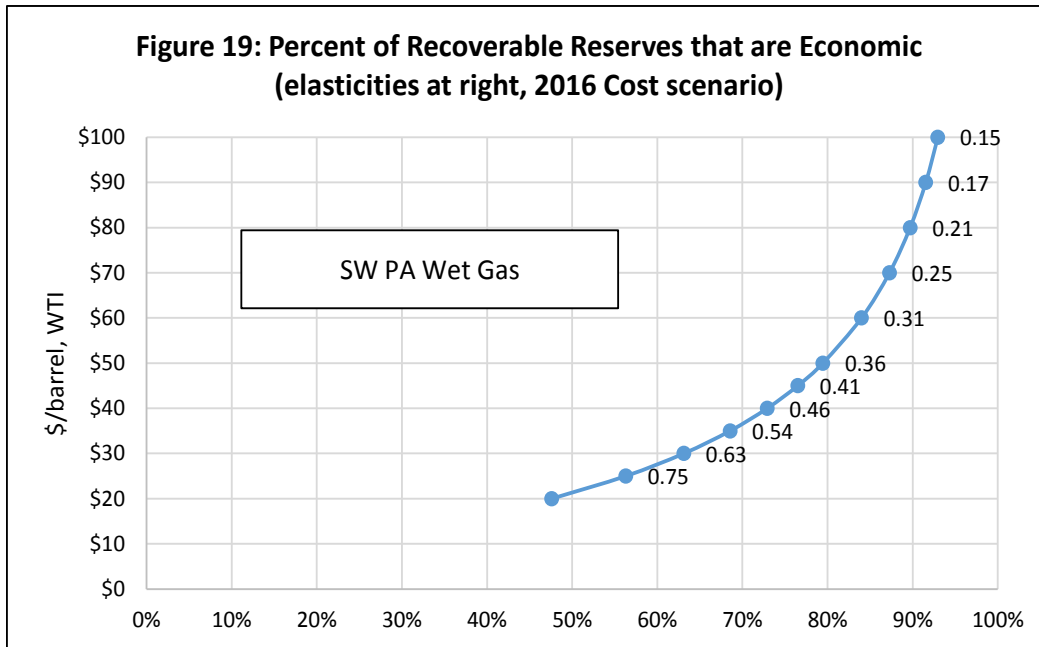


Source: Authors calculation.

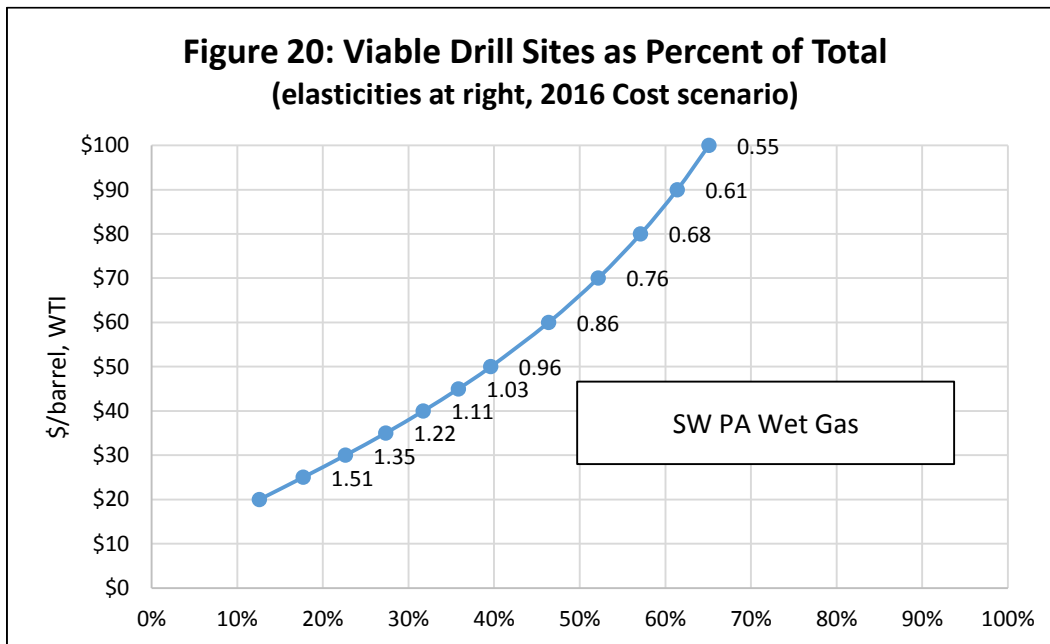


Source: Authors calculation.

The impact of the cost linkage can be gauged by comparing the two previous charts to the alternative results derived for the same play but on the assumption that costs remain fixed at the 2016 level as the oil price is varied (2016 Cost scenario), as shown in Figures 19 and 20.



Source: Authors calculation.



Source: Authors calculation.

5.5 Resilience of Drilled but not Completed Wells (DUCs)

The individual well economic model was also applied to evaluate the profitability of completing pre-drilled wells. The cost of drilling the well is treated as a sunk cost and excluded from the calculation. The lead time to first production is also reduced by time saved through pre-drilling.

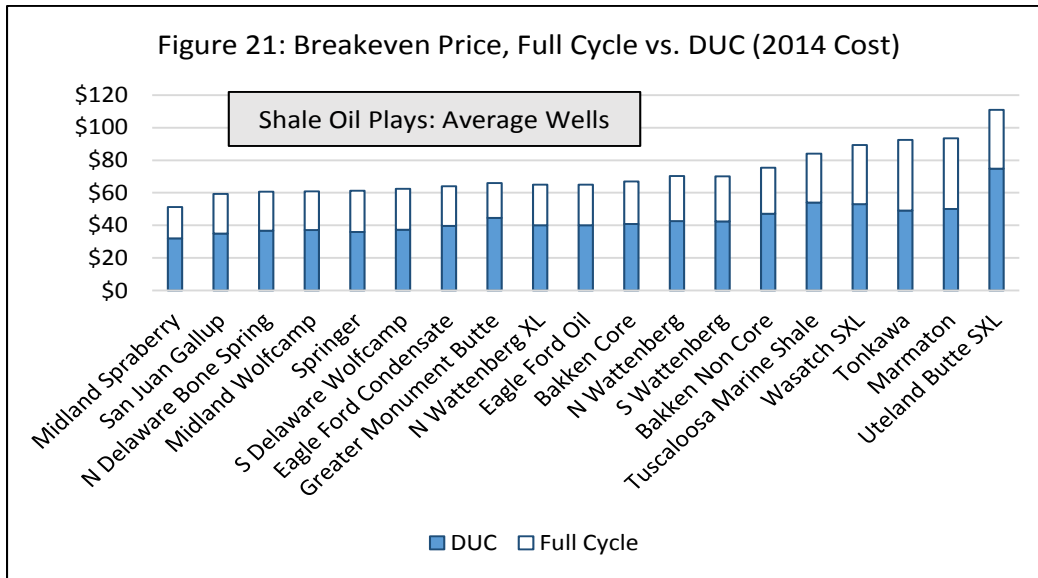
The objective of the analysis is to identify the breakeven price that justifies the incremental cost of completing the DUC; i.e., the minimum oil price that is consistent with nonnegative NPV.

To create a benchmark, we assume that 50% of the total capital cost of drilling and completion is sunk. However, in many cases the cost of drilling could be lower and the remaining cost of completion higher than we have assumed.¹³ The actual percentage varies among wells depending on the design of the well.

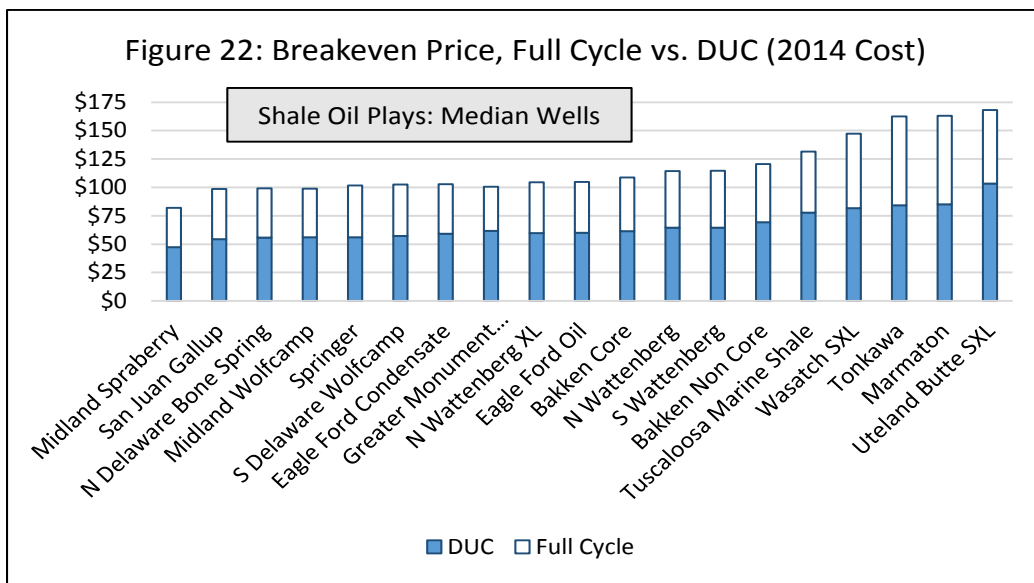
Because the NPV of a well depends on its productivity, so does the breakeven price for each DUC vary with the productivity of the drill site in question. For each shale oil play, we have therefore calculated two breakeven prices: one based on average well productivity (EUR) and one based on median well productivity within the play. The results appear in Figures 21 (average productivity wells) and 22 (median productivity wells). Breakeven prices required to recover the full cost of drilling and completing an average well vary across the shale oil plays between roughly \$50 and \$100/barrel (2014 Cost scenario). In contrast, the price required to recover the incremental cost to complete a DUC well is considerably lower, ranging roughly from \$35 to \$75/barrel. On average, across all oil plays, the breakeven price for a DUC of average productivity is 39% below the breakeven price for a new well. For wells with completion costs that exceed 50% of total capital expenditure, breakeven prices would be higher, but still substantially below the threshold for a new well.

Breakeven prices for median wells are much higher due to their lower productivity, as seen in Figure 22. The breakeven price to recover the full cost of a new well of median productivity varies across plays from roughly \$80 to \$170/barrel. Breakeven cost to recover the incremental portion of this cost varies between roughly \$50 and \$100/barrel. Across all these combo plays, the breakeven price for a median DUC is 43% below the breakeven cost for a new well of similar productivity.

¹³Cowan provides a detailed breakdown of expenditure on a typical Eagle Ford well that puts completion costs at 62% of the total. See Trey Cowan, "Costs for Drilling the Eagle Ford," *Rigzone* (online), June 20, 2011. A more recent analysis by Bloomberg Intelligence that encompasses the Eagle Ford and Permian Basins sees completion costs at 70% of the total. See *Bloomberg Intelligence*, "Break-even model: Cracking the Shale Enigma," (online) February 8, 2016.



Source: Authors calculation.



Source: Authors calculation.

It seems unlikely that many median productivity sites would have been chosen for pre-drilling. They would have faced a breakeven price above \$100 at the initial investment stage, which would have been a strong deterrent. In contrast, average productivity sites would have represented a much better gamble, with breakeven prices in many plays in the \$65/barrel range at the initial investment stage. We strongly suspect, therefore, that Figure 21 paints a current picture of the inventory of DUCs that presently exist. However, this estimate of the number of DUCs could be substantially different from other existing sources because of differences in methodology and operational assumptions as pointed by EIA (EIA 2016).

Fortunately, from September 2016, EIA started to provide estimates of the number of DUCs in different regions using a consistent methodology and uniform assumptions.¹⁴ Going forward, one may use this information as a benchmark when estimating of the number of DUCs.

Nonetheless, we make no presumption, regarding either DUCs or new wells, that operators will invest as soon as the market price attains the breakeven level. There are several reasons why they might not, including insufficient funding, physical bottlenecks, etc. Even in the absence of such constraints, however, operators may delay investment hoping for even better prices in the future. The timing of irreversible investments like the drilling of an oil well should, in theory, be guided by the principle of real options.¹⁵ And, in practice, there is considerable evidence that drilling decisions in Texas have been in accord with the tenets of real option theory.¹⁶ Consequently, the breakeven prices shown in Figures 21 and 22 should not be viewed as trigger prices that will automatically release investment once the threshold is attained. What really matters is that, consistent with real option theory, the threshold prices that would trigger investments in DUCs must be proportionately lower than the threshold price to drill a new well.

5.6 The Impact of Low Prices on Mature Shale Oil Wells

Mature producing wells shut down once production has declined to the point where sales revenue fails to cover variable expense. Low prices reduce sales revenue, of course, and therefore advance the date of abandonment, which causes some recoverable oil to be left behind. We have used the individual well economic model to measure the potential size of this effect as it applies to the shale oil plays included in our study. The results show that although low prices may shorten the life of some shale oil wells by several years, this has a negligible impact on remaining reserves.

Table 4 provides some indicative results for the Delaware Bone Spring play in the Permian Basin. The table shows, for wells of varying productivity and different prices, time at which net cash flow becomes negative. The months of “lost production” reported in the table are measured relative to a natural life of 30 years. Thus, with an oil price of \$40, a 250,000 EUR well in the Bone Spring would be shut in after 257 months of production—103 months early. It requires a combination of very lowest well productivity and very lowest price level to generate this type of effect. After capital costs have been sunk, and because variable operating costs are low, maintaining positive net operating cash flow is not a high bar. Many of these wells can produce profitably for thirty years even at very low prices. A Bone Spring well with 1,000,000 EUR, for example, would remain in production the full 30 years, even at \$40.

¹⁴ For more its methodological details, see https://www.eia.gov/petroleum/drilling/pdf/duc_supplement.pdf.

¹⁵ James L. Paddock, Daniel R. Siegel, and James L. Smith, “Option Valuation of Claims on Real Assets: The Case of Offshore Petroleum Leases,” *Quarterly Journal of Economics*, August, 1988.

¹⁶ Ryan Kellogg, “The Effect of Uncertainty on Investment: Evidence from Texas Oil Drilling,” *American Economic Review*, June, 2014.

		Oil Price (\$/barrel)								
		\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
EUR (1000 barrels/well)	100	216	192	173	158	146	135	126	117	110
	250	146	122	103	88	76	65	56	47	40
	500	93	69	50	35	23	12	3	0	0
	750	62	38	19	4	0	0	0	0	0
	1,000	40	16	0	0	0	0	0	0	0
	1,250	23	0	0	0	0	0	0	0	0
	1,500	9	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Northern Delaware Basin: Bone Spring

The loss of 103 months of production may seem significant, but it is not. Given the decline rate of shale oil wells, production that occurs at the tail end does not amount to much. As a percentage of the total reserves of the well, the loss is negligible. Table 4 illustrates this for the Bone Spring play. The cumulative production lost due to abandoning 103 months early amounts to only 4% of the potential remaining reserves. In making this calculation, we assume the well has already produced for three years (it is mature), and the 4% loss is relative to the remaining volume of future production (i.e., remaining reserves). That volume of lost production would constitute an even smaller portion of the well's initial reserves.

		Oil Price (\$/barrel)								
		\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
EUR (1000 barrels/well)	100	76%	83%	87%	89%	91%	93%	94%	94%	95%
	250	91%	94%	96%	97%	97%	98%	98%	99%	99%
	500	96%	98%	99%	99%	99%	100%	100%	100%	100%
	750	98%	99%	100%	100%	100%	100%	100%	100%	100%
	1,000	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Northern Delaware Basin: Bone Spring

Similar tables showing months of lost production and tail-end recovery factors for all shale oil and combo plays are provided in Appendix F.

5.7 Sensitivity of Results to the Coefficient of Variation in Well Productivity

All results presented thus far were based on a common coefficient of variation ($\eta = 1.50$), assumed to be the same in each play. This particular value was derived as the overall average

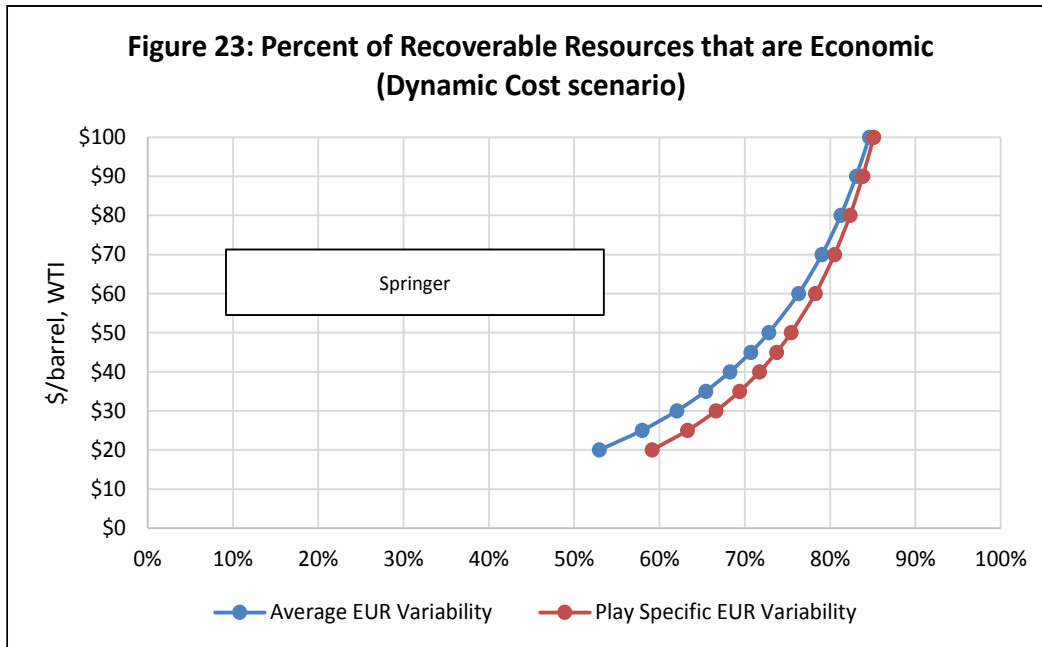
of the twenty plays assessed by USGS.¹⁷ As discussed in Section 3.2, we have tested the robustness of our conclusions by introducing variation in the assumed value of η across plays. Specifically, where our plays and the USGS assessment units overlap in the same petroleum basin, we apply to our plays the average coefficient of variation derived just from those USGS assessments taken from the relevant basin.

Table 6 compares the overall average with the basin-specific coefficients of variation constructed in this way. There is considerable variation across basins. The greatest disparity is seen in the Permian Basin, where the coefficient of variation is well below average. At the other extreme are the Anadarko/MidContinent and Williston (Bakken) Basins, where the coefficients of variation are well above average. The Eagle Ford Basin falls close to the overall average. In some of the basins, there is little or no overlap between our plays and the USGS. For example, the Anadarko/MidContinent Basin, which encompasses eleven plays in our study, is represented by a single assessment unit (Woodford Shale Oil) in the USGS analysis. The Permian Basin, which encompasses six plays in our study, is also represented by a single assessment unit (Spraberry). Therefore, the most we can hope to learn from this sensitivity analysis is whether variations in η of the magnitude suggested by the USGS assessments really matter, and if so, how our conclusions might be affected.

Petroleum Basin	Basin Average Coefficient of Variation
Anadarko/MidContinent	1.991
Bakken	1.970
Denver/Julesburg	1.082
Eagle Ford	1.620
Permian	0.805
Overall Average	1.500

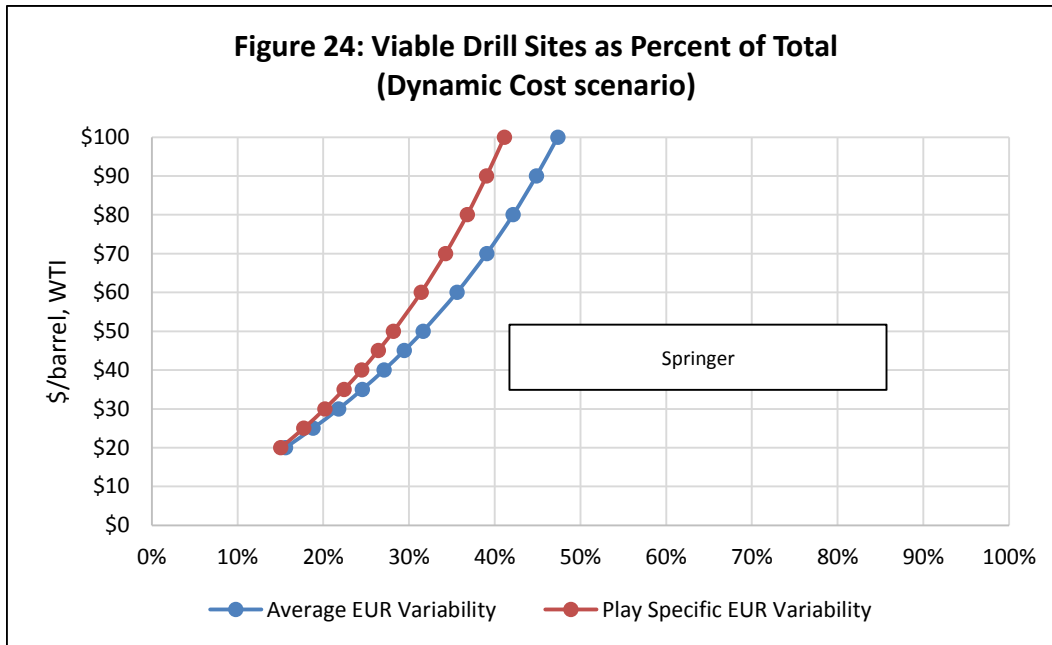
We begin by reviewing sensitivity results for the Springer shale oil play in the Anadarko Basin, where the basin-specific coefficient of variation (1.991) most exceeds the overall average (1.50). After updating the analysis of Springer accordingly, we find that the supply curves of reserves and drill sites are affected by this change, but only to a limited degree. The impact of higher variation in well productivity on the supply curve of reserves is shown in Figure 23. Above \$70/barrel, the volume of reserves is hardly affected. But at \$30/barrel, the estimated volume of reserves is about 8% higher than our earlier result.

¹⁷ A detailed explanation of the process used by USGS to fitting the lognormal distribution to their data, along with some alternatives, is presented in Appendix G.



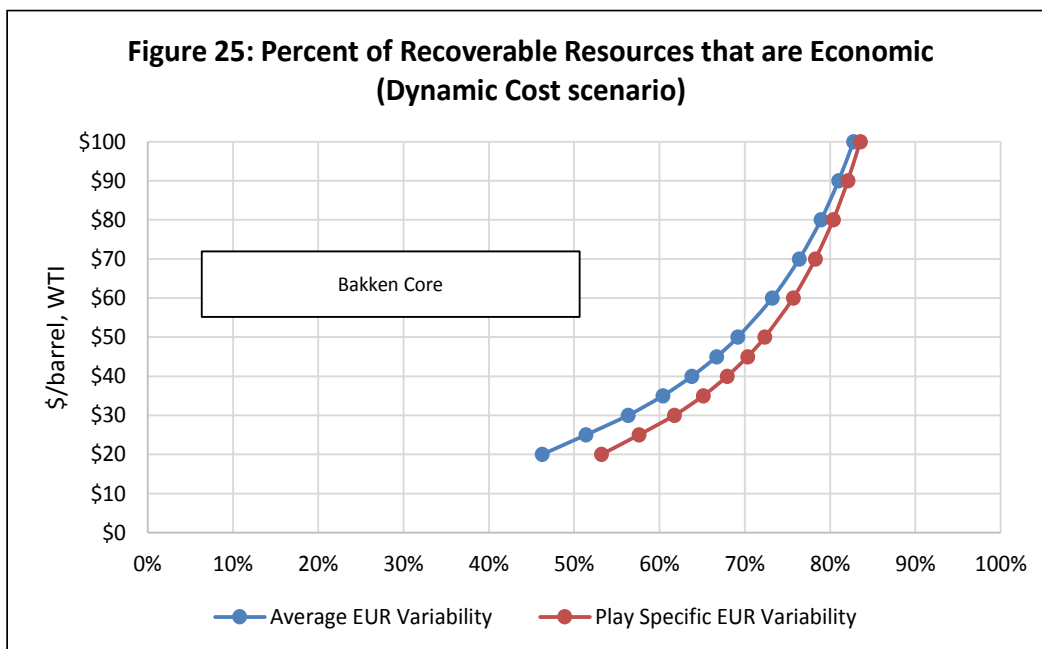
Source: Authors calculation.

The supply curve of drill sites is more sensitive to variations in η and follows a different pattern, as shown in Figure 24. At \$30/barrel, the estimated number of viable wells is hardly affected by the change in coefficient of variation, but at \$70, it is about 15% higher than our earlier result. One may ask, if the number of wells viable at \$70 has risen, why does the volume of reserves not also increase relative to our earlier result? This might look like a contradiction or error, but it is neither. Although the number of wells is greater, they belong to a different distribution (one with greater variability, same mean, but lower median) and do not therefore automatically boost the volume of reserves.

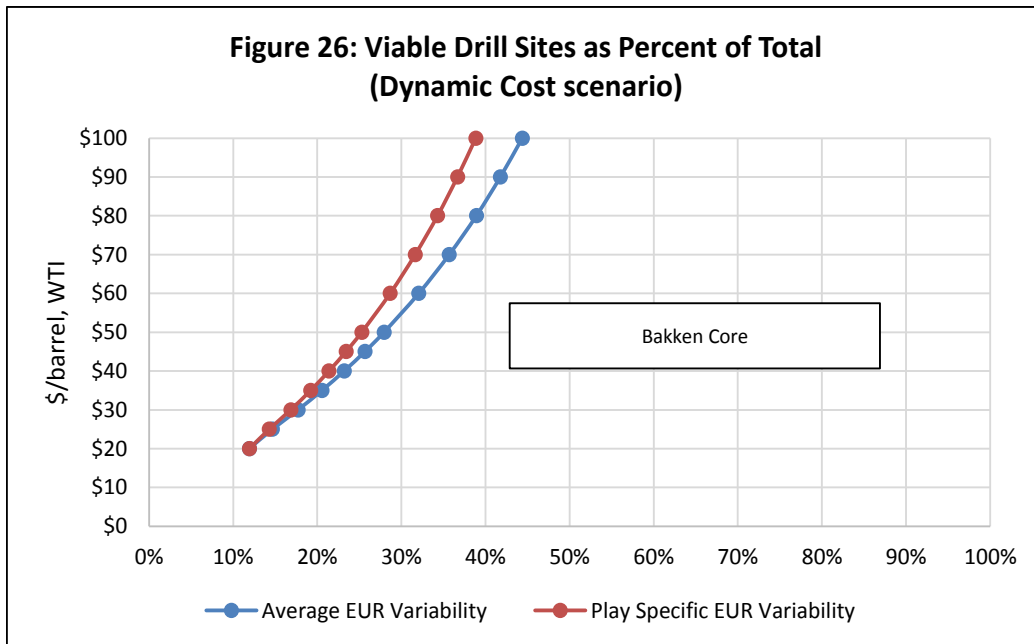


Source: Authors calculation.

We move to the Bakken shale, which like the Anadarko Basin deviates from the mean at the high end of the range. The results mirror what we have seen already, as shown in Figures 25 and 26. The estimated supply of reserves is affected by the change in η only at low prices; it increases by 11% at the \$30 level, for example, relative to our previous result. The estimated supply of viable drill sites also reacts as in the Anadarko: it is unaffected in the low-price range, but falls by 11% at the \$70 level, relative to our earlier result.

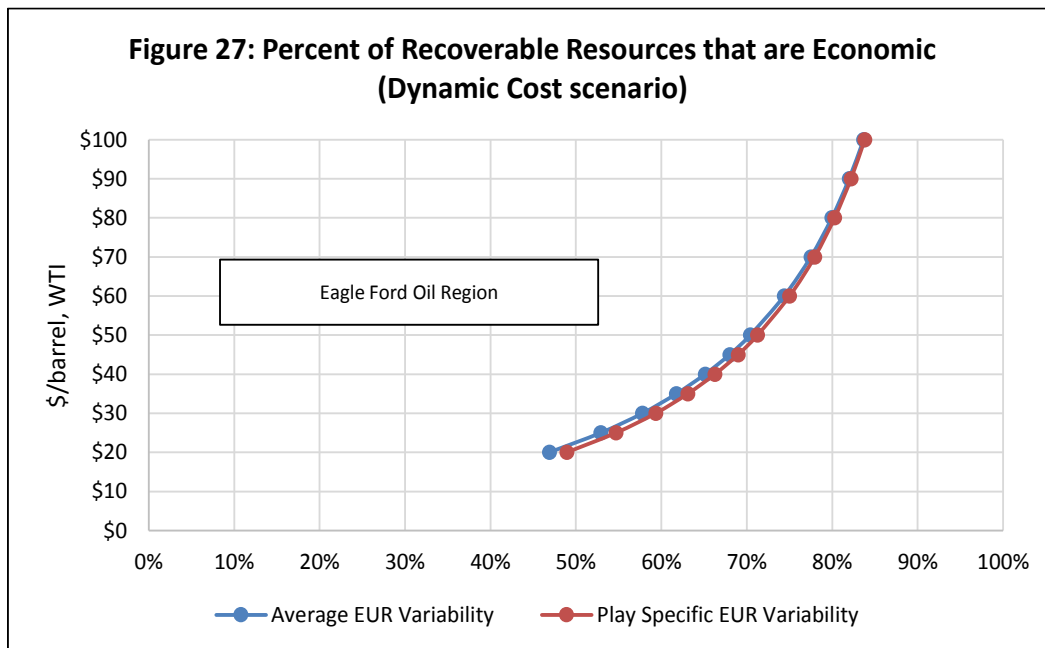


Source: Authors calculation.

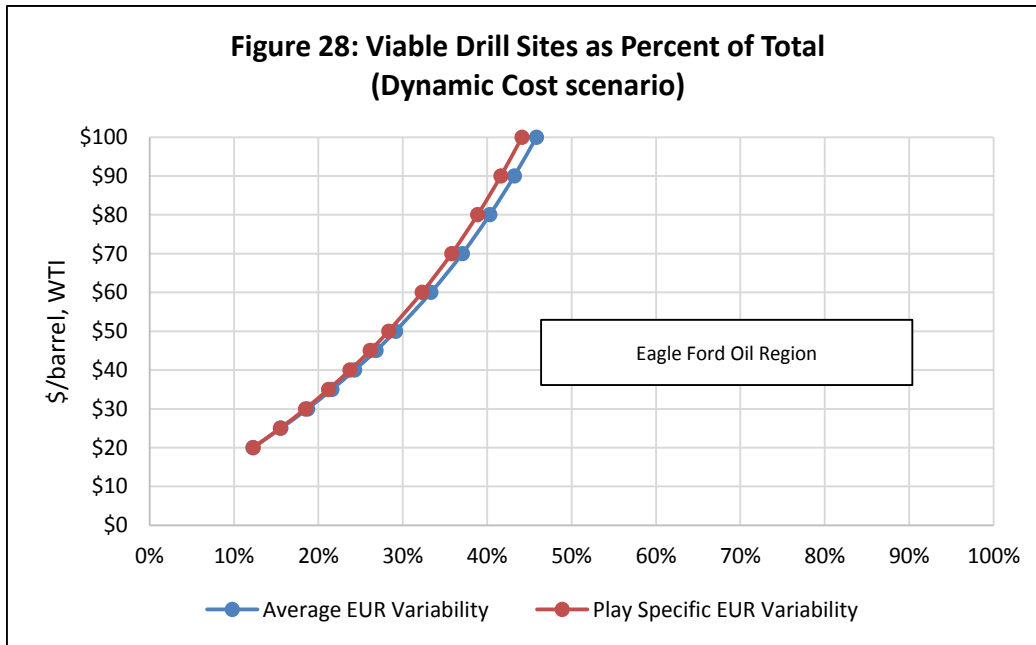


Source: Authors calculation.

For the record, we present the sensitivity analysis also for the Eagle Ford shale, but since the play-specific coefficient of variation there (1.620) is close to the overall average, the estimated supply curves of reserves and drill sites are hardly affected, as shown in Figures 27 and 28.

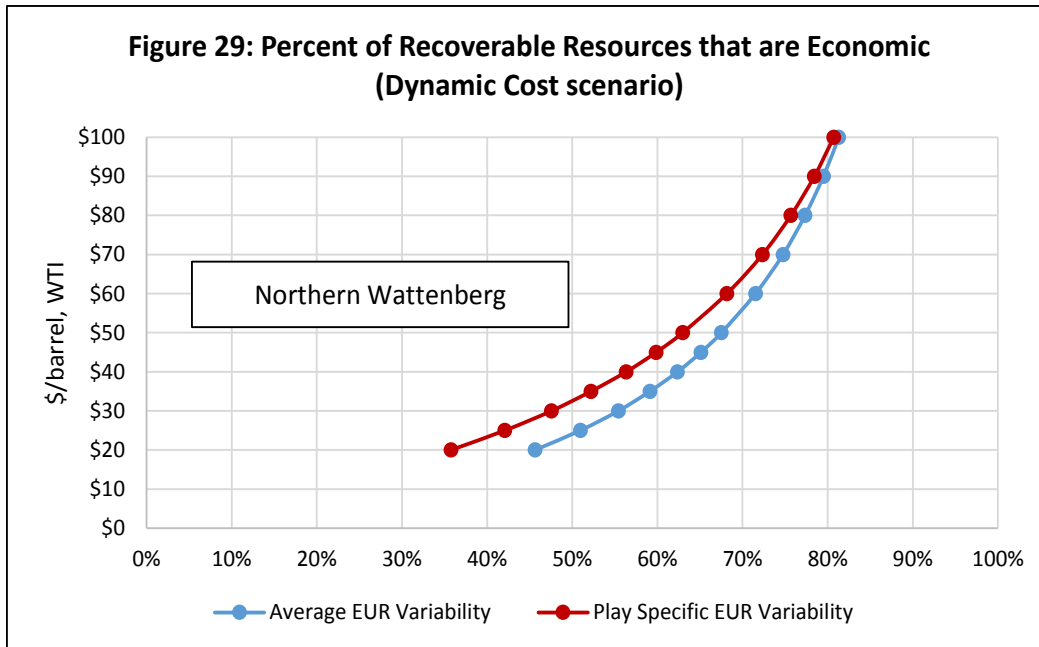


Source: Authors calculation.

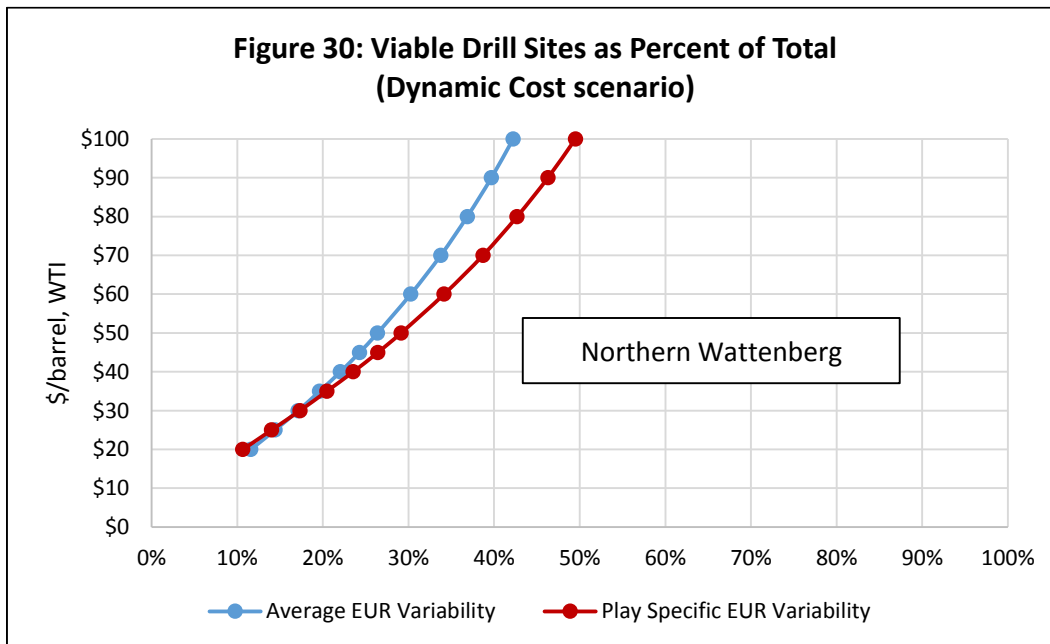


Source: Authors calculation.

Whereas the Anadarko-specific coefficient of variation was one-third higher than the overall average, in the Denver-Julesburg Basin it is one-third lower. This difference produces a less skewed distribution with higher median. The impact on the estimated supply curves, not surprisingly, runs in the opposite direction to the Anadarko, as shown in Figures 29 and 30 for the Northern Wattenberg play. At \$70, the estimated volume of reserves falls by 4% relative to our previous result; at \$30 it falls by 13%. The estimated number of viable drill sites is unaffected at \$30, but at \$70 it falls by 15% relative to our earlier results.



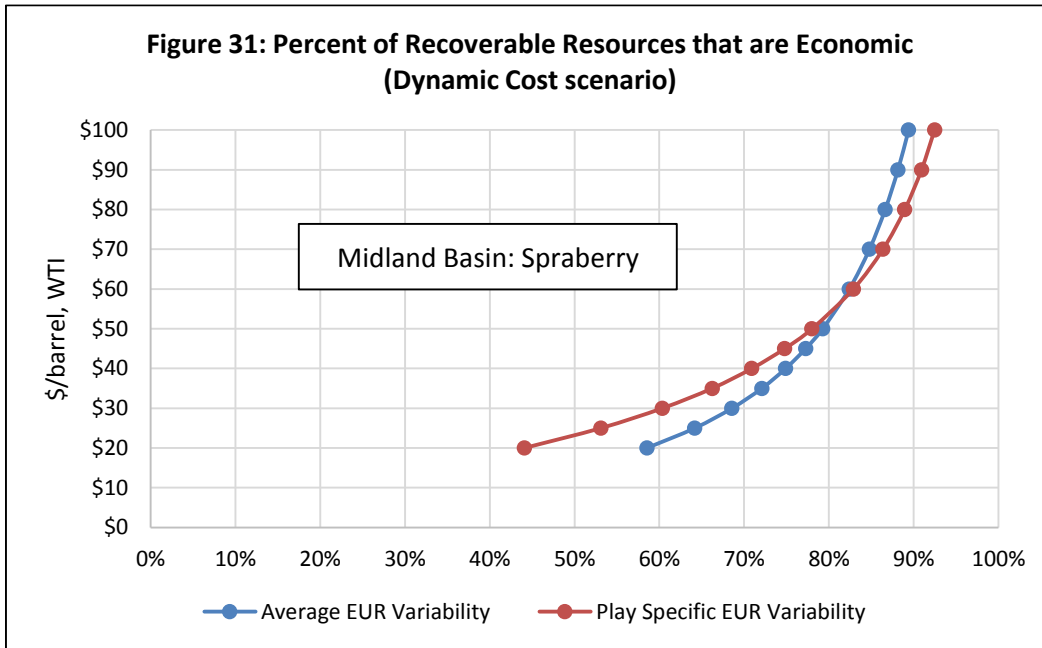
Sources: Authors calculation.



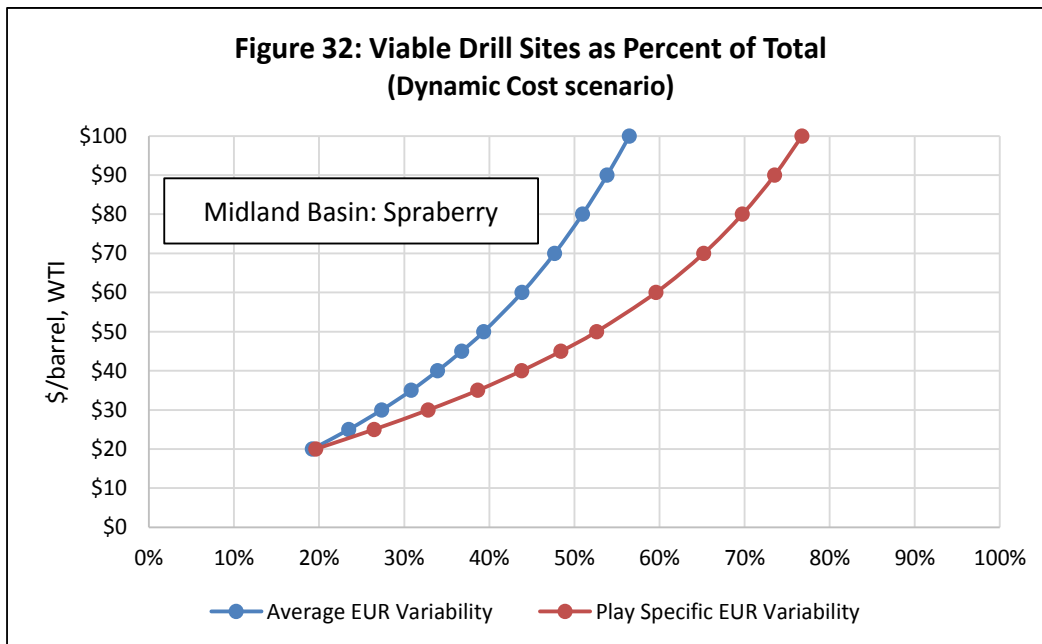
Source: Authors calculation

Last, we turn to the Permian Basin, where the play-specific coefficient of variation (0.805) is only about half the overall average (1.500). Here we find the largest impact relative to our earlier results. Inserting the lower coefficient of variation into the Midland Spraberry analysis leaves the estimated volume of reserves unchanged for an oil price of \$70, but causes it to fall by 13% relative to our earlier results at the \$30 level. The estimated number of viable well sites

is quite affected at all price levels: rising by 22% at the \$30 level, and by 35% at the \$70 level. The impact on estimated supply curves are illustrated in Figures 31 and 32.



Source: Authors calculation.



Source: Authors calculation.

6. Limitations of the Study and Suggestions for Further Research

Technology in the shale oil industry will continue to evolve. The industry is young and still discovering numerous innovations that may increase the productivity of individual wells. For example, recent experiments with extended reach laterals (see the “XL” designation appended to some of our play names) have increased the EUR of individual wells directly, by exposing the well bore to more of the resource. Although this innovation does not increase the total volume of technically recoverable resources within the play, it does reduce the density of wells and increases their average productivity.

If we may assume that such technical innovations increase the productivity of all potential drill sites in the play by the same proportion, then the standard deviation of EUR within the play would increase by the same percentage as the mean, but the coefficient of variation would remain constant. Our model is well able to incorporate the impact of this type of “neutral” technical change. One need only estimate the extent to which technological change has increased average productivity, update the parameters of the lognormal distribution to reflect this change, and repeat the analysis that has been outlined in this report.

Technical change may also change the cost of individual wells. Cost may rise (as in the case of extended laterals) or fall (due to enhanced efficiencies). In either case, the individual well economic model can accommodate these changes directly via a corresponding revision to the cost inputs.

Our knowledge of the variability of well productivity within a play is also likely to increase as the USGS continues with its series of geological assessments. Although we have indicated that moderate deviations from the “typical” coefficient of variation have relatively small impacts on our results, large deviations do appear to have a material impact, especially in a low-price environment. If more precise play-specific estimates of the coefficient of variation become available through the ongoing research of USGS, our analysis should be updated to incorporate them. Again, this type of updating can be accomplished directly, simply by substituting the new coefficients of variation in place of the old. The most recent USGS assessments may also shed further light on differences in average well productivity across plays, and that information could also be incorporated directly—although the rapid pace of technical change in this industry may cause the USGS estimates always to lag somewhat behind.

Apart from the USGS research program, it may also be possible to learn more about the variation in productivity across the population of potential drill sites within a given play applying particular statistical techniques to the subpopulation of existing wells. Estimates of the size distribution of conventional oil reservoirs have been developed based on the principle of “sampling without replacement and proportional to size.”¹⁸ Similar techniques could

¹⁸ See, for example, James L. Smith, “A Probabilistic Model of Oil Discovery,” *Review of Economics and Statistics*, November, 1980; and G. Andreatta and G. M. Kaufman, “Estimation of Finite Population Properties When Sampling is Without Replacement and Proportional to Magnitude,” *Journal of the American Statistical Association*, September 1986.

perhaps be applied to estimate the distribution of EUR from which existing shale oil wells were sampled—but this goes well beyond the scope of the present model.

References

- Addison, Velda (2016). "U.S. Tight Oil Wins on Lower Global Cost Curve," *E&P Magazine*, Harts Energy, July 13 (<http://www.epmag.com/report-us-tight-oil-wins-lower-global-cost-curve-1019126#p=full>).
- Agerton, Mark, Peter Hartley, Kenneth B. Medlock III, and Ted Temzelides (2015). "Employment Impacts of Upstream Oil and Gas Investment in the United States," working paper no. 15/28. Washington: International Monetary Fund.
- Aitchison, J. and A. C. Brown (1966). *The Lognormal Distribution*, Cambridge University Press.
- Allais, Maurice (1957). "Method of Appraising Economic Prospects of Mining Exploration over Large Territories: Algerian Sahara Case Study," *Management Science*, 3(4): 285-347.
- Anderson, Soren T., Ryan Kellogg, and Stephen W. Salant (2016). "Hotelling Under Pressure," *Journal of Political Economy*, forthcoming.
- Browning, John, et al. (2013a). "Study Develops Decline Analysis, Geologic Parameters for Reserves, Production Forecast," *Oil and Gas Journal*, August 5, pp. 62-73.
- Browning, John, et al. (2013b). "Barnett Study Determines Full-Field Reserves, Production Forecast," *Oil and Gas Journal*, September 2, pp. 88-95.
- Browning, John, et al. (2014). "Study Develops Fayetteville Shale Reserves, Production Forecast," *Oil and Gas Journal*, January 6, pp. 64-73.
- Browning, John, et al. (2015). "Study Forecasts Gradual Haynesville Production Recovery Before Final Decline," *Oil and Gas Journal*, December 7, pp. 64-71.
- Congressional Budget Office (2014). "The Economic and Budgetary Effects of Producing Oil and Natural Gas from Shale," Washington.
- Cook, Troy (2015). "The Resource Hierarchy Relationship," U.S. Energy Information Administration Working Paper Series, September 27.
- Covert, Thomas (2015). "Experiential and Social Learning in Firms: The Case of Hydraulic Fracturing in the Bakken Shale," Working Paper, Energy Policy Institute and Department of Economics, University of Chicago.
- Fitzgerald, Timothy (2015). "Experiential Gains with a New Technology: An Empirical Investigation of Hydraulic Fracturing," *Agricultural and Resource Economics Review*, 44(2): 83-105.
- Gaswirth, Stephanie, et al. (2016). "Assessment of undiscovered continuous oil resources in the Wolfcamp shale of the Midland Basin, Permian Basin Province, Texas, 2016," U.S.

Geological Survey Fact Sheet 2016–3092
(<https://pubs.er.usgs.gov/publication/fs20163092>).

- Hausman, Catherine and Ryan Kellogg (2015). “Welfare and Distributional Implications of Shale Gas,” *Brookings Papers on Economic Activity*, Spring.
- Ikonnikova, Svetlana, and Gürcan Gülen (2015). “Impact of Low Prices on Shale Gas Production Strategies,” *The Energy Journal*, vol. 36, Special Issue 1.
- Ikonnikova, Svetlana, et al. (2015). “Factors Influencing Shale Gas Production Forecasting: Empirical Studies of Barnett, Fayetteville, Haynesville, and Marcellus Shale Plays,” *Economics of Energy & Environmental Policy*, 4(1): 19-35.
- Kaufman, Gordon M., Y. Balcer, and D. Kruyt (1975). “A Probabilistic Model of Oil and Gas Discovery,” in (J.D. Haun, ed.), *Methods of Estimating the volume of Undiscovered Oil and Gas Resources*, (Studies in Geology No. 1), American Association of Petroleum Geologists, Tulsa, OK, pp. 113-142.
- Kellogg, Ryan (2011) “Learning by Drilling: Inter-Firm Learning and Relationship Persistence in the Texas Oilpatch,” *Quarterly Journal of Economics*, 26, pp. 1961-2004.
- Kilian, Lutz (2014a). “The Impact of the Shale Oil Revolution on U.S. Oil and Gasoline Prices,” working paper no. 499, Frankfurt, Germany: Center for Financial Studies.
- Kilian, Lutz (2014b). “Oil Price Shocks: Causes and Consequences,” *Annual Review of Resource Economics*, 6, pp. 133-154.
- Kleinberg, Robert L., Sergey Paltsev, Charles K. Ebinger, and David Hobbs (2016). “Tight Oil Development Economics: Benchmarks, Breakeven Points, and Inelasticities,” CEEPR WP 2016-012, Massachusetts Institute of Technology.
- Mason, Charles, Lucija Muehlenbachs, and Sheila Olmstead (2014). “The Economics of Shale Gas Development,” RFF Discussion Paper no. 14-42-REV. Washington: Resources for the Future.
- Newell, Richard G., and Daniel Raimi (2014). “Implications of Shale Gas Development for Climate Change,” *Environmental Science and Technology*, 48:15, pp. 8306-8308.
- Newell, Richard G., Brian C. Prest, and Ashley Vissing (2016). “Trophy Hunting vs. Manufacturing Energy: The Price Responsiveness of Shale Gas,” NBER Working Paper 22532, August, National Bureau of Economic Research.
- Oil & Gas 360 (2016). “Median Breakeven Price for Oil is \$55 per Barrel,” May 23
(<http://www.oilandgas360.com/median-breakeven-price-oil-55-per-barrel-gas-3-50-per-mcfe-klr/>).

- Osmundsen, Petter, Knut Einar Rosendahl, and Terje Skjerpen (2015). "Understanding Rig Rate Formation in the Gulf of Mexico," *Energy Economics*, 49, pp. 430-439.
- Petroleum Intelligence Weekly* (2015a). "Shale Producers Eye Risky Ramp-Up," April 27.
- Petroleum Intelligence Weekly* (2015b). "Pundits Skeptical Over Fresh Fall in Oil Prices," October 12.
- Petroleum Intelligence Weekly* (2016a). "Bankruptcies May Spell End for Some Shale Plays," February 1.
- Petroleum Intelligence Weekly* (2016b). "Have Operators Made Sustainable Cost Savings?" Sept. 12.
- Robinson, Joan (1941). "Rising Supply Price," *Economica*, 8(29): 1-8.
- Rystad Energy (2016). "Average Shale Wellhead Breakeven Prices are Below \$40/bbl.," Press Release, July 28 (<http://www.rystadenergy.com/NewsEvents/PressReleases/shale-well-breakeven>).
- Sheehan, Chris (2016). "Proppant: Secure or Scare?" *Oil and Gas Investor*, 36(9): 60-61.
- Simmons & Company International (2015). "U.S. Well Economics," Houston, TX, August.
- Smith, James L. and Geoffrey L. Ward (1981). "Maximum Likelihood Estimates of the Size Distribution of North Sea Oil Fields," *Mathematical Geology*, 13(5); 399-413.
- Toews, Gerhard, and Alexander Naumov (2015). "The Relationship Between Oil Price and Costs in the Oil Industry," *The Energy Journal*, 36(Special Issue 1): 237-254.
- U.S. Energy Information Administration (2015). "Assumptions to the Annual Energy Outlook 2015," September.
- U.S. Energy Information Administration (2016). "EIA Estimates of Drilled but Uncompleted Wells (DUCs)," September.
- U.S. Geological Survey (2012). "Variability of Distributions of Well-Scale Estimated Ultimate Recovery for Continuous (Unconventional) Oil and Gas Resources in the United States," Open-File Report 2012-1118, U.S. Department of the Interior.
- U.S. Geological Survey (2013). "Assessment of Undiscovered Oil Resources in the Bakken and Three Forks Formations, Williston Basin Province, Montana, North Dakota, and South Dakota, 2013," Fact Sheet 2013-3013, April.

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Midland Basin Spraberry

Midland Basin: Spraberry				My Assumptions:	
Basin Characteristics		Average Well		100% oilfield service & supply factor price scalar	
\$6.50 cost/well (\$mm)	IP	EUR	30	days/month	
529 EUR/well (mboe)	825	753	-1.03%	exponential decline rate after year 3 (monthly)	
-65% 1st yr decline	-8.4%	286	\$50.00	oil price WTI (\$/bbl)	
-37% 2nd yr decline	-3.8%	179	0%	oil price appreciation (per month)	
-24% 3rd yr decline	-2.3%	156	\$3.50	gas price Henry Hub (\$/mcf)	
580 IP rate (boe/d)			0%	gas price appreciation	
\$7.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)	
76% oil			0.68%	discount rate (compound monthly)	
12% gas			8.5%	discount rate (annual)	
12% NGL			80%	intangible drilling cost / total capex	
20.0% royalty rate			1.09%	IP/EUR ratio, (B8/B4 = fixed ratio)	
4.6% oil prod tax					
7.5% gas prod tax					
7.5% NGL prod tax					
35.0% income tax rate					
-5% oil differential					
-5% gas differential					
0 1 = DUC					
25% auxiliary cost/well cost					
50% completion cost/well cost					
\$2,000 min opex (\$/month)					

Results	
-50.004	= NPV/well (\$ million)
0	= EUR check (mboe)
0.68%	= ATIRR (monthly)
8.48%	= ATIRR (annual)
529	= total production (mboe)
\$3.081	= "tail end" NPV/well (\$ million)
100%	= "tail end" recovery factor
0	= months of lost production

Midland Basin: Spraberry					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	1,981	2,170	983	1,077	
\$25	1,359	1,489	675	740	
\$30	1,034	1,133	514	563	
\$35	835	915	415	455	
\$40	700	767	349	382	
\$45	603	661	300	329	
\$50	529	580	264	289	
\$60	426	467	212	232	
\$70	356	390	178	195	
\$80	306	335	153	168	
\$90	268	294	134	147	
\$100	239	262	120	131	

Midland Basin: Spraberry					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	4,161	4,559	2065	2,262	
\$25	2,416	2,647	1199	1,314	
\$30	1,702	1,865	845	926	
\$35	1,314	1,440	652	714	
\$40	1,070	1,172	531	582	
\$45	902	988	448	491	
\$50	780	855	388	425	
\$60	614	673	305	334	
\$70	506	554	252	276	
\$80	430	471	214	234	
\$90	375	411	187	205	
\$100	332	364	165	181	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)								ATNPV -\$4	Active 1/0				
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex			Depreciation	Tax. Inc.	Income Tax	NCF
1	\$1,625	\$406					417	\$47.50	\$14.25	\$3.33	\$627.687	\$41.626	\$29.733	\$139.81	\$23.10	\$2.50	\$1.78	\$121.712	\$13.542	\$396.602	\$138.811	\$271.333	0.973	\$264.054	1
2	\$1,625	\$406					382	\$47.50	\$14.25	\$3.33	\$574.649	\$38.108	\$27.220	\$127.995	\$21.147	\$2.286	\$1.633	\$111.428	\$13.542	\$361.946	\$126.681	\$248.806	0.967	\$240.491	1
3	\$1,625	\$406					350	\$47.50	\$14.25	\$3.33	\$526.092	\$34.888	\$24.920	\$117.180	\$19.360	\$2.093	\$1.495	\$102.012	\$13.542	\$330.218	\$115.576	\$228.183	0.960	\$219.063	1
4	\$1,625	\$406					320	\$47.50	\$14.25	\$3.33	\$481.638	\$31.940	\$22.814	\$107.279	\$17.724	\$1.916	\$1.369	\$93.392	\$13.542	\$301.171	\$105.410	\$209.303	0.954	\$199.576	1
5			580	440	70	70	417	\$47.50	\$14.25	\$3.33	\$440.941	\$29.241	\$20.887	\$98.214	\$16.227	\$1.754	\$1.253	\$85.501	\$13.542	\$274.578	\$96.102	\$192.018	0.947	\$181.853	1
6			531	403	64	64	382	\$47.50	\$14.25	\$3.33	\$403.682	\$26.771	\$19.122	\$89.915	\$14.856	\$1.606	\$1.147	\$78.276	\$13.542	\$250.233	\$87.581	\$176.193	0.941	\$165.736	1
7			486	369	58	58	350	\$47.50	\$14.25	\$3.33	\$369.572	\$24.508	\$17.506	\$82.317	\$13.600	\$1.471	\$1.050	\$71.662	\$13.542	\$227.944	\$79.781	\$161.705	0.934	\$151.078	1
8			445	338	53	53	320	\$47.50	\$14.25	\$3.33	\$338.344	\$22.438	\$16.027	\$75.362	\$12.451	\$1.346	\$0.962	\$65.607	\$13.542	\$207.539	\$72.639	\$148.442	0.928	\$137.746	1
9			407	309	49	49	293	\$47.50	\$14.25	\$3.33	\$309.755	\$20.542	\$14.673	\$68.994	\$11.399	\$1.232	\$0.880	\$60.063	\$13.542	\$188.858	\$66.100	\$136.300	0.922	\$125.622	1
10			373	283	45	45	268	\$47.50	\$14.25	\$3.33	\$283.581	\$18.806	\$13.433	\$63.164	\$10.436	\$1.128	\$0.806	\$54.988	\$13.542	\$171.756	\$60.115	\$125.183	0.915	\$114.594	1
11			341	259	41	41	246	\$47.50	\$14.25	\$3.33	\$259.619	\$17.217	\$12.298	\$57.827	\$9.554	\$1.033	\$0.738	\$50.342	\$13.542	\$156.099	\$54.635	\$115.006	0.909	\$104.565	1
12			312	237	37	37	225	\$47.50	\$14.25	\$3.33	\$237.682	\$15.762	\$11.259	\$52.940	\$8.747	\$0.946	\$0.676	\$46.088	\$13.542	\$141.764	\$49.618	\$105.689	0.903	\$95.442	1
13			286	217	34	34	206	\$47.50	\$14.25	\$3.33	\$228.579	\$15.158	\$10.827	\$50.913	\$8.412	\$0.910	\$0.650	\$44.323	\$13.542	\$135.817	\$47.536	\$101.822	0.897	\$91.328	1
14			262	199	31	31	189	\$47.50	\$14.25	\$3.33	\$219.825	\$14.578	\$10.413	\$48.963	\$8.090	\$0.875	\$0.625	\$42.625	\$13.542	\$130.096	\$45.534	\$98.104	0.891	\$87.397	1
15			240	182	29	29	173	\$47.50	\$14.25	\$3.33	\$211.406	\$14.020	\$10.014	\$47.088	\$7.780	\$0.841	\$0.601	\$40.993	\$13.542	\$124.595	\$43.608	\$94.529	0.885	\$83.641	1
16			219	167	26	26	158	\$47.50	\$14.25	\$3.33	\$203.310	\$13.483	\$9.630	\$45.285	\$7.482	\$0.809	\$0.578	\$39.423	\$13.542	\$119.305	\$41.757	\$91.090	0.879	\$80.052	1
17			211	160	25	25	152	\$47.50	\$14.25	\$3.33	\$195.523	\$12.966	\$9.262	\$43.550	\$7.195	\$0.778	\$0.556	\$37.913	\$13.542	\$114.217	\$39.976	\$87.783	0.873	\$76.623	1
18			203	154	24	24	146	\$47.50	\$14.25	\$3.33	\$188.035	\$12.470	\$8.907	\$41.882	\$6.920	\$0.748	\$0.534	\$36.461	\$13.542	\$109.324	\$38.264	\$84.603	0.867	\$73.347	1
19			181	137	22	22	130	\$47.50	\$14.25	\$3.33	\$180.834	\$11.992	\$8.566	\$40.278	\$6.655	\$0.720	\$0.514	\$35.065	\$13.542	\$104.619	\$36.617	\$81.544	0.861	\$70.216	1
20			188	143	23	23	135	\$47.50	\$14.25	\$3.33	\$173.908	\$11.533	\$8.238	\$38.736	\$6.400	\$0.692	\$0.494	\$33.722	\$13.542	\$100.094	\$35.033	\$78.603	0.855	\$67.225	1
21			181	137	22	22	130	\$47.50	\$14.25	\$3.33	\$167.248	\$11.091	\$7.922	\$37.252	\$6.155	\$0.665	\$0.475	\$32.430	\$13.542	\$95.742	\$33.510	\$75.774	0.849	\$64.366	1
22			174	132	21	21	125	\$47.50	\$14.25	\$3.33	\$160.843	\$10.666	\$7.619	\$35.826	\$5.919	\$0.640	\$0.457	\$31.188	\$13.542	\$91.556	\$32.045	\$73.053	0.844	\$61.635	1
23			167	127	20	20	120	\$47.50	\$14.25	\$3.33	\$154.683	\$10.258	\$7.327	\$34.454	\$5.692	\$0.615	\$0.440	\$29.994	\$13.542	\$87.531	\$30.636	\$70.347	0.838	\$59.025	1
24			161	122	19	19	116	\$47.50	\$14.25	\$3.33	\$148.759	\$9.865	\$7.046	\$33.134	\$5.474	\$0.592	\$0.423	\$28.845	\$13.542	\$83.660	\$29.281	\$67.921	0.832	\$56.531	1
25			154	117	19	19	111	\$47.50	\$14.25	\$3.33	\$145.388	\$9.642	\$6.887	\$32.383	\$5.350	\$0.578	\$0.413	\$28.192	\$13.542	\$81.458	\$28.510	\$66.489	0.827	\$54.964	1
26			149	113	18	18	107	\$47.50	\$14.25	\$3.33	\$142.093	\$9.423	\$6.731	\$31.649	\$5.229	\$0.565	\$0.404	\$27.553	\$13.542	\$79.305	\$27.757	\$65.090	0.821	\$53.443	1
27			143	109	17	17	103	\$47.50	\$14.25	\$3.33	\$138.873	\$9.209	\$6.578	\$30.932	\$5.111	\$0.553	\$0.395	\$26.928	\$13.542	\$77.201	\$27.020	\$63.722	0.816	\$51.966	1
28			137	104	16	16	99	\$47.50	\$14.25	\$3.33	\$135.726	\$9.001	\$6.429	\$30.231	\$4.995	\$0.540	\$0.386	\$26.318	\$13.542	\$75.145	\$26.301	\$62.386	0.810	\$50.531	1
29			134	102	16	16	97	\$47.50	\$14.25	\$3.33	\$132.651	\$8.797	\$6.283	\$29.546	\$4.882	\$0.528	\$0.377	\$25.722	\$13.542	\$73.135	\$25.597	\$61.079	0.804	\$49.138	1
30			131	100	16	16	94	\$47.50	\$14.25	\$3.33	\$129.645	\$8.597	\$6.141	\$28.877	\$4.771	\$0.516	\$0.368	\$25.139	\$13.542	\$71.171	\$24.910	\$59.803	0.799	\$47.785	1
31			128	97	15	15	92	\$47.50	\$14.25	\$3.33	\$126.707	\$8.403	\$6.002	\$28.222	\$4.663	\$0.504	\$0.360	\$24.569	\$13.542	\$69.251	\$24.238	\$58.555	0.794	\$46.471	1
32			125	95	15	15	90	\$47.50	\$14.25	\$3.33	\$123.835	\$8.212	\$5.866	\$27.583	\$4.557	\$0.493	\$0.352	\$24.012	\$13.542	\$67.375	\$23.581	\$57.335	0.788	\$45.195	1
33			122	93	15	15	88	\$47.50	\$14.25	\$3.33	\$121.029	\$8.026	\$5.733	\$26.958	\$4.454	\$0.482	\$0.344	\$23.468	\$13.542	\$65.541	\$22.939	\$56.144	0.783	\$43.955	1
34			120	91	14	14	86	\$47.50	\$14.25	\$3.33	\$118.287	\$7.844	\$5.603	\$26.347	\$4.353	\$0.471	\$0.336	\$22.936	\$13.542	\$63.749	\$22.312	\$54.979	0.778	\$42.752	1
35			117	89	14	14	84	\$47.50	\$14.25	\$3.33	\$115.606	\$7.667	\$5.476	\$25.750	\$4.254	\$0.460	\$0.329	\$22.417	\$13.542	\$61.998	\$21.699	\$53.840	0.772	\$41.583	1
36			114	87	14	14	82	\$47.50	\$14.25</																

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Northern Delaware Bone Spring

Northern Delaware Basin: Bone Springs				My Assumptions:			
Basin Characteristics		Average Well		100% oilfield service & supply factor price scalar			
\$6.50 cost/well (\$mm)	IP	EUR	EUR	30	days/month		
100 EUR/well (mboe)	1,000	676	-1.30%	exponential decline rate after year 3 (monthly)			
-70% 1st yr decline	-9.5%	300	\$20.00	oil price WTI (\$/bbl)			
-47% 2nd yr decline	-5.2%	158	0%	oil price appreciation (per month)			
-20% 3rd yr decline	-1.8%	142	\$3.50	gas price Henry Hub (\$/mcf)			
148 IP rate (boe/d)			0%	gas price appreciation			
\$7.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
60% oil			0.68%	discount rate (compound monthly)			
20% gas			8.5%	discount rate (annual)			
20% NGL			80%	intangible drilling cost / total capex			
20.0% royalty rate			1.479	IP/EUR ratio, (B8/B4 = fixed ratio)			
3.8% oil prod tax							
3.8% gas prod tax							
3.8% NGL prod tax							
35.0% income tax rate							
-6% oil differential							
-6% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Northern Delaware Basin: Bone Springs					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,067	3,058	1,027	1,519	
\$25	1,448	2,142	720	1,065	
\$30	1,115	1,649	555	821	
\$35	907	1,342	451	667	
\$40	764	1,130	380	562	
\$45	660	976	329	487	
\$50	581	859	290	429	
\$60	469	694	234	346	
\$70	393	581	196	290	
\$80	338	500	169	250	
\$90	297	439	149	220	
\$100	265	392	133	197	

Northern Delaware Basin: Bone Springs					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	4,686	6,932	2326	3,441	
\$25	2,711	4,010	1346	1,991	
\$30	1,907	2,821	947	1,401	
\$35	1,471	2,176	731	1,081	
\$40	1,198	1,772	595	880	
\$45	1,010	1,494	502	743	
\$50	873	1,291	434	642	
\$60	687	1,016	342	506	
\$70	566	837	282	417	
\$80	482	713	240	355	
\$90	419	620	209	309	
\$100	371	549	185	274	

Per Well Net Cash Flow Analysis		Production (boe/d)				Prices			Cash Flows (\$1,000)										AT NPV	Active					
Month	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	mcf/d	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax	NCF	PV Factor	AT NPV	1/0
1	\$1,625	\$406						\$18.80	\$5.64	\$3.29	\$18.80	\$5.64	\$3.29					\$1,625.000	\$1,625.000	-\$1,625.00	-\$568.750	-1.463	1.000	-\$1,462.50	
2	\$1,625	\$406						\$18.80	\$5.64	\$3.29	\$18.80	\$5.64	\$3.29					\$1,625.000	\$1,625.000	-\$1,625.00	-\$568.750	-1.463	0.993	-\$1,452.59	
3	\$1,625	\$406						\$18.80	\$5.64	\$3.29	\$18.80	\$5.64	\$3.29					\$1,625.000	\$1,625.000	-\$1,625.00	-\$568.750	-1.463	0.986	-\$1,442.75	
4	\$1,625	\$406						\$18.80	\$5.64	\$3.29	\$18.80	\$5.64	\$3.29					\$1,625.000	\$1,625.000	-\$1,625.00	-\$568.750	-1.463	0.980	-\$1,432.97	
5			148	89	30	30	178	\$18.80	\$5.64	\$3.29	\$50.059	\$17.521	\$5.006	\$14.52	\$1.52	\$0.53	\$0.15	\$31.065	\$13.542	\$11.255	\$3.939	\$20.858	0.973	\$20.298	1
6			134	80	27	27	161	\$18.80	\$5.64	\$3.29	\$45.280	\$15.848	\$4.528	\$13.131	\$1.377	\$0.482	\$0.138	\$28.100	\$13.542	\$8.888	\$3.111	\$19.319	0.967	\$18.673	1
7			121	73	24	24	145	\$18.80	\$5.64	\$3.29	\$40.958	\$14.335	\$4.096	\$11.878	\$1.245	\$0.436	\$0.125	\$25.417	\$13.542	\$6.747	\$2.361	\$17.927	0.960	\$17.211	1
8			109	66	22	22	131	\$18.80	\$5.64	\$3.29	\$37.048	\$12.967	\$3.705	\$10.744	\$1.126	\$0.394	\$0.113	\$22.991	\$13.542	\$4.810	\$1.684	\$16.668	0.954	\$15.894	1
9			99	59	20	20	119	\$18.80	\$5.64	\$3.29	\$33.511	\$11.729	\$3.351	\$9.718	\$1.019	\$0.357	\$0.102	\$20.796	\$13.542	\$3.058	\$1.070	\$15.530	0.947	\$14.707	1
10			90	54	18	18	107	\$18.80	\$5.64	\$3.29	\$30.312	\$10.609	\$3.031	\$8.791	\$0.921	\$0.323	\$0.092	\$18.811	\$13.542	\$1.474	\$0.516	\$14.499	0.941	\$13.639	1
11			81	49	16	16	97	\$18.80	\$5.64	\$3.29	\$27.419	\$9.596	\$2.742	\$7.951	\$0.834	\$0.292	\$0.083	\$17.015	\$13.542	\$0.040	\$0.014	\$13.568	0.934	\$12.676	1
12			73	44	15	15	88	\$18.80	\$5.64	\$3.29	\$24.801	\$8.680	\$2.480	\$7.192	\$0.754	\$0.264	\$0.075	\$15.391	\$13.542	-\$1.256	-\$0.440	\$12.725	0.928	\$11.808	1
13			66	40	13	13	80	\$18.80	\$5.64	\$3.29	\$22.434	\$7.852	\$2.243	\$6.506	\$0.682	\$0.239	\$0.068	\$13.922	\$13.542	-\$2.429	-\$0.850	\$11.963	0.922	\$11.026	1
14			60	36	12	12	72	\$18.80	\$5.64	\$3.29	\$20.292	\$7.102	\$2.029	\$5.885	\$0.617	\$0.216	\$0.062	\$12.593	\$13.542	-\$3.490	-\$1.221	\$11.273	0.915	\$10.320	1
15			54	33	11	11	65	\$18.80	\$5.64	\$3.29	\$18.355	\$6.424	\$1.835	\$5.323	\$0.558	\$0.195	\$0.056	\$11.390	\$13.542	-\$4.450	-\$1.557	\$10.649	0.909	\$9.683	1
16			49	29	10	10	59	\$18.80	\$5.64	\$3.29	\$16.603	\$5.811	\$1.660	\$4.815	\$0.505	\$0.177	\$0.050	\$10.303	\$13.542	-\$5.317	-\$1.861	\$10.085	0.903	\$9.108	1
17			47	28	9	9	56	\$18.80	\$5.64	\$3.29	\$15.742	\$5.510	\$1.574	\$4.565	\$0.479	\$0.167	\$0.048	\$9.769	\$13.542	-\$5.744	-\$2.010	\$9.808	0.897	\$8.797	1
18			44	26	9	9	53	\$18.80	\$5.64	\$3.29	\$14.925	\$5.224	\$1.493	\$4.328	\$0.454	\$0.159	\$0.045	\$9.262	\$13.542	-\$6.148	-\$2.152	\$9.545	0.891	\$8.503	1
19			42	25	8	8	50	\$18.80	\$5.64	\$3.29	\$14.151	\$4.953	\$1.415	\$4.104	\$0.430	\$0.151	\$0.043	\$8.782	\$13.542	-\$6.532	-\$2.286	\$9.296	0.885	\$8.225	1
20			40	24	8	8	48	\$18.80	\$5.64	\$3.29	\$13.417	\$4.696	\$1.342	\$3.891	\$0.408	\$0.143	\$0.041	\$8.326	\$13.542	-\$6.895	-\$2.413	\$9.060	0.879	\$7.962	1
21			38	23	8	8	45	\$18.80	\$5.64	\$3.29	\$12.721	\$4.452	\$1.272	\$3.689	\$0.387	\$0.135	\$0.039	\$7.894	\$13.542	-\$7.240	-\$2.534	\$8.836	0.873	\$7.712	1
22			36	21	7	7	43	\$18.80	\$5.64	\$3.29	\$12.061	\$4.222	\$1.206	\$3.498	\$0.367	\$0.128	\$0.037	\$7.485	\$13.542	-\$7.567	-\$2.648	\$8.623	0.867	\$7.476	1
23			34	20	7	7	41	\$18.80	\$5.64	\$3.29	\$11.436	\$4.003	\$1.144	\$3.316	\$0.348	\$0.122	\$0.035	\$7.097	\$13.542	-\$7.877	-\$2.757	\$8.422	0.861	\$7.252	1
24			32	19	6	6	38	\$18.80	\$5.64	\$3.29	\$10.843	\$3.795	\$1.084	\$3.144	\$0.330	\$0.115	\$0.033	\$6.729	\$13.542	-\$8.171	-\$2.860	\$8.231	0.855	\$7.039	1
25			30	18	6	6	36	\$18.80	\$5.64	\$3.29	\$10.280	\$3.598	\$1.028	\$2.981	\$0.313	\$0.109	\$0.031	\$6.380	\$13.542	-\$8.449	-\$2.957	\$8.050	0.849	\$6.838	1
26			29	17	6	6	35	\$18.80	\$5.64	\$3.29	\$9.747	\$3.412	\$0.975	\$2.827	\$0.296	\$0.104	\$0.030	\$6.049	\$13.542	-\$8.713	-\$3.050	\$7.878	0.844	\$6.647	1
27			27	16	5	5	33	\$18.80	\$5.64	\$3.29	\$9.242	\$3.235	\$0.924	\$2.680	\$0.281	\$0.098	\$0.028	\$5.735	\$13.542	-\$8.964	-\$3.137	\$7.715	0.838	\$6.465	1
28			26	16	5	5	31	\$18.80	\$5.64	\$3.29	\$8.762	\$3.067	\$0.876	\$2.541	\$0.266	\$0.093	\$0.027	\$5.438	\$13.542	-\$9.201	-\$3.220	\$7.561	0.832	\$6.293	1
29			25	15	5	5	31	\$18.80	\$5.64	\$3.29	\$8.601	\$3.011	\$0.860	\$2.494	\$0.261	\$0.092	\$0.026	\$5.338	\$13.542	-\$9.281	-\$3.248	\$7.509	0.827	\$6.208	1
30			25	15	5	5	30	\$18.80	\$5.64	\$3.29	\$8.444	\$2.955	\$0.844	\$2.449	\$0.257	\$0.090	\$0.026	\$5.240	\$13.542	-\$9.359	-\$3.276	\$7.458	0.821	\$6.124	1
31			24	15	5	5	29	\$18.80	\$5.64	\$3.29	\$8.289	\$2.901	\$0.829	\$2.404	\$0.252	\$0.088	\$0.025	\$5.144	\$13.542	-\$9.436	-\$3.303	\$7.408	0.816	\$6.042	1
32			24	14	5	5	29	\$18.80	\$5.64	\$3.29	\$8.136	\$2.848	\$0.814	\$2.360	\$0.247	\$0.087	\$0.025	\$5.049	\$13.542	-\$9.511	-\$3.329	\$7.359	0.810	\$5.961	1
33			24	14	5	5	28	\$18.80	\$5.64	\$3.29	\$7.987	\$2.795	\$0.799	\$2.316	\$0.243	\$0.085	\$0.024	\$4.956	\$13.542	-\$9.585	-\$3.355	\$7.311	0.804	\$5.882	1
34			23	14	5	5	28	\$18.80	\$5.64	\$3.29	\$7.840	\$2.744	\$0.784	\$2.274	\$0.238	\$0.083	\$0.024	\$4.865	\$13.542	-\$9.658	-\$3.380	\$7.264	0.799	\$5.804	1
35			23	14	5	5	27	\$18.80	\$5.64	\$3.29	\$7.696	\$2.694	\$0.770	\$2.232	\$0.234	\$0.082	\$0.023	\$4.776	\$13.542	-\$9.729	-\$3.405	\$7.218	0.794	\$5.728	1
36			22	13	4	4	27	\$18.80	\$5.64	\$3.29	\$7.555	\$2.644	\$0.756	\$2.191	\$0.230	\$0.080	\$0.023	\$4.688	\$13.542	-\$9.799	-\$3.430	\$7.172	0.788	\$5.653	1
37			22	13	4	4	26	\$18.80	\$5.64	\$3.29	\$7.416	\$2.596	\$0.742	\$2.151	\$0.225	\$0.079	\$0.023	\$4.602	\$13.542	-\$9.868	-\$3.454	\$7.128	0.783	\$5.580	1
38			22	13	4	4	26	\$18.80	\$5.64	\$3.29	\$7.280	\$2.548	\$0.728	\$2.111	\$0.221	\$0.077	\$0.022	\$4.518	\$13.542	-\$9.935	-\$3.477	\$7.084	0.778	\$5.508	1
39			21	13	4	4	25	\$18.80	\$5.64	\$3.29	\$7.147	\$2.501	\$0.715	\$2.073	\$0.217	\$0.076	\$0.022	\$4.435	\$13.542	-\$10.002	-\$3.501	\$7.041	0.772	\$5.438	1
40			21	13	4	4	25	\$18.80	\$5.64	\$3.29	\$7.015	\$2.455	\$0.702	\$2.034	\$0.213	\$0.075	\$0.021								

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Southern Delaware Wolfcamp

Southern Delaware Basin: Wolfcamp				My Assumptions:			
Basin Characteristics		Average Well		100% oilfield service & supply factor price scalar			
\$7.80 cost/well (\$mm)	IP	EUR	30	days/month			
251 EUR/well (mboe)	1,100	883	-0.98%	exponential decline rate after year 3 (monthly)			
-67% 1st yr decline	-8.8%	364	\$100.00	oil price WTI (\$/bbl)			
-35% 2nd yr decline	-3.5%	236	0%	oil price appreciation (per month)			
-41% 3rd yr decline	-4.2%	182	\$3.50	gas price Henry Hub (\$/mcf)			
312 IP rate (boe/d)			0%	gas price appreciation			
\$7.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
55% oil			0.68%	discount rate (compound monthly)			
25% gas			8.5%	discount rate (annual)			
20% NGL			80%	intangible drilling cost / total capex			
20.0% royalty rate			1.246	IP/EUR ratio, (B8/B4 = fixed ratio)			
3.8% oil prod tax							
3.8% gas prod tax							
3.8% NGL prod tax							
35.0% income tax rate							
-6% oil differential							
-6% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Southern Delaware Basin: Wolfcamp					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,601	3,240	1,291	1,608	
\$25	1,868	2,327	927	1,155	
\$30	1,458	1,816	724	902	
\$35	1,195	1,489	594	740	
\$40	1,012	1,261	503	627	
\$45	878	1,094	437	544	
\$50	776	967	386	481	
\$60	629	784	313	390	
\$70	529	659	263	328	
\$80	456	568	227	283	
\$90	401	500	200	249	
\$100	358	446	179	223	

Southern Delaware Basin: Wolfcamp					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	5,872	7,315	2914	3,630	
\$25	3,525	4,391	1750	2,180	
\$30	2,518	3,137	1250	1,557	
\$35	1,959	2,440	972	1,211	
\$40	1,603	1,997	796	992	
\$45	1,356	1,689	673	838	
\$50	1,175	1,464	584	728	
\$60	928	1,156	461	574	
\$70	767	955	381	475	
\$80	653	813	325	405	
\$90	569	709	283	353	
\$100	504	628	251	313	

Results	
-\$1.955 = NPV/well (\$ million)	
0 = EUR check (mboe)	
-0.05% = ATIRR (monthly)	
0.58% = ATIRR (annual)	
251 = total production (mboe)	
\$2.427 = "tail end" NPV/well (\$ million)	
100% = "tail end" recovery factor	
0 = months of lost production	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)						ATNPV	Active						
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax			NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax	NCF
1	\$1,950	\$488						\$94.00	\$28.20	\$3.29	\$484.347	\$46.233	\$52.838	\$116.68	\$14.72	\$1.41	\$1.61	\$65.579	\$16.250	\$367.170	\$128.509	\$254.910	0.973	\$248.072	1
2	\$1,950	\$488						\$94.00	\$28.20	\$3.29	\$441.705	\$42.163	\$48.186	\$106.411	\$13.428	\$1.282	\$1.465	\$59.805	\$16.250	\$333.413	\$116.695	\$232.969	0.967	\$225.183	1
3	\$1,950	\$488						\$94.00	\$28.20	\$3.29	\$402.817	\$38.451	\$43.944	\$97.042	\$12.246	\$1.169	\$1.336	\$54.540	\$16.250	\$302.629	\$105.920	\$212.599	0.960	\$204.447	1
4	\$1,950	\$488						\$94.00	\$28.20	\$3.29	\$367.353	\$35.066	\$40.075	\$88.499	\$11.168	\$1.066	\$1.218	\$49.738	\$16.250	\$274.555	\$96.094	\$194.711	0.954	\$185.662	1
5			312	172	62	78	468	\$94.00	\$28.20	\$3.29	\$335.011	\$31.978	\$36.547	\$80.707	\$10.184	\$0.972	\$1.111	\$45.359	\$16.250	\$248.952	\$87.133	\$178.609	0.947	\$168.643	1
6			285	157	57	71	427	\$94.00	\$28.20	\$3.29	\$305.517	\$29.163	\$33.329	\$73.602	\$9.288	\$0.887	\$1.013	\$41.366	\$16.250	\$225.604	\$78.961	\$162.892	0.941	\$153.225	1
7			260	143	52	65	390	\$94.00	\$28.20	\$3.29	\$278.619	\$26.595	\$30.395	\$67.122	\$8.470	\$0.809	\$0.924	\$37.724	\$16.250	\$204.311	\$71.509	\$149.052	0.934	\$139.256	1
8			237	130	47	59	355	\$94.00	\$28.20	\$3.29	\$254.090	\$24.254	\$27.719	\$61.212	\$7.724	\$0.737	\$0.843	\$34.403	\$16.250	\$184.893	\$64.712	\$136.430	0.928	\$126.600	1
9			216	119	43	54	324	\$94.00	\$28.20	\$3.29	\$231.719	\$22.119	\$25.278	\$55.823	\$7.044	\$0.672	\$0.768	\$31.374	\$16.250	\$167.184	\$58.514	\$124.920	0.922	\$115.133	1
10			197	108	39	49	295	\$94.00	\$28.20	\$3.29	\$211.319	\$20.171	\$23.053	\$50.909	\$6.424	\$0.613	\$0.701	\$28.612	\$16.250	\$151.035	\$52.862	\$114.422	0.915	\$104.744	1
11			180	99	36	45	269	\$94.00	\$28.20	\$3.29	\$192.714	\$18.395	\$21.023	\$46.427	\$5.859	\$0.559	\$0.639	\$26.093	\$16.250	\$136.307	\$47.707	\$104.849	0.909	\$95.330	1
12			164	90	33	41	246	\$94.00	\$28.20	\$3.29	\$175.748	\$16.776	\$19.172	\$42.339	\$5.343	\$0.510	\$0.583	\$23.796	\$16.250	\$122.876	\$43.006	\$96.119	0.903	\$86.801	1
13			149	82	30	37	224	\$94.00	\$28.20	\$3.29	\$169.515	\$16.181	\$18.493	\$40.838	\$5.153	\$0.492	\$0.562	\$22.952	\$16.250	\$117.941	\$41.280	\$92.912	0.897	\$83.336	1
14			136	75	27	34	204	\$94.00	\$28.20	\$3.29	\$163.503	\$15.607	\$17.837	\$39.389	\$4.970	\$0.474	\$0.542	\$22.138	\$16.250	\$113.182	\$39.614	\$89.818	0.891	\$80.015	1
15			124	68	25	31	186	\$94.00	\$28.20	\$3.29	\$157.704	\$15.054	\$17.204	\$37.992	\$4.794	\$0.458	\$0.523	\$21.353	\$16.250	\$108.592	\$38.007	\$86.835	0.885	\$76.833	1
16			113	62	23	28	170	\$94.00	\$28.20	\$3.29	\$152.111	\$14.520	\$16.594	\$36.645	\$4.624	\$0.441	\$0.504	\$20.595	\$16.250	\$104.164	\$36.457	\$83.957	0.879	\$73.783	1
17			109	60	22	27	164	\$94.00	\$28.20	\$3.29	\$146.716	\$14.005	\$16.005	\$35.345	\$4.460	\$0.426	\$0.487	\$19.865	\$16.250	\$99.894	\$34.963	\$81.181	0.873	\$70.860	1
18			105	58	21	26	158	\$94.00	\$28.20	\$3.29	\$141.513	\$13.508	\$15.438	\$34.092	\$4.302	\$0.411	\$0.469	\$19.160	\$16.250	\$95.774	\$33.521	\$78.503	0.867	\$68.059	1
19			102	56	20	25	153	\$94.00	\$28.20	\$3.29	\$136.494	\$13.029	\$14.890	\$32.883	\$4.149	\$0.396	\$0.453	\$18.481	\$16.250	\$91.801	\$32.130	\$75.921	0.861	\$65.374	1
20			98	54	20	25	147	\$94.00	\$28.20	\$3.29	\$131.653	\$12.567	\$14.362	\$31.716	\$4.002	\$0.382	\$0.437	\$17.825	\$16.250	\$87.969	\$30.789	\$73.430	0.855	\$62.801	1
21			95	52	19	24	142	\$94.00	\$28.20	\$3.29	\$126.984	\$12.121	\$13.853	\$30.592	\$3.860	\$0.368	\$0.421	\$17.193	\$16.250	\$84.273	\$29.496	\$71.027	0.849	\$60.335	1
22			91	50	18	23	137	\$94.00	\$28.20	\$3.29	\$122.480	\$11.691	\$13.361	\$29.507	\$3.723	\$0.355	\$0.406	\$16.583	\$16.250	\$80.708	\$28.248	\$68.710	0.844	\$57.971	1
23			88	48	18	22	132	\$94.00	\$28.20	\$3.29	\$118.136	\$11.277	\$12.888	\$28.460	\$3.591	\$0.343	\$0.392	\$15.995	\$16.250	\$77.269	\$27.044	\$66.475	0.838	\$55.705	1
24			85	47	17	21	127	\$94.00	\$28.20	\$3.29	\$113.946	\$10.877	\$12.431	\$27.451	\$3.464	\$0.333	\$0.378	\$15.428	\$16.250	\$73.952	\$25.883	\$64.319	0.832	\$53.533	1
25			82	45	16	20	123	\$94.00	\$28.20	\$3.29	\$109.117	\$10.416	\$11.904	\$26.287	\$3.317	\$0.317	\$0.362	\$14.774	\$16.250	\$70.130	\$24.545	\$61.834	0.827	\$51.116	1
26			79	43	16	20	118	\$94.00	\$28.20	\$3.29	\$104.493	\$9.974	\$11.399	\$25.173	\$3.177	\$0.303	\$0.347	\$14.148	\$16.250	\$66.469	\$23.264	\$59.455	0.821	\$48.816	1
27			76	42	15	19	114	\$94.00	\$28.20	\$3.29	\$100.064	\$9.552	\$10.916	\$24.106	\$3.042	\$0.290	\$0.332	\$13.548	\$16.250	\$62.963	\$22.037	\$57.176	0.816	\$46.627	1
28			73	40	15	18	110	\$94.00	\$28.20	\$3.29	\$95.824	\$9.147	\$10.454	\$23.085	\$2.913	\$0.276	\$0.318	\$12.974	\$16.250	\$59.606	\$20.862	\$54.994	0.810	\$44.544	1
29			70	39	14	18	106	\$94.00	\$28.20	\$3.29	\$91.763	\$8.759	\$10.010	\$22.106	\$2.790	\$0.266	\$0.304	\$12.424	\$16.250	\$56.391	\$19.737	\$52.904	0.804	\$42.561	1
30			67	37	13	17	101	\$94.00	\$28.20	\$3.29	\$87.874	\$8.388	\$9.586	\$21.170	\$2.671	\$0.255	\$0.291	\$11.898	\$16.250	\$53.313	\$18.659	\$50.903	0.799	\$40.674	1
31			65	35	13	16	97	\$94.00	\$28.20	\$3.29	\$84.150	\$8.032	\$9.180	\$20.272	\$2.558	\$0.244	\$0.279	\$11.394	\$16.250	\$50.365	\$17.628	\$48.987	0.794	\$38.877	1
32			62	34	12	15	93	\$94.00	\$28.20	\$3.29	\$80.583	\$7.692	\$8.791	\$19.413	\$2.450	\$0.234	\$0.267	\$10.911	\$16.250	\$47.542	\$16.640	\$47.152	0.788	\$37.168	1
33			59	33	12	15	89	\$94.00	\$28.20	\$3.29	\$77.168	\$7.366	\$8.418	\$18.591	\$2.346	\$0.224	\$0.256	\$10.448	\$16.250	\$44.838	\$15.693	\$45.395	0.783	\$35.540	1
34			57	31	11	14	85	\$94.00	\$28.20	\$3.29	\$73.898	\$7.054	\$8.062	\$17.803	\$2.246	\$0.214	\$0.245	\$10.006	\$16.250	\$42.249	\$14.787	\$43.712	0.778	\$33.991	1
35			54	30	11	14	81	\$94.00	\$28.20	\$3.29	\$70.766	\$6.755	\$7.720	\$17.048	\$2.151	\$0.205	\$0.235	\$9.581	\$16.250	\$39.770	\$13.920	\$42.101	0.772	\$32.516	1
36			52	29	10	13	78	\$94.00	\$28.20	\$3.29	\$67.767	\$6.469	\$7.393	\$16.326	\$2.060	\$0.197	\$0.225	\$9.175	\$16.250	\$37.396	\$13.089	\$40.557	0.767	\$31.112	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Culberson LL Wolfcamp

Culberson LL: Wolfcamp		Average Well		My Assumptions:	
Basin Characteristics		IP	EUR	100%	oilfield service & supply factor price scalar
\$11.90	cost/well (\$mm)			-30	days/month
919	EUR/well (mboe)	2,450	1,955	-0.36%	exponential decline rate after year 3 (monthly)
-78%	1st yr decline	-11.7%	547	\$100.00	oil price WTI (\$/bbl)
-43%	2nd yr decline	-4.5%	314	0%	oil price appreciation (per month)
-41%	3rd yr decline	-4.2%	242	\$3.50	gas price Henry Hub (\$/mcf)
1,152	IP rate (boe/d)			0%	gas price appreciation
\$7.00	opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)
20%	% oil			0.68%	discount rate (compound monthly)
50%	% gas			8.5%	discount rate (annual)
30%	% NGL			80%	intangible drilling cost / total capex
20.0%	royalty rate			1.253	IP/EUR ratio, (B8/B4 = fixed ratio)
4.6%	oil prod tax				
7.5%	gas prod tax				
7.5%	NGL prod tax				
35.0%	income tax rate				
-5%	oil differential				
-5%	gas differential				
0	1 = DUC				
25%	auxiliary cost/well cost				
50%	completion cost/well cost				
\$2.00	min opex (\$/month)				

Results	
-\$2.567	= NPV/well (\$ million)
0	= EUR check (mboe)
0.27%	= ATIRR (monthly)
3.26%	= ATIRR (annual)
919	= total production (mboe)
\$4.376	= "tail end" NPV/well (\$ million)
100%	= "tail end" recovery factor
0	= months of lost production

Culberson LL: Wolfcamp					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	5,787	7,252	2,872	3,599	
\$25	4,708	5,900	2,337	2,929	
\$30	3,969	4,974	1,970	2,469	
\$35	3,430	4,298	1,703	2,134	
\$40	3,020	3,785	1,499	1,879	
\$45	2,698	3,381	1,339	1,678	
\$50	2,437	3,054	1,210	1,516	
\$60	2,043	2,560	1,014	1,271	
\$70	1,759	2,204	873	1,094	
\$80	1,544	1,935	766	960	
\$90	1,376	1,724	683	856	
\$100	1,241	1,555	616	772	

Culberson LL: Wolfcamp					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	15,643	19,604	7765	9,731	
\$25	10,647	13,343	5298	6,639	
\$30	8,101	10,152	4021	5,039	
\$35	6,527	8,180	3240	4,060	
\$40	5,466	6,850	2713	3,400	
\$45	4,701	5,891	2333	2,924	
\$50	4,124	5,168	2047	2,565	
\$60	3,311	4,149	1644	2,060	
\$70	2,766	3,466	1373	1,721	
\$80	2,375	2,976	1179	1,478	
\$90	2,081	2,608	1033	1,295	
\$100	1,852	2,321	919	1,152	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)								AT NPV	Active				
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex			Depreciation	Tax. Inc.	Income Tax	NCF
1	\$2,975	\$744						\$95.00	\$28.50	\$3.33								\$2,975.000	-\$2,975.000	-\$1,041.250	-2,678	1.000	-\$2,677.50		
2	\$2,975	\$744						\$95.00	\$28.50	\$3.33								\$2,975.000	-\$2,975.000	-\$1,041.250	-2,678	0.993	-\$2,659.36		
3	\$2,975	\$744						\$95.00	\$28.50	\$3.33								\$2,975.000	-\$2,975.000	-\$1,041.250	-2,678	0.986	-\$2,641.34		
4	\$2,975	\$744						\$95.00	\$28.50	\$3.33								\$2,975.000	-\$2,975.000	-\$1,041.250	-2,678	0.980	-\$2,623.45		
5			1152	230	346	576	3,455	\$95.00	\$28.50	\$3.33	\$656.528	\$344.677	\$295.438	\$259.33	\$24.16	\$20.68	\$17.73	\$241.879	\$24.792	\$708.077	\$247.827	\$485.042	0.973	\$472.300	1
6			1017	203	305	508	3,050	\$95.00	\$28.50	\$3.33	\$579.413	\$304.192	\$260.736	\$228.868	\$21.322	\$18.252	\$15.644	\$213.468	\$24.792	\$621.995	\$217.698	\$429.089	0.967	\$414.748	1
7			897	179	269	449	2,691	\$95.00	\$28.50	\$3.33	\$511.356	\$268.462	\$230.110	\$201.986	\$18.818	\$16.108	\$13.807	\$188.394	\$24.792	\$546.025	\$191.109	\$379.708	0.960	\$364.531	1
8			792	158	238	396	2,375	\$95.00	\$28.50	\$3.33	\$451.293	\$236.929	\$203.082	\$178.261	\$16.608	\$14.216	\$12.185	\$166.266	\$24.792	\$478.977	\$167.642	\$336.127	0.954	\$320.506	1
9			699	140	210	349	2,096	\$95.00	\$28.50	\$3.33	\$398.285	\$209.100	\$179.228	\$157.323	\$14.657	\$12.546	\$10.754	\$146.737	\$24.792	\$419.805	\$146.932	\$297.665	0.947	\$281.909	1
10			617	123	185	308	1,850	\$95.00	\$28.50	\$3.33	\$351.503	\$184.539	\$158.176	\$138.844	\$12.935	\$11.072	\$9.491	\$129.501	\$24.792	\$367.584	\$128.654	\$263.721	0.941	\$248.069	1
11			544	109	163	272	1,633	\$95.00	\$28.50	\$3.33	\$310.216	\$162.863	\$139.597	\$122.535	\$11.416	\$9.772	\$8.376	\$114.290	\$24.792	\$321.496	\$112.524	\$233.764	0.934	\$218.400	1
12			480	96	144	240	1,441	\$95.00	\$28.50	\$3.33	\$273.778	\$143.734	\$123.200	\$108.142	\$10.075	\$8.624	\$7.392	\$100.866	\$24.792	\$280.821	\$98.287	\$207.326	0.928	\$192.387	1
13			424	85	127	212	1,272	\$95.00	\$28.50	\$3.33	\$241.621	\$126.851	\$108.729	\$95.440	\$8.892	\$7.611	\$6.524	\$89.018	\$24.792	\$244.925	\$85.724	\$183.993	0.922	\$169.578	1
14			374	75	112	187	1,122	\$95.00	\$28.50	\$3.33	\$213.240	\$111.951	\$95.958	\$84.230	\$7.847	\$6.717	\$5.757	\$78.562	\$24.792	\$213.244	\$74.635	\$163.400	0.915	\$149.579	1
15			330	66	99	165	990	\$95.00	\$28.50	\$3.33	\$188.193	\$98.802	\$84.687	\$74.336	\$6.926	\$5.928	\$5.081	\$69.334	\$24.792	\$185.285	\$64.850	\$145.227	0.909	\$132.042	1
16			291	58	87	146	874	\$95.00	\$28.50	\$3.33	\$166.089	\$87.196	\$74.740	\$65.605	\$6.112	\$5.232	\$4.484	\$61.191	\$24.792	\$160.609	\$56.213	\$129.188	0.903	\$116.663	1
17			278	56	83	139	835	\$95.00	\$28.50	\$3.33	\$158.581	\$83.255	\$71.361	\$62.640	\$5.836	\$4.995	\$4.282	\$58.425	\$24.792	\$152.229	\$53.280	\$123.741	0.897	\$110.987	1
18			266	53	80	133	797	\$95.00	\$28.50	\$3.33	\$151.413	\$79.492	\$68.136	\$59.808	\$5.572	\$4.770	\$4.088	\$55.784	\$24.792	\$144.228	\$50.480	\$118.540	0.891	\$105.602	1
19			254	51	76	127	761	\$95.00	\$28.50	\$3.33	\$144.569	\$75.899	\$65.056	\$57.105	\$5.320	\$4.554	\$3.903	\$53.262	\$24.792	\$136.588	\$47.806	\$113.574	0.885	\$100.492	1
20			242	48	73	121	726	\$95.00	\$28.50	\$3.33	\$138.034	\$72.468	\$62.115	\$54.524	\$5.080	\$4.348	\$3.727	\$50.855	\$24.792	\$129.293	\$45.253	\$108.832	0.879	\$95.645	1
21			231	46	69	116	694	\$95.00	\$28.50	\$3.33	\$131.795	\$69.192	\$59.308	\$52.059	\$4.850	\$4.152	\$3.558	\$48.556	\$24.792	\$122.328	\$42.815	\$104.305	0.873	\$91.045	1
22			221	44	66	110	662	\$95.00	\$28.50	\$3.33	\$125.838	\$66.065	\$56.627	\$49.706	\$4.631	\$3.964	\$3.398	\$46.361	\$24.792	\$115.678	\$40.487	\$99.983	0.867	\$86.681	1
23			211	42	63	105	632	\$95.00	\$28.50	\$3.33	\$120.150	\$63.079	\$54.067	\$47.459	\$4.422	\$3.785	\$3.244	\$44.266	\$24.792	\$109.329	\$38.265	\$95.855	0.861	\$82.540	1
24			201	40	60	101	604	\$95.00	\$28.50	\$3.33	\$114.719	\$60.227	\$51.623	\$45.314	\$4.222	\$3.614	\$3.097	\$42.265	\$24.792	\$103.266	\$36.143	\$91.915	0.855	\$78.610	1
25			192	38	58	96	576	\$95.00	\$28.50	\$3.33	\$109.533	\$57.505	\$49.290	\$43.266	\$4.031	\$3.450	\$2.957	\$40.354	\$24.792	\$97.478	\$34.117	\$88.152	0.849	\$74.882	1
26			183	37	55	92	550	\$95.00	\$28.50	\$3.33	\$104.582	\$54.906	\$47.062	\$41.310	\$3.849	\$3.294	\$2.824	\$38.530	\$24.792	\$91.951	\$32.183	\$84.560	0.844	\$71.343	1
27			175	35	53	88	526	\$95.00	\$28.50	\$3.33	\$99.855	\$52.424	\$44.935	\$39.443	\$3.675	\$3.145	\$2.696	\$36.789	\$24.792	\$86.674	\$30.336	\$81.130	0.838	\$67.986	1
28			167	33	50	84	502	\$95.00	\$28.50	\$3.33	\$95.341	\$50.054	\$42.904	\$37.660	\$3.509	\$3.003	\$2.574	\$35.126	\$24.792	\$81.636	\$28.573	\$77.855	0.832	\$64.799	1
29			160	32	48	80	480	\$95.00	\$28.50	\$3.33	\$91.291	\$47.928	\$41.081	\$36.060	\$3.360	\$2.876	\$2.465	\$33.634	\$24.792	\$77.115	\$26.990	\$74.916	0.827	\$61.931	1
30			153	31	46	77	460	\$95.00	\$28.50	\$3.33	\$87.413	\$45.892	\$39.336	\$34.528	\$3.217	\$2.754	\$2.360	\$32.205	\$24.792	\$72.786	\$25.475	\$72.102	0.821	\$59.201	1
31			147	29	44	73	441	\$95.00	\$28.50	\$3.33	\$83.700	\$43.942	\$37.665	\$33.061	\$3.080	\$2.637	\$2.260	\$30.837	\$24.792	\$68.641	\$24.024	\$69.408	0.816	\$56.603	1
32			141	28	42	70	422	\$95.00	\$28.50	\$3.33	\$80.144	\$42.076	\$36.065	\$31.657	\$2.949	\$2.525	\$2.164	\$29.527	\$24.792	\$64.672	\$22.635	\$66.828	0.810	\$54.129	1
33			135	27	40	67	404	\$95.00	\$28.50	\$3.33	\$76.740	\$40.288	\$34.533	\$30.312	\$2.824	\$2.417	\$2.072	\$28.273	\$24.792	\$60.871	\$21.305	\$64.358	0.804	\$51.775	1
34			129	26	39	64	387	\$95.00	\$28.50	\$3.33	\$73.480	\$38.577	\$33.066	\$29.024	\$2.704	\$2.315	\$1.984	\$27.071	\$24.792	\$57.232	\$20.031	\$61.993	0.799	\$49.535	1
35			123	25	37	62	370	\$95.00	\$28.50	\$3.33	\$70.358	\$36.938	\$31.661	\$27.792	\$2.589										

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Midland Basin Wolfcamp

Midland Basin: Wolfcamp				My Assumptions:			
Basin Characteristics		Average Well		100% oilfield service & supply factor price scalar			
\$6.50 cost/well (\$mm)	IP	EUR	30	days/month			
204 EUR/well (mboe)	745	746	-0.97%	exponential decline rate after year 3 (monthly)			
-63% 1st yr decline	-8.0%	273	\$100.00	oil price WTI (\$/bbl)			
-34% 2nd yr decline	-3.4%	180	0%	oil price appreciation (per month)			
-26% 3rd yr decline	-2.5%	155	\$3.50	gas price Henry Hub (\$/mcf)			
203 IP rate (boe/d)			0%	gas price appreciation			
\$7.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
60% oil			0.68%	discount rate (compound monthly)			
19% gas			8.5%	discount rate (annual)			
21% NGL			80%	intangible drilling cost / total capex			
20.0% royalty rate			0.999	IP/EUR ratio, (B8/B4 = fixed ratio)			
4.6% oil prod tax							
7.5% gas prod tax							
7.5% NGL prod tax							
35.0% income tax rate							
-5% oil differential							
-5% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Midland Basin: Wolfcamp					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,362	2,359	1,172	1,170	
\$25	1,635	1,633	812	811	
\$30	1,250	1,248	621	620	
\$35	1,012	1,011	503	502	
\$40	850	849	423	422	
\$45	733	732	365	365	
\$50	644	643	321	321	
\$60	519	518	258	258	
\$70	434	433	217	217	
\$80	373	373	186	186	
\$90	327	327	164	164	
\$100	292	292	146	146	

Midland Basin: Wolfcamp					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	5,496	5,489	2728	2,724	
\$25	3,091	3,087	1534	1,532	
\$30	2,151	2,148	1067	1,066	
\$35	1,649	1,647	818	817	
\$40	1,337	1,335	664	663	
\$45	1,124	1,122	558	557	
\$50	970	969	482	481	
\$60	761	760	378	377	
\$70	626	625	311	311	
\$80	532	531	265	265	
\$90	462	461	230	230	
\$100	409	408	204	204	

Results			
-\$1.644 = NPV/well (\$ million)			
0 = EUR check (mboe)			
-0.09% = ATIRR (monthly)			
1.10% = ATIRR (annual)			
204 = total production (mboe)			
\$2.306 = "tail end" NPV/well (\$ million)			
100% = "tail end" recovery factor			
0 = months of lost production			

Per Well Net Cash Flow Analysis																										
Month	Capex (\$1,000s)			Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)						AT NPV -\$1,644	Active 1/0						
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	Gas Prod		Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax			Opex	Depreciation	Tax. Inc.	Income Tax	NCF	PV Factor
1	\$1,625	\$406					232	\$95.00	\$28.50	\$3.33	\$347.602	\$23.116	\$36.498	\$81.44	\$12.79	\$1.39	\$2.19	\$42.688	\$13.542	\$253.175	\$88.611	\$178.105	0.973	\$173.327	1	
2	\$1,625	\$406		203	122	43	39	213	\$95.00	\$28.50	\$3.33	\$319.705	\$21.260	\$33.569	\$74.907	\$11.765	\$1.276	\$2.014	\$39.262	\$13.542	\$231.769	\$81.119	\$164.192	0.967	\$158.704	1
3	\$1,625	\$406		172	103	36	33	196	\$95.00	\$28.50	\$3.33	\$294.047	\$19.554	\$30.875	\$68.895	\$10.821	\$1.173	\$1.852	\$36.111	\$13.542	\$212.082	\$74.229	\$151.395	0.960	\$145.344	1
4	\$1,625	\$406		158	95	33	30	180	\$95.00	\$28.50	\$3.33	\$270.448	\$17.985	\$28.397	\$63.366	\$9.953	\$1.079	\$1.704	\$33.213	\$13.542	\$193.974	\$67.891	\$139.625	0.954	\$133.136	1
5				145	87	31	28	166	\$95.00	\$28.50	\$3.33	\$248.743	\$16.541	\$26.118	\$58.281	\$9.154	\$0.992	\$1.567	\$30.547	\$13.542	\$177.320	\$62.062	\$128.800	0.947	\$121.982	1
6				134	80	28	25	153	\$95.00	\$28.50	\$3.33	\$228.780	\$15.214	\$24.022	\$53.603	\$8.419	\$0.913	\$1.441	\$28.096	\$13.542	\$162.002	\$56.701	\$118.843	0.941	\$111.790	1
7				123	74	26	23	140	\$95.00	\$28.50	\$3.33	\$210.420	\$13.993	\$22.094	\$49.301	\$7.743	\$0.840	\$1.326	\$25.841	\$13.542	\$147.914	\$51.770	\$109.686	0.934	\$102.477	1
8				113	68	24	22	129	\$95.00	\$28.50	\$3.33	\$193.532	\$12.870	\$20.321	\$45.345	\$7.122	\$0.772	\$1.219	\$23.767	\$13.542	\$134.956	\$47.235	\$101.263	0.928	\$93.967	1
9				104	62	22	20	119	\$95.00	\$28.50	\$3.33	\$178.000	\$11.837	\$18.690	\$41.705	\$6.550	\$0.710	\$1.121	\$21.860	\$13.542	\$123.038	\$43.063	\$93.517	0.922	\$86.190	1
10				96	57	20	18	109	\$95.00	\$28.50	\$3.33	\$163.715	\$10.887	\$17.190	\$38.358	\$6.025	\$0.653	\$1.031	\$20.105	\$13.542	\$112.077	\$39.227	\$86.392	0.915	\$79.084	1
11				88	53	18	17	100	\$95.00	\$28.50	\$3.33	\$150.576	\$10.013	\$15.810	\$35.280	\$5.541	\$0.601	\$0.949	\$18.492	\$13.542	\$101.995	\$35.698	\$79.839	0.909	\$72.590	1
12				81	49	17	15	92	\$95.00	\$28.50	\$3.33	\$138.491	\$9.210	\$14.542	\$32.448	\$5.096	\$0.553	\$0.872	\$17.008	\$13.542	\$92.723	\$32.453	\$73.812	0.903	\$66.656	1
13				78	47	16	15	89	\$95.00	\$28.50	\$3.33	\$133.767	\$8.895	\$14.045	\$31.342	\$4.923	\$0.534	\$0.843	\$16.427	\$13.542	\$89.098	\$31.184	\$71.455	0.897	\$64.091	1
14				76	45	16	14	86	\$95.00	\$28.50	\$3.33	\$129.203	\$8.592	\$13.566	\$30.272	\$4.755	\$0.516	\$0.814	\$15.867	\$13.542	\$85.596	\$29.959	\$69.179	0.891	\$61.629	1
15				73	44	15	14	83	\$95.00	\$28.50	\$3.33	\$124.796	\$8.299	\$13.104	\$29.240	\$4.592	\$0.498	\$0.786	\$15.326	\$13.542	\$82.214	\$28.775	\$66.981	0.885	\$59.266	1
16				70	42	15	13	80	\$95.00	\$28.50	\$3.33	\$120.538	\$8.016	\$12.657	\$28.242	\$4.436	\$0.481	\$0.759	\$14.803	\$13.542	\$78.948	\$27.632	\$64.858	0.879	\$56.999	1
17				68	41	14	13	78	\$95.00	\$28.50	\$3.33	\$116.426	\$7.742	\$12.225	\$27.279	\$4.284	\$0.465	\$0.733	\$14.298	\$13.542	\$75.793	\$26.527	\$62.807	0.873	\$54.822	1
18				66	39	14	12	75	\$95.00	\$28.50	\$3.33	\$112.455	\$7.478	\$11.808	\$26.348	\$4.138	\$0.449	\$0.708	\$13.810	\$13.542	\$72.745	\$25.461	\$60.826	0.867	\$52.734	1
19				64	38	13	12	72	\$95.00	\$28.50	\$3.33	\$108.618	\$7.223	\$11.405	\$25.449	\$3.997	\$0.433	\$0.684	\$13.339	\$13.542	\$69.801	\$24.431	\$58.913	0.861	\$50.729	1
20				61	37	13	12	70	\$95.00	\$28.50	\$3.33	\$104.913	\$6.977	\$11.016	\$24.581	\$3.861	\$0.419	\$0.661	\$12.884	\$13.542	\$66.958	\$23.435	\$57.065	0.855	\$48.804	1
21				59	36	12	11	68	\$95.00	\$28.50	\$3.33	\$101.334	\$6.739	\$10.640	\$23.743	\$3.729	\$0.404	\$0.638	\$12.445	\$13.542	\$64.212	\$22.474	\$55.280	0.849	\$46.957	1
22				25	37	12	11	65	\$95.00	\$28.50	\$3.33	\$97.877	\$6.509	\$10.277	\$22.933	\$3.602	\$0.391	\$0.617	\$12.020	\$13.542	\$61.560	\$21.546	\$53.555	0.844	\$45.185	1
23				55	33	12	11	63	\$95.00	\$28.50	\$3.33	\$94.538	\$6.287	\$9.926	\$22.150	\$3.479	\$0.377	\$0.596	\$11.610	\$13.542	\$58.998	\$20.649	\$51.890	0.838	\$43.483	1
24				53	32	11	10	61	\$95.00	\$28.50	\$3.33	\$91.313	\$6.072	\$9.588	\$21.395	\$3.360	\$0.364	\$0.575	\$11.214	\$13.542	\$56.523	\$19.783	\$50.282	0.832	\$41.851	1
25				52	31	11	10	59	\$95.00	\$28.50	\$3.33	\$89.065	\$5.923	\$9.352	\$20.868	\$3.278	\$0.355	\$0.561	\$10.938	\$13.542	\$54.798	\$19.179	\$49.161	0.827	\$40.639	1
26				51	30	11	10	58	\$95.00	\$28.50	\$3.33	\$86.873	\$5.777	\$9.122	\$20.354	\$3.197	\$0.347	\$0.547	\$10.669	\$13.542	\$53.116	\$18.591	\$48.067	0.821	\$39.466	1
27				50	30	10	9	56	\$95.00	\$28.50	\$3.33	\$84.735	\$5.635	\$8.897	\$19.853	\$3.118	\$0.338	\$0.534	\$10.406	\$13.542	\$51.476	\$18.016	\$47.001	0.816	\$38.329	1
28				48	29	10	9	55	\$95.00	\$28.50	\$3.33	\$82.649	\$5.496	\$8.678	\$19.365	\$3.041	\$0.330	\$0.521	\$10.150	\$13.542	\$49.875	\$17.456	\$45.961	0.810	\$37.227	1
29				47	28	10	9	54	\$95.00	\$28.50	\$3.33	\$80.615	\$5.361	\$8.465	\$18.888	\$2.967	\$0.322	\$0.508	\$9.900	\$13.542	\$48.314	\$16.910	\$44.946	0.804	\$36.159	1
30				46	28	10	9	52	\$95.00	\$28.50	\$3.33	\$78.631	\$5.229	\$8.256	\$18.423	\$2.894	\$0.314	\$0.495	\$9.656	\$13.542	\$46.792	\$16.377	\$43.956	0.799	\$35.123	1
31				45	27	9	9	51	\$95.00	\$28.50	\$3.33	\$76.695	\$5.100	\$8.053	\$17.970	\$2.822	\$0.306	\$0.483	\$9.419	\$13.542	\$45.307	\$15.857	\$42.991	0.794	\$34.119	1
32				44	26	9	8	50	\$95.00	\$28.50	\$3.33	\$74.807	\$4.975	\$7.855	\$17.527	\$2.753	\$0.298	\$0.471	\$9.187	\$13.542	\$43.858	\$15.350	\$42.050	0.788	\$33.145	1
33				43	26	9	8	49	\$95.00	\$28.50	\$3.33	\$72.966	\$4.852	\$7.661	\$17.096	\$2.685	\$0.291	\$0.460	\$8.961	\$13.542	\$42.445	\$14.856	\$41.131	0.783	\$32.202	1
34				42	25	9	8	47	\$95.00	\$28.50	\$3.33	\$71.170	\$4.733	\$7.473	\$16.675	\$2.619	\$0.284	\$0.448	\$8.740	\$13.542	\$41.067	\$14.374	\$40.235	0.778	\$31.287	1
35				41	24	9	8	46	\$95.00	\$28.50	\$3.33	\$69.418	\$4.616	\$7.289	\$16.265	\$2.555	\$0.277	\$0.437	\$8.525	\$13.542	\$39.723	\$13.903	\$39.362	0.772	\$30.400	1
36				40			8	45	\$95.00	\$28.50	\$3.33	\$67.710	\$4.503	\$7.110	\$15.864	\$2.492	\$0.270	\$0.427	\$8.315	\$13.542	\$38.412	\$13.444	\$38.510	0.767	\$29.541	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Southern Midland Basin Wolfcamp

Southern Midland Basin: Wolfcamp				My Assumptions:			
Basin Characteristics		Average Well		100% oilfield service & supply factor price scalar			
\$4.80 cost/well (\$mm)	IP	EUR	30	days/month			
180 EUR/well (mboe)	525	500	-0.93%	exponential decline rate after year 3 (monthly)			
-66% 1st yr decline	-8.6%	178	\$100.00	oil price WTI (\$/bbl)			
-34% 2nd yr decline	-3.4%	117	0%	oil price appreciation (per month)			
-27% 3rd yr decline	-2.6%	100	\$3.50	gas price Henry Hub (\$/mcf)			
189 IP rate (boe/d)			0%	gas price appreciation			
\$7.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
48% oil			0.68%	discount rate (compound monthly)			
27% gas			8.5%	discount rate (annual)			
25% NGL			80%	intangible drilling cost / total capex			
20.0% royalty rate			1.050	IP/EUR ratio, (B8/B4 = fixed ratio)			
4.6% oil prod tax							
7.5% gas prod tax							
7.5% NGL prod tax							
35.0% income tax rate							
-5% oil differential							
-5% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Southern Midland Basin: Wolfcamp					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	1,888	1,982	937	984	
\$25	1,348	1,415	669	702	
\$30	1,048	1,100	521	547	
\$35	857	900	427	448	
\$40	726	762	361	379	
\$45	629	660	313	329	
\$50	555	583	277	291	
\$60	449	471	224	235	
\$70	378	397	189	198	
\$80	326	342	163	171	
\$90	286	300	144	151	
\$100	255	268	128	134	

Southern Midland Basin: Wolfcamp					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	4,667	4,900	2317	2,433	
\$25	2,675	2,809	1328	1,394	
\$30	1,875	1,969	931	978	
\$35	1,443	1,515	716	752	
\$40	1,173	1,232	582	611	
\$45	988	1,037	491	516	
\$50	854	897	424	445	
\$60	671	705	333	350	
\$70	553	581	275	289	
\$80	470	494	234	246	
\$90	409	429	204	214	
\$100	362	380	180	189	

Results	
-1.188 = NPV/well (\$ million)	
0 = EUR check (mboe)	
0.10% = ATIRR (monthly)	
1.23% = ATIRR (annual)	
180 = total production (mboe)	
\$1.699 = "tail end" NPV/well (\$ million)	
100% = "tail end" recovery factor	
0 = months of lost production	

Per Well Net Cash Flow Analysis																												
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)						PV Factor	AT NPV	Active								
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax				NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax	NCF		
1	\$1,200	\$300					307	\$95.00	\$28.50	\$3.33	\$95.00	\$28.50	\$3.33	\$258.884	\$30.581	\$40.451	\$65.98	\$9.53	\$1.83	\$2.43	\$39.741	\$10.000	\$200.402	\$70.141	\$140.262	0.973	\$136.499	1
2	\$1,200	\$300					280	\$95.00	\$28.50	\$3.33	\$236.570	\$27.945	\$36.964	\$60.296	\$8.706	\$1.677	\$2.218	\$36.316	\$10.000	\$182.267	\$63.794	\$128.474	\$9.967	\$124.180	1			
3	\$1,200	\$300					256	\$95.00	\$28.50	\$3.33	\$216.180	\$25.536	\$33.778	\$55.099	\$7.955	\$1.532	\$2.027	\$33.185	\$10.000	\$165.695	\$57.993	\$117.702	\$9.960	\$112.998	1			
4	\$1,200	\$300					234	\$95.00	\$28.50	\$3.33	\$197.547	\$23.335	\$30.867	\$50.350	\$7.270	\$1.400	\$1.852	\$30.325	\$10.000	\$150.552	\$52.693	\$107.859	\$9.954	\$102.846	1			
5			189	91	47	51	307	\$95.00	\$28.50	\$3.33	\$180.520	\$21.324	\$28.206	\$46.010	\$6.643	\$1.279	\$1.692	\$27.711	\$10.000	\$136.714	\$47.850	\$98.864	\$9.947	\$93.631	1			
6			173	83	43	47	280	\$95.00	\$28.50	\$3.33	\$164.961	\$19.486	\$25.775	\$42.044	\$6.071	\$1.169	\$1.547	\$25.323	\$10.000	\$124.068	\$43.424	\$90.644	\$9.941	\$85.265	1			
7			158	76	40	43	256	\$95.00	\$28.50	\$3.33	\$150.742	\$17.806	\$23.553	\$38.420	\$5.547	\$1.068	\$1.413	\$23.140	\$10.000	\$112.513	\$39.379	\$83.133	\$9.934	\$77.669	1			
8			144	69	36	39	234	\$95.00	\$28.50	\$3.33	\$137.750	\$16.272	\$21.523	\$35.109	\$5.069	\$0.976	\$1.291	\$21.146	\$10.000	\$101.953	\$35.684	\$76.269	\$9.928	\$70.774	1			
9			132	63	33	36	214	\$95.00	\$28.50	\$3.33	\$125.877	\$14.869	\$19.668	\$32.083	\$4.632	\$0.892	\$1.180	\$19.323	\$10.000	\$92.304	\$32.306	\$69.997	\$9.922	\$64.514	1			
10			121	58	30	33	195	\$95.00	\$28.50	\$3.33	\$115.027	\$13.588	\$17.973	\$29.318	\$4.233	\$0.815	\$1.078	\$17.658	\$10.000	\$83.486	\$29.220	\$64.266	\$9.915	\$58.830	1			
11			110	53	28	30	179	\$95.00	\$28.50	\$3.33	\$105.113	\$12.416	\$16.424	\$26.791	\$3.868	\$0.745	\$0.985	\$16.136	\$10.000	\$75.428	\$26.400	\$59.028	\$9.909	\$53.669	1			
12			101	48	25	27	163	\$95.00	\$28.50	\$3.33	\$96.053	\$11.346	\$15.008	\$24.481	\$3.535	\$0.681	\$0.900	\$14.745	\$10.000	\$68.065	\$23.823	\$54.242	\$9.903	\$48.984	1			
13			92	44	23	25	149	\$95.00	\$28.50	\$3.33	\$92.752	\$10.956	\$14.493	\$23.640	\$3.413	\$0.657	\$0.870	\$14.238	\$10.000	\$65.382	\$22.884	\$52.499	\$9.897	\$47.088	1			
14			84	40	21	23	136	\$95.00	\$28.50	\$3.33	\$89.565	\$10.580	\$13.995	\$22.828	\$3.296	\$0.635	\$0.840	\$13.749	\$10.000	\$62.792	\$21.977	\$50.815	\$9.891	\$45.269	1			
15			77	37	19	21	124	\$95.00	\$28.50	\$3.33	\$86.487	\$10.216	\$13.514	\$22.043	\$3.183	\$0.613	\$0.811	\$13.277	\$10.000	\$60.291	\$21.102	\$49.189	\$9.885	\$43.523	1			
16			70	34	18	19	114	\$95.00	\$28.50	\$3.33	\$83.515	\$9.865	\$13.049	\$21.286	\$3.073	\$0.592	\$0.783	\$12.820	\$10.000	\$57.875	\$20.256	\$47.619	\$9.879	\$41.849	1			
17			68	33	17	18	110	\$95.00	\$28.50	\$3.33	\$80.645	\$9.526	\$12.601	\$20.554	\$2.968	\$0.572	\$0.756	\$12.380	\$10.000	\$55.543	\$19.440	\$46.103	\$9.873	\$40.242	1			
18			65	31	16	18	106	\$95.00	\$28.50	\$3.33	\$77.874	\$9.199	\$12.168	\$19.848	\$2.866	\$0.552	\$0.730	\$11.954	\$10.000	\$53.291	\$18.652	\$44.639	\$9.867	\$38.700	1			
19			63	30	16	17	102	\$95.00	\$28.50	\$3.33	\$75.198	\$8.883	\$11.750	\$19.166	\$2.767	\$0.533	\$0.705	\$11.544	\$10.000	\$51.116	\$17.891	\$43.225	\$9.861	\$37.221	1			
20			61	29	15	16	99	\$95.00	\$28.50	\$3.33	\$72.614	\$8.578	\$11.346	\$18.508	\$2.672	\$0.515	\$0.681	\$11.147	\$10.000	\$49.016	\$17.155	\$41.860	\$9.855	\$35.801	1			
21			59	28	15	16	96	\$95.00	\$28.50	\$3.33	\$70.119	\$8.283	\$10.956	\$17.872	\$2.580	\$0.497	\$0.657	\$10.764	\$10.000	\$46.988	\$16.446	\$40.542	\$9.849	\$34.439	1			
22			57	27	14	15	92	\$95.00	\$28.50	\$3.33	\$67.709	\$7.998	\$10.580	\$17.257	\$2.492	\$0.480	\$0.635	\$10.394	\$10.000	\$45.029	\$15.760	\$39.269	\$9.844	\$33.131	1			
23			55	26	14	15	89	\$95.00	\$28.50	\$3.33	\$65.383	\$7.723	\$10.216	\$16.664	\$2.406	\$0.463	\$0.613	\$10.037	\$10.000	\$43.138	\$15.098	\$38.040	\$9.838	\$31.877	1			
24			53	25	13	14	86	\$95.00	\$28.50	\$3.33	\$63.136	\$7.458	\$9.865	\$16.092	\$2.323	\$0.447	\$0.592	\$9.692	\$10.000	\$41.312	\$14.459	\$36.853	\$9.832	\$30.673	1			
25			51	25	13	14	83	\$95.00	\$28.50	\$3.33	\$61.505	\$7.265	\$9.610	\$15.676	\$2.263	\$0.436	\$0.577	\$9.442	\$10.000	\$39.987	\$13.995	\$35.992	\$9.827	\$29.753	1			
26			49	24	12	13	79	\$95.00	\$28.50	\$3.33	\$59.917	\$7.078	\$9.362	\$15.271	\$2.205	\$0.425	\$0.562	\$9.198	\$10.000	\$38.696	\$13.544	\$35.152	\$9.821	\$28.862	1			
27			48	24	12	13	77	\$95.00	\$28.50	\$3.33	\$58.369	\$6.895	\$9.120	\$14.877	\$2.148	\$0.414	\$0.547	\$8.960	\$10.000	\$37.438	\$13.103	\$34.335	\$9.816	\$28.000	1			
28			46	23	12	13	74	\$95.00	\$28.50	\$3.33	\$56.862	\$6.717	\$8.885	\$14.493	\$2.093	\$0.403	\$0.533	\$8.729	\$10.000	\$36.213	\$12.675	\$33.538	\$9.810	\$27.165	1			
29			44	22	11	12	71	\$95.00	\$28.50	\$3.33	\$55.393	\$6.543	\$8.655	\$14.118	\$2.038	\$0.393	\$0.519	\$8.503	\$10.000	\$35.019	\$12.257	\$32.763	\$9.804	\$26.357	1			
30			43	21	11	12	69	\$95.00	\$28.50	\$3.33	\$53.962	\$6.374	\$8.432	\$13.754	\$1.986	\$0.382	\$0.506	\$8.284	\$10.000	\$33.857	\$11.850	\$32.007	\$9.799	\$25.575	1			
31			42	20	10	11	66	\$95.00	\$28.50	\$3.33	\$52.569	\$6.210	\$8.214	\$13.398	\$1.935	\$0.373	\$0.493	\$8.070	\$10.000	\$32.724	\$11.453	\$31.271	\$9.794	\$24.817	1			
32			40	19	10	11	64	\$95.00	\$28.50	\$3.33	\$51.211	\$6.049	\$8.002	\$13.052	\$1.885	\$0.363	\$0.480	\$7.861	\$10.000	\$31.621	\$11.067	\$30.553	\$9.788	\$24.084	1			
33			39	18	10	10	61	\$95.00	\$28.50	\$3.33	\$49.888	\$5.893	\$7.795	\$12.715	\$1.836	\$0.354	\$0.468	\$7.658	\$10.000	\$30.546	\$10.691	\$29.855	\$9.783	\$23.373	1			
34			37	18	9	10	59	\$95.00	\$28.50	\$3.33	\$48.600	\$5.741	\$7.594	\$12.387	\$1.788	\$0.344	\$0.456	\$7.460	\$10.000	\$29.498	\$10.324	\$29.174	\$9.778	\$22.686	1			
35			36	17	9	10	58	\$95.00	\$28.50	\$3.33	\$47.344	\$5.593	\$7.398	\$12.067	\$1.742	\$0.336	\$0.444	\$7.268	\$10.000	\$28.478	\$9.967	\$28.511	\$9.772	\$22.020	1			
36			35	17	9	9	56	\$95.00	\$28.50	\$3.33	\$46.122	\$5.448	\$7.207	\$11.755	\$1.697	\$0.327	\$0.432	\$7.080	\$10.000	\$27.484	\$9.620	\$27.865	\$9.767	\$21.375	1			

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Eagle Ford Condensate

Eagle Ford: Condensate Region				My Assumptions:			
Basin Characteristics				100% oilfield service & supply factor price scalar			
\$8.00 cost/well (\$mm)	Average Well		IP	EUR	30	days/month	
229 EUR/well (mboe)	1,367	801			-1.08%	exponential decline rate after year 3 (monthly)	
-74% 1st yr decline	-10.7%	353			\$100.00	oil price WTI (\$/bbl)	
-43% 2nd yr decline	-4.6%	200			0%	oil price appreciation (per month)	
-41% 3rd yr decline	-4.4%	153			\$3.50	gas price Henry Hub (\$/mcf)	
390 IP rate (boe/d)					0%	gas price appreciation	
\$8.00 opex-LOE (\$/boe)					30%	NGL price/oil price (fixed ratio)	
63% oil					0.68%	discount rate (compound monthly)	
20% gas					8.5%	discount rate (annual)	
17% NGL					80%	intangible drilling cost / total capex	
20.0% royalty rate					1.707	IP/EUR ratio, (B8/B4 = fixed ratio)	
4.6% oil prod tax							
7.5% gas prod tax							
7.5% NGL prod tax							
35.0% income tax rate							
-6% oil differential							
-5% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Eagle Ford: Condensate Region					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	3,014	5,144	1,496	2,553	
\$25	1,985	3,388	986	1,683	
\$30	1,480	2,526	735	1,254	
\$35	1,180	2,014	586	1,000	
\$40	981	1,674	488	833	
\$45	839	1,432	418	713	
\$50	734	1,253	365	623	
\$60	586	1,000	292	498	
\$70	488	833	243	415	
\$80	418	713	208	355	
\$90	366	625	182	311	
\$100	325	555	162	276	

Eagle Ford: Condensate Region					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	9,143	15,604	4538	7,745	
\$25	4,190	7,151	2080	3,550	
\$30	2,717	4,637	1349	2,302	
\$35	2,011	3,432	998	1,703	
\$40	1,596	2,724	792	1,352	
\$45	1,323	2,258	657	1,121	
\$50	1,130	1,928	561	957	
\$60	874	1,492	434	741	
\$70	713	1,217	355	606	
\$80	602	1,027	299	510	
\$90	521	889	259	442	
\$100	459	783	229	391	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)			mcf/d	Prices			Cash Flows (\$1,000)							AT NPV	Active							
	Well Cost	Aux. Cost	Total	Oil	NGL		Gas	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax			NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax	NCF	PV Factor
1	\$2,000	\$500					\$94.00	\$28.20	\$3.33	\$693.075	\$46.697	\$56.106	\$159.18	\$25.51	\$2.80	\$3.37	\$93.627	\$16.667	\$494.735	\$173.157	\$338.245	0.973	\$329.170	1	
2	\$2,000	\$500					\$94.00	\$28.20	\$3.33	\$619.129	\$41.714	\$50.120	\$142.193	\$22.784	\$2.503	\$3.007	\$83.638	\$16.667	\$440.172	\$154.660	\$302.778	0.967	\$292.659	1	
3	\$2,000	\$500					\$94.00	\$28.20	\$3.33	\$553.072	\$37.264	\$44.772	\$127.022	\$20.353	\$2.936	\$2.686	\$74.714	\$16.667	\$391.430	\$137.001	\$271.096	0.960	\$260.261	1	
4	\$2,000	\$500					\$94.00	\$28.20	\$3.33	\$494.063	\$33.288	\$39.996	\$113.469	\$18.182	\$1.997	\$2.400	\$66.743	\$16.667	\$347.889	\$121.761	\$242.795	0.954	\$231.511	1	
5			390	246	66	78	468	\$94.00	\$28.20	\$3.33	\$441.349	\$29.736	\$35.728	\$101.363	\$16.242	\$1.784	\$2.144	\$59.622	\$16.667	\$308.993	\$108.148	\$217.512	0.947	\$205.998	1
6			348	220	59	70	418	\$94.00	\$28.20	\$3.33	\$394.260	\$26.564	\$31.916	\$90.548	\$14.509	\$1.594	\$1.915	\$53.260	\$16.667	\$274.248	\$95.987	\$194.928	0.941	\$183.358	1
7			311	196	53	62	374	\$94.00	\$28.20	\$3.33	\$352.195	\$23.729	\$28.511	\$80.887	\$12.961	\$1.424	\$1.711	\$47.578	\$16.667	\$243.209	\$85.123	\$174.752	0.934	\$163.267	1
8			278	175	47	56	334	\$94.00	\$28.20	\$3.33	\$314.618	\$21.198	\$25.469	\$72.257	\$11.578	\$1.272	\$1.528	\$42.502	\$16.667	\$215.482	\$75.419	\$156.730	0.928	\$145.437	1
9			242	157	42	50	298	\$94.00	\$28.20	\$3.33	\$281.051	\$18.936	\$22.752	\$64.548	\$10.343	\$1.136	\$1.365	\$37.967	\$16.667	\$190.713	\$66.750	\$140.630	0.922	\$129.613	1
10			228	140	38	44	266	\$94.00	\$28.20	\$3.33	\$251.064	\$16.916	\$20.324	\$57.661	\$9.239	\$1.015	\$1.219	\$33.916	\$16.667	\$168.587	\$59.005	\$126.248	0.915	\$115.569	1
11			198	125	34	40	238	\$94.00	\$28.20	\$3.33	\$224.277	\$15.111	\$18.156	\$51.509	\$8.253	\$0.907	\$1.089	\$30.298	\$16.667	\$148.822	\$52.088	\$113.401	0.909	\$103.105	1
12			177	112	30	35	213	\$94.00	\$28.20	\$3.33	\$200.349	\$13.499	\$16.219	\$46.013	\$7.373	\$0.810	\$0.973	\$27.065	\$16.667	\$131.165	\$45.908	\$101.924	0.903	\$92.043	1
13			158	100	27	32	190	\$94.00	\$28.20	\$3.33	\$191.084	\$12.874	\$15.469	\$43.885	\$7.032	\$0.772	\$0.928	\$25.813	\$16.667	\$124.329	\$43.515	\$97.841	0.897	\$87.434	1
14			141	89	24	28	170	\$94.00	\$28.20	\$3.33	\$182.248	\$12.279	\$14.753	\$41.856	\$6.707	\$0.737	\$0.885	\$24.620	\$16.667	\$117.809	\$41.233	\$93.243	0.891	\$83.066	1
15			126	80	21	25	151	\$94.00	\$28.20	\$3.33	\$173.820	\$11.711	\$14.071	\$39.921	\$6.397	\$0.703	\$0.844	\$23.481	\$16.667	\$111.591	\$39.057	\$89.201	0.885	\$78.926	1
16			113	71	19	23	135	\$94.00	\$28.20	\$3.33	\$165.782	\$11.170	\$13.420	\$38.074	\$6.101	\$0.670	\$0.805	\$22.395	\$16.667	\$105.660	\$36.981	\$85.345	0.879	\$75.004	1
17			108	68	18	22	129	\$94.00	\$28.20	\$3.33	\$158.116	\$10.653	\$12.800	\$36.314	\$5.819	\$0.639	\$0.768	\$21.360	\$16.667	\$100.003	\$35.001	\$81.669	0.873	\$71.286	1
18			98	62	17	21	117	\$94.00	\$28.20	\$3.33	\$150.804	\$10.161	\$12.208	\$34.635	\$5.550	\$0.610	\$0.732	\$20.372	\$16.667	\$94.608	\$33.113	\$78.162	0.867	\$67.763	1
19			89	56	15	18	107	\$94.00	\$28.20	\$3.33	\$143.831	\$9.691	\$11.643	\$33.033	\$5.293	\$0.581	\$0.699	\$19.430	\$16.667	\$89.462	\$31.312	\$74.817	0.861	\$64.424	1
20			85	53	14	17	102	\$94.00	\$28.20	\$3.33	\$137.180	\$9.243	\$11.105	\$31.505	\$5.048	\$0.555	\$0.666	\$18.532	\$16.667	\$84.555	\$29.594	\$71.627	0.855	\$61.259	1
21			77	49	13	15	93	\$94.00	\$28.20	\$3.33	\$130.836	\$8.815	\$10.591	\$30.049	\$4.815	\$0.529	\$0.635	\$17.675	\$16.667	\$79.874	\$27.956	\$68.585	0.849	\$58.260	1
22			74	46	13	15	88	\$94.00	\$28.20	\$3.33	\$124.786	\$8.408	\$10.102	\$28.659	\$4.592	\$0.504	\$0.606	\$16.857	\$16.667	\$75.410	\$26.393	\$65.683	0.844	\$55.417	1
23			67	42	11	13	80	\$94.00	\$28.20	\$3.33	\$119.015	\$8.019	\$9.635	\$27.334	\$4.380	\$0.481	\$0.578	\$16.078	\$16.667	\$71.152	\$24.903	\$62.915	0.838	\$52.722	1
24			64	40	11	13	77	\$94.00	\$28.20	\$3.33	\$113.512	\$7.648	\$9.189	\$26.070	\$4.177	\$0.459	\$0.551	\$15.334	\$16.667	\$67.091	\$23.482	\$60.276	0.832	\$50.168	1
25			61	38	10	12	73	\$94.00	\$28.20	\$3.33	\$108.555	\$7.314	\$8.788	\$24.931	\$3.995	\$0.439	\$0.527	\$14.665	\$16.667	\$63.434	\$22.202	\$57.898	0.827	\$47.863	1
26			58	37	10	12	70	\$94.00	\$28.20	\$3.33	\$103.815	\$6.995	\$8.404	\$23.843	\$3.820	\$0.420	\$0.504	\$14.024	\$16.667	\$59.936	\$20.978	\$55.625	0.821	\$45.672	1
27			56	35	10	11	67	\$94.00	\$28.20	\$3.33	\$99.282	\$6.689	\$8.037	\$22.802	\$3.654	\$0.401	\$0.482	\$13.412	\$16.667	\$56.591	\$19.807	\$53.451	0.816	\$43.589	1
28			53	34	9	11	64	\$94.00	\$28.20	\$3.33	\$94.947	\$6.397	\$7.686	\$21.806	\$3.494	\$0.384	\$0.461	\$12.826	\$16.667	\$53.392	\$18.687	\$51.372	0.810	\$41.610	1
29			51	32	9	10	61	\$94.00	\$28.20	\$3.33	\$90.801	\$6.118	\$7.351	\$20.854	\$3.341	\$0.367	\$0.441	\$12.266	\$16.667	\$50.333	\$17.617	\$49.383	0.804	\$39.728	1
30			49	31	8	10	59	\$94.00	\$28.20	\$3.33	\$86.837	\$5.851	\$7.030	\$19.943	\$3.196	\$0.351	\$0.422	\$11.731	\$16.667	\$47.408	\$16.593	\$47.482	0.799	\$37.940	1
31			47	29	8	9	56	\$94.00	\$28.20	\$3.33	\$83.045	\$5.595	\$6.723	\$19.075	\$3.056	\$0.336	\$0.403	\$11.218	\$16.667	\$44.610	\$15.613	\$45.663	0.794	\$36.239	1
32			45	28	8	9	54	\$94.00	\$28.20	\$3.33	\$79.419	\$5.351	\$6.429	\$18.240	\$2.923	\$0.321	\$0.386	\$10.729	\$16.667	\$41.934	\$14.677	\$43.924	0.788	\$34.623	1
33			43	27	7	9	51	\$94.00	\$28.20	\$3.33	\$75.951	\$5.117	\$6.148	\$17.443	\$2.795	\$0.307	\$0.369	\$10.260	\$16.667	\$39.376	\$13.781	\$42.261	0.783	\$33.086	1
34			41	26	7	8	49	\$94.00	\$28.20	\$3.33	\$72.635	\$4.894	\$5.880	\$16.682	\$2.673	\$0.294	\$0.353	\$9.812	\$16.667	\$36.929	\$12.925	\$40.670	0.778	\$31.625	1
35			39	25	7	8	47	\$94.00	\$28.20	\$3.33	\$69.463	\$4.680	\$5.623	\$15.953	\$2.556	\$0.281	\$0.337	\$9.384	\$16.667	\$34.588	\$12.106	\$39.149	0.772	\$30.236	1
36			37	24	7	8	45	\$94.00	\$28.20	\$3.33	\$66.430	\$4.476	\$5.378	\$15.257	\$2.445	\$0.269	\$0.323	\$8.974	\$16.667	\$32.350	\$11.323	\$37.694	0.767	\$28.915	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Eagle Ford Oil

Eagle Ford: Oil Region				My Assumptions:			
Basin Characteristics				133% oilfield service & supply factor price scalar			
\$6.00 cost/well (\$mm)	Average Well		IP	EUR	30	days/month	
368 EUR/well (mboe)	915	515			-1.25%	exponential decline rate after year 3 (monthly)	
-75% 1st yr decline	-11.0%	227			\$100.00	oil price WTI (\$/bbl)	
-47% 2nd yr decline	-5.1%	121			0%	oil price appreciation (per month)	
-31% 3rd yr decline	-3.0%	101			\$3.50	gas price Henry Hub (\$/mcf)	
654 IP rate (boe/d)					0%	gas price appreciation	
\$8.00 opex-LOE (\$/boe)					30%	NGL price/oil price (fixed ratio)	
71% oil					0.68%	discount rate (compound monthly)	
15% gas					8.5%	discount rate (annual)	
14% NGL					80%	intangible drilling cost / total capex	
20.0% royalty rate					1.777	IP/EUR ratio, (B8/B4 = fixed ratio)	
4.6% oil prod tax					Results		
7.5% gas prod tax					\$1.442 = NPV/well (\$ million)		
7.5% NGL prod tax					0 = EUR check (mboe)		
35.0% income tax rate					1.29% = ATIRR (monthly)		
-5% oil differential					16.61% = ATIRR (annual)		
-5% gas differential					368 = total production (mboe)		
0 1 = DUC					\$3.468 = "tail end" NPV/well (\$ million)		
25% auxiliary cost/well cost					100% = "tail end" recovery factor		
50% completion cost/well cost					0 = months of lost production		
\$2,000 min opex (\$/month)							

Eagle Ford: Oil Region					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,048	3,639	1,017	1,807	
\$25	1,336	2,374	664	1,180	
\$30	991	1,761	493	876	
\$35	788	1,400	392	696	
\$40	654	1,162	326	579	
\$45	559	993	279	496	
\$50	488	867	244	434	
\$60	390	693	195	346	
\$70	324	576	162	288	
\$80	278	494	139	247	
\$90	243	432	122	217	
\$100	216	384	108	192	

Eagle Ford: Oil Region					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	5,645	10,029	2802	4,978	
\$25	2,681	4,763	1331	2,365	
\$30	1,758	3,123	873	1,551	
\$35	1,307	2,322	650	1,155	
\$40	1,041	1,850	517	919	
\$45	865	1,537	430	764	
\$50	740	1,315	368	654	
\$60	574	1,020	286	508	
\$70	469	833	233	414	
\$80	396	704	197	350	
\$90	343	609	171	304	
\$100	303	538	151	268	

Per Well Net Cash Flow Analysis																										
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices			Cash Flows (\$1,000)							PV Factor	AT NPV \$1,442	Active 1/0						
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax				NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax	NCF
1	\$1,995	\$499						\$95.00	\$28.50	\$3.33										\$1,995.000	-\$1,995.00	-\$698.250	-1.796	1.000	\$1,795.50	
2	\$1,995	\$499						\$95.00	\$28.50	\$3.33										\$1,995.000	-\$1,995.00	-\$698.250	-1.796	0.993	-\$1,783.33	
3	\$1,995	\$499						\$95.00	\$28.50	\$3.33										\$1,995.000	-\$1,995.00	-\$698.250	-1.796	0.986	-\$1,771.25	
4	\$1,995	\$499						\$95.00	\$28.50	\$3.33										\$1,995.000	-\$1,995.00	-\$698.250	-1.796	0.980	-\$1,759.25	
5			654	464	92	98	588	\$95.00	\$28.50	\$3.33	\$1,322.902	\$58.692	\$78.256	\$291.97	\$48.68	\$3.52	\$4.70	\$208.683	\$16.625	\$885.673	\$309.985	\$592.312	0.973	0.973	\$576.422	1
6			582	413	81	87	524	\$95.00	\$28.50	\$3.33	\$1,177.818	\$52.255	\$69.674	\$259.949	\$43.344	\$3.135	\$4.180	\$185.797	\$16.625	\$786.717	\$275.351	\$527.991	0.967	0.967	\$510.345	1
7			518	368	73	78	466	\$95.00	\$28.50	\$3.33	\$1,048.645	\$46.524	\$62.033	\$231.440	\$38.590	\$2.791	\$3.722	\$165.420	\$16.625	\$698.613	\$244.515	\$470.724	0.960	0.960	\$451.909	1
8			461	328	65	69	415	\$95.00	\$28.50	\$3.33	\$933.639	\$41.422	\$55.229	\$206.058	\$34.358	\$2.485	\$3.314	\$147.278	\$16.625	\$620.172	\$217.060	\$419.737	0.954	0.954	\$400.230	1
9			411	292	58	62	370	\$95.00	\$28.50	\$3.33	\$831.246	\$36.879	\$49.172	\$183.459	\$30.590	\$2.213	\$2.950	\$131.126	\$16.625	\$550.334	\$192.617	\$374.342	0.947	0.947	\$354.526	1
10			366	260	51	55	329	\$95.00	\$28.50	\$3.33	\$740.082	\$32.835	\$43.779	\$163.339	\$27.235	\$1.970	\$2.627	\$116.745	\$16.625	\$488.155	\$170.854	\$333.926	0.941	0.941	\$314.107	1
11			326	231	46	49	293	\$95.00	\$28.50	\$3.33	\$658.916	\$29.234	\$38.978	\$145.426	\$24.248	\$1.754	\$2.339	\$103.942	\$16.625	\$432.795	\$151.478	\$297.942	0.934	0.934	\$278.360	1
12			290	206	41	43	261	\$95.00	\$28.50	\$3.33	\$586.652	\$26.028	\$34.703	\$129.477	\$21.589	\$1.562	\$2.082	\$92.542	\$16.625	\$383.506	\$134.227	\$265.904	0.928	0.928	\$246.745	1
13			258	183	36	39	232	\$95.00	\$28.50	\$3.33	\$522.313	\$23.173	\$30.897	\$115.277	\$19.221	\$1.390	\$1.854	\$82.393	\$16.625	\$339.623	\$118.868	\$237.380	0.922	0.922	\$218.784	1
14			230	163	32	34	207	\$95.00	\$28.50	\$3.33	\$465.030	\$20.632	\$27.509	\$102.634	\$17.113	\$1.238	\$1.651	\$73.357	\$16.625	\$300.553	\$105.194	\$211.985	0.915	0.915	\$194.054	1
15			205	145	29	31	184	\$95.00	\$28.50	\$3.33	\$414.030	\$18.369	\$24.492	\$91.378	\$15.236	\$1.102	\$1.470	\$65.312	\$16.625	\$265.768	\$93.019	\$189.374	0.909	0.909	\$172.181	1
16			182	129	26	27	164	\$95.00	\$28.50	\$3.33	\$368.623	\$16.354	\$21.806	\$81.357	\$13.565	\$0.981	\$1.308	\$58.149	\$16.625	\$234.798	\$82.179	\$169.243	0.903	0.903	\$152.836	1
17			173	123	24	26	156	\$95.00	\$28.50	\$3.33	\$349.890	\$15.523	\$20.698	\$77.222	\$12.876	\$0.931	\$1.242	\$55.194	\$16.625	\$222.021	\$77.707	\$160.938	0.897	0.897	\$144.351	1
18			164	117	23	25	148	\$95.00	\$28.50	\$3.33	\$332.109	\$14.734	\$19.646	\$73.298	\$12.222	\$0.884	\$1.179	\$52.389	\$16.625	\$209.893	\$73.463	\$153.056	0.891	0.891	\$136.351	1
19			156	111	22	23	140	\$95.00	\$28.50	\$3.33	\$315.232	\$13.986	\$18.648	\$69.573	\$11.601	\$0.839	\$1.119	\$49.727	\$16.625	\$198.382	\$69.434	\$145.573	0.885	0.885	\$128.806	1
20			148	105	21	22	133	\$95.00	\$28.50	\$3.33	\$299.213	\$13.275	\$17.700	\$66.037	\$11.011	\$0.796	\$1.062	\$47.200	\$16.625	\$187.456	\$65.609	\$138.471	0.879	0.879	\$121.692	1
21			140	100	20	21	126	\$95.00	\$28.50	\$3.33	\$284.007	\$12.600	\$16.800	\$62.682	\$10.451	\$0.756	\$1.008	\$44.801	\$16.625	\$177.085	\$61.980	\$131.730	0.873	0.873	\$114.983	1
22			133	95	19	20	120	\$95.00	\$28.50	\$3.33	\$269.574	\$11.960	\$15.947	\$59.496	\$9.920	\$0.718	\$0.957	\$42.524	\$16.625	\$167.241	\$58.534	\$125.331	0.867	0.867	\$108.657	1
23			126	90	18	19	114	\$95.00	\$28.50	\$3.33	\$255.875	\$11.352	\$15.136	\$56.473	\$9.416	\$0.681	\$0.908	\$40.363	\$16.625	\$157.897	\$55.264	\$119.258	0.861	0.861	\$102.691	1
24			120	85	17	18	108	\$95.00	\$28.50	\$3.33	\$242.872	\$10.775	\$14.367	\$53.603	\$8.938	\$0.647	\$0.862	\$38.312	\$16.625	\$149.028	\$52.160	\$113.493	0.855	0.855	\$97.065	1
25			114	81	16	17	103	\$95.00	\$28.50	\$3.33	\$230.530	\$10.228	\$13.637	\$50.879	\$8.483	\$0.614	\$0.818	\$36.365	\$16.625	\$140.610	\$49.213	\$108.021	0.849	0.849	\$91.759	1
26			108	77	15	16	97	\$95.00	\$28.50	\$3.33	\$218.815	\$9.708	\$12.944	\$48.293	\$8.052	\$0.582	\$0.777	\$34.517	\$16.625	\$132.619	\$46.417	\$102.828	0.844	0.844	\$86.756	1
27			103	73	14	15	92	\$95.00	\$28.50	\$3.33	\$207.695	\$9.215	\$12.286	\$45.839	\$7.643	\$0.553	\$0.737	\$32.763	\$16.625	\$125.035	\$43.762	\$97.898	0.838	0.838	\$82.037	1
28			97	69	14	15	88	\$95.00	\$28.50	\$3.33	\$197.140	\$8.746	\$11.662	\$43.510	\$7.255	\$0.525	\$0.700	\$31.098	\$16.625	\$117.836	\$41.243	\$93.219	0.832	0.832	\$77.586	1
29			94	67	13	14	85	\$95.00	\$28.50	\$3.33	\$191.187	\$8.482	\$11.310	\$42.196	\$7.036	\$0.509	\$0.679	\$30.159	\$16.625	\$113.776	\$39.822	\$90.579	0.827	0.827	\$74.879	1
30			92	65	13	14	82	\$95.00	\$28.50	\$3.33	\$185.414	\$8.226	\$10.968	\$40.922	\$6.823	\$0.494	\$0.658	\$29.248	\$16.625	\$109.838	\$38.443	\$88.020	0.821	0.821	\$72.270	1
31			89	63	12	13	80	\$95.00	\$28.50	\$3.33	\$179.815	\$7.978	\$10.637	\$39.686	\$6.617	\$0.479	\$0.638	\$28.365	\$16.625	\$106.020	\$37.107	\$85.538	0.816	0.816	\$69.756	1
32			86	61	12	13	78	\$95.00	\$28.50	\$3.33	\$174.385	\$7.737	\$10.316	\$38.488	\$6.417	\$0.464	\$0.619	\$27.509	\$16.625	\$102.316	\$35.811	\$83.131	0.810	0.810	\$67.334	1
33			84	59	12	13	75	\$95.00	\$28.50	\$3.33	\$169.120	\$7.503	\$10.004	\$37.325	\$6.224	\$0.450	\$0.600	\$26.678	\$16.625	\$98.725	\$34.554	\$80.796	0.804	0.804	\$65.000	1
34			81	58	11	12	73	\$95.00	\$28.50	\$3.33	\$164.013	\$7.277	\$9.702	\$36.198	\$6.036	\$0.437	\$0.582	\$25.872	\$16.625	\$95.241	\$33.334	\$78.532	0.799	0.799	\$62.750	1
35			79	56	11	12	71	\$95.00	\$28.50	\$3.33	\$159.060	\$7.057	\$9.409	\$35.105	\$5.853	\$0.423	\$0.565	\$25.091	\$16.625	\$91.863	\$32.152	\$76.336	0.794	0.794	\$60.582	1
36			76	54	11	11	69	\$95.00	\$28.50	\$3.33	\$154.257	\$6.844	\$9.125	\$34.045	\$5.677											

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Eagle Ford Combo

Eagle Ford: Combo Region			My Assumptions:		
Basin Characteristics			133% oilfield service & supply factor price scalar		
\$5.50 cost/well (\$mm)	Average Well		30 days/month		
2,082 EUR/well (mboe)	IP	EUR	-1.33% exponential decline rate after year 3 (monthly)		
-58% 1st yr decline	-7.0%	452	\$20.00 oil price WTI (\$/bbl)		
-40% 2nd yr decline	-4.2%	270	0% oil price appreciation (per month)		
-35% 3rd yr decline	-3.6%	217	\$3.50 gas price Henry Hub (\$/mcf)		
2,515 IP rate (boe/d)			0% gas price appreciation		
\$6.00 opex-LOE (\$/boe)			30% NGL price/oil price (fixed ratio)		
21% % oil			0.68% discount rate (compound monthly)		
45% % gas			8.5% discount rate (annual)		
34% % NGL			80% intangible drilling cost / total capex		
20.0% royalty rate			1.208 IP/EUR ratio, (B8/B4 = fixed ratio)		
4.6% oil prod tax					
7.5% gas prod tax					
7.5% NGL prod tax					
35.0% income tax rate					
-6% oil differential					
-5% gas differential					
1 = DUC					
25% auxiliary cost/well cost					
50% completion cost/well cost					
\$2,000 min opex (\$/month)					

Results	
\$0.000	= NPV/well (\$ million)
0	= EUR check (mboe)
0.68%	= ATIRR (monthly)
8.50%	= ATIRR (annual)
2,082	= total production (mboe)
\$1.463	= "tail end" NPV/well (\$ million)
100%	= "tail end" recovery factor
1	= months of lost production

Eagle Ford: Combo Region					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUR		
Price	EUR	IP	EUR	IP	
\$20	1,923	2,323	956	1,155	
\$25	1,579	1,908	786	950	
\$30	1,340	1,619	667	806	
\$35	1,163	1,405	579	700	
\$40	1,028	1,242	512	619	
\$45	921	1,113	459	555	
\$50	834	1,008	416	503	
\$60	702	848	350	423	
\$70	606	732	302	365	
\$80	533	644	266	321	
\$90	476	575	238	288	
\$100	429	518	215	260	

Eagle Ford: Combo Region					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	4,193	5,066	2,082	2,516	
\$25	3,088	3,731	1,533	1,852	
\$30	2,444	2,953	1,214	1,467	
\$35	2,022	2,443	1,005	1,214	
\$40	1,724	2,083	857	1,035	
\$45	1,503	1,816	747	903	
\$50	1,333	1,611	663	801	
\$60	1,086	1,312	540	652	
\$70	916	1,107	456	551	
\$80	793	958	395	477	
\$90	698	843	348	420	
\$100	624	754	311	376	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)			Production (boe/d)			mcf/d	Prices			Cash Flows (\$1,000)							PV Factor	AT NPV \$0	Active 1/0					
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Oil/bbl	NGU/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax				Opex	Depreciation	Tax. Inc.	Income Tax	NCF
1	\$0	\$0						\$18.80	\$5.64	\$3.33								\$0.000	\$0.000	\$0.000	0	1.000	\$0.00		
2	\$0	\$0						\$18.80	\$5.64	\$3.33								\$0.000	\$0.000	\$0.000	0	0.993	\$0.00		
3	\$1,829	\$457						\$18.80	\$5.64	\$3.33								\$1,828.750	-\$1,828.75	-\$640.063	-1,646	0.986	-\$1,623.65		
4	\$1,829	\$457						\$18.80	\$5.64	\$3.33								\$1,828.750	-\$1,828.75	-\$640.063	-1,646	0.980	-\$1,612.65		
5			2515	528	855	1132	6,790	\$18.80	\$5.64	\$3.33	\$297.875	\$677.348	\$144.682	\$223.98	\$10.96	\$40.64	\$8.68	\$602.087	\$7.620	\$225.933	\$79.077	\$154.476	0.973	\$150.332	1
6			2338	491	795	1052	6,313	\$18.80	\$5.64	\$3.33	\$276.913	\$629.682	\$134.500	\$208.219	\$10.190	\$37.781	\$8.070	\$559.717	\$7.620	\$209.498	\$73.324	\$143.793	0.967	\$138.988	1
7			2173	456	739	978	5,868	\$18.80	\$5.64	\$3.33	\$257.426	\$585.369	\$125.035	\$193.566	\$9.473	\$35.122	\$7.502	\$520.328	\$7.620	\$194.219	\$67.976	\$133.862	0.960	\$128.511	1
8			2021	424	687	909	5,455	\$18.80	\$5.64	\$3.33	\$239.310	\$544.176	\$116.236	\$179.944	\$8.807	\$31.651	\$6.974	\$483.712	\$7.620	\$180.015	\$63.005	\$124.629	0.954	\$118.837	1
9			1878	394	639	845	5,071	\$18.80	\$5.64	\$3.33	\$222.469	\$505.881	\$108.056	\$167.281	\$8.187	\$30.353	\$6.483	\$449.672	\$7.620	\$166.810	\$58.384	\$116.047	0.947	\$109.904	1
10			1746	367	594	786	4,715	\$18.80	\$5.64	\$3.33	\$206.814	\$470.281	\$100.452	\$155.509	\$7.611	\$28.217	\$6.027	\$418.027	\$7.620	\$154.535	\$54.087	\$108.068	0.941	\$101.654	1
11			1623	341	552	730	4,383	\$18.80	\$5.64	\$3.33	\$192.260	\$437.186	\$93.383	\$144.566	\$7.075	\$26.231	\$5.603	\$388.610	\$7.620	\$143.124	\$50.093	\$100.650	0.934	\$94.035	1
12			1509	317	513	679	4,074	\$18.80	\$5.64	\$3.33	\$178.730	\$406.420	\$86.812	\$134.392	\$6.577	\$24.385	\$5.209	\$361.262	\$7.620	\$132.516	\$46.381	\$93.755	0.928	\$87.000	1
13			1403	295	477	631	3,788	\$18.80	\$5.64	\$3.33	\$166.152	\$377.819	\$80.702	\$124.935	\$6.114	\$22.669	\$4.842	\$335.840	\$7.620	\$122.654	\$42.929	\$87.345	0.922	\$80.502	1
14			1304	274	443	587	3,521	\$18.80	\$5.64	\$3.33	\$154.460	\$351.231	\$75.023	\$116.143	\$5.684	\$21.074	\$4.501	\$312.206	\$7.620	\$113.487	\$39.720	\$81.386	0.915	\$74.502	1
15			1212	255	412	546	3,273	\$18.80	\$5.64	\$3.33	\$143.590	\$326.514	\$69.744	\$107.970	\$5.284	\$19.591	\$4.185	\$290.235	\$7.620	\$104.964	\$36.737	\$75.846	0.909	\$68.961	1
16			1127	237	383	507	3,043	\$18.80	\$5.64	\$3.33	\$133.485	\$303.537	\$64.836	\$100.372	\$4.912	\$18.212	\$3.890	\$269.811	\$7.620	\$97.041	\$33.964	\$70.697	0.903	\$63.843	1
17			1080	227	367	486	2,915	\$18.80	\$5.64	\$3.33	\$127.875	\$290.779	\$62.111	\$96.153	\$4.706	\$17.447	\$3.727	\$258.471	\$7.620	\$92.642	\$32.425	\$67.837	0.897	\$60.846	1
18			1034	217	352	465	2,793	\$18.80	\$5.64	\$3.33	\$122.500	\$278.558	\$59.500	\$92.112	\$4.508	\$16.713	\$3.570	\$247.607	\$7.620	\$88.428	\$30.950	\$65.098	0.891	\$57.993	1
19			991	208	337	446	2,675	\$18.80	\$5.64	\$3.33	\$117.352	\$266.850	\$56.999	\$88.240	\$4.319	\$16.011	\$3.420	\$237.200	\$7.620	\$84.392	\$29.537	\$62.474	0.885	\$55.279	1
20			949	199	323	427	2,563	\$18.80	\$5.64	\$3.33	\$112.420	\$255.635	\$54.604	\$84.532	\$4.137	\$15.338	\$3.276	\$227.231	\$7.620	\$80.524	\$28.184	\$59.961	0.879	\$52.695	1
21			909	191	309	409	2,455	\$18.80	\$5.64	\$3.33	\$107.695	\$244.891	\$52.309	\$80.979	\$3.963	\$14.693	\$3.139	\$217.681	\$7.620	\$76.820	\$26.887	\$57.553	0.873	\$50.236	1
22			871	183	296	392	2,352	\$18.80	\$5.64	\$3.33	\$103.168	\$234.598	\$50.110	\$77.575	\$3.797	\$14.076	\$3.007	\$208.532	\$7.620	\$73.271	\$25.645	\$55.246	0.867	\$47.896	1
23			834	175	284	376	2,253	\$18.80	\$5.64	\$3.33	\$98.832	\$224.738	\$48.004	\$74.315	\$3.637	\$13.484	\$2.880	\$199.767	\$7.620	\$69.871	\$24.455	\$53.036	0.861	\$45.668	1
24			799	168	272	360	2,158	\$18.80	\$5.64	\$3.33	\$94.678	\$215.292	\$45.987	\$71.191	\$3.484	\$12.918	\$2.759	\$191.371	\$7.620	\$66.614	\$23.315	\$50.919	0.855	\$43.548	1
25			766	161	260	345	2,068	\$18.80	\$5.64	\$3.33	\$90.699	\$206.244	\$44.054	\$68.199	\$3.338	\$12.375	\$2.643	\$183.328	\$7.620	\$63.994	\$22.223	\$48.891	0.849	\$41.531	1
26			734	154	249	330	1,981	\$18.80	\$5.64	\$3.33	\$86.887	\$197.575	\$42.202	\$65.333	\$3.187	\$11.855	\$2.532	\$175.622	\$7.620	\$60.505	\$21.177	\$46.948	0.844	\$39.610	1
27			703	148	239	316	1,897	\$18.80	\$5.64	\$3.33	\$83.235	\$189.271	\$40.428	\$62.587	\$3.063	\$11.356	\$2.426	\$168.241	\$7.620	\$57.642	\$20.175	\$45.087	0.838	\$37.782	1
28			673	141	229	303	1,818	\$18.80	\$5.64	\$3.33	\$79.737	\$181.316	\$38.729	\$59.956	\$2.934	\$10.879	\$2.324	\$161.170	\$7.620	\$54.899	\$19.215	\$43.304	0.832	\$36.042	1
29			649	136	221	292	1,753	\$18.80	\$5.64	\$3.33	\$76.885	\$174.831	\$37.344	\$57.812	\$2.829	\$10.490	\$2.241	\$155.406	\$7.620	\$52.663	\$18.432	\$41.851	0.827	\$34.597	1
30			626	131	213	282	1,690	\$18.80	\$5.64	\$3.33	\$74.135	\$168.578	\$36.008	\$55.744	\$2.728	\$10.115	\$2.161	\$149.848	\$7.620	\$50.507	\$17.677	\$40.449	0.821	\$33.212	1
31			604	127	205	272	1,630	\$18.80	\$5.64	\$3.33	\$71.484	\$162.549	\$34.721	\$53.751	\$2.631	\$9.753	\$2.083	\$144.488	\$7.620	\$48.428	\$16.950	\$39.098	0.816	\$31.885	1
32			582	122	198	262	1,571	\$18.80	\$5.64	\$3.33	\$68.927	\$156.736	\$33.479	\$51.828	\$2.537	\$9.404	\$2.009	\$139.320	\$7.620	\$46.423	\$16.248	\$37.795	0.810	\$30.613	1
33			561	118	191	253	1,515	\$18.80	\$5.64	\$3.33	\$66.462	\$151.130	\$32.281	\$49.975	\$2.446	\$9.068	\$1.937	\$134.338	\$7.620	\$44.491	\$15.572	\$36.539	0.804	\$29.395	1
34			541	114	184	243	1,461	\$18.80	\$5.64	\$3.33	\$64.085	\$145.725	\$31.127	\$48.187	\$2.358	\$8.743	\$1.868	\$129.533	\$7.620	\$42.627	\$14.919	\$35.327	0.799	\$28.228	1
35			522	110	177	235	1,409	\$18.80	\$5.64	\$3.33	\$61.793	\$140.513	\$30.014	\$46.464	\$2.274	\$8.431	\$1.801	\$124.900	\$7.620	\$40.830	\$14.290	\$34.159	0.794	\$27.110	1
36			503	106	171	226	1,358	\$18.80	\$5.64	\$3.33	\$59.583	\$135.487	\$28.940	\$44.802	\$2.193	\$8.129	\$1.736	\$120.433	\$7.620	\$39.097	\$13.684	\$33.033	0.788	\$26.038	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Bakken Core

Bakken: Core				My Assumptions:			
Basin Characteristics				Oilfield service & supply factor price scalar			
\$7.50 cost/well (\$mm)	Average Well		100%	30			
100 EUR/well (mboe)	IP	EUR	days/month				
-71% 1st yr decline	851	725	-0.73%	exponential decline rate after year 3 (monthly)			
-38% 2nd yr decline	250		\$20.00	oil price WTI (\$/bbl)			
-34% 3rd yr decline	154		0%	oil price appreciation (per month)			
	125		\$3.50	gas price Henry Hub (\$/mcf)			
117 IP rate (boe/d)			0%	gas price appreciation			
\$7.57 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
85% oil			0.68%	discount rate (compound monthly)			
13% gas			8.5%	discount rate (annual)			
2% NGL			80%	intangible drilling cost / total capex			
20.0% royalty rate			1.174	IP/EUR ratio, (B8/B4 = fixed ratio)			
10.0% oil prod tax	Results						
10.0% gas prod tax							
10.0% NGL prod tax							
35.0% income tax rate							
-13.3% oil differential	-\$6.050 = NPV/well (\$ million)						
0% gas differential	0 = EUR check (mboe)						
0 1 = DUC	-2.57% = ATIRR (monthly)						
25% auxiliary cost/well cost	-26.80% = ATIRR (annual)						
50% completion cost/well cost	100 = total production (mboe)						
\$2,000 min opex (\$/month)	\$0.437 = "tail end" NPV/well (\$ million)						
	73% = "tail end" recovery factor						
	174 = months of lost production						

Bakken: Core					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,970	3,486	1,474	1,730	
\$25	1,946	2,284	966	1,134	
\$30	1,448	1,700	719	844	
\$35	1,152	1,352	572	671	
\$40	957	1,123	475	558	
\$45	818	960	406	477	
\$50	715	839	355	417	
\$60	571	670	284	333	
\$70	475	558	236	277	
\$80	406	477	202	237	
\$90	355	417	177	208	
\$100	316	371	157	184	

Bakken: Core					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	7,767	9,117	3855	4,525	
\$25	3,819	4,483	1896	2,226	
\$30	2,532	2,972	1257	1,475	
\$35	1,894	2,223	940	1,103	
\$40	1,513	1,776	751	882	
\$45	1,259	1,478	625	734	
\$50	1,078	1,265	535	628	
\$60	838	984	416	488	
\$70	685	804	340	399	
\$80	579	680	288	338	
\$90	502	589	249	292	
\$100	443	520	220	258	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)			Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)						PV Factor	AT NPV	Active 1/0				
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	Gas Prod		Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax				Opex	Depreciation	Tax. Inc.	Income Tax
1	\$1,875	\$469					92	\$17.34	\$5.20	\$3.50	\$51,902	\$9,613	\$0,366	\$12.38	\$4.15	\$0.77	\$0.03	\$26,657	\$15,625	\$2,273	\$0,795	\$17,102	0.973	\$16,643	1
2	\$1,875	\$469					83	\$17.34	\$5.20	\$3.50	\$46,865	\$8,680	\$0,331	\$11,175	\$3,749	\$0,694	\$0,026	\$24,070	\$15,625	\$0,536	\$0,188	\$15,973	0.967	\$15,439	1
3	\$1,875	\$469					75	\$17.34	\$5.20	\$3.50	\$42,317	\$7,838	\$0,299	\$10,091	\$3,385	\$0,627	\$0,024	\$21,734	\$15,625	-\$1,032	-\$0,361	\$14,954	0.960	\$14,356	1
4	\$1,875	\$469					67	\$17.34	\$5.20	\$3.50	\$38,211	\$7,077	\$0,270	\$9,112	\$3,057	\$0,566	\$0,022	\$19,625	\$15,625	-\$2,448	-\$0,857	\$14,033	0.954	\$13,381	1
5			117	100	2	15	92	\$17.34	\$5.20	\$3.50	\$34,503	\$6,391	\$0,244	\$8,227	\$2,760	\$0,511	\$0,019	\$17,721	\$15,625	-\$3,727	-\$1,305	\$13,202	0.947	\$12,503	1
6			106	90	2	14	83	\$17.34	\$5.20	\$3.50	\$31,154	\$5,770	\$0,220	\$7,429	\$2,492	\$0,462	\$0,018	\$16,001	\$15,625	-\$4,882	-\$1,709	\$12,452	0.941	\$11,713	1
7			96	81	2	12	75	\$17.34	\$5.20	\$3.50	\$28,131	\$5,211	\$0,199	\$6,708	\$2,250	\$0,417	\$0,016	\$14,448	\$15,625	-\$5,924	-\$2,074	\$11,774	0.934	\$11,000	1
8			86	73	2	11	67	\$17.34	\$5.20	\$3.50	\$25,401	\$4,705	\$0,179	\$6,057	\$2,032	\$0,376	\$0,014	\$13,046	\$15,625	-\$6,866	-\$2,403	\$11,162	0.928	\$10,358	1
9			78	66	2	10	61	\$17.34	\$5.20	\$3.50	\$22,936	\$4,248	\$0,162	\$5,469	\$1,835	\$0,340	\$0,013	\$11,780	\$15,625	-\$7,716	-\$2,700	\$10,610	0.922	\$9,779	1
10			70	60	1	9	55	\$17.34	\$5.20	\$3.50	\$20,710	\$3,836	\$0,146	\$4,939	\$1,657	\$0,307	\$0,012	\$10,637	\$15,625	-\$8,483	-\$2,969	\$10,111	0.915	\$9,256	1
11			64	54	1	8	50	\$17.34	\$5.20	\$3.50	\$18,701	\$3,464	\$0,132	\$4,459	\$1,496	\$0,277	\$0,011	\$9,605	\$15,625	-\$9,176	-\$3,212	\$9,660	0.909	\$8,783	1
12			57	49	1	7	45	\$17.34	\$5.20	\$3.50	\$16,886	\$3,128	\$0,119	\$4,027	\$1,351	\$0,250	\$0,010	\$8,673	\$15,625	-\$9,802	-\$3,431	\$9,254	0.903	\$8,357	1
13			52	44	1	7	40	\$17.34	\$5.20	\$3.50	\$16,218	\$3,004	\$0,114	\$3,867	\$1,297	\$0,240	\$0,009	\$8,329	\$15,625	-\$10,033	-\$3,511	\$9,104	0.897	\$8,166	1
14			47	40	1	6	37	\$17.34	\$5.20	\$3.50	\$15,576	\$2,885	\$0,110	\$3,714	\$1,246	\$0,231	\$0,009	\$8,000	\$15,625	-\$10,254	-\$3,589	\$8,960	0.891	\$7,982	1
15			42	36	1	5	33	\$17.34	\$5.20	\$3.50	\$14,960	\$2,771	\$0,106	\$3,567	\$1,197	\$0,222	\$0,008	\$7,683	\$15,625	-\$10,466	-\$3,663	\$8,822	0.885	\$7,806	1
16			38	32	1	5	30	\$17.34	\$5.20	\$3.50	\$14,368	\$2,661	\$0,101	\$3,426	\$1,149	\$0,213	\$0,008	\$7,379	\$15,625	-\$10,670	-\$3,735	\$8,689	0.879	\$7,636	1
17			37	31	1	5	29	\$17.34	\$5.20	\$3.50	\$13,799	\$2,556	\$0,097	\$3,290	\$1,104	\$0,204	\$0,008	\$7,087	\$15,625	-\$10,867	-\$3,803	\$8,562	0.873	\$7,473	1
18			35	30	1	5	27	\$17.34	\$5.20	\$3.50	\$13,253	\$2,455	\$0,094	\$3,160	\$1,060	\$0,196	\$0,007	\$6,807	\$15,625	-\$11,055	-\$3,869	\$8,439	0.867	\$7,317	1
19			34	29	1	4	26	\$17.34	\$5.20	\$3.50	\$12,729	\$2,358	\$0,090	\$3,035	\$1,018	\$0,189	\$0,007	\$6,537	\$15,625	-\$11,236	-\$3,932	\$8,322	0.861	\$7,166	1
20			31	27	1	4	24	\$17.34	\$5.20	\$3.50	\$12,225	\$2,264	\$0,086	\$2,915	\$0,978	\$0,181	\$0,007	\$6,279	\$15,625	-\$11,409	-\$3,993	\$8,209	0.855	\$7,021	1
21			29	24	1	4	22	\$17.34	\$5.20	\$3.50	\$11,741	\$2,175	\$0,083	\$2,800	\$0,939	\$0,174	\$0,007	\$6,030	\$15,625	-\$11,576	-\$4,052	\$8,100	0.849	\$6,881	1
22			28	24	1	4	22	\$17.34	\$5.20	\$3.50	\$11,277	\$2,089	\$0,080	\$2,689	\$0,902	\$0,167	\$0,006	\$5,792	\$15,625	-\$11,736	-\$4,108	\$7,996	0.844	\$6,747	1
23			27	23	1	3	21	\$17.34	\$5.20	\$3.50	\$10,830	\$2,006	\$0,076	\$2,583	\$0,866	\$0,160	\$0,006	\$5,562	\$15,625	-\$11,890	-\$4,162	\$7,896	0.838	\$6,617	1
24			24	21	0	3	19	\$17.34	\$5.20	\$3.50	\$10,402	\$1,927	\$0,073	\$2,480	\$0,832	\$0,154	\$0,006	\$5,342	\$15,625	-\$12,038	-\$4,213	\$7,800	0.832	\$6,492	1
25			23	19	0	3	18	\$17.34	\$5.20	\$3.50	\$10,046	\$1,861	\$0,071	\$2,396	\$0,804	\$0,149	\$0,006	\$5,160	\$15,625	-\$12,161	-\$4,256	\$7,721	0.827	\$6,382	1
26			22	19	0	3	17	\$17.34	\$5.20	\$3.50	\$9,703	\$1,797	\$0,068	\$2,314	\$0,776	\$0,144	\$0,005	\$4,983	\$15,625	-\$12,279	-\$4,298	\$7,644	0.821	\$6,276	1
27			21	18	0	3	17	\$17.34	\$5.20	\$3.50	\$9,371	\$1,736	\$0,066	\$2,235	\$0,750	\$0,139	\$0,005	\$4,813	\$15,625	-\$12,393	-\$4,338	\$7,569	0.816	\$6,173	1
28			20	17	0	3	16	\$17.34	\$5.20	\$3.50	\$9,051	\$1,676	\$0,064	\$2,158	\$0,724	\$0,134	\$0,005	\$4,649	\$15,625	-\$12,504	-\$4,376	\$7,497	0.810	\$6,073	1
29			20	17	0	3	15	\$17.34	\$5.20	\$3.50	\$8,742	\$1,619	\$0,062	\$2,085	\$0,699	\$0,130	\$0,005	\$4,490	\$15,625	-\$12,611	-\$4,414	\$7,428	0.804	\$5,976	1
30			19	16	0	2	15	\$17.34	\$5.20	\$3.50	\$8,443	\$1,564	\$0,060	\$2,013	\$0,675	\$0,125	\$0,005	\$4,336	\$15,625	-\$12,714	-\$4,450	\$7,361	0.799	\$5,882	1
31			18	16	0	2	14	\$17.34	\$5.20	\$3.50	\$8,154	\$1,510	\$0,058	\$1,944	\$0,652	\$0,121	\$0,005	\$4,188	\$15,625	-\$12,813	-\$4,485	\$7,297	0.794	\$5,791	1
32			18	15	0	2	14	\$17.34	\$5.20	\$3.50	\$7,876	\$1,459	\$0,056	\$1,878	\$0,630	\$0,117	\$0,004	\$4,045	\$15,625	-\$12,909	-\$4,518	\$7,234	0.788	\$5,702	1
33			17	15	0	2	13	\$17.34	\$5.20	\$3.50	\$7,607	\$1,409	\$0,054	\$1,814	\$0,609	\$0,113	\$0,004	\$3,907	\$15,625	-\$13,002	-\$4,551	\$7,174	0.783	\$5,616	1
34			17	14	0	2	13	\$17.34	\$5.20	\$3.50	\$7,347	\$1,361	\$0,052	\$1,752	\$0,588	\$0,109	\$0,004	\$3,773	\$15,625	-\$13,092	-\$4,582	\$7,115	0.778	\$5,533	1
35			16	14	0	2	13	\$17.34	\$5.20	\$3.50	\$7,096	\$1,314	\$0,050	\$1,692	\$0,568	\$0,105	\$0,004	\$3,644	\$15,625	-\$13,178	-\$4,612	\$7,059	0.772	\$5,452	1
36			15	14	0	2	12	\$17.34	\$5.20	\$3.50	\$6,853	\$1,269	\$0,048	\$1,634	\$0,548	\$0,102	\$0,004	\$3,520	\$15,625	-\$13,262	-\$4,642	\$7,005	0.767	\$5,373	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Bakken Non-Core

Bakken: Non Core				My Assumptions:			
Basin Characteristics				oilfield service & supply factor price scalar			
\$6.50 cost/well (\$mm)	Average Well	100%	30	days/month			
193 EUR/well (mboe)	IP	EUR	655	558	-0.82%	exponential decline rate after year 3 (monthly)	
-75% 1st yr decline	-10.9%	165	\$100.00	oil price WTI (\$/bbl)			
-30% 2nd yr decline	-3.0%	115	0%	oil price appreciation (per month)			
-24% 3rd yr decline	-2.3%	100	\$3.50	gas price Henry Hub (\$/mcf)			
227 IP rate (boe/d)			0%	gas price appreciation			
\$9.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
88% % oil			0.68%	discount rate (compound monthly)			
9% % gas			8.5%	discount rate (annual)			
3% % NGL			80%	intangible drilling cost / total capex			
20.0% royalty rate			1.174	IP/EUR ratio, (B8/B4 = fixed ratio)			
10.0% oil prod tax	Results						
10.0% gas prod tax	-\$1.606 = NPV/well (\$ million)						
10.0% NGL prod tax	0 = EUR check (mboe)						
35.0% income tax rate	0.14% = ATIRR (monthly)						
-13.3% oil differential	1.67% = ATIRR (annual)						
0% gas differential	193 = total production (mboe)						
0 1 = DUC	\$2.364 = "tail end" NPV/well (\$ million)						
25% auxiliary cost/well cost	100% = "tail end" recovery factor						
50% completion cost/well cost	0 = months of lost production						
\$2,000 min opex (\$/month)							

Bakken: Non Core					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	3,787	4,445	1,880	2,207	
\$25	2,101	2,466	1,043	1,224	
\$30	1,454	1,707	722	848	
\$35	1,112	1,305	552	648	
\$40	900	1,056	447	525	
\$45	756	887	375	440	
\$50	652	765	324	380	
\$60	511	600	254	298	
\$70	420	493	209	245	
\$80	357	419	178	209	
\$90	310	364	154	181	
\$100	274	322	137	161	

Bakken: Non Core					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	35,582	41,767	17,661	20,731	
\$25	5,338	6,266	2,650	3,111	
\$30	2,886	3,388	1,432	1,681	
\$35	1,977	2,321	981	1,152	
\$40	1,504	1,765	746	876	
\$45	1,213	1,424	602	707	
\$50	1,017	1,194	505	593	
\$60	768	902	381	447	
\$70	617	724	306	359	
\$80	516	606	256	301	
\$90	443	520	220	258	
\$100	388	455	193	227	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)										Active 1/0			
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax, Inc.		Income Tax	NCF	PV Factor
1	\$1,625	\$406						\$86.70	\$26.01	\$3.50	\$518.500	\$12.844	\$5.303	\$107.33	\$41.48	\$1.03	\$0.42	\$61.163	\$13.542	\$311.681	\$109.088	\$216.134	0.973	\$210.336	1
2	\$1,625	\$406						\$86.70	\$26.01	\$3.50	\$462.224	\$11.450	\$4.727	\$95.680	\$36.978	\$0.916	\$0.378	\$54.525	\$13.542	\$276.383	\$96.734	\$193.190	0.967	\$186.734	1
3	\$1,625	\$406						\$86.70	\$26.01	\$3.50	\$412.056	\$10.207	\$4.214	\$85.295	\$32.964	\$0.817	\$0.337	\$48.607	\$13.542	\$244.915	\$85.720	\$172.737	0.960	\$165.832	1
4	\$1,625	\$406						\$86.70	\$26.01	\$3.50	\$367.332	\$9.100	\$3.757	\$76.038	\$29.387	\$0.728	\$0.301	\$43.331	\$13.542	\$216.863	\$75.902	\$154.503	0.954	\$147.322	1
5			227	199	7	20	122	\$86.70	\$26.01	\$3.50	\$327.463	\$8.112	\$3.349	\$67.785	\$26.197	\$0.649	\$0.268	\$38.628	\$13.542	\$191.856	\$67.150	\$138.248	0.947	\$130.930	1
6			202	178	6	18	109	\$86.70	\$26.01	\$3.50	\$291.922	\$7.231	\$2.986	\$60.428	\$23.354	\$0.579	\$0.239	\$34.436	\$13.542	\$169.563	\$59.347	\$113.757	0.941	\$116.412	1
7			180	158	5	16	97	\$86.70	\$26.01	\$3.50	\$260.238	\$6.447	\$2.662	\$53.869	\$20.819	\$0.516	\$0.213	\$30.698	\$13.542	\$149.689	\$52.391	\$110.840	0.934	\$103.555	1
8			160	141	5	14	87	\$86.70	\$26.01	\$3.50	\$231.992	\$5.747	\$2.373	\$48.022	\$18.559	\$0.460	\$0.190	\$27.366	\$13.542	\$131.973	\$46.190	\$99.324	0.928	\$92.167	1
9			143	126	4	13	77	\$86.70	\$26.01	\$3.50	\$206.813	\$5.123	\$2.115	\$42.810	\$16.545	\$0.410	\$0.169	\$24.396	\$13.542	\$116.179	\$40.663	\$89.058	0.922	\$82.081	1
10			128	112	4	11	69	\$86.70	\$26.01	\$3.50	\$184.366	\$4.567	\$1.886	\$38.164	\$14.749	\$0.365	\$0.151	\$21.748	\$13.542	\$102.100	\$35.735	\$79.906	0.915	\$73.147	1
11			114	100	3	10	61	\$86.70	\$26.01	\$3.50	\$164.355	\$4.071	\$1.681	\$34.022	\$13.148	\$0.326	\$0.134	\$19.388	\$13.542	\$89.548	\$31.342	\$71.748	0.909	\$65.234	1
12			101	89	3	9	55	\$86.70	\$26.01	\$3.50	\$146.517	\$3.630	\$1.498	\$30.329	\$11.721	\$0.290	\$0.120	\$17.283	\$13.542	\$78.359	\$27.426	\$64.475	0.903	\$58.224	1
13			90	80	3	8	49	\$86.70	\$26.01	\$3.50	\$142.175	\$3.522	\$1.454	\$29.430	\$11.374	\$0.282	\$0.116	\$16.771	\$13.542	\$75.636	\$26.472	\$62.705	0.897	\$56.242	1
14			81	71	2	7	43	\$86.70	\$26.01	\$3.50	\$137.961	\$3.418	\$1.411	\$28.558	\$11.037	\$0.273	\$0.113	\$16.274	\$13.542	\$72.993	\$25.547	\$60.987	0.891	\$54.331	1
15			72	63	2	6	39	\$86.70	\$26.01	\$3.50	\$133.872	\$3.316	\$1.369	\$27.712	\$10.710	\$0.265	\$0.110	\$15.792	\$13.542	\$70.428	\$24.650	\$59.320	0.885	\$52.488	1
16			64	56	2	6	35	\$86.70	\$26.01	\$3.50	\$129.905	\$3.218	\$1.329	\$26.890	\$10.392	\$0.257	\$0.106	\$15.324	\$13.542	\$67.940	\$23.779	\$57.702	0.879	\$50.710	1
17			62	55	2	6	34	\$86.70	\$26.01	\$3.50	\$126.055	\$3.123	\$1.289	\$26.093	\$10.084	\$0.250	\$0.103	\$14.870	\$13.542	\$65.525	\$22.934	\$56.133	0.873	\$48.997	1
18			60	53	2	5	33	\$86.70	\$26.01	\$3.50	\$122.319	\$3.030	\$1.251	\$25.320	\$9.786	\$0.242	\$0.100	\$14.429	\$13.542	\$63.182	\$22.114	\$54.610	0.867	\$47.344	1
19			58	51	2	5	32	\$86.70	\$26.01	\$3.50	\$118.694	\$2.940	\$1.214	\$24.570	\$9.496	\$0.235	\$0.097	\$14.001	\$13.542	\$60.908	\$21.318	\$53.132	0.861	\$45.751	1
20			55	48	2	5	30	\$86.70	\$26.01	\$3.50	\$115.176	\$2.853	\$1.178	\$23.842	\$9.214	\$0.228	\$0.094	\$13.586	\$13.542	\$58.701	\$20.545	\$51.698	0.855	\$44.214	1
21			53	47	2	5	29	\$86.70	\$26.01	\$3.50	\$111.763	\$2.769	\$1.143	\$23.135	\$8.941	\$0.221	\$0.091	\$13.184	\$13.542	\$56.560	\$19.796	\$50.306	0.849	\$42.733	1
22			52	46	2	5	28	\$86.70	\$26.01	\$3.50	\$108.451	\$2.687	\$1.109	\$22.449	\$8.676	\$0.215	\$0.089	\$12.793	\$13.542	\$54.483	\$19.069	\$48.955	0.844	\$41.304	1
23			49	43	1	4	26	\$86.70	\$26.01	\$3.50	\$105.237	\$2.607	\$1.076	\$21.784	\$8.419	\$0.209	\$0.086	\$12.414	\$13.542	\$52.467	\$18.363	\$47.645	0.838	\$39.926	1
24			46	40	1	4	25	\$86.70	\$26.01	\$3.50	\$102.118	\$2.530	\$1.044	\$21.138	\$8.169	\$0.202	\$0.084	\$12.046	\$13.542	\$50.511	\$17.679	\$46.373	0.832	\$38.597	1
25			44	38	1	4	24	\$86.70	\$26.01	\$3.50	\$99.767	\$2.471	\$1.020	\$20.652	\$7.981	\$0.198	\$0.082	\$11.769	\$13.542	\$49.036	\$17.163	\$45.415	0.827	\$37.543	1
26			43	37	1	4	23	\$86.70	\$26.01	\$3.50	\$97.470	\$2.415	\$0.997	\$20.176	\$7.798	\$0.193	\$0.080	\$11.498	\$13.542	\$47.595	\$16.658	\$44.478	0.821	\$36.520	1
27			42	37	1	4	22	\$86.70	\$26.01	\$3.50	\$95.225	\$2.359	\$0.974	\$19.712	\$7.618	\$0.189	\$0.078	\$11.233	\$13.542	\$46.187	\$16.166	\$43.563	0.816	\$35.526	1
28			41	36	1	4	22	\$86.70	\$26.01	\$3.50	\$93.033	\$2.305	\$0.951	\$19.258	\$7.443	\$0.184	\$0.076	\$10.974	\$13.542	\$44.812	\$15.684	\$42.670	0.810	\$34.561	1
29			40	35	1	4	21	\$86.70	\$26.01	\$3.50	\$90.891	\$2.252	\$0.930	\$18.814	\$7.271	\$0.180	\$0.074	\$10.722	\$13.542	\$43.469	\$15.214	\$41.796	0.804	\$33.625	1
30			39	34	1	3	21	\$86.70	\$26.01	\$3.50	\$88.798	\$2.200	\$0.908	\$18.381	\$7.104	\$0.176	\$0.073	\$10.475	\$13.542	\$42.156	\$14.755	\$40.943	0.799	\$32.715	1
31			38	33	1	3	20	\$86.70	\$26.01	\$3.50	\$86.754	\$2.149	\$0.887	\$17.958	\$6.940	\$0.172	\$0.071	\$10.234	\$13.542	\$40.873	\$14.306	\$40.109	0.794	\$31.832	1
32			37	33	1	3	20	\$86.70	\$26.01	\$3.50	\$84.756	\$2.100	\$0.867	\$17.545	\$6.780	\$0.168	\$0.069	\$9.998	\$13.542	\$39.621	\$13.867	\$39.295	0.788	\$30.974	1
33			36	32	1	3	20	\$86.70	\$26.01	\$3.50	\$82.805	\$2.051	\$0.847	\$17.141	\$6.624	\$0.164	\$0.068	\$9.768	\$13.542	\$38.397	\$13.439	\$38.499	0.783	\$30.142	1
34			35	31	1	3	19	\$86.70	\$26.01	\$3.50	\$80.898	\$2.004	\$0.827	\$16.746	\$6.472	\$0.160	\$0.066	\$9.543	\$13.542	\$37.201	\$13.020	\$37.722	0.778	\$29.333	1
35			35	30	1	3	19	\$86.70	\$26.01	\$3.50	\$79.036	\$1.958	\$0.808	\$16.360	\$6.323	\$0.157	\$0.065	\$9.323	\$13.542	\$36.032	\$12.611	\$36.963	0.772	\$28.548	1
36			34	30	1	3	18	\$86.70	\$26.01	\$3.50	\$77.216	\$1.913	\$0.790	\$15.984	\$6.177	\$0.153	\$0.063	\$9.108	\$13.542	\$34.891	\$12.212	\$36.221	0.767	\$27.785	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Springer

Springer			My Assumptions:		
Basin Characteristics			100% oilfield service & supply factor price scalar		
\$9.00 cost/well (\$mm)	Average Well IP	EUR	30	days/month	
1,318 EUR/well (mboe)	720	904	-1.08%	exponential decline rate after year 3 (monthly)	
-47% 1st yr decline	-5.1%	385	\$20.00	oil price WTI (\$/bbl)	
-36% 2nd yr decline	-3.6%	247	0%	oil price appreciation (per month)	
-26% 3rd yr decline	-2.5%	212	\$3.50	gas price Henry Hub (\$/mcf)	
1,050 IP rate (boe/d)			0%	gas price appreciation	
\$6.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)	
68% oil			0.68%	discount rate (compound monthly)	
16% gas			8.5%	discount rate (annual)	
17% NGL			80%	intangible drilling cost / total capex	
20.0% royalty rate			0.79%	IP/EUR ratio, (B8/B4 = fixed ratio)	
7.0% oil prod tax					
7.0% gas prod tax					
7.0% NGL prod tax					
35.0% income tax rate					
-6% oil differential					
-6% gas differential					
0 1 = DUC					
25% auxiliary cost/well cost					
50% completion cost/well cost					
\$2,000 min opex (\$/month)					

Results	
-\$3.773	= NPV/well (\$ million)
0	= EUR check (mboe)
-0.29%	= ATIRR (monthly)
-3.40%	= ATIRR (annual)
1,318	= total production (mboe)
\$2.440	= "tail end" NPV/well (\$ million)
100%	= "tail end" recovery factor
0	= months of lost production

Springer					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	2,655	2,115	1,318	1,050	
\$25	1,911	1,522	949	756	
\$30	1,493	1,189	742	591	
\$35	1,225	976	609	485	
\$40	1,039	828	517	412	
\$45	902	718	449	358	
\$50	797	635	396	315	
\$60	646	515	322	256	
\$70	544	433	271	216	
\$80	469	374	234	186	
\$90	413	329	206	164	
\$100	368	293	184	147	

Springer					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	5,052	4,024	2508	1,998	
\$25	3,246	2,585	1611	1,283	
\$30	2,391	1,904	1187	945	
\$35	1,893	1,508	940	749	
\$40	1,566	1,247	778	620	
\$45	1,336	1,064	663	528	
\$50	1,165	928	578	460	
\$60	927	738	461	367	
\$70	770	613	383	305	
\$80	658	524	327	260	
\$90	575	458	286	228	
\$100	510	406	254	202	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d			Prices				Cash Flows (\$1,000)							PV Factor	AT NPV -\$3.773	Active 1/0		
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.				Income Tax	NCF
1	\$2,250	\$563						\$18.80	\$5.64	\$3.29	\$402.524	\$99.447	\$30.189	\$106.43	\$22.54	\$5.57	\$1.69	\$188.919	\$18.750	\$188.258	\$65.890	\$141.118	0.973	\$137.332	1
2	\$2,250	\$563						\$18.80	\$5.64	\$3.29	\$382.063	\$94.392	\$28.655	\$101.022	\$21.396	\$5.286	\$1.605	\$179.316	\$18.750	\$177.736	\$62.207	\$134.278	0.967	\$129.791	1
3	\$2,250	\$563						\$18.80	\$5.64	\$3.29	\$362.643	\$89.594	\$27.198	\$95.887	\$20.308	\$5.017	\$1.523	\$170.202	\$18.750	\$167.748	\$58.712	\$127.786	0.960	\$122.679	1
4	\$2,250	\$563						\$18.80	\$5.64	\$3.29	\$344.210	\$85.040	\$25.816	\$91.013	\$19.276	\$4.762	\$1.446	\$163.550	\$18.750	\$158.269	\$55.394	\$121.625	0.954	\$115.972	1
5			1050	714	178	168	1,008	\$18.80	\$5.64	\$3.29	\$326.714	\$80.718	\$24.504	\$86.387	\$18.296	\$4.520	\$1.372	\$153.339	\$18.750	\$149.271	\$52.245	\$115.776	0.947	\$109.647	1
6			996	677	169	159	956	\$18.80	\$5.64	\$3.29	\$310.107	\$76.615	\$23.258	\$81.996	\$17.366	\$4.290	\$1.302	\$145.545	\$18.750	\$140.730	\$49.256	\$110.225	0.941	\$103.683	1
7			946	643	161	151	908	\$18.80	\$5.64	\$3.29	\$294.344	\$72.720	\$22.076	\$77.828	\$16.483	\$4.072	\$1.236	\$138.147	\$18.750	\$132.624	\$46.418	\$104.956	0.934	\$98.057	1
8			898	610	153	144	862	\$18.80	\$5.64	\$3.29	\$279.383	\$69.024	\$20.954	\$73.872	\$15.645	\$3.865	\$1.173	\$131.125	\$18.750	\$124.930	\$43.725	\$99.954	0.928	\$92.752	1
9			852	579	145	136	818	\$18.80	\$5.64	\$3.29	\$265.182	\$65.515	\$19.889	\$70.117	\$14.850	\$3.669	\$1.114	\$124.459	\$18.750	\$117.626	\$41.169	\$95.207	0.922	\$87.748	1
10			809	550	137	129	776	\$18.80	\$5.64	\$3.29	\$251.702	\$62.185	\$18.878	\$66.553	\$14.095	\$3.482	\$1.057	\$118.133	\$18.750	\$110.694	\$38.743	\$90.701	0.915	\$83.029	1
11			767	522	130	123	737	\$18.80	\$5.64	\$3.29	\$238.908	\$59.024	\$17.918	\$63.170	\$13.379	\$3.305	\$1.003	\$112.128	\$18.750	\$104.115	\$36.440	\$86.425	0.909	\$78.578	1
12			728	495	124	117	699	\$18.80	\$5.64	\$3.29	\$226.765	\$56.024	\$17.007	\$59.959	\$12.699	\$3.137	\$0.952	\$106.429	\$18.750	\$97.869	\$34.254	\$82.365	0.903	\$74.380	1
13			691	470	118	111	664	\$18.80	\$5.64	\$3.29	\$218.530	\$53.990	\$16.300	\$57.782	\$12.238	\$3.023	\$0.918	\$102.564	\$18.750	\$93.635	\$32.772	\$79.613	0.897	\$71.407	1
14			656	446	112	105	630	\$18.80	\$5.64	\$3.29	\$210.595	\$52.029	\$15.795	\$55.684	\$11.793	\$2.914	\$0.884	\$98.840	\$18.750	\$89.554	\$31.344	\$76.960	0.891	\$68.560	1
15			623	424	106	100	598	\$18.80	\$5.64	\$3.29	\$202.948	\$50.140	\$15.221	\$53.662	\$11.365	\$2.808	\$0.852	\$95.251	\$18.750	\$85.621	\$29.967	\$74.404	0.885	\$65.834	1
16			591	402	101	95	568	\$18.80	\$5.64	\$3.29	\$195.578	\$48.319	\$14.668	\$51.713	\$10.952	\$2.706	\$0.821	\$91.792	\$18.750	\$81.831	\$28.641	\$71.940	0.879	\$63.223	1
17			570	387	97	91	547	\$18.80	\$5.64	\$3.29	\$188.477	\$46.565	\$14.136	\$49.835	\$10.555	\$2.608	\$0.792	\$88.459	\$18.750	\$78.179	\$27.363	\$69.566	0.873	\$60.722	1
18			549	373	93	88	527	\$18.80	\$5.64	\$3.29	\$181.633	\$44.874	\$13.622	\$48.026	\$10.171	\$2.513	\$0.763	\$85.241	\$18.750	\$74.659	\$26.131	\$67.278	0.867	\$58.328	1
19			529	360	90	85	508	\$18.80	\$5.64	\$3.29	\$175.037	\$43.244	\$13.128	\$46.282	\$9.802	\$2.422	\$0.735	\$82.151	\$18.750	\$71.267	\$24.944	\$65.074	0.861	\$56.034	1
20			510	347	87	82	490	\$18.80	\$5.64	\$3.29	\$168.681	\$41.674	\$12.651	\$44.601	\$9.446	\$2.334	\$0.708	\$79.168	\$18.750	\$67.998	\$23.799	\$62.949	0.855	\$53.837	1
21			491	334	84	79	472	\$18.80	\$5.64	\$3.29	\$162.556	\$40.161	\$12.192	\$42.982	\$9.103	\$2.249	\$0.683	\$76.293	\$18.750	\$64.848	\$22.697	\$60.901	0.849	\$51.733	1
22			474	322	81	76	455	\$18.80	\$5.64	\$3.29	\$156.653	\$38.703	\$11.749	\$41.421	\$8.773	\$2.167	\$0.658	\$73.523	\$18.750	\$61.813	\$21.634	\$58.928	0.844	\$49.718	1
23			456	310	78	73	438	\$18.80	\$5.64	\$3.29	\$150.965	\$37.297	\$11.322	\$39.917	\$8.454	\$2.089	\$0.634	\$70.853	\$18.750	\$58.887	\$20.611	\$57.027	0.838	\$47.788	1
24			440	299	75	70	422	\$18.80	\$5.64	\$3.29	\$145.483	\$35.943	\$10.911	\$38.467	\$8.147	\$2.013	\$0.611	\$68.280	\$18.750	\$56.068	\$19.624	\$55.194	0.832	\$45.939	1
25			424	288	72	68	407	\$18.80	\$5.64	\$3.29	\$141.825	\$35.039	\$10.637	\$37.500	\$7.942	\$1.962	\$0.596	\$66.563	\$18.750	\$54.187	\$18.965	\$53.971	0.827	\$44.616	1
26			408	278	69	65	392	\$18.80	\$5.64	\$3.29	\$138.258	\$34.158	\$10.369	\$36.557	\$7.742	\$1.913	\$0.581	\$64.890	\$18.750	\$52.353	\$18.323	\$52.779	0.821	\$43.335	1
27			394	268	67	63	378	\$18.80	\$5.64	\$3.29	\$134.782	\$33.299	\$10.109	\$35.638	\$7.548	\$1.865	\$0.566	\$63.258	\$18.750	\$50.565	\$17.698	\$51.617	0.816	\$42.094	1
28			379	258	64	61	364	\$18.80	\$5.64	\$3.29	\$131.393	\$32.462	\$9.854	\$34.742	\$7.358	\$1.818	\$0.552	\$61.667	\$18.750	\$48.822	\$17.088	\$50.484	0.810	\$40.891	1
29			360	245	61	58	346	\$18.80	\$5.64	\$3.29	\$128.089	\$31.645	\$9.607	\$33.868	\$7.173	\$1.772	\$0.538	\$60.117	\$18.750	\$47.123	\$16.493	\$49.380	0.804	\$39.726	1
30			351	239	60	56	337	\$18.80	\$5.64	\$3.29	\$124.868	\$30.850	\$9.365	\$33.017	\$6.993	\$1.728	\$0.524	\$58.605	\$18.750	\$45.466	\$15.913	\$48.303	0.799	\$38.596	1
31			343	233	58	55	329	\$18.80	\$5.64	\$3.29	\$121.728	\$30.074	\$9.130	\$32.186	\$6.817	\$1.684	\$0.511	\$57.131	\$18.750	\$43.852	\$15.348	\$47.254	0.794	\$37.502	1
32			334	227	57	53	321	\$18.80	\$5.64	\$3.29	\$118.667	\$29.318	\$8.900	\$31.377	\$6.645	\$1.642	\$0.498	\$55.695	\$18.750	\$42.278	\$14.797	\$46.230	0.788	\$36.441	1
33			326	221	55	52	313	\$18.80	\$5.64	\$3.29	\$115.683	\$28.581	\$8.676	\$30.588	\$6.478	\$1.601	\$0.486	\$54.294	\$18.750	\$40.743	\$14.260	\$45.233	0.783	\$35.413	1
34			317	216	54	51	305	\$18.80	\$5.64	\$3.29	\$112.774	\$27.862	\$8.458	\$29.819	\$6.315	\$1.560	\$0.474	\$52.929	\$18.750	\$39.247	\$13.736	\$44.261	0.778	\$34.417	1
35			309	210	53	50	297	\$18.80	\$5.64	\$3.29	\$109.938	\$27.161	\$8.245	\$29.069	\$6.157	\$1.521	\$0.462	\$51.598	\$18.750	\$37.789	\$13.226	\$43.313	0.772		

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

STACK

STACK				My Assumptions:			
Basin Characteristics				100% oilfield service & supply factor price scalar			
Average Well				30 days/month			
IP				EUR			
826				940			
100 EUR/well (mboe)				-0.91% exponential decline rate after year 3 (monthly)			
-56% 1st yr decline				-6.6%			
-33% 2nd yr decline				-3.3%			
-33% 3rd yr decline				-3.3%			
88 IP rate (boe/d)							
\$2.50 opex-LOE (\$/boe)				30% NGL price/oil price (fixed ratio)			
40% oil				0.68% discount rate (compound monthly)			
30% gas				8.5% discount rate (annual)			
30% NGL				80% intangible drilling cost / total capex			
20.0% royalty rate				0.879 IP/EUR ratio, (B8/B4 = fixed ratio)			
7.0% oil prod tax							
7.0% gas prod tax							
7.0% NGL prod tax							
35.0% income tax rate							
-6% oil differential							
-6% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Results	
-56.777	= NPV/well (\$ million)
0	= EUR check (mboe)
-2.64%	= ATIRR (monthly)
-27.47%	= ATIRR (annual)
100	= total production (mboe)
\$0.510	= "tail end" NPV/well (\$ million)
72%	= "tail end" recovery factor
195	= months of lost production

STACK					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	1,927	1,693	958	842	
\$25	1,612	1,417	802	705	
\$30	1,385	1,217	690	606	
\$35	1,215	1,068	605	532	
\$40	1,082	951	539	474	
\$45	975	857	486	427	
\$50	887	779	443	389	
\$60	752	661	376	330	
\$70	653	574	326	286	
\$80	577	507	288	253	
\$90	517	454	259	228	
\$100	468	411	234	206	

STACK					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,829	2,486	1404	1,234	
\$25	2,326	2,044	1155	1,015	
\$30	1,976	1,736	981	862	
\$35	1,717	1,509	853	750	
\$40	1,518	1,334	754	663	
\$45	1,360	1,195	676	594	
\$50	1,232	1,083	613	539	
\$60	1,037	911	516	453	
\$70	896	787	446	392	
\$80	788	692	392	344	
\$90	704	619	350	308	
\$100	636	559	317	279	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)			Production (boe/d)				mcf/d			Prices				Cash Flows (\$1,000)						PV Factor	AT NPV	Active 1/0		
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.				Income Tax	NCF
1	\$2,125	\$531						\$18.80	\$5.64	\$3.29								\$2,125,000	\$2,125,000	-\$743,750	-1,913	1,000	-\$1,912,500		
2	\$2,125	\$531						\$18.80	\$5.64	\$3.29								\$2,125,000	\$2,125,000	-\$743,750	-1,913	0.993	-\$1,899,540		
3	\$2,125	\$531						\$18.80	\$5.64	\$3.29								\$2,125,000	\$2,125,000	-\$743,750	-1,913	0.986	-\$1,886,670		
4	\$2,125	\$531						\$18.80	\$5.64	\$3.29								\$2,125,000	\$2,125,000	-\$743,750	-1,913	0.980	-\$1,873,890		
5			88	35	26	26	158	\$18.80	\$5.64	\$3.29	\$19,824	\$15,611	\$4,460	\$7.98	\$1.11	\$0.87	\$0.25	\$6,590	\$17,708	\$5,384	\$1,884	\$21,208	0.973	\$20,639	1
6			82	33	25	25	148	\$18.80	\$5.64	\$3.29	\$18,511	\$14,578	\$4,165	\$7,451	\$1,037	\$0.816	\$0.233	\$6,154	\$17,708	\$3,855	\$1,349	\$20,214	0.967	\$19,538	1
7			77	31	23	23	138	\$18.80	\$5.64	\$3.29	\$17,285	\$13,612	\$3,889	\$6,957	\$0,968	\$0.762	\$0.218	\$5,746	\$17,708	\$2,427	\$0,849	\$19,286	0.960	\$18,515	1
8			72	29	21	21	129	\$18.80	\$5.64	\$3.29	\$16,141	\$12,711	\$3,632	\$6,497	\$0,904	\$0.712	\$0.203	\$5,366	\$17,708	\$1,093	\$0,383	\$18,419	0.954	\$17,563	1
9			67	27	20	20	120	\$18.80	\$5.64	\$3.29	\$15,072	\$11,869	\$3,391	\$6,066	\$0,844	\$0.665	\$0.190	\$5,011	\$17,708	-\$0,152	-\$0,053	\$17,610	0.947	\$16,677	1
10			62	25	19	19	112	\$18.80	\$5.64	\$3.29	\$14,074	\$11,083	\$3,167	\$5,665	\$0,788	\$0.621	\$0.177	\$4,679	\$17,708	-\$1,314	-\$0,460	\$16,854	0.941	\$15,854	1
11			58	23	17	17	105	\$18.80	\$5.64	\$3.29	\$13,142	\$10,349	\$2,957	\$5,290	\$0,736	\$0.580	\$0.166	\$4,369	\$17,708	-\$2,400	-\$0,840	\$16,148	0.934	\$15,087	1
12			54	22	16	16	98	\$18.80	\$5.64	\$3.29	\$12,272	\$9,664	\$2,761	\$4,939	\$0,687	\$0.541	\$0.155	\$4,080	\$17,708	-\$3,414	-\$1,195	\$15,489	0.928	\$14,373	1
13			51	20	15	15	91	\$18.80	\$5.64	\$3.29	\$11,459	\$9,024	\$2,578	\$4,612	\$0,642	\$0.505	\$0.144	\$3,809	\$17,708	-\$4,360	-\$1,526	\$14,874	0.922	\$13,709	1
14			47	19	14	14	85	\$18.80	\$5.64	\$3.29	\$10,700	\$8,426	\$2,408	\$4,307	\$0,599	\$0.472	\$0.135	\$3,557	\$17,708	-\$5,244	-\$1,836	\$14,300	0.915	\$13,090	1
15			44	18	13	13	80	\$18.80	\$5.64	\$3.29	\$9,991	\$7,868	\$2,248	\$4,022	\$0,560	\$0.441	\$0.126	\$3,322	\$17,708	-\$6,070	-\$2,124	\$13,763	0.909	\$12,514	1
16			41	17	12	12	74	\$18.80	\$5.64	\$3.29	\$9,330	\$7,347	\$2,099	\$3,755	\$0,522	\$0.411	\$0.118	\$3,102	\$17,708	-\$6,840	-\$2,394	\$13,262	0.903	\$11,976	1
17			40	16	12	12	72	\$18.80	\$5.64	\$3.29	\$8,026	\$7,108	\$2,031	\$3,633	\$0,505	\$0.398	\$0.114	\$3,001	\$17,708	-\$7,194	-\$2,518	\$13,032	0.897	\$11,689	1
18			39	15	12	12	70	\$18.80	\$5.64	\$3.29	\$8,732	\$6,877	\$1,965	\$3,515	\$0,489	\$0.385	\$0.110	\$2,903	\$17,708	-\$7,537	-\$2,638	\$12,810	0.891	\$11,411	1
19			37	15	11	11	67	\$18.80	\$5.64	\$3.29	\$8,448	\$6,653	\$1,901	\$3,400	\$0,473	\$0.373	\$0.106	\$2,808	\$17,708	-\$7,868	-\$2,754	\$12,594	0.885	\$11,144	1
20			36	14	11	11	65	\$18.80	\$5.64	\$3.29	\$8,173	\$6,436	\$1,839	\$3,290	\$0,458	\$0.360	\$0.103	\$2,717	\$17,708	-\$8,188	-\$2,866	\$12,386	0.879	\$10,885	1
21			35	14	11	11	63	\$18.80	\$5.64	\$3.29	\$7,907	\$6,226	\$1,779	\$3,182	\$0,443	\$0.349	\$0.100	\$2,629	\$17,708	-\$8,498	-\$2,974	\$12,184	0.873	\$10,635	1
22			34	14	10	10	61	\$18.80	\$5.64	\$3.29	\$7,649	\$6,024	\$1,721	\$3,079	\$0,428	\$0.337	\$0.096	\$2,543	\$17,708	-\$8,798	-\$3,079	\$11,990	0.867	\$10,394	1
23			33	13	10	10	59	\$18.80	\$5.64	\$3.29	\$7,400	\$5,828	\$1,665	\$2,979	\$0,414	\$0.326	\$0.093	\$2,460	\$17,708	-\$9,088	-\$3,181	\$11,801	0.861	\$10,162	1
24			32	13	10	10	57	\$18.80	\$5.64	\$3.29	\$7,159	\$5,638	\$1,611	\$2,882	\$0,401	\$0.316	\$0.090	\$2,380	\$17,708	-\$9,369	-\$3,279	\$11,619	0.855	\$9,937	1
25			31	12	9	9	55	\$18.80	\$5.64	\$3.29	\$6,926	\$5,454	\$1,558	\$2,788	\$0,388	\$0.305	\$0.087	\$2,303	\$17,708	-\$9,640	-\$3,374	\$11,442	0.849	\$9,719	1
26			30	12	9	9	53	\$18.80	\$5.64	\$3.29	\$6,701	\$5,277	\$1,508	\$2,697	\$0,375	\$0.295	\$0.084	\$2,228	\$17,708	-\$9,903	-\$3,466	\$11,271	0.844	\$9,510	1
27			29	11	9	9	52	\$18.80	\$5.64	\$3.29	\$6,482	\$5,105	\$1,459	\$2,609	\$0,363	\$0.286	\$0.082	\$2,155	\$17,708	-\$10,157	-\$3,555	\$11,106	0.838	\$9,307	1
28			28	11	8	8	50	\$18.80	\$5.64	\$3.29	\$6,271	\$4,939	\$1,411	\$2,524	\$0,351	\$0.277	\$0.079	\$2,085	\$17,708	-\$10,403	-\$3,641	\$10,946	0.832	\$9,111	1
29			27	11	8	8	48	\$18.80	\$5.64	\$3.29	\$6,067	\$4,778	\$1,365	\$2,442	\$0,340	\$0.268	\$0.076	\$2,017	\$17,708	-\$10,641	-\$3,724	\$10,791	0.827	\$8,921	1
30			26	10	8	8	47	\$18.80	\$5.64	\$3.29	\$5,869	\$4,622	\$1,321	\$2,362	\$0,329	\$0.259	\$0.074	\$1,940	\$17,708	-\$10,921	-\$3,822	\$10,610	0.821	\$8,711	1
31			25	10	8	8	45	\$18.80	\$5.64	\$3.29	\$5,678	\$4,471	\$1,277	\$2,285	\$0,318	\$0.250	\$0.072	\$1,869	\$17,708	-\$11,207	-\$3,922	\$10,424	0.816	\$8,501	1
32			24	10	7	7	44	\$18.80	\$5.64	\$3.29	\$5,493	\$4,325	\$1,236	\$2,211	\$0,308	\$0.242	\$0.069	\$1,800	\$17,708	-\$11,484	-\$4,019	\$10,244	0.810	\$8,297	1
33			24	9	7	7	42	\$18.80	\$5.64	\$3.29	\$5,314	\$4,184	\$1,196	\$2,139	\$0,298	\$0.234	\$0.067	\$1,732	\$17,708	-\$11,752	-\$4,113	\$10,069	0.804	\$8,101	1
34			23	9	7	7	41	\$18.80	\$5.64	\$3.29	\$5,140	\$4,048	\$1,157	\$2,069	\$0,288	\$0.227	\$0.065	\$1,665	\$17,708	-\$12,012	-\$4,204	\$9,901	0.799	\$7,911	1
35			22	9	7	7	40	\$18.80	\$5.64	\$3.29	\$4,973	\$3,916	\$1,119	\$2,002	\$0,278										

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

SCOOP Condensate

SCOOP Condensate				My Assumptions:			
Basin Characteristics				100% oilfield service & supply factor price scalar			
Average Well		IP		EUR		30 days/month	
\$9.60 cost/well (\$mm)		1,400	1,952	-0.82%	exponential decline rate after year 3 (monthly)		
704 EUR/well (mboe)				\$100.00	oil price WTI (\$/bbl)		
-50% 1st yr decline	-5.7%	694		0%	oil price appreciation (per month)		
-32% 2nd yr decline	-3.2%	471		\$3.50	gas price Henry Hub (\$/mcf)		
-28% 3rd yr decline	-2.7%	400		0%	gas price appreciation		
505 IP rate (boe/d)				30%	NGL price/oil price (fixed ratio)		
\$3.00 opex-LOE (\$/boe)				0.68%	discount rate (compound monthly)		
10% oil				8.5%	discount rate (annual)		
50% gas				80%	intangibile drilling cost / total capex		
40% NGL				0.717	IP/EUR ratio, (B8/B4 = fixed ratio)		
20.0% royalty rate				Results			
7.0% oil prod tax				-\$2.440 = NPV/well (\$ million)			
7.0% gas prod tax				0 = EUR check (mboe)			
7.0% NGL prod tax				-0.16% = ATIRR (monthly)			
35.0% income tax rate				704 = total production (mboe)			
-6% oil differential				\$3.735 = "tail end" NPV/well (\$ million)			
-6% gas differential				100% = "tail end" recovery factor			
0 1 = DUC				0 = months of lost production			
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

SCOOP Condensate					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,692	1,931	1,336	958	
\$25	2,439	1,749	1,211	869	
\$30	2,229	1,599	1,107	794	
\$35	2,053	1,472	1,019	731	
\$40	1,903	1,365	945	678	
\$45	1,773	1,272	881	632	
\$50	1,659	1,190	824	591	
\$60	1,471	1,055	731	524	
\$70	1,322	948	657	471	
\$80	1,200	861	596	427	
\$90	1,098	788	546	392	
\$100	1,013	727	504	361	

SCOOP Condensate					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	4,131	2,963	2,050	1,470	
\$25	3,689	2,646	1,831	1,313	
\$30	3,333	2,390	1,655	1,187	
\$35	3,040	2,180	1,509	1,082	
\$40	2,794	2,004	1,387	995	
\$45	2,585	1,854	1,283	920	
\$50	2,405	1,725	1,194	856	
\$60	2,111	1,514	1,048	752	
\$70	1,881	1,349	934	670	
\$80	1,696	1,216	842	604	
\$90	1,544	1,107	767	550	
\$100	1,418	1,017	704	505	

Per Well Net Cash Flow Analysis																	Active								
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices			Cash Flows (\$1,000)						PV Factor	AT NPV -\$2,440	1/0						
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax				Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax
1	\$2,400	\$600						\$94.00	\$28.20	\$3.29								\$2,400.000	\$2,400.000	-\$2,400.000	-\$840.000	-2.160	1.000	-\$2,160.000	
2	\$2,400	\$600						\$94.00	\$28.20	\$3.29								\$2,400.000	\$2,400.000	-\$2,400.000	-\$840.000	-2.160	0.993	-\$2,145.37	
3	\$2,400	\$600						\$94.00	\$28.20	\$3.29								\$2,400.000	\$2,400.000	-\$2,400.000	-\$840.000	-2.160	0.986	-\$2,130.83	
4	\$2,400	\$600						\$94.00	\$28.20	\$3.29								\$2,400.000	\$2,400.000	-\$2,400.000	-\$840.000	-2.160	0.980	-\$2,116.39	
5			505	202	252	1,515	\$94.00	\$28.20	\$3.29	\$142.369	\$149.487	\$170.843	\$92.54	\$7.97	\$8.37	\$9.57	\$45.437	\$20.000	\$278.811	\$97.584	\$201.227	\$97.3	0.973	\$195.829	1
6			476	190	238	1,429	\$94.00	\$28.20	\$3.29	\$134.282	\$140.996	\$161.138	\$87.283	\$7.520	\$7.896	\$9.024	\$42.856	\$20.000	\$261.838	\$91.643	\$190.194	\$96.7	0.967	\$183.838	1
7			449	180	225	1,347	\$94.00	\$28.20	\$3.29	\$126.654	\$132.987	\$151.985	\$82.325	\$7.093	\$7.447	\$8.511	\$40.422	\$20.000	\$245.829	\$86.040	\$179.789	\$96.0	0.960	\$172.603	1
8			424	169	212	1,271	\$94.00	\$28.20	\$3.29	\$119.460	\$125.433	\$143.352	\$77.649	\$6.690	\$7.024	\$8.028	\$38.126	\$20.000	\$230.729	\$80.755	\$169.974	\$95.4	0.954	\$162.074	1
9			400	160	200	1,199	\$94.00	\$28.20	\$3.29	\$112.674	\$118.308	\$135.209	\$73.238	\$6.310	\$6.625	\$7.572	\$35.960	\$20.000	\$216.487	\$75.770	\$160.716	\$94.7	0.947	\$152.209	1
10			377	151	188	1,131	\$94.00	\$28.20	\$3.29	\$106.274	\$111.588	\$127.529	\$69.078	\$5.951	\$6.249	\$7.142	\$33.917	\$20.000	\$203.054	\$71.069	\$151.985	\$94.1	0.941	\$142.965	1
11			355	142	178	1,066	\$94.00	\$28.20	\$3.29	\$100.238	\$105.249	\$120.285	\$65.154	\$5.613	\$5.894	\$6.736	\$31.991	\$20.000	\$190.384	\$66.634	\$143.749	\$93.4	0.934	\$134.302	1
12			335	134	168	1,006	\$94.00	\$28.20	\$3.29	\$94.544	\$99.271	\$113.453	\$61.453	\$5.294	\$5.559	\$6.353	\$30.174	\$20.000	\$178.433	\$62.452	\$135.982	\$92.8	0.928	\$126.184	1
13			316	126	158	949	\$94.00	\$28.20	\$3.29	\$89.173	\$93.632	\$107.008	\$57.963	\$4.994	\$5.243	\$5.992	\$28.460	\$20.000	\$167.162	\$58.507	\$128.655	\$92.2	0.922	\$118.576	1
14			298	119	149	895	\$94.00	\$28.20	\$3.29	\$84.108	\$88.314	\$100.930	\$54.760	\$4.710	\$4.946	\$5.652	\$26.843	\$20.000	\$156.531	\$54.786	\$121.745	\$91.5	0.915	\$111.447	1
15			281	113	141	844	\$94.00	\$28.20	\$3.29	\$79.331	\$83.297	\$95.197	\$51.565	\$4.443	\$4.665	\$5.331	\$25.318	\$20.000	\$146.503	\$51.276	\$115.227	\$90.9	0.909	\$104.766	1
16			265	106	133	796	\$94.00	\$28.20	\$3.29	\$74.824	\$78.566	\$89.789	\$48.636	\$4.190	\$4.400	\$5.028	\$23.880	\$20.000	\$137.045	\$47.966	\$109.080	\$90.3	0.903	\$98.504	1
17			257	103	128	771	\$94.00	\$28.20	\$3.29	\$72.446	\$76.068	\$86.935	\$47.090	\$4.057	\$4.260	\$4.868	\$23.121	\$20.000	\$132.054	\$46.219	\$105.835	\$89.7	0.897	\$94.927	1
18			249	99	124	746	\$94.00	\$28.20	\$3.29	\$70.143	\$73.651	\$84.172	\$45.593	\$3.928	\$4.124	\$4.714	\$22.386	\$20.000	\$127.221	\$44.527	\$102.693	\$89.1	0.891	\$91.485	1
19			241	96	120	722	\$94.00	\$28.20	\$3.29	\$67.914	\$71.310	\$81.497	\$44.144	\$3.803	\$3.993	\$4.564	\$21.675	\$20.000	\$122.541	\$42.889	\$99.652	\$88.5	0.885	\$88.174	1
20			233	93	117	700	\$94.00	\$28.20	\$3.29	\$65.755	\$69.043	\$78.906	\$42.741	\$3.682	\$3.866	\$4.419	\$20.986	\$20.000	\$118.011	\$41.304	\$96.707	\$87.9	0.879	\$84.969	1
21			226	90	113	677	\$94.00	\$28.20	\$3.29	\$63.665	\$66.849	\$76.398	\$41.382	\$3.565	\$3.744	\$4.278	\$20.319	\$20.000	\$113.624	\$39.768	\$93.856	\$87.3	0.873	\$81.924	1
22			219	87	109	656	\$94.00	\$28.20	\$3.29	\$61.642	\$64.724	\$73.970	\$40.067	\$3.452	\$3.625	\$4.142	\$19.673	\$20.000	\$109.377	\$38.282	\$91.095	\$86.7	0.867	\$78.975	1
23			212	85	106	635	\$94.00	\$28.20	\$3.29	\$59.682	\$62.667	\$71.619	\$38.794	\$3.342	\$3.509	\$4.011	\$19.048	\$20.000	\$105.264	\$36.843	\$88.422	\$86.1	0.861	\$76.139	1
24			205	82	102	615	\$94.00	\$28.20	\$3.29	\$57.785	\$60.675	\$69.342	\$37.560	\$3.236	\$3.398	\$3.883	\$18.442	\$20.000	\$101.283	\$35.449	\$85.834	\$85.5	0.855	\$73.409	1
25			198	79	99	595	\$94.00	\$28.20	\$3.29	\$55.949	\$58.746	\$67.138	\$36.367	\$3.133	\$3.290	\$3.760	\$17.856	\$20.000	\$97.428	\$34.100	\$83.328	\$84.9	0.849	\$70.784	1
26			192	77	96	576	\$94.00	\$28.20	\$3.29	\$54.170	\$56.879	\$65.004	\$35.211	\$3.034	\$3.185	\$3.640	\$17.288	\$20.000	\$93.695	\$32.793	\$80.902	\$84.4	0.844	\$68.257	1
27			186	74	93	558	\$94.00	\$28.20	\$3.29	\$52.449	\$55.071	\$62.938	\$34.092	\$2.937	\$3.084	\$3.525	\$16.739	\$20.000	\$90.082	\$31.529	\$78.553	\$83.8	0.838	\$65.826	1
28			180	72	90	540	\$94.00	\$28.20	\$3.29	\$50.781	\$53.321	\$60.938	\$33.008	\$2.844	\$2.986	\$3.415	\$16.207	\$20.000	\$86.583	\$30.304	\$76.279	\$83.2	0.832	\$63.487	1
29			175	70	88	526	\$94.00	\$28.20	\$3.29	\$49.417	\$51.888	\$59.301	\$32.121	\$2.767	\$2.906	\$3.321	\$15.771	\$20.000	\$83.719	\$29.302	\$74.418	\$82.7	0.827	\$61.519	1
30			171	68	85	512	\$94.00	\$28.20	\$3.29	\$48.090	\$50.494	\$57.708	\$31.258	\$2.693	\$2.828	\$3.232	\$15.348	\$20.000	\$80.933	\$28.327	\$72.606	\$82.1	0.821	\$59.615	1
31			166	66	83	498	\$94.00	\$28.20	\$3.29	\$46.798	\$49.138	\$56.157	\$30.419	\$2.621	\$2.752	\$3.145	\$14.935	\$20.000	\$78.221	\$27.377	\$70.844	\$81.6	0.816	\$57.773	1
32			161	65	81	484	\$94.00	\$28.20	\$3.29	\$45.541	\$47.818	\$54.649	\$29.601	\$2.550	\$2.678	\$3.060	\$14.534	\$20.000	\$75.583	\$26.544	\$69.129	\$81.0	0.810	\$55.993	1
33			157	63	79	471	\$94.00	\$28.20	\$3.29	\$44.317	\$46.533	\$53.180	\$28.806	\$2.482	\$2.602	\$2.978	\$14.144	\$20.000	\$73.015	\$25.555	\$67.460	\$80.4	0.804	\$54.271	1
34			153	61	76	459	\$94.00	\$28.20	\$3.29	\$43.126	\$45.283	\$51.752	\$28.032	\$2.415	\$2.536	\$2.898	\$13.764	\$20.000	\$70.516	\$24.681	\$65.835	\$79.9	0.799	\$52.605	1
35			149	60	74	446	\$94.00	\$28.20	\$3.29	\$41.968	\$44.066	\$50.361	\$27.279	\$2.350	\$2.468	\$2.820	\$13.394	\$20.000	\$68.084	\$23.830	\$64.255	\$79.4	0.794	\$50.994	1
36			145	58	72	434	\$94.00	\$28.20	\$3.29</																

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Meramec

Meramec				My Assumptions:			
Basin Characteristics				100% oilfield service & supply factor price scalar			
\$7.60 cost/well (\$mm)	Average Well		IP	EUR	30	days/month	
459 EUR/well (mboe)	1,425	1,338	-0.80%	exponential decline rate after year 3 (monthly)			
-69% 1st yr decline	-9.3%	444	\$100.00	oil price WTI (\$/bbl)			
-35% 2nd yr decline	-3.5%	289	0%	oil price appreciation (per month)			
-29% 3rd yr decline	-2.8%	244	\$3.50	gas price Henry Hub (\$/mcf)			
489 IP rate (boe/d)			0%	gas price appreciation			
\$5.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
22% % oil			0.68%	discount rate (compound monthly)			
47% % gas			8.5%	discount rate (annual)			
31% % NGL			80%	intangible drilling cost / total capex			
20.0% royalty rate			1.065	IP/EUR ratio, (B8/B4 = fixed ratio)			
7.0% oil prod tax			Results				
7.0% gas prod tax							
7.0% NGL prod tax			-\$1.842 = NPV/well (\$ million)				
35.0% income tax rate			0 = EUR check (mboe)				
-6% oil differential			0.16% = ATIRR (monthly)				
-6% gas differential			1.89% = ATIRR (annual)				
0 1 DUC			459 = total production (mboe)				
25% auxiliary cost/well cost			\$2.771 = "tail end" NPV/well (\$ million)				
50% completion cost/well cost			100% = "tail end" recovery factor				
\$2,000 min opex (\$/month)			0 = months of lost production				

Meramec					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	2,450	2,609	1,216	1,295	
\$25	2,086	2,222	1,035	1,102	
\$30	1,816	1,934	902	961	
\$35	1,609	1,714	799	851	
\$40	1,443	1,537	717	764	
\$45	1,309	1,394	650	692	
\$50	1,197	1,275	595	634	
\$60	1,023	1,090	508	541	
\$70	893	951	444	473	
\$80	792	843	394	420	
\$90	712	758	354	377	
\$100	647	689	322	343	

Meramec					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	4,419	4,706	2193	2,336	
\$25	3,574	3,806	1774	1,889	
\$30	3,000	3,195	1489	1,586	
\$35	2,585	2,753	1283	1,366	
\$40	2,271	2,419	1127	1,200	
\$45	2,025	2,157	1005	1,070	
\$50	1,827	1,946	907	966	
\$60	1,529	1,628	759	808	
\$70	1,314	1,399	652	694	
\$80	1,152	1,227	572	609	
\$90	1,025	1,092	509	542	
\$100	924	984	459	489	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d			Prices				Cash Flows (\$1,000)							PV Factor	ATNPV -\$1.842	Active 1/0		
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.				Income Tax	NCF
1	\$1,900	\$475						\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29					\$1,900.000	\$1,900.000	-\$1,900.00	-\$665.000	-1,710	1.000	-\$1,710.00	
2	\$1,900	\$475						\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29					\$1,900.000	\$1,900.000	-\$1,900.00	-\$665.000	-1,710	0.993	-\$1,698.41	
3	\$1,900	\$475						\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29					\$1,900.000	\$1,900.000	-\$1,900.00	-\$665.000	-1,710	0.986	-\$1,686.91	
4	\$1,900	\$475						\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29					\$1,900.000	\$1,900.000	-\$1,900.00	-\$665.000	-1,710	0.980	-\$1,675.48	
5			489	108	151	230	1,378	\$94.00	\$28.20	\$3.29	\$303.194	\$136.024	\$128.168	\$113.48	\$16.98	\$7.62	\$7.18	\$73.306	\$15.833	\$332.996	\$116.549	\$232.281	0.973	\$226.049	1
6			443	98	137	208	1,251	\$94.00	\$28.20	\$3.29	\$275.117	\$123.428	\$116.300	\$102.969	\$15.407	\$6.912	\$6.513	\$66.518	\$15.833	\$300.693	\$105.243	\$211.284	0.967	\$204.223	1
7			402	89	125	189	1,135	\$94.00	\$28.20	\$3.29	\$249.641	\$111.998	\$105.530	\$93.434	\$13.980	\$6.272	\$5.910	\$60.358	\$15.833	\$271.382	\$94.984	\$192.232	0.960	\$184.548	1
8			365	80	113	172	1,030	\$94.00	\$28.20	\$3.29	\$226.523	\$101.626	\$95.757	\$84.781	\$12.685	\$5.691	\$5.362	\$54.769	\$15.833	\$244.785	\$85.675	\$174.943	0.954	\$166.813	1
9			331	73	103	156	934	\$94.00	\$28.20	\$3.29	\$205.546	\$92.216	\$86.890	\$76.930	\$11.511	\$5.164	\$4.866	\$49.697	\$15.833	\$220.651	\$77.228	\$159.256	0.947	\$150.826	1
10			301	66	93	141	848	\$94.00	\$28.20	\$3.29	\$186.512	\$83.676	\$78.844	\$69.806	\$10.445	\$4.686	\$4.415	\$45.095	\$15.833	\$198.752	\$69.563	\$145.022	0.941	\$136.415	1
11			273	60	85	128	769	\$94.00	\$28.20	\$3.29	\$169.241	\$75.927	\$71.543	\$63.342	\$9.477	\$4.252	\$4.006	\$40.919	\$15.833	\$178.880	\$62.608	\$132.106	0.934	\$123.423	1
12			248	54	77	116	698	\$94.00	\$28.20	\$3.29	\$153.568	\$68.896	\$64.918	\$57.476	\$8.600	\$3.858	\$3.635	\$37.130	\$15.833	\$160.849	\$56.297	\$120.385	0.928	\$111.711	1
13			225	49	70	106	633	\$94.00	\$28.20	\$3.29	\$139.347	\$62.516	\$58.906	\$52.154	\$7.803	\$3.501	\$3.299	\$33.691	\$15.833	\$144.488	\$50.571	\$109.751	0.922	\$101.153	1
14			204	45	63	96	575	\$94.00	\$28.20	\$3.29	\$126.443	\$56.727	\$53.451	\$47.324	\$7.081	\$3.177	\$2.993	\$30.571	\$15.833	\$129.642	\$45.375	\$100.101	0.915	\$91.633	1
15			185	41	57	87	522	\$94.00	\$28.20	\$3.29	\$114.734	\$51.474	\$48.501	\$42.942	\$6.425	\$2.883	\$2.716	\$27.740	\$15.833	\$116.170	\$40.660	\$91.344	0.909	\$83.051	1
16			168	37	52	79	473	\$94.00	\$28.20	\$3.29	\$104.110	\$46.707	\$44.010	\$38.965	\$5.830	\$2.616	\$2.465	\$25.172	\$15.833	\$103.946	\$36.381	\$83.399	0.903	\$75.313	1
17			162	36	50	76	457	\$94.00	\$28.20	\$3.29	\$100.450	\$45.066	\$42.463	\$37.596	\$5.625	\$2.524	\$2.378	\$24.287	\$15.833	\$99.736	\$34.908	\$80.662	0.897	\$72.348	1
18			156	34	48	73	441	\$94.00	\$28.20	\$3.29	\$96.919	\$43.482	\$40.970	\$36.274	\$5.427	\$2.435	\$2.294	\$23.433	\$15.833	\$95.674	\$33.486	\$78.021	0.891	\$69.506	1
19			151	33	47	71	425	\$94.00	\$28.20	\$3.29	\$93.513	\$41.953	\$39.530	\$34.999	\$5.237	\$2.349	\$2.214	\$22.609	\$15.833	\$91.754	\$32.114	\$75.474	0.885	\$66.781	1
20			145	32	45	68	410	\$94.00	\$28.20	\$3.29	\$90.226	\$40.478	\$38.141	\$33.769	\$5.053	\$2.267	\$2.136	\$21.815	\$15.833	\$87.973	\$30.790	\$73.015	0.879	\$64.168	1
21			140	31	43	66	396	\$94.00	\$28.20	\$3.29	\$87.054	\$39.056	\$36.800	\$32.582	\$4.875	\$2.187	\$2.061	\$21.048	\$15.833	\$84.324	\$29.513	\$70.644	0.873	\$61.663	1
22			135	30	42	64	382	\$94.00	\$28.20	\$3.29	\$83.994	\$37.683	\$35.507	\$31.437	\$4.704	\$2.110	\$1.988	\$20.308	\$15.833	\$80.803	\$28.281	\$68.355	0.867	\$59.261	1
23			131	29	40	61	368	\$94.00	\$28.20	\$3.29	\$81.042	\$36.358	\$34.259	\$30.332	\$4.538	\$2.036	\$1.918	\$19.594	\$15.833	\$77.406	\$27.092	\$66.147	0.861	\$56.958	1
24			126	28	39	59	355	\$94.00	\$28.20	\$3.29	\$78.193	\$35.080	\$33.054	\$29.265	\$4.379	\$1.964	\$1.851	\$18.905	\$15.833	\$74.129	\$25.945	\$64.017	0.855	\$54.751	1
25			122	27	38	57	343	\$94.00	\$28.20	\$3.29	\$75.444	\$33.847	\$31.892	\$28.237	\$4.225	\$1.895	\$1.786	\$18.241	\$15.833	\$70.967	\$24.838	\$61.962	0.849	\$52.634	1
26			117	26	36	55	331	\$94.00	\$28.20	\$3.29	\$72.793	\$32.657	\$30.771	\$27.244	\$4.076	\$1.829	\$1.723	\$17.600	\$15.833	\$67.916	\$23.770	\$59.978	0.844	\$50.604	1
27			113	25	35	53	319	\$94.00	\$28.20	\$3.29	\$70.234	\$31.509	\$29.690	\$26.287	\$3.933	\$1.765	\$1.663	\$16.981	\$15.833	\$64.972	\$22.740	\$58.065	0.838	\$48.658	1
28			109	24	34	51	308	\$94.00	\$28.20	\$3.29	\$67.765	\$30.402	\$28.646	\$25.363	\$3.795	\$1.703	\$1.604	\$16.384	\$15.833	\$62.131	\$21.746	\$56.219	0.832	\$46.791	1
29			106	23	33	50	299	\$94.00	\$28.20	\$3.29	\$65.880	\$29.556	\$27.849	\$24.657	\$3.689	\$1.655	\$1.560	\$15.928	\$15.833	\$59.963	\$20.987	\$54.809	0.827	\$45.309	1
30			103	23	32	49	291	\$94.00	\$28.20	\$3.29	\$64.048	\$28.734	\$27.075	\$23.971	\$3.587	\$1.609	\$1.516	\$15.485	\$15.833	\$57.854	\$20.249	\$53.439	0.821	\$43.877	1
31			100	22	31	47	283	\$94.00	\$28.20	\$3.29	\$62.266	\$27.935	\$26.322	\$23.305	\$3.487	\$1.564	\$1.474	\$15.055	\$15.833	\$55.805	\$19.532	\$52.106	0.816	\$42.493	1
32			98	21	30	46	275	\$94.00	\$28.20	\$3.29	\$60.534	\$27.158	\$25.589	\$22.656	\$3.390	\$1.521	\$1.433	\$14.636	\$15.833	\$53.812	\$18.834	\$50.811	0.810	\$41.156	1
33			95	21	29	45	268	\$94.00	\$28.20	\$3.29	\$58.850	\$26.402	\$24.878	\$22.026	\$3.296	\$1.479	\$1.393	\$14.229	\$15.833	\$51.875	\$18.156	\$49.552	0.804	\$39.864	1
34			92	20	29	43	260	\$94.00	\$28.20	\$3.29	\$57.213	\$25.668	\$24.186	\$21.413	\$3.204	\$1.437	\$1.354	\$13.833	\$15.833	\$49.992	\$17.497	\$48.328	0.799	\$38.616	1
35			90	20	28	42	253	\$94.00	\$28.20	\$3.29	\$55.622	\$24.954	\$23.513	\$20.818	\$3.115	\$1.397	\$1.317	\$13.448	\$15.833	\$48.161	\$16.856	\$47.138	0.794	\$37.410	1
36			87	19	27	41	246	\$94.00	\$28.20	\$3.29	\$54.075	\$24.260	\$22.859	\$20.239	\$3.028	\$1.359	\$1.280	\$13.074	\$15.833	\$46.381	\$16.233	\$45.981	0.788	\$36.244	1
37			85	19	26	40	239	\$94.00	\$28.20	\$3.29	\$52.571	\$23.585	\$22.223	\$19.676	\$2.944	\$1.321	\$1.244	\$12.711	\$15.833	\$44.650	\$15.628	\$44.856	0.783	\$35.118	1
38			82	18	26	39																			

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

SCOOP Oil

SCOOP Oil			My Assumptions:	
Basin Characteristics			100% oilfield service & supply factor price scalar	
\$9.35 cost/well (\$mm)	Average Well		30 days/month	
337 EUR/well (mboe)	IP	EUR	-0.83%	exponential decline rate after year 3 (monthly)
-54% 1st yr decline	-6.2%	353	\$100.00	oil price WTI (\$/bbl)
-33% 2nd yr decline	-3.2%	238	0%	oil price appreciation (per month)
-29% 3rd yr decline	-2.9%	200	\$3.50	gas price Henry Hub (\$/mcf)
262 IP rate (boe/d)			0%	gas price appreciation
\$4.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)
48% % oil			0.68%	discount rate (compound monthly)
23% % gas			8.5%	discount rate (annual)
29% % NGL			80%	intangible drilling cost / total capex
20.0% royalty rate			0.778	IP/EUR ratio, (B8/B4 = fixed ratio)
7.0% oil prod tax				
7.0% gas prod tax				
7.0% NGL prod tax				
35.0% income tax rate				
-6% oil differential				
-6% gas differential				
0 1 = DUC				
25% auxiliary cost/well cost				
50% completion cost/well cost				
\$2,000 min opex (\$/month)				

Results	
-52.470	= NPV/well (\$ million)
0	= EUR check (mboe)
0.12%	= ATIRR (monthly)
1.47%	= ATIRR (annual)
337	= total production (mboe)
\$3.487	= "tail end" NPV/well (\$ million)
100%	= "tail end" recovery factor
0	= months of lost production

SCOOP Oil					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,630	2,047	1,305	1,016	
\$25	2,069	1,610	1,027	799	
\$30	1,705	1,327	846	658	
\$35	1,450	1,129	720	560	
\$40	1,261	981	627	488	
\$45	1,116	869	555	432	
\$50	1,001	779	498	388	
\$60	830	646	413	321	
\$70	709	552	353	275	
\$80	618	481	308	240	
\$90	548	427	273	212	
\$100	493	384	246	191	

SCOOP Oil					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	4,269	3,323	2,119	1,649	
\$25	3,207	2,496	1,592	1,239	
\$30	2,568	1,999	1,275	992	
\$35	2,142	1,667	1,063	827	
\$40	1,837	1,430	912	710	
\$45	1,608	1,252	798	621	
\$50	1,429	1,112	710	553	
\$60	1,170	911	581	452	
\$70	990	771	492	383	
\$80	858	668	426	332	
\$90	758	590	376	293	
\$100	678	528	337	262	

Per Well Net Cash Flow Analysis

Month	Capex (\$1,000s)		Production (boe/d)			mcf/d	Prices			Cash Flows (\$1,000)							PV Factor	AT NPV	Active 1/0					
	Well Cost	Aux. Cost	Total	Oil	NGL		Gas	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax				NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax
1	\$2,338	\$584					\$94.00	\$28.20	\$3.29	\$355.034	\$35.725	\$64.350	\$91.02	\$19.88	\$2.00	\$3.60	\$31.475	\$19.479	\$287.647	\$100.676	\$206.450	0.973	\$200.911	1
2	\$2,338	\$584					\$94.00	\$28.20	\$3.29	\$332.982	\$33.506	\$60.353	\$85.368	\$18.647	\$1.876	\$3.380	\$29.520	\$19.479	\$268.571	\$94.000	\$194.051	0.967	\$187.565	1
3	\$2,338	\$584					\$94.00	\$28.20	\$3.29	\$312.301	\$31.425	\$56.604	\$80.066	\$17.489	\$1.760	\$3.170	\$27.686	\$19.479	\$250.680	\$87.738	\$182.421	0.960	\$175.130	1
4	\$2,338	\$584					\$94.00	\$28.20	\$3.29	\$292.903	\$29.473	\$53.089	\$75.093	\$16.403	\$1.651	\$2.973	\$25.967	\$19.479	\$233.901	\$81.865	\$171.515	0.954	\$163.544	1
5			262	126	76	60	\$94.00	\$28.20	\$3.29	\$274.711	\$27.643	\$49.791	\$70.429	\$15.384	\$1.548	\$2.788	\$24.354	\$19.479	\$218.163	\$76.357	\$161.285	0.947	\$152.748	1
6			246	118	71	57	\$94.00	\$28.20	\$3.29	\$257.649	\$25.926	\$46.699	\$66.055	\$14.428	\$1.452	\$2.615	\$22.841	\$19.479	\$203.403	\$71.191	\$151.691	0.941	\$142.688	1
7			231	111	67	53	\$94.00	\$28.20	\$3.29	\$241.646	\$24.316	\$43.798	\$61.952	\$13.532	\$1.362	\$2.453	\$21.423	\$19.479	\$189.560	\$66.346	\$142.693	0.934	\$133.315	1
8			216	104	63	50	\$94.00	\$28.20	\$3.29	\$226.637	\$22.805	\$41.078	\$58.104	\$12.692	\$1.277	\$2.300	\$20.092	\$19.479	\$176.576	\$61.802	\$134.254	0.928	\$124.580	1
9			203	97	59	47	\$94.00	\$28.20	\$3.29	\$212.561	\$21.389	\$38.527	\$54.495	\$11.903	\$1.198	\$2.157	\$18.844	\$19.479	\$164.399	\$57.540	\$126.339	0.922	\$116.441	1
10			190	91	55	44	\$94.00	\$28.20	\$3.29	\$199.358	\$20.060	\$36.134	\$51.110	\$11.164	\$1.123	\$2.023	\$17.674	\$19.479	\$152.978	\$53.542	\$118.915	0.915	\$108.857	1
11			179	86	52	41	\$94.00	\$28.20	\$3.29	\$186.976	\$18.814	\$33.889	\$47.936	\$10.471	\$1.054	\$1.898	\$16.576	\$19.479	\$142.267	\$49.793	\$111.953	0.909	\$101.789	1
12			167	80	49	39	\$94.00	\$28.20	\$3.29	\$175.363	\$17.646	\$31.785	\$44.959	\$9.820	\$0.988	\$1.780	\$15.546	\$19.479	\$132.221	\$46.277	\$105.423	0.903	\$95.202	1
13			157	75	46	36	\$94.00	\$28.20	\$3.29	\$169.696	\$17.076	\$30.757	\$43.506	\$9.503	\$0.956	\$1.722	\$15.044	\$19.479	\$127.318	\$44.561	\$102.236	0.897	\$91.699	1
14			147	71	43	34	\$94.00	\$28.20	\$3.29	\$164.212	\$16.524	\$29.763	\$42.100	\$9.196	\$0.925	\$1.667	\$14.558	\$19.479	\$122.574	\$42.901	\$99.153	0.891	\$88.331	1
15			138	66	40	32	\$94.00	\$28.20	\$3.29	\$158.905	\$15.890	\$28.802	\$40.739	\$8.899	\$0.895	\$1.613	\$14.087	\$19.479	\$117.984	\$41.294	\$96.169	0.885	\$85.092	1
16			130	62	38	30	\$94.00	\$28.20	\$3.29	\$153.770	\$15.473	\$27.871	\$39.423	\$8.611	\$0.866	\$1.561	\$13.632	\$19.479	\$113.542	\$39.740	\$93.281	0.879	\$81.978	1
17			125	60	36	29	\$94.00	\$28.20	\$3.29	\$148.801	\$14.973	\$26.970	\$38.149	\$8.333	\$0.838	\$1.510	\$13.192	\$19.479	\$109.243	\$38.235	\$90.487	0.873	\$78.984	1
18			121	58	35	28	\$94.00	\$28.20	\$3.29	\$143.992	\$14.489	\$26.099	\$36.916	\$8.064	\$0.811	\$1.462	\$12.765	\$19.479	\$105.083	\$36.779	\$87.783	0.867	\$76.104	1
19			110	53	32	25	\$94.00	\$28.20	\$3.29	\$139.339	\$14.021	\$25.255	\$35.723	\$7.803	\$0.785	\$1.414	\$12.353	\$19.479	\$101.058	\$35.370	\$85.167	0.861	\$73.336	1
20			100	48	29	23	\$94.00	\$28.20	\$3.29	\$134.836	\$13.568	\$24.439	\$34.569	\$7.551	\$0.760	\$1.369	\$11.954	\$19.479	\$97.162	\$34.007	\$82.635	0.855	\$70.673	1
21			96	46	28	22	\$94.00	\$28.20	\$3.29	\$130.479	\$13.129	\$23.649	\$33.451	\$7.307	\$0.735	\$1.324	\$11.567	\$19.479	\$93.393	\$32.688	\$80.185	0.849	\$68.113	1
22			93	45	27	21	\$94.00	\$28.20	\$3.29	\$126.262	\$12.705	\$22.885	\$32.370	\$7.071	\$0.711	\$1.282	\$11.193	\$19.479	\$89.745	\$31.411	\$77.814	0.844	\$65.651	1
23			90	43	26	21	\$94.00	\$28.20	\$3.29	\$122.182	\$12.295	\$22.145	\$31.324	\$6.842	\$0.688	\$1.240	\$10.832	\$19.479	\$86.216	\$30.175	\$75.519	0.838	\$63.284	1
24			87	42	25	20	\$94.00	\$28.20	\$3.29	\$118.233	\$11.897	\$21.430	\$30.312	\$6.621	\$0.666	\$1.200	\$10.482	\$19.479	\$82.800	\$28.980	\$73.299	0.832	\$61.007	1
25			85	41	25	20	\$94.00	\$28.20	\$3.29	\$114.855	\$11.557	\$20.817	\$29.446	\$6.432	\$0.647	\$1.166	\$10.182	\$19.479	\$79.877	\$27.957	\$71.399	0.827	\$59.024	1
26			82	40	24	19	\$94.00	\$28.20	\$3.29	\$111.573	\$11.227	\$20.223	\$28.604	\$6.248	\$0.629	\$1.132	\$9.891	\$19.479	\$77.038	\$26.963	\$69.554	0.821	\$57.108	1
27			80	38	23	18	\$94.00	\$28.20	\$3.29	\$108.384	\$10.906	\$19.645	\$27.787	\$6.070	\$0.611	\$1.100	\$9.609	\$19.479	\$74.280	\$25.998	\$67.761	0.816	\$55.259	1
28			78	37	23	18	\$94.00	\$28.20	\$3.29	\$105.287	\$10.595	\$19.083	\$26.993	\$5.896	\$0.593	\$1.069	\$9.334	\$19.479	\$71.601	\$25.060	\$66.020	0.810	\$53.474	1
29			76	36	22	17	\$94.00	\$28.20	\$3.29	\$102.278	\$10.292	\$18.538	\$26.222	\$5.728	\$0.576	\$1.038	\$9.067	\$19.479	\$68.998	\$24.149	\$64.328	0.804	\$51.751	1
30			73	35	21	17	\$94.00	\$28.20	\$3.29	\$99.356	\$9.998	\$18.008	\$25.472	\$5.564	\$0.560	\$1.008	\$8.808	\$19.479	\$66.470	\$23.264	\$62.684	0.799	\$50.087	1
31			71	34	21	16	\$94.00	\$28.20	\$3.29	\$96.517	\$9.712	\$17.494	\$24.744	\$5.405	\$0.540	\$0.980	\$8.556	\$19.479	\$64.014	\$22.405	\$61.088	0.794	\$48.481	1
32			69	33	20	16	\$94.00	\$28.20	\$3.29	\$93.758	\$9.434	\$16.994	\$24.037	\$5.250	\$0.528	\$0.952	\$8.312	\$19.479	\$61.628	\$21.570	\$59.537	0.788	\$46.930	1
33			67	32	20	15	\$94.00	\$28.20	\$3.29	\$91.079	\$9.165	\$16.508	\$23.350	\$5.100	\$0.510	\$0.924	\$8.074	\$19.479	\$59.310	\$20.759	\$58.031	0.783	\$45.433	1
34			65	31	19	15	\$94.00	\$28.20	\$3.29	\$88.477	\$8.903	\$16.036	\$22.683	\$4.955	\$0.499	\$0.898	\$7.844	\$19.479	\$57.059	\$19.971	\$56.567	0.778	\$43.967	1
35			63	30	18	15	\$94.00	\$28.20	\$3.29	\$85.948	\$8.649	\$15.578	\$22.035	\$4.813	\$0.484	\$0.872	\$7.620	\$19.479	\$54.871	\$19.205	\$55.146	0.772	\$42.591	1
39			62	29	18	14	\$94.00	\$28.20	\$3.29	\$83.492	\$8.401	\$15.133	\$21.405	\$4.676	\$0.470	\$0.847	\$7.402	\$19.479	\$52.747	\$18.461	\$53.765	0.767	\$41.243	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Cana Woodford

Cana Woodford				My Assumptions:			
Basin Characteristics				100% oilfield service & supply factor price scalar			
\$7.00 cost/well (\$mm)	Average Well		IP	EUR	30	days/month	
738 EUR/well (mboe)	1,606	1,826	-0.91%	exponential decline rate after year 3 (monthly)			
-65% 1st yr decline	-8.4%	560	\$100.00	oil price WTI (\$/bbl)			
-31% 2nd yr decline	-3.0%	387	0%	oil price appreciation (per month)			
-13% 3rd yr decline	-1.2%	360	\$3.50	gas price Henry Hub (\$/mcf)			
649 IP rate (boe/d)			0%	gas price appreciation			
\$5.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
5% oil			0.68%	discount rate (compound monthly)			
63% gas			8.5%	discount rate (annual)			
32% NGL			80%	intangibile drilling cost / total capex			
20.0% royalty rate			0.880	IP/EUR ratio, (B8/B4 = fixed ratio)			
7.0% oil prod tax			Results				
7.0% gas prod tax							
7.0% NGL prod tax			-\$1.486 = NPV/well (\$ million)				
35.0% income tax rate			0 = EUR check (mboe)				
-6% oil differential			0.23% = ATIRR (monthly)				
-6% gas differential			2.85% = ATIRR (annual)				
0 1 = DUC			738 = total production (mboe)				
25% auxiliary cost/well cost			\$2.923 = "tail end" NPV/well (\$ million)				
50% completion cost/well cost			100% = "tail end" recovery factor				
\$2,000 min opex (\$/month)			0 = months of lost production				

Cana Woodford					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,277	2,003	1,130	994	
\$25	2,106	1,852	1,045	919	
\$30	1,959	1,723	972	855	
\$35	1,831	1,610	909	799	
\$40	1,719	1,512	853	750	
\$45	1,620	1,425	804	707	
\$50	1,531	1,347	761	669	
\$60	1,381	1,215	686	603	
\$70	1,257	1,106	625	550	
\$80	1,154	1,015	573	504	
\$90	1,066	938	530	466	
\$100	991	872	493	434	

Cana Woodford					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	4,104	3,610	2037	1,792	
\$25	3,697	3,252	1835	1,614	
\$30	3,364	2,959	1670	1,469	
\$35	3,086	2,714	1532	1,347	
\$40	2,850	2,507	1415	1,245	
\$45	2,648	2,329	1314	1,156	
\$50	2,473	2,175	1227	1,079	
\$60	2,183	1,920	1084	953	
\$70	1,955	1,719	970	853	
\$80	1,770	1,557	878	772	
\$90	1,616	1,421	802	705	
\$100	1,487	1,308	738	649	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d			Prices				Cash Flows (\$1,000)							PV Factor	ATNPV -\$1.486	Active 1/0		
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.				Income Tax	NCF
1	\$1,750	\$438						\$94.00	\$28.20	\$3.29	\$91.570	\$242.294	\$175.814	\$101.94	\$5.13	\$13.57	\$9.85	\$97.415	\$14.583	\$267.203	\$93.521	\$188.265	0.973	\$183.215	1
2	\$1,750	\$438						\$94.00	\$28.20	\$3.29	\$83.873	\$221.929	\$161.037	\$93.368	\$4.697	\$12.428	\$9.018	\$89.227	\$14.583	\$243.518	\$85.231	\$172.870	0.967	\$167.092	1
3	\$1,750	\$438						\$94.00	\$28.20	\$3.29	\$76.823	\$203.275	\$147.501	\$85.520	\$4.302	\$11.383	\$8.260	\$81.727	\$14.583	\$221.824	\$77.638	\$158.769	0.960	\$152.423	1
4	\$1,750	\$438						\$94.00	\$28.20	\$3.29	\$70.366	\$186.189	\$135.103	\$78.332	\$3.941	\$10.427	\$7.566	\$74.858	\$14.583	\$201.953	\$70.683	\$145.853	0.954	\$139.074	1
5			649	32	208	409	2,455	\$94.00	\$28.20	\$3.29	\$64.452	\$170.539	\$123.747	\$71.748	\$3.609	\$9.550	\$6.930	\$68.566	\$14.583	\$183.752	\$64.313	\$134.022	0.947	\$126.928	1
6			595	30	190	375	2,249	\$94.00	\$28.20	\$3.29	\$59.034	\$156.205	\$113.346	\$65.717	\$3.306	\$8.747	\$6.347	\$62.802	\$14.583	\$167.081	\$58.478	\$123.186	0.941	\$115.875	1
7			545	27	174	343	2,060	\$94.00	\$28.20	\$3.29	\$54.072	\$143.075	\$103.819	\$60.193	\$3.028	\$8.012	\$5.814	\$57.524	\$14.583	\$151.812	\$53.134	\$113.261	0.934	\$105.817	1
8			499	25	160	314	1,886	\$94.00	\$28.20	\$3.29	\$49.527	\$131.049	\$95.092	\$55.134	\$2.774	\$7.339	\$5.325	\$52.689	\$14.583	\$137.826	\$48.239	\$104.170	0.928	\$96.664	1
9			457	23	146	288	1,728	\$94.00	\$28.20	\$3.29	\$45.364	\$120.034	\$87.100	\$50.500	\$2.540	\$6.722	\$4.878	\$48.260	\$14.583	\$125.015	\$43.755	\$95.843	0.922	\$88.335	1
10			419	21	134	264	1,583	\$94.00	\$28.20	\$3.29	\$41.551	\$109.945	\$79.779	\$46.255	\$2.327	\$6.157	\$4.468	\$44.204	\$14.583	\$113.282	\$39.649	\$88.216	0.915	\$80.755	1
11			383	19	123	242	1,450	\$94.00	\$28.20	\$3.29	\$38.059	\$100.704	\$73.073	\$42.367	\$2.131	\$5.639	\$4.092	\$40.488	\$14.583	\$102.534	\$35.887	\$81.231	0.909	\$73.856	1
12			351	18	112	221	1,328	\$94.00	\$28.20	\$3.29	\$34.869	\$92.239	\$66.931	\$38.806	\$1.952	\$5.165	\$3.748	\$37.085	\$14.583	\$92.690	\$32.442	\$74.832	0.903	\$67.577	1
13			322	16	103	203	1,216	\$94.00	\$28.20	\$3.29	\$33.803	\$89.442	\$64.901	\$37.629	\$1.893	\$5.009	\$3.634	\$35.960	\$14.583	\$89.437	\$31.303	\$72.717	0.897	\$65.223	1
14			295	15	94	186	1,114	\$94.00	\$28.20	\$3.29	\$32.778	\$86.730	\$62.933	\$36.488	\$1.836	\$4.857	\$3.524	\$34.870	\$14.583	\$86.283	\$30.199	\$70.667	0.891	\$62.954	1
15			270	13	86	170	1,020	\$94.00	\$28.20	\$3.29	\$31.784	\$84.100	\$61.025	\$35.382	\$1.780	\$4.710	\$3.417	\$33.813	\$14.583	\$83.224	\$29.128	\$68.679	0.885	\$60.769	1
16			247	12	79	156	935	\$94.00	\$28.20	\$3.29	\$30.820	\$81.550	\$59.174	\$34.309	\$1.726	\$4.567	\$3.314	\$32.787	\$14.583	\$80.258	\$28.090	\$66.751	0.879	\$58.663	1
17			240	12	77	151	906	\$94.00	\$28.20	\$3.29	\$29.885	\$79.077	\$57.380	\$33.269	\$1.674	\$4.428	\$3.213	\$31.793	\$14.583	\$77.382	\$27.084	\$64.882	0.873	\$56.634	1
18			232	12	74	146	879	\$94.00	\$28.20	\$3.29	\$28.979	\$76.679	\$55.640	\$32.260	\$1.623	\$4.294	\$3.116	\$30.829	\$14.583	\$74.594	\$26.108	\$63.069	0.867	\$54.678	1
19			225	11	72	142	852	\$94.00	\$28.20	\$3.29	\$28.101	\$74.354	\$53.953	\$31.281	\$1.574	\$4.164	\$3.021	\$29.894	\$14.583	\$71.890	\$25.161	\$61.312	0.861	\$52.794	1
20			219	11	70	138	826	\$94.00	\$28.20	\$3.29	\$27.248	\$72.099	\$52.317	\$30.333	\$1.526	\$4.038	\$2.930	\$28.988	\$14.583	\$69.267	\$24.244	\$59.607	0.855	\$50.979	1
21			212	11	68	134	801	\$94.00	\$28.20	\$3.29	\$26.422	\$69.913	\$50.730	\$29.413	\$1.480	\$3.915	\$2.841	\$28.109	\$14.583	\$66.725	\$23.354	\$57.954	0.849	\$49.230	1
22			206	10	66	129	777	\$94.00	\$28.20	\$3.29	\$25.621	\$67.793	\$49.192	\$28.521	\$1.435	\$3.796	\$2.755	\$27.256	\$14.583	\$64.259	\$22.491	\$56.352	0.844	\$47.544	1
23			199	10	64	126	753	\$94.00	\$28.20	\$3.29	\$24.844	\$65.737	\$47.701	\$27.656	\$1.391	\$3.681	\$2.671	\$26.430	\$14.583	\$61.869	\$21.654	\$54.798	0.838	\$45.920	1
24			193	10	62	122	730	\$94.00	\$28.20	\$3.29	\$24.091	\$63.744	\$46.254	\$26.818	\$1.349	\$3.570	\$2.590	\$25.628	\$14.583	\$59.550	\$20.843	\$53.291	0.832	\$44.354	1
25			187	9	60	118	708	\$94.00	\$28.20	\$3.29	\$23.802	\$62.980	\$45.700	\$26.496	\$1.333	\$3.527	\$2.559	\$25.321	\$14.583	\$58.662	\$20.532	\$52.714	0.827	\$43.577	1
26			182	9	58	114	687	\$94.00	\$28.20	\$3.29	\$23.517	\$62.226	\$45.152	\$26.179	\$1.317	\$3.485	\$2.529	\$25.018	\$14.583	\$57.784	\$20.225	\$52.143	0.821	\$42.813	1
27			176	9	56	111	666	\$94.00	\$28.20	\$3.29	\$23.235	\$61.480	\$44.611	\$25.865	\$1.301	\$3.443	\$2.498	\$24.718	\$14.583	\$56.917	\$19.921	\$51.580	0.816	\$42.063	1
28			171	9	55	108	646	\$94.00	\$28.20	\$3.29	\$22.957	\$60.743	\$44.077	\$25.555	\$1.286	\$3.402	\$2.468	\$24.422	\$14.583	\$56.061	\$19.621	\$51.023	0.810	\$41.327	1
29			167	8	53	105	630	\$94.00	\$28.20	\$3.29	\$22.682	\$60.016	\$43.549	\$25.249	\$1.270	\$3.361	\$2.439	\$24.129	\$14.583	\$55.214	\$19.325	\$50.473	0.804	\$40.605	1
30			165	8	53	104	623	\$94.00	\$28.20	\$3.29	\$22.410	\$59.297	\$43.027	\$24.947	\$1.255	\$3.321	\$2.410	\$23.840	\$14.583	\$54.378	\$19.032	\$49.929	0.799	\$39.895	1
31			163	8	52	103	615	\$94.00	\$28.20	\$3.29	\$22.141	\$58.586	\$42.512	\$24.648	\$1.240	\$3.282	\$2.381	\$23.555	\$14.583	\$53.552	\$18.743	\$49.392	0.794	\$39.199	1
32			161	8	51	101	608	\$94.00	\$28.20	\$3.29	\$21.876	\$57.884	\$42.002	\$24.353	\$1.225	\$3.242	\$2.352	\$23.272	\$14.583	\$52.736	\$18.457	\$48.861	0.788	\$38.515	1
33			159	8	51	100	601	\$94.00	\$28.20	\$3.29	\$21.614	\$57.191	\$41.499	\$24.061	\$1.210	\$3.203	\$2.324	\$22.994	\$14.583	\$51.929	\$18.175	\$48.337	0.783	\$37.844	1
34			157	8	50	99	594	\$94.00	\$28.20	\$3.29	\$21.355	\$56.506	\$41.002	\$23.772	\$1.196	\$3.164	\$2.296	\$22.718	\$14.583	\$51.132	\$17.896	\$47.819	0.778	\$37.184	1
35			155	8	49	97	586	\$94.00	\$28.20	\$3.29	\$21.099	\$55.829	\$40.511	\$23.488	\$1.182	\$3.126	\$2.269	\$22.446	\$14.583	\$50.345	\$17.621	\$47.307	0.772	\$36.537	1
36			153	8	49	98	579	\$94.00	\$28.20	\$3.29	\$20.846	\$55.160	\$40.025	\$23.206	\$1.167	\$3.089	\$2.241	\$22.177	\$14.583	\$49.567	\$17.348	\$46.802	0.767	\$35.902	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Mississippian

Mississippian			My Assumptions:	
Basin Characteristics			100% oilfield service & supply factor price scalar	
\$2.80 cost/well (\$mm)	Average Well		30 days/month	
147 EUR/well (mboe)	IP	EUR	-0.68% exponential decline rate after year 3 (monthly)	
-71% 1st yr decline	409	410	\$100.00 oil price WTI (\$/bbl)	
-31% 2nd yr decline	120		0% oil price appreciation (per month)	
-29% 3rd yr decline	83		\$3.50 gas price Henry Hub (\$/mcf)	
147 IP rate (boe/d)			0% gas price appreciation	
\$6.00 opex-LOE (\$/boe)			30% NGL price/oil price (fixed ratio)	
34% oil			0.68% discount rate (compound monthly)	
46% gas			8.5% discount rate (annual)	
20% NGL			80% intangible drilling cost / total capex	
20.0% royalty rate			0.998 IP/EUR ratio, (B8/B4 = fixed ratio)	
7.0% oil prod tax				
7.0% gas prod tax				
7.0% NGL prod tax				
35.0% income tax rate				
-6% oil differential				
-6% gas differential				
0 1 = DUC				
25% auxiliary cost/well cost				
50% completion cost/well cost				
\$2,000 min opex (\$/month)				

Results	
-50.686	= NPV/well (\$ million)
0	= EUR check (mboe)
0.16%	= ATIRR (monthly)
1.96%	= ATIRR (annual)
147	= total production (mboe)
\$1.055	= "tail end" NPV/well (\$ million)
100%	= "tail end" recovery factor
0	= months of lost production

Mississippian					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	931	929	462	461	
\$25	763	761	379	378	
\$30	646	644	322	321	
\$35	560	559	279	278	
\$40	495	494	247	246	
\$45	443	442	222	221	
\$50	401	400	201	201	
\$60	337	336	169	169	
\$70	291	290	147	147	
\$80	256	255	130	130	
\$90	229	228	116	116	
\$100	207	206	105	105	

Mississippian					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	1,799	1,795	893	891	
\$25	1,363	1,360	676	674	
\$30	1,097	1,094	544	543	
\$35	918	916	455	454	
\$40	789	787	392	391	
\$45	692	690	344	343	
\$50	616	614	306	305	
\$60	505	504	251	250	
\$70	428	427	213	212	
\$80	372	371	185	185	
\$90	328	327	164	164	
\$100	294	293	147	147	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)						PV Factor	AT NPV -\$686	Active 1/0					
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax				NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax
1	\$700	\$175						\$94.00	\$28.20	\$3.29								\$700.000		-\$700.00	-\$245.000	-630	1.000	-\$630.00	
2	\$700	\$175						\$94.00	\$28.20	\$3.29								\$700.000		-\$700.00	-\$245.000	-630	0.993	-\$625.73	
3	\$700	\$175						\$94.00	\$28.20	\$3.29								\$700.000		-\$700.00	-\$245.000	-630	0.986	-\$621.49	
4	\$700	\$175						\$94.00	\$28.20	\$3.29								\$700.000		-\$700.00	-\$245.000	-630	0.980	-\$617.28	
5			147	50	29	67	405	\$94.00	\$28.20	\$3.29	\$140.617	\$39.952	\$24.815	\$41.08	\$7.87	\$2.24	\$1.39	\$26.399	\$5.833	\$120.573	\$42.201	\$84.206	0.973	\$81.947	1
6			132	45	26	61	365	\$94.00	\$28.20	\$3.29	\$126.958	\$36.071	\$22.404	\$37.087	\$7.110	\$2.020	\$1.255	\$23.834	\$5.833	\$108.294	\$37.903	\$76.225	0.967	\$73.677	1
7			120	41	24	55	330	\$94.00	\$28.20	\$3.29	\$114.625	\$32.567	\$20.228	\$33.484	\$6.419	\$1.824	\$1.133	\$21.519	\$5.833	\$97.208	\$34.023	\$69.019	0.960	\$66.260	1
8			108	37	22	50	298	\$94.00	\$28.20	\$3.29	\$103.491	\$29.404	\$18.263	\$30.232	\$5.795	\$1.647	\$1.023	\$19.429	\$5.833	\$87.199	\$30.520	\$62.513	0.954	\$59.608	1
9			97	33	19	45	269	\$94.00	\$28.20	\$3.29	\$93.438	\$26.547	\$16.489	\$27.295	\$5.233	\$1.487	\$0.923	\$17.542	\$5.833	\$78.162	\$27.357	\$56.639	0.947	\$53.641	1
10			88	30	18	40	243	\$94.00	\$28.20	\$3.29	\$84.362	\$23.969	\$14.887	\$24.644	\$4.724	\$1.342	\$0.834	\$15.838	\$5.833	\$70.003	\$24.501	\$51.335	0.941	\$48.288	1
11			79	27	16	37	219	\$94.00	\$28.20	\$3.29	\$76.167	\$21.640	\$13.441	\$22.250	\$4.265	\$1.212	\$0.753	\$14.299	\$5.833	\$62.636	\$21.923	\$46.547	0.934	\$43.488	1
12			72	24	14	33	198	\$94.00	\$28.20	\$3.29	\$68.768	\$19.538	\$12.136	\$20.088	\$3.851	\$1.094	\$0.680	\$12.910	\$5.833	\$55.985	\$19.595	\$42.224	0.928	\$39.181	1
13			65	22	13	30	179	\$94.00	\$28.20	\$3.29	\$62.088	\$17.640	\$10.957	\$18.137	\$3.477	\$0.988	\$0.614	\$11.656	\$5.833	\$49.980	\$17.493	\$38.321	0.922	\$35.319	1
14			58	20	12	27	161	\$94.00	\$28.20	\$3.29	\$56.057	\$15.927	\$9.892	\$16.375	\$3.139	\$0.892	\$0.554	\$10.524	\$5.833	\$44.559	\$15.596	\$34.797	0.915	\$31.853	1
15			53	18	11	24	146	\$94.00	\$28.20	\$3.29	\$50.612	\$14.380	\$8.932	\$14.785	\$2.834	\$0.805	\$0.500	\$9.502	\$5.833	\$39.664	\$13.882	\$31.615	0.909	\$28.745	1
16			48	16	10	22	132	\$94.00	\$28.20	\$3.29	\$45.696	\$12.983	\$8.064	\$13.348	\$2.559	\$0.727	\$0.452	\$8.579	\$5.833	\$35.244	\$12.336	\$28.742	0.903	\$25.956	1
17			46	16	9	21	128	\$94.00	\$28.20	\$3.29	\$44.313	\$12.590	\$7.820	\$12.945	\$2.482	\$0.705	\$0.438	\$8.319	\$5.833	\$34.002	\$11.901	\$27.934	0.897	\$25.055	1
18			45	15	9	21	124	\$94.00	\$28.20	\$3.29	\$42.972	\$12.209	\$7.583	\$12.553	\$2.406	\$0.684	\$0.425	\$8.067	\$5.833	\$32.796	\$11.479	\$27.151	0.891	\$24.188	1
19			43	15	9	20	120	\$94.00	\$28.20	\$3.29	\$41.672	\$11.840	\$7.354	\$12.173	\$2.334	\$0.663	\$0.412	\$7.823	\$5.833	\$31.628	\$11.070	\$26.391	0.885	\$23.352	1
20			42	14	8	19	116	\$94.00	\$28.20	\$3.29	\$40.412	\$11.482	\$7.131	\$11.805	\$2.263	\$0.643	\$0.399	\$7.587	\$5.833	\$30.494	\$10.673	\$25.655	0.879	\$22.546	1
21			41	14	8	19	113	\$94.00	\$28.20	\$3.29	\$39.189	\$11.134	\$6.916	\$11.448	\$2.195	\$0.624	\$0.387	\$7.357	\$5.833	\$29.395	\$10.288	\$24.940	0.873	\$21.770	1
22			40	13	8	18	109	\$94.00	\$28.20	\$3.29	\$38.003	\$10.797	\$6.706	\$11.101	\$2.128	\$0.605	\$0.376	\$7.135	\$5.833	\$28.330	\$9.915	\$24.248	0.867	\$21.022	1
23			38	13	8	18	106	\$94.00	\$28.20	\$3.29	\$36.854	\$10.471	\$6.504	\$10.766	\$2.064	\$0.586	\$0.364	\$6.919	\$5.833	\$27.296	\$9.554	\$23.576	0.861	\$20.301	1
24			37	13	7	17	103	\$94.00	\$28.20	\$3.29	\$35.739	\$10.154	\$6.307	\$10.440	\$2.001	\$0.569	\$0.353	\$6.709	\$5.833	\$26.294	\$9.203	\$22.924	0.855	\$19.606	1
25			36	12	7	17	100	\$94.00	\$28.20	\$3.29	\$34.657	\$9.847	\$6.116	\$10.124	\$1.941	\$0.551	\$0.342	\$6.506	\$5.833	\$25.322	\$8.863	\$22.292	0.849	\$18.936	1
26			35	12	7	16	97	\$94.00	\$28.20	\$3.29	\$33.609	\$9.549	\$5.931	\$9.818	\$1.882	\$0.535	\$0.332	\$6.310	\$5.833	\$24.379	\$8.533	\$21.680	0.844	\$18.291	1
27			34	12	7	16	94	\$94.00	\$28.20	\$3.29	\$32.592	\$9.260	\$5.752	\$9.521	\$1.825	\$0.519	\$0.322	\$6.119	\$5.833	\$23.465	\$8.213	\$21.086	0.838	\$17.669	1
28			33	11	7	15	91	\$94.00	\$28.20	\$3.29	\$31.606	\$8.980	\$5.578	\$9.233	\$1.770	\$0.503	\$0.312	\$5.934	\$5.833	\$22.579	\$7.903	\$20.510	0.832	\$17.070	1
29			32	11	6	15	88	\$94.00	\$28.20	\$3.29	\$30.721	\$8.728	\$5.421	\$8.974	\$1.720	\$0.489	\$0.304	\$5.767	\$5.833	\$21.783	\$7.624	\$19.993	0.827	\$16.527	1
30			31	11	6	14	86	\$94.00	\$28.20	\$3.29	\$29.861	\$8.484	\$5.270	\$8.723	\$1.672	\$0.475	\$0.295	\$5.606	\$5.833	\$21.010	\$7.354	\$19.490	0.821	\$16.003	1
31			30	10	6	14	84	\$94.00	\$28.20	\$3.29	\$29.026	\$8.247	\$5.122	\$8.479	\$1.625	\$0.462	\$0.287	\$5.449	\$5.833	\$20.259	\$7.091	\$19.002	0.816	\$15.496	1
32			29	10	6	14	81	\$94.00	\$28.20	\$3.29	\$28.213	\$8.016	\$4.979	\$8.242	\$1.580	\$0.449	\$0.279	\$5.297	\$5.833	\$19.529	\$6.835	\$18.527	0.810	\$15.006	1
33			29	10	6	13	79	\$94.00	\$28.20	\$3.29	\$27.423	\$7.791	\$4.839	\$8.011	\$1.536	\$0.436	\$0.271	\$5.148	\$5.833	\$18.819	\$6.587	\$18.065	0.804	\$14.534	1
34			28	9	6	13	77	\$94.00	\$28.20	\$3.29	\$26.656	\$7.573	\$4.704	\$7.787	\$1.493	\$0.424	\$0.263	\$5.004	\$5.833	\$18.129	\$6.345	\$17.617	0.799	\$14.077	1
35			27	9	5	12	75	\$94.00	\$28.20	\$3.29	\$25.910	\$7.361	\$4.572	\$7.569	\$1.451	\$0.412	\$0.256	\$4.864	\$5.833	\$17.458	\$6.110	\$17.181	0.794	\$13.635	1
36			26	9	5	12	72	\$94.00	\$28.20	\$3.29	\$25.184	\$7.155	\$4.444	\$7.357	\$1.410	\$0.401	\$0.249	\$4.728	\$5.833	\$16.806	\$5.882	\$16.757	0.788	\$13.209	1
37			26	9	5	12	70	\$94.00	\$28.20	\$3.29	\$24.479	\$6.955	\$4.320	\$7.151	\$1.371	\$0.389	\$0.242	\$4.596	\$5.833	\$16.172	\$5.660	\$16.345	0.783	\$12.797	1
38			25	8	5	11	68	\$94.00	\$28.20	\$3.29	\$23.794	\$6.760	\$4.199	\$6.951	\$1.332	\$0.379	\$0.235	\$4.467	\$5.833	\$15.556	\$5.445	\$15.945	0.		

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Marmaton

Marmaton			My Assumptions:		
Basin Characteristics			100% oilfield service & supply factor price scalar		
\$3.06 cost/well (\$mm)	Average Well		30 days/month		
94 EUR/well (mboe)	IP	EUR	-1.22% exponential decline rate after year 3 (monthly)		
-69% 1st yr decline	276	201	\$100.00 oil price WTI (\$/bbl)		
-41% 2nd yr decline	85		0% oil price appreciation (per month)		
-26% 3rd yr decline	50		\$3.50 gas price Henry Hub (\$/mcf)		
130 IP rate (boe/d)			0% gas price appreciation		
\$5.00 opex-LOE (\$/boe)			30% NGL price/oil price (fixed ratio)		
55% oil			0.68% discount rate (compound monthly)		
25% gas			8.5% discount rate (annual)		
20% NGL			80% intangible drilling cost / total capex		
20.0% royalty rate			1.373 IP/EUR ratio, (B8/B4 = fixed ratio)		
7.0% oil prod tax					
7.0% gas prod tax					
7.0% NGL prod tax					
35.0% income tax rate					
-6% oil differential					
-6% gas differential					
0 1 = DUC					
25% auxiliary cost/well cost					
50% completion cost/well cost					
\$2,000 min opex (\$/month)					

Results	
-50.805	= NPV/well (\$ million)
0	= EUR check (mboe)
-0.12%	= ATIRR (monthly)
-1.42%	= ATIRR (annual)
94	= total production (mboe)
\$0.879	= "tail end" NPV/well (\$ million)
94%	= "tail end" recovery factor
110	= months of lost production

Marmaton					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	771	1,059	385	529	
\$25	595	817	298	409	
\$30	485	666	244	335	
\$35	409	562	206	283	
\$40	354	486	179	246	
\$45	312	428	158	217	
\$50	279	383	141	194	
\$60	231	317	117	161	
\$70	196	269	100	137	
\$80	171	235	87	119	
\$90	152	209	78	107	
\$100	136	187	70	96	

Marmaton					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	1,326	1,821	660	906	
\$25	959	1,317	478	656	
\$30	751	1,031	375	515	
\$35	617	847	308	423	
\$40	524	720	262	360	
\$45	455	625	228	313	
\$50	403	553	202	277	
\$60	327	449	164	225	
\$70	275	378	138	189	
\$80	238	327	120	165	
\$90	209	287	106	146	
\$100	187	257	94	129	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)								PV Factor	AT NPV -\$805	Active 1/0			
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex				Depreciation	Tax. Inc.	Income Tax
1	\$765	\$191					194	\$94.00	\$28.20	\$3.29	\$201.014	\$19.188	\$21.929	\$48.43	\$11.26	\$1.07	\$1.23	\$19.440	\$6.375	\$154.330	\$54.015	\$106.689	0.973	\$103.827	1
2	\$765	\$191					176	\$94.00	\$28.20	\$3.29	\$182.223	\$17.394	\$19.879	\$43.899	\$10.204	\$0.974	\$1.113	\$17.623	\$6.375	\$139.307	\$48.757	\$96.924	0.967	\$93.685	1
3	\$765	\$191					107	\$94.00	\$28.20	\$3.29	\$165.188	\$15.768	\$18.021	\$39.795	\$9.251	\$0.883	\$1.009	\$15.976	\$6.375	\$125.688	\$43.991	\$88.072	0.960	\$84.552	1
4	\$765	\$191					97	\$94.00	\$28.20	\$3.29	\$149.746	\$14.294	\$16.336	\$36.075	\$8.386	\$0.800	\$0.915	\$14.482	\$6.375	\$113.342	\$39.670	\$80.047	0.954	\$76.327	1
5			130	71	26	32	194	\$94.00	\$28.20	\$3.29	\$135.747	\$12.958	\$14.809	\$32.703	\$7.602	\$0.726	\$0.829	\$13.128	\$6.375	\$102.151	\$35.753	\$72.773	0.947	\$68.921	1
6			117	65	23	29	119	\$94.00	\$28.20	\$3.29	\$123.057	\$11.746	\$13.424	\$29.646	\$6.891	\$0.658	\$0.752	\$11.901	\$6.375	\$92.005	\$32.202	\$66.778	0.941	\$62.251	1
7			107	59	21	27	108	\$94.00	\$28.20	\$3.29	\$111.553	\$10.648	\$12.169	\$26.874	\$6.247	\$0.596	\$0.681	\$10.789	\$6.375	\$82.808	\$28.983	\$60.200	0.934	\$56.244	1
8			97	53	19	24	98	\$94.00	\$28.20	\$3.29	\$101.125	\$9.653	\$11.032	\$24.362	\$5.663	\$0.541	\$0.618	\$9.780	\$6.375	\$74.471	\$26.065	\$54.781	0.928	\$50.834	1
9			88	48	18	22	89	\$94.00	\$28.20	\$3.29	\$91.671	\$8.750	\$10.001	\$22.084	\$5.134	\$0.490	\$0.560	\$8.866	\$6.375	\$66.914	\$23.420	\$49.869	0.922	\$45.962	1
10			79	44	16	20	80	\$94.00	\$28.20	\$3.29	\$83.102	\$7.932	\$9.066	\$20.020	\$4.654	\$0.444	\$0.508	\$8.037	\$6.375	\$60.062	\$21.022	\$45.415	0.915	\$41.574	1
11			72	40	14	18	73	\$94.00	\$28.20	\$3.29	\$75.333	\$7.191	\$8.218	\$18.148	\$4.219	\$0.403	\$0.460	\$7.286	\$6.375	\$53.851	\$18.848	\$41.378	0.909	\$37.622	1
12			65	36	13	16	66	\$94.00	\$28.20	\$3.29	\$68.291	\$6.519	\$7.450	\$16.452	\$3.824	\$0.365	\$0.417	\$6.605	\$6.375	\$48.221	\$16.877	\$37.719	0.903	\$34.062	1
13			59	33	12	15	63	\$94.00	\$28.20	\$3.29	\$65.337	\$6.237	\$7.128	\$15.740	\$3.659	\$0.349	\$0.399	\$6.319	\$6.375	\$45.860	\$16.051	\$36.184	0.897	\$32.454	1
14			54	29	11	13	60	\$94.00	\$28.20	\$3.29	\$62.511	\$5.967	\$6.819	\$15.059	\$3.501	\$0.334	\$0.382	\$6.046	\$6.375	\$43.600	\$15.260	\$34.715	0.891	\$30.926	1
15			49	27	10	12	58	\$94.00	\$28.20	\$3.29	\$59.807	\$5.709	\$6.524	\$14.408	\$3.349	\$0.320	\$0.365	\$5.784	\$6.375	\$41.439	\$14.503	\$33.310	0.885	\$29.473	1
16			44	24	9	11	55	\$94.00	\$28.20	\$3.29	\$57.220	\$5.462	\$6.242	\$13.785	\$3.204	\$0.306	\$0.350	\$5.534	\$6.375	\$39.370	\$13.780	\$31.966	0.879	\$28.092	1
17			42	23	8	11	53	\$94.00	\$28.20	\$3.29	\$54.745	\$5.226	\$5.972	\$13.188	\$3.066	\$0.293	\$0.334	\$5.294	\$6.375	\$37.392	\$13.087	\$30.680	0.873	\$26.779	1
18			39	21	8	10	51	\$94.00	\$28.20	\$3.29	\$52.377	\$5.000	\$5.714	\$12.618	\$2.933	\$0.280	\$0.320	\$5.065	\$6.375	\$35.498	\$12.424	\$29.449	0.867	\$25.531	1
19			37	20	7	9	48	\$94.00	\$28.20	\$3.29	\$50.111	\$4.783	\$5.467	\$12.072	\$2.806	\$0.268	\$0.306	\$4.846	\$6.375	\$33.687	\$11.791	\$28.272	0.861	\$24.344	1
20			35	19	7	8	46	\$94.00	\$28.20	\$3.29	\$47.943	\$4.576	\$5.230	\$11.550	\$2.685	\$0.256	\$0.293	\$4.637	\$6.375	\$31.954	\$11.184	\$27.145	0.855	\$23.216	1
21			34	19	7	8	44	\$94.00	\$28.20	\$3.29	\$45.870	\$4.378	\$5.004	\$11.050	\$2.569	\$0.245	\$0.280	\$4.436	\$6.375	\$30.296	\$10.604	\$26.068	0.849	\$22.143	1
22			32	18	6	8	42	\$94.00	\$28.20	\$3.29	\$43.885	\$4.189	\$4.788	\$10.572	\$2.458	\$0.235	\$0.268	\$4.244	\$6.375	\$28.710	\$10.049	\$25.037	0.844	\$21.123	1
23			30	16	6	7	41	\$94.00	\$28.20	\$3.29	\$41.987	\$4.008	\$4.580	\$10.115	\$2.351	\$0.224	\$0.257	\$4.061	\$6.375	\$27.192	\$9.517	\$24.050	0.838	\$20.154	1
24			28	16	6	7	39	\$94.00	\$28.20	\$3.29	\$40.171	\$3.835	\$4.382	\$9.678	\$2.250	\$0.215	\$0.245	\$3.885	\$6.375	\$25.740	\$9.009	\$23.106	0.832	\$19.232	1
25			27	15	5	7	38	\$94.00	\$28.20	\$3.29	\$39.174	\$3.739	\$4.274	\$9.437	\$2.194	\$0.209	\$0.239	\$3.789	\$6.375	\$24.943	\$8.730	\$22.588	0.827	\$18.673	1
26			26	14	5	6	37	\$94.00	\$28.20	\$3.29	\$38.201	\$3.646	\$4.167	\$9.203	\$2.139	\$0.204	\$0.233	\$3.695	\$6.375	\$24.166	\$8.458	\$22.083	0.821	\$18.131	1
27			25	14	5	6	36	\$94.00	\$28.20	\$3.29	\$37.253	\$3.556	\$4.064	\$8.975	\$2.086	\$0.199	\$0.228	\$3.603	\$6.375	\$23.408	\$8.193	\$21.590	0.816	\$17.607	1
28			24	13	5	6	35	\$94.00	\$28.20	\$3.29	\$36.328	\$3.468	\$3.963	\$8.752	\$2.034	\$0.194	\$0.222	\$3.513	\$6.375	\$22.668	\$7.934	\$21.109	0.810	\$17.098	1
29			23	13	5	6	34	\$94.00	\$28.20	\$3.29	\$35.426	\$3.382	\$3.865	\$8.535	\$1.984	\$0.189	\$0.216	\$3.426	\$6.375	\$21.947	\$7.682	\$20.641	0.804	\$16.605	1
30			22	12	4	6	33	\$94.00	\$28.20	\$3.29	\$34.547	\$3.298	\$3.769	\$8.323	\$1.935	\$0.185	\$0.211	\$3.341	\$6.375	\$21.244	\$7.436	\$20.184	0.799	\$16.128	1
31			22	12	4	5	33	\$94.00	\$28.20	\$3.29	\$33.689	\$3.216	\$3.675	\$8.116	\$1.887	\$0.180	\$0.206	\$3.258	\$6.375	\$20.559	\$7.196	\$19.738	0.794	\$15.665	1
32			21	12	4	5	32	\$94.00	\$28.20	\$3.29	\$32.853	\$3.136	\$3.584	\$7.915	\$1.840	\$0.176	\$0.201	\$3.177	\$6.375	\$19.890	\$6.962	\$19.304	0.788	\$15.216	1
33			21	11	4	5	31	\$94.00	\$28.20	\$3.29	\$32.038	\$3.058	\$3.495	\$7.718	\$1.794	\$0.171	\$0.196	\$3.098	\$6.375	\$19.238	\$6.733	\$18.880	0.783	\$14.781	1
34			20	11	4	5	30	\$94.00	\$28.20	\$3.29	\$31.242	\$2.982	\$3.408	\$7.527	\$1.750	\$0.167	\$0.191	\$3.021	\$6.375	\$18.602	\$6.511	\$18.466	0.778	\$14.360	1
35			20	11	4	5	29	\$94.00	\$28.20	\$3.29	\$30.467	\$2.908	\$3.324	\$7.340	\$1.706	\$0.163	\$0.186	\$2.946	\$6.375	\$17.982	\$6.294	\$18.063	0.772	\$13.951	1
36			19	10	4	5	29	\$94.00	\$28.20	\$3.29	\$29.710	\$2.836	\$3.241	\$7.158	\$1.664	\$0.159	\$0.182	\$2.873	\$6.375	\$17.378	\$6.082	\$17.670	0.767	\$13.555	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Tonkawa

Tonkawa				My Assumptions:			
Basin Characteristics				100% oilfield service & supply factor price scalar			
\$3.70 cost/well (\$mm)	Average Well		IP	EUR	30	days/month	
115 EUR/well (mboe)	340	249			-1.12%	exponential decline rate after year 3 (monthly)	
-73% 1st yr decline	-10.4%	92			\$100.00	oil price WTI (\$/bbl)	
-38% 2nd yr decline	-4.0%	56			0%	oil price appreciation (per month)	
-20% 3rd yr decline	-1.9%	50			\$3.50	gas price Henry Hub (\$/mcf)	
157 IP rate (boe/d)					0%	gas price appreciation	
\$5.00 opex-LOE (\$/boe)					30%	NGL price/oil price (fixed ratio)	
56% oil					0.68%	discount rate (compound monthly)	
28% gas					8.5%	discount rate (annual)	
17% NGL					80%	intangible drilling cost / total capex	
20.0% royalty rate					1.365	IP/EUR ratio, (B8/B4 = fixed ratio)	
7.0% oil prod tax					Results		
7.0% gas prod tax					-\$0.972 = NPV/well (\$ million)		
7.0% NGL prod tax					0 = EUR check (mboe)		
35.0% income tax rate					-0.05% = ATIRR (monthly)		
-6% oil differential					-0.57% = ATIRR (annual)		
-6% gas differential					115 = total production (mboe)		
0 1 = DUC					\$1.150 = "tail end" NPV/well (\$ million)		
25% auxiliary cost/well cost					96% = "tail end" recovery factor		
50% completion cost/well cost					72 = months of lost production		
\$2,000 min opex (\$/month)							

Tonkawa					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	901	1,230	449	613	
\$25	705	963	352	481	
\$30	579	791	290	396	
\$35	491	670	246	336	
\$40	427	583	214	292	
\$45	377	515	190	259	
\$50	338	462	170	232	
\$60	280	382	141	193	
\$70	239	326	121	165	
\$80	209	285	106	145	
\$90	185	253	94	128	
\$100	166	227	85	116	

Tonkawa					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	1,525	2,082	758	1,035	
\$25	1,125	1,536	560	765	
\$30	891	1,217	444	606	
\$35	738	1,008	368	502	
\$40	630	860	314	429	
\$45	550	751	274	374	
\$50	487	665	244	333	
\$60	398	543	199	272	
\$70	336	459	168	229	
\$80	291	397	146	199	
\$90	256	350	129	176	
\$100	229	313	115	157	

Per Well Net Cash Flow Analysis																												
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)								PV Factor	AT NPV -\$972	Active 1/0						
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex				Depreciation	Tax. Inc.	Income Tax	NCF		
1	\$925	\$231					264	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$248,208	\$26,062	\$22,605	\$59.38	\$13.90	\$1.46	\$1.27	\$925,000	-\$925,000	-\$323,750	-833	1.000	-\$932,500	1	
2	\$925	\$231					237	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$222,389	\$23,351	\$20,253	\$53.199	\$12,454	\$1,308	\$1,134	\$925,000	-\$925,000	-\$323,750	-833	0.993	-\$826.86	1	
3	\$925	\$231					126	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$199,256	\$20,922	\$18,146	\$47,665	\$11,158	\$1,172	\$1,016	\$925,000	-\$925,000	-\$323,750	-833	0.986	-\$821.26	1	
4	\$925	\$231					113	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$178,528	\$18,745	\$16,259	\$42,707	\$9,998	\$1,050	\$0,910	\$925,000	-\$925,000	-\$323,750	-833	0.980	-\$815.69	1	
5			157	88	27	44	264	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$248,208	\$26,062	\$22,605	\$59.38	\$13.90	\$1.46	\$1.27	\$23,576	\$7,708	\$189,591	\$66,357	\$130,942	0.973	\$127,430	1
6			141	79	24	39	237	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$222,389	\$23,351	\$20,253	\$53.199	\$12,454	\$1,308	\$1,134	\$21,124	\$7,708	\$169,067	\$59,173	\$117,602	0.967	\$113,672	1
7			126	71	21	35	212	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$199,256	\$20,922	\$18,146	\$47,665	\$11,158	\$1,172	\$1,016	\$18,926	\$7,708	\$150,678	\$52,737	\$105,649	0.960	\$101,427	1
8			113	63	19	32	190	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$178,528	\$18,745	\$16,259	\$42,707	\$9,998	\$1,050	\$0,910	\$16,957	\$7,708	\$134,203	\$46,971	\$94,940	0.954	\$90,528	1
9			101	57	17	28	170	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$159,957	\$16,796	\$14,568	\$38,264	\$8,958	\$0,941	\$0,816	\$15,194	\$7,708	\$119,441	\$41,804	\$85,345	0.947	\$80,827	1
10			91	51	15	25	152	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$143,318	\$15,048	\$13,052	\$34,284	\$8,026	\$0,843	\$0,731	\$13,613	\$7,708	\$106,214	\$37,175	\$76,748	0.941	\$72,192	1
11			81	46	14	23	137	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$128,410	\$13,483	\$11,694	\$30,717	\$7,191	\$0,755	\$0,655	\$12,197	\$7,708	\$94,364	\$33,027	\$69,045	0.934	\$64,507	1
12			73	41	12	20	122	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$115,052	\$12,080	\$10,478	\$27,522	\$6,443	\$0,677	\$0,587	\$10,928	\$7,708	\$83,746	\$29,311	\$62,143	0.928	\$57,665	1
13			65	37	11	18	110	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$103,084	\$10,824	\$9,388	\$24,659	\$5,773	\$0,606	\$0,526	\$9,791	\$7,708	\$74,232	\$25,981	\$55,959	0.922	\$51,575	1
14			58	33	10	16	98	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$92,361	\$9,698	\$8,411	\$22,094	\$5,172	\$0,543	\$0,471	\$8,773	\$7,708	\$65,709	\$22,998	\$50,419	0.915	\$46,154	1
15			52	29	9	15	88	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$82,753	\$8,689	\$7,536	\$19,796	\$4,634	\$0,487	\$0,422	\$7,860	\$7,708	\$58,072	\$20,325	\$45,455	0.909	\$41,328	1
16			47	26	8	13	79	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$74,145	\$7,785	\$6,752	\$17,737	\$4,152	\$0,436	\$0,378	\$7,043	\$7,708	\$51,229	\$17,930	\$41,007	0.903	\$37,032	1
17			45	25	8	13	76	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$71,205	\$7,477	\$6,485	\$17,033	\$3,987	\$0,419	\$0,363	\$6,763	\$7,708	\$48,892	\$17,112	\$39,488	0.897	\$35,418	1
18			43	24	7	12	73	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$68,382	\$7,180	\$6,228	\$16,358	\$3,829	\$0,402	\$0,349	\$6,495	\$7,708	\$46,648	\$16,327	\$38,029	0.891	\$33,879	1
19			42	23	7	12	70	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$65,670	\$6,895	\$5,981	\$15,709	\$3,678	\$0,386	\$0,335	\$6,238	\$7,708	\$44,492	\$15,572	\$36,628	0.885	\$32,410	1
20			40	22	7	11	67	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$63,066	\$6,622	\$5,744	\$15,086	\$3,532	\$0,371	\$0,322	\$5,990	\$7,708	\$42,423	\$14,848	\$35,283	0.879	\$31,008	1
21			38	21	7	11	64	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$60,566	\$6,359	\$5,516	\$14,488	\$3,392	\$0,356	\$0,309	\$5,753	\$7,708	\$40,435	\$14,152	\$33,991	0.873	\$29,670	1
22			37	21	6	10	62	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$58,164	\$6,107	\$5,297	\$13,914	\$3,257	\$0,342	\$0,297	\$5,525	\$7,708	\$38,526	\$13,484	\$32,750	0.867	\$28,393	1
23			35	20	6	10	59	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$55,858	\$5,865	\$5,087	\$13,362	\$3,128	\$0,328	\$0,285	\$5,306	\$7,708	\$36,693	\$12,842	\$31,559	0.861	\$27,175	1
24			34	19	6	10	57	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$53,643	\$5,633	\$4,885	\$12,832	\$3,004	\$0,315	\$0,274	\$5,095	\$7,708	\$34,932	\$12,226	\$30,414	0.855	\$26,012	1
25			33	18	6	9	55	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$51,516	\$5,409	\$4,692	\$12,323	\$2,885	\$0,303	\$0,263	\$4,893	\$7,708	\$33,241	\$11,634	\$29,315	0.849	\$24,902	1
26			31	18	5	9	53	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$49,473	\$5,195	\$4,506	\$11,835	\$2,771	\$0,291	\$0,253	\$4,699	\$7,708	\$31,618	\$11,066	\$28,260	0.844	\$23,843	1
27			30	17	5	8	51	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$47,512	\$4,989	\$4,327	\$11,365	\$2,661	\$0,279	\$0,242	\$4,513	\$7,708	\$30,058	\$10,520	\$27,246	0.838	\$22,832	1
28			29	16	5	8	49	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$45,628	\$4,791	\$4,155	\$10,915	\$2,555	\$0,268	\$0,233	\$4,334	\$7,708	\$28,561	\$9,996	\$26,273	0.832	\$21,867	1
29			28	16	5	8	48	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$44,774	\$4,701	\$4,078	\$10,711	\$2,507	\$0,263	\$0,228	\$4,253	\$7,708	\$27,882	\$9,759	\$25,832	0.827	\$21,354	1
30			28	16	5	8	47	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$43,936	\$4,613	\$4,001	\$10,510	\$2,460	\$0,258	\$0,224	\$4,173	\$7,708	\$27,216	\$9,526	\$25,399	0.821	\$20,854	1
31			27	15	5	8	46	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$43,114	\$4,527	\$3,926	\$10,314	\$2,414	\$0,254	\$0,220	\$4,095	\$7,708	\$26,563	\$9,297	\$24,974	0.816	\$20,366	1
32			27	15	5	8	45	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$42,307	\$4,442	\$3,853	\$10,121	\$2,369	\$0,249	\$0,216	\$4,019	\$7,708	\$25,922	\$9,073	\$24,557	0.810	\$19,891	1
33			26	15	4	7	44	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$41,516	\$4,359	\$3,781	\$9,931	\$2,325	\$0,244	\$0,212	\$3,943	\$7,708	\$25,292	\$8,852	\$24,148	0.804	\$19,427	1
34			26	14	4	7	43	\$94.00	\$28.20	\$3.29	\$94.00	\$28.20	\$3.29	\$40,739	\$4,278	\$3,710	\$9,745	\$2,281	\$0,24									

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Granite Wash

Granite Wash				My Assumptions:			
Basin Characteristics				100% oilfield service & supply factor price scalar			
\$7.50 cost/well (\$mm)	Average Well		IP	EUR	30	days/month	
397 EUR/well (mboe)	1,340	736			-1.58%	exponential decline rate after year 3 (monthly)	
-74% 1st yr decline	-10.5%	353			\$100.00	oil price WTI (\$/bbl)	
-43% 2nd yr decline	-4.6%	200			0%	oil price appreciation (per month)	
-32% 3rd yr decline	-3.2%	165			\$3.50	gas price Henry Hub (\$/mcf)	
723 IP rate (boe/d)					0%	gas price appreciation	
\$5.00 opex-LOE (\$/boe)					30%	NGL price/oil price (fixed ratio)	
20% oil					0.68%	discount rate (compound monthly)	
50% gas					8.5%	discount rate (annual)	
30% NGL					80%	intangible drilling cost / total capex	
20.0% royalty rate					1.821	IP/EUR ratio, (B8/B4 = fixed ratio)	
7.0% oil prod tax					Results		
7.0% gas prod tax					-\$1.802 = NPV/well (\$ million)		
7.0% NGL prod tax					0 = EUR check (mboe)		
35.0% income tax rate					-0.13% = ATIRR (monthly)		
-6% oil differential					-1.53% = ATIRR (annual)		
-6% gas differential					397 = total production (mboe)		
0 1 = DUC					\$1.907 = "tail end" NPV/well (\$ million)		
25% auxiliary cost/well cost					98% = "tail end" recovery factor		
50% completion cost/well cost					99 = months of lost production		
\$2,000 min opex (\$/month)							

Granite Wash					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	1,964	3,576	977	1,779	
\$25	1,696	3,088	844	1,537	
\$30	1,492	2,716	743	1,353	
\$35	1,332	2,425	663	1,207	
\$40	1,203	2,190	599	1,091	
\$45	1,097	1,997	546	994	
\$50	1,008	1,835	502	914	
\$60	867	1,579	432	787	
\$70	761	1,386	380	692	
\$80	678	1,234	338	615	
\$90	612	1,114	305	555	
\$100	557	1,014	278	506	

Granite Wash					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	3,518	6,405	1,747	3,181	
\$25	2,899	5,278	1,440	2,622	
\$30	2,466	4,490	1,225	2,230	
\$35	2,145	3,905	1,066	1,941	
\$40	1,898	3,456	943	1,717	
\$45	1,702	3,099	846	1,540	
\$50	1,543	2,809	767	1,396	
\$60	1,300	2,367	646	1,176	
\$70	1,123	2,045	559	1,018	
\$80	989	1,801	492	896	
\$90	883	1,608	439	799	
\$100	798	1,453	397	723	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)								PV Factor	ATNPV -\$1,802	Active 1/0			
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex				Depreciation	Tax. Inc.	Income Tax
1	\$1,875	\$469						\$94.00	\$28.20	\$3.29	\$407.703	\$214.004	\$183.466	\$161.04	\$22.83	\$11.99	\$10.27	\$108.432	\$15.625	\$475.022	\$166.258	\$324.389	0.973	\$315.687	1
2	\$1,875	\$469						\$94.00	\$28.20	\$3.29	\$364.809	\$191.525	\$164.164	\$144.100	\$20.429	\$10.725	\$9.193	\$97.024	\$15.625	\$423.402	\$148.191	\$290.836	0.967	\$281.116	1
3	\$1,875	\$469						\$94.00	\$28.20	\$3.29	\$326.429	\$171.375	\$146.893	\$128.939	\$18.280	\$9.597	\$8.226	\$86.816	\$15.625	\$377.213	\$132.025	\$260.814	0.960	\$250.389	1
4	\$1,875	\$469						\$94.00	\$28.20	\$3.29	\$292.086	\$153.345	\$131.439	\$115.374	\$16.357	\$8.587	\$7.361	\$77.682	\$15.625	\$335.884	\$117.559	\$233.949	0.954	\$223.077	1
5			723	145	217	361	2,169	\$94.00	\$28.20	\$3.29	\$261.357	\$137.212	\$117.610	\$103.236	\$14.636	\$7.684	\$6.586	\$69.510	\$15.625	\$298.903	\$104.616	\$209.912	0.947	\$198.800	1
6			647	129	194	323	1,940	\$94.00	\$28.20	\$3.29	\$233.860	\$122.776	\$105.237	\$92.375	\$13.096	\$6.875	\$5.893	\$62.197	\$15.625	\$265.812	\$93.034	\$188.403	0.941	\$177.221	1
7			579	116	174	289	1,736	\$94.00	\$28.20	\$3.29	\$209.256	\$109.860	\$94.165	\$82.656	\$11.718	\$6.152	\$5.273	\$55.653	\$15.625	\$236.203	\$82.671	\$169.157	0.934	\$158.039	1
8			518	104	155	259	1,554	\$94.00	\$28.20	\$3.29	\$187.241	\$98.302	\$84.258	\$73.960	\$10.485	\$5.505	\$4.718	\$49.798	\$15.625	\$209.709	\$73.398	\$151.936	0.928	\$140.988	1
9			463	93	139	232	1,390	\$94.00	\$28.20	\$3.29	\$167.542	\$87.959	\$75.394	\$66.179	\$9.382	\$4.926	\$4.222	\$44.559	\$15.625	\$186.002	\$65.101	\$136.526	0.922	\$125.831	1
10			415	83	124	207	1,244	\$94.00	\$28.20	\$3.29	\$149.915	\$78.706	\$67.462	\$59.217	\$8.395	\$4.408	\$3.778	\$39.871	\$15.625	\$164.789	\$57.676	\$122.738	0.915	\$112.356	1
11			371	74	111	186	1,113	\$94.00	\$28.20	\$3.29	\$134.143	\$70.425	\$60.364	\$52.987	\$7.512	\$3.944	\$3.380	\$35.676	\$15.625	\$145.809	\$51.033	\$110.401	0.909	\$100.378	1
12			332	66	100	166	996	\$94.00	\$28.20	\$3.29	\$120.030	\$63.016	\$54.014	\$47.412	\$6.722	\$3.529	\$3.025	\$31.923	\$15.625	\$128.825	\$45.089	\$99.361	0.903	\$89.728	1
13			297	59	89	149	891	\$94.00	\$28.20	\$3.29	\$114.480	\$60.102	\$51.516	\$45.220	\$6.411	\$3.366	\$2.885	\$30.447	\$15.625	\$122.145	\$42.751	\$95.019	0.897	\$85.226	1
14			266	53	80	133	797	\$94.00	\$28.20	\$3.29	\$109.186	\$57.323	\$49.134	\$43.128	\$6.114	\$3.210	\$2.751	\$29.039	\$15.625	\$115.774	\$40.521	\$90.878	0.891	\$80.959	1
15			238	48	71	119	714	\$94.00	\$28.20	\$3.29	\$104.137	\$54.672	\$46.862	\$41.134	\$5.832	\$3.062	\$2.624	\$27.696	\$15.625	\$109.698	\$38.394	\$86.929	0.885	\$76.916	1
16			213	43	64	106	638	\$94.00	\$28.20	\$3.29	\$99.321	\$52.144	\$44.695	\$39.232	\$5.562	\$2.920	\$2.503	\$26.415	\$15.625	\$103.903	\$36.366	\$83.162	0.879	\$73.085	1
17			203	41	61	101	609	\$94.00	\$28.20	\$3.29	\$94.728	\$49.732	\$42.628	\$37.418	\$5.305	\$2.785	\$2.387	\$25.194	\$15.625	\$98.375	\$34.431	\$79.569	0.873	\$69.453	1
18			194	39	58	97	581	\$94.00	\$28.20	\$3.29	\$90.348	\$47.433	\$40.657	\$35.687	\$5.059	\$2.656	\$2.277	\$24.029	\$15.625	\$93.104	\$32.586	\$76.142	0.867	\$66.012	1
19			185	37	55	92	554	\$94.00	\$28.20	\$3.29	\$86.170	\$45.239	\$38.777	\$34.037	\$4.826	\$2.533	\$2.171	\$22.918	\$15.625	\$88.076	\$30.827	\$72.874	0.861	\$62.751	1
20			168	34	50	84	504	\$94.00	\$28.20	\$3.29	\$82.185	\$43.147	\$36.983	\$32.463	\$4.602	\$2.412	\$2.071	\$21.858	\$15.625	\$83.280	\$29.148	\$69.757	0.855	\$59.660	1
21			160	32	48	80	481	\$94.00	\$28.20	\$3.29	\$78.385	\$41.152	\$35.273	\$30.962	\$4.390	\$2.305	\$1.975	\$20.847	\$15.625	\$78.707	\$27.547	\$66.784	0.849	\$56.730	1
22			153	31	46	76	458	\$94.00	\$28.20	\$3.29	\$74.760	\$39.249	\$33.642	\$29.530	\$4.187	\$2.198	\$1.884	\$19.883	\$15.625	\$74.345	\$26.021	\$63.949	0.844	\$53.954	1
23			146	29	44	73	437	\$94.00	\$28.20	\$3.29	\$71.303	\$37.434	\$32.086	\$28.165	\$3.993	\$2.096	\$1.797	\$18.964	\$15.625	\$70.184	\$24.564	\$61.245	0.838	\$51.322	1
24			139	28	42	69	417	\$94.00	\$28.20	\$3.29	\$68.006	\$35.703	\$30.603	\$26.862	\$3.808	\$1.999	\$1.714	\$18.087	\$15.625	\$66.216	\$23.176	\$58.665	0.832	\$48.828	1
25			133	27	40	66	398	\$94.00	\$28.20	\$3.29	\$65.860	\$34.577	\$29.637	\$26.015	\$3.688	\$1.936	\$1.660	\$17.516	\$15.625	\$63.634	\$22.272	\$56.987	0.827	\$47.109	1
26			126	25	38	63	379	\$94.00	\$28.20	\$3.29	\$63.782	\$33.485	\$28.702	\$25.194	\$3.572	\$1.875	\$1.607	\$16.963	\$15.625	\$61.133	\$21.396	\$55.361	0.821	\$45.455	1
27			121	24	36	60	362	\$94.00	\$28.20	\$3.29	\$61.769	\$32.429	\$27.796	\$24.399	\$3.459	\$1.816	\$1.557	\$16.428	\$15.625	\$58.711	\$20.549	\$53.787	0.816	\$43.864	1
28			117	23	35	58	350	\$94.00	\$28.20	\$3.29	\$59.820	\$31.406	\$26.919	\$23.629	\$3.350	\$1.759	\$1.507	\$15.910	\$15.625	\$56.365	\$19.728	\$52.262	0.810	\$42.331	1
29			113	23	34	57	339	\$94.00	\$28.20	\$3.29	\$57.933	\$30.415	\$26.070	\$22.883	\$3.244	\$1.703	\$1.460	\$15.408	\$15.625	\$54.094	\$18.933	\$50.786	0.804	\$40.857	1
30			110	22	33	55	329	\$94.00	\$28.20	\$3.29	\$56.105	\$29.455	\$25.247	\$22.161	\$3.142	\$1.649	\$1.414	\$14.921	\$15.625	\$51.894	\$18.163	\$49.356	0.799	\$39.437	1
31			106	21	32	53	318	\$94.00	\$28.20	\$3.29	\$54.335	\$28.526	\$24.451	\$21.462	\$3.043	\$1.597	\$1.369	\$14.451	\$15.625	\$49.763	\$17.417	\$47.971	0.794	\$38.071	1
32			103	21	31	51	308	\$94.00	\$28.20	\$3.29	\$52.620	\$27.626	\$23.679	\$20.785	\$2.947	\$1.547	\$1.326	\$13.995	\$15.625	\$47.700	\$16.695	\$46.630	0.788	\$36.756	1
33			99	20	30	50	298	\$94.00	\$28.20	\$3.29	\$50.960	\$26.754	\$22.932	\$20.129	\$2.854	\$1.498	\$1.284	\$13.553	\$15.625	\$45.702	\$15.996	\$45.331	0.783	\$35.490	1
34			96	19	29	48	289	\$94.00	\$28.20	\$3.29	\$49.352	\$25.910	\$22.208	\$19.494	\$2.764	\$1.451	\$1.244	\$13.125	\$15.625	\$43.767	\$15.318	\$44.074	0.778	\$34.272	1
35			93	19	28	47	280	\$94.00	\$28.20	\$3.29	\$47.795	\$25.092	\$21.508	\$18.879	\$2.676	\$1.405	\$1.204	\$12.711	\$15.625	\$41.893	\$14.663	\$42.855	0.772	\$33.099	1
36			90	18	27	45	271	\$94.00	\$28.20	\$3.29	\$46.286	\$24.300	\$20.829	\$18.283	\$2.592	\$1.361	\$1.166	\$12.310	\$15.625	\$40.078	\$14.027	\$41.676	0.767	\$31.970	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Cleveland

Cleveland			My Assumptions:		
Basin Characteristics			100% oilfield service & supply factor price scalar		
\$2.80 cost/well (\$mm)	Average Well		30 days/month		
123 EUR/well (mboe)	IP	EUR	-1.50% exponential decline rate after year 3 (monthly)		
-74% 1st yr decline	-10.5%	106	\$100.00 oil price WTI (\$/bbl)		
-47% 2nd yr decline	-5.2%	56	0% oil price appreciation (per month)		
-20% 3rd yr decline	-1.9%	50	\$3.50 gas price Henry Hub (\$/mcf)		
213 IP rate (boe/d)			0% gas price appreciation		
\$5.00 opex-LOE (\$/boe)			30% NGL price/oil price (fixed ratio)		
30% oil			0.68% discount rate (compound monthly)		
45% gas			8.5% discount rate (annual)		
25% NGL			80% intangible drilling cost / total capex		
20.0% royalty rate			1.724 IP/EUR ratio, (B8/B4 = fixed ratio)		
7.0% oil prod tax					
7.0% gas prod tax					
7.0% NGL prod tax					
35.0% income tax rate					
-6% oil differential					
-6% gas differential					
0 1 = DUC					
25% auxiliary cost/well cost					
50% completion cost/well cost					
\$2,000 min opex (\$/month)					

Results	
-50.702	= NPV/well (\$ million)
0	= EUR check (mboe)
-0.19%	= ATIRR (monthly)
-2.27%	= ATIRR (annual)
123	= total production (mboe)
\$0.728	= "tail end" NPV/well (\$ million)
93%	= "tail end" recovery factor
151	= months of lost production

Cleveland					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	701	1,209	351	605	
\$25	589	1,016	295	509	
\$30	508	876	255	440	
\$35	447	771	225	388	
\$40	399	688	201	347	
\$45	360	621	181	312	
\$50	328	566	165	284	
\$60	279	481	141	243	
\$70	243	419	123	212	
\$80	215	371	109	188	
\$90	193	333	98	169	
\$100	175	302	89	153	

Cleveland					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	1,225	2,112	610	1,052	
\$25	979	1,688	488	841	
\$30	815	1,405	407	702	
\$35	699	1,205	349	602	
\$40	611	1,053	305	526	
\$45	543	936	272	469	
\$50	489	843	245	422	
\$60	408	703	204	352	
\$70	349	602	175	302	
\$80	306	528	154	266	
\$90	272	469	137	236	
\$100	245	422	123	212	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)						PV Factor	ATNPV -\$702	Active 1/0					
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax				NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax
1	\$700	\$175						\$94.00	\$28.20	\$3.29	\$179.776	\$56.629	\$44.944	\$56.27	\$10.07	\$3.17	\$2.52	\$31.875	\$5.833	\$171.615	\$60.065	\$117.383	0.973	\$114.234	1
2	\$700	\$175						\$94.00	\$28.20	\$3.29	\$160.942	\$50.697	\$40.235	\$50.375	\$9.013	\$2.839	\$2.253	\$28.536	\$5.833	\$153.025	\$53.559	\$105.300	0.967	\$101.780	1
3	\$700	\$175						\$94.00	\$28.20	\$3.29	\$144.081	\$45.385	\$36.200	\$45.097	\$8.069	\$2.542	\$2.017	\$25.546	\$5.833	\$136.382	\$47.734	\$94.482	0.960	\$90.705	1
4	\$700	\$175						\$94.00	\$28.20	\$3.29	\$128.986	\$40.631	\$32.247	\$40.373	\$7.223	\$2.275	\$1.806	\$22.870	\$5.833	\$121.483	\$42.519	\$84.797	0.954	\$80.856	1
5			213	64	53	96	574	\$94.00	\$28.20	\$3.29	\$115.473	\$36.374	\$28.868	\$36.143	\$6.466	\$2.037	\$1.617	\$20.474	\$5.833	\$108.145	\$37.851	\$76.127	0.947	\$72.098	1
6			190	57	48	86	514	\$94.00	\$28.20	\$3.29	\$103.375	\$32.563	\$25.844	\$32.356	\$5.789	\$1.824	\$1.447	\$18.329	\$5.833	\$96.204	\$33.671	\$68.366	0.941	\$64.308	1
7			170	51	43	77	460	\$94.00	\$28.20	\$3.29	\$92.545	\$29.152	\$23.136	\$28.967	\$5.183	\$1.632	\$1.296	\$16.409	\$5.833	\$85.514	\$29.930	\$61.417	0.934	\$57.381	1
8			152	46	38	69	412	\$94.00	\$28.20	\$3.29	\$82.850	\$26.098	\$20.712	\$25.932	\$4.640	\$1.461	\$1.160	\$14.690	\$5.833	\$75.944	\$26.580	\$55.197	0.928	\$51.220	1
9			136	41	34	61	369	\$94.00	\$28.20	\$3.29	\$74.170	\$23.364	\$18.543	\$23.215	\$4.154	\$1.308	\$1.038	\$13.151	\$5.833	\$67.377	\$23.582	\$49.628	0.922	\$45.740	1
10			122	37	31	55	330	\$94.00	\$28.20	\$3.29	\$66.400	\$20.916	\$16.600	\$20.783	\$3.718	\$1.171	\$0.930	\$11.773	\$5.833	\$59.707	\$20.897	\$44.643	0.915	\$40.867	1
11			109	33	27	49	295	\$94.00	\$28.20	\$3.29	\$59.443	\$18.725	\$14.861	\$18.606	\$3.329	\$1.049	\$0.832	\$10.540	\$5.833	\$52.840	\$18.494	\$40.180	0.909	\$36.532	1
12			98	29	24	44	264	\$94.00	\$28.20	\$3.29	\$53.216	\$16.763	\$13.304	\$16.657	\$2.980	\$0.939	\$0.745	\$9.435	\$5.833	\$46.694	\$16.343	\$36.184	0.903	\$32.676	1
13			88	26	22	39	237	\$94.00	\$28.20	\$3.29	\$50.460	\$15.895	\$12.615	\$15.794	\$2.826	\$0.890	\$0.706	\$8.947	\$5.833	\$43.973	\$15.391	\$34.416	0.897	\$30.869	1
14			78	24	20	35	212	\$94.00	\$28.20	\$3.29	\$47.847	\$15.072	\$11.962	\$14.976	\$2.679	\$0.844	\$0.670	\$8.483	\$5.833	\$41.394	\$14.488	\$32.740	0.891	\$29.166	1
15			70	21	18	32	190	\$94.00	\$28.20	\$3.29	\$45.369	\$14.291	\$11.342	\$14.201	\$2.541	\$0.800	\$0.635	\$8.044	\$5.833	\$38.949	\$13.632	\$31.150	0.885	\$27.562	1
16			63	19	16	28	170	\$94.00	\$28.20	\$3.29	\$43.020	\$13.551	\$10.755	\$13.465	\$2.409	\$0.759	\$0.602	\$7.628	\$5.833	\$36.629	\$12.820	\$29.643	0.879	\$26.051	1
17			60	18	15	27	161	\$94.00	\$28.20	\$3.29	\$40.792	\$12.849	\$10.198	\$12.768	\$2.284	\$0.720	\$0.571	\$7.233	\$5.833	\$34.431	\$12.051	\$28.213	0.873	\$24.627	1
18			57	17	14	25	153	\$94.00	\$28.20	\$3.29	\$38.680	\$12.184	\$9.670	\$12.107	\$2.166	\$0.682	\$0.542	\$6.858	\$5.833	\$32.345	\$11.321	\$26.858	0.867	\$23.285	1
19			54	16	13	24	145	\$94.00	\$28.20	\$3.29	\$36.677	\$11.553	\$9.169	\$11.480	\$2.054	\$0.647	\$0.513	\$6.503	\$5.833	\$30.368	\$10.629	\$25.573	0.861	\$22.020	1
20			48	14	12	22	130	\$94.00	\$28.20	\$3.29	\$34.777	\$10.955	\$8.694	\$10.885	\$1.948	\$0.617	\$0.487	\$6.166	\$5.833	\$28.494	\$9.973	\$24.354	0.855	\$20.829	1
21			43	13	11	20	117	\$94.00	\$28.20	\$3.29	\$32.972	\$10.388	\$8.244	\$10.322	\$1.847	\$0.582	\$0.462	\$5.847	\$5.833	\$26.716	\$9.351	\$23.199	0.849	\$19.706	1
22			40	12	10	18	105	\$94.00	\$28.20	\$3.29	\$31.269	\$9.850	\$7.817	\$9.787	\$1.751	\$0.552	\$0.438	\$5.544	\$5.833	\$25.031	\$8.761	\$22.103	0.844	\$18.648	1
23			39	12	10	18	105	\$94.00	\$28.20	\$3.29	\$29.649	\$9.340	\$7.412	\$9.280	\$1.660	\$0.523	\$0.415	\$5.257	\$5.833	\$23.432	\$8.201	\$21.064	0.838	\$17.652	1
24			35	11	9	16	95	\$94.00	\$28.20	\$3.29	\$28.114	\$8.856	\$7.028	\$8.800	\$1.574	\$0.496	\$0.394	\$4.985	\$5.833	\$21.917	\$7.671	\$20.079	0.832	\$16.712	1
25			33	10	8	15	88	\$94.00	\$28.20	\$3.29	\$27.588	\$8.690	\$6.897	\$8.635	\$1.545	\$0.487	\$0.386	\$4.891	\$5.833	\$21.397	\$7.489	\$19.742	0.827	\$16.320	1
26			32	10	8	14	86	\$94.00	\$28.20	\$3.29	\$27.072	\$8.528	\$6.768	\$8.473	\$1.516	\$0.478	\$0.379	\$4.800	\$5.833	\$20.888	\$7.311	\$19.411	0.821	\$15.937	1
27			31	9	8	14	85	\$94.00	\$28.20	\$3.29	\$26.565	\$8.368	\$6.641	\$8.315	\$1.488	\$0.469	\$0.372	\$4.710	\$5.833	\$20.388	\$7.136	\$19.086	0.816	\$15.564	1
28			31	9	8	14	83	\$94.00	\$28.20	\$3.29	\$26.068	\$8.211	\$6.517	\$8.159	\$1.460	\$0.460	\$0.365	\$4.622	\$5.833	\$19.897	\$6.964	\$18.767	0.810	\$15.201	1
29			30	9	8	14	82	\$94.00	\$28.20	\$3.29	\$25.580	\$8.058	\$6.395	\$8.007	\$1.433	\$0.451	\$0.358	\$4.536	\$5.833	\$19.416	\$6.796	\$18.454	0.804	\$14.846	1
30			30	9	7	13	80	\$94.00	\$28.20	\$3.29	\$25.102	\$7.907	\$6.275	\$7.857	\$1.406	\$0.443	\$0.351	\$4.451	\$5.833	\$18.943	\$6.630	\$18.147	0.799	\$14.500	1
31			29	9	7	13	79	\$94.00	\$28.20	\$3.29	\$24.632	\$7.759	\$6.158	\$7.710	\$1.379	\$0.435	\$0.345	\$4.367	\$5.833	\$18.480	\$6.468	\$17.845	0.794	\$14.162	1
32			29	9	7	13	77	\$94.00	\$28.20	\$3.29	\$24.171	\$7.614	\$6.043	\$7.566	\$1.354	\$0.426	\$0.338	\$4.286	\$5.833	\$18.025	\$6.309	\$17.550	0.788	\$13.833	1
33			28	8	7	13	76	\$94.00	\$28.20	\$3.29	\$23.719	\$7.471	\$5.930	\$7.424	\$1.328	\$0.418	\$0.332	\$4.205	\$5.833	\$17.579	\$6.152	\$17.259	0.783	\$13.513	1
34			28	8	7	12	74	\$94.00	\$28.20	\$3.29	\$23.275	\$7.332	\$5.819	\$7.285	\$1.303	\$0.411	\$0.326	\$4.127	\$5.833	\$17.141	\$5.999	\$16.975	0.778	\$13.200	1
35			27	8	7	12	73	\$94.00	\$28.20	\$3.29	\$22.840	\$7.194	\$5.710	\$7.149	\$1.279	\$0.403	\$0.320	\$4.050	\$5.833	\$16.711	\$5.849	\$16.695	0.772	\$12.894	1
36			30	8	7	12	72	\$94.00	\$28.20	\$3.29	\$22.412	\$7.060	\$5.603	\$7.015	\$1.255	\$0.395	\$0.314	\$3.974	\$5.833	\$16.289	\$5.701	\$16.421	0.767	\$12.597	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Northern Wattenberg XL

Julesburg Basin: Northern Wattenberg				My Assumptions:			
Basin Characteristics				Average Well			
\$6.60 cost/well (\$mm)	IP			EUR			100% oilfield service & supply factor price scalar
211 EUR/well (mboe)	722	727		30 days/month	-0.90% exponential decline rate after year 3 (monthly)		
-58% 1st yr decline	-7.1%	300		\$100.00 oil price WTI (\$/bbl)	0% oil price appreciation (per month)		
-43% 2nd yr decline	-4.5%	172		\$3.50 gas price Henry Hub (\$/mcf)	0% gas price appreciation		
-30% 3rd yr decline	-2.9%	144		30% NGL price/oil price (fixed ratio)	0.68% discount rate (compound monthly)		
210 IP rate (boe/d)				0% gas price appreciation	8.5% discount rate (annual)		
\$8.00 opex-LOE (\$/boe)				80% intangible drilling cost / total capex	0.993 IP/EUR ratio, (B8/B4 = fixed ratio)		
67% % oil				Results			
21% % gas				-\$1.635 = NPV/well (\$ million)			
13% % NGL				0 = EUR check (mboe)			
20.0% royalty rate				0.11% = ATIRR (monthly)			
5.0% oil prod tax				1.30% = ATIRR (annual)			
5.0% gas prod tax				211 = total production (mboe)			
5.0% NGL prod tax				\$2.283 = "tail end" NPV/well (\$ million)			
35.0% income tax rate				100% = "tail end" recovery factor			
-11% oil differential				0 = months of lost production			
-7% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Denver Julesburg Basin: Northern Wattenberg XL					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	2,736	2,717	1,358	1,349	
\$25	1,814	1,802	901	895	
\$30	1,357	1,348	674	669	
\$35	1,084	1,077	538	534	
\$40	902	896	448	445	
\$45	773	768	384	381	
\$50	676	671	336	334	
\$60	540	536	269	267	
\$70	450	447	224	222	
\$80	386	383	192	191	
\$90	338	336	168	167	
\$100	300	298	150	149	

Denver Julesburg Basin: Northern Wattenberg XL					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	8,237	8,180	4,088	4,060	
\$25	3,831	3,805	1,902	1,889	
\$30	2,496	2,479	1,239	1,230	
\$35	1,851	1,838	919	913	
\$40	1,471	1,461	730	725	
\$45	1,220	1,212	606	602	
\$50	1,043	1,036	518	514	
\$60	808	802	401	398	
\$70	659	654	327	325	
\$80	557	553	277	275	
\$90	482	479	239	237	
\$100	425	422	211	210	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices			Cash Flows (\$1,000)								AT NPV	Active 1/0					
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex			Depreciation	Tax. Inc.	Income Tax	NCF	PV Factor
1	\$1,650	\$413					\$89.20	\$26.76	\$3.26	\$376.027	\$25.805	\$21.888	\$84.74	\$15.04	\$1.03	\$0.88	\$50.335	\$13.750	\$257.942	\$90.280	\$181.412	0.973	\$176.546	1	
2	\$1,650	\$413					\$89.20	\$26.76	\$3.26	\$349.490	\$23.984	\$20.343	\$78.763	\$13.980	\$0.959	\$0.814	\$46.783	\$13.750	\$238.768	\$83.569	\$168.949	0.967	\$163.303	1	
3	\$1,650	\$413					\$89.20	\$26.76	\$3.26	\$324.825	\$22.291	\$18.908	\$73.205	\$12.993	\$0.892	\$0.756	\$43.481	\$13.750	\$220.947	\$77.332	\$157.366	0.960	\$151.076	1	
4	\$1,650	\$413					\$89.20	\$26.76	\$3.26	\$301.901	\$20.718	\$17.573	\$68.039	\$12.076	\$0.829	\$0.703	\$40.412	\$13.750	\$204.384	\$71.534	\$146.600	0.954	\$139.787	1	
5			210	141	27	44	264	\$89.20	\$26.76	\$3.26	\$280.595	\$19.256	\$16.333	\$63.237	\$11.224	\$0.770	\$0.653	\$37.560	\$13.750	\$188.990	\$66.146	\$136.593	0.947	\$129.363	1
6			195	131	25	41	246	\$89.20	\$26.76	\$3.26	\$260.793	\$17.897	\$15.180	\$58.774	\$10.432	\$0.716	\$0.607	\$34.910	\$13.750	\$174.682	\$61.139	\$127.293	0.941	\$119.738	1
7			181	121	24	38	228	\$89.20	\$26.76	\$3.26	\$242.388	\$16.634	\$14.109	\$54.626	\$9.696	\$0.665	\$0.564	\$32.446	\$13.750	\$161.383	\$56.484	\$118.649	0.934	\$110.851	1
8			168	113	22	35	212	\$89.20	\$26.76	\$3.26	\$225.282	\$15.460	\$13.113	\$50.771	\$9.011	\$0.618	\$0.525	\$30.156	\$13.750	\$149.024	\$52.158	\$110.615	0.928	\$102.645	1
9			157	105	20	33	197	\$89.20	\$26.76	\$3.26	\$209.383	\$14.369	\$12.188	\$47.188	\$8.375	\$0.575	\$0.488	\$28.028	\$13.750	\$137.536	\$48.138	\$103.149	0.922	\$95.068	1
10			145	97	19	31	183	\$89.20	\$26.76	\$3.26	\$194.606	\$13.355	\$11.328	\$43.858	\$7.784	\$0.534	\$0.453	\$26.050	\$13.750	\$126.860	\$44.401	\$96.209	0.915	\$88.071	1
11			135	91	18	28	170	\$89.20	\$26.76	\$3.26	\$180.872	\$12.412	\$10.528	\$40.763	\$7.235	\$0.496	\$0.421	\$24.212	\$13.750	\$116.936	\$40.928	\$89.759	0.909	\$81.610	1
12			126	84	16	26	158	\$89.20	\$26.76	\$3.26	\$168.108	\$11.536	\$9.785	\$37.886	\$6.724	\$0.461	\$0.391	\$22.503	\$13.750	\$107.714	\$37.700	\$83.764	0.903	\$75.643	1
13			117	78	15	25	147	\$89.20	\$26.76	\$3.26	\$160.493	\$11.014	\$9.342	\$36.170	\$6.420	\$0.441	\$0.374	\$21.484	\$13.750	\$102.211	\$35.774	\$80.187	0.897	\$71.923	1
14			109	73	14	23	137	\$89.20	\$26.76	\$3.26	\$153.222	\$10.515	\$8.919	\$34.531	\$6.129	\$0.421	\$0.357	\$20.510	\$13.750	\$96.958	\$33.935	\$76.773	0.891	\$68.394	1
15			101	68	13	21	127	\$89.20	\$26.76	\$3.26	\$146.282	\$10.039	\$8.515	\$32.967	\$5.851	\$0.402	\$0.341	\$19.581	\$13.750	\$91.943	\$32.180	\$73.513	0.885	\$65.046	1
16			94	63	12	20	118	\$89.20	\$26.76	\$3.26	\$139.655	\$9.584	\$8.129	\$31.474	\$5.586	\$0.383	\$0.325	\$18.694	\$13.750	\$87.156	\$30.504	\$70.401	0.879	\$61.870	1
17			90	60	12	19	113	\$89.20	\$26.76	\$3.26	\$133.329	\$9.150	\$7.761	\$30.048	\$5.333	\$0.366	\$0.310	\$17.847	\$13.750	\$82.585	\$28.905	\$67.430	0.873	\$58.858	1
18			85	57	11	18	108	\$89.20	\$26.76	\$3.26	\$127.289	\$8.735	\$7.409	\$28.687	\$5.092	\$0.349	\$0.296	\$17.039	\$13.750	\$78.221	\$27.377	\$64.593	0.867	\$56.000	1
19			82	55	11	17	103	\$89.20	\$26.76	\$3.26	\$121.523	\$8.340	\$7.074	\$27.387	\$4.861	\$0.334	\$0.283	\$16.267	\$13.750	\$74.054	\$25.919	\$61.885	0.861	\$53.289	1
20			78	52	10	16	98	\$89.20	\$26.76	\$3.26	\$116.018	\$7.962	\$6.753	\$26.147	\$4.641	\$0.318	\$0.270	\$15.530	\$13.750	\$70.077	\$24.527	\$59.300	0.855	\$50.716	1
21			74	50	10	16	94	\$89.20	\$26.76	\$3.26	\$110.763	\$7.601	\$6.447	\$24.962	\$4.431	\$0.304	\$0.258	\$14.827	\$13.750	\$66.280	\$23.198	\$56.832	0.849	\$48.276	1
22			71	48	9	15	89	\$89.20	\$26.76	\$3.26	\$105.745	\$7.257	\$6.155	\$23.831	\$4.230	\$0.290	\$0.246	\$14.155	\$13.750	\$62.654	\$21.929	\$54.475	0.844	\$45.961	1
23			68	45	9	14	85	\$89.20	\$26.76	\$3.26	\$100.955	\$6.928	\$5.876	\$22.752	\$4.038	\$0.277	\$0.235	\$13.514	\$13.750	\$59.193	\$20.718	\$52.226	0.838	\$43.764	1
24			65	43	8	14	82	\$89.20	\$26.76	\$3.26	\$96.382	\$6.614	\$5.610	\$21.721	\$3.855	\$0.265	\$0.224	\$12.902	\$13.750	\$55.889	\$19.561	\$50.078	0.832	\$41.680	1
25			62	41	8	13	78	\$89.20	\$26.76	\$3.26	\$93.569	\$6.421	\$5.447	\$21.087	\$3.743	\$0.257	\$0.218	\$12.525	\$13.750	\$53.857	\$18.850	\$48.757	0.827	\$40.306	1
26			59	39	7	12	74	\$89.20	\$26.76	\$3.26	\$90.839	\$6.234	\$5.288	\$20.472	\$3.634	\$0.249	\$0.212	\$12.160	\$13.750	\$51.884	\$18.160	\$47.475	0.821	\$38.980	1
27			56	37	7	11	70	\$89.20	\$26.76	\$3.26	\$88.188	\$6.052	\$5.133	\$19.875	\$3.528	\$0.242	\$0.205	\$11.805	\$13.750	\$49.969	\$17.489	\$46.230	0.816	\$37.701	1
28			53	36	6	10	67	\$89.20	\$26.76	\$3.26	\$85.615	\$5.875	\$4.984	\$19.295	\$3.425	\$0.235	\$0.199	\$11.460	\$13.750	\$48.110	\$16.838	\$45.021	0.810	\$36.466	1
29			48	32	6	10	60	\$89.20	\$26.76	\$3.26	\$83.117	\$5.704	\$4.838	\$18.732	\$3.325	\$0.228	\$0.194	\$11.126	\$13.750	\$46.305	\$16.207	\$43.848	0.804	\$35.275	1
30			45	30	6	9	57	\$89.20	\$26.76	\$3.26	\$80.692	\$5.537	\$4.697	\$18.185	\$3.228	\$0.221	\$0.188	\$10.801	\$13.750	\$44.552	\$15.593	\$42.709	0.799	\$34.126	1
31			44	29	6	9	55	\$89.20	\$26.76	\$3.26	\$78.337	\$5.376	\$4.560	\$17.655	\$3.133	\$0.215	\$0.182	\$10.486	\$13.750	\$42.851	\$14.998	\$41.603	0.794	\$33.017	1
32			42	28	6	9	53	\$89.20	\$26.76	\$3.26	\$76.051	\$5.219	\$4.427	\$17.139	\$3.042	\$0.209	\$0.177	\$10.180	\$13.750	\$41.200	\$14.420	\$40.530	0.788	\$31.948	1
33			41	28	5	9	52	\$89.20	\$26.76	\$3.26	\$73.832	\$5.067	\$4.298	\$16.639	\$2.953	\$0.203	\$0.172	\$9.883	\$13.750	\$39.596	\$13.859	\$39.488	0.783	\$30.915	1
34			40	27	5	8	50	\$89.20	\$26.76	\$3.26	\$71.678	\$4.919	\$4.172	\$16.154	\$2.867	\$0.197	\$0.167	\$9.595	\$13.750	\$38.040	\$13.314	\$38.476	0.778	\$29.919	1
35			39	26	5	8	49	\$89.20	\$26.76	\$3.26	\$69.586	\$4.775	\$4.051	\$15.682	\$2.783	\$0.191	\$0.162	\$9.315	\$13.750	\$36.528	\$12.785	\$37.494	0.772	\$28.958	1
36			38	26	5	8	47	\$89.20	\$26.76	\$3.26	\$67.556	\$4.636	\$3.932	\$15.225	\$2.702	\$0.185	\$0.157	\$9.043	\$13.750	\$35.061	\$12.271	\$36.540	0.767	\$28.030	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Southern Wattenberg

Denver Julesburg Basin: Southern Wattenberg				My Assumptions:				
Basin Characteristics				Average Well				
\$3.40 cost/well (\$mm)	Average Well			100% oilfield service & supply factor price scalar				
128 EUR/well (mboe)	IP	EUR		30 days/month				
-55% 1st yr decline	430	395		-1.16% exponential decline rate after year 3 (monthly)				
-37% 2nd yr decline	193			\$100.00 oil price WTI (\$/bbl)				
-41% 3rd yr decline	121			0% oil price appreciation (per month)				
	93			\$3.50 gas price Henry Hub (\$/mcf)				
				0% gas price appreciation				
140 IP rate (boe/d)				30% NGL price/oil price (fixed ratio)				
\$8.00 opex-LOE (\$/boe)				0.68% discount rate (compound monthly)				
51% % oil				8.5% discount rate (annual)				
33% % gas				80% intangible drilling cost / total capex				
17% % NGL				1.089 IP/EUR ratio, (B8/B4 = fixed ratio)				
20.0% royalty rate	Results							
5.0% oil prod tax	-\$0.815 = NPV/well (\$ million)							
5.0% gas prod tax	0 = EUR check (mboe)							
5.0% NGL prod tax	0.00% = ATIRR (monthly)							
35.0% income tax rate	0.01% = ATIRR (annual)							
-11% oil differential	128 = total production (mboe)							
-7% gas differential	\$1.036 = "tail end" NPV/well (\$ million)							
0 1 = DUC	96% = "tail end" recovery factor							
25% auxiliary cost/well cost	82 = months of lost production							
50% completion cost/well cost								
\$2,000 min opex (\$/month)								

Denver Julesburg Basin: Southern Wattenberg					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	1,379	1,501	686	747	
\$25	970	1,056	483	526	
\$30	749	815	373	406	
\$35	610	664	304	331	
\$40	514	560	257	280	
\$45	445	484	222	242	
\$50	392	427	196	213	
\$60	316	344	159	173	
\$70	266	290	133	145	
\$80	229	249	115	125	
\$90	201	219	101	110	
\$100	179	195	91	99	

Denver Julesburg Basin: Southern Wattenberg					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	4,432	4,825	2,200	2,395	
\$25	2,194	2,388	1,089	1,185	
\$30	1,458	1,587	724	788	
\$35	1,092	1,189	543	591	
\$40	873	950	434	472	
\$45	727	791	362	394	
\$50	623	678	310	337	
\$60	484	527	241	262	
\$70	396	431	198	216	
\$80	335	365	168	183	
\$90	291	317	145	158	
\$100	257	280	128	139	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices			Cash Flows (\$1,000)							AT NPV -\$815	Active 1/0						
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax			NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax	NCF
1	\$850	\$213					277	\$89.20	\$26.76	\$3.26	\$190.851	\$27.038	\$19.085	\$47.39	\$7.63	\$1.08	\$0.76	\$33.562	\$7.083	\$139.455	\$48.809	\$97.729	0.973	\$95.107	1
2	\$850	\$213					259	\$89.20	\$26.76	\$3.26	\$178.526	\$25.292	\$17.853	\$44.334	\$7.141	\$1.012	\$0.714	\$31.395	\$7.083	\$129.992	\$45.497	\$91.578	0.967	\$88.517	1
3	\$850	\$213					242	\$89.20	\$26.76	\$3.26	\$166.997	\$23.659	\$16.700	\$41.471	\$6.680	\$0.946	\$0.668	\$29.367	\$7.083	\$121.140	\$42.399	\$85.824	0.960	\$82.394	1
4	\$850	\$213					227	\$89.20	\$26.76	\$3.26	\$156.213	\$22.131	\$15.621	\$38.793	\$6.249	\$0.885	\$0.625	\$27.471	\$7.083	\$112.859	\$39.501	\$80.442	0.954	\$76.703	1
5			140	71	24	46	277	\$89.20	\$26.76	\$3.26	\$146.125	\$20.702	\$14.612	\$36.288	\$5.845	\$0.828	\$0.584	\$25.697	\$7.083	\$105.114	\$36.790	\$75.407	0.947	\$71.416	1
6			131	67	22	43	259	\$89.20	\$26.76	\$3.26	\$136.688	\$19.365	\$13.669	\$33.944	\$5.468	\$0.775	\$0.547	\$24.037	\$7.083	\$97.868	\$34.254	\$70.698	0.941	\$66.502	1
7			122	62	21	40	242	\$89.20	\$26.76	\$3.26	\$127.861	\$18.114	\$12.786	\$31.752	\$5.114	\$0.725	\$0.511	\$22.485	\$7.083	\$91.091	\$31.882	\$66.292	0.934	\$61.935	1
8			114	48	15	29	174	\$89.20	\$26.76	\$3.26	\$119.604	\$16.944	\$11.960	\$29.702	\$4.784	\$0.678	\$0.478	\$21.033	\$7.083	\$84.751	\$29.663	\$62.171	0.928	\$57.692	1
9			88	42	14	27	162	\$89.20	\$26.76	\$3.26	\$111.880	\$15.850	\$11.188	\$27.784	\$4.475	\$0.634	\$0.448	\$19.675	\$7.083	\$78.820	\$27.587	\$58.316	0.922	\$53.748	1
10			77	39	13	25	152	\$89.20	\$26.76	\$3.26	\$104.655	\$14.827	\$10.466	\$25.990	\$4.186	\$0.593	\$0.419	\$18.404	\$7.083	\$73.273	\$25.645	\$54.711	0.915	\$50.083	1
11			72	37	12	24	142	\$89.20	\$26.76	\$3.26	\$97.897	\$13.869	\$9.790	\$24.311	\$3.916	\$0.555	\$0.392	\$17.216	\$7.083	\$68.083	\$23.829	\$51.338	0.909	\$46.677	1
12			67	34	11	22	133	\$89.20	\$26.76	\$3.26	\$91.575	\$12.974	\$9.157	\$22.741	\$3.663	\$0.519	\$0.366	\$16.104	\$7.083	\$63.229	\$22.130	\$48.182	0.903	\$43.511	1
13			65	33	11	21	128	\$89.20	\$26.76	\$3.26	\$88.080	\$12.478	\$8.808	\$21.873	\$3.523	\$0.499	\$0.352	\$15.489	\$7.083	\$60.546	\$21.191	\$46.438	0.897	\$41.652	1
14			62	32	11	20	123	\$89.20	\$26.76	\$3.26	\$84.719	\$12.002	\$8.472	\$21.039	\$3.389	\$0.480	\$0.339	\$14.898	\$7.083	\$57.965	\$20.288	\$44.761	0.891	\$39.875	1
15			60	30	10	20	118	\$89.20	\$26.76	\$3.26	\$81.486	\$11.544	\$8.149	\$20.236	\$3.259	\$0.462	\$0.326	\$14.330	\$7.083	\$55.483	\$19.419	\$43.147	0.885	\$38.178	1
16			57	29	10	19	114	\$89.20	\$26.76	\$3.26	\$78.376	\$11.104	\$7.838	\$19.464	\$3.135	\$0.444	\$0.314	\$13.783	\$7.083	\$53.095	\$18.583	\$41.595	0.879	\$36.555	1
17			55	28	9	18	109	\$89.20	\$26.76	\$3.26	\$75.386	\$10.680	\$7.539	\$18.721	\$3.015	\$0.427	\$0.302	\$13.257	\$7.083	\$50.799	\$17.780	\$40.103	0.873	\$35.004	1
18			53	27	9	18	105	\$89.20	\$26.76	\$3.26	\$72.509	\$10.272	\$7.251	\$18.006	\$2.900	\$0.411	\$0.290	\$12.751	\$7.083	\$48.590	\$17.006	\$38.667	0.867	\$33.522	1
19			51	26	9	17	101	\$89.20	\$26.76	\$3.26	\$69.742	\$9.880	\$6.974	\$17.319	\$2.790	\$0.395	\$0.279	\$12.264	\$7.083	\$46.465	\$16.263	\$37.286	0.861	\$32.106	1
20			49	25	8	16	97	\$89.20	\$26.76	\$3.26	\$67.080	\$9.503	\$6.708	\$16.658	\$2.683	\$0.380	\$0.268	\$11.796	\$7.083	\$44.422	\$15.548	\$35.958	0.855	\$30.753	1
21			47	24	8	16	94	\$89.20	\$26.76	\$3.26	\$64.520	\$9.141	\$6.452	\$16.023	\$2.581	\$0.366	\$0.258	\$11.346	\$7.083	\$42.456	\$14.860	\$34.680	0.849	\$29.459	1
22			45	23	8	15	90	\$89.20	\$26.76	\$3.26	\$62.058	\$8.792	\$6.206	\$15.411	\$2.482	\$0.352	\$0.248	\$10.913	\$7.083	\$40.566	\$14.198	\$33.451	0.844	\$28.223	1
23			44	22	7	14	87	\$89.20	\$26.76	\$3.26	\$59.690	\$8.456	\$5.969	\$14.823	\$2.388	\$0.338	\$0.239	\$10.497	\$7.083	\$38.748	\$13.562	\$32.269	0.838	\$27.041	1
24			42	21	7	14	83	\$89.20	\$26.76	\$3.26	\$57.412	\$8.134	\$5.741	\$14.257	\$2.296	\$0.325	\$0.230	\$10.096	\$7.083	\$36.999	\$12.950	\$31.132	0.832	\$25.912	1
25			40	21	7	13	80	\$89.20	\$26.76	\$3.26	\$54.948	\$7.785	\$5.495	\$13.646	\$2.198	\$0.311	\$0.220	\$9.663	\$7.083	\$35.107	\$12.287	\$29.903	0.827	\$24.720	1
26			39	20	7	13	76	\$89.20	\$26.76	\$3.26	\$52.590	\$7.450	\$5.259	\$13.060	\$2.104	\$0.298	\$0.210	\$9.248	\$7.083	\$33.296	\$11.654	\$28.726	0.821	\$23.586	1
27			37	19	6	12	73	\$89.20	\$26.76	\$3.26	\$50.333	\$7.131	\$5.033	\$12.499	\$2.013	\$0.285	\$0.201	\$8.851	\$7.083	\$31.563	\$11.047	\$27.599	0.816	\$22.507	1
28			35	18	6	12	70	\$89.20	\$26.76	\$3.26	\$48.173	\$6.825	\$4.817	\$11.963	\$1.927	\$0.273	\$0.193	\$8.471	\$7.083	\$29.905	\$10.467	\$26.521	0.810	\$21.482	1
29			34	17	6	11	67	\$89.20	\$26.76	\$3.26	\$46.105	\$6.532	\$4.611	\$11.450	\$1.844	\$0.261	\$0.184	\$8.108	\$7.083	\$28.317	\$9.911	\$25.489	0.804	\$20.506	1
30			32	16	5	11	64	\$89.20	\$26.76	\$3.26	\$44.127	\$6.251	\$4.413	\$10.958	\$1.765	\$0.250	\$0.177	\$7.760	\$7.083	\$26.798	\$9.379	\$24.502	0.799	\$19.578	1
31			31	16	5	10	61	\$89.20	\$26.76	\$3.26	\$42.233	\$5.983	\$4.223	\$10.488	\$1.689	\$0.239	\$0.169	\$7.427	\$7.083	\$25.344	\$8.870	\$23.557	0.794	\$18.695	1
32			30	15	5	10	59	\$89.20	\$26.76	\$3.26	\$40.420	\$5.726	\$4.042	\$10.038	\$1.617	\$0.229	\$0.162	\$7.108	\$7.083	\$23.952	\$8.383	\$22.652	0.788	\$17.856	1
33			28	14	5	9	56	\$89.20	\$26.76	\$3.26	\$38.686	\$5.481	\$3.869	\$9.607	\$1.547	\$0.219	\$0.155	\$6.803	\$7.083	\$22.620	\$7.917	\$21.786	0.783	\$17.057	1
34			27	14	5	9	54	\$89.20	\$26.76	\$3.26	\$37.025	\$5.245	\$3.703	\$9.195	\$1.481	\$0.210	\$0.148	\$6.511	\$7.083	\$21.345	\$7.471	\$20.958	0.778	\$16.297	1
35			26	13	4	9	51	\$89.20	\$26.76	\$3.26	\$35.436	\$5.020	\$3.544	\$8.800	\$1.417	\$0.201	\$0.142	\$6.232	\$7.083	\$20.125	\$7.044	\$20.165	0.772	\$15.574	1
36			49				49	\$89.20	\$26.76	\$3.26	\$33.916	\$4.805	\$3.392	\$8.422	\$1.357	\$0.192	\$0.136	\$5.964	\$7.083	\$18.958	\$6.635	\$19.406	0.767	\$14.886	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Greater Monument Butte

Uinta Basin: Greater Monument Butte/Uinta				My Assumptions:			
Basin Characteristics		Average Well		100% oilfield service & supply factor price scalar			
\$1.40 cost/well (\$mm)		IP	EUR	30	days/month		
53 EUR/well (mboe)		120	188	-0.68%	exponential decline rate after year 3 (monthly)		
-55% 1st yr decline	-6.4%	54		\$100.00	oil price WTI (\$/bbl)		
-30% 2nd yr decline	-2.9%	38		0%	oil price appreciation (per month)		
-20% 3rd yr decline	-1.8%	34		\$3.50	gas price Henry Hub (\$/mcf)		
34 IP rate (boe/d)				0%	gas price appreciation		
\$10.00 opex-LOE (\$/boe)				30%	NGL price/oil price (fixed ratio)		
87% % oil				0.68%	discount rate (compound monthly)		
9% % gas				8.5%	discount rate (annual)		
4% % NGL				80%	intangible drilling cost / total capex		
20.0% royalty rate				0.638	IP/EUR ratio, (B8/B4 = fixed ratio)		
8.0% oil prod tax				Results			
8.0% gas prod tax				-\$0.343 = NPV/well (\$ million)			
8.0% NGL prod tax				0 = EUR check (mboe)			
35.0% income tax rate				0.16% = ATIRR (monthly)			
-20% oil differential				1.98% = ATIRR (annual)			
-20% gas differential				53 = total production (mboe)			
0 1 = DUC				\$0.579 = "tail end" NPV/well (\$ million)			
25% auxiliary cost/well cost				97% = "tail end" recovery factor			
50% completion cost/well cost				27 = months of lost production			
\$2,000 min opex (\$/month)							

Uinta Basin: Greater Monument Butte/Uinta					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20	2,075	1,324	1,030	657	
\$25	760	485	377	241	
\$30	465	297	231	147	
\$35	335	214	167	107	
\$40	262	167	132	84	
\$45	215	137	108	70	
\$50	183	117	93	59	
\$60	140	89	72	46	
\$70	114	73	59	38	
\$80	96	61	50	32	
\$90	84	54	44	28	
\$100	74	47	39	25	

Uinta Basin: Greater Monument Butte/Uinta					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	
\$20		0		0	
\$25	5,200	3,319		1,647	
\$30	1,220	779		606	
\$35	691	441		343	
\$40	482	308		239	
\$45	370	236		184	
\$50	300	191		150	
\$60	218	139		109	
\$70	171	109		86	
\$80	141	90		71	
\$90	120	77		61	
\$100	105	67		53	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)								Active 1/0					
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex		Depreciation	Tax. Inc.	Income Tax	NCF	PV Factor
1	\$350	\$88						\$80.00	\$24.00	\$2.80	\$71.081	\$1.544	\$0.980	\$14.72	\$4.55	\$0.10	\$0.06	\$10.213	\$2.917	\$41.045	\$14.366	\$29.596	0.973	\$28.802	1
2	\$350	\$88						\$80.00	\$24.00	\$2.80	\$66.506	\$1.445	\$0.917	\$13.774	\$4.256	\$0.092	\$0.059	\$9.555	\$2.756	\$38.214	\$13.375	\$27.756	0.967	\$26.828	1
3	\$350	\$88						\$80.00	\$24.00	\$2.80	\$62.224	\$1.352	\$0.858	\$12.887	\$3.982	\$0.087	\$0.055	\$8.940	\$2.917	\$35.567	\$12.448	\$26.035	0.960	\$24.994	1
4	\$350	\$88						\$80.00	\$24.00	\$2.80	\$58.218	\$1.265	\$0.803	\$12.057	\$3.726	\$0.081	\$0.051	\$8.365	\$2.917	\$33.089	\$11.581	\$24.425	0.954	\$23.290	1
5			34	30	1	3	18	\$80.00	\$24.00	\$2.80	\$54.470	\$1.183	\$0.751	\$11.281	\$3.486	\$0.076	\$0.048	\$7.826	\$2.917	\$30.771	\$10.770	\$22.918	0.947	\$21.705	1
6			32	28	1	3	17	\$80.00	\$24.00	\$2.80	\$50.964	\$1.107	\$0.703	\$10.555	\$3.262	\$0.071	\$0.045	\$7.322	\$2.917	\$28.603	\$10.011	\$21.508	0.941	\$20.232	1
7			30	26	1	3	16	\$80.00	\$24.00	\$2.80	\$47.683	\$1.036	\$0.658	\$9.875	\$3.052	\$0.066	\$0.042	\$6.851	\$2.917	\$26.573	\$9.301	\$20.189	0.934	\$18.862	1
8			28	24	1	3	15	\$80.00	\$24.00	\$2.80	\$44.613	\$0.969	\$0.615	\$9.240	\$2.855	\$0.062	\$0.039	\$6.410	\$2.917	\$24.675	\$8.636	\$18.955	0.928	\$17.590	1
9			26	23	1	2	14	\$80.00	\$24.00	\$2.80	\$41.741	\$0.907	\$0.576	\$8.645	\$2.671	\$0.058	\$0.037	\$5.997	\$2.917	\$22.899	\$8.015	\$17.801	0.922	\$16.406	1
10			24	21	1	2	13	\$80.00	\$24.00	\$2.80	\$39.054	\$0.848	\$0.539	\$8.088	\$2.499	\$0.054	\$0.034	\$5.611	\$2.917	\$21.237	\$7.433	\$16.721	0.915	\$15.306	1
11			23	20	1	2	12	\$80.00	\$24.00	\$2.80	\$36.540	\$0.794	\$0.504	\$7.568	\$2.339	\$0.051	\$0.032	\$5.250	\$2.917	\$19.682	\$6.889	\$15.710	0.909	\$14.284	1
12			21	19	1	2	11	\$80.00	\$24.00	\$2.80	\$34.188	\$0.743	\$0.472	\$7.080	\$2.188	\$0.048	\$0.030	\$4.912	\$2.917	\$18.227	\$6.379	\$14.764	0.903	\$13.333	1
13			20	17	1	2	11	\$80.00	\$24.00	\$2.80	\$33.201	\$0.721	\$0.458	\$6.876	\$2.125	\$0.046	\$0.029	\$4.770	\$2.917	\$17.617	\$6.166	\$14.368	0.897	\$12.887	1
14			19	16	1	2	10	\$80.00	\$24.00	\$2.80	\$32.243	\$0.700	\$0.445	\$6.678	\$2.064	\$0.045	\$0.028	\$4.633	\$2.917	\$17.024	\$5.959	\$13.982	0.891	\$12.456	1
15			18	15	1	1	8	\$80.00	\$24.00	\$2.80	\$31.312	\$0.680	\$0.432	\$6.485	\$2.004	\$0.044	\$0.028	\$4.499	\$2.917	\$16.449	\$5.757	\$13.608	0.885	\$12.041	1
16			17	15	1	1	8	\$80.00	\$24.00	\$2.80	\$30.409	\$0.661	\$0.419	\$6.298	\$1.946	\$0.042	\$0.027	\$4.369	\$2.917	\$15.890	\$5.561	\$13.245	0.879	\$11.640	1
17			16	14	1	1	8	\$80.00	\$24.00	\$2.80	\$29.531	\$0.642	\$0.407	\$6.116	\$1.890	\$0.041	\$0.026	\$4.243	\$2.917	\$15.347	\$5.372	\$12.892	0.873	\$11.253	1
18			15	14	1	1	7	\$80.00	\$24.00	\$2.80	\$28.679	\$0.623	\$0.396	\$5.940	\$1.835	\$0.040	\$0.025	\$4.121	\$2.917	\$14.820	\$5.187	\$12.550	0.867	\$10.880	1
19			14	12	1	1	7	\$80.00	\$24.00	\$2.80	\$27.851	\$0.605	\$0.384	\$5.768	\$1.782	\$0.039	\$0.025	\$4.002	\$2.917	\$14.308	\$5.008	\$12.217	0.861	\$10.520	1
20			13	12	1	1	7	\$80.00	\$24.00	\$2.80	\$27.048	\$0.588	\$0.373	\$5.602	\$1.731	\$0.038	\$0.024	\$3.886	\$2.917	\$13.811	\$4.834	\$11.894	0.855	\$10.172	1
21			13	11	1	1	7	\$80.00	\$24.00	\$2.80	\$26.267	\$0.571	\$0.362	\$5.440	\$1.681	\$0.037	\$0.023	\$3.774	\$2.917	\$13.328	\$4.665	\$11.580	0.849	\$9.837	1
22			12	11	1	1	7	\$80.00	\$24.00	\$2.80	\$25.509	\$0.554	\$0.352	\$5.283	\$1.633	\$0.035	\$0.023	\$3.665	\$2.917	\$12.860	\$4.501	\$11.275	0.844	\$9.513	1
23			12	10	0	1	6	\$80.00	\$24.00	\$2.80	\$24.773	\$0.538	\$0.342	\$5.131	\$1.585	\$0.034	\$0.022	\$3.559	\$2.917	\$12.404	\$4.342	\$10.980	0.838	\$9.201	1
24			12	10	0	1	6	\$80.00	\$24.00	\$2.80	\$24.058	\$0.523	\$0.332	\$4.982	\$1.540	\$0.033	\$0.021	\$3.457	\$2.917	\$11.962	\$4.187	\$10.692	0.832	\$8.899	1
25			11	10	0	1	6	\$80.00	\$24.00	\$2.80	\$23.616	\$0.513	\$0.326	\$4.891	\$1.511	\$0.033	\$0.021	\$3.393	\$2.917	\$11.689	\$4.091	\$10.514	0.827	\$8.692	1
26			11	10	0	1	6	\$80.00	\$24.00	\$2.80	\$23.182	\$0.504	\$0.320	\$4.801	\$1.484	\$0.032	\$0.020	\$3.331	\$2.917	\$11.421	\$3.997	\$10.340	0.821	\$8.490	1
27			11	9	0	1	6	\$80.00	\$24.00	\$2.80	\$22.757	\$0.494	\$0.314	\$4.713	\$1.456	\$0.032	\$0.020	\$3.270	\$2.917	\$11.157	\$3.905	\$10.169	0.816	\$8.293	1
28			11	9	0	1	6	\$80.00	\$24.00	\$2.80	\$22.339	\$0.485	\$0.308	\$4.626	\$1.430	\$0.031	\$0.020	\$3.210	\$2.917	\$10.899	\$3.815	\$10.001	0.810	\$8.101	1
29			11	9	0	1	6	\$80.00	\$24.00	\$2.80	\$21.928	\$0.476	\$0.302	\$4.541	\$1.403	\$0.030	\$0.019	\$3.151	\$2.917	\$10.645	\$3.726	\$9.836	0.804	\$7.913	1
30			10	9	0	1	6	\$80.00	\$24.00	\$2.80	\$21.525	\$0.468	\$0.297	\$4.458	\$1.378	\$0.030	\$0.019	\$3.093	\$2.917	\$10.396	\$3.639	\$9.674	0.799	\$7.730	1
31			10	9	0	1	5	\$80.00	\$24.00	\$2.80	\$21.130	\$0.459	\$0.291	\$4.376	\$1.352	\$0.029	\$0.019	\$3.036	\$2.917	\$10.152	\$3.553	\$9.515	0.794	\$7.551	1
32			10	9	0	1	5	\$80.00	\$24.00	\$2.80	\$20.742	\$0.451	\$0.286	\$4.296	\$1.327	\$0.029	\$0.018	\$2.980	\$2.917	\$9.912	\$3.469	\$9.359	0.788	\$7.377	1
33			10	8	0	1	5	\$80.00	\$24.00	\$2.80	\$20.361	\$0.442	\$0.281	\$4.217	\$1.303	\$0.028	\$0.018	\$2.925	\$2.917	\$9.676	\$3.387	\$9.206	0.783	\$7.207	1
34			10	8	0	1	5	\$80.00	\$24.00	\$2.80	\$19.987	\$0.434	\$0.276	\$4.139	\$1.279	\$0.028	\$0.018	\$2.872	\$2.917	\$9.445	\$3.306	\$9.056	0.778	\$7.042	1
35			9	8	0	1	5	\$80.00	\$24.00	\$2.80	\$19.620	\$0.426	\$0.271	\$4.063	\$1.256	\$0.027	\$0.017	\$2.819	\$2.917	\$9.218	\$3.226	\$8.908	0.772	\$6.880	1
36			9	8	0	1	5	\$80.00	\$24.00	\$2.80	\$19.260	\$0.418	\$0.266	\$3.989	\$1.233	\$0.027	\$0.017	\$2.767	\$2.917	\$8.995	\$3.148	\$8.763	0.767	\$6.722	1

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Wasatch SXL

Uinta Basin: Wasatch SXL			My Assumptions:		
Basin Characteristics			oilfield service & supply factor price scalar		
\$14.00 cost/well (\$mm)	Average Well IP	EUR	100%	30	days/month
433 EUR/well (mboe)	1,444	1,000	-1.64%	3	exponential decline rate after year 3 (monthly)
-68% 1st yr decline	-9.0%	467	\$100.00	0	oil price WTI (\$/bbl)
-36% 2nd yr decline	-3.6%	300	0%	0	oil price appreciation (per month)
-28% 3rd yr decline	-2.7%	255	\$3.50	0	gas price Henry Hub (\$/mcf)
626 IP rate (boe/d)			0%	0	gas price appreciation
\$8.00 opex-LOE (\$/boe)			30%	0	NGL price/oil price (fixed ratio)
75% % oil			0.68%	0	discount rate (compound monthly)
25% % gas			8.5%	0	discount rate (annual)
0% % NGL			80%	0	intangible drilling cost / total capex
20.0% royalty rate			1.444	0	IP/EUR ratio, (B8/B4 = fixed ratio)
8.0% oil prod tax					
8.0% gas prod tax					
8.0% NGL prod tax					
35.0% income tax rate					
-20% oil differential					
-20% gas differential					
0 1= DUC					
25% auxiliary cost/well cost					
50% completion cost/well cost					
\$2,000 min opex (\$/month)					

Uinta Basin: Wasatch SXL					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	6,114	8,829	3,036	4,384	
\$25	3,913	5,650	1,943	2,806	
\$30	2,877	4,154	1,429	2,063	
\$35	2,275	3,285	1,130	1,632	
\$40	1,881	2,716	935	1,350	
\$45	1,604	2,316	797	1,151	
\$50	1,398	2,019	695	1,004	
\$60	1,112	1,606	553	799	
\$70	923	1,333	459	663	
\$80	789	1,139	393	567	
\$90	689	995	343	495	
\$100	612	884	304	439	

Uinta Basin: Wasatch SXL					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	24,862	35,901	12,341	17,820	
\$25	9,138	13,195	4,536	6,550	
\$30	5,598	8,084	2,779	4,013	
\$35	4,035	5,827	2,003	2,892	
\$40	3,154	4,554	1,566	2,261	
\$45	2,589	3,739	1,286	1,857	
\$50	2,196	3,171	1,091	1,575	
\$60	1,684	2,432	837	1,209	
\$70	1,366	1,973	679	980	
\$80	1,149	1,659	571	825	
\$90	991	1,431	493	712	
\$100	872	1,259	433	625	

Results		
-\$3.409 = NPV/well (\$ million)		
0 = EUR check (mboe)		
-0.07% = ATIRR (monthly)		
-0.85% = ATIRR (annual)		
433 = total production (mboe)		
\$4.003 = "tail end" NPV/well (\$ million)		
99% = "tail end" recovery factor		
60 = months of lost production		

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d Gas Prod	Prices			Cash Flows (\$1,000)										AT NPV -\$3,409	Active 1/0			
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.			Income Tax	NCF	PV Factor
1	\$3,500	\$875					\$80.00	\$24.00	\$2.80	\$1,126,229	\$78,836	\$0.000	\$241.01	\$72.08	\$5.05	\$0.00	\$150,164	\$29,167	\$707,598	\$247,659	\$489,105	0.973	\$475,984	1	
2	\$3,500	\$875					\$80.00	\$24.00	\$2.80	\$1,025,115	\$71,758	\$0.000	\$219,375	\$65,607	\$4,593	\$0.000	\$136,682	\$29,167	\$641,450	\$224,508	\$446,109	0.967	\$431,200	1	
3	\$3,500	\$875					\$80.00	\$24.00	\$2.80	\$933,079	\$65,316	\$0.000	\$199,679	\$59,717	\$4,180	\$0.000	\$124,411	\$29,167	\$581,241	\$203,434	\$406,973	0.960	\$390,707	1	
4	\$3,500	\$875					\$80.00	\$24.00	\$2.80	\$849,306	\$59,451	\$0.000	\$181,752	\$54,356	\$3,805	\$0.000	\$113,241	\$29,167	\$526,438	\$184,253	\$371,351	0.954	\$354,093	1	
5			626	469	0	156	939	\$80.00	\$24.00	\$2.80	\$773,054	\$54,114	\$0.000	\$165,434	\$49,475	\$3,463	\$0.000	\$103,074	\$29,167	\$476,555	\$166,794	\$338,928	0.947	\$320,987	1
6			570	427	0	142	854	\$80.00	\$24.00	\$2.80	\$703,649	\$49,255	\$0.000	\$150,581	\$45,034	\$3,152	\$0.000	\$93,820	\$29,167	\$431,151	\$150,903	\$309,415	0.941	\$291,051	1
7			518	389	0	130	778	\$80.00	\$24.00	\$2.80	\$640,474	\$44,833	\$0.000	\$137,061	\$40,990	\$2,869	\$0.000	\$85,397	\$29,167	\$389,823	\$136,438	\$282,552	0.934	\$263,981	1
8			472	354	0	118	708	\$80.00	\$24.00	\$2.80	\$582,972	\$40,808	\$0.000	\$124,756	\$37,310	\$2,612	\$0.000	\$77,730	\$29,167	\$352,206	\$123,272	\$258,100	0.928	\$239,503	1
9			429	322	0	107	644	\$80.00	\$24.00	\$2.80	\$530,632	\$37,144	\$0.000	\$113,555	\$33,960	\$2,377	\$0.000	\$70,751	\$29,167	\$317,966	\$111,288	\$235,844	0.922	\$217,368	1
10			391	293	0	98	586	\$80.00	\$24.00	\$2.80	\$482,991	\$33,809	\$0.000	\$103,360	\$30,911	\$2,164	\$0.000	\$64,399	\$29,167	\$286,800	\$100,380	\$215,586	0.915	\$197,351	1
11			356	267	0	89	534	\$80.00	\$24.00	\$2.80	\$439,628	\$30,774	\$0.000	\$94,080	\$28,136	\$1,970	\$0.000	\$58,617	\$29,167	\$258,432	\$90,451	\$197,147	0.909	\$179,249	1
12			324	243	0	81	486	\$80.00	\$24.00	\$2.80	\$400,157	\$28,011	\$0.000	\$85,634	\$25,610	\$1,793	\$0.000	\$53,354	\$29,167	\$232,611	\$81,414	\$180,364	0.903	\$162,878	1
13			295	221	0	74	442	\$80.00	\$24.00	\$2.80	\$385,669	\$26,997	\$0.000	\$82,533	\$24,683	\$1,728	\$0.000	\$51,422	\$29,167	\$223,133	\$78,096	\$174,203	0.897	\$156,248	1
14			268	201	0	67	402	\$80.00	\$24.00	\$2.80	\$371,705	\$26,019	\$0.000	\$79,545	\$23,789	\$1,665	\$0.000	\$49,561	\$29,167	\$213,998	\$74,899	\$168,265	0.891	\$149,900	1
15			244	183	0	61	366	\$80.00	\$24.00	\$2.80	\$358,246	\$25,077	\$0.000	\$76,665	\$22,928	\$1,605	\$0.000	\$47,766	\$29,167	\$205,193	\$71,818	\$162,542	0.885	\$143,821	1
16			222	167	0	56	333	\$80.00	\$24.00	\$2.80	\$345,275	\$24,169	\$0.000	\$73,889	\$22,098	\$1,547	\$0.000	\$46,037	\$29,167	\$196,708	\$68,848	\$157,027	0.879	\$137,999	1
17			214	161	0	54	321	\$80.00	\$24.00	\$2.80	\$332,774	\$23,294	\$0.000	\$71,214	\$21,298	\$1,491	\$0.000	\$44,370	\$29,167	\$188,530	\$65,985	\$151,711	0.873	\$132,424	1
18			207	155	0	52	310	\$80.00	\$24.00	\$2.80	\$320,725	\$22,451	\$0.000	\$68,635	\$20,526	\$1,437	\$0.000	\$42,763	\$29,167	\$180,647	\$63,227	\$146,587	0.867	\$127,085	1
19			199	149	0	50	299	\$80.00	\$24.00	\$2.80	\$309,113	\$21,638	\$0.000	\$66,150	\$19,783	\$1,385	\$0.000	\$41,215	\$29,167	\$173,051	\$60,568	\$141,650	0.861	\$121,972	1
20			185	139	0	46	277	\$80.00	\$24.00	\$2.80	\$297,920	\$20,854	\$0.000	\$63,755	\$19,067	\$1,335	\$0.000	\$39,723	\$29,167	\$165,729	\$58,005	\$136,890	0.855	\$117,076	1
21			172	129	0	43	258	\$80.00	\$24.00	\$2.80	\$287,134	\$20,099	\$0.000	\$61,447	\$18,377	\$1,286	\$0.000	\$38,284	\$29,167	\$158,672	\$55,535	\$132,304	0.849	\$112,386	1
22			166	124	0	41	248	\$80.00	\$24.00	\$2.80	\$276,737	\$19,372	\$0.000	\$59,222	\$17,711	\$1,240	\$0.000	\$36,898	\$29,167	\$151,871	\$53,155	\$127,883	0.844	\$107,895	1
23			160	120	0	40	239	\$80.00	\$24.00	\$2.80	\$266,717	\$18,670	\$0.000	\$57,078	\$17,070	\$1,195	\$0.000	\$35,562	\$29,167	\$145,316	\$50,861	\$123,622	0.838	\$103,593	1
24			148	111	0	37	222	\$80.00	\$24.00	\$2.80	\$257,060	\$17,994	\$0.000	\$55,011	\$16,452	\$1,152	\$0.000	\$34,275	\$29,167	\$138,999	\$48,650	\$119,516	0.832	\$99,474	1
25			143	107	0	36	214	\$80.00	\$24.00	\$2.80	\$250,191	\$17,513	\$0.000	\$53,541	\$16,012	\$1,121	\$0.000	\$33,359	\$29,167	\$134,505	\$47,077	\$116,595	0.827	\$96,385	1
26			139	104	0	35	208	\$80.00	\$24.00	\$2.80	\$243,505	\$17,045	\$0.000	\$52,110	\$15,584	\$1,091	\$0.000	\$32,467	\$29,167	\$130,131	\$45,546	\$113,752	0.821	\$93,398	1
27			132	99	0	34	203	\$80.00	\$24.00	\$2.80	\$236,998	\$16,590	\$0.000	\$50,718	\$15,168	\$1,062	\$0.000	\$31,600	\$29,167	\$125,874	\$44,056	\$110,985	0.816	\$90,509	1
28			128	96	0	32	192	\$80.00	\$24.00	\$2.80	\$230,665	\$16,147	\$0.000	\$49,362	\$14,763	\$1,033	\$0.000	\$30,755	\$29,167	\$121,731	\$42,606	\$108,292	0.810	\$87,714	1
29			125	94	0	31	187	\$80.00	\$24.00	\$2.80	\$224,501	\$15,715	\$0.000	\$48,043	\$14,368	\$1,006	\$0.000	\$29,933	\$29,167	\$117,699	\$41,195	\$105,671	0.804	\$85,011	1
30			121	91	0	30	182	\$80.00	\$24.00	\$2.80	\$218,501	\$15,295	\$0.000	\$46,759	\$13,984	\$979	\$0.000	\$29,134	\$29,167	\$113,774	\$39,821	\$103,120	0.799	\$82,397	1
31			118	89	0	30	177	\$80.00	\$24.00	\$2.80	\$212,662	\$14,886	\$0.000	\$45,510	\$13,610	\$953	\$0.000	\$28,355	\$29,167	\$109,954	\$38,484	\$100,637	0.794	\$79,868	1
32			115	86	0	29	172	\$80.00	\$24.00	\$2.80	\$206,979	\$14,489	\$0.000	\$44,294	\$13,247	\$927	\$0.000	\$27,597	\$29,167	\$106,236	\$37,183	\$98,220	0.788	\$77,422	1
33			112	84	0	28	168	\$80.00	\$24.00	\$2.80	\$201,448	\$14,101	\$0.000	\$43,100	\$12,893	\$902	\$0.000	\$26,860	\$29,167	\$102,618	\$35,916	\$95,868	0.783	\$75,056	1
34			109	82	0	27	163	\$80.00	\$24.00	\$2.80	\$196,065	\$13,725	\$0.000	\$41,958	\$12,548	\$878	\$0.000	\$26,142	\$29,167	\$99,096	\$34,684	\$93,579	0.778	\$72,768	1
35			106	80	0	27	159	\$80.00	\$24.00	\$2.80	\$190,826	\$13,358	\$0.000	\$40,837	\$12,213	\$855	\$0.000	\$25,443	\$29,167	\$95,669	\$33,484	\$91,351	0.772	\$70,554	1
36			103	78	0	26	155	\$80.00	\$24.00	\$2.80	\$185,726	\$13,001	\$0.000	\$39,745	\$11,886	\$832	\$0.000	\$24,763	\$29,167</						

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Uteland Butte SXL

Uteland Butte SXL			My Assumptions:		
Basin Characteristics			100% oilfield service & supply factor price scalar		
\$11.00 cost/well (\$mm)	Average Well		IP	EUR	30 days/month
410 EUR/well (mboe)	1,290	700	-3.13%		exponential decline rate after year 3 (monthly)
-55% 1st yr decline	-6.4%	580	\$100.00		oil price WTI (\$/bbl)
-48% 2nd yr decline	-5.3%	300	0%		oil price appreciation (per month)
-55% 3rd yr decline	-6.5%	201	\$3.50		gas price Henry Hub (\$/mcf)
75% IP rate (boe/d)			0%		gas price appreciation
\$15.43 opex-LOE (\$/boe)			30%		NGL price/oil price (fixed ratio)
75% % oil			0.68%		discount rate (compound monthly)
25% % gas			8.5%		discount rate (annual)
0% % NGL			80%		intangible drilling cost / total capex
20.0% royalty rate			1.843		IP/EUR ratio, (B8/B4 = fixed ratio)
8.0% oil prod tax					
8.0% gas prod tax					
8.0% NGL prod tax					
35.0% income tax rate					
-20% oil differential					
-20% gas differential					
0 1 = DUC					
25% auxiliary cost/well cost					
50% completion cost/well cost					
\$2,000 min opex (\$/month)					

Results	
-\$1.962	= NPV/well (\$ million)
0	= EUR check (mboe)
-0.19%	= ATRR (monthly)
-2.20%	= ATRR (annual)
410	= total production (mboe)
\$1.835	= "tail end" NPV/well (\$ million)
98%	= "tail end" recovery factor
192	= months of lost production

Uteland Butte SXL						
Baseline Results (2016 factor prices)						
minimum (breakeven) EUR and IP (flow) for the given price:						
Price	Full Cycle			DUC		
	EUR	IP	EUR	IP	EUR	IP
\$20		0		0		0
\$25		0		0		0
\$30	18,221	33,579	9,045	16,669		
\$35	5,315	9,795	2,639	4,863		
\$40	3,112	5,735	1,545	2,847		
\$45	2,200	4,054	1,093	2,014		
\$50	1,701	3,135	845	1,557		
\$60	1,171	2,158	582	1,073		
\$70	893	1,646	444	818		
\$80	721	1,329	359	662		
\$90	605	1,115	301	555		
\$100	521	960	259	477		

Uteland Butte SXL						
Sensitivity Results (2014 factor prices, G2-133%)						
minimum (breakeven) EUR and IP (flow) for the given price:						
Price	Full Cycle			DUC		
	EUR	IP	EUR	IP	EUR	IP
\$20		0		0		0
\$25		0		0		0
\$30		0		0		0
\$35		0		0		0
\$40	94,438	174,036	46,876	86,386		
\$45	9,025	16,632	4,480	8,256		
\$50	4,739	8,733	2,353	4,336		
\$60	2,431	4,480	1,207	2,224		
\$70	1,635	3,013	812	1,496		
\$80	1,232	2,270	612	1,128		
\$90	988	1,821	491	905		
\$100	825	1,520	410	756		

Per Well Net Cash Flow Analysis

Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)										Active 1/0			
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax		NCF	PV Factor	AT NPV
1	\$2,750	\$688					\$80.00	\$24.00	\$2.80	\$1,359.384	\$95.157	\$0.000	\$290.91	\$87.00	\$6.09	\$0.00	\$349.588	\$22.917	\$698.037	\$244.313	\$476.641	0.973	\$463.854	1	
2	\$2,750	\$688					\$80.00	\$24.00	\$2.80	\$1,271.780	\$89.025	\$0.000	\$272.161	\$81.394	\$5.698	\$0.000	\$327.059	\$22.917	\$651.576	\$228.052	\$446.441	0.967	\$431.521	1	
3	\$2,750	\$688					\$80.00	\$24.00	\$2.80	\$1,189.822	\$83.288	\$0.000	\$254.622	\$76.149	\$5.330	\$0.000	\$305.982	\$22.917	\$608.109	\$212.838	\$418.188	0.960	\$401.473	1	
4	\$2,750	\$688					\$80.00	\$24.00	\$2.80	\$1,113.145	\$77.920	\$0.000	\$238.213	\$71.241	\$4.987	\$0.000	\$286.264	\$22.917	\$567.443	\$198.605	\$391.755	0.954	\$373.549	1	
5			755	566	0	189	1,133	\$80.00	\$24.00	\$2.80	\$1,041.409	\$72.899	\$0.000	\$222.862	\$66.650	\$4.666	\$0.000	\$267.816	\$22.917	\$529.398	\$185.289	\$367.026	0.947	\$347.597	1
6			541	406	0	135	812	\$80.00	\$24.00	\$2.80	\$974.297	\$68.201	\$0.000	\$208.500	\$62.355	\$4.365	\$0.000	\$250.557	\$22.917	\$493.805	\$172.832	\$343.890	0.941	\$323.480	1
7			506	380	0	127	760	\$80.00	\$24.00	\$2.80	\$911.510	\$63.806	\$0.000	\$195.063	\$58.337	\$4.084	\$0.000	\$234.410	\$22.917	\$460.505	\$161.177	\$322.245	0.934	\$301.066	1
8			474	355	0	118	711	\$80.00	\$24.00	\$2.80	\$852.768	\$59.694	\$0.000	\$182.492	\$54.577	\$3.820	\$0.000	\$219.304	\$22.917	\$429.352	\$150.273	\$301.995	0.928	\$280.235	1
9			443	332	0	111	665	\$80.00	\$24.00	\$2.80	\$797.813	\$55.847	\$0.000	\$170.732	\$51.060	\$3.574	\$0.000	\$205.171	\$22.917	\$400.206	\$140.072	\$283.051	0.922	\$260.876	1
10			415	311	0	104	622	\$80.00	\$24.00	\$2.80	\$746.399	\$52.248	\$0.000	\$159.729	\$47.770	\$3.344	\$0.000	\$191.949	\$22.917	\$372.938	\$130.528	\$265.327	0.915	\$242.884	1
11			388	291	0	97	582	\$80.00	\$24.00	\$2.80	\$698.298	\$48.881	\$0.000	\$149.436	\$44.691	\$3.128	\$0.000	\$179.579	\$22.917	\$347.428	\$121.604	\$248.745	0.909	\$226.162	1
12			363	272	0	91	544	\$80.00	\$24.00	\$2.80	\$653.297	\$45.731	\$0.000	\$139.806	\$41.811	\$2.927	\$0.000	\$168.006	\$22.917	\$323.561	\$113.247	\$233.232	0.903	\$210.620	1
13			344	258	0	86	515	\$80.00	\$24.00	\$2.80	\$618.375	\$43.286	\$0.000	\$132.332	\$39.576	\$2.770	\$0.000	\$159.025	\$22.917	\$305.040	\$106.764	\$221.193	0.897	\$198.395	1
14			325	244	0	81	488	\$80.00	\$24.00	\$2.80	\$585.319	\$40.972	\$0.000	\$125.258	\$37.460	\$2.622	\$0.000	\$150.525	\$22.917	\$287.509	\$100.628	\$209.798	0.891	\$186.900	1
15			308	231	0	77	462	\$80.00	\$24.00	\$2.80	\$554.031	\$38.782	\$0.000	\$118.563	\$35.458	\$2.482	\$0.000	\$142.478	\$22.917	\$270.915	\$94.820	\$199.012	0.885	\$176.090	1
16			291	219	0	73	437	\$80.00	\$24.00	\$2.80	\$524.415	\$36.709	\$0.000	\$112.225	\$33.563	\$2.349	\$0.000	\$134.862	\$22.917	\$255.208	\$89.323	\$188.802	0.879	\$165.924	1
17			276	207	0	69	414	\$80.00	\$24.00	\$2.80	\$496.382	\$34.747	\$0.000	\$106.226	\$31.768	\$2.224	\$0.000	\$127.653	\$22.917	\$240.341	\$84.119	\$179.138	0.873	\$156.365	1
18			261	196	0	65	392	\$80.00	\$24.00	\$2.80	\$469.848	\$32.889	\$0.000	\$100.547	\$30.070	\$2.105	\$0.000	\$120.829	\$22.917	\$226.269	\$79.194	\$169.991	0.867	\$147.375	1
19			247	185	0	62	371	\$80.00	\$24.00	\$2.80	\$444.732	\$31.131	\$0.000	\$95.173	\$28.463	\$1.992	\$0.000	\$114.370	\$22.917	\$212.948	\$74.532	\$161.333	0.861	\$138.921	1
20			234	175	0	58	351	\$80.00	\$24.00	\$2.80	\$420.959	\$29.467	\$0.000	\$90.085	\$26.941	\$1.886	\$0.000	\$108.257	\$22.917	\$200.340	\$70.119	\$153.138	0.855	\$130.971	1
21			221	166	0	55	332	\$80.00	\$24.00	\$2.80	\$398.456	\$27.892	\$0.000	\$85.270	\$25.501	\$1.785	\$0.000	\$102.470	\$22.917	\$188.406	\$65.942	\$145.380	0.849	\$123.494	1
22			210	157	0	52	314	\$80.00	\$24.00	\$2.80	\$377.156	\$26.401	\$0.000	\$80.711	\$24.138	\$1.690	\$0.000	\$96.992	\$22.917	\$177.110	\$61.988	\$138.038	0.844	\$116.463	1
23			198	149	0	50	297	\$80.00	\$24.00	\$2.80	\$356.995	\$24.990	\$0.000	\$76.397	\$22.848	\$1.599	\$0.000	\$91.807	\$22.917	\$166.417	\$58.246	\$131.088	0.838	\$109.849	1
24			188	141	0	47	282	\$80.00	\$24.00	\$2.80	\$337.912	\$23.654	\$0.000	\$72.313	\$21.626	\$1.514	\$0.000	\$86.900	\$22.917	\$156.296	\$54.704	\$124.509	0.832	\$103.630	1
25			176	132	0	44	263	\$80.00	\$24.00	\$2.80	\$316.094	\$22.127	\$0.000	\$67.644	\$20.230	\$1.416	\$0.000	\$81.289	\$22.917	\$144.725	\$50.654	\$116.988	0.827	\$96.710	1
26			164	123	0	41	246	\$80.00	\$24.00	\$2.80	\$295.685	\$20.698	\$0.000	\$63.277	\$18.924	\$1.325	\$0.000	\$76.040	\$22.917	\$133.901	\$46.865	\$109.952	0.821	\$90.278	1
27			154	115	0	38	230	\$80.00	\$24.00	\$2.80	\$276.593	\$19.362	\$0.000	\$59.191	\$17.702	\$1.239	\$0.000	\$71.131	\$22.917	\$123.775	\$43.321	\$103.371	0.816	\$84.299	1
28			144	108	0	36	216	\$80.00	\$24.00	\$2.80	\$258.734	\$18.111	\$0.000	\$55.369	\$16.559	\$1.159	\$0.000	\$66.538	\$22.917	\$114.304	\$40.006	\$97.214	0.810	\$78.741	1
29			134	101	0	34	202	\$80.00	\$24.00	\$2.80	\$242.028	\$16.942	\$0.000	\$51.794	\$15.490	\$1.084	\$0.000	\$62.242	\$22.917	\$105.444	\$36.905	\$91.455	0.804	\$73.575	1
30			126	94	0	31	189	\$80.00	\$24.00	\$2.80	\$226.401	\$15.848	\$0.000	\$48.450	\$14.490	\$1.014	\$0.000	\$58.223	\$22.917	\$97.156	\$34.005	\$86.068	0.799	\$68.772	1
31			118	88	0	29	176	\$80.00	\$24.00	\$2.80	\$211.783	\$14.825	\$0.000	\$45.322	\$13.554	\$0.949	\$0.000	\$54.464	\$22.917	\$89.403	\$31.291	\$81.029	0.794	\$64.306	1
32			110	83	0	28	165	\$80.00	\$24.00	\$2.80	\$198.109	\$13.868	\$0.000	\$42.395	\$12.679	\$0.888	\$0.000	\$50.947	\$22.917	\$82.151	\$28.753	\$76.315	0.788	\$60.155	1
33			103	77	0	26	154	\$80.00	\$24.00	\$2.80	\$185.317	\$12.972	\$0.000	\$39.658	\$11.860	\$0.830	\$0.000	\$47.657	\$22.917	\$75.367	\$26.378	\$71.905	0.783	\$56.295	1
34			96	72	0	24	144	\$80.00	\$24.00	\$2.80	\$173.352	\$12.135	\$0.000	\$37.097	\$11.095	\$0.777	\$0.000	\$44.580	\$22.917	\$69.021	\$24.157	\$67.780	0.778	\$52.706	1
35																									

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

SW PA Wet Gas

Appalachia Basin: SW PA Wet Gas			My Assumptions:		
Basin Characteristics			Average Well		
\$5.90 cost/well (\$mm)	IP	EUR	100%	oilfield service & supply factor price scalar	
878 EUR/well (mboe)	2,485	2,933	30	days/month	
-63% 1st yr decline	-8.0%	917	-0.70%	exponential decline rate after year 3 (monthly)	
-27% 2nd yr decline	-2.6%	667	\$100.00	oil price WTI (\$/bbl)	
-34% 3rd yr decline	-3.4%	542	0%	oil price appreciation (per month)	
744 IP rate (boe/d)			\$3.50	gas price Henry Hub (\$/mcf)	
\$7.00 opex-LOE (\$/boe)			0%	gas price appreciation	
27% oil			30%	NGL price/oil price (fixed ratio)	
49% gas			0.68%	discount rate (compound monthly)	
50% NGL			8.5%	discount rate (annual)	
20.0% royalty rate			80%	intangibile drilling cost / total capex	
3.0% oil prod tax			0.847	IP/EUR ratio, (B8/B4 = fixed ratio)	
3.0% gas prod tax					
3.0% NGL prod tax					
35.0% income tax rate					
-10% oil differential					
-14% gas differential					
0 1 = DUC					
25% auxiliary cost/well cost					
50% completion cost/well cost					
\$2,000 min opex (\$/month)					

Appalachia Basin: SW PA Wet Gas					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	5,642	4,780	2,800	2,372	
\$25	4,451	3,771	2,209	1,872	
\$30	3,675	3,114	1,824	1,545	
\$35	3,129	2,651	1,553	1,316	
\$40	2,725	2,309	1,352	1,145	
\$45	2,413	2,044	1,198	1,015	
\$50	2,165	1,834	1,075	911	
\$60	1,796	1,522	891	755	
\$70	1,534	1,300	762	646	
\$80	1,339	1,134	665	563	
\$90	1,188	1,007	590	500	
\$100	1,068	905	530	449	

Appalachia Basin: SW PA Wet Gas					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20		0		0	
\$25	33,191	28,121	16,475	13,959	
\$30	15,197	12,876	7,543	6,391	
\$35	9,855	8,350	4,891	4,144	
\$40	7,291	6,177	3,619	3,066	
\$45	5,786	4,902	2,872	2,433	
\$50	4,796	4,063	2,381	2,017	
\$60	3,573	3,027	1,774	1,503	
\$70	2,847	2,412	1,413	1,197	
\$80	2,367	2,005	1,175	996	
\$90	2,025	1,716	1,005	851	
\$100	1,769	1,499	878	744	

Results					
-50.873 = NPV/well (\$ million)					
0 = EUR check (mboe)					
0.38% = ATIRR (monthly)					
4.71% = ATIRR (annual)					
878 = total production (mboe)					
\$2.623 = "tail end" NPV/well (\$ million)					
100% = "tail end" recovery factor					
0 = months of lost production					

Per Well Net Cash Flow Analysis																									
Capex (\$1,000s)			Production (boe/d)				mcf/d			Prices				Cash Flows (\$1,000)											
Month	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax	NCF	PV Factor	ATNPV	Active
1	\$1,475	\$369						\$90.00	\$27.00	\$3.00	\$40.178	\$196.837	\$301.331	\$107.67	\$0.96	\$4.72	\$7.23	\$156.246	\$12.292	\$249.219	\$87.227	\$174.284	0.973	\$169.608	1
2	\$1,475	\$369						\$90.00	\$27.00	\$3.00	\$36.975	\$181.145	\$277.309	\$99.086	\$0.887	\$4.347	\$6.655	\$143.790	\$12.292	\$228.371	\$79.930	\$160.733	0.967	\$155.361	1
3	\$1,475	\$369						\$90.00	\$27.00	\$3.00	\$34.027	\$166.705	\$255.203	\$91.187	\$0.817	\$4.001	\$6.125	\$132.327	\$12.292	\$209.186	\$73.215	\$148.263	0.960	\$142.327	1
4	\$1,475	\$369						\$90.00	\$27.00	\$3.00	\$31.314	\$153.415	\$234.858	\$83.917	\$0.752	\$3.682	\$5.637	\$121.778	\$12.292	\$191.530	\$67.035	\$136.786	0.954	\$130.439	1
5			744	15	372	365	2,187	\$90.00	\$27.00	\$3.00	\$28.818	\$141.185	\$216.135	\$77.228	\$0.692	\$3.388	\$5.187	\$112.070	\$12.292	\$175.281	\$61.348	\$126.225	0.947	\$119.543	1
6			685	14	342	336	1,329	\$90.00	\$27.00	\$3.00	\$26.521	\$129.930	\$198.905	\$71.071	\$0.636	\$3.118	\$4.774	\$103.136	\$12.292	\$160.328	\$56.115	\$116.505	0.941	\$109.590	1
7			630	13	315	309	1,223	\$90.00	\$27.00	\$3.00	\$24.406	\$119.572	\$183.048	\$65.405	\$0.586	\$2.870	\$4.393	\$94.914	\$12.292	\$146.567	\$51.298	\$107.560	0.934	\$100.491	1
8			580	12	290	284	1,125	\$90.00	\$27.00	\$3.00	\$22.461	\$110.039	\$168.456	\$60.191	\$0.539	\$2.641	\$4.043	\$87.347	\$12.292	\$133.903	\$46.866	\$99.329	0.928	\$92.171	1
9			534	11	267	261	1,036	\$90.00	\$27.00	\$3.00	\$20.670	\$101.267	\$155.027	\$55.393	\$0.496	\$2.430	\$3.721	\$80.384	\$12.292	\$122.248	\$42.787	\$91.753	0.922	\$84.565	1
10			491	10	246	241	953	\$90.00	\$27.00	\$3.00	\$19.022	\$93.194	\$142.668	\$50.977	\$0.457	\$2.237	\$3.424	\$73.976	\$12.292	\$111.523	\$39.033	\$84.782	0.915	\$77.610	1
11			452	9	226	221	877	\$90.00	\$27.00	\$3.00	\$17.506	\$85.765	\$131.295	\$46.913	\$0.420	\$2.058	\$3.151	\$68.079	\$12.292	\$101.652	\$35.578	\$78.366	0.909	\$71.251	1
12			416	8	208	204	804	\$90.00	\$27.00	\$3.00	\$16.110	\$78.928	\$120.828	\$43.173	\$0.387	\$1.894	\$2.900	\$62.651	\$12.292	\$92.569	\$32.399	\$72.461	0.903	\$65.436	1
13			383	8	191	188	742	\$90.00	\$27.00	\$3.00	\$15.689	\$76.862	\$117.665	\$42.043	\$0.377	\$1.845	\$2.824	\$61.011	\$12.292	\$89.824	\$31.438	\$70.677	0.897	\$63.393	1
14			352	7	176	173	682	\$90.00	\$27.00	\$3.00	\$15.278	\$74.850	\$114.585	\$40.942	\$0.367	\$1.796	\$2.750	\$59.414	\$12.292	\$87.151	\$30.503	\$68.940	0.891	\$61.415	1
15			324	6	162	159	626	\$90.00	\$27.00	\$3.00	\$14.878	\$72.890	\$111.585	\$39.871	\$0.357	\$1.749	\$2.678	\$57.859	\$12.292	\$84.548	\$29.592	\$67.248	0.885	\$59.502	1
16			298	6	149	146	574	\$90.00	\$27.00	\$3.00	\$14.489	\$70.982	\$108.664	\$38.827	\$0.348	\$1.704	\$2.608	\$56.344	\$12.292	\$82.012	\$28.704	\$65.600	0.879	\$57.651	1
17			291	6	145	142	524	\$90.00	\$27.00	\$3.00	\$14.109	\$69.124	\$105.819	\$37.811	\$0.339	\$1.659	\$2.540	\$54.869	\$12.292	\$79.544	\$27.840	\$63.995	0.873	\$55.860	1
18			283	6	141	139	474	\$90.00	\$27.00	\$3.00	\$13.740	\$67.314	\$103.049	\$36.821	\$0.330	\$1.616	\$2.473	\$53.433	\$12.292	\$77.140	\$26.999	\$62.433	0.867	\$54.126	1
19			261	5	131	128	424	\$90.00	\$27.00	\$3.00	\$13.380	\$65.552	\$100.352	\$35.857	\$0.321	\$1.573	\$2.408	\$52.034	\$12.292	\$74.799	\$26.180	\$60.911	0.861	\$52.449	1
20			268	5	134	131	374	\$90.00	\$27.00	\$3.00	\$13.030	\$63.836	\$97.725	\$34.918	\$0.313	\$1.532	\$2.345	\$50.672	\$12.292	\$72.519	\$25.382	\$59.429	0.855	\$50.827	1
21			261	5	131	128	324	\$90.00	\$27.00	\$3.00	\$12.689	\$62.165	\$95.167	\$34.004	\$0.305	\$1.492	\$2.284	\$49.346	\$12.292	\$70.299	\$24.605	\$57.986	0.849	\$49.256	1
22			254	5	127	125	274	\$90.00	\$27.00	\$3.00	\$12.357	\$60.538	\$92.675	\$33.114	\$0.297	\$1.453	\$2.224	\$48.054	\$12.292	\$68.137	\$23.848	\$56.580	0.844	\$47.737	1
23			248	5	124	121	224	\$90.00	\$27.00	\$3.00	\$12.033	\$58.953	\$90.249	\$32.247	\$0.289	\$1.415	\$2.166	\$46.796	\$12.292	\$66.031	\$23.111	\$55.212	0.838	\$46.267	1
24			241	5	121	118	174	\$90.00	\$27.00	\$3.00	\$11.718	\$57.410	\$87.887	\$31.403	\$0.281	\$1.378	\$2.109	\$45.571	\$12.292	\$63.981	\$22.393	\$53.879	0.832	\$44.844	1
25			235	5	117	115	124	\$90.00	\$27.00	\$3.00	\$11.320	\$55.458	\$84.899	\$30.335	\$0.272	\$1.331	\$2.038	\$44.022	\$12.292	\$61.388	\$21.486	\$52.194	0.827	\$43.147	1
26			229	5	114	112	74	\$90.00	\$27.00	\$3.00	\$10.935	\$53.573	\$82.013	\$29.304	\$0.262	\$1.286	\$1.968	\$42.525	\$12.292	\$58.883	\$20.609	\$50.566	0.821	\$41.518	1
27			223	4	111	109	24	\$90.00	\$27.00	\$3.00	\$10.563	\$51.751	\$79.225	\$28.308	\$0.254	\$1.242	\$1.901	\$41.079	\$12.292	\$56.463	\$19.762	\$48.993	0.816	\$39.954	1
28			217	4	109	106	24	\$90.00	\$27.00	\$3.00	\$10.204	\$49.992	\$76.531	\$27.346	\$0.245	\$1.200	\$1.837	\$39.683	\$12.292	\$54.126	\$18.944	\$47.474	0.810	\$38.453	1
29			210	4	105	103	24	\$90.00	\$27.00	\$3.00	\$9.857	\$48.293	\$73.930	\$26.416	\$0.237	\$1.159	\$1.774	\$38.334	\$12.292	\$51.868	\$18.154	\$46.006	0.804	\$37.011	1
30			203	4	101	99	24	\$90.00	\$27.00	\$3.00	\$9.522	\$46.651	\$71.416	\$25.518	\$0.229	\$1.120	\$1.714	\$37.031	\$12.292	\$49.687	\$17.390	\$44.588	0.799	\$35.628	1
31			196	4	98	96	24	\$90.00	\$27.00	\$3.00	\$9.198	\$45.065	\$68.988	\$24.650	\$0.221	\$1.082	\$1.656	\$35.772	\$12.292	\$47.580	\$16.653	\$43.219	0.794	\$34.299	1
32			189	4	94	93	24	\$90.00	\$27.00	\$3.00	\$8.886	\$43.533	\$66.643	\$23.812	\$0.213	\$1.045	\$1.599	\$34.556	\$12.292	\$45.545	\$15.941	\$41.896	0.788	\$33.024	1
33			183	4	91	89	24	\$90.00	\$27.00	\$3.00	\$8.584	\$42.053	\$64.377	\$23.003	\$0.206	\$1.009	\$1.545	\$33.381	\$12.292	\$43.578	\$15.252	\$40.618	0.783	\$31.800	1
34			176	4	88	86	24	\$90.00	\$27.00	\$3.00	\$8.292	\$40.623	\$62.189	\$22.221	\$0.199	\$0.975	\$1.493	\$32.246	\$12.292	\$41.679	\$14.588	\$39.383	0.778	\$30.624	1
35			170	3	85	83	24	\$90.00	\$27.00	\$3.00	\$8.010	\$39.242	\$60.075	\$21.465	\$0.192	\$0.942	\$1.442	\$31.150	\$12.292	\$39.844	\$13.945	\$38.190	0.772	\$29.496	1
36			165	3	82	81	24	\$90.00	\$27.00	\$3.00	\$7.738	\$37.908	\$58.032	\$20.736	\$0.186	\$0.910	\$1.393	\$30.091	\$12.292	\$38.072	\$13.325	\$37.038	0.767	\$28.412	1
37			159	3	79	78	24																		

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

SW PA Super Rich

Appalachia Basin: SW PA Super Rich				My Assumptions:			
Basin Characteristics		Average Well		100%		oilfield service & supply factor price scalar	
\$5.90 cost/well (\$mm)		IP	EUR	30	days/month		
684 EUR/well (mboe)		1,536	2,150	-0.67%	exponential decline rate after year 3 (monthly)		
-55% 1st yr decline	-6.5%	688		\$100.00	oil price WTI (\$/bbl)		
-29% 2nd yr decline	-2.8%	488		0%	oil price appreciation (per month)		
-33% 3rd yr decline	-3.3%	400		\$3.50	gas price Henry Hub (\$/mcf)		
489 IP rate (boe/d)				0%	gas price appreciation		
\$7.00 opex-LOE (\$/boe)				30%	NGL price/oil price (fixed ratio)		
8% oil				0.68%	discount rate (compound monthly)		
46% gas				8.5%	discount rate (annual)		
46% NGL				80%	intangible drilling cost / total capex		
20.0% royalty rate				0.714	IP/EUR ratio, (B8/B4 = fixed ratio)		
3.0% oil prod tax							
3.0% gas prod tax							
3.0% NGL prod tax							
35.0% income tax rate							
-10% oil differential							
-14% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							
				Results			
				-\$1.062 = NPV/well (\$ million)			
				0 = EUR check (mboe)			
				0.33% = ATRR (monthly)			
				4.08% = ATRR (annual)			
				684 = total production (mboe)			
				\$2.609 = "tail end" NPV/well (\$ million)			
				100% = "tail end" recovery factor			
				0 = months of lost production			

Appalachia Basin: SW PA Super Rich					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	5,180	3,701	2,571	1,837	
\$25	3,960	2,829	1,965	1,404	
\$30	3,205	2,290	1,591	1,137	
\$35	2,691	1,923	1,336	954	
\$40	2,320	1,657	1,151	822	
\$45	2,038	1,456	1,012	723	
\$50	1,818	1,299	902	644	
\$60	1,494	1,067	742	530	
\$70	1,269	907	630	450	
\$80	1,102	787	547	391	
\$90	974	696	484	346	
\$100	873	624	433	309	

Appalachia Basin: SW PA Super Rich					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	106,843	76,331	53,033	37,888	
\$25	18,483	13,205	9,174	6,554	
\$30	10,116	7,227	5,021	3,587	
\$35	6,964	4,975	3,457	2,470	
\$40	5,309	3,793	2,635	1,882	
\$45	4,290	3,065	2,130	1,522	
\$50	3,599	2,571	1,787	1,277	
\$60	2,722	1,945	1,351	965	
\$70	2,189	1,564	1,087	777	
\$80	1,830	1,307	909	649	
\$90	1,573	1,124	781	558	
\$100	1,379	985	684	489	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)				AT NPV -\$1.062	Active 1/0								
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty			Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax	NCF
1	1475	\$369						\$90.00	\$27.00	\$3.00	\$105.607	\$121.428	\$182.173	\$81.84	\$2.53	\$2.91	\$4.37	\$102.674	12.2916667	\$202.580	70.903007	\$143.969	0.973	140.10644	1
2	1475	\$369						\$90.00	\$27.00	\$3.00	\$98.770	\$113.567	\$170.379	\$76.543	\$2.370	\$2.726	\$4.089	\$96.027	\$12.292	\$188.670	\$66.034	\$134.927	0.967	\$130.418	1
3	1475	\$369						\$90.00	\$27.00	\$3.00	\$92.376	\$106.215	\$159.349	\$71.588	\$2.217	\$2.549	\$3.824	\$89.810	\$12.292	\$175.660	\$61.481	\$126.470	0.960	\$121.416	1
4	1475	\$369						\$90.00	\$27.00	\$3.00	\$86.396	\$99.339	\$149.033	\$66.954	\$2.074	\$2.384	\$3.577	\$83.996	\$12.292	\$163.492	\$57.222	\$118.561	0.954	\$113.051	1
5			489	39	225	225	1,349	\$90.00	\$27.00	\$3.00	\$80.803	\$92.908	\$139.385	\$62.619	\$1.939	\$2.230	\$3.345	\$78.558	\$12.292	\$152.112	\$53.239	\$111.164	0.947	\$105.280	1
6			457	37	210	210	1,262	\$90.00	\$27.00	\$3.00	\$75.572	\$86.893	\$130.361	\$58.565	\$1.814	\$2.085	\$3.129	\$73.473	\$12.292	\$141.469	\$49.514	\$104.246	0.941	\$98.059	1
7			428	34	197	197	1,180	\$90.00	\$27.00	\$3.00	\$70.679	\$81.268	\$121.922	\$54.774	\$1.696	\$1.950	\$2.926	\$68.716	\$12.292	\$131.515	\$46.030	\$97.776	0.934	\$91.350	1
8			400	32	184	184	1,104	\$90.00	\$27.00	\$3.00	\$66.104	\$76.007	\$114.029	\$51.228	\$1.586	\$1.824	\$2.737	\$64.267	\$12.292	\$122.205	\$42.772	\$91.725	0.928	\$85.116	1
9			374	30	172	172	1,032	\$90.00	\$27.00	\$3.00	\$61.824	\$71.086	\$106.647	\$47.911	\$1.484	\$1.706	\$2.560	\$60.107	\$12.292	\$113.498	\$39.724	\$86.065	0.922	\$79.323	1
10			350	28	161	161	966	\$90.00	\$27.00	\$3.00	\$57.822	\$66.484	\$99.743	\$44.810	\$1.388	\$1.596	\$2.394	\$56.216	\$12.292	\$105.354	\$36.874	\$80.772	0.915	\$73.940	1
11			327	26	151	151	903	\$90.00	\$27.00	\$3.00	\$54.079	\$62.180	\$93.285	\$41.909	\$1.298	\$1.492	\$2.239	\$52.576	\$12.292	\$97.738	\$34.208	\$75.821	0.909	\$68.938	1
12			306	24	141	141	845	\$90.00	\$27.00	\$3.00	\$50.578	\$58.155	\$87.246	\$39.196	\$1.214	\$1.396	\$2.094	\$49.173	\$12.292	\$90.615	\$31.715	\$71.191	0.903	\$64.290	1
13			286	23	132	132	790	\$90.00	\$27.00	\$3.00	\$49.150	\$56.514	\$84.784	\$38.090	\$1.180	\$1.356	\$2.035	\$47.785	\$12.292	\$87.711	\$30.699	\$69.304	0.897	\$62.161	1
14			268	21	123	123	739	\$90.00	\$27.00	\$3.00	\$47.764	\$54.919	\$82.392	\$37.015	\$1.146	\$1.318	\$1.977	\$46.437	\$12.292	\$84.889	\$29.711	\$67.470	0.891	\$60.106	1
15			250	20	115	115	691	\$90.00	\$27.00	\$3.00	\$46.416	\$53.369	\$80.067	\$35.970	\$1.114	\$1.281	\$1.922	\$45.126	\$12.292	\$82.147	\$28.752	\$65.687	0.885	\$58.122	1
16			234	19	108	108	646	\$90.00	\$27.00	\$3.00	\$45.106	\$51.863	\$77.808	\$34.955	\$1.083	\$1.245	\$1.867	\$43.853	\$12.292	\$79.482	\$27.819	\$63.955	0.879	\$56.206	1
17			228	18	105	105	628	\$90.00	\$27.00	\$3.00	\$43.833	\$50.400	\$75.612	\$33.969	\$1.052	\$1.210	\$1.815	\$42.616	\$12.292	\$76.893	\$26.913	\$62.272	0.873	\$54.356	1
18			221	18	102	102	610	\$90.00	\$27.00	\$3.00	\$42.596	\$48.978	\$73.479	\$33.011	\$1.022	\$1.175	\$1.763	\$41.413	\$12.292	\$74.376	\$26.032	\$60.636	0.867	\$52.569	1
19			215	17	99	99	593	\$90.00	\$27.00	\$3.00	\$41.395	\$47.596	\$71.406	\$32.079	\$0.993	\$1.142	\$1.714	\$40.245	\$12.292	\$71.931	\$25.176	\$59.047	0.861	\$50.844	1
20			209	17	96	96	576	\$90.00	\$27.00	\$3.00	\$40.227	\$46.253	\$69.391	\$31.174	\$0.965	\$1.110	\$1.665	\$39.109	\$12.292	\$69.554	\$24.344	\$57.502	0.855	\$49.179	1
21			203	16	93	93	560	\$90.00	\$27.00	\$3.00	\$39.091	\$44.948	\$67.433	\$30.294	\$0.938	\$1.079	\$1.618	\$38.006	\$12.292	\$67.245	\$23.536	\$56.001	0.849	\$47.570	1
22			197	16	91	91	544	\$90.00	\$27.00	\$3.00	\$37.988	\$43.679	\$65.530	\$29.440	\$0.912	\$1.048	\$1.573	\$36.933	\$12.292	\$65.001	\$22.750	\$54.542	0.844	\$46.017	1
23			192	15	88	88	529	\$90.00	\$27.00	\$3.00	\$36.916	\$42.447	\$63.681	\$28.609	\$0.886	\$1.019	\$1.528	\$35.891	\$12.292	\$62.820	\$21.987	\$53.124	0.838	\$44.517	1
24			186	15	86	86	514	\$90.00	\$27.00	\$3.00	\$35.875	\$41.249	\$61.884	\$27.802	\$0.861	\$0.990	\$1.485	\$34.878	\$12.292	\$60.700	\$21.245	\$51.747	0.832	\$43.069	1
25			181	14	83	83	500	\$90.00	\$27.00	\$3.00	\$34.705	\$39.904	\$59.867	\$26.895	\$0.833	\$0.958	\$1.437	\$33.741	\$12.292	\$58.321	\$20.412	\$50.200	0.827	\$41.499	1
26			176	14	81	81	485	\$90.00	\$27.00	\$3.00	\$33.574	\$38.604	\$57.915	\$26.019	\$0.806	\$0.926	\$1.390	\$32.641	\$12.292	\$56.019	\$19.607	\$48.704	0.821	\$39.989	1
27			171	14	79	79	472	\$90.00	\$27.00	\$3.00	\$32.480	\$37.345	\$56.027	\$25.170	\$0.780	\$0.896	\$1.345	\$31.577	\$12.292	\$53.792	\$18.827	\$47.257	0.816	\$38.538	1
28			166	13	76	76	458	\$90.00	\$27.00	\$3.00	\$31.421	\$36.128	\$54.201	\$24.350	\$0.754	\$0.867	\$1.301	\$30.548	\$12.292	\$51.638	\$18.073	\$45.856	0.810	\$37.143	1
29			161	13	74	74	443	\$90.00	\$27.00	\$3.00	\$30.396	\$34.950	\$52.434	\$23.556	\$0.730	\$0.839	\$1.258	\$29.552	\$12.292	\$49.554	\$17.344	\$44.502	0.804	\$35.801	1
30			155	12	72	72	429	\$90.00	\$27.00	\$3.00	\$29.406	\$33.811	\$50.725	\$22.788	\$0.706	\$0.811	\$1.217	\$28.589	\$12.292	\$47.538	\$16.638	\$43.191	0.799	\$34.511	1
31			150	12	69	69	415	\$90.00	\$27.00	\$3.00	\$28.447	\$32.709	\$49.071	\$22.045	\$0.683	\$0.785	\$1.178	\$27.657	\$12.292	\$45.587	\$15.956	\$41.923	0.794	\$33.272	1
32			145	11	65	65	388	\$90.00	\$27.00	\$3.00	\$27.520	\$31.642	\$47.471	\$21.327	\$0.660	\$0.759	\$1.139	\$26.755	\$12.292	\$43.701	\$15.295	\$40.697	0.788	\$32.079	1
33			141	11	63	63	376	\$90.00	\$27.00	\$3.00	\$26.623	\$30.611	\$45.924	\$20.631	\$0.639	\$0.735	\$1.102	\$25.883	\$12.292	\$41.875	\$14.656	\$39.511	0.783	\$30.933	1
34			136	11	61	61	363	\$90.00	\$27.00	\$3.00	\$25.755	\$29.613	\$44.427	\$19.959	\$0.618	\$0.711	\$1.066	\$25.039	\$12.292	\$40.110	\$14.038	\$38.363	0.778	\$29.831	1
35			132	11	61	61	353	\$90.00	\$27.00	\$3.00	\$24.915	\$28.648	\$42.979	\$19.308	\$0.598	\$0.688	\$1.031	\$24.223	\$12.292	\$38.401					

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Utica Wet Gas

Appalachia Basin: Utica Wet Gas				My Assumptions:			
Basin Characteristics		Average Well		100% oilfield service & supply factor price scalar			
\$10.25 cost/well (\$mm)	IP	EUR	EUR	30	days/month		
1,695 EUR/well (mboe)	3,000	3,000	-1.41%	exponential decline rate after year 3 (monthly)			
-46% 1st yr decline	-5.0%	1625	\$100.00	oil price WTI (\$/bbl)			
-38% 2nd yr decline	-4.0%	1000	0%	oil price appreciation (per month)			
-36% 3rd yr decline	-3.7%	800	\$3.50	gas price Henry Hub (\$/mcf)			
1,695 IP rate (boe/d)			0%	gas price appreciation			
\$8.00 opex-LOE (\$/boe)			30%	NGL price/oil price (fixed ratio)			
3% oil			0.68%	discount rate (compound monthly)			
67% gas			8.5%	discount rate (annual)			
30% NGL			80%	intangibile drilling cost / total capex			
20.0% royalty rate			1.000	IP/EUR ratio, (B8/B4 = fixed ratio)			
3.0% oil prod tax							
3.0% gas prod tax							
3.0% NGL prod tax							
35.0% income tax rate							
-10% oil differential							
-14% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Results	
-50.806	= NPV/well (\$ million)
0	= EUR check (mboe)
0.46%	= ATIRR (monthly)
5.66%	= ATIRR (annual)
1,695	= total production (mboe)
\$3.894	= "tail end" NPV/well (\$ million)
100%	= "tail end" recovery factor
0	= months of lost production

Appalachia Basin: Utica Wet Gas					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle		DUC		IP
	EUR	IP	EUR	IP	
\$20	6,006	6,006	2,981	2,981	
\$25	5,277	5,277	2,619	2,619	
\$30	4,706	4,706	2,336	2,336	
\$35	4,246	4,246	2,108	2,108	
\$40	3,868	3,868	1,921	1,921	
\$45	3,552	3,552	1,764	1,764	
\$50	3,284	3,284	1,631	1,631	
\$60	2,853	2,853	1,417	1,417	
\$70	2,522	2,522	1,253	1,253	
\$80	2,260	2,260	1,123	1,123	
\$90	2,047	2,047	1,017	1,017	
\$100	1,871	1,871	930	930	

Appalachia Basin: Utica Wet Gas					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle		DUC		IP
	EUR	IP	EUR	IP	
\$20	61,623	61,623	30,587	30,587	
\$25	29,830	29,830	14,806	14,806	
\$30	19,678	19,678	9,767	9,767	
\$35	14,681	14,681	7,287	7,287	
\$40	11,708	11,708	5,811	5,811	
\$45	9,736	9,736	4,833	4,833	
\$50	8,333	8,333	4,136	4,136	
\$60	6,469	6,469	3,211	3,211	
\$70	5,286	5,286	2,624	2,624	
\$80	4,469	4,469	2,218	2,218	
\$90	3,870	3,870	1,921	1,921	
\$100	3,413	3,413	1,695	1,695	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)								AT NPV -\$806	Active 1/0				
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex			Depreciation	Tax. Inc.	Income Tax	NCF
1	\$2,563	\$641					6,812	\$90.00	\$27.00	\$3.00	\$137.257	\$612.977	\$411.770	\$232.40	\$3.29	\$14.71	\$9.88	\$406.686	\$21.354	\$473.674	\$165.786	\$329.243	0.973	\$320.410	1
2	\$2,563	\$641					6,473	\$90.00	\$27.00	\$3.00	\$130.420	\$582.446	\$391.260	\$220.825	\$3.130	\$13.979	\$9.390	\$386.430	\$21.354	\$449.018	\$157.156	\$313.216	0.967	\$302.748	1
3	\$2,563	\$641					6,150	\$90.00	\$27.00	\$3.00	\$123.924	\$553.435	\$371.772	\$209.826	\$2.974	\$13.282	\$8.923	\$367.182	\$21.354	\$425.589	\$148.956	\$297.987	0.960	\$286.077	1
4	\$2,563	\$641					5,844	\$90.00	\$27.00	\$3.00	\$117.751	\$525.869	\$353.254	\$199.375	\$2.826	\$12.621	\$8.478	\$348.893	\$21.354	\$403.327	\$141.165	\$283.517	0.954	\$270.341	1
5			1695	51	508	1135	6,812	\$90.00	\$27.00	\$3.00	\$111.886	\$499.676	\$335.659	\$189.444	\$2.685	\$11.992	\$8.056	\$331.515	\$21.354	\$382.174	\$133.761	\$269.768	0.947	\$255.488	1
6			1610	48	483	1079	6,473	\$90.00	\$27.00	\$3.00	\$106.313	\$474.788	\$318.940	\$180.008	\$2.552	\$11.395	\$7.655	\$315.003	\$21.354	\$362.075	\$126.726	\$256.703	0.941	\$241.467	1
7			1530	46	459	1025	6,150	\$90.00	\$27.00	\$3.00	\$101.018	\$451.139	\$303.054	\$171.042	\$2.424	\$10.827	\$7.273	\$299.313	\$21.354	\$342.977	\$120.042	\$244.289	0.934	\$228.234	1
8			1454	44	436	974	5,844	\$90.00	\$27.00	\$3.00	\$95.987	\$428.668	\$287.960	\$162.523	\$2.304	\$10.288	\$6.911	\$284.405	\$21.354	\$324.830	\$113.691	\$232.494	0.928	\$215.742	1
9			1381	41	414	925	5,553	\$90.00	\$27.00	\$3.00	\$91.206	\$407.317	\$273.617	\$154.428	\$2.189	\$9.776	\$6.567	\$270.239	\$21.354	\$307.587	\$107.655	\$221.286	0.922	\$203.950	1
10			1313	39	394	879	5,276	\$90.00	\$27.00	\$3.00	\$86.663	\$387.029	\$259.988	\$146.736	\$2.080	\$9.289	\$6.240	\$256.778	\$21.354	\$291.203	\$101.921	\$210.636	0.915	\$192.819	1
11			1247	37	374	836	5,013	\$90.00	\$27.00	\$3.00	\$82.346	\$367.751	\$247.038	\$139.427	\$1.976	\$8.826	\$5.929	\$243.989	\$21.354	\$275.635	\$96.472	\$200.517	0.909	\$182.312	1
12			1185	36	356	794	4,764	\$90.00	\$27.00	\$3.00	\$78.245	\$349.434	\$234.734	\$132.483	\$1.878	\$8.386	\$5.634	\$231.836	\$21.354	\$260.842	\$91.295	\$190.902	0.903	\$172.394	1
13			1126	34	338	754	4,526	\$90.00	\$27.00	\$3.00	\$75.142	\$335.579	\$225.426	\$127.229	\$1.803	\$8.054	\$5.410	\$222.643	\$21.354	\$249.653	\$87.378	\$183.628	0.897	\$164.703	1
14			1070	32	321	717	4,301	\$90.00	\$27.00	\$3.00	\$72.163	\$322.272	\$216.488	\$122.185	\$1.732	\$7.735	\$5.196	\$213.815	\$21.354	\$238.907	\$83.617	\$176.644	0.891	\$157.364	1
15			1017	30	305	681	4,087	\$90.00	\$27.00	\$3.00	\$69.301	\$309.494	\$207.904	\$117.340	\$1.663	\$7.428	\$4.990	\$205.337	\$21.354	\$228.587	\$80.005	\$169.936	0.885	\$150.363	1
16			966	29	290	647	3,883	\$90.00	\$27.00	\$3.00	\$66.553	\$297.222	\$199.660	\$112.687	\$1.597	\$7.133	\$4.792	\$197.195	\$21.354	\$218.677	\$76.537	\$163.494	0.879	\$143.683	1
17			928	28	278	622	3,729	\$90.00	\$27.00	\$3.00	\$63.914	\$285.437	\$191.743	\$108.219	\$1.534	\$6.850	\$4.602	\$189.376	\$21.354	\$209.159	\$73.206	\$157.308	0.873	\$137.309	1
18			891	27	267	597	3,581	\$90.00	\$27.00	\$3.00	\$61.380	\$274.119	\$184.140	\$103.928	\$1.473	\$6.579	\$4.419	\$181.867	\$21.354	\$200.019	\$70.007	\$151.366	0.867	\$131.228	1
19			856	26	257	573	3,439	\$90.00	\$27.00	\$3.00	\$58.946	\$263.250	\$176.839	\$99.807	\$1.415	\$6.318	\$4.244	\$174.656	\$21.354	\$191.241	\$66.934	\$145.661	0.861	\$125.426	1
20			822	25	246	551	3,303	\$90.00	\$27.00	\$3.00	\$56.609	\$252.811	\$169.827	\$95.849	\$1.359	\$6.067	\$4.076	\$167.730	\$21.354	\$182.811	\$63.984	\$140.182	0.855	\$119.890	1
21			789	24	237	529	3,172	\$90.00	\$27.00	\$3.00	\$54.364	\$242.787	\$163.093	\$92.409	\$1.305	\$5.827	\$3.914	\$161.080	\$21.354	\$174.716	\$61.151	\$134.920	0.849	\$114.608	1
22			758	23	227	508	3,046	\$90.00	\$27.00	\$3.00	\$52.209	\$233.160	\$156.626	\$88.399	\$1.253	\$5.596	\$3.759	\$154.693	\$21.354	\$166.941	\$58.430	\$129.866	0.844	\$109.568	1
23			728	22	218	488	2,925	\$90.00	\$27.00	\$3.00	\$50.139	\$223.915	\$150.416	\$84.894	\$1.203	\$5.374	\$3.610	\$148.559	\$21.354	\$159.475	\$55.816	\$125.013	0.838	\$104.759	1
24			699	21	210	468	2,809	\$90.00	\$27.00	\$3.00	\$48.151	\$215.036	\$144.452	\$81.528	\$1.156	\$5.161	\$3.467	\$142.668	\$21.354	\$152.305	\$53.307	\$120.352	0.832	\$100.170	1
25			671	20	201	450	2,698	\$90.00	\$27.00	\$3.00	\$46.393	\$207.186	\$139.178	\$78.551	\$1.113	\$4.972	\$3.340	\$137.460	\$21.354	\$145.965	\$51.088	\$116.232	0.827	\$96.085	1
26			645	19	193	432	2,591	\$90.00	\$27.00	\$3.00	\$44.699	\$199.622	\$134.097	\$75.684	\$1.073	\$4.791	\$3.218	\$132.441	\$21.354	\$139.857	\$48.950	\$112.261	0.821	\$92.174	1
27			619	19	186	415	2,488	\$90.00	\$27.00	\$3.00	\$43.067	\$192.334	\$129.201	\$72.921	\$1.034	\$4.616	\$3.101	\$127.606	\$21.354	\$133.971	\$46.890	\$108.436	0.816	\$88.430	1
28			594	18	178	398	2,390	\$90.00	\$27.00	\$3.00	\$41.495	\$185.313	\$124.485	\$70.258	\$0.996	\$4.448	\$2.988	\$122.948	\$21.354	\$128.301	\$44.905	\$104.750	0.810	\$84.845	1
29			573	17	172	384	2,302	\$90.00	\$27.00	\$3.00	\$39.980	\$178.547	\$119.940	\$67.693	\$0.960	\$4.285	\$2.879	\$118.459	\$21.354	\$122.837	\$42.993	\$101.198	0.804	\$81.413	1
30			552	17	166	370	2,218	\$90.00	\$27.00	\$3.00	\$38.520	\$172.029	\$115.561	\$65.222	\$0.924	\$4.129	\$2.773	\$114.135	\$21.354	\$117.573	\$41.151	\$97.777	0.799	\$78.128	1
31			532	16	160	356	2,137	\$90.00	\$27.00	\$3.00	\$37.114	\$165.749	\$111.342	\$62.841	\$0.891	\$3.978	\$2.672	\$109.968	\$21.354	\$112.501	\$39.375	\$94.480	0.794	\$74.982	1
32			512	15	154	343	2,059	\$90.00	\$27.00	\$3.00	\$35.759	\$159.698	\$107.278	\$60.547	\$0.858	\$3.833	\$2.575	\$105.953	\$21.354	\$107.615	\$37.665	\$91.304	0.788	\$71.970	1
33			494	15	148	331	1,984	\$90.00	\$27.00	\$3.00	\$34.454	\$153.868	\$103.361	\$58.336	\$0.827	\$3.693	\$2.481	\$102.085	\$21.354	\$102.906	\$36.017	\$88.243	0.783	\$69.086	1
34			476	14	143	319	1,912	\$90.00	\$27.00	\$3.00	\$33.196	\$148.250	\$99.588	\$56.207	\$0.797	\$3.558	\$2.390	\$98.358	\$21.354	\$98.370	\$34.429	\$85.295	0		

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Utica Condensate

Appalachia Basin: Utica Condensate				My Assumptions:			
Basin Characteristics				Average Well			
\$9.40 cost/well (\$mm)		IP	EUR	100%	oilfield service & supply factor price scalar		
533 EUR/well (mboe)		1,186	1,186	30	days/month		
-46% 1st yr decline	-5.0%			-1.47%	exponential decline rate after year 3 (monthly)		
-39% 2nd yr decline	-4.0%	640		\$100.00	oil price WTI (\$/bbl)		
-33% 3rd yr decline	-3.2%	390		0%	oil price appreciation (per month)		
533 IP rate (boe/d)		320		\$3.50	gas price Henry Hub (\$/mcf)		
\$8.00 opex-LOE (\$/boe)				0%	gas price appreciation		
28% oil				30%	NGL price/oil price (fixed ratio)		
48% gas				0.68%	discount rate (compound monthly)		
24% NGL				8.5%	discount rate (annual)		
20.0% royalty rate				80%	intangible drilling cost / total capex		
3.0% oil prod tax				1.000	IP/EUR ratio, (B8/B4 = fixed ratio)		
3.0% gas prod tax				Results			
3.0% NGL prod tax				-\$2.001 = NPV/well (\$ million)			
35.0% income tax rate				0 = EUR check (mboe)			
-10% oil differential				0.08% = ATIRR (monthly)			
-14% gas differential				0.91% = ATIRR (annual)			
0 = DUC				533 = total production (mboe)			
25% auxiliary cost/well cost				\$3.027 = "tail end" NPV/well (\$ million)			
50% completion cost/well cost				99% = "tail end" recovery factor			
\$2,000 min opex (\$/month)				46 = months of lost production			

Appalachia Basin: Utica Condensate					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	4,600	4,600	2,284	2,284	
\$25	3,434	3,434	1,705	1,705	
\$30	2,740	2,740	1,361	1,361	
\$35	2,279	2,279	1,132	1,132	
\$40	1,951	1,951	969	969	
\$45	1,706	1,706	848	848	
\$50	1,515	1,515	753	753	
\$60	1,239	1,239	616	616	
\$70	1,047	1,047	521	521	
\$80	907	907	451	451	
\$90	800	800	398	398	
\$100	716	716	356	356	

Appalachia Basin: Utica Condensate					
Sensitivity Results (2014 factor prices, G2-133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Price	Full Cycle			DUC	
	EUR	IP	EUR	IP	EUR
\$20	22,595	22,595	11,215	11,215	
\$25	10,025	10,025	4,976	4,976	
\$30	6,441	6,441	3,197	3,197	
\$35	4,745	4,745	2,355	2,355	
\$40	3,756	3,756	1,865	1,865	
\$45	3,108	3,108	1,543	1,543	
\$50	2,651	2,651	1,316	1,316	
\$60	2,048	2,048	1,017	1,017	
\$70	1,669	1,669	829	829	
\$80	1,408	1,408	700	700	
\$90	1,218	1,218	605	605	
\$100	1,073	1,073	533	533	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices			Cash Flows (\$1,000)										AT NPV -\$2,001	Active 1/0			
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation			Tax. Inc.	Income Tax	NCF
1	\$2,350	\$588						\$90.00	\$27.00	\$3.00									\$2,350.00	-\$2,350.00	-\$822.500	-2,115	1.000	-\$2,115.00	
2	\$2,350	\$588						\$90.00	\$27.00	\$3.00									\$2,350.00	-\$2,350.00	-\$822.500	-2,115	0.993	-\$2,100.67	
3	\$2,350	\$588						\$90.00	\$27.00	\$3.00									\$2,350.00	-\$2,350.00	-\$822.500	-2,115	0.986	-\$2,086.44	
4	\$2,350	\$588						\$90.00	\$27.00	\$3.00									\$2,350.00	-\$2,350.00	-\$822.500	-2,115	0.980	-\$2,072.30	
5			533	149	128	256	1,536	\$90.00	\$27.00	\$3.00	\$403.182	\$138.211	\$103.675	\$129.01	\$9.68	\$3.32	\$2.49	\$127.994	\$19.583	\$352.995	\$123.548	\$249.030	0.973	\$242.349	1
6			507	142	122	243	1,459	\$90.00	\$27.00	\$3.00	\$382.980	\$131.285	\$98.480	\$122.549	\$9.192	\$3.151	\$2.364	\$121.581	\$19.583	\$334.326	\$117.014	\$236.895	0.967	\$228.978	1
7			481	135	115	231	1,386	\$90.00	\$27.00	\$3.00	\$363.790	\$124.707	\$93.546	\$116.409	\$8.731	\$2.993	\$2.245	\$115.489	\$19.583	\$316.593	\$110.808	\$225.369	0.960	\$216.361	1
8			457	128	110	219	1,316	\$90.00	\$27.00	\$3.00	\$345.561	\$118.458	\$88.859	\$110.576	\$8.293	\$2.843	\$2.133	\$109.702	\$19.583	\$299.748	\$104.912	\$214.420	0.954	\$204.455	1
9			434	122	104	208	1,250	\$90.00	\$27.00	\$3.00	\$328.246	\$112.523	\$84.406	\$105.035	\$7.878	\$2.701	\$2.026	\$104.205	\$19.583	\$283.747	\$99.312	\$204.019	0.947	\$193.219	1
10			412	115	99	198	1,188	\$90.00	\$27.00	\$3.00	\$311.799	\$106.885	\$80.177	\$99.772	\$7.483	\$2.565	\$1.924	\$98.984	\$19.583	\$268.548	\$93.992	\$194.140	0.941	\$182.617	1
11			392	110	94	188	1,128	\$90.00	\$27.00	\$3.00	\$296.175	\$101.529	\$76.159	\$94.773	\$7.108	\$2.437	\$1.828	\$94.024	\$19.583	\$254.111	\$88.939	\$184.755	0.934	\$172.612	1
12			372	104	89	179	1,072	\$90.00	\$27.00	\$3.00	\$281.335	\$96.442	\$72.343	\$90.024	\$6.752	\$2.315	\$1.736	\$89.313	\$19.583	\$240.397	\$84.139	\$175.841	0.928	\$163.171	1
13			353	99	85	170	1,018	\$90.00	\$27.00	\$3.00	\$267.238	\$91.609	\$68.718	\$85.513	\$6.414	\$2.199	\$1.649	\$84.837	\$19.583	\$227.370	\$79.579	\$167.374	0.922	\$154.262	1
14			336	94	81	161	967	\$90.00	\$27.00	\$3.00	\$253.847	\$87.019	\$65.275	\$81.228	\$6.092	\$2.088	\$1.567	\$80.586	\$19.583	\$214.996	\$75.249	\$159.331	0.915	\$145.854	1
15			319	89	77	153	919	\$90.00	\$27.00	\$3.00	\$241.128	\$82.659	\$62.004	\$77.158	\$5.787	\$1.984	\$1.488	\$76.548	\$19.583	\$203.242	\$71.135	\$151.690	0.909	\$137.919	1
16			303	85	73	145	873	\$90.00	\$27.00	\$3.00	\$229.045	\$78.517	\$58.897	\$73.292	\$5.497	\$1.884	\$1.414	\$72.713	\$19.583	\$192.077	\$67.227	\$144.433	0.903	\$130.431	1
17			291	81	70	140	837	\$90.00	\$27.00	\$3.00	\$219.784	\$75.342	\$56.516	\$70.328	\$5.275	\$1.808	\$1.356	\$69.773	\$19.583	\$183.518	\$64.231	\$138.870	0.897	\$124.557	1
18			279	78	67	134	803	\$90.00	\$27.00	\$3.00	\$210.896	\$72.295	\$54.231	\$67.484	\$5.062	\$1.735	\$1.302	\$66.951	\$19.583	\$175.305	\$61.357	\$133.532	0.891	\$118.958	1
19			268	75	64	128	771	\$90.00	\$27.00	\$3.00	\$202.368	\$69.372	\$52.038	\$64.756	\$4.857	\$1.665	\$1.249	\$64.244	\$19.583	\$167.424	\$58.599	\$128.409	0.885	\$113.619	1
20			257	72	62	123	740	\$90.00	\$27.00	\$3.00	\$194.185	\$66.567	\$49.933	\$62.137	\$4.660	\$1.598	\$1.198	\$61.646	\$19.583	\$159.862	\$55.952	\$123.494	0.879	\$108.530	1
21			246	69	59	118	710	\$90.00	\$27.00	\$3.00	\$186.333	\$63.875	\$47.914	\$59.625	\$4.472	\$1.533	\$1.150	\$59.153	\$19.583	\$152.606	\$53.412	\$118.777	0.873	\$103.677	1
22			237	66	57	114	681	\$90.00	\$27.00	\$3.00	\$178.799	\$61.292	\$45.977	\$57.213	\$4.291	\$1.471	\$1.103	\$56.761	\$19.583	\$145.644	\$50.975	\$114.252	0.867	\$99.051	1
23			227	64	54	109	654	\$90.00	\$27.00	\$3.00	\$171.569	\$58.814	\$44.118	\$54.900	\$4.118	\$1.412	\$1.059	\$54.466	\$19.583	\$138.962	\$48.637	\$109.909	0.861	\$94.641	1
24			218	61	52	105	627	\$90.00	\$27.00	\$3.00	\$164.631	\$56.435	\$42.334	\$52.680	\$3.951	\$1.354	\$1.016	\$52.264	\$19.583	\$132.551	\$46.393	\$105.742	0.855	\$90.436	1
25			209	59	50	100	602	\$90.00	\$27.00	\$3.00	\$157.974	\$54.153	\$40.622	\$50.550	\$3.791	\$1.300	\$0.975	\$50.150	\$19.583	\$126.400	\$44.240	\$101.743	0.849	\$86.426	1
26			201	56	48	96	577	\$90.00	\$27.00	\$3.00	\$151.586	\$51.964	\$38.979	\$48.506	\$3.638	\$1.247	\$0.936	\$48.123	\$19.583	\$120.497	\$42.174	\$97.906	0.844	\$82.603	1
27			192	54	46	92	554	\$90.00	\$27.00	\$3.00	\$145.456	\$49.862	\$37.403	\$46.544	\$3.491	\$1.197	\$0.898	\$46.177	\$19.583	\$114.832	\$40.191	\$94.224	0.838	\$78.958	1
28			185	52	44	89	532	\$90.00	\$27.00	\$3.00	\$139.575	\$47.846	\$35.891	\$44.662	\$3.350	\$1.148	\$0.861	\$44.309	\$19.583	\$109.397	\$38.289	\$90.691	0.832	\$75.483	1
29			179	50	43	86	514	\$90.00	\$27.00	\$3.00	\$135.048	\$46.294	\$34.727	\$43.214	\$3.241	\$1.111	\$0.833	\$42.872	\$19.583	\$105.214	\$36.825	\$87.972	0.827	\$72.724	1
30			173	48	41	83	498	\$90.00	\$27.00	\$3.00	\$130.668	\$44.793	\$33.600	\$41.812	\$3.136	\$1.075	\$0.806	\$41.482	\$19.583	\$101.166	\$35.408	\$85.341	0.821	\$70.071	1
31			167	47	40	80	482	\$90.00	\$27.00	\$3.00	\$126.430	\$43.340	\$32.510	\$40.456	\$3.034	\$1.040	\$0.780	\$40.136	\$19.583	\$97.250	\$34.037	\$82.796	0.816	\$67.520	1
32			162	45	39	78	466	\$90.00	\$27.00	\$3.00	\$122.329	\$41.934	\$31.456	\$39.144	\$2.936	\$1.006	\$0.755	\$38.835	\$19.583	\$93.460	\$32.711	\$80.333	0.810	\$65.068	1
33			157	44	38	75	451	\$90.00	\$27.00	\$3.00	\$118.362	\$40.574	\$30.436	\$37.874	\$2.841	\$0.974	\$0.730	\$37.575	\$19.583	\$89.794	\$31.428	\$77.949	0.804	\$62.710	1
34			151	42	36	73	436	\$90.00	\$27.00	\$3.00	\$114.523	\$39.258	\$29.449	\$36.646	\$2.749	\$0.942	\$0.707	\$36.356	\$19.583	\$86.247	\$30.186	\$75.644	0.799	\$60.442	1
35			147	41	35	70	422	\$90.00	\$27.00	\$3.00	\$110.808	\$37.985	\$28.494	\$35.457	\$2.659	\$0.912	\$0.684	\$35.177	\$19.583	\$82.814	\$28.985	\$73.413	0.794	\$58.262	1
36			142	40	34	68	408	\$90.00	\$27.00	\$3.00	\$107.214	\$36.753	\$27.569	\$34.307	\$2.573	\$0.882	\$0.662	\$34.036	\$19.583	\$79.493	\$27.823	\$71.254	0.788	\$56.166	1
37			137	38	33	66	395	\$90.00	\$27.00	\$3.00	\$103.737	\$35.561	\$26.675	\$33.195	\$2										

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

San Juan - Gallup

Other Regions: San Juan - Gallup				My Assumptions:			
Basin Characteristics				100% oilfield service & supply factor price scalar			
\$4.20 cost/well (\$mm)	Average Well		IP	EUR	30	days/month	
123 EUR/well (mboe)	550	451			-0.98%	exponential decline rate after year 3 (monthly)	
-69% 1st yr decline	-9.3%	170			\$100.00	oil price WTI (\$/bbl)	
-41% 2nd yr decline	-4.3%	100			0%	oil price appreciation (per month)	
-24% 3rd yr decline	-2.3%	87			\$3.50	gas price Henry Hub (\$/mcf)	
150 IP rate (boe/d)					0%	gas price appreciation	
\$6.00 opex-LOE (\$/boe)					30%	NGL price/oil price (fixed ratio)	
65% oil					0.68%	discount rate (compound monthly)	
18% gas					8.5%	discount rate (annual)	
18% NGL					80%	intangible drilling cost / total capex	
20.0% royalty rate					1.220	IP/EUR ratio, (B8/B4 = fixed ratio)	
3.8% oil prod tax							
3.8% gas prod tax							
3.8% NGL prod tax							
35.0% income tax rate							
-10% oil differential							
-5% gas differential							
0 1 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Results	
-	\$-1.091 = NPV/well (\$ million)
0	= EUR check (mboe)
0.02%	= ATIRR (monthly)
	= ATIRR (annual)
123	= total production (mboe)
\$1.363	= "tail end" NPV/well (\$ million)
99%	= "tail end" recovery factor
28	= months of lost production

Other Regions: San Juan - Gallup					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	1,235	1,506	614	749	
\$25	899	1,096	448	546	
\$30	707	862	353	430	
\$35	582	710	291	355	
\$40	495	604	248	302	
\$45	431	526	216	263	
\$50	381	465	191	233	
\$60	310	378	156	190	
\$70	262	320	132	161	
\$80	226	276	114	139	
\$90	199	243	101	123	
\$100	178	217	90	110	

Other Regions: San Juan - Gallup					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
	Full Cycle			DUC	
Price	EUR	IP	EUR	IP	
\$20	2,359	2,877	1,171	1,428	
\$25	1,534	1,871	762	929	
\$30	1,137	1,387	565	689	
\$35	903	1,101	449	548	
\$40	749	913	373	455	
\$45	640	780	319	389	
\$50	559	682	278	339	
\$60	445	543	222	271	
\$70	370	451	185	226	
\$80	317	387	159	194	
\$90	277	338	139	170	
\$100	246	300	123	150	

Per Well Net Cash Flow Analysis

Month	Capex (\$1,000s)		Production (boe/d)				mcf/d			Prices				Cash Flows (\$1,000)								PV Factor	AT NPV -\$1.091	Active 1/0	
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas	Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex	Depreciation	Tax. Inc.	Income Tax				NCF
1	\$1,050	\$263						\$90.00	\$27.00	\$3.33	\$264.083	\$16.211	\$21.939	\$60.45	\$8.03	\$0.49	\$0.67	\$27.085	\$8.750	\$196.763	\$68.867	\$136.646	0.973	\$132.980	1
2	\$1,050	\$263						\$90.00	\$27.00	\$3.33	\$239.468	\$14.700	\$19.894	\$54.812	\$7.280	\$0.447	\$0.605	\$24.561	\$8.750	\$177.607	\$62.163	\$124.195	0.967	\$120.044	1
3	\$1,050	\$263						\$90.00	\$27.00	\$3.33	\$217.148	\$13.330	\$18.040	\$49.703	\$6.601	\$0.405	\$0.548	\$22.272	\$8.750	\$160.237	\$56.083	\$112.904	0.960	\$108.392	1
4	\$1,050	\$263						\$90.00	\$27.00	\$3.33	\$196.908	\$12.087	\$16.358	\$45.071	\$5.986	\$0.367	\$0.497	\$20.196	\$8.750	\$144.486	\$50.570	\$102.666	0.954	\$97.895	1
5			150	98	27	27	163	\$90.00	\$27.00	\$3.33	\$178.554	\$10.960	\$14.834	\$40.870	\$5.428	\$0.333	\$0.451	\$18.313	\$8.750	\$130.203	\$45.571	\$93.382	0.947	\$88.439	1
6			136	89	25	25	147	\$90.00	\$27.00	\$3.33	\$161.911	\$9.939	\$13.451	\$37.060	\$4.922	\$0.302	\$0.409	\$16.606	\$8.750	\$117.251	\$41.038	\$84.963	0.941	\$79.921	1
7			124	80	22	22	134	\$90.00	\$27.00	\$3.33	\$146.820	\$9.012	\$12.197	\$33.606	\$4.463	\$0.274	\$0.371	\$15.058	\$8.750	\$105.507	\$36.927	\$77.330	0.934	\$72.247	1
8			112	73	20	20	121	\$90.00	\$27.00	\$3.33	\$133.135	\$8.172	\$11.060	\$30.474	\$4.047	\$0.248	\$0.336	\$13.655	\$8.750	\$94.857	\$33.200	\$70.407	0.928	\$65.334	1
9			102	66	18	18	110	\$90.00	\$27.00	\$3.33	\$120.725	\$7.411	\$10.029	\$27.633	\$3.670	\$0.225	\$0.305	\$12.382	\$8.750	\$85.200	\$29.820	\$64.130	0.922	\$59.106	1
10			92	60	17	17	100	\$90.00	\$27.00	\$3.33	\$109.473	\$6.720	\$9.095	\$25.057	\$3.328	\$0.204	\$0.276	\$11.228	\$8.750	\$76.443	\$26.755	\$58.438	0.915	\$53.495	1
11			84	54	15	15	90	\$90.00	\$27.00	\$3.33	\$99.269	\$6.094	\$8.247	\$22.722	\$3.018	\$0.185	\$0.251	\$10.181	\$8.750	\$68.502	\$23.976	\$53.277	0.909	\$48.440	1
12			76	49	14	14	82	\$90.00	\$27.00	\$3.33	\$90.016	\$5.526	\$7.478	\$20.604	\$2.736	\$0.168	\$0.227	\$9.232	\$8.750	\$61.302	\$21.456	\$48.596	0.903	\$43.885	1
13			69	45	12	12	74	\$90.00	\$27.00	\$3.33	\$86.122	\$5.287	\$7.155	\$19.713	\$2.618	\$0.161	\$0.218	\$8.833	\$8.750	\$58.272	\$20.395	\$46.627	0.897	\$41.821	1
14			62	41	11	11	67	\$90.00	\$27.00	\$3.33	\$82.397	\$5.058	\$6.845	\$18.860	\$2.505	\$0.154	\$0.208	\$8.451	\$8.750	\$55.373	\$19.380	\$44.742	0.891	\$39.859	1
15			57	37	10	10	61	\$90.00	\$27.00	\$3.33	\$78.833	\$4.839	\$6.549	\$18.044	\$2.397	\$0.147	\$0.199	\$8.085	\$8.750	\$52.599	\$18.410	\$42.939	0.885	\$37.994	1
16			51	33	9	9	55	\$90.00	\$27.00	\$3.33	\$75.423	\$4.630	\$6.266	\$17.264	\$2.293	\$0.141	\$0.190	\$7.736	\$8.750	\$49.945	\$17.481	\$41.214	0.879	\$36.220	1
17			49	32	9	9	53	\$90.00	\$27.00	\$3.33	\$72.160	\$4.430	\$5.995	\$16.517	\$2.194	\$0.135	\$0.182	\$7.401	\$8.750	\$47.406	\$16.592	\$39.564	0.873	\$34.534	1
18			47	31	8	8	51	\$90.00	\$27.00	\$3.33	\$69.039	\$4.238	\$5.736	\$15.803	\$2.099	\$0.129	\$0.174	\$7.081	\$8.750	\$44.977	\$15.742	\$37.985	0.867	\$32.932	1
19			45	29	8	8	49	\$90.00	\$27.00	\$3.33	\$66.053	\$4.055	\$5.487	\$15.119	\$2.008	\$0.123	\$0.167	\$6.775	\$8.750	\$42.653	\$14.929	\$36.475	0.861	\$31.408	1
20			43	28	8	8	46	\$90.00	\$27.00	\$3.33	\$63.196	\$3.879	\$5.250	\$14.465	\$1.921	\$0.118	\$0.160	\$6.482	\$8.750	\$40.430	\$14.150	\$35.029	0.855	\$29.959	1
21			41	27	7	7	44	\$90.00	\$27.00	\$3.33	\$60.462	\$3.711	\$5.023	\$13.839	\$1.838	\$0.113	\$0.153	\$6.201	\$8.750	\$38.302	\$13.406	\$33.647	0.849	\$28.581	1
22			39	26	7	7	42	\$90.00	\$27.00	\$3.33	\$57.847	\$3.551	\$4.806	\$13.241	\$1.759	\$0.108	\$0.146	\$5.933	\$8.750	\$36.267	\$12.693	\$32.324	0.844	\$27.271	1
23			38	24	7	7	41	\$90.00	\$27.00	\$3.33	\$55.345	\$3.397	\$4.598	\$12.668	\$1.682	\$0.103	\$0.140	\$5.676	\$8.750	\$34.320	\$12.012	\$31.058	0.838	\$26.026	1
24			36	23	6	6	39	\$90.00	\$27.00	\$3.33	\$52.951	\$3.250	\$4.399	\$12.120	\$1.610	\$0.099	\$0.134	\$5.431	\$8.750	\$32.457	\$11.360	\$29.847	0.832	\$24.842	1
25			34	22	6	6	37	\$90.00	\$27.00	\$3.33	\$51.736	\$3.176	\$4.298	\$11.842	\$1.573	\$0.097	\$0.131	\$5.306	\$8.750	\$31.511	\$11.029	\$29.232	0.827	\$24.166	1
26			33	21	6	6	36	\$90.00	\$27.00	\$3.33	\$50.549	\$3.103	\$4.199	\$11.570	\$1.537	\$0.094	\$0.128	\$5.184	\$8.750	\$30.588	\$10.706	\$28.632	0.821	\$23.509	1
27			32	20	5	5	35	\$90.00	\$27.00	\$3.33	\$49.389	\$3.032	\$4.103	\$11.305	\$1.501	\$0.092	\$0.125	\$5.066	\$8.750	\$29.685	\$10.390	\$28.045	0.816	\$22.871	1
28			30	19	5	5	33	\$90.00	\$27.00	\$3.33	\$48.256	\$2.962	\$4.009	\$11.045	\$1.467	\$0.090	\$0.122	\$4.949	\$8.750	\$28.803	\$10.081	\$27.472	0.810	\$22.252	1
29			29	18	5	5	32	\$90.00	\$27.00	\$3.33	\$47.149	\$2.894	\$3.917	\$10.792	\$1.433	\$0.088	\$0.119	\$4.836	\$8.750	\$27.942	\$9.780	\$26.912	0.804	\$21.651	1
30			28	17	5	5	28	\$90.00	\$27.00	\$3.33	\$46.067	\$2.828	\$3.827	\$10.544	\$1.400	\$0.086	\$0.116	\$4.725	\$8.750	\$27.100	\$9.485	\$26.365	0.799	\$21.067	1
31			26	17	5	5	28	\$90.00	\$27.00	\$3.33	\$45.010	\$2.763	\$3.739	\$10.302	\$1.368	\$0.084	\$0.114	\$4.616	\$8.750	\$26.277	\$9.197	\$25.830	0.794	\$20.500	1
32			25	16	5	5	27	\$90.00	\$27.00	\$3.33	\$43.977	\$2.700	\$3.654	\$10.066	\$1.337	\$0.082	\$0.111	\$4.511	\$8.750	\$25.474	\$8.916	\$25.308	0.788	\$19.949	1
33			24	16	4	4	26	\$90.00	\$27.00	\$3.33	\$42.968	\$2.638	\$3.570	\$9.835	\$1.306	\$0.080	\$0.109	\$4.407	\$8.750	\$24.689	\$8.641	\$24.798	0.783	\$19.414	1
34			24	16	4	4	26	\$90.00	\$27.00	\$3.33	\$41.983	\$2.577	\$3.488	\$9.610	\$1.276	\$0.078	\$0.106	\$4.306	\$8.750	\$23.921	\$8.373	\$24.299	0.778	\$18.895	1
35			23	15	4	4	25	\$90.00	\$27.00	\$3.33	\$41.019	\$2.518	\$3.408	\$9.389	\$1.247	\$0.077	\$0.104	\$4.207	\$8.750	\$23.172	\$8.110	\$23.812	0.772	\$18.391	1
36			23	15	4	4	25	\$90.00	\$27.00	\$3.33	\$40.078	\$2.460	\$3.3												

Appendix A: Minimum EUR as function of price, 2014 and 2016 Cost scenarios.

Tuscaloosa Marine Shale

Other Regions: Tuscaloosa Marine Shale				My Assumptions:			
Basin Characteristics				Average Well			
\$11.00 cost/well (\$mm)	267 EUR/well (mboe)	1,048	683	100%	30	oilfield service & supply factor price scalar	days/month
-78% 1st yr decline	-11.8%	233		-1.01%	3	exponential decline rate after year 3 (monthly)	
-39% 2nd yr decline	-4.0%	142		\$100.00		oil price WTI (\$/bbl)	
-23% 3rd yr decline	-2.1%	125		0%		oil price appreciation (per month)	
\$13.50 opex-LOE (\$/boe)				\$3.50		gas price Henry Hub (\$/mcf)	
92% oil				0%		gas price appreciation	
8% gas				30%		NGL price/oil price (fixed ratio)	
0% NGL				0.68%		discount rate (compound monthly)	
20.0% royalty rate				8.5%		discount rate (annual)	
12.5% oil prod tax				80%		intangible drilling cost / total capex	
4.2% gas prod tax				1.534		IP/EUR ratio, (B8/B4 = fixed ratio)	
0.0% NGL prod tax							
35.0% income tax rate							
5% oil differential							
0% gas differential							
0 = DUC							
25% auxiliary cost/well cost							
50% completion cost/well cost							
\$2,000 min opex (\$/month)							

Other Regions: Tuscaloosa Marine Shale					
Baseline Results (2016 factor prices)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	15,694	24,081	7,790	11,953	
\$25	4,387	6,731	2,177	3,340	
\$30	2,550	3,913	1,266	1,943	
\$35	1,797	2,757	892	1,369	
\$40	1,387	2,128	688	1,057	
\$45	1,130	1,734	561	861	
\$50	953	1,462	473	726	
\$60	726	1,114	360	552	
\$70	586	899	291	447	
\$80	491	753	244	374	
\$90	423	649	210	322	
\$100	372	571	185	284	

Other Regions: Tuscaloosa Marine Shale					
Sensitivity Results (2014 factor prices, G2=133%)					
minimum (breakeven) EUR and IP (flow) for the given price:					
Full Cycle			DUC		
Price	EUR	IP	EUR	IP	
\$20	0	0	0	0	
\$25	115,246	176,834	57,204	87,774	
\$30	7,566	11,609	3,755	5,762	
\$35	3,911	6,001	1,941	2,978	
\$40	2,637	4,046	1,309	2,009	
\$45	1,989	3,052	987	1,514	
\$50	1,597	2,450	793	1,217	
\$60	1,145	1,757	568	872	
\$70	893	1,370	443	680	
\$80	731	1,122	363	557	
\$90	620	951	308	473	
\$100	537	824	267	410	

Per Well Net Cash Flow Analysis																									
Month	Capex (\$1,000s)		Production (boe/d)				mcf/d	Prices				Cash Flows (\$1,000)								Active 1/0					
	Well Cost	Aux. Cost	Total	Oil	NGL	Gas		Gas Prod	Oil/bbl	NGL/bbl	Gas/mcf	Oil Rev	Gas Rev	NGL Rev	Royalty	Oil Tax	Gas Tax	NGL Tax	Opex		Depreciation	Tax. Inc.	Income Tax	NCF	PV Factor
1	\$2,750	\$688						\$105.00	\$31.50	\$3.50									\$2,750.000		-\$2,750.00	-\$962.500	-2,475	1.000	-\$2,475.00
2	\$2,750	\$688						\$105.00	\$31.50	\$3.50									\$2,750.000		-\$2,750.00	-\$962.500	-2,475	0.993	-\$2,458.23
3	\$2,750	\$688						\$105.00	\$31.50	\$3.50									\$2,750.000		-\$2,750.00	-\$962.500	-2,475	0.986	-\$2,441.58
4	\$2,750	\$688						\$105.00	\$31.50	\$3.50									\$2,750.000		-\$2,750.00	-\$962.500	-2,475	0.980	-\$2,425.03
5			409	377	0		33	197	\$105.00	\$31.50	\$3.50	\$1,186.411	\$20.633	\$0.000	\$241.41	\$118.64	\$0.69	\$0.00	\$165.803	\$22.917	\$657.581	\$230.153	\$450.345	0.973	\$438.263
6			361	332	0		29	173	\$105.00	\$31.50	\$3.50	\$1,046.690	\$18.203	\$0.000	\$212.979	\$104.669	\$0.612	\$0.000	\$146.276	\$22.917	\$577.441	\$202.104	\$398.253	0.967	\$384.943
7			319	293	0		25	153	\$105.00	\$31.50	\$3.50	\$923.423	\$16.060	\$0.000	\$187.897	\$92.342	\$0.540	\$0.000	\$129.050	\$22.917	\$506.738	\$177.358	\$352.296	0.960	\$338.215
8			281	259	0		22	135	\$105.00	\$31.50	\$3.50	\$814.674	\$14.168	\$0.000	\$165.768	\$81.467	\$0.476	\$0.000	\$113.852	\$22.917	\$444.362	\$155.527	\$311.752	0.954	\$297.263
9			248	228	0		20	119	\$105.00	\$31.50	\$3.50	\$718.731	\$12.500	\$0.000	\$146.246	\$71.873	\$0.420	\$0.000	\$100.444	\$22.917	\$389.331	\$136.266	\$275.982	0.947	\$261.373
10			219	201	0		18	105	\$105.00	\$31.50	\$3.50	\$634.088	\$11.028	\$0.000	\$129.023	\$63.409	\$0.371	\$0.000	\$88.615	\$22.917	\$340.782	\$119.274	\$244.425	0.941	\$229.918
11			193	178	0		15	93	\$105.00	\$31.50	\$3.50	\$559.413	\$9.729	\$0.000	\$113.828	\$55.941	\$0.327	\$0.000	\$78.179	\$22.917	\$297.950	\$104.282	\$216.584	0.934	\$202.349
12			170	157	0		14	82	\$105.00	\$31.50	\$3.50	\$493.532	\$8.583	\$0.000	\$100.423	\$49.353	\$0.288	\$0.000	\$68.972	\$22.917	\$260.162	\$91.057	\$192.022	0.928	\$178.186
13			150	138	0		12	72	\$105.00	\$31.50	\$3.50	\$435.410	\$7.572	\$0.000	\$88.596	\$43.541	\$0.254	\$0.000	\$60.849	\$22.917	\$226.824	\$79.389	\$170.353	0.922	\$157.007
14			133	122	0		11	64	\$105.00	\$31.50	\$3.50	\$384.132	\$6.681	\$0.000	\$78.163	\$38.413	\$0.224	\$0.000	\$53.683	\$22.917	\$197.413	\$69.095	\$151.235	0.915	\$138.443
15			117	108	0		9	56	\$105.00	\$31.50	\$3.50	\$338.894	\$5.894	\$0.000	\$68.958	\$33.889	\$0.198	\$0.000	\$47.361	\$22.917	\$171.465	\$60.013	\$134.369	0.909	\$122.170
16			103	95	0		8	50	\$105.00	\$31.50	\$3.50	\$298.983	\$5.200	\$0.000	\$60.837	\$29.898	\$0.175	\$0.000	\$41.783	\$22.917	\$148.573	\$52.001	\$119.489	0.903	\$107.905
17			99	91	0		8	48	\$105.00	\$31.50	\$3.50	\$286.896	\$4.989	\$0.000	\$58.377	\$28.690	\$0.168	\$0.000	\$40.094	\$22.917	\$141.640	\$49.574	\$114.983	0.897	\$103.132
18			95	87	0		8	46	\$105.00	\$31.50	\$3.50	\$275.297	\$4.788	\$0.000	\$56.017	\$27.530	\$0.161	\$0.000	\$38.473	\$22.917	\$134.988	\$47.246	\$110.659	0.891	\$98.581
19			91	84	0		7	44	\$105.00	\$31.50	\$3.50	\$264.168	\$4.594	\$0.000	\$53.752	\$26.417	\$0.154	\$0.000	\$36.918	\$22.917	\$128.604	\$45.011	\$106.509	0.885	\$94.242
20			87	80	0		7	42	\$105.00	\$31.50	\$3.50	\$253.488	\$4.408	\$0.000	\$51.579	\$25.349	\$0.148	\$0.000	\$35.425	\$22.917	\$122.478	\$42.867	\$102.528	0.879	\$90.104
21			84	77	0		7	40	\$105.00	\$31.50	\$3.50	\$243.240	\$4.230	\$0.000	\$49.494	\$24.324	\$0.142	\$0.000	\$33.993	\$22.917	\$116.600	\$40.810	\$98.707	0.873	\$86.158
22			81	74	0		6	39	\$105.00	\$31.50	\$3.50	\$233.407	\$4.059	\$0.000	\$47.493	\$23.341	\$0.136	\$0.000	\$32.619	\$22.917	\$110.960	\$38.836	\$95.041	0.867	\$82.396
23			77	71	0		6	37	\$105.00	\$31.50	\$3.50	\$223.970	\$3.895	\$0.000	\$45.573	\$22.397	\$0.131	\$0.000	\$31.300	\$22.917	\$105.548	\$36.942	\$91.523	0.861	\$78.809
24			74	68	0		6	36	\$105.00	\$31.50	\$3.50	\$214.916	\$3.738	\$0.000	\$43.731	\$21.492	\$0.126	\$0.000	\$30.035	\$22.917	\$100.354	\$35.124	\$88.147	0.855	\$75.388
25			71	65	0		6	34	\$105.00	\$31.50	\$3.50	\$206.227	\$3.587	\$0.000	\$41.963	\$20.623	\$0.121	\$0.000	\$28.821	\$22.917	\$95.371	\$33.380	\$84.908	0.849	\$72.125
26			68	63	0		5	33	\$105.00	\$31.50	\$3.50	\$197.890	\$3.442	\$0.000	\$40.266	\$19.789	\$0.116	\$0.000	\$27.655	\$22.917	\$90.588	\$31.706	\$81.799	0.844	\$69.014
27			66	60	0		5	31	\$105.00	\$31.50	\$3.50	\$189.890	\$3.302	\$0.000	\$38.638	\$18.989	\$0.111	\$0.000	\$26.537	\$22.917	\$86.000	\$30.100	\$78.816	0.838	\$66.047
28			63	58	0		5	30	\$105.00	\$31.50	\$3.50	\$182.213	\$3.169	\$0.000	\$37.076	\$18.221	\$0.106	\$0.000	\$25.465	\$22.917	\$81.597	\$28.559	\$75.954	0.832	\$63.217
29			62	57	0		5	30	\$105.00	\$31.50	\$3.50	\$178.381	\$3.102	\$0.000	\$36.297	\$17.838	\$0.104	\$0.000	\$24.929	\$22.917	\$79.399	\$27.790	\$74.526	0.827	\$61.608
30			60	55	0		5	29	\$105.00	\$31.50	\$3.50	\$174.630	\$3.037	\$0.000	\$35.533	\$17.463	\$0.102	\$0.000	\$24.405	\$22.917	\$77.247	\$27.037	\$73.127	0.821	\$60.042
31			59	54	0		5	28	\$105.00	\$31.50	\$3.50	\$170.958	\$2.973	\$0.000	\$34.786	\$17.096	\$0.100	\$0.000	\$23.892	\$22.917	\$75.141	\$26.299	\$71.758	0.816	\$58.519
32			58	53	0		5	28	\$105.00	\$31.50	\$3.50	\$167.363	\$2.911	\$0.000	\$34.055	\$16.736	\$0.098	\$0.000	\$23.389	\$22.917	\$73.079	\$25.578	\$70.418	0.810	\$57.037
33			57	52	0		5	27	\$105.00	\$31.50	\$3.50	\$163.844	\$2.849	\$0.000	\$33.339	\$16.384	\$0.096	\$0.000	\$22.897	\$22.917	\$71.061	\$24.871	\$69.106	0.804	\$55.595
34			55	51	0		4	27	\$105.00	\$31.50	\$3.50	\$160.399	\$2.790	\$0.000	\$32.638	\$16.040	\$0.094	\$0.000	\$22.416	\$22.917	\$69.084	\$24.180	\$67.822	0.799	\$54.192
35			54	50	0		4	26	\$105.00	\$31.50	\$3.50	\$157.026	\$2.731	\$0.000	\$31.951	\$15.703	\$0.092	\$0.000	\$21.945	\$22.917	\$67.150	\$23.502	\$66.564	0.794	\$52.827
36			53	49	0		4	25	\$105.00	\$31.50	\$3.50	\$153.724	\$2.673	\$0.000	\$31.279	\$15.372	\$0.090	\$0.000	\$21.483	\$22.917	\$65.256	\$22.840	\$65.333	0.788	\$51.499
37			52	48	0		4	25	\$105.00	\$31.50	\$3.50	\$150.491	\$2.617	\$0.000	\$30.622	\$15.049	\$0.088	\$0.000	\$21.031	\$22.917	\$63.402	\$22.191	\$64.128	0.783	\$50.206
38			51	47	0		4	24	\$105.00	\$31.50	\$3.50	\$147.327	\$2.562	\$0.000	\$29.978	\$14.733	\$0.086	\$0.000	\$20.589	\$22.917	\$61.587	\$21.555	\$62.948	0.778	\$48.949
39	</																								

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Midland Basin Spraberry				
Midland Basin: Spraberry				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,074	1,177	535	586
\$25	915	1,002	456	500
\$30	803	880	400	438
\$35	719	788	358	392
\$40	655	718	326	357
\$45	603	661	300	329
\$50	560	614	279	306
\$60	494	541	246	270
\$70	445	488	222	243
\$80	407	446	203	222
\$90	376	412	187	205
\$100	350	383	174	191

Northern Delaware Bone Spring				
Northern Delaware Basin: Bone Springs				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,089	1,611	543	803
\$25	955	1,413	476	704
\$30	854	1,263	426	630
\$35	775	1,146	386	571
\$40	712	1,053	355	525
\$45	660	976	329	487
\$50	616	911	307	454
\$60	548	811	273	404
\$70	495	732	247	365
\$80	454	672	226	334
\$90	420	621	209	309
\$100	393	581	196	290

Southern Delaware Wolfcamp				
Southern Delaware Basin: Wolfcamp				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,371	1,708	682	850
\$25	1,227	1,529	610	760
\$30	1,112	1,385	553	689
\$35	1,019	1,269	507	632
\$40	942	1,173	469	584
\$45	878	1,094	437	544
\$50	824	1,027	410	511
\$60	736	917	366	456
\$70	669	833	333	415
\$80	615	766	306	381
\$90	571	711	284	354
\$100	534	665	265	330

Culberson LL Wolfcamp				
Culberson LL: Wolfcamp				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	2,870	3,597	1,425	1,786
\$25	2,902	3,637	1,441	1,806
\$30	2,883	3,613	1,431	1,793
\$35	2,834	3,552	1,407	1,763
\$40	2,770	3,471	1,375	1,723
\$45	2,698	3,381	1,339	1,678
\$50	2,622	3,286	1,302	1,632
\$60	2,473	3,099	1,227	1,538
\$70	2,332	2,922	1,158	1,451
\$80	2,204	2,762	1,094	1,371
\$90	2,089	2,618	1,037	1,300
\$100	1,985	2,488	986	1,236

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Midland Basin Wolfcamp				
Midland Basin: Wolfcamp				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,230	1,228	612	611
\$25	1,073	1,072	534	533
\$30	955	954	475	474
\$35	864	863	430	429
\$40	792	791	394	393
\$45	733	732	365	365
\$50	684	683	340	340
\$60	606	605	302	302
\$70	547	546	272	272
\$80	501	500	249	249
\$90	464	463	231	231
\$100	433	432	215	215

Southern Midland Basin Wolfcamp				
Southern Midland Basin: Wolfcamp				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	964	1,012	480	504
\$25	869	912	433	455
\$30	791	831	394	414
\$35	727	763	362	380
\$40	674	708	336	353
\$45	629	660	313	329
\$50	591	621	294	309
\$60	528	554	263	276
\$70	480	504	239	251
\$80	442	464	220	231
\$90	410	431	204	214
\$100	383	402	191	201

Eagle Ford Condensate

Eagle Ford: Condensate Region				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,449	2,473	721	1,230
\$25	1,252	2,137	623	1,063
\$30	1,108	1,891	551	940
\$35	997	1,701	496	846
\$40	910	1,553	453	773
\$45	839	1,432	418	713
\$50	781	1,333	388	662
\$60	689	1,176	343	585
\$70	620	1,058	309	527
\$80	566	966	282	481
\$90	523	893	260	444
\$100	487	831	242	413

Eagle Ford Oil

Eagle Ford: Oil Region				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,011	1,796	504	895
\$25	858	1,524	428	760
\$30	750	1,333	374	664
\$35	671	1,192	334	593
\$40	609	1,082	303	538
\$45	559	993	279	496
\$50	519	922	259	460
\$60	456	810	227	403
\$70	409	727	204	362
\$80	373	663	186	330
\$90	344	611	172	306
\$100	320	569	160	284

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Eagle Ford Combo

Eagle Ford:Combo Region				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,029	1,243	514	621
\$25	1,024	1,237	511	617
\$30	1,005	1,214	501	605
\$35	979	1,183	488	590
\$40	950	1,148	474	573
\$45	921	1,113	459	555
\$50	891	1,077	444	536
\$60	836	1,010	416	503
\$70	785	948	391	472
\$80	740	894	369	446
\$90	701	847	349	422
\$100	666	805	331	400

Bakken Core

Bakken: Core				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,448	1,700	739	867
\$25	1,259	1,478	625	734
\$30	1,100	1,291	546	641
\$35	982	1,153	488	573
\$40	891	1,046	442	519
\$45	818	960	406	477
\$50	759	891	377	443
\$60	667	783	331	389
\$70	599	703	297	349
\$80	546	641	271	318
\$90	504	592	250	293
\$100	469	551	233	273

Bakken Non-Core

Bakken: Non Core				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,552	1,822	770	904
\$25	1,255	1,473	623	731
\$30	1,064	1,249	529	621
\$35	931	1,093	462	542
\$40	833	978	413	485
\$45	756	887	375	440
\$50	695	816	345	405
\$60	602	707	299	351
\$70	535	628	266	312
\$80	485	569	241	283
\$90	444	521	221	259
\$100	412	484	205	241

Springer

Springer				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,504	1,198	748	596
\$25	1,311	1,044	652	519
\$30	1,169	931	582	464
\$35	1,060	844	527	420
\$40	973	775	484	385
\$45	902	718	449	358
\$50	843	671	419	334
\$60	749	597	373	297
\$70	678	540	337	268
\$80	622	495	309	246
\$90	577	460	287	229
\$100	539	429	268	213

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

STACK				
STACK				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
	Full Cycle		DUC	
Price	EUR	IP	EUR	IP
\$20	1,274	1,119	637	560
\$25	1,202	1,056	600	527
\$30	1,136	998	567	498
\$35	1,076	946	537	472
\$40	1,023	899	510	448
\$45	975	857	486	427
\$50	932	819	465	409
\$60	859	755	428	376
\$70	799	702	398	350
\$80	749	658	373	328
\$90	706	620	351	308
\$100	669	588	333	293

SCOOP Condensate				
SCOOP Condensate				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
	Full Cycle		DUC	
Price	EUR	IP	EUR	IP
\$20	1,724	1,236	858	615
\$25	1,771	1,270	880	631
\$30	1,791	1,285	890	638
\$35	1,795	1,287	892	640
\$40	1,787	1,282	888	637
\$45	1,773	1,272	881	632
\$50	1,753	1,257	871	625
\$60	1,706	1,224	847	607
\$70	1,653	1,186	821	589
\$80	1,601	1,148	795	570
\$90	1,549	1,111	769	552
\$100	1,500	1,076	745	534

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Meramec

Meramec				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,425	1,518	709	755
\$25	1,425	1,518	708	754
\$30	1,407	1,498	699	744
\$35	1,378	1,468	684	728
\$40	1,344	1,431	668	711
\$45	1,309	1,394	650	692
\$50	1,273	1,356	632	673
\$60	1,204	1,282	598	637
\$70	1,139	1,213	566	603
\$80	1,081	1,151	537	572
\$90	1,029	1,096	511	544
\$100	982	1,046	487	519

SCOOP Oil

SCOOP Oil				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,624	1,264	808	629
\$25	1,483	1,154	737	574
\$30	1,366	1,063	679	528
\$35	1,268	987	630	490
\$40	1,186	923	590	459
\$45	1,116	869	555	432
\$50	1,055	821	525	409
\$60	956	744	475	370
\$70	877	683	436	339
\$80	813	633	404	314
\$90	760	592	378	294
\$100	715	557	355	276

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Cana Woodford				
Cana Woodford				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,325	1,165	660	580
\$25	1,424	1,252	708	623
\$30	1,497	1,317	744	654
\$35	1,552	1,365	771	678
\$40	1,591	1,399	790	695
\$45	1,620	1,425	804	707
\$50	1,639	1,442	814	716
\$60	1,657	1,457	823	724
\$70	1,656	1,456	822	723
\$80	1,643	1,445	816	718
\$90	1,623	1,427	805	708
\$100	1,597	1,405	793	697

Mississippian				
Mississippian				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	524	523	264	263
\$25	512	511	257	256
\$30	496	495	249	248
\$35	478	477	240	239
\$40	460	459	230	229
\$45	443	442	222	221
\$50	427	426	213	212
\$60	397	396	198	198
\$70	371	370	185	185
\$80	349	348	174	174
\$90	329	328	164	164
\$100	312	311	156	156

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Marmaton

Marmaton				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	462	634	234	321
\$25	420	577	212	291
\$30	385	529	195	268
\$35	357	490	180	247
\$40	333	457	168	231
\$45	312	428	158	217
\$50	295	405	149	205
\$60	266	365	134	184
\$70	243	334	123	169
\$80	225	309	113	155
\$90	210	288	106	146
\$100	197	271	99	136

Tonkawa

Tonkawa				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	545	744	275	376
\$25	499	681	251	343
\$30	461	629	232	317
\$35	428	584	216	295
\$40	401	548	202	276
\$45	377	515	190	259
\$50	357	487	179	244
\$60	323	441	162	221
\$70	297	406	149	203
\$80	275	376	138	188
\$90	257	351	129	176
\$100	242	330	121	165

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Granite Wash				
Granite Wash				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,149	2,092	573	1,043
\$25	1,161	2,114	579	1,054
\$30	1,156	2,105	576	1,049
\$35	1,141	2,077	568	1,034
\$40	1,120	2,039	558	1,016
\$45	1,097	1,997	546	994
\$50	1,072	1,952	534	972
\$60	1,021	1,859	508	925
\$70	973	1,771	484	881
\$80	927	1,688	462	841
\$90	886	1,613	441	803
\$100	848	1,544	422	768

Cleveland				
Cleveland				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	418	721	212	366
\$25	410	707	207	357
\$30	399	688	201	347
\$35	386	666	195	336
\$40	373	643	188	324
\$45	360	621	181	312
\$50	348	600	175	302
\$60	325	560	164	283
\$70	305	526	154	266
\$80	288	497	145	250
\$90	273	471	137	236
\$100	259	447	130	224

Northern Wattenberg XL

Denver Julesburg Basin: Northern Wattenberg XL				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	1,318	1,309	655	650
\$25	1,144	1,136	568	564
\$30	1,015	1,008	504	501
\$35	916	910	455	452
\$40	837	831	416	413
\$45	773	768	384	381
\$50	720	715	358	356
\$60	636	632	316	314
\$70	573	569	285	283
\$80	523	519	260	258
\$90	483	480	240	238
\$100	450	447	224	222

Northern Wattenberg

Denver Julesburg Basin: Northern Wattenberg				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	725	812	362	406
\$25	627	703	314	352
\$30	555	622	278	311
\$35	501	561	250	280
\$40	457	512	229	257
\$45	422	473	211	236
\$50	393	440	196	220
\$60	347	389	173	194
\$70	312	350	156	175
\$80	285	319	143	160
\$90	263	295	132	148
\$100	245	275	123	138

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Southern Wattenberg

Denver Julesburg Basin: Southern Wattenberg				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	656	714	328	357
\$25	600	653	300	327
\$30	552	601	276	300
\$35	510	555	255	278
\$40	475	517	238	259
\$45	445	484	222	242
\$50	418	455	209	228
\$60	375	408	188	205
\$70	342	372	171	186
\$80	314	342	157	171
\$90	292	318	146	159
\$100	273	297	136	148

Greater Monument Butte

Uinta Basin: Greater Monument Butte/Uinta				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	510	326	255	163
\$25	389	248	196	125
\$30	319	204	161	103
\$35	273	174	138	88
\$40	240	153	121	77
\$45	215	137	109	70
\$50	196	125	99	63
\$60	167	107	85	54
\$70	147	94	75	48
\$80	132	84	67	43
\$90	121	77	61	39
\$100	111	71	56	36

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

Wasatch SXL

Uinta Basin: Wasatch SXL				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	2,760	3,985	1,372	1,981
\$25	2,391	3,453	1,188	1,715
\$30	2,117	3,057	1,052	1,519
\$35	1,907	2,754	947	1,367
\$40	1,740	2,513	864	1,248
\$45	1,604	2,316	797	1,151
\$50	1,491	2,153	741	1,070
\$60	1,314	1,897	653	943
\$70	1,182	1,707	587	848
\$80	1,078	1,557	536	774
\$90	995	1,437	494	713
\$100	926	1,337	460	664

Uteland Butte SXL

Uteland Butte SXL				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	13,112	24,164	6,509	11,995
\$25	6,360	11,721	3,158	5,820
\$30	4,245	7,823	2,108	3,885
\$35	3,214	5,923	1,596	2,941
\$40	2,604	4,799	1,293	2,383
\$45	2,200	4,054	1,093	2,014
\$50	1,913	3,525	950	1,751
\$60	1,531	2,821	760	1,401
\$70	1,287	2,372	639	1,178
\$80	1,118	2,060	555	1,023
\$90	993	1,830	493	909
\$100	896	1,651	445	820

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

SW PA Wet Gas				
Appalachia Basin: SW PA Wet Gas				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	2,119	1,795	1,052	891
\$25	2,266	1,920	1,125	953
\$30	2,356	1,996	1,169	990
\$35	2,403	2,036	1,193	1,011
\$40	2,419	2,050	1,201	1,018
\$45	2,413	2,044	1,198	1,015
\$50	2,391	2,026	1,187	1,006
\$60	2,319	1,965	1,151	975
\$70	2,228	1,888	1,106	937
\$80	2,131	1,806	1,058	896
\$90	2,036	1,725	1,010	856
\$100	1,944	1,647	965	818

SW PA Super Rich				
Appalachia Basin: SW PA Super Rich				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	2,044	1,460	1,015	725
\$25	2,112	1,509	1,048	749
\$30	2,130	1,522	1,057	755
\$35	2,116	1,512	1,050	750
\$40	2,083	1,488	1,034	739
\$45	2,038	1,456	1,012	723
\$50	1,987	1,420	986	704
\$60	1,879	1,342	933	667
\$70	1,772	1,266	879	628
\$80	1,672	1,195	830	593
\$90	1,580	1,129	784	560
\$100	1,497	1,069	743	531

Utica Wet Gas

Appalachia Basin: Utica Wet Gas				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	2,447	2,447	1,216	1,216
\$25	2,754	2,754	1,368	1,368
\$30	3,013	3,013	1,497	1,497
\$35	3,229	3,229	1,604	1,604
\$40	3,408	3,408	1,692	1,692
\$45	3,552	3,552	1,764	1,764
\$50	3,667	3,667	1,821	1,821
\$60	3,822	3,822	1,897	1,897
\$70	3,898	3,898	1,935	1,935
\$80	3,917	3,917	1,945	1,945
\$90	3,896	3,896	1,934	1,934
\$100	3,948	3,948	1,910	1,910

Utica Condensate

Appalachia Basin: Utica Condensate				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	2,015	2,015	1,002	1,002
\$25	1,984	1,984	986	986
\$30	1,924	1,924	956	956
\$35	1,853	1,853	921	921
\$40	1,779	1,779	884	884
\$45	1,706	1,706	848	848
\$50	1,636	1,636	813	813
\$60	1,509	1,509	750	750
\$70	1,399	1,399	695	695
\$80	1,305	1,305	648	648
\$90	1,223	1,223	608	608
\$100	1,152	1,152	572	572

Appendix B: Minimum EUR as function of price, Dynamic Cost scenario.

San Juan - Gallup

Other Regions: San Juan - Gallup				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	700	854	351	428
\$25	616	751	309	377
\$30	553	674	277	338
\$35	504	615	252	307
\$40	464	566	232	283
\$45	431	526	216	263
\$50	403	491	202	246
\$60	360	439	180	220
\$70	326	398	163	199
\$80	300	366	150	183
\$90	278	339	139	170
\$100	260	317	130	159

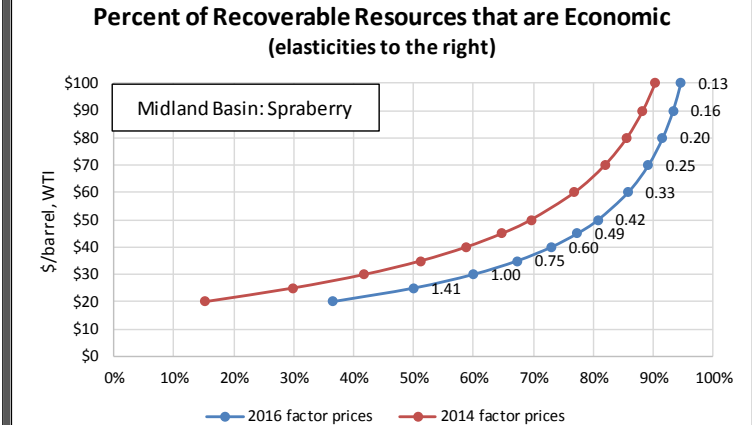
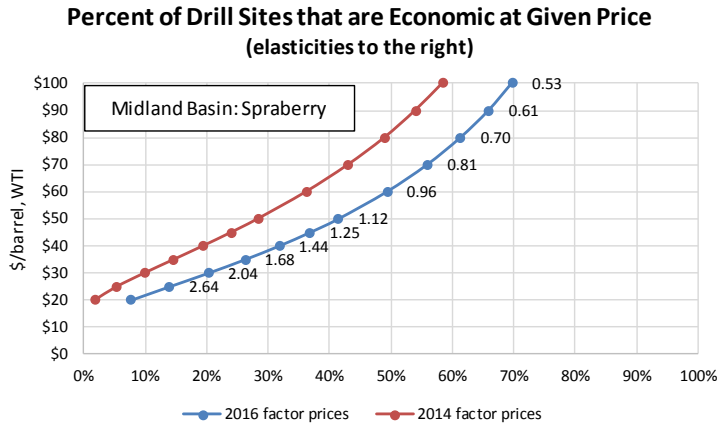
Tuscaloosa Marine Shale

Other Regions: Tuscaloosa Marine Shale				
(Dynamic Cost scenario)				
minimum (breakeven) EUR and IP (flow) for the given price:				
Price	Full Cycle		DUC	
	EUR	IP	EUR	IP
\$20	2,844	4,364	1,412	2,167
\$25	2,118	3,250	1,051	1,613
\$30	1,711	2,625	850	1,304
\$35	1,450	2,225	720	1,105
\$40	1,266	1,943	629	965
\$45	1,130	1,734	561	861
\$50	1,024	1,571	508	779
\$60	870	1,335	432	663
\$70	763	1,171	379	582
\$80	683	1,048	339	520
\$90	622	954	309	474
\$100	572	878	284	436

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Midland Basin Spraberry

EUR Distribution	
min:	0.0000
median:	0.4177
mean:	0.7530
μ :	-0.8730
σ :	1.0857
η :	1.5000
mean:	0.7530
stdev:	1.1295
a=b/e eur:	1.3590
transform:	1.0867
$E[x x>a]$:	2.7145
$Pr[x>a]$:	13.9%
$Q[R a]$:	0.3762

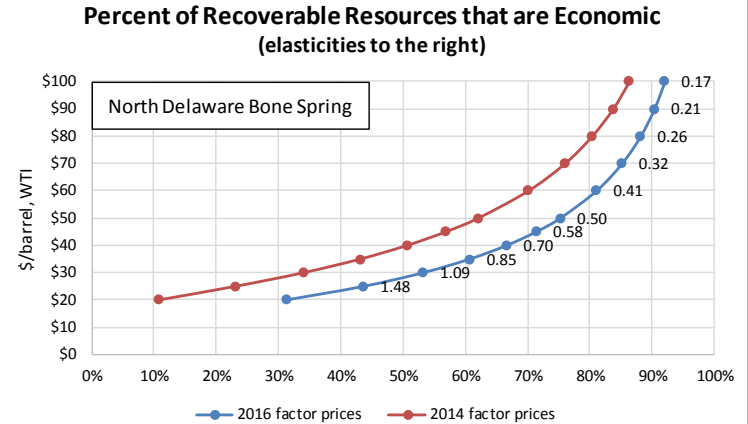
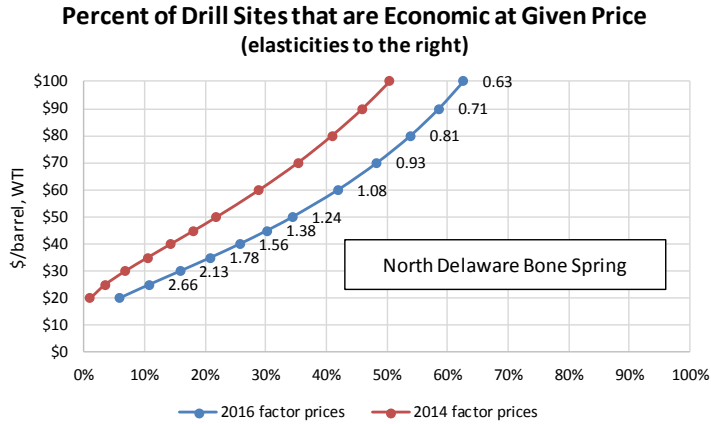


Midland Basin: Spraberry Baseline Results (2016 factor prices)								Midland Basin: Spraberry Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	1,981	1.43	3.614	8%	36%			\$20	4,161	2.12	6.649	2%	15%	
2.64	\$25	1,359	1.09	2.714	14%	50%	1.41	4.61	\$25	2,416	1.62	4.232	5%	30%	2.94
2.04	\$30	1,034	0.83	2.234	20%	60%	1.00	3.27	\$30	1,702	1.29	3.213	10%	42%	1.84
1.68	\$35	835	0.64	1.936	26%	67%	0.75	2.55	\$35	1,314	1.06	2.648	15%	51%	1.32
1.44	\$40	700	0.48	1.731	32%	73%	0.60	2.11	\$40	1,070	0.87	2.288	19%	59%	1.02
1.25	\$45	603	0.34	1.583	37%	77%	0.49	1.81	\$45	902	0.71	2.037	24%	65%	0.83
1.12	\$50	529	0.22	1.469	41%	81%	0.42	1.58	\$50	780	0.58	1.852	28%	70%	0.68
0.96	\$60	426	0.02	1.310	49%	86%	0.33	1.35	\$60	614	0.35	1.599	36%	77%	0.54
0.81	\$70	356	-0.15	1.202	56%	89%	0.25	1.13	\$70	506	0.18	1.433	43%	82%	0.42
0.70	\$80	306	-0.29	1.124	61%	92%	0.20	0.97	\$80	430	0.03	1.316	49%	86%	0.33
0.61	\$90	268	-0.41	1.066	66%	93%	0.16	0.83	\$90	375	-0.10	1.231	54%	88%	0.26
0.53	\$100	239	-0.51	1.022	70%	95%	0.13	0.75	\$100	332	-0.21	1.164	58%	90%	0.22

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Northern Delaware Bone Spring

EUR Distribution	
min:	0.0000
median:	0.3750
mean:	0.6760
μ :	-0.9809
σ :	1.0857
η :	1.5000
mean:	0.6760
stdev:	1.0140
a=b/e eur:	1.3590
transform:	1.1860
$E[x x>a]$:	2.6398
$Pr[x>a]$:	11.8%
$Q[R a]$:	0.3110

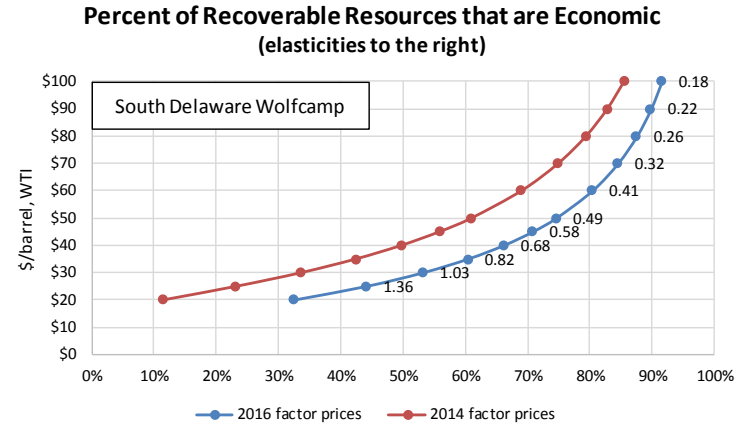
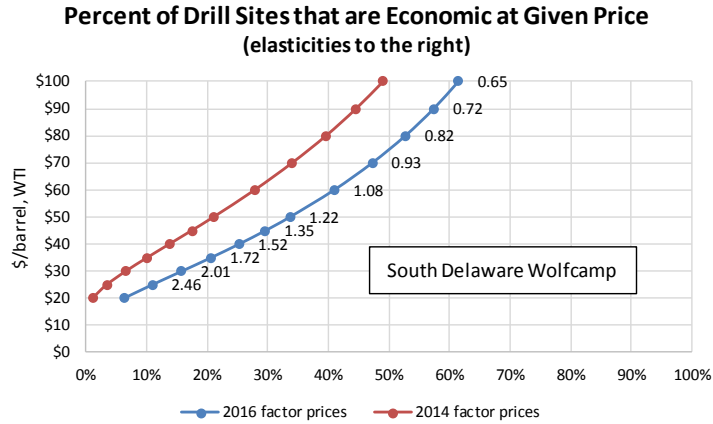


North Delaware Bone Spring Baseline Results (2016 factor prices)								North Delaware Bone Spring Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
2.66	\$20	2,067	1.57	3.655	6%	31%	1.48	4.93	\$20	4,686	2.33	7.257	1%	11%	3.28
2.13	\$25	1,448	1.24	2.769	11%	44%	1.09	3.57	\$25	2,711	1.82	4.558	3%	23%	2.11
1.78	\$30	1,115	1.00	2.283	16%	53%	0.85	2.81	\$30	1,907	1.50	3.428	7%	34%	1.54
1.56	\$35	907	0.81	1.974	21%	61%	0.70	2.33	\$35	1,471	1.26	2.802	10%	43%	1.20
1.38	\$40	764	0.66	1.759	26%	67%	0.58	2.02	\$40	1,198	1.07	2.405	14%	51%	0.99
1.24	\$45	660	0.52	1.602	30%	71%	0.50	1.78	\$45	1,010	0.91	2.127	18%	57%	0.83
1.08	\$50	581	0.40	1.482	34%	75%	0.41	1.53	\$50	873	0.78	1.923	22%	62%	0.67
0.93	\$60	469	0.21	1.310	42%	81%	0.32	1.29	\$60	687	0.56	1.643	29%	70%	0.52
0.81	\$70	393	0.04	1.192	48%	85%	0.26	1.11	\$70	566	0.38	1.459	35%	76%	0.42
0.71	\$80	338	-0.10	1.107	54%	88%	0.21	0.99	\$80	482	0.23	1.330	41%	80%	0.35
0.63	\$90	297	-0.21	1.044	59%	90%	0.17	0.88	\$90	419	0.10	1.232	46%	84%	0.29
0.63	\$100	265	-0.32	0.994	63%	92%	0.17	0.88	\$100	371	-0.01	1.158	50%	86%	0.29

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Southern Delaware Wolfcamp

EUR Distribution	
min:	0.0000
median:	0.4898
mean:	0.8830
μ :	-0.7138
σ :	1.0857
η :	1.5000
mean:	0.8830
stdev:	1.3245
a=b/e eur:	1.3590
transform:	0.9400
$E[x x>a]$:	2.8376
$Pr[x>a]$:	17.4%
$Q[R a]$:	0.4926

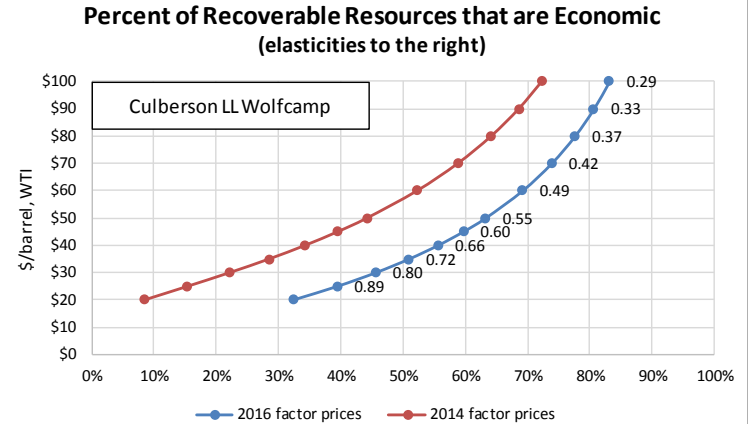
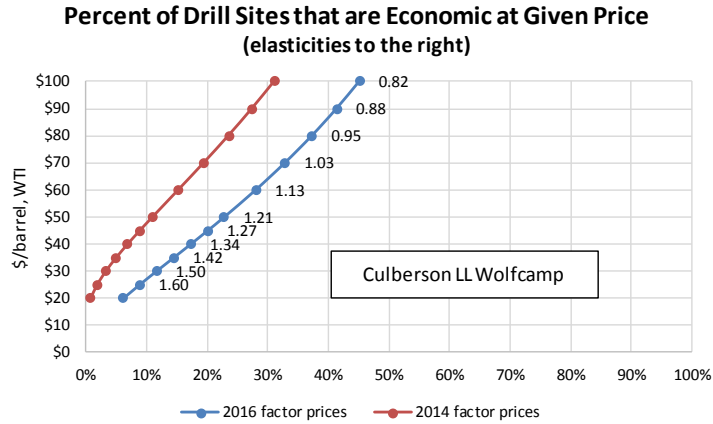


South Delaware Wolfcamp Baseline Results (2016 factor prices)							South Delaware Wolfcamp Sensitivity Results (2014 factor prices, G2=133%)										
% of wells and technical recoverable reserves economic at given price:							% of wells and technical recoverable reserves economic at given price:										
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity		
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			
2.46	\$20	2,601	1.54	4.634	6%	33%	1.36	4.63	\$20	5,872	2.29	9.143	1%	11%	3.05		
2.01	\$25	1,868	1.23	3.583	11%	44%		4.63	\$25	3,525	1.82	5.931	3%	23%			
1.72	\$30	1,458	1.00	2.984	16%	53%		1.03	3.43	\$30	2,518	1.51	4.516	7%		34%	2.02
1.52	\$35	1,195	0.82	2.594	21%	60%		0.82	2.74	\$35	1,959	1.28	3.715	10%		42%	1.50
1.35	\$40	1,012	0.67	2.319	25%	66%		0.68	2.30	\$40	1,603	1.09	3.197	14%		50%	1.19
1.22	\$45	878	0.54	2.117	30%	71%		0.58	2.00	\$45	1,356	0.94	2.833	17%		56%	0.99
1.08	\$50	776	0.42	1.961	34%	75%		0.49	1.78	\$50	1,175	0.81	2.564	21%		61%	0.84
0.93	\$60	629	0.23	1.736	41%	80%		0.41	1.53	\$60	928	0.59	2.192	28%		69%	0.68
0.82	\$70	529	0.07	1.581	47%	84%		0.32	1.30	\$70	767	0.41	1.948	34%		75%	0.53
0.72	\$80	456	-0.07	1.469	53%	88%		0.26	1.14	\$80	653	0.26	1.773	40%		79%	0.43
0.65	\$90	401	-0.18	1.384	57%	90%		0.22	1.00	\$90	569	0.14	1.643	45%		83%	0.36
0.65	\$100	358	-0.29	1.317	61%	92%		0.18	0.90	\$100	504	0.03	1.543	49%		86%	0.30

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Culberson LL Wolfcamp

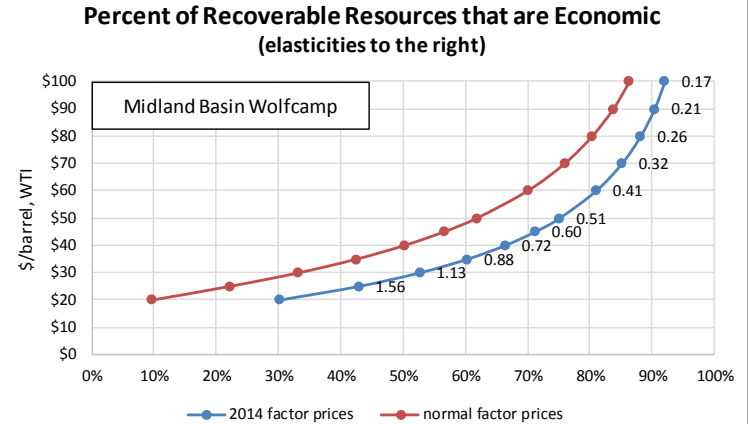
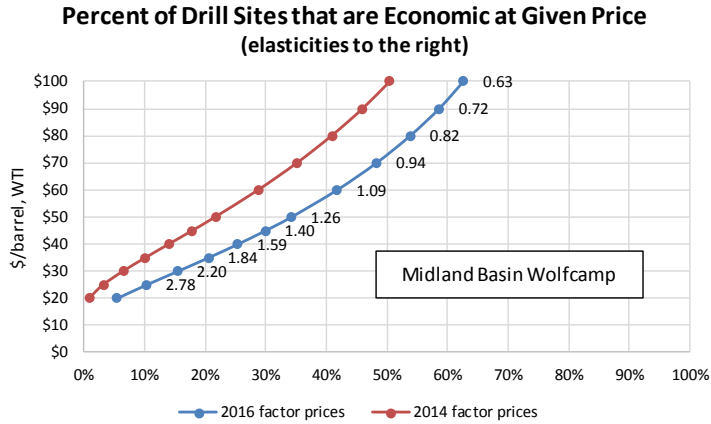
EUR Distribution	
min:	0.0000
median:	1.0844
mean:	1.9550
μ :	0.0811
σ :	1.0857
η :	1.5000
mean:	1.9550
stdev:	2.9325
a=b/e eur:	1.3590
transform:	0.2079
$E[x x>a]$:	3.7913
$Pr[x>a]$:	41.8%
$Q[R a]$:	1.5835



Culberson LL Wolfcamp Baseline Results (2016 factor prices)								Culberson LL Wolfcamp Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
1.60	\$20	5,787	1.54	10.299	6%	32%	0.89	3.91	\$20	15,643	2.46	23.791	1%	8%	2.61
1.50	\$25	4,708	1.35	8.759	9%	39%	0.80	3.17	\$25	10,647	2.10	17.048	2%	15%	2.61
1.42	\$30	3,969	1.20	7.691	12%	46%	0.80	3.17	\$30	8,101	1.85	13.544	3%	22%	1.97
1.42	\$35	3,430	1.06	6.903	14%	51%	0.72	2.75	\$35	6,527	1.65	11.345	5%	29%	1.63
1.34	\$40	3,020	0.94	6.299	17%	56%	0.66	2.43	\$40	5,466	1.49	9.843	7%	34%	1.38
1.27	\$45	2,698	0.84	5.821	20%	60%	0.60	2.20	\$45	4,701	1.35	8.749	9%	40%	1.21
1.21	\$50	2,437	0.75	5.430	23%	63%	0.55	2.01	\$50	4,124	1.23	7.916	11%	44%	1.07
1.13	\$60	2,043	0.58	4.837	28%	69%	0.49	1.80	\$60	3,311	1.03	6.728	15%	52%	0.92
1.03	\$70	1,759	0.45	4.405	33%	74%	0.42	1.59	\$70	2,766	0.86	5.922	19%	59%	0.76
0.95	\$80	1,544	0.33	4.076	37%	78%	0.37	1.43	\$80	2,375	0.72	5.337	24%	64%	0.65
0.88	\$90	1,376	0.22	3.818	41%	81%	0.33	1.30	\$90	2,081	0.60	4.894	27%	69%	0.57
0.82	\$100	1,241	0.12	3.609	45%	83%	0.29	1.20	\$100	1,852	0.49	4.547	31%	72%	0.50

Midland Basin Wolfcamp

EUR Distribution	
min:	0.0000
median:	0.4138
mean:	0.7460
μ :	-0.8824
σ :	1.0857
η :	1.5000
mean:	0.7460
stdev:	1.1190
a=b/e eur:	1.3590
transform:	1.0953
$E[x x>a]$:	2.7077
$Pr[x>a]$:	13.7%
$Q[R a]$:	0.3701

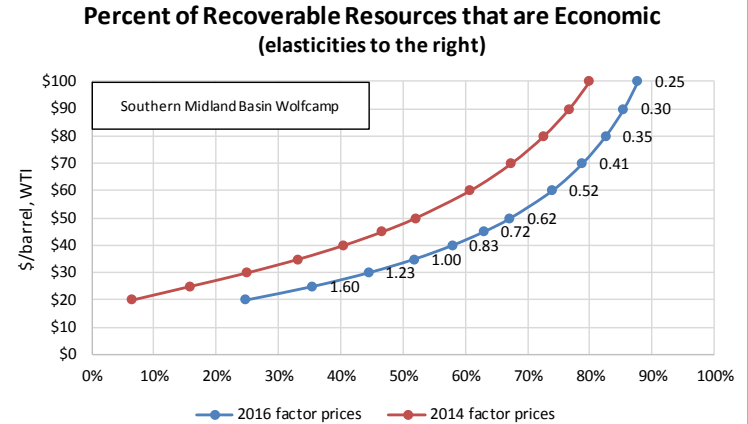
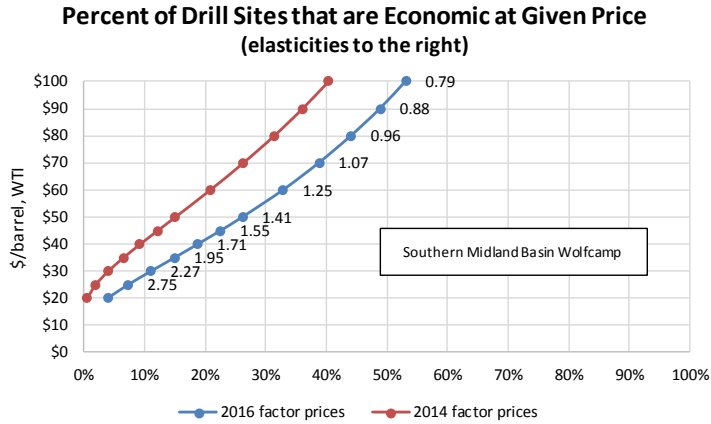


Midland Basin Wolfcamp Baseline Results (2016 factor prices)								Midland Basin Wolfcamp Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
2.78	\$20	2,362	1.60	4.148	5%	30%	1.56	5.19	\$20	5,496	2.38	8.445	1%	10%	3.51
2.20	\$25	1,635	1.27	3.109	10%	43%	1.13	3.70	\$25	3,091	1.85	5.168	3%	22%	2.20
1.84	\$30	1,250	1.02	2.548	15%	53%	0.88	2.90	\$30	2,151	1.52	3.849	6%	33%	1.59
1.59	\$35	1,012	0.82	2.195	21%	60%	0.72	2.40	\$35	1,649	1.27	3.130	10%	43%	1.24
1.40	\$40	850	0.66	1.952	25%	66%	0.60	2.06	\$40	1,337	1.08	2.675	14%	50%	1.01
1.26	\$45	733	0.53	1.775	30%	71%	0.51	1.81	\$45	1,124	0.92	2.362	18%	57%	0.85
1.09	\$50	644	0.41	1.639	34%	75%	0.41	1.55	\$50	970	0.78	2.132	22%	62%	0.68
0.94	\$60	519	0.21	1.447	42%	81%	0.32	1.31	\$60	761	0.56	1.817	29%	70%	0.53
0.82	\$70	434	0.04	1.316	48%	85%	0.26	1.13	\$70	626	0.38	1.612	35%	76%	0.42
0.72	\$80	373	-0.10	1.222	54%	88%	0.21	1.00	\$80	532	0.23	1.467	41%	80%	0.35
0.63	\$90	327	-0.22	1.151	59%	90%	0.17	0.88	\$90	462	0.10	1.359	46%	84%	0.29
0.63	\$100	292	-0.32	1.097	63%	92%	0.17	0.88	\$100	409	-0.01	1.277	50%	86%	0.29

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Southern Midland Basin Wolfcamp

EUR Distribution	
min:	0.0000
median:	0.2774
mean:	0.5000
μ :	-1.2825
σ :	1.0857
η :	1.5000
mean:	0.5000
stdev:	0.7500
a=b/e eur:	1.3590
transform:	1.4638
$E[x x>a]$:	2.4620
$Pr[x>a]$:	7.2%
$Q[R a]$:	0.1763

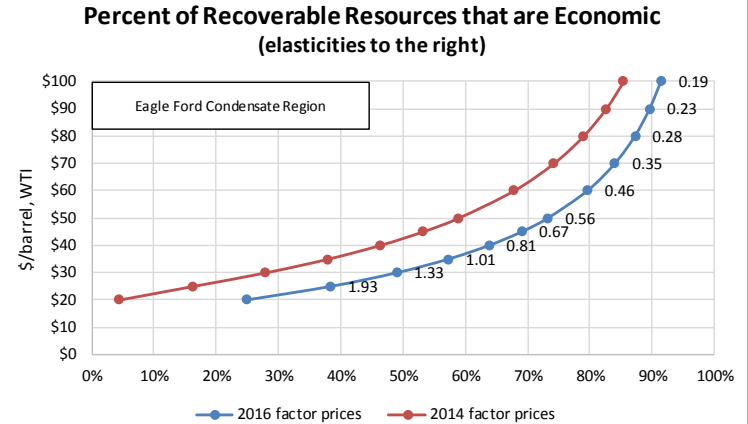
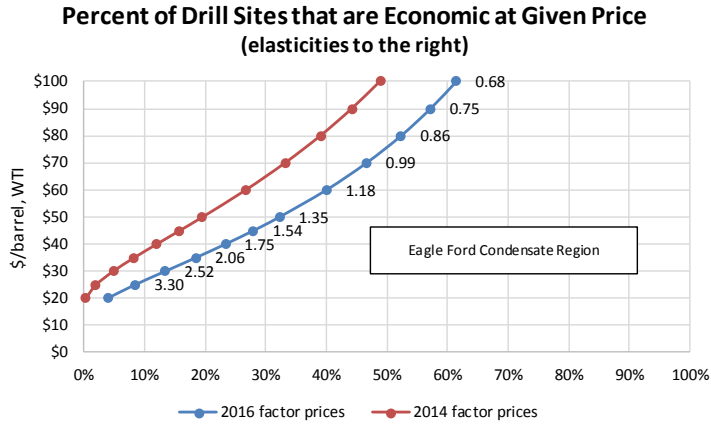


Southern Midland Basin Wolfcamp Baseline Results (2016 factor prices)								Southern Midland Basin Wolfcamp Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:															
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	1,888	1.77	3.208	4%	25%		\$20	4,667	2.60	6.971	0%	6%		
2.75	\$25	1,348	1.46	2.446	7%	36%	1.60	\$25	2,675	2.09	4.295	2%	16%	3.76	
2.27	\$30	1,048	1.22	2.015	11%	44%	1.23	\$30	1,875	1.76	3.190	4%	25%	2.47	
1.95	\$35	857	1.04	1.736	15%	52%	1.00	\$35	1,443	1.52	2.582	6%	33%	1.84	
1.71	\$40	726	0.89	1.542	19%	58%	0.83	\$40	1,173	1.33	2.195	9%	40%	1.46	
1.55	\$45	629	0.75	1.397	23%	63%	0.72	\$45	988	1.17	1.927	12%	47%	1.21	
1.41	\$50	555	0.64	1.286	26%	67%	0.62	\$50	854	1.04	1.731	15%	52%	1.03	
1.25	\$60	449	0.44	1.125	33%	74%	0.52	\$60	671	0.81	1.460	21%	61%	0.85	
1.07	\$70	378	0.29	1.016	39%	79%	0.41	\$70	553	0.64	1.283	26%	67%	0.68	
0.96	\$80	326	0.15	0.936	44%	83%	0.35	\$80	470	0.49	1.157	31%	73%	0.56	
0.88	\$90	286	0.03	0.875	49%	85%	0.30	\$90	409	0.36	1.064	36%	77%	0.47	
0.79	\$100	255	-0.08	0.827	53%	88%	0.25	\$100	362	0.25	0.992	40%	80%	0.40	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Eagle Ford Condensate

EUR Distribution	
min:	0.0000
median:	0.4443
mean:	0.8010
μ :	-0.8112
σ :	1.0857
η :	1.5000
mean:	0.8010
stdev:	1.2015
a=b/e eur:	1.3590
transform:	1.0298
$E[x x>a]$:	2.7603
$Pr[x>a]$:	15.2%
$Q[R a]$:	0.4184

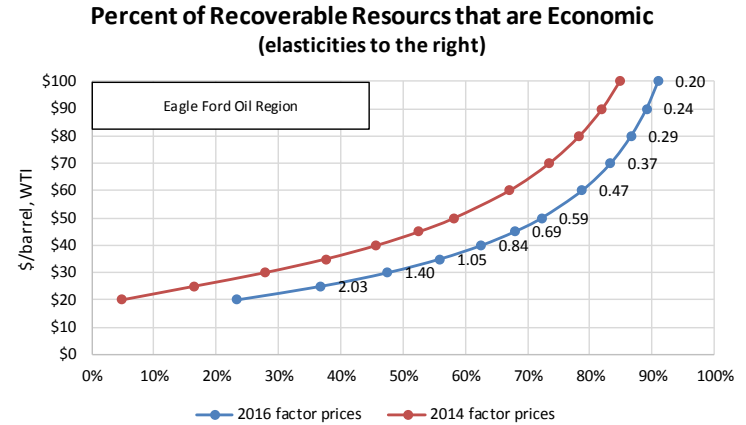
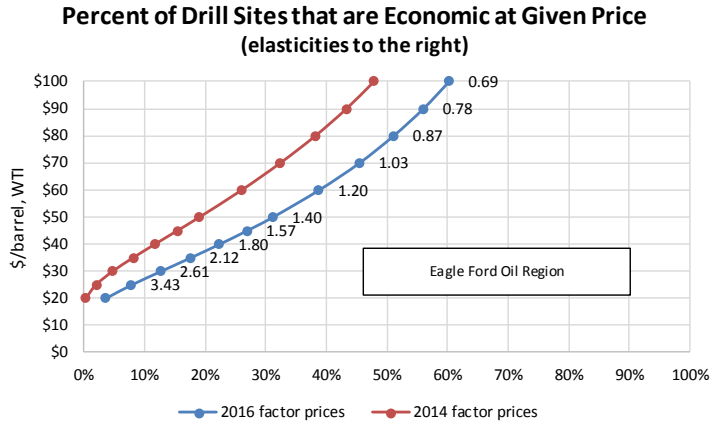


Eagle Ford Condensate Region Baseline Results (2016 factor prices)								Eagle Ford Condensate Region Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:															
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	3,014	1.76	5.125	4%	25%		\$20	9,143	2.79	13.364	0%	4%		
3.30	\$25	1,985	1.38	3.669	8%	38%	1.93	\$25	4,190	2.07	6.750	2%	16%	5.14	
2.52	\$30	1,480	1.11	2.938	13%	49%	1.33	\$30	2,717	1.67	4.708	5%	28%	2.90	
2.06	\$35	1,180	0.90	2.496	18%	57%	1.01	\$35	2,011	1.39	3.707	8%	38%	1.97	
1.75	\$40	981	0.73	2.199	23%	64%	0.81	\$40	1,596	1.18	3.107	12%	46%	1.48	
1.54	\$45	839	0.59	1.985	28%	69%	0.67	\$45	1,323	1.01	2.707	16%	53%	1.18	
1.35	\$50	734	0.46	1.825	32%	73%	0.56	\$50	1,130	0.86	2.421	19%	59%	0.97	
1.18	\$60	586	0.25	1.598	40%	80%	0.46	\$60	874	0.62	2.038	27%	68%	0.77	
0.99	\$70	488	0.09	1.447	47%	84%	0.35	\$70	713	0.44	1.793	33%	74%	0.59	
0.86	\$80	418	-0.06	1.339	52%	87%	0.28	\$80	602	0.28	1.623	39%	79%	0.47	
0.75	\$90	366	-0.18	1.258	57%	90%	0.23	\$90	521	0.15	1.498	44%	83%	0.38	
0.68	\$100	325	-0.29	1.195	61%	92%	0.19	\$100	459	0.03	1.402	49%	85%	0.32	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Eagle Ford Oil

EUR Distribution	
min:	0.0000
median:	0.2857
mean:	0.5150
μ :	-1.2529
σ :	1.0857
η :	1.5000
mean:	0.5150
stdev:	0.7725
a=b/e eur:	1.3590
transform:	1.4366
$E[x x>a]$:	2.4776
$Pr[x>a]$:	7.5%
$Q[R a]$:	0.1868

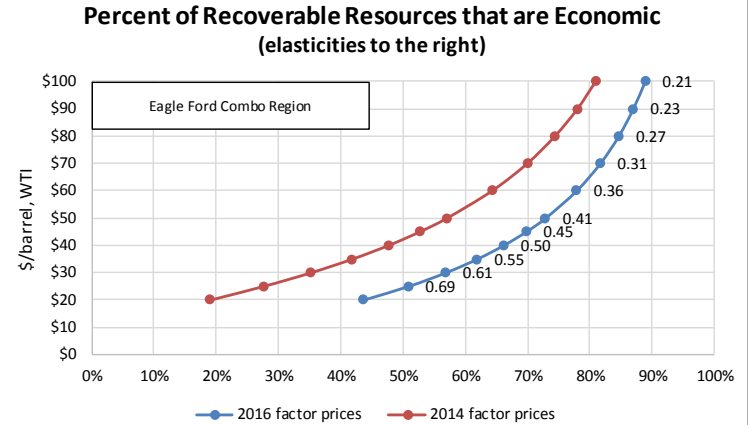
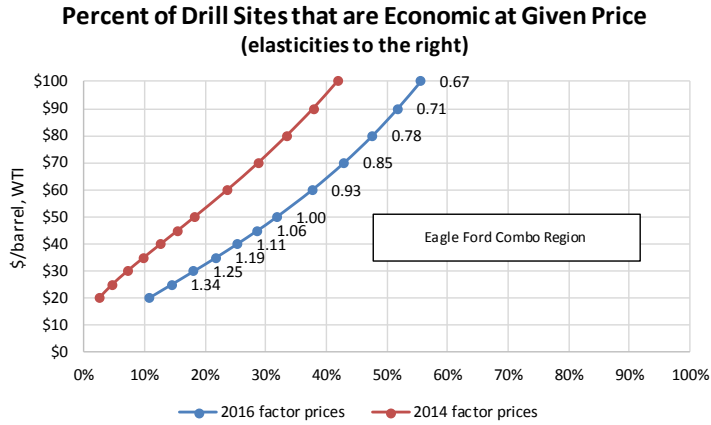


Eagle Ford Oil Region Baseline Results (2016 factor prices)								Eagle Ford Oil Region Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
3.43	\$20	2,048	1.81	3.448	3%	23%	2.03	6.61	\$20	5,645	2.75	8.286	0%	5%	4.92
2.61	\$25	1,336	1.42	2.445	8%	37%	1.40	4.54	\$25	2,681	2.06	4.322	2%	16%	2.83
2.12	\$30	991	1.15	1.946	13%	48%	1.40	4.54	\$30	1,758	1.67	3.043	5%	28%	2.83
1.80	\$35	788	0.93	1.648	17%	56%	1.05	3.42	\$35	1,307	1.40	2.403	8%	38%	1.95
1.57	\$40	654	0.76	1.449	22%	63%	0.84	2.75	\$40	1,041	1.19	2.019	12%	46%	1.47
1.40	\$45	559	0.62	1.306	27%	68%	0.69	2.32	\$45	865	1.02	1.762	15%	53%	1.17
1.20	\$50	488	0.49	1.198	31%	72%	0.59	2.02	\$50	740	0.88	1.577	19%	58%	0.97
1.03	\$60	390	0.29	1.048	39%	79%	0.47	1.71	\$60	574	0.64	1.328	26%	67%	0.77
0.87	\$70	324	0.12	0.946	45%	83%	0.37	1.42	\$70	469	0.46	1.169	32%	74%	0.59
0.78	\$80	278	-0.03	0.875	51%	87%	0.29	1.23	\$80	396	0.30	1.057	38%	78%	0.48
0.78	\$90	243	-0.15	0.821	56%	89%	0.24	1.07	\$90	343	0.17	0.976	43%	82%	0.39
0.69	\$100	216	-0.26	0.779	60%	91%	0.20	0.94	\$100	303	0.05	0.914	48%	85%	0.32

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Eagle Ford Combo

EUR Distribution	
min:	0.0000
median:	0.4981
mean:	0.8980
μ :	-0.6969
σ :	1.0857
η :	1.5000
mean:	0.8980
stdev:	1.3470
a=b/e eur:	1.3590
transform:	0.9245
$E[x x>a]$:	2.8516
$Pr[x>a]$:	17.8%
$Q[R a]$:	0.5065

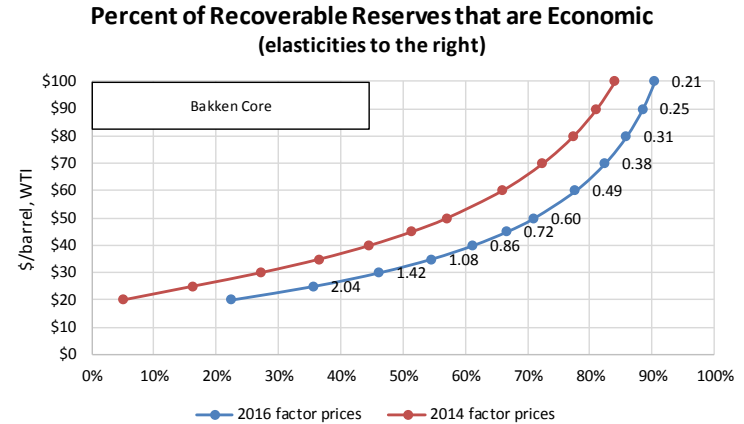
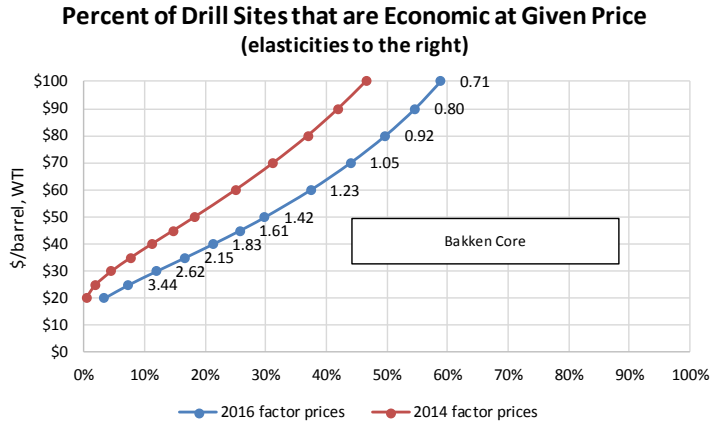


Eagle Ford Combo Region Baseline Results (2016 factor prices)							Eagle Ford Combo Region Sensitivity Results (2014 factor prices, G2=133%)								
% of wells and technical recoverable reserves economic at given price:							% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
1.34	\$20	1,923	1.24	3.678	11%	44%	0.69	2.72	\$20	4,193	1.96	6.874	2%	19%	1.65
1.25	\$25	1,579	1.06	3.176	14%	51%	0.61	2.33	\$25	3,088	1.68	5.338	5%	28%	1.33
1.19	\$30	1,340	0.91	2.823	18%	57%	0.55	2.07	\$30	2,444	1.47	4.426	7%	35%	1.12
1.11	\$35	1,163	0.78	2.560	22%	62%	0.50	1.86	\$35	2,022	1.29	3.821	10%	42%	0.97
1.06	\$40	1,028	0.67	2.357	25%	66%	0.45	1.70	\$40	1,724	1.14	3.388	13%	48%	0.85
1.00	\$45	921	0.57	2.195	29%	70%	0.41	1.57	\$45	1,503	1.02	3.064	15%	53%	0.76
0.93	\$50	834	0.47	2.063	32%	73%	0.36	1.42	\$50	1,333	0.91	2.813	18%	57%	0.66
0.85	\$60	702	0.32	1.861	38%	78%	0.31	1.26	\$60	1,086	0.72	2.444	24%	64%	0.55
0.78	\$70	606	0.18	1.713	43%	82%	0.27	1.13	\$70	916	0.56	2.188	29%	70%	0.46
0.71	\$80	533	0.06	1.601	48%	85%	0.23	1.04	\$80	793	0.43	2.000	33%	74%	0.40
0.67	\$90	476	-0.04	1.512	52%	87%	0.21	0.95	\$90	698	0.31	1.855	38%	78%	0.35
0.67	\$100	429	-0.14	1.440	55%	89%	0.21	0.95	\$100	624	0.21	1.741	42%	81%	0.35

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Bakken Core

EUR Distribution	
min:	0.0000
median:	0.4022
mean:	0.7250
μ :	-0.9109
σ :	1.0857
η :	1.5000
mean:	0.7250
stdev:	1.0875
a=b/e eur:	1.3590
transform:	1.1216
$E[x x>a]$:	2.6875
$Pr[x>a]$:	13.1%
$Q[R a]$:	0.3521

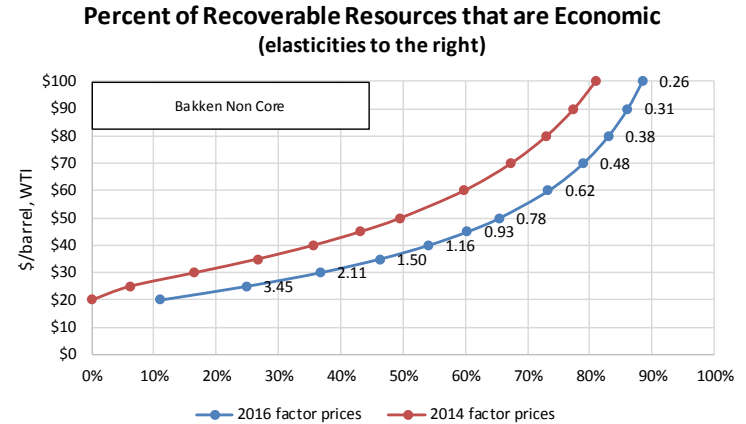
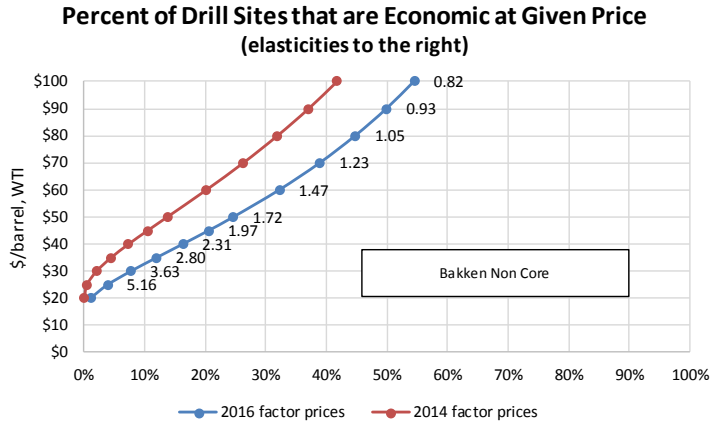


Bakken Core Baseline Results (2016 factor prices)							Bakken Core Sensitivity Results (2014 factor prices, G2=133%)								
% of wells and technical recoverable reserves economic at given price:							% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
3.44	\$20	2,970	1.84	4.975	3%	22%	2.04	6.42	\$20	7,767	2.73	11.428	0%	5%	
2.62	\$25	1,946	1.45	3.535	7%	36%	2.04	6.42	\$25	3,819	2.07	6.145	2%	16%	4.73
2.15	\$30	1,448	1.18	2.817	12%	46%	1.42	4.46	\$30	2,532	1.69	4.364	5%	27%	2.78
2.15	\$35	1,152	0.97	2.383	17%	55%	1.08	3.38	\$35	1,894	1.43	3.461	8%	37%	1.94
1.83	\$40	957	0.80	2.094	21%	61%	0.86	2.75	\$40	1,513	1.22	2.912	11%	45%	1.48
1.61	\$45	818	0.65	1.885	26%	67%	0.72	2.34	\$45	1,259	1.05	2.541	15%	51%	1.19
1.42	\$50	715	0.53	1.729	30%	71%	0.60	2.04	\$50	1,078	0.91	2.274	18%	57%	0.99
1.23	\$60	571	0.32	1.509	37%	78%	0.49	1.72	\$60	838	0.68	1.915	25%	66%	0.79
1.05	\$70	475	0.15	1.361	44%	82%	0.38	1.45	\$70	685	0.49	1.683	31%	72%	0.61
0.92	\$80	406	0.01	1.255	50%	86%	0.31	1.25	\$80	579	0.34	1.521	37%	77%	0.49
0.80	\$90	355	-0.11	1.176	55%	89%	0.25	1.09	\$90	502	0.20	1.403	42%	81%	0.40
0.71	\$100	316	-0.22	1.116	59%	90%	0.21	0.98	\$100	443	0.09	1.312	46%	84%	0.34

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Bakken Non-Core

EUR Distribution	
min:	0.0000
median:	0.3095
mean:	0.5580
μ :	-1.1727
σ :	1.0857
η :	1.5000
mean:	0.5580
stdev:	0.8370
a=b/e eur:	1.3590
transform:	1.3627
$E[x x>a]$:	2.5219
$Pr[x>a]$:	8.6%
$Q[R a]$:	0.2181

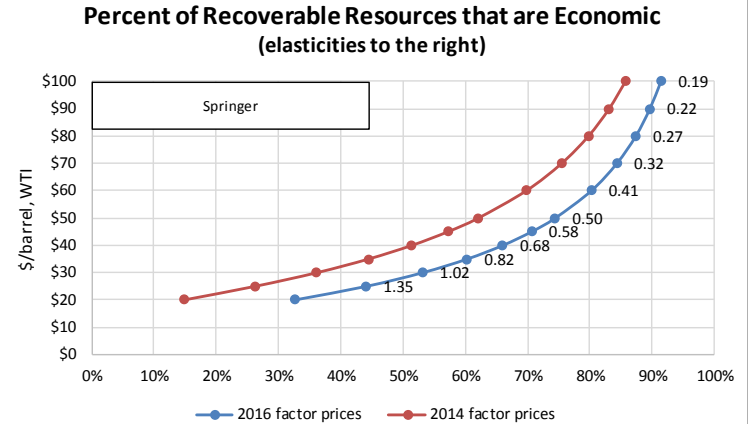
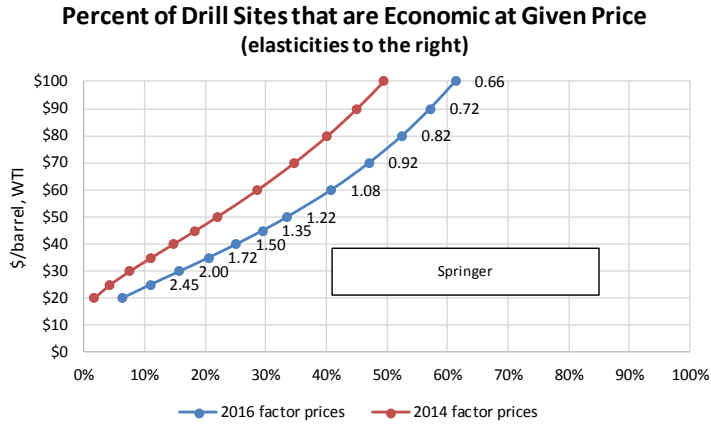


Bakken Non Core Baseline Results (2016 factor prices)								Bakken Non Core Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:															
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	3,787	2.31	5.881	1%	11%		\$20	35,582	4.37	45.918	0%	0%		
5.16	\$25	2,101	1.76	3.572	4%	25%	3.45	\$25	5,338	2.62	7.951	0%	6%	8.85	
3.63	\$30	1,454	1.42	2.658	8%	37%	2.11	\$30	2,886	2.06	4.657	2%	17%	5.00	
2.80	\$35	1,112	1.18	2.165	12%	46%	1.50	\$35	1,977	1.71	3.398	4%	27%	3.04	
2.31	\$40	900	0.98	1.854	16%	54%	1.16	\$40	1,504	1.46	2.730	7%	36%	2.14	
1.97	\$45	756	0.82	1.640	21%	60%	0.93	\$45	1,213	1.26	2.311	10%	43%	1.64	
1.72	\$50	652	0.69	1.484	25%	66%	0.78	\$50	1,017	1.10	2.026	14%	50%	1.32	
1.47	\$60	511	0.46	1.271	32%	73%	0.62	\$60	768	0.84	1.658	20%	60%	1.03	
1.23	\$70	420	0.28	1.132	39%	79%	0.48	\$70	617	0.64	1.432	26%	67%	0.77	
1.05	\$80	357	0.13	1.034	45%	83%	0.38	\$80	516	0.47	1.279	32%	73%	0.61	
0.93	\$90	310	0.00	0.962	50%	86%	0.31	\$90	443	0.33	1.167	37%	77%	0.50	
0.82	\$100	274	-0.11	0.906	54%	88%	0.26	\$100	388	0.21	1.082	42%	81%	0.42	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Springer

EUR Distribution	
min:	0.0000
median:	0.5014
mean:	0.9040
μ :	-0.6903
σ :	1.0857
η :	1.5000
mean:	0.9040
stdev:	1.3560
a=b/e eur:	1.3590
transform:	0.9183
$E[x x>a]$:	2.8572
$Pr[x>a]$:	17.9%
$Q[R a]$:	0.5121

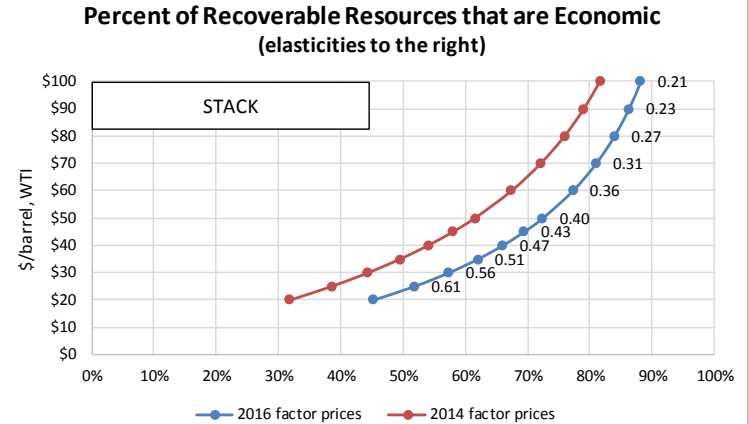
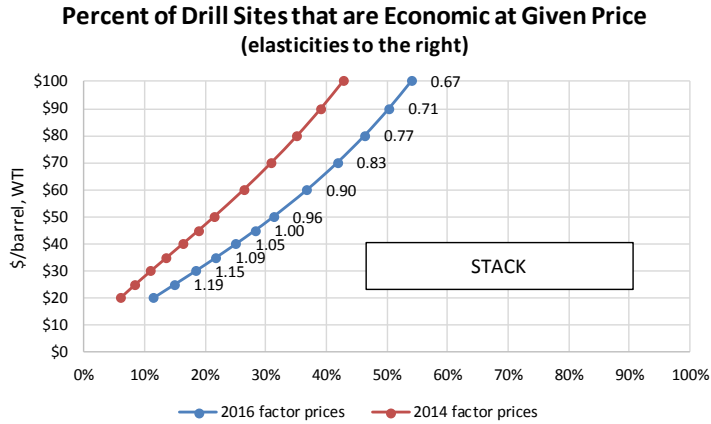


Springer Baseline Results (2016 factor prices)								Springer Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
2.45	\$20	2,655	1.54	4.733	6%	33%	1.35	3.94	\$20	5,052	2.13	8.059	2%	15%	2.50
2.00	\$25	1,911	1.23	3.666	11%	44%	1.02	3.03	\$25	3,246	1.72	5.566	4%	26%	1.75
1.72	\$30	1,493	1.00	3.055	16%	53%	0.82	2.48	\$30	2,391	1.44	4.357	8%	36%	1.34
1.50	\$35	1,225	0.82	2.658	21%	60%	0.68	2.13	\$35	1,893	1.22	3.640	11%	45%	1.09
1.35	\$40	1,039	0.67	2.379	25%	66%	0.58	1.87	\$40	1,566	1.05	3.163	15%	51%	0.91
1.22	\$45	902	0.54	2.172	29%	71%	0.50	1.67	\$45	1,336	0.90	2.823	18%	57%	0.78
1.08	\$50	797	0.43	2.012	33%	75%	0.41	1.46	\$50	1,165	0.78	2.568	22%	62%	0.64
0.92	\$60	646	0.23	1.780	41%	80%	0.32	1.25	\$60	927	0.57	2.210	29%	70%	0.51
0.82	\$70	544	0.08	1.623	47%	84%	0.27	1.10	\$70	770	0.40	1.971	35%	76%	0.42
0.72	\$80	469	-0.06	1.507	52%	87%	0.22	0.97	\$80	658	0.25	1.799	40%	80%	0.35
0.66	\$90	413	-0.18	1.420	57%	90%	0.19	0.88	\$90	575	0.13	1.671	45%	83%	0.30
	\$100	368	-0.29	1.351	61%	91%			\$100	510	0.02	1.570	49%	86%	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

STACK

EUR Distribution	
min:	0.0000
median:	0.5214
mean:	0.9400
μ :	-0.6512
σ :	1.0857
η :	1.5000
mean:	0.9400
stdev:	1.4100
a=b/e eur:	1.3590
transform:	0.8824
$E[x x>a]$:	2.8906
$Pr[x>a]$:	18.9%
$Q[R a]$:	0.5457

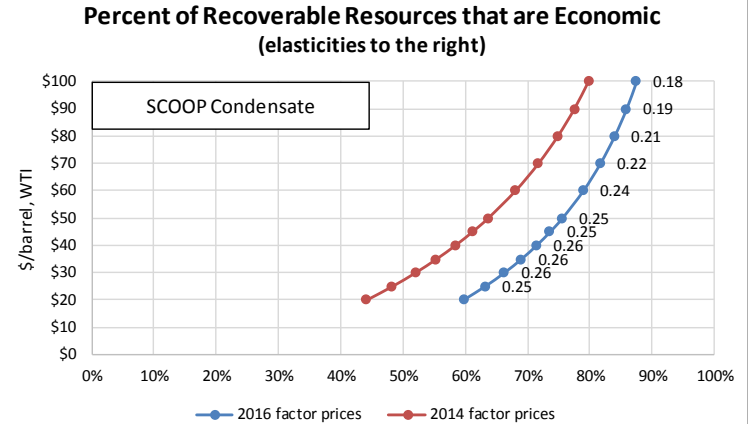
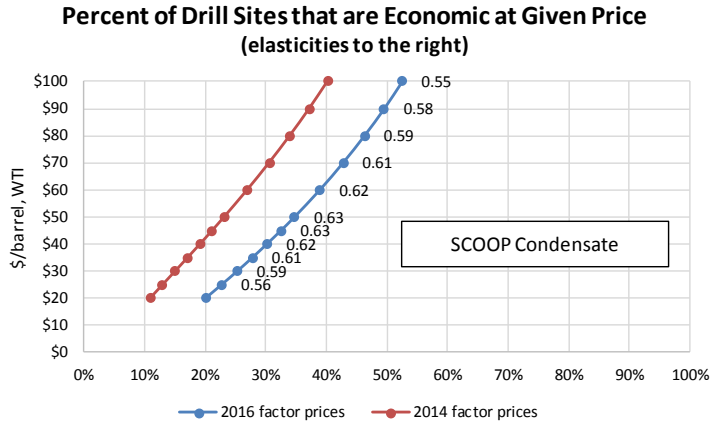


STACK Baseline Results (2016 factor prices)							STACK Sensitivity Results (2014 factor prices, G2=133%)								
% of wells and technical recoverable reserves economic at given price:							% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	1,927	1.20	3.725	11%	45%		\$20	2,829	1.56	5.018	6%	32%		
1.19	\$25	1,612	1.04	3.265	15%	52%	0.61	\$25	2,326	1.38	4.301	8%	39%	0.85	
1.15	\$30	1,385	0.90	2.929	18%	57%	0.56	\$30	1,976	1.23	3.796	11%	44%	0.78	
1.09	\$35	1,215	0.78	2.676	22%	62%	0.51	\$35	1,717	1.10	3.419	14%	50%	0.71	
1.05	\$40	1,082	0.67	2.476	25%	66%	0.47	\$40	1,518	0.98	3.126	16%	54%	0.65	
1.00	\$45	975	0.58	2.314	28%	69%	0.43	\$45	1,360	0.88	2.892	19%	58%	0.61	
0.96	\$50	887	0.49	2.181	31%	72%	0.40	\$50	1,232	0.79	2.701	21%	62%	0.56	
0.90	\$60	752	0.34	1.974	37%	77%	0.36	\$60	1,037	0.63	2.408	26%	67%	0.50	
0.83	\$70	653	0.21	1.822	42%	81%	0.31	\$70	896	0.50	2.194	31%	72%	0.44	
0.77	\$80	577	0.09	1.705	46%	84%	0.27	\$80	788	0.38	2.030	35%	76%	0.39	
0.71	\$90	517	-0.01	1.612	50%	86%	0.23	\$90	704	0.28	1.901	39%	79%	0.34	
0.67	\$100	468	-0.10	1.536	54%	88%	0.21	\$100	636	0.18	1.796	43%	82%	0.31	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

SCOOP Condensate

EUR Distribution	
min:	0.0000
median:	1.0828
mean:	1.9520
μ :	0.0795
σ :	1.0857
η :	1.5000
mean:	1.9520
stdev:	2.9280
a=b/e eur:	1.3590
transform:	0.2093
$E[x x>a]$:	3.7887
$Pr[x>a]$:	41.7%
$Q[R a]$:	1.5803

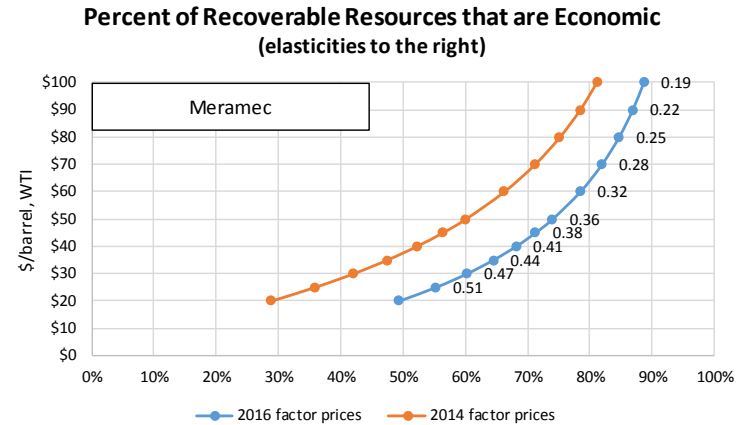
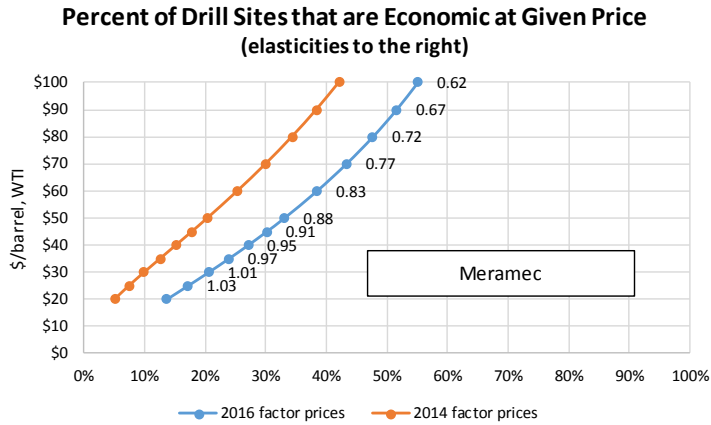


SCOOP Condensate Baseline Results (2016 factor prices)								SCOOP Condensate Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.56	\$20	2,692	0.84	5.809	20%	60%	0.25	0.78	\$20	4,131	1.23	7.923	11%	44%	0.40
0.59	\$25	2,439	0.75	5.431	23%	63%	0.26	0.82	\$25	3,689	1.13	7.280	13%	48%	0.41
0.61	\$30	2,229	0.67	5.115	25%	66%	0.26	0.84	\$30	3,333	1.04	6.758	15%	52%	0.41
0.62	\$35	2,053	0.59	4.849	28%	69%	0.26	0.85	\$35	3,040	0.95	6.326	17%	55%	0.40
0.63	\$40	1,903	0.52	4.622	30%	71%	0.25	0.85	\$40	2,794	0.87	5.961	19%	58%	0.38
0.63	\$45	1,773	0.45	4.424	32%	74%	0.25	0.85	\$45	2,585	0.80	5.649	21%	61%	0.37
0.63	\$50	1,659	0.39	4.249	35%	76%	0.24	0.85	\$50	2,405	0.74	5.380	23%	64%	0.34
0.62	\$60	1,471	0.28	3.961	39%	79%	0.22	0.84	\$60	2,111	0.61	4.937	27%	68%	0.32
0.61	\$70	1,322	0.18	3.732	43%	82%	0.21	0.82	\$70	1,881	0.51	4.588	31%	72%	0.30
0.59	\$80	1,200	0.09	3.543	46%	84%	0.19	0.80	\$80	1,696	0.41	4.306	34%	75%	0.27
0.58	\$90	1,098	0.01	3.386	49%	86%	0.18	0.77	\$90	1,544	0.33	4.073	37%	78%	0.25
0.55	\$100	1,013	-0.06	3.254	52%	87%	0.18	0.74	\$100	1,418	0.25	3.880	40%	80%	0.22

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Meramec

EUR Distribution	
min:	0.0000
median:	0.7422
mean:	1.3380
μ :	-0.2982
σ :	1.0857
η :	1.5000
mean:	1.3380
stdev:	2.0070
a=b/e eur:	1.3590
transform:	0.5572
$E[x x>a]$:	3.2507
$Pr[x>a]$:	28.9%
$Q[R a]$:	0.9385

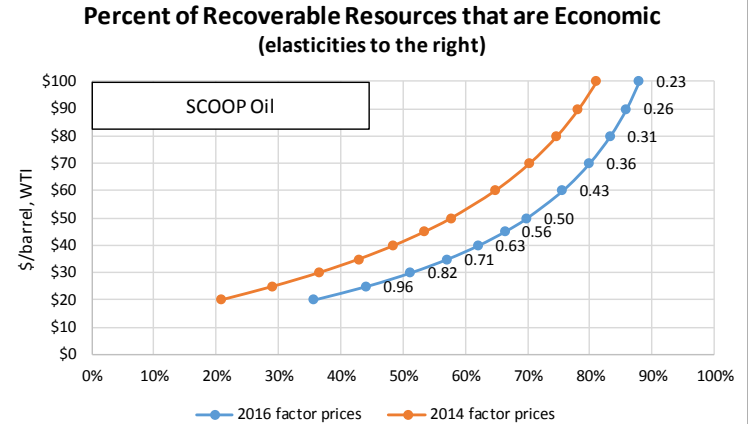
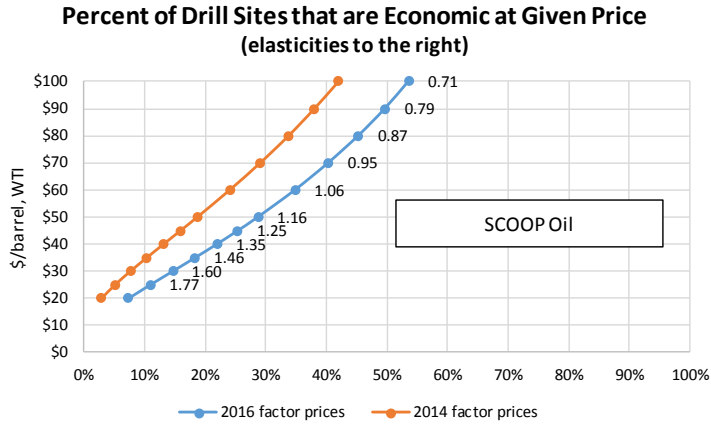


Meramec Baseline Results (2016 factor prices)							Meramec Sensitivity Results (2014 factor prices, G2=133%)								
% of wells and technical recoverable reserves economic at given price:							% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
1.03	\$20	2,450	1.10	4.875	14%	49%	0.51	1.72	\$20	4,419	1.64	7.697	5%	29%	0.97
1.01	\$25	2,086	0.95	4.339	17%	55%	0.47	1.61	\$25	3,574	1.45	6.499	7%	36%	0.87
0.97	\$30	1,816	0.82	3.938	20%	60%	0.44	1.51	\$30	3,000	1.29	5.675	10%	42%	0.79
0.95	\$35	1,609	0.71	3.628	24%	65%	0.41	1.42	\$35	2,585	1.15	5.072	13%	47%	0.72
0.91	\$40	1,443	0.61	3.378	27%	68%	0.38	1.35	\$40	2,271	1.03	4.612	15%	52%	0.66
0.88	\$45	1,309	0.52	3.175	30%	71%	0.36	1.28	\$45	2,025	0.92	4.249	18%	56%	0.60
0.83	\$50	1,197	0.44	3.004	33%	74%	0.32	1.19	\$50	1,827	0.83	3.955	20%	60%	0.54
0.77	\$60	1,023	0.30	2.738	38%	79%	0.28	1.10	\$60	1,529	0.67	3.508	25%	66%	0.47
0.72	\$70	893	0.17	2.538	43%	82%	0.25	1.01	\$70	1,314	0.53	3.182	30%	71%	0.41
0.67	\$80	792	0.06	2.382	48%	85%	0.22	0.94	\$80	1,152	0.40	2.935	34%	75%	0.36
0.62	\$90	712	-0.04	2.258	52%	87%	0.19	0.87	\$90	1,025	0.30	2.741	38%	78%	0.32
	\$100	647	-0.13	2.157	55%	89%			\$100	924	0.20	2.585	42%	81%	0.22

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

SCOOP Oil

EUR Distribution	
min:	0.0000
median:	0.5431
mean:	0.9790
μ :	-0.6106
σ :	1.0857
η :	1.5000
mean:	0.9790
stdev:	1.4685
a=b/e eur:	1.3590
transform:	0.8449
$E[x x>a]$:	2.9266
$Pr[x>a]$:	19.9%
$Q[R a]$:	0.5826

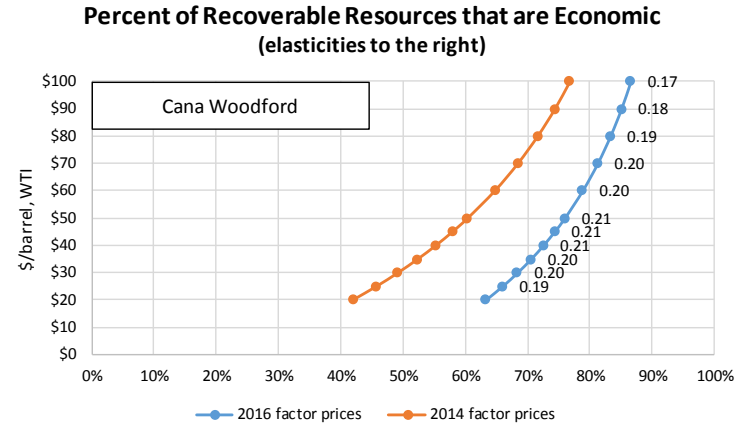
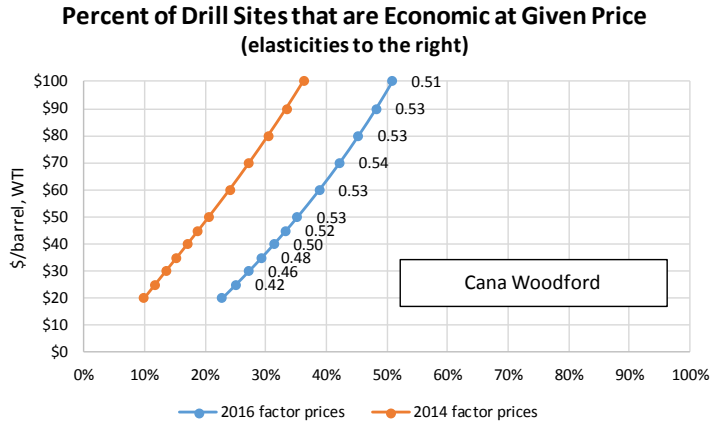


SCOOP Oil Baseline Results (2016 factor prices)								SCOOP Oil Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
1.77	\$20	2,630	1.45	4.776	7%	36%	0.96	2.50	\$20	4,269	1.90	7.077	3%	21%	1.50
1.60	\$25	2,069	1.23	3.970	11%	44%	0.82	2.19	\$25	3,207	1.64	5.595	5%	29%	1.24
1.46	\$30	1,705	1.05	3.438	15%	51%	0.71	1.95	\$30	2,568	1.43	4.688	8%	36%	1.05
1.35	\$35	1,450	0.90	3.062	18%	57%	0.63	1.78	\$35	2,142	1.26	4.075	10%	43%	0.92
1.25	\$40	1,261	0.78	2.780	22%	62%	0.56	1.64	\$40	1,837	1.12	3.632	13%	49%	0.82
1.16	\$45	1,116	0.66	2.562	25%	66%	0.50	1.53	\$45	1,608	1.00	3.296	16%	53%	0.73
1.06	\$50	1,001	0.56	2.389	29%	70%	0.43	1.38	\$50	1,429	0.89	3.031	19%	58%	0.63
0.95	\$60	830	0.39	2.128	35%	76%	0.36	1.23	\$60	1,170	0.71	2.644	24%	65%	0.53
0.87	\$70	709	0.25	1.942	40%	80%	0.31	1.12	\$70	990	0.55	2.372	29%	70%	0.45
0.79	\$80	618	0.12	1.802	45%	83%	0.26	1.01	\$80	858	0.42	2.171	34%	75%	0.39
0.71	\$90	548	0.01	1.694	50%	86%	0.23	0.94	\$90	758	0.31	2.018	38%	78%	0.35
0.71	\$100	493	-0.09	1.609	54%	88%	0.23	0.94	\$100	678	0.20	1.895	42%	81%	0.35

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Cana Woodford

EUR Distribution	
min:	0.0000
median:	1.0129
mean:	1.8260
μ :	0.0128
σ :	1.0857
η :	1.5000
mean:	1.8260
stdev:	2.7390
a=b/e eur:	1.3590
transform:	0.2708
$E[x x>a]$:	3.6792
$Pr[x>a]$:	39.3%
$Q[R a]$:	1.4470

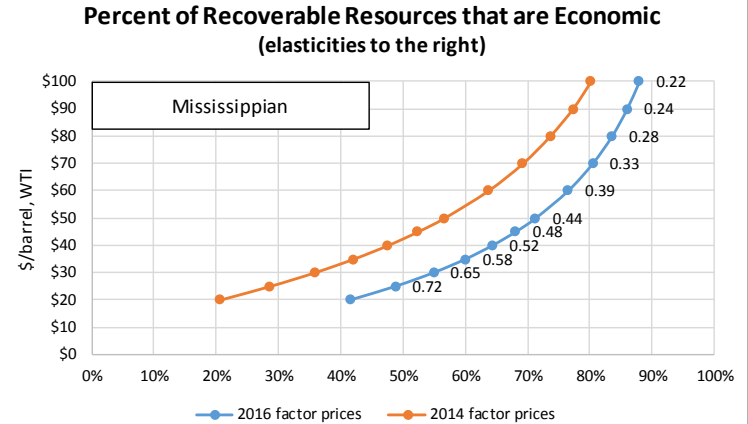
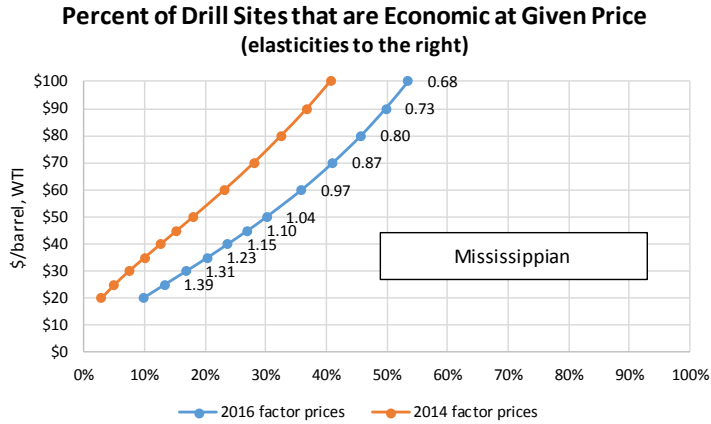


Cana Woodford Baseline Results (2016 factor prices)								Cana Woodford Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.42	\$20	2,277	0.75	5.073	23%	63%	0.19	0.74	\$20	4,104	1.29	7.758	10%	42%	0.39
0.46	\$25	2,106	0.67	4.816	25%	66%	0.20	0.79	\$25	3,697	1.19	7.168	12%	46%	0.40
0.48	\$30	1,959	0.61	4.594	27%	68%	0.20	0.81	\$30	3,364	1.11	6.683	13%	49%	0.41
0.50	\$35	1,831	0.55	4.400	29%	71%	0.21	0.83	\$35	3,086	1.03	6.275	15%	52%	0.41
0.52	\$40	1,719	0.49	4.230	31%	73%	0.21	0.84	\$40	2,850	0.95	5.927	17%	55%	0.41
0.53	\$45	1,620	0.43	4.079	33%	74%	0.21	0.84	\$45	2,648	0.89	5.627	19%	58%	0.40
0.53	\$50	1,531	0.38	3.943	35%	76%	0.21	0.85	\$50	2,473	0.82	5.367	21%	60%	0.39
0.53	\$60	1,381	0.29	3.713	39%	79%	0.20	0.85	\$60	2,183	0.71	4.932	24%	65%	0.38
0.54	\$70	1,257	0.20	3.522	42%	81%	0.20	0.83	\$70	1,955	0.61	4.588	27%	68%	0.36
0.53	\$80	1,154	0.12	3.363	45%	83%	0.19	0.81	\$80	1,770	0.51	4.308	30%	72%	0.34
0.53	\$90	1,066	0.05	3.227	48%	85%	0.18	0.80	\$90	1,616	0.43	4.073	33%	74%	0.32
0.51	\$100	991	-0.02	3.111	51%	87%	0.17	0.77	\$100	1,487	0.35	3.876	36%	77%	0.30

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Mississippi

EUR Distribution	
min:	0.0000
median:	0.2274
mean:	0.4100
μ :	-1.4809
σ :	1.0857
η :	1.5000
mean:	0.4100
stdev:	0.6150
a=b/e eur:	1.3590
transform:	1.6466
$E[x x>a]$:	2.3654
$Pr[x>a]$:	5.0%
$Q[R a]$:	0.1178

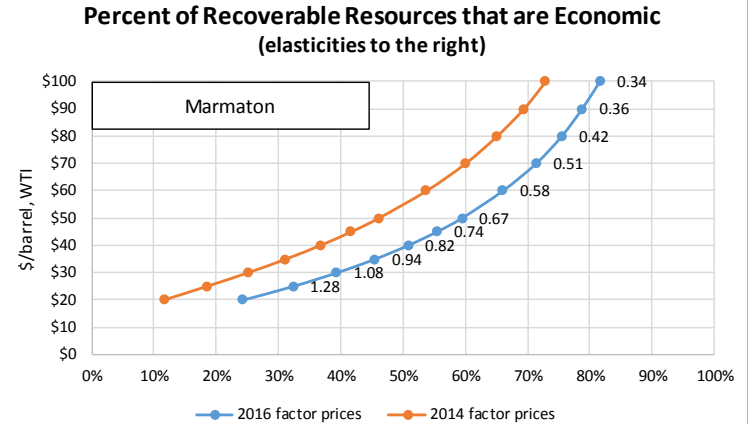
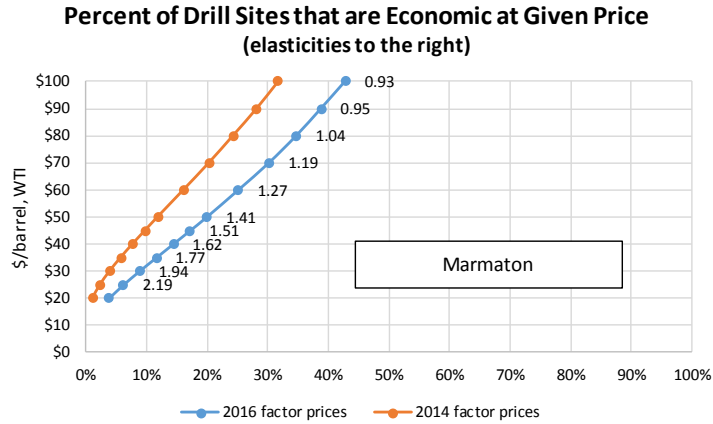


Mississippi Baseline Results (2016 factor prices)								Mississippi Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
1.39	\$20	931	1.30	1.756	10%	42%	0.72	2.44	\$20	1,799	1.90	2.979	3%	21%	1.46
1.31	\$25	763	1.11	1.512	13%	49%	0.65	2.15	\$25	1,363	1.65	2.371	5%	29%	1.22
1.23	\$30	646	0.96	1.340	17%	55%	0.58	1.93	\$30	1,097	1.45	1.994	7%	36%	1.05
1.15	\$35	560	0.83	1.212	20%	60%	0.52	1.77	\$35	918	1.29	1.737	10%	42%	0.92
1.10	\$40	495	0.72	1.115	24%	64%	0.48	1.63	\$40	789	1.15	1.550	13%	48%	0.82
1.04	\$45	443	0.61	1.036	27%	68%	0.44	1.53	\$45	692	1.02	1.408	15%	52%	0.74
0.97	\$50	401	0.52	0.973	30%	71%	0.39	1.39	\$50	616	0.92	1.295	18%	57%	0.64
0.87	\$60	337	0.36	0.875	36%	77%	0.33	1.24	\$60	505	0.73	1.130	23%	64%	0.54
0.80	\$70	291	0.23	0.804	41%	80%	0.28	1.12	\$70	428	0.58	1.014	28%	69%	0.46
0.73	\$80	256	0.11	0.750	46%	84%	0.24	1.05	\$80	372	0.45	0.929	33%	74%	0.41
0.68	\$90	229	0.01	0.709	50%	86%	0.22	0.95	\$90	328	0.34	0.861	37%	77%	0.35
0.68	\$100	207	-0.09	0.675	53%	88%	0.22	0.95	\$100	294	0.24	0.809	41%	80%	0.35

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Marmaton

EUR Distribution	
min:	0.0000
median:	0.1115
mean:	0.2010
μ :	-2.1938
σ :	1.0857
η :	1.5000
mean:	0.2010
stdev:	0.3015
a=b/e eur:	1.3590
transform:	2.3032
$E[x x>a]$:	2.1114
$Pr[x>a]$:	1.1%
$Q[R a]$:	0.0225

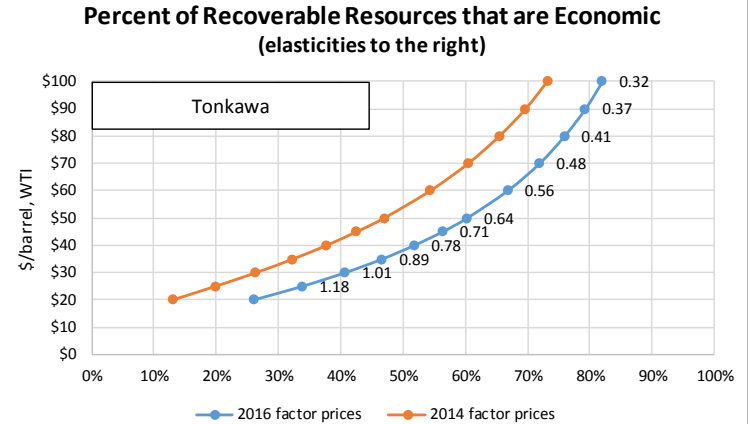
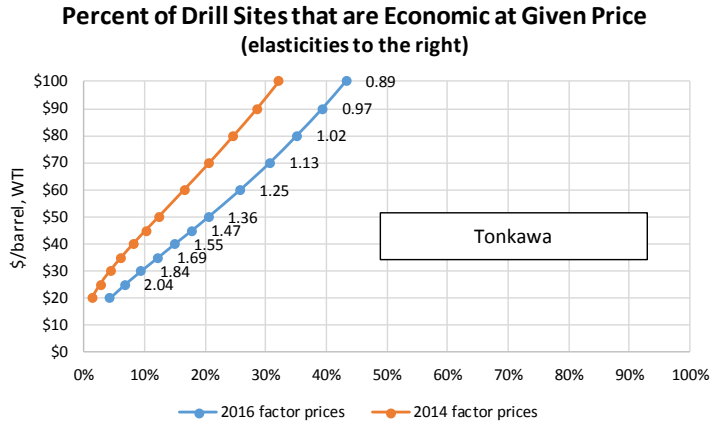


Marmaton Baseline Results (2016 factor prices)								Marmaton Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
2.19	\$20	771	1.78	1.306	4%	24%	1.28	3.20	\$20	1,326	2.28	2.067	1%	12%	2.06
1.94	\$25	595	1.54	1.059	6%	32%	1.08	2.74	\$25	959	1.98	1.567	2%	19%	1.67
1.77	\$30	485	1.35	0.902	9%	39%	0.94	2.42	\$30	751	1.76	1.279	4%	25%	1.41
1.62	\$35	409	1.20	0.792	12%	46%	0.82	2.17	\$35	617	1.58	1.090	6%	31%	1.22
1.51	\$40	354	1.06	0.712	14%	51%	0.74	2.00	\$40	524	1.43	0.958	8%	37%	1.08
1.41	\$45	312	0.95	0.650	17%	55%	0.67	1.82	\$45	455	1.30	0.859	10%	42%	0.95
1.27	\$50	279	0.84	0.601	20%	60%	0.58	1.68	\$50	403	1.18	0.783	12%	46%	0.84
1.19	\$60	231	0.67	0.529	25%	66%	0.51	1.50	\$60	327	0.99	0.672	16%	54%	0.72
1.04	\$70	196	0.52	0.476	30%	71%	0.42	1.33	\$70	275	0.83	0.595	20%	60%	0.60
0.95	\$80	171	0.39	0.438	35%	76%	0.36	1.26	\$80	238	0.70	0.539	24%	65%	0.55
0.93	\$90	152	0.29	0.409	39%	79%	0.34	1.13	\$90	209	0.58	0.496	28%	69%	0.47
	\$100	136	0.18	0.384	43%	82%	0.34		\$100	187	0.48	0.462	32%	73%	0.47

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Tonkawa

EUR Distribution	
min:	0.0000
median:	0.1381
mean:	0.2490
μ :	-1.9796
σ :	1.0857
η :	1.5000
mean:	0.2490
stdev:	0.3735
a=b/e eur:	1.3590
transform:	2.1060
$E[x x>a]$:	2.1754
$Pr[x>a]$:	1.8%
$Q[R a]$:	0.0383

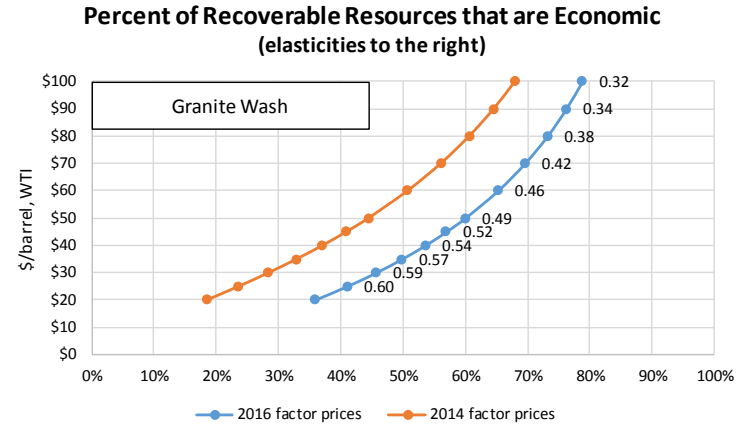
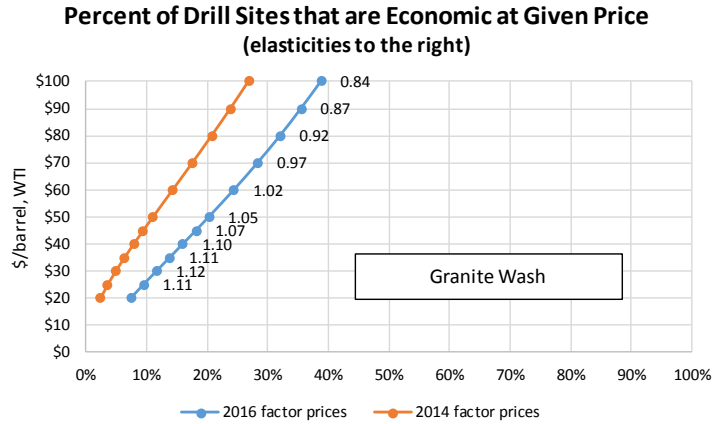


Tonkawa Baseline Results (2016 factor prices)								Tonkawa Sensitivity Results (2014 factor prices, G2=133%)								
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity	
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$		
2.04	\$20	901	1.73	1.543	4%	26%	1.18	2.96	\$20	1,525	2.21	2.401	1%	13%	1.88	
1.84	\$25	705	1.50	1.266	7%	34%		2.57	\$25	1,125	1.93	1.854	3%	20%		
1.69	\$30	579	1.32	1.086	9%	41%		1.01	\$30	891	1.72	1.529	4%	26%		1.55
1.55	\$35	491	1.17	0.958	12%	47%		0.89	\$35	738	1.54	1.313	6%	32%		1.32
1.47	\$40	427	1.04	0.865	15%	52%		0.78	\$40	630	1.40	1.159	8%	38%		1.15
1.36	\$45	377	0.92	0.791	18%	56%		0.71	\$45	550	1.27	1.044	10%	43%		1.02
1.25	\$50	338	0.82	0.733	20%	60%		0.64	\$50	487	1.16	0.953	12%	47%		0.94
1.13	\$60	280	0.65	0.646	26%	67%		0.56	\$60	398	0.97	0.822	16%	54%		0.80
1.02	\$70	239	0.51	0.584	31%	72%		0.48	\$70	336	0.82	0.730	21%	61%		0.69
0.97	\$80	209	0.38	0.538	35%	76%		0.41	\$80	291	0.69	0.663	25%	66%		0.59
0.89	\$90	185	0.27	0.501	39%	79%	0.37	\$90	256	0.57	0.610	28%	70%	0.53		
	\$100	166	0.17	0.472	43%	82%	0.32	\$100	229	0.47	0.569	32%	73%	0.46		

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Granite Wash

EUR Distribution	
min:	0.0000
median:	0.4083
mean:	0.7360
μ :	-0.8959
σ :	1.0857
η :	1.5000
mean:	0.7360
stdev:	1.1040
a=b/e eur:	1.3590
transform:	1.1077
$E[x x>a]$:	2.6981
$Pr[x>a]$:	13.4%
$Q[R a]$:	0.3615

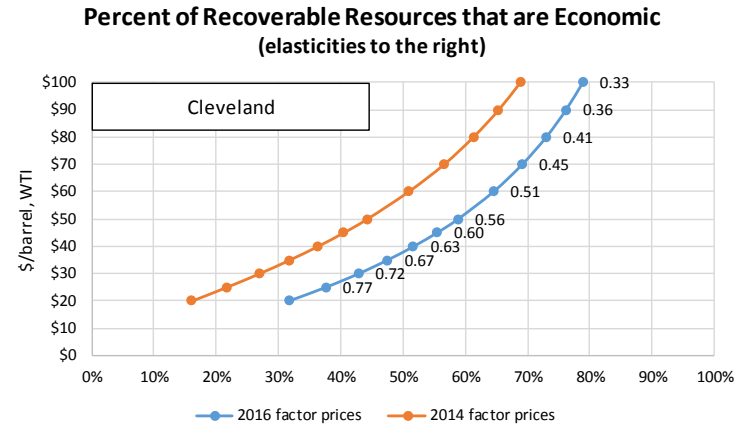
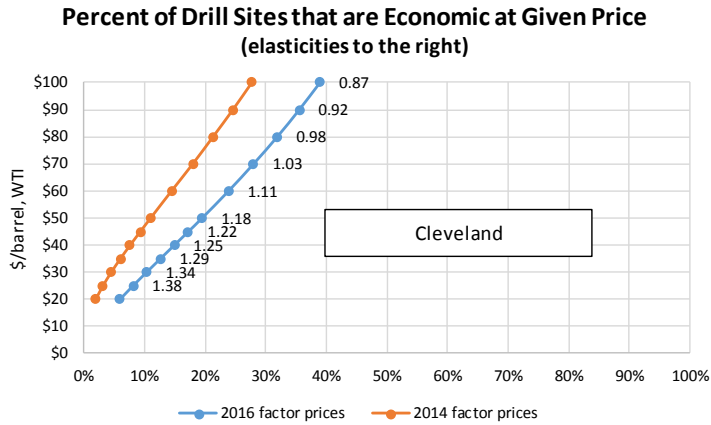


Granite Wash Baseline Results (2016 factor prices)								Granite Wash Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
1.11	\$20	1,964	1.45	3.572	7%	36%	0.60	1.80	\$20	3,518	1.98	5.746	2%	18%	1.10
1.12	\$25	1,696	1.31	3.187	9%	41%	0.59	1.74	\$25	2,899	1.81	4.889	4%	24%	1.02
1.11	\$30	1,492	1.19	2.892	12%	46%	0.57	1.68	\$30	2,466	1.66	4.283	5%	28%	0.96
1.11	\$35	1,332	1.09	2.659	14%	50%	0.57	1.68	\$35	2,145	1.53	3.830	6%	33%	0.96
1.10	\$40	1,203	1.00	2.469	16%	54%	0.54	1.61	\$40	1,898	1.42	3.478	8%	37%	0.89
1.07	\$45	1,097	0.91	2.312	18%	57%	0.52	1.55	\$45	1,702	1.32	3.196	9%	41%	0.84
1.05	\$50	1,008	0.83	2.180	20%	60%	0.49	1.49	\$50	1,543	1.22	2.966	11%	44%	0.79
1.02	\$60	867	0.69	1.969	24%	65%	0.46	1.42	\$60	1,300	1.07	2.612	14%	51%	0.73
0.97	\$70	761	0.57	1.809	28%	70%	0.42	1.33	\$70	1,123	0.93	2.351	18%	56%	0.65
0.92	\$80	678	0.47	1.682	32%	73%	0.38	1.25	\$80	989	0.81	2.151	21%	61%	0.59
0.87	\$90	612	0.37	1.582	35%	76%	0.34	1.19	\$90	883	0.71	1.993	24%	65%	0.54
0.84	\$100	557	0.29	1.497	39%	79%	0.32	1.12	\$100	798	0.62	1.865	27%	68%	0.49

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Cleveland

EUR Distribution	
min:	0.0000
median:	0.1287
mean:	0.2320
μ :	-2.0503
σ :	1.0857
η :	1.5000
mean:	0.2320
stdev:	0.3480
a=b/e eur:	1.3590
transform:	2.1711
$E[x x>a]$:	2.1533
$Pr[x>a]$:	1.5%
$Q[R a]$:	0.0322

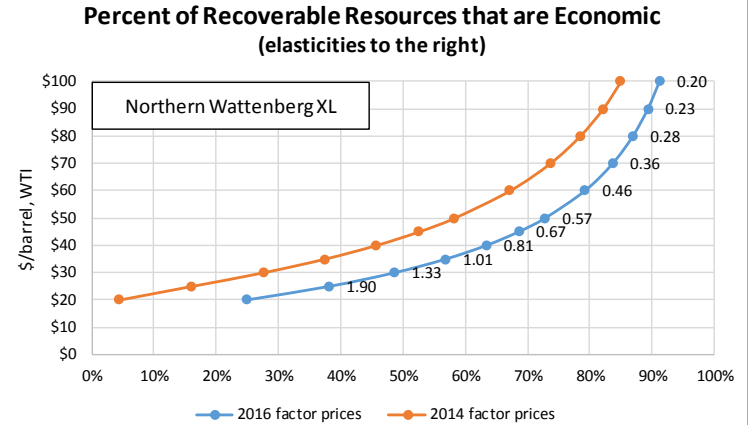
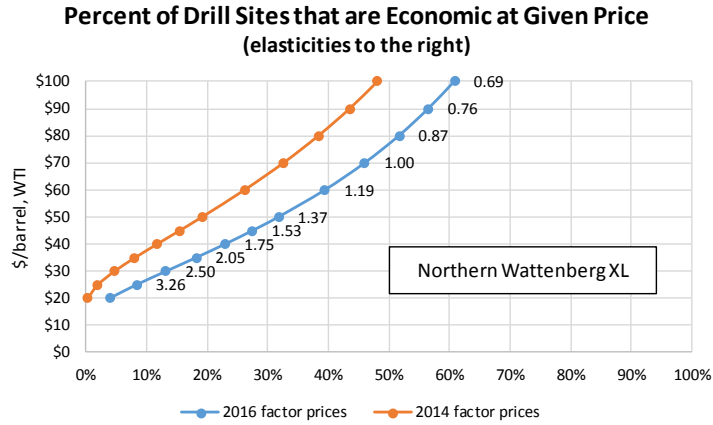


Cleveland Baseline Results (2016 factor prices)								Cleveland Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
1.38	\$20	701	1.56	1.242	6%	32%	0.77	2.14	\$20	1,225	2.08	1.971	2%	16%	1.32
1.34	\$25	589	1.40	1.083	8%	38%	0.72	2.01	\$25	979	1.87	1.632	3%	22%	1.19
1.29	\$30	508	1.26	0.966	10%	43%	0.67	1.87	\$30	815	1.70	1.403	4%	27%	1.08
1.25	\$35	447	1.15	0.878	13%	48%	0.63	1.79	\$35	699	1.56	1.240	6%	32%	1.00
1.22	\$40	399	1.04	0.807	15%	52%	0.60	1.69	\$40	611	1.43	1.114	8%	36%	0.92
1.18	\$45	360	0.95	0.750	17%	55%	0.56	1.60	\$45	543	1.33	1.017	9%	40%	0.85
1.11	\$50	328	0.86	0.702	19%	59%	0.51	1.50	\$50	489	1.23	0.939	11%	44%	0.77
1.03	\$60	279	0.71	0.629	24%	65%	0.45	1.41	\$60	408	1.06	0.821	14%	51%	0.69
0.98	\$70	243	0.59	0.575	28%	69%	0.41	1.28	\$70	349	0.92	0.734	18%	57%	0.60
0.92	\$80	215	0.47	0.532	32%	73%	0.36	1.22	\$80	306	0.80	0.670	21%	61%	0.55
0.87	\$90	193	0.37	0.499	35%	76%	0.33	1.14	\$90	272	0.69	0.619	25%	65%	0.49
	\$100	175	0.28	0.471	39%	79%			\$100	245	0.59	0.578	28%	69%	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Northern Wattenberg XL

EUR Distribution	
min:	0.0000
median:	0.4033
mean:	0.7270
μ :	-0.9082
σ :	1.0857
η :	1.5000
mean:	0.7270
stdev:	1.0905
a=b/e eur:	1.3590
transform:	1.1190
$E[x x>a]$:	2.6894
$Pr[x>a]$:	13.2%
$Q[R a]$:	0.3538

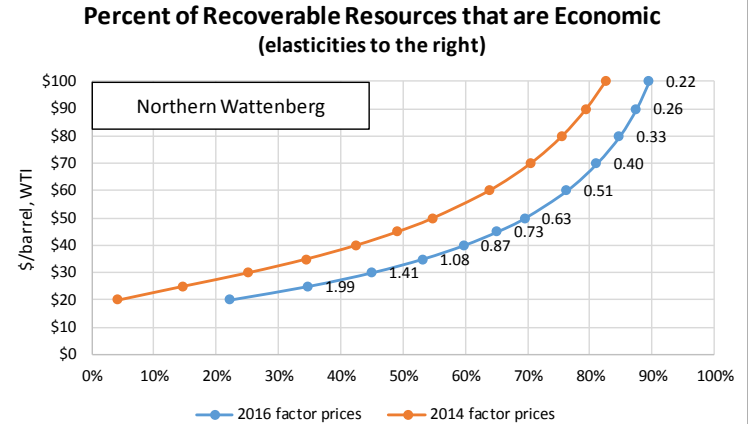
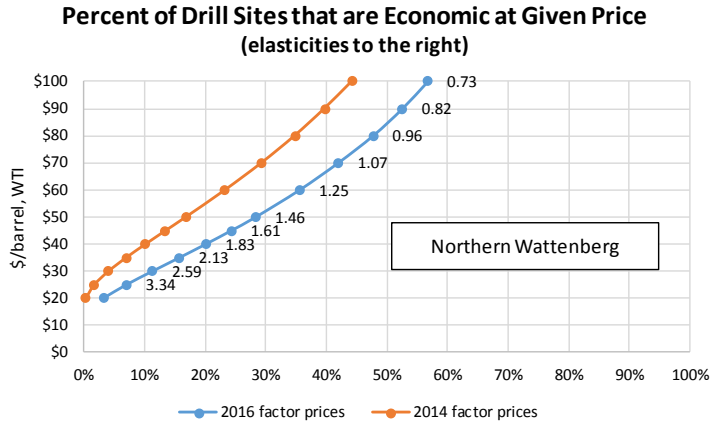


Northern Wattenberg XL Baseline Results (2016 factor prices)							Northern Wattenberg XL Sensitivity Results (2014 factor prices, G2=133%)								
% of wells and technical recoverable reserves economic at given price:							% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	2,736	1.76	4.652	4%	25%		\$20	8,237	2.78	12.049	0%	5%		
3.26	\$25	1,814	1.39	3.348	8%	38%	1.90	\$25	3,831	2.07	6.164	2%	16%	5.06	
2.50	\$30	1,357	1.12	2.686	13%	49%	1.33	\$30	2,496	1.68	4.316	5%	28%	2.89	
2.05	\$35	1,084	0.91	2.285	18%	57%	1.01	\$35	1,851	1.40	3.401	8%	38%	1.97	
1.75	\$40	902	0.74	2.013	23%	63%	0.81	\$40	1,471	1.19	2.853	12%	46%	1.48	
1.53	\$45	773	0.60	1.819	27%	69%	0.67	\$45	1,220	1.02	2.485	15%	53%	1.19	
1.37	\$50	676	0.48	1.671	32%	73%	0.57	\$50	1,043	0.88	2.224	19%	58%	0.98	
1.19	\$60	540	0.27	1.463	39%	79%	0.46	\$60	808	0.64	1.872	26%	67%	0.78	
1.00	\$70	450	0.10	1.324	46%	84%	0.36	\$70	659	0.45	1.645	33%	74%	0.60	
0.87	\$80	386	-0.04	1.225	52%	87%	0.28	\$80	557	0.30	1.489	38%	78%	0.47	
0.76	\$90	338	-0.16	1.151	56%	89%	0.23	\$90	482	0.16	1.374	43%	82%	0.39	
0.69	\$100	300	-0.27	1.093	61%	91%	0.20	\$100	425	0.05	1.286	48%	85%	0.33	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Northern Wattenberg

EUR Distribution	
min:	0.0000
median:	0.1980
mean:	0.3570
μ :	-1.6193
σ :	1.0857
η :	1.5000
mean:	0.3570
stdev:	0.5355
a=b/e eur:	1.3590
transform:	1.7741
$E[x x>a]$:	2.3059
$Pr[x>a]$:	3.8%
$Q[R a]$:	0.0877

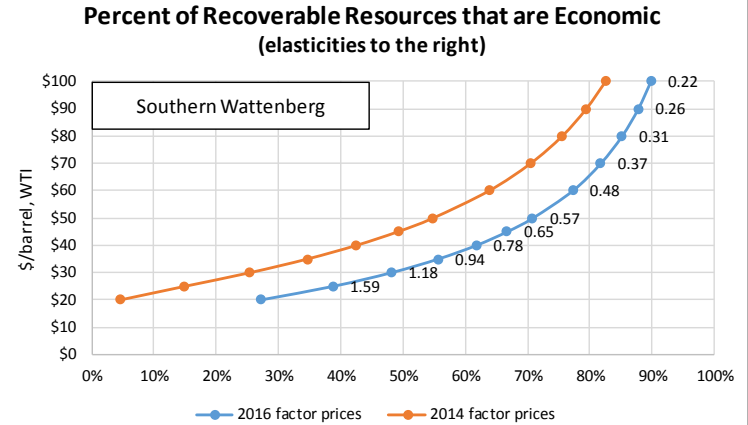
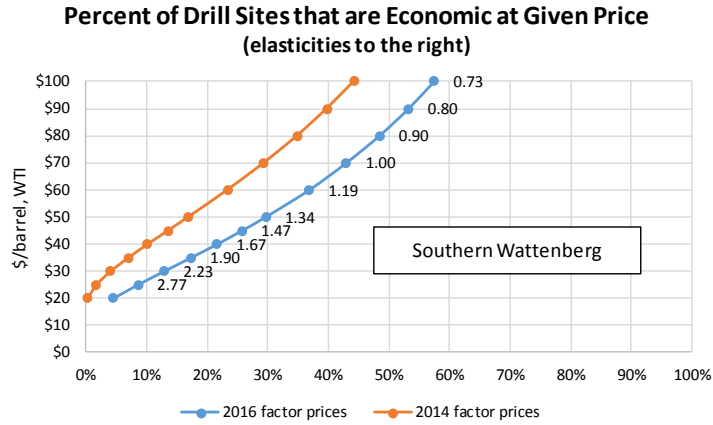


Northern Wattenberg Baseline Results (2016 factor prices)								Northern Wattenberg Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
3.34	\$20	1,476	1.85	2.469	3%	22%	1.99	6.59	\$20	4,158	2.80	6.065	0%	4%	4.93
2.59	\$25	983	1.48	1.776	7%	35%	1.41	4.59	\$25	2,016	2.14	3.211	2%	15%	2.91
2.13	\$30	737	1.21	1.422	11%	45%	1.08	3.49	\$30	1,331	1.75	2.267	4%	25%	2.03
1.83	\$35	590	1.01	1.207	16%	53%	0.87	2.84	\$35	993	1.49	1.790	7%	34%	1.55
1.61	\$40	492	0.84	1.062	20%	60%	0.73	2.40	\$40	792	1.28	1.502	10%	42%	1.25
1.46	\$45	422	0.70	0.957	24%	65%	0.63	2.11	\$45	659	1.11	1.308	13%	49%	1.04
1.25	\$50	369	0.57	0.877	28%	70%	0.51	1.78	\$50	564	0.96	1.169	17%	55%	0.84
1.07	\$60	296	0.37	0.766	36%	76%	0.40	1.50	\$60	438	0.73	0.981	23%	64%	0.65
0.96	\$70	247	0.20	0.691	42%	81%	0.33	1.29	\$70	358	0.55	0.860	29%	71%	0.52
0.82	\$80	211	0.06	0.635	48%	85%	0.26	1.13	\$80	303	0.39	0.777	35%	76%	0.43
0.73	\$90	185	-0.06	0.595	52%	87%	0.22	1.02	\$90	263	0.26	0.715	40%	80%	0.37
0.73	\$100	165	-0.17	0.564	57%	90%	0.22	1.02	\$100	232	0.15	0.667	44%	83%	0.37

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Southern Wattenberg

EUR Distribution	
min:	0.0000
median:	0.2191
mean:	0.3950
μ :	-1.5182
σ :	1.0857
η :	1.5000
mean:	0.3950
stdev:	0.5925
a=b/e eur:	1.3590
transform:	1.6810
$E[x x>a]$:	2.3488
$Pr[x>a]$:	4.6%
$Q[R a]$:	0.1089

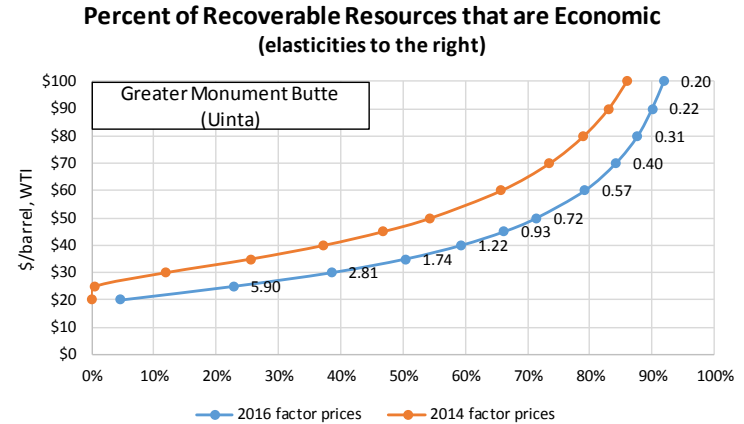
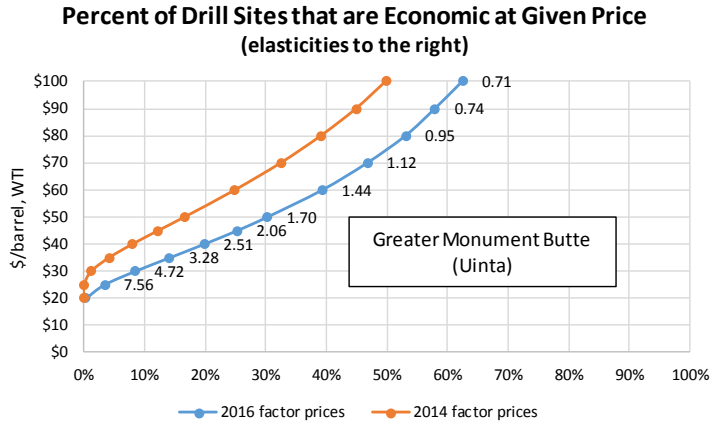


Southern Wattenberg Baseline Results (2016 factor prices)								Southern Wattenberg Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	1,379	1.69	2.377	5%	27%		\$20	4,432	2.77	6.490	0%	5%		
2.77	\$25	970	1.37	1.797	9%	39%	1.59	\$25	2,194	2.12	3.503	2%	15%	4.77	
2.23	\$30	749	1.13	1.477	13%	48%	1.18	\$30	1,458	1.75	2.488	4%	25%	2.84	
1.90	\$35	610	0.94	1.272	17%	56%	0.94	\$35	1,092	1.48	1.971	7%	35%	1.99	
1.67	\$40	514	0.79	1.130	22%	62%	0.78	\$40	873	1.27	1.657	10%	43%	1.53	
1.47	\$45	445	0.65	1.026	26%	67%	0.65	\$45	727	1.10	1.445	13%	49%	1.24	
1.34	\$50	392	0.54	0.946	30%	71%	0.57	\$50	623	0.96	1.292	17%	55%	1.03	
1.19	\$60	316	0.34	0.830	37%	77%	0.48	\$60	484	0.73	1.085	23%	64%	0.83	
1.00	\$70	266	0.18	0.753	43%	82%	0.37	\$70	396	0.55	0.952	29%	71%	0.64	
0.90	\$80	229	0.04	0.696	48%	85%	0.31	\$80	335	0.39	0.859	35%	76%	0.52	
0.80	\$90	201	-0.08	0.652	53%	88%	0.26	\$90	291	0.26	0.791	40%	80%	0.42	
0.73	\$100	179	-0.19	0.618	57%	90%	0.22	\$100	257	0.15	0.739	44%	83%	0.36	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Greater Monument Butte

EUR Distribution	
min:	0.0000
median:	0.1043
mean:	0.1880
μ :	-2.2606
σ :	1.0857
η :	1.5000
mean:	0.1880
stdev:	0.2820
a=b/e eur:	1.3590
transform:	2.3648
$E[x x>a]$:	2.0932
$Pr[x>a]$:	0.9%
$Q[R a]$:	0.0189

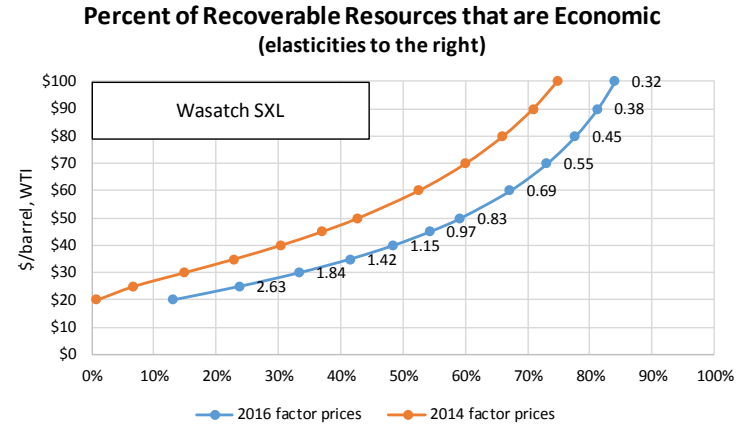
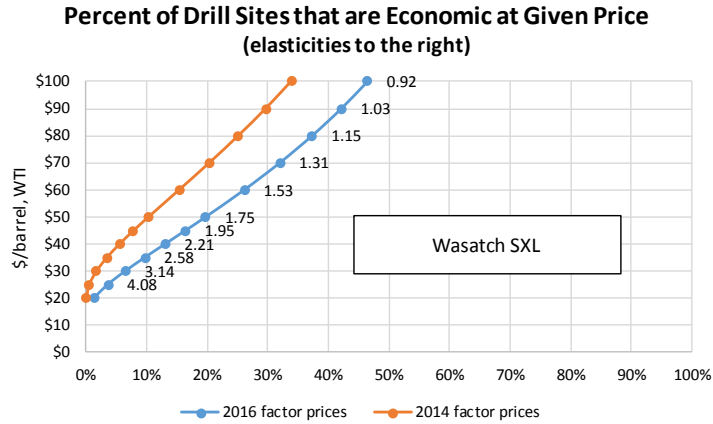


Greater Monument Butte (Uinta) Baseline Results (2016 factor prices)								Greater Monument Butte (Uinta) Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:															
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	2,075	2.75	3.044	0%	5%		\$20	5,200	3.60	7.052	0%	0%		
7.56	\$25	760	1.83	1.276	3%	23%	5.90	\$25	5,200	3.60	7.052	0%	1%		
4.72	\$30	465	1.38	0.860	8%	39%	2.81	\$30	1,220	2.27	1.906	1%	12%	9.95	
3.28	\$35	335	1.07	0.671	14%	50%	1.74	\$35	691	1.74	1.180	4%	26%	4.74	
2.51	\$40	262	0.85	0.564	20%	59%	1.22	\$40	482	1.41	0.884	8%	37%	2.79	
2.06	\$45	215	0.67	0.493	25%	66%	0.93	\$45	370	1.17	0.723	12%	47%	1.92	
1.70	\$50	183	0.52	0.445	30%	71%	0.72	\$50	300	0.97	0.620	17%	54%	1.44	
1.44	\$60	140	0.27	0.379	39%	79%	0.57	\$60	218	0.68	0.498	25%	66%	1.03	
1.12	\$70	114	0.08	0.339	47%	84%	0.40	\$70	171	0.46	0.426	32%	74%	0.73	
0.95	\$80	96	-0.08	0.311	53%	88%	0.31	\$80	141	0.28	0.380	39%	79%	0.54	
0.74	\$90	84	-0.20	0.292	58%	90%	0.22	\$90	120	0.13	0.348	45%	83%	0.42	
0.71	\$100	74	-0.32	0.277	62%	92%	0.20	\$100	105	0.01	0.325	50%	86%	0.33	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Wasatch SXL

EUR Distribution	
min:	0.0000
median:	0.5547
mean:	1.0000
μ :	-0.5893
σ :	1.0857
η :	1.5000
mean:	1.0000
stdev:	1.5000
a=b/e eur:	1.3590
transform:	0.8254
$E[x x>a]$:	2.9459
$Pr[x>a]$:	20.5%
$Q[R a]$:	0.6027

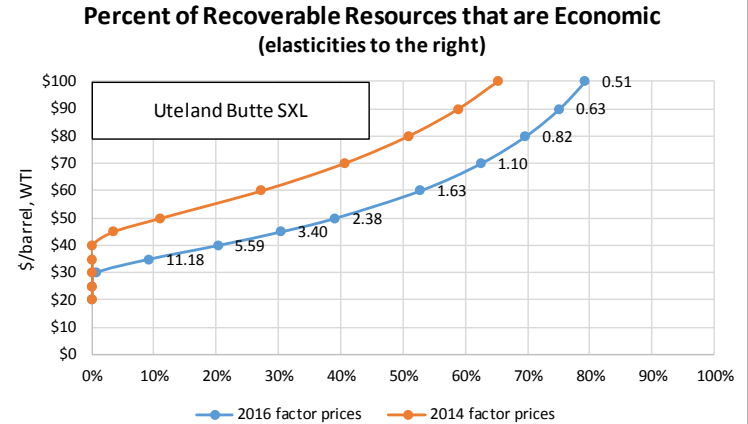
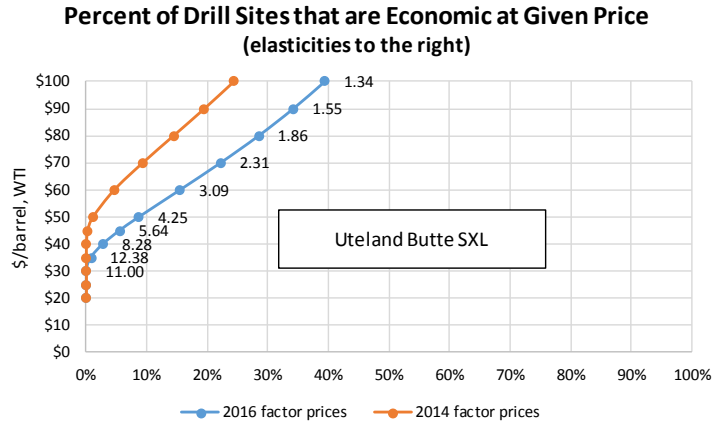


Wasatch SXL Baseline Results (2016 factor prices)								Wasatch SXL Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	6,114	2.21	9.629	1%	13%		\$20	24,862	3.50	33.972	0%	1%		
4.08	\$25	3,913	1.80	6.607	4%	24%	2.63	\$25	9,138	2.58	13.682	0%	7%	7.13	
3.14	\$30	2,877	1.52	5.150	6%	33%	1.84	\$30	5,598	2.13	8.928	2%	15%	4.12	
2.58	\$35	2,275	1.30	4.288	10%	42%	1.42	\$35	4,035	1.83	6.777	3%	23%	2.78	
2.21	\$40	1,881	1.12	3.716	13%	48%	1.15	\$40	3,154	1.60	5.543	5%	30%	2.09	
1.95	\$45	1,604	0.98	3.310	16%	54%	0.97	\$45	2,589	1.42	4.740	8%	37%	1.67	
1.75	\$50	1,398	0.85	3.004	20%	59%	0.83	\$50	2,196	1.27	4.174	10%	43%	1.39	
1.53	\$60	1,112	0.64	2.575	26%	67%	0.69	\$60	1,684	1.02	3.427	15%	53%	1.12	
1.31	\$70	923	0.47	2.289	32%	73%	0.55	\$70	1,366	0.83	2.956	20%	60%	0.88	
1.15	\$80	789	0.32	2.084	37%	78%	0.45	\$80	1,149	0.67	2.631	25%	66%	0.71	
1.03	\$90	689	0.20	1.930	42%	81%	0.38	\$90	991	0.53	2.392	30%	71%	0.60	
0.92	\$100	612	0.09	1.811	46%	84%	0.32	\$100	872	0.42	2.211	34%	75%	0.51	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Uteland Butte SXL

EUR Distribution	
min:	0.0000
median:	0.3883
mean:	0.7000
μ :	-0.9460
σ :	1.0857
η :	1.5000
mean:	0.7000
stdev:	1.0500
a=b/e eur:	1.3590
transform:	1.1539
$E[x x>a]$:	2.6632
$Pr[x>a]$:	12.4%
$Q[R a]$:	0.3310

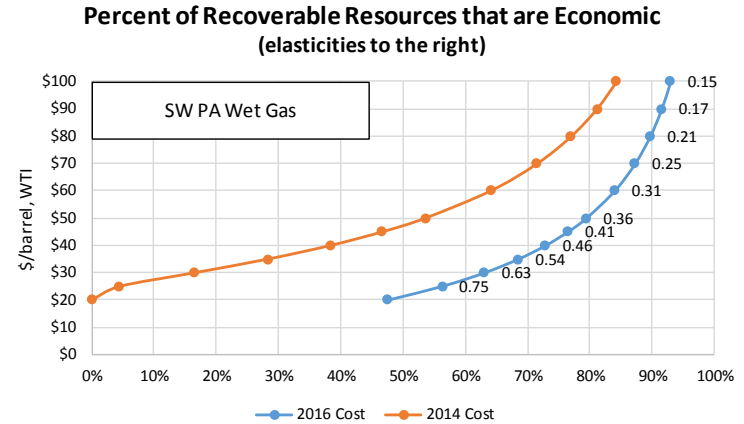
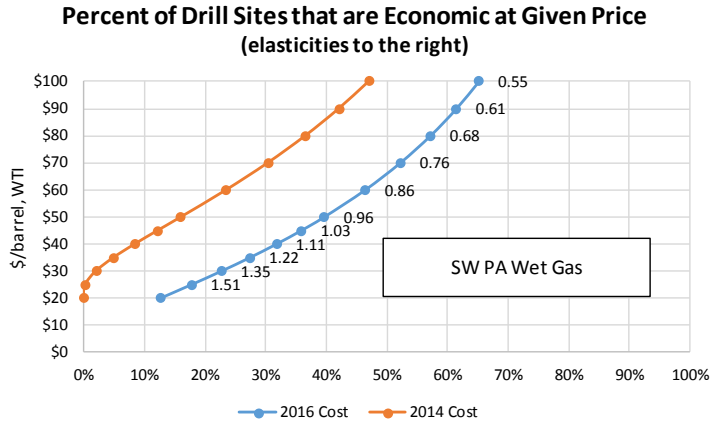


Uteland Butte SXL Baseline Results (2016 factor prices)								Uteland Butte SXL Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:															
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20				0%	0%		\$20					0%	0%	
	\$25				0%	0%		\$25					0%	0%	
11.00	\$30	18,221	3.54	24.815	0%	1%		\$30					0%	0%	
12.38	\$35	5,315	2.41	8.136	1%	9%	11.18	\$35					0%	0%	
8.28	\$40	3,112	1.92	5.142	3%	20%	5.59	\$40	94,438	5.06	117.891		0%	0%	
5.64	\$45	2,200	1.60	3.869	6%	30%	3.40	\$45	9,025	2.90	13.032		0%	3%	16.97
4.25	\$50	1,701	1.36	3.158	9%	39%	2.38	\$50	4,739	2.30	7.361		1%	11%	9.92
3.09	\$60	1,171	1.02	2.388	15%	53%	1.63	\$60	2,431	1.69	4.194		5%	27%	4.62
2.31	\$70	893	0.77	1.975	22%	62%	1.10	\$70	1,635	1.32	3.063		9%	41%	2.54
1.86	\$80	721	0.57	1.716	28%	70%	0.82	\$80	1,232	1.06	2.477		14%	51%	1.69
1.55	\$90	605	0.41	1.539	34%	75%	0.63	\$90	988	0.86	2.117		19%	59%	1.24
1.34	\$100	521	0.27	1.410	39%	79%	0.51	\$100	825	0.69	1.873		24%	65%	0.97

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

SW PA Wet Gas

EUR Distribution	
min:	0.0000
median:	1.6269
mean:	2.9330
μ :	0.4867
σ :	1.0857
η :	1.5000
mean:	2.9330
stdev:	4.3995
a=b/e eur:	1.3590
transform:	-0.1658
$E[x > a]$:	4.6373
$Pr[x > a]$:	56.6%
$Q[R a]$:	2.6239

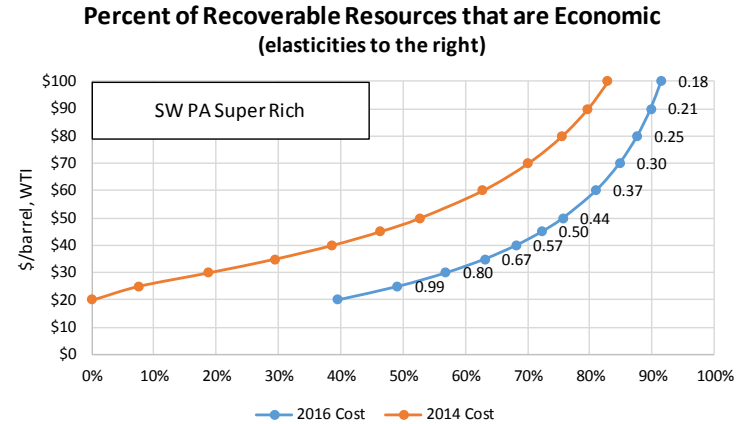
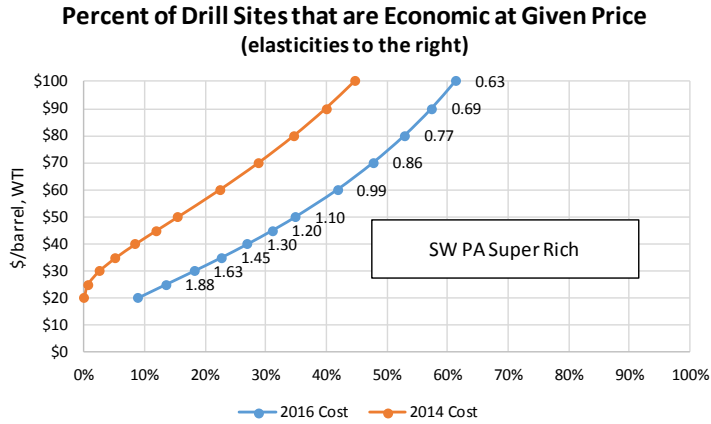


SW PA Wet Gas Baseline Results (2016 factor prices)								SW PA Wet Gas Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x > a]$	$Pr[x > a]$	$Q[R a]$	
1.51	\$20	5,642	1.15	11.083	13%	48%	0.75	#NUM!	\$20	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1.35	\$25	4,451	0.93	9.332	18%	56%	0.63	8.33	\$25	33,191	2.78	48.558	0%	5%	#NUM!
1.22	\$30	3,675	0.75	8.175	23%	63%	0.63	3.06	\$30	15,197	2.06	24.515	2%	17%	6.27
1.11	\$35	3,129	0.60	7.353	27%	69%	0.54	5.47	\$35	9,855	1.66	17.109	5%	28%	3.41
1.03	\$40	2,725	0.48	6.740	32%	73%	0.46	3.98	\$40	7,291	1.38	13.468	8%	38%	2.26
1.03	\$45	2,413	0.36	6.263	36%	77%	0.41	3.13	\$45	5,786	1.17	11.293	12%	47%	1.66
0.96	\$50	2,165	0.26	5.882	40%	79%	0.36	2.60	\$50	4,796	1.00	9.842	16%	54%	1.30
0.86	\$60	1,796	0.09	5.313	46%	84%	0.31	2.08	\$60	3,573	0.72	8.022	23%	64%	0.98
0.76	\$70	1,534	-0.05	4.908	52%	87%	0.25	1.66	\$70	2,847	0.52	6.925	30%	72%	0.72
0.68	\$80	1,339	-0.18	4.606	57%	90%	0.21	1.39	\$80	2,367	0.35	6.192	36%	77%	0.55
0.61	\$90	1,188	-0.29	4.374	61%	92%	0.17	1.20	\$90	2,025	0.20	5.667	42%	81%	0.44
0.55	\$100	1,068	-0.39	4.189	65%	93%	0.15	1.05	\$100	1,769	0.08	5.271	47%	84%	0.36

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

SW PA Super Rich

EUR Distribution	
min:	0.0000
median:	1.1926
mean:	2.1500
μ :	0.1761
σ :	1.0857
η :	1.5000
mean:	2.1500
stdev:	3.2250
a=b/e eur:	1.3590
transform:	0.1203
$E[x x>a]$:	3.9603
$Pr[x>a]$:	45.2%
$Q[R a]$:	1.7906

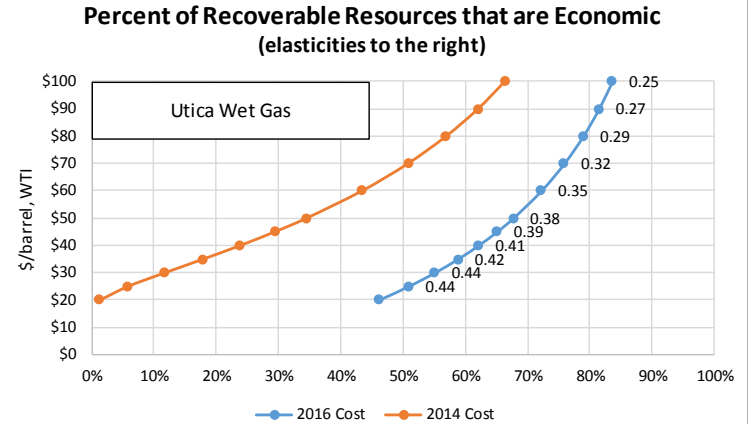
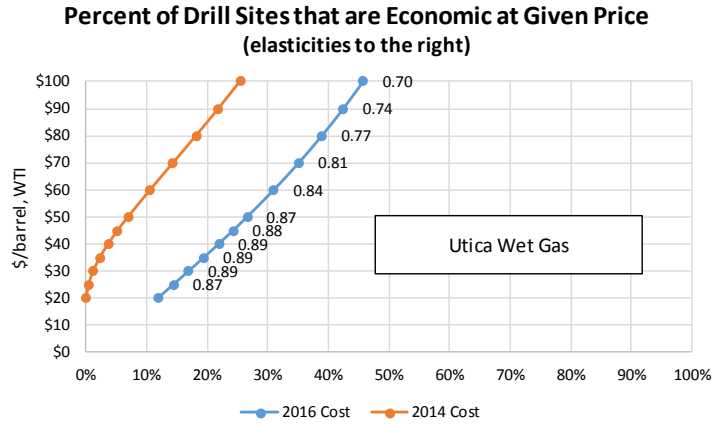


SW PA Super Rich Baseline Results (2016 factor prices)								SW PA Super Rich Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
1.88	\$20	5,180	1.35	9.636	9%	39%	0.99	8.95	\$20	106,843	4.14	139.708	0%	0%	8.73
1.63	\$25	3,960	1.11	7.867	13%	49%	0.80	6.79	\$25	18,483	2.52	27.870	1%	8%	4.73
1.45	\$30	3,205	0.91	6.755	18%	57%	0.67	4.69	\$30	10,116	1.97	16.564	2%	19%	2.86
1.30	\$35	2,691	0.75	5.988	23%	63%	0.57	3.57	\$35	6,964	1.63	12.175	5%	29%	2.01
1.20	\$40	2,320	0.61	5.430	27%	68%	0.50	2.89	\$40	5,309	1.38	9.821	8%	39%	1.54
1.10	\$45	2,038	0.49	5.002	31%	72%	0.44	2.45	\$45	4,290	1.18	8.349	12%	46%	1.24
0.99	\$50	1,818	0.39	4.666	35%	76%	0.37	2.01	\$50	3,599	1.02	7.337	15%	53%	0.96
0.86	\$60	1,494	0.21	4.169	42%	81%	0.30	1.64	\$60	2,722	0.76	6.035	22%	63%	0.71
0.77	\$70	1,269	0.06	3.821	48%	85%	0.25	1.39	\$70	2,189	0.56	5.231	29%	70%	0.56
0.69	\$80	1,102	-0.07	3.563	53%	88%	0.21	1.20	\$80	1,830	0.39	4.685	35%	76%	0.46
0.63	\$90	974	-0.19	3.365	57%	90%	0.18	1.07	\$90	1,573	0.26	4.290	40%	80%	0.38
0.63	\$100	873	-0.29	3.209	61%	92%	0.18	1.07	\$100	1,379	0.13	3.991	45%	83%	0.38

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Utica Wet Gas

EUR Distribution	
min:	0.0000
median:	1.6641
mean:	3.0000
μ :	0.5093
σ :	1.0857
η :	1.5000
mean:	3.0000
stdev:	4.5000
a=b/e eur:	1.3590
transform:	-0.1866
$E[x x > a]$:	4.6953
$Pr[x > a]$:	57.4%
$Q[R a]$:	2.6951

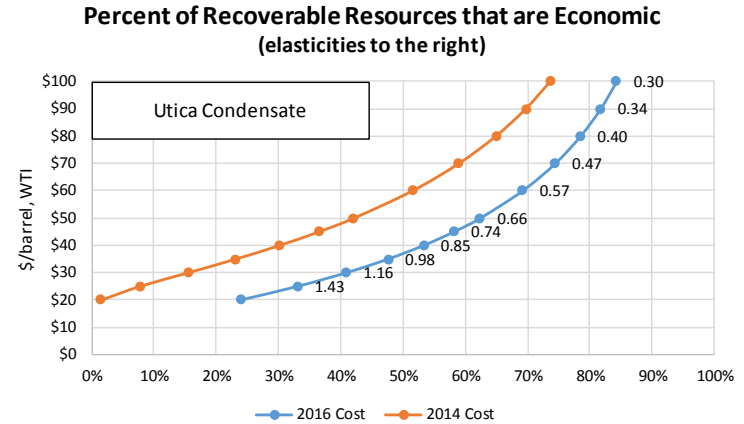
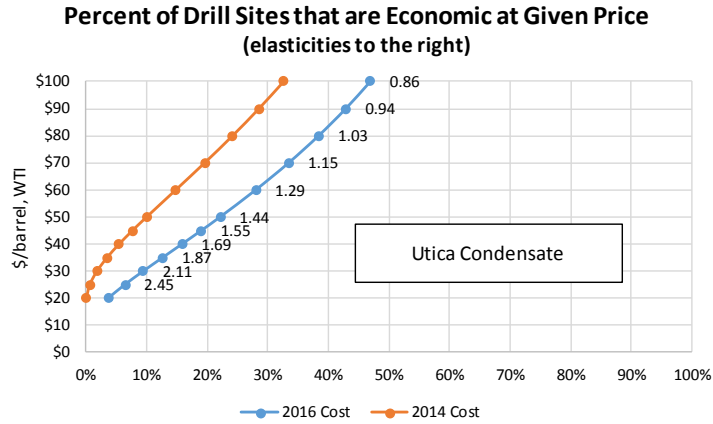


Utica Wet Gas Baseline Results (2016 factor prices)								Utica Wet Gas Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
0.87	\$20	6,006	1.18	11.679	12%	46%	0.44	7.19	\$20	61,623	3.33	85.430	0%	1%	5.80
0.89	\$25	5,277	1.06	10.613	14%	51%	0.44	5.38	\$25	29,830	2.66	44.244	0%	6%	3.72
0.89	\$30	4,706	0.96	9.772	17%	55%	0.44	5.38	\$30	19,678	2.28	30.696	1%	12%	3.72
0.89	\$35	4,246	0.86	9.090	19%	59%	0.42	4.22	\$35	14,681	2.01	23.891	2%	18%	2.71
0.89	\$40	3,868	0.78	8.525	22%	62%	0.41	3.51	\$40	11,708	1.80	19.778	4%	24%	2.14
0.88	\$45	3,552	0.70	8.051	24%	65%	0.39	3.03	\$45	9,736	1.63	17.015	5%	29%	1.78
0.87	\$50	3,284	0.63	7.647	27%	68%	0.38	2.69	\$50	8,333	1.48	15.027	7%	35%	1.52
0.84	\$60	2,853	0.50	6.994	31%	72%	0.35	2.31	\$60	6,469	1.25	12.351	11%	43%	1.26
0.81	\$70	2,522	0.38	6.488	35%	76%	0.32	1.98	\$70	5,286	1.06	10.626	14%	51%	1.02
0.77	\$80	2,260	0.28	6.087	39%	79%	0.29	1.75	\$80	4,469	0.91	9.421	18%	57%	0.85
0.74	\$90	2,047	0.19	5.759	42%	81%	0.27	1.57	\$90	3,870	0.78	8.528	22%	62%	0.73
0.70	\$100	1,871	0.11	5.487	46%	84%	0.25	1.43	\$100	3,413	0.66	7.842	25%	66%	0.64

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Utica Condensate

EUR Distribution	
min:	0.0000
median:	0.6579
mean:	1.1860
μ :	-0.4187
σ :	1.0857
η :	1.5000
mean:	1.1860
stdev:	1.7790
a=b/e eur:	1.3590
transform:	0.6682
$E[x x>a]$:	3.1149
$Pr[x>a]$:	25.2%
$Q[R a]$:	0.7849

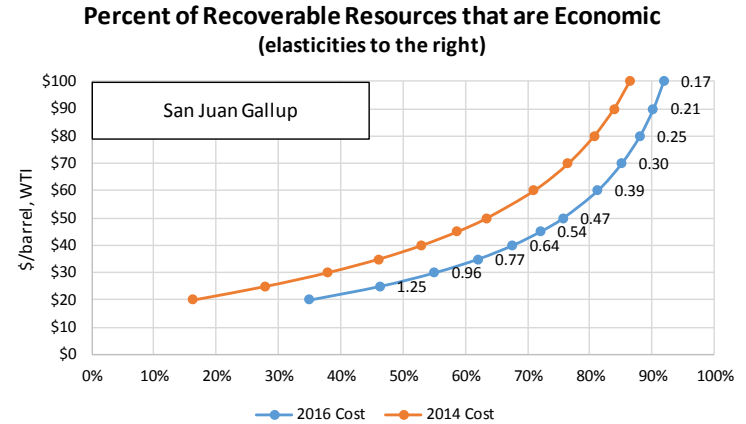
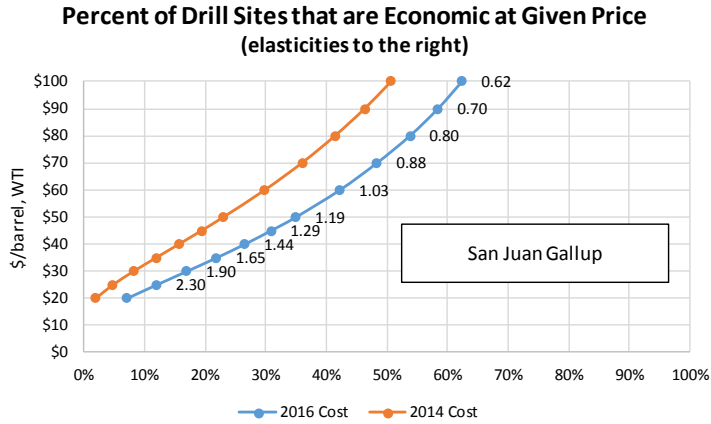


Utica Condensate Baseline Results (2016 factor prices)								Utica Condensate Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
2.45	\$20	4,600	1.79	7.779	4%	24%	1.43	7.47	\$20	22,595	3.26	31.514	0%	1%	6.09
2.11	\$25	3,434	1.52	6.139	6%	33%	1.16	5.42	\$25	10,025	2.51	15.147	1%	8%	3.67
1.87	\$30	2,740	1.31	5.146	9%	41%	0.98	4.13	\$30	6,441	2.10	10.318	2%	15%	2.58
1.69	\$35	2,279	1.14	4.478	13%	48%	0.85	3.37	\$35	4,745	1.82	7.981	3%	23%	1.98
1.55	\$40	1,951	1.00	3.997	16%	53%	0.74	2.87	\$40	3,756	1.60	6.595	5%	30%	1.61
1.44	\$45	1,706	0.88	3.634	19%	58%	0.66	2.52	\$45	3,108	1.43	5.675	8%	37%	1.36
1.29	\$50	1,515	0.77	3.349	22%	62%	0.57	2.14	\$50	2,651	1.28	5.018	10%	42%	1.11
1.15	\$60	1,239	0.58	2.934	28%	69%	0.47	1.81	\$60	2,048	1.05	4.140	15%	52%	0.87
1.03	\$70	1,047	0.43	2.642	33%	74%	0.40	1.58	\$70	1,669	0.86	3.579	20%	59%	0.72
0.94	\$80	907	0.30	2.427	38%	79%	0.34	1.40	\$80	1,408	0.70	3.189	24%	65%	0.61
0.86	\$90	800	0.18	2.262	43%	82%	0.30	1.27	\$90	1,218	0.57	2.902	29%	70%	0.52
	\$100	716	0.08	2.133	47%	84%			\$100	1,073	0.45	2.681	33%	74%	

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

San Juan - Gallup

EUR Distribution	
min:	0.0000
median:	0.2502
mean:	0.4510
μ :	-1.3856
σ :	1.0857
η :	1.5000
mean:	0.4510
stdev:	0.6765
a=b/e eur:	1.3590
transform:	1.5588
$E[x x>a]$:	2.4100
$Pr[x>a]$:	6.0%
$Q[R a]$:	0.1434

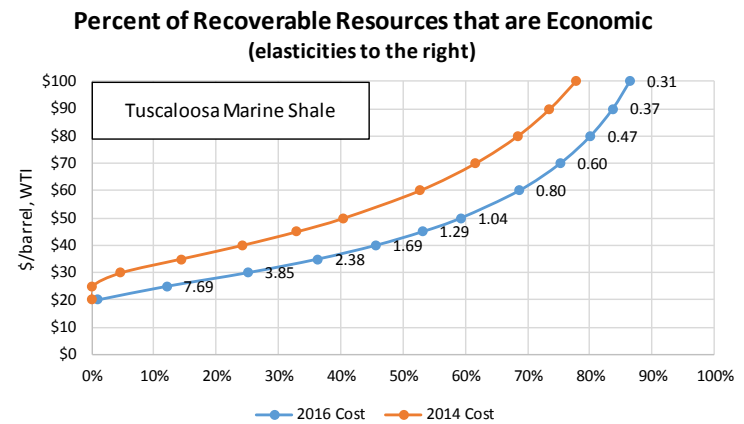
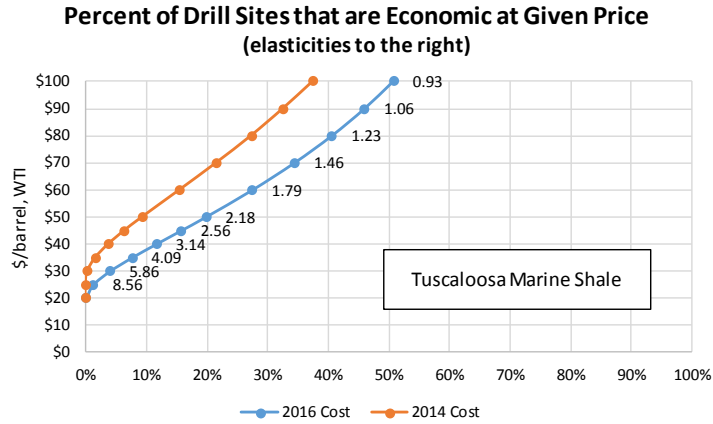


San Juan Gallup Baseline Results (2016 factor prices)								San Juan Gallup Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
2.30	\$20	1,235	1.47	2.234	7%	35%	1.25	3.78	\$20	2,359	2.07	3.800	2%	16%	2.36
1.90	\$25	899	1.18	1.750	12%	46%	0.96	2.91	\$25	1,534	1.67	2.657	5%	28%	1.66
1.65	\$30	707	0.96	1.468	17%	55%	0.77	2.40	\$30	1,137	1.39	2.094	8%	38%	1.28
1.44	\$35	582	0.78	1.282	22%	62%	0.64	2.06	\$35	903	1.18	1.756	12%	46%	1.04
1.29	\$40	495	0.63	1.152	26%	68%	0.54	1.81	\$40	749	1.01	1.530	16%	53%	0.87
1.19	\$45	431	0.50	1.055	31%	72%	0.47	1.62	\$45	640	0.87	1.369	19%	59%	0.74
1.03	\$50	381	0.39	0.978	35%	76%	0.39	1.43	\$50	559	0.74	1.248	23%	63%	0.62
0.88	\$60	310	0.20	0.869	42%	81%	0.30	1.21	\$60	445	0.53	1.076	30%	71%	0.49
0.80	\$70	262	0.04	0.795	48%	85%	0.25	1.06	\$70	370	0.36	0.961	36%	77%	0.39
0.70	\$80	226	-0.09	0.739	54%	88%	0.21	0.95	\$80	317	0.22	0.880	41%	81%	0.33
0.62	\$90	199	-0.21	0.698	58%	90%	0.17	0.85	\$90	277	0.09	0.818	46%	84%	0.28
0.62	\$100	178	-0.31	0.665	62%	92%	0.17	0.85	\$100	246	-0.02	0.770	51%	86%	0.28

Appendix C: Reserve Elasticity & Drill Site Elasticity, 2014 and 2016 Cost scenarios.

Tuscaloosa Marine Shale

EUR Distribution	
min:	0.0000
median:	0.3789
mean:	0.6830
μ :	-0.9706
σ :	1.0857
η :	1.5000
mean:	0.6830
stdev:	1.0245
a=b/e eur:	1.3590
transform:	1.1766
$E[x x>a]$:	2.6466
$Pr[x>a]$:	12.0%
$Q[R a]$:	0.3168

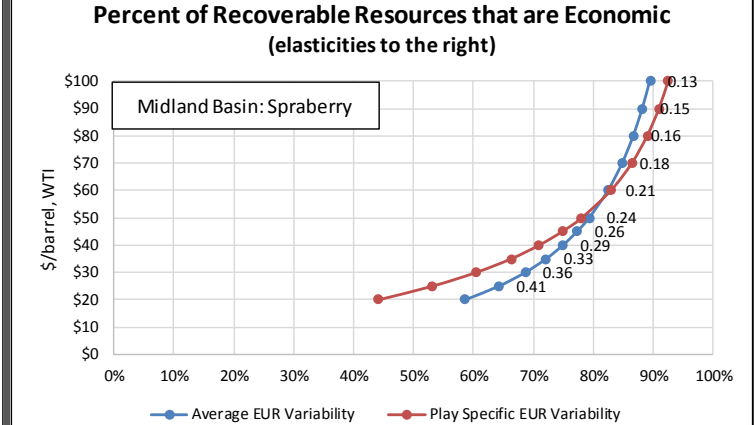
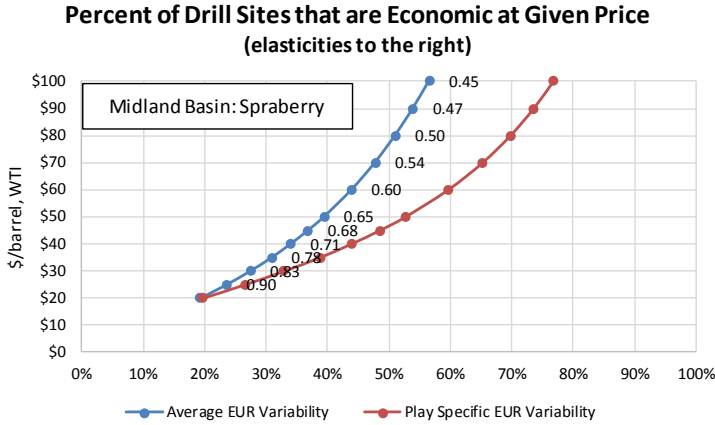


Tuscaloosa Marine Shale Baseline Results (2016 factor prices)								Tuscaloosa Marine Shale Sensitivity Results (2014 factor prices, G2=133%)							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	15,694	3.43	21.570	0%	1%		\$20	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	
8.56	\$25	4,387	2.26	6.863	1%	12%	7.69	#NUM!	115,246	5.27	142.663	0%	0%	#NUM!	#NUM!
5.86	\$30	2,550	1.76	4.342	4%	25%	3.85	11.00	7,566	2.76	11.093	0%	5%	10.99	
4.09	\$35	1,797	1.43	3.278	8%	36%	2.38	8.95	3,911	2.15	6.217	2%	14%	6.56	
3.14	\$40	1,387	1.20	2.687	12%	46%	1.69	6.03	2,637	1.79	4.463	4%	24%	3.82	
2.56	\$45	1,130	1.01	2.311	16%	53%	1.29	4.47	1,989	1.53	3.552	6%	33%	2.62	
2.18	\$50	953	0.85	2.049	20%	59%	1.04	3.56	1,597	1.33	2.991	9%	41%	1.97	
1.79	\$60	726	0.60	1.708	27%	69%	0.80	2.75	1,145	1.02	2.333	15%	53%	1.43	
1.46	\$70	586	0.40	1.495	34%	75%	0.60	2.14	893	0.79	1.960	21%	62%	1.02	
1.23	\$80	491	0.24	1.350	41%	80%	0.47	1.77	731	0.61	1.716	27%	68%	0.79	
1.06	\$90	423	0.10	1.245	46%	84%	0.37	1.50	620	0.45	1.547	33%	74%	0.62	
0.93	\$100	372	-0.02	1.166	51%	86%	0.31	1.33	537	0.32	1.420	37%	78%	0.52	

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Midland Basin Spraberry

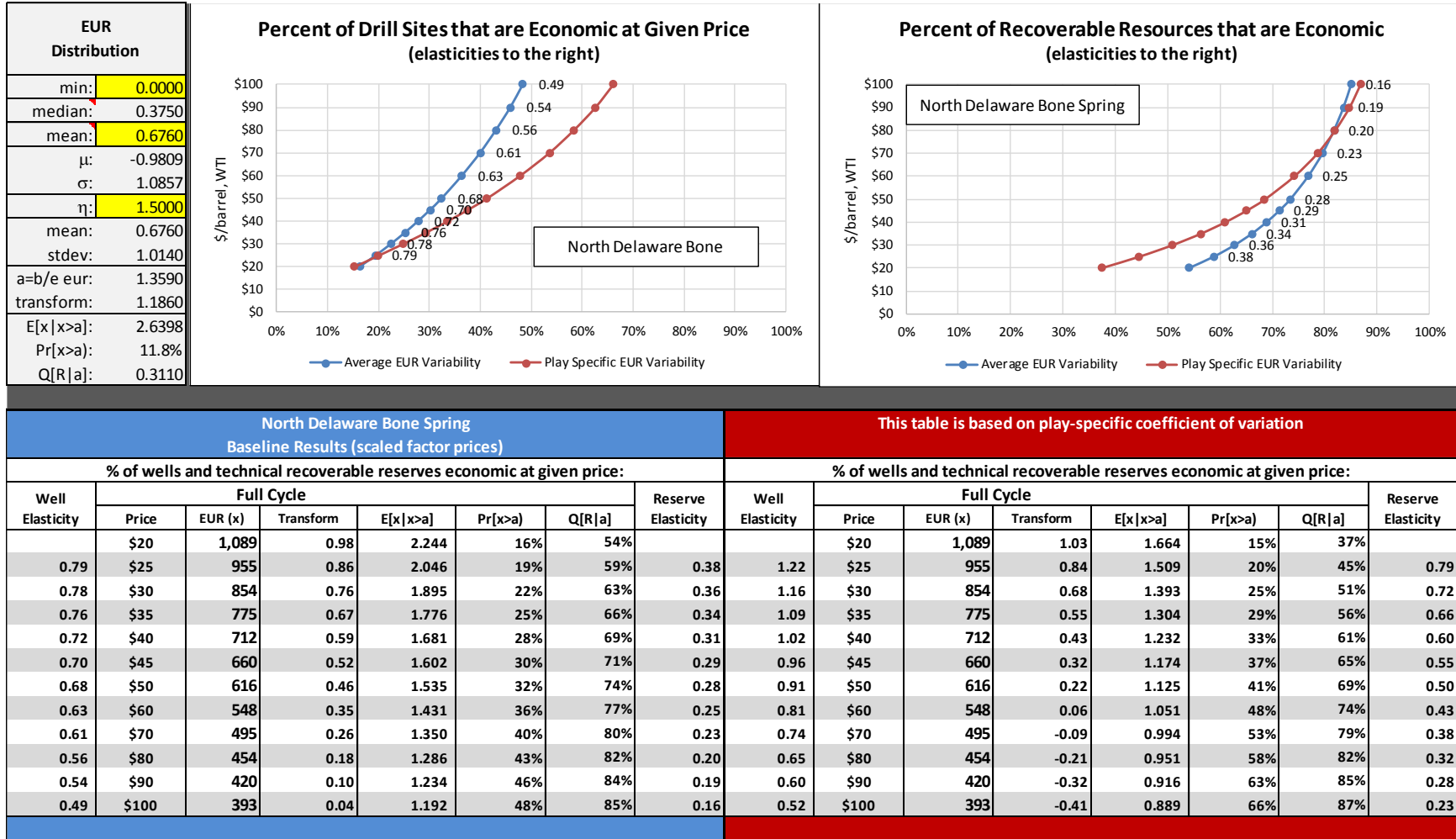
EUR Distribution	
min:	0.0000
median:	0.4177
mean:	0.7530
μ :	-0.8730
σ :	1.0857
η :	1.5000
mean:	0.7530
stdev:	1.1295
a=b/e eur:	1.3590
transform:	1.0867
$E[x x>a]$:	2.7145
$Pr[x>a]$:	13.9%
$Q[R a]$:	0.3762



Midland Basin: Spraberry Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	1,074	0.87	2.294	19%	59%			\$20	1,074	0.86	1.693	20%	44%	
0.90	\$25	915	0.72	2.056	24%	64%	0.41	1.34	\$25	915	0.63	1.511	26%	53%	0.84
0.83	\$30	803	0.60	1.887	27%	69%	0.36	1.18	\$30	803	0.44	1.384	33%	60%	0.70
0.78	\$35	719	0.50	1.760	31%	72%	0.33	1.06	\$35	719	0.29	1.290	39%	66%	0.60
0.71	\$40	655	0.41	1.662	34%	75%	0.29	0.93	\$40	655	0.16	1.219	44%	71%	0.51
0.68	\$45	603	0.34	1.583	37%	77%	0.26	0.86	\$45	603	0.04	1.163	48%	75%	0.45
0.65	\$50	560	0.27	1.517	39%	79%	0.24	0.78	\$50	560	-0.07	1.116	53%	78%	0.40
0.60	\$60	494	0.15	1.415	44%	82%	0.21	0.68	\$60	494	-0.24	1.047	60%	83%	0.33
0.54	\$70	445	0.06	1.339	48%	85%	0.18	0.58	\$70	445	-0.39	0.998	65%	86%	0.27
0.50	\$80	407	-0.02	1.280	51%	87%	0.16	0.50	\$80	407	-0.52	0.960	70%	89%	0.22
0.47	\$90	376	-0.10	1.232	54%	88%	0.15	0.45	\$90	376	-0.63	0.931	74%	91%	0.19
0.45	\$100	350	-0.16	1.192	56%	89%	0.13	0.41	\$100	350	-0.73	0.907	77%	92%	0.16

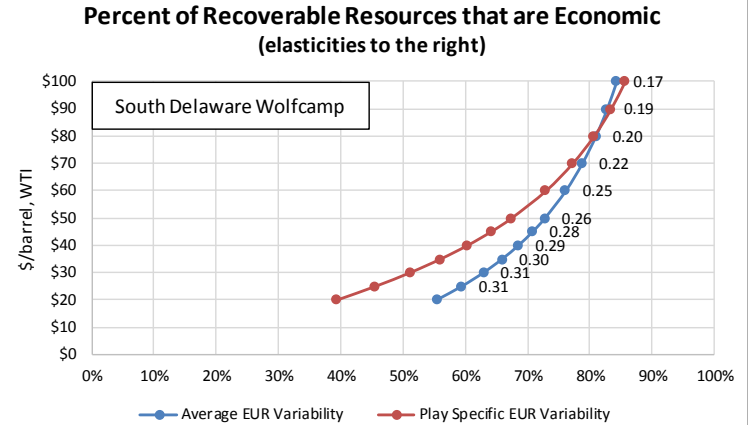
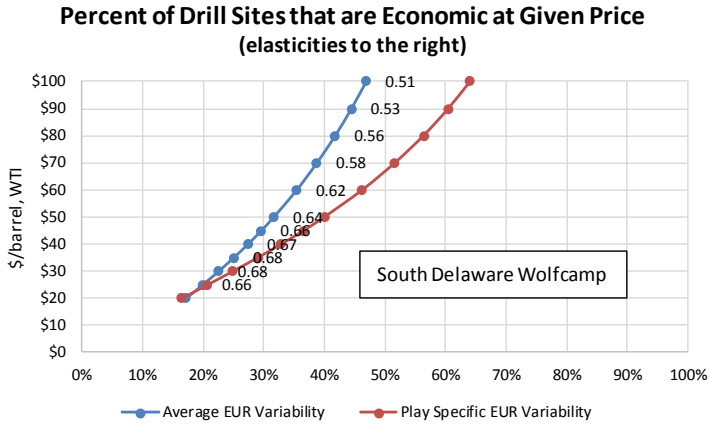
Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Northern Delaware Bone Spring



Southern Delaware Wolfcamp

EUR Distribution	
min:	0.0000
median:	0.4898
mean:	0.8830
μ :	-0.7138
σ :	1.0857
η :	1.5000
mean:	0.8830
stdev:	1.3245
a=b/e eur:	1.3590
transform:	0.9400
$E[x x > a]$:	2.8376
$Pr[x > a]$:	17.4%
$Q[R a]$:	0.4926

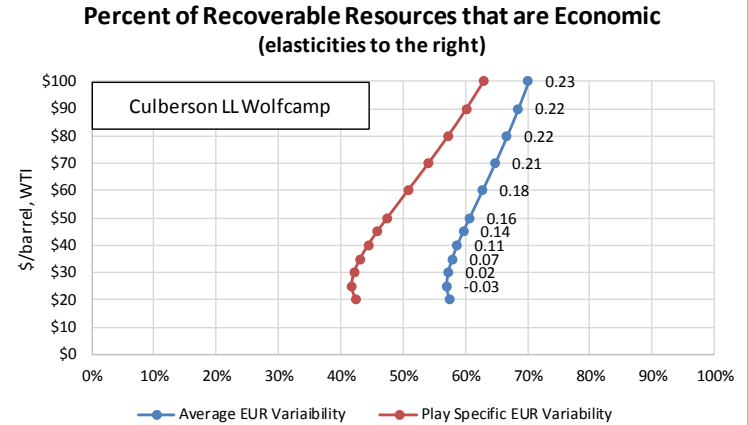
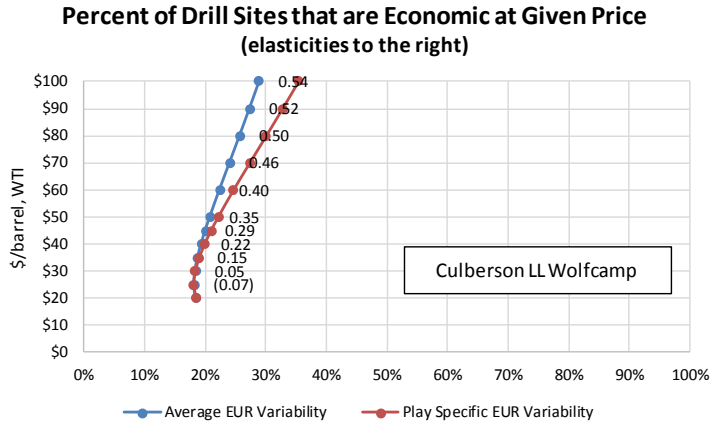


South Delaware Wolfcamp Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
0.66	\$20	1,371	0.95	2.855	17%	55%	0.31	1.02	\$20	1,371	0.98	2.114	16%	39%	0.65
0.68	\$25	1,227	0.85	2.642	20%	59%	0.31	1.01	\$25	1,227	0.82	1.948	21%	46%	0.63
0.68	\$30	1,112	0.76	2.470	23%	63%	0.30	0.98	\$30	1,112	0.68	1.816	25%	51%	0.63
0.67	\$35	1,019	0.67	2.330	25%	66%	0.30	0.98	\$35	1,019	0.56	1.710	29%	56%	0.60
0.67	\$40	942	0.60	2.214	27%	69%	0.29	0.95	\$40	942	0.44	1.623	33%	60%	0.56
0.66	\$45	878	0.54	2.117	30%	71%	0.28	0.90	\$45	878	0.35	1.551	36%	64%	0.52
0.64	\$50	824	0.48	2.035	32%	73%	0.26	0.85	\$50	824	0.26	1.491	40%	67%	0.48
0.62	\$60	736	0.38	1.900	35%	76%	0.25	0.80	\$60	736	0.10	1.395	46%	73%	0.43
0.58	\$70	669	0.29	1.797	39%	79%	0.22	0.72	\$70	669	-0.04	1.322	52%	77%	0.37
0.56	\$80	615	0.21	1.714	42%	81%	0.20	0.66	\$80	615	-0.16	1.265	56%	81%	0.33
0.53	\$90	571	0.14	1.646	44%	83%	0.19	0.60	\$90	571	-0.26	1.220	60%	83%	0.28
0.51	\$100	534	0.08	1.589	47%	84%	0.17	0.55	\$100	534	-0.36	1.182	64%	86%	0.25

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Culberson LL Wolfcamp

EUR Distribution	
min:	0.0000
median:	1.0844
mean:	1.9550
μ :	0.0811
σ :	1.0857
η :	1.5000
mean:	1.9550
stdev:	2.9325
a=b/e eur:	1.3590
transform:	0.2079
$E[x x>a]$:	3.7913
$Pr[x>a]$:	41.8%
$Q[R a]$:	1.5835

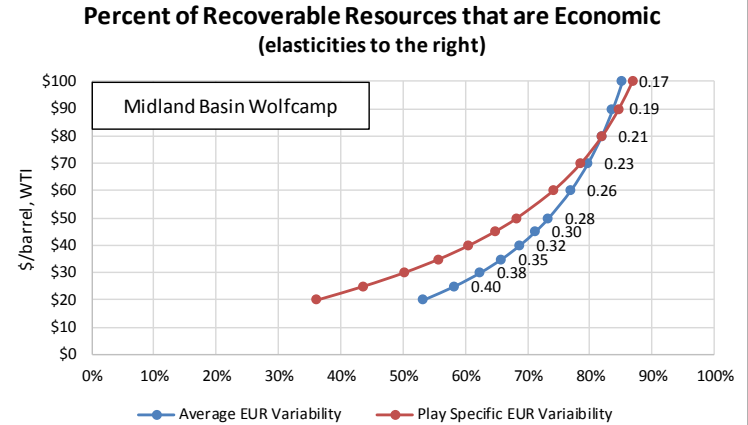
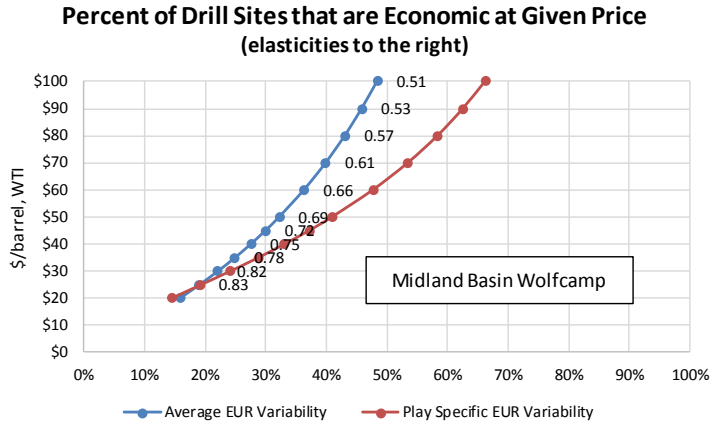


Culberson LL Wolfcamp Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	2,870	0.90	6.077	19%	58%		\$20	2,870	0.90	4.489	18%	42%		
(0.07)	\$25	2,902	0.91	6.124	18%	57%	-0.03	(0.10)	\$25	2,902	0.91	4.526	18%	42%	-0.07
0.05	\$30	2,883	0.90	6.096	18%	57%	0.02	0.07	\$30	2,883	0.90	4.504	18%	42%	0.05
0.15	\$35	2,834	0.88	6.023	19%	58%	0.07	0.23	\$35	2,834	0.88	4.448	19%	43%	0.14
0.22	\$40	2,770	0.86	5.928	19%	59%	0.11	0.34	\$40	2,770	0.85	4.374	20%	44%	0.22
0.29	\$45	2,698	0.84	5.821	20%	60%	0.14	0.44	\$45	2,698	0.81	4.291	21%	46%	0.28
0.35	\$50	2,622	0.81	5.707	21%	61%	0.16	0.52	\$50	2,622	0.77	4.204	22%	48%	0.33
0.40	\$60	2,473	0.76	5.484	22%	63%	0.18	0.60	\$60	2,473	0.69	4.034	25%	51%	0.37
0.46	\$70	2,332	0.71	5.273	24%	65%	0.21	0.67	\$70	2,332	0.60	3.873	27%	54%	0.41
0.50	\$80	2,204	0.65	5.080	26%	67%	0.22	0.71	\$80	2,204	0.52	3.727	30%	57%	0.42
0.52	\$90	2,089	0.60	4.906	27%	69%	0.22	0.73	\$90	2,089	0.45	3.598	33%	60%	0.43
0.54	\$100	1,985	0.56	4.749	29%	70%	0.23	0.74	\$100	1,985	0.37	3.481	35%	63%	0.43

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Midland Basin Wolfcamp

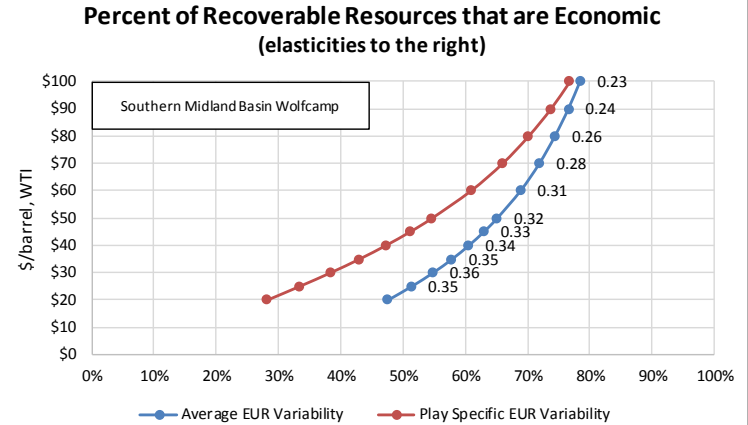
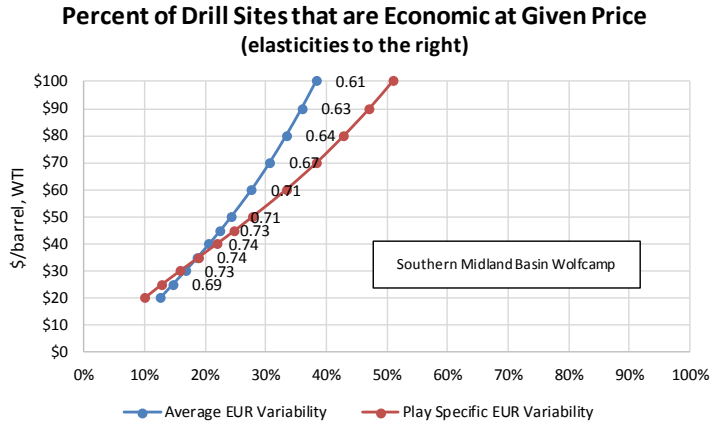
EUR Distribution	
min:	0.0000
median:	0.4138
mean:	0.7460
μ :	-0.8824
σ :	1.0857
η :	1.5000
mean:	0.7460
stdev:	1.1190
a=b/e eur:	1.3590
transform:	1.0953
$E[x x>a]$:	2.7077
$Pr[x>a]$:	13.7%
$Q[R a]$:	0.3701



Midland Basin Wolfcamp Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:															
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.83	\$20	1,230	1.00	2.518	16%	53%	0.40	1.29	\$20	1,230	1.06	1.869	14%	36%	
0.82	\$25	1,073	0.88	2.286	19%	58%	0.38	1.22	\$25	1,073	0.87	1.688	19%	44%	0.84
0.78	\$30	955	0.77	2.110	22%	62%	0.38	1.22	\$30	955	0.70	1.552	24%	50%	0.77
0.78	\$35	864	0.68	1.973	25%	66%	0.35	1.14	\$35	864	0.56	1.448	29%	56%	0.69
0.75	\$40	792	0.60	1.864	27%	69%	0.32	1.05	\$40	792	0.44	1.367	33%	61%	0.62
0.72	\$45	733	0.53	1.775	30%	71%	0.30	0.98	\$45	733	0.33	1.301	37%	65%	0.56
0.69	\$50	684	0.46	1.700	32%	73%	0.28	0.91	\$50	684	0.23	1.246	41%	68%	0.51
0.66	\$60	606	0.35	1.581	36%	77%	0.26	0.84	\$60	606	0.06	1.161	48%	74%	0.45
0.61	\$70	547	0.26	1.490	40%	80%	0.23	0.74	\$70	547	-0.09	1.098	53%	79%	0.38
0.57	\$80	501	0.18	1.420	43%	82%	0.21	0.66	\$80	501	-0.21	1.049	58%	82%	0.32
0.53	\$90	464	0.11	1.362	46%	84%	0.19	0.59	\$90	464	-0.32	1.012	62%	85%	0.28
0.51	\$100	433	0.04	1.315	48%	85%	0.17	0.54	\$100	433	-0.42	0.981	66%	87%	0.24

Southern Midland Basin Wolfcamp

EUR Distribution	
min:	0.0000
median:	0.2774
mean:	0.5000
μ :	-1.2825
σ :	1.0857
η :	1.5000
mean:	0.5000
stdev:	0.7500
a=b/e eur:	1.3590
transform:	1.4638
$E[x x > a]$:	2.4620
$Pr[x > a]$:	7.2%
$Q[R a]$:	0.1763

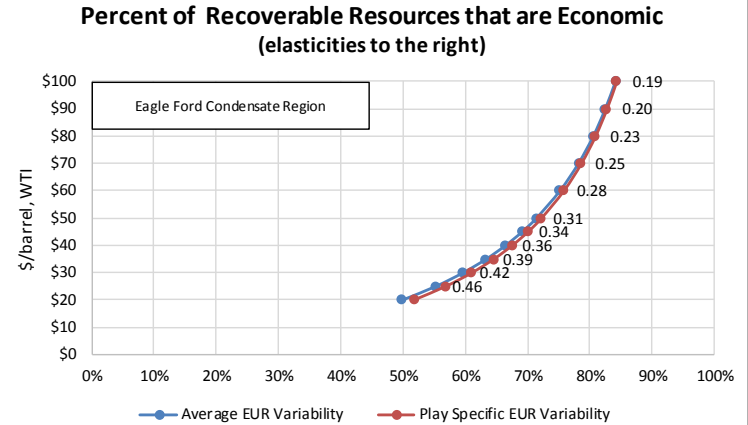
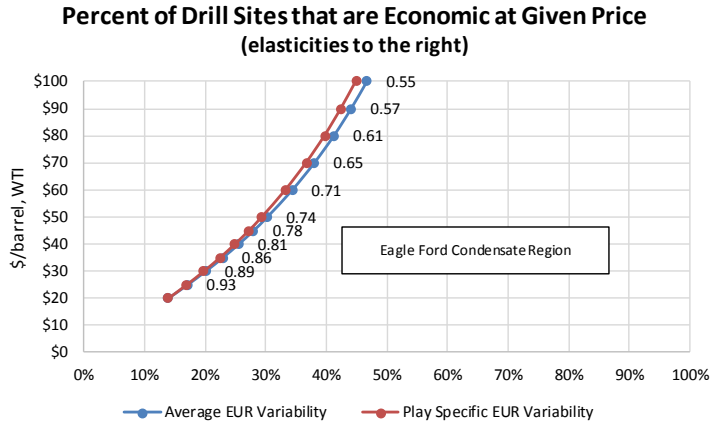


Southern Midland Basin Wolfcamp Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
0.69	\$20	964	1.15	1.893	13%	48%	0.35	1.11	\$20	964	1.28	1.414	10%	28%	0.75
0.73	\$25	869	1.05	1.753	15%	51%	0.36	1.15	\$25	869	1.14	1.304	13%	33%	0.75
0.74	\$30	791	0.97	1.639	17%	55%	0.36	1.15	\$30	791	1.00	1.214	16%	38%	0.76
0.74	\$35	727	0.89	1.544	19%	58%	0.35	1.14	\$35	727	0.88	1.140	19%	43%	0.74
0.74	\$40	674	0.82	1.465	21%	61%	0.34	1.11	\$40	674	0.78	1.079	22%	47%	0.70
0.73	\$45	629	0.75	1.397	23%	63%	0.33	1.09	\$45	629	0.68	1.028	25%	51%	0.67
0.71	\$50	591	0.70	1.340	24%	65%	0.32	1.04	\$50	591	0.59	0.984	28%	55%	0.63
0.71	\$60	528	0.59	1.245	28%	69%	0.31	1.00	\$60	528	0.43	0.913	33%	61%	0.59
0.67	\$70	480	0.51	1.172	31%	72%	0.28	0.91	\$70	480	0.30	0.859	38%	66%	0.52
0.64	\$80	442	0.43	1.115	33%	74%	0.26	0.83	\$80	442	0.18	0.817	43%	70%	0.46
0.63	\$90	410	0.36	1.066	36%	77%	0.24	0.79	\$90	410	0.07	0.782	47%	74%	0.42
0.61	\$100	383	0.30	1.024	38%	78%	0.23	0.74	\$100	383	-0.02	0.753	51%	77%	0.38

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Eagle Ford Condensate

EUR Distribution	
min:	0.0000
median:	0.4443
mean:	0.8010
μ :	-0.8112
σ :	1.0857
η :	1.5000
mean:	0.8010
stdev:	1.2015
a=b/e eur:	1.3590
transform:	1.0298
$E[x x>a]$:	2.7603
$Pr[x>a]$:	15.2%
$Q[R a]$:	0.4184

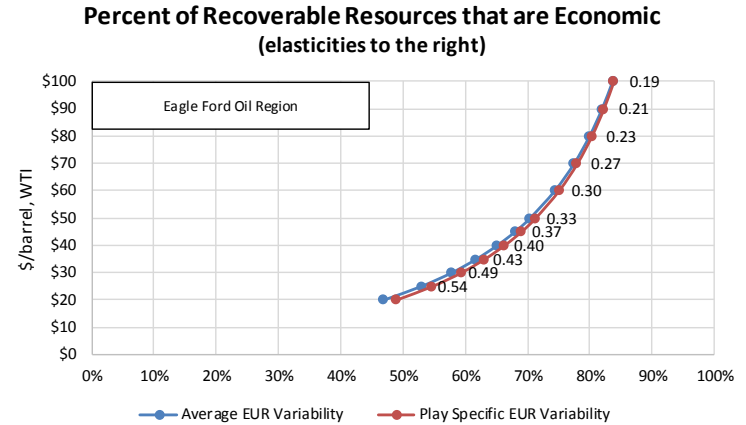
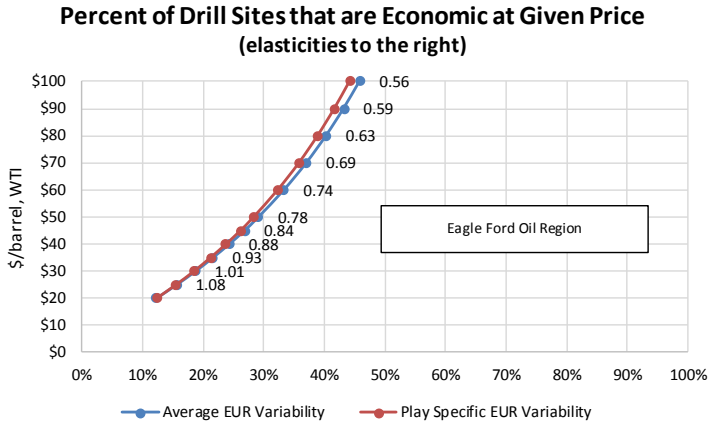


Eagle Ford Condensate Region Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.93	\$20	1,449	1.09	2.892	14%	50%	0.46	0.89	\$20	1,449	1.09	3.008	14%	52%	0.42
0.89	\$25	1,252	0.95	2.602	17%	55%	0.42	0.86	\$25	1,252	0.96	2.708	17%	57%	0.39
0.86	\$30	1,108	0.84	2.389	20%	60%	0.39	0.83	\$30	1,108	0.85	2.487	20%	61%	0.36
0.81	\$35	997	0.74	2.223	23%	63%	0.36	0.79	\$35	997	0.76	2.315	22%	65%	0.33
0.78	\$40	910	0.66	2.092	25%	66%	0.34	0.76	\$40	910	0.68	2.179	25%	68%	0.31
0.74	\$45	839	0.59	1.985	28%	69%	0.31	0.72	\$45	839	0.61	2.067	27%	70%	0.29
0.71	\$50	781	0.52	1.897	30%	71%	0.28	0.69	\$50	781	0.55	1.976	29%	72%	0.27
0.65	\$60	689	0.40	1.756	34%	75%	0.25	0.64	\$60	689	0.43	1.829	33%	76%	0.24
0.61	\$70	620	0.31	1.651	38%	78%	0.23	0.60	\$70	620	0.34	1.719	37%	79%	0.21
0.57	\$80	566	0.22	1.568	41%	81%	0.20	0.56	\$80	566	0.26	1.632	40%	81%	0.19
0.55	\$90	523	0.15	1.501	44%	83%	0.19	0.54	\$90	523	0.19	1.563	42%	83%	0.18
0.55	\$100	487	0.08	1.446	47%	84%	0.19	0.54	\$100	487	0.13	1.504	45%	84%	0.18

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Eagle Ford Oil

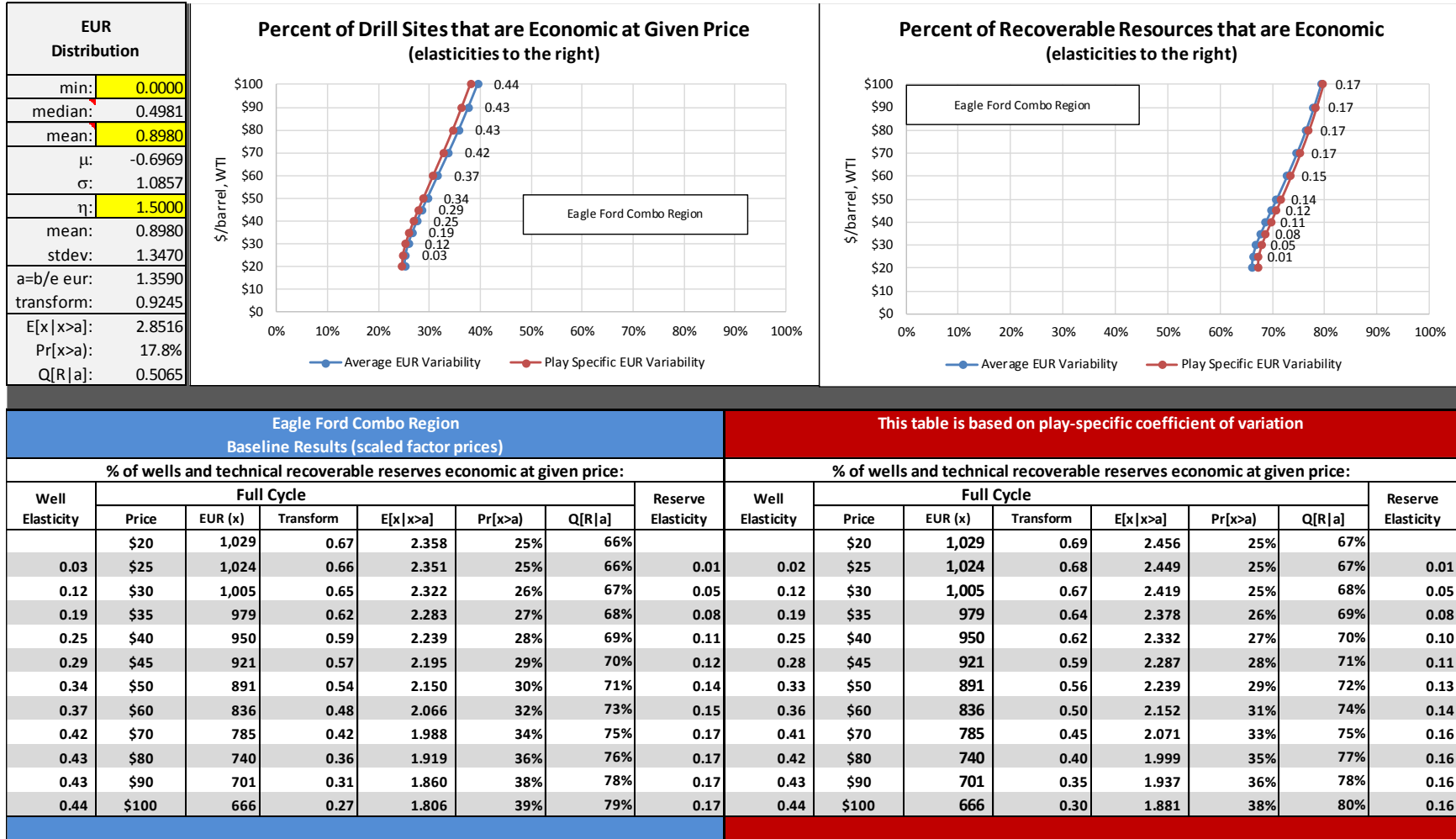
EUR Distribution	
min:	0.0000
median:	0.2857
mean:	0.5150
μ :	-1.2529
σ :	1.0857
η :	1.5000
mean:	0.5150
stdev:	0.7725
a=b/e eur:	1.3590
transform:	1.4366
$E[x x>a]$:	2.4776
$Pr[x>a]$:	7.5%
$Q[R a]$:	0.1868



Eagle Ford Oil Region Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	1,011	1.16	1.976	12%	47%			\$20	1,011	1.16	2.054	12%	49%	
1.08	\$25	858	1.01	1.752	16%	53%	0.54	1.03	\$25	858	1.02	1.822	15%	55%	0.50
1.01	\$30	750	0.89	1.592	19%	58%	0.49	0.97	\$30	750	0.90	1.657	18%	59%	0.45
0.93	\$35	671	0.79	1.474	22%	62%	0.43	0.90	\$35	671	0.80	1.535	21%	63%	0.40
0.88	\$40	609	0.70	1.381	24%	65%	0.40	0.85	\$40	609	0.72	1.438	24%	66%	0.37
0.84	\$45	559	0.62	1.306	27%	68%	0.37	0.82	\$45	559	0.64	1.360	26%	69%	0.34
0.78	\$50	519	0.55	1.245	29%	70%	0.33	0.76	\$50	519	0.57	1.297	28%	71%	0.31
0.74	\$60	456	0.43	1.149	33%	74%	0.30	0.72	\$60	456	0.46	1.197	32%	75%	0.28
0.69	\$70	409	0.33	1.077	37%	77%	0.27	0.67	\$70	409	0.36	1.122	36%	78%	0.25
0.63	\$80	373	0.25	1.022	40%	80%	0.23	0.62	\$80	373	0.28	1.064	39%	80%	0.22
0.59	\$90	344	0.17	0.977	43%	82%	0.21	0.58	\$90	344	0.21	1.017	42%	82%	0.20
0.56	\$100	320	0.10	0.940	46%	84%	0.19	0.55	\$100	320	0.15	0.978	44%	84%	0.18

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

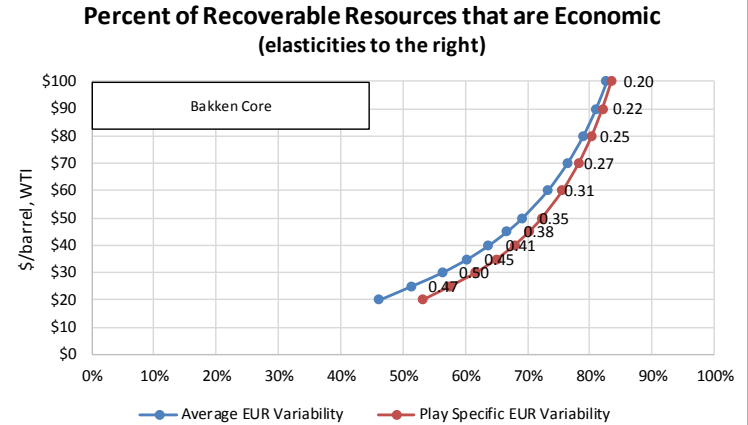
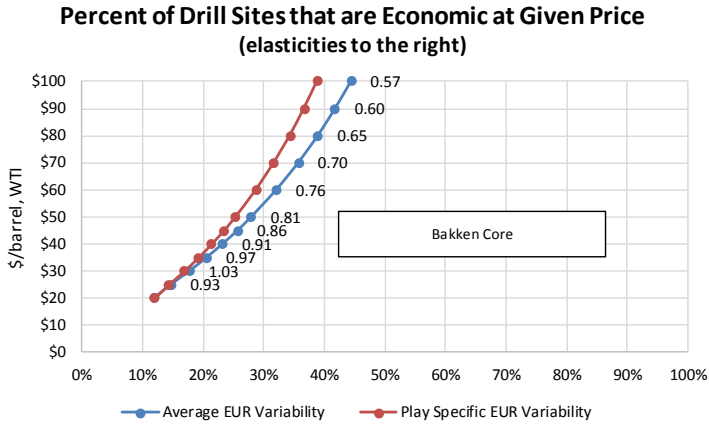
Eagle Ford Combo



Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Bakken Core

EUR Distribution	
min:	0.0000
median:	0.4022
mean:	0.7250
μ :	-0.9109
σ :	1.0857
η :	1.5000
mean:	0.7250
stdev:	1.0875
a=b/e eur:	1.3590
transform:	1.1216
$E[x x>a]$:	2.6875
$Pr[x>a]$:	13.1%
$Q[R a]$:	0.3521

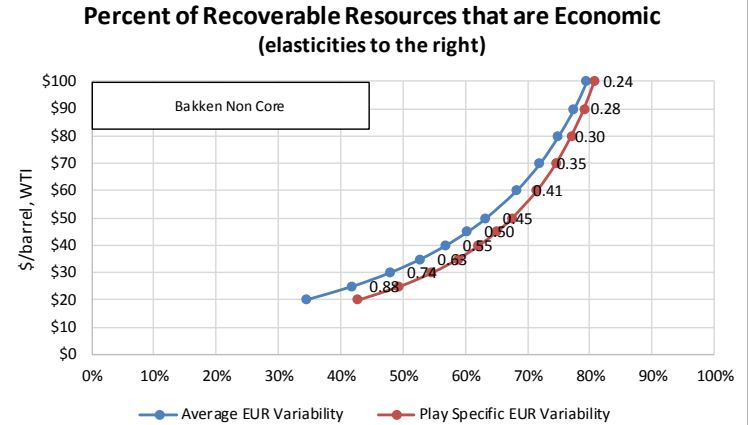
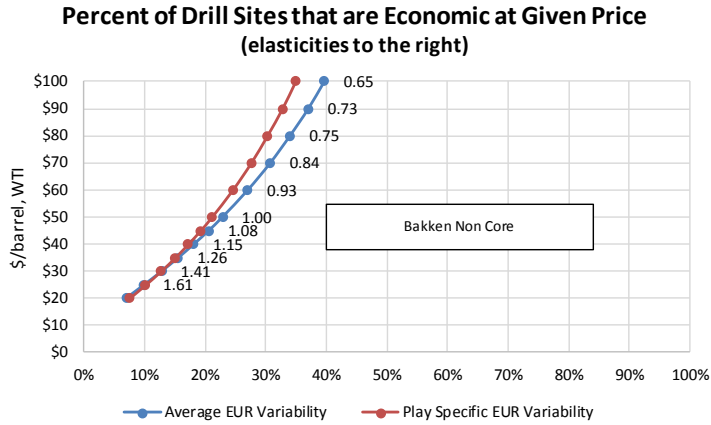


Bakken Core Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.93	\$20	1,448	1.18	2.817	12%	46%	0.47	0.81	\$20	1,448	1.18	3.235	12%	53%	0.36
1.03	\$25	1,259	1.05	2.541	15%	51%	0.50	0.90	\$25	1,259	1.07	2.924	14%	58%	0.38
0.97	\$30	1,100	0.93	2.306	18%	56%	0.45	0.85	\$30	1,100	0.96	2.658	17%	62%	0.38
0.91	\$35	982	0.82	2.131	21%	60%	0.41	0.81	\$35	982	0.87	2.459	19%	65%	0.35
0.86	\$40	891	0.73	1.995	23%	64%	0.38	0.77	\$40	891	0.79	2.304	21%	68%	0.32
0.81	\$45	818	0.65	1.885	26%	67%	0.35	0.73	\$45	818	0.73	2.178	23%	70%	0.29
0.76	\$50	759	0.59	1.796	28%	69%	0.31	0.69	\$50	759	0.67	2.075	25%	72%	0.27
0.70	\$60	667	0.47	1.656	32%	73%	0.27	0.64	\$60	667	0.56	1.914	29%	76%	0.25
0.65	\$70	599	0.37	1.552	36%	76%	0.25	0.61	\$70	599	0.48	1.794	32%	78%	0.22
0.60	\$80	546	0.28	1.471	39%	79%	0.22	0.57	\$80	546	0.40	1.699	34%	80%	0.20
0.57	\$90	504	0.21	1.406	42%	81%	0.20	0.55	\$90	504	0.34	1.623	37%	82%	0.18
0.57	\$100	469	0.14	1.352	44%	83%	0.20	0.55	\$100	469	0.28	1.559	39%	84%	0.17

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Bakken Non-Core

EUR Distribution	
min:	0.0000
median:	0.3095
mean:	0.5580
μ :	-1.1727
σ :	1.0857
η :	1.5000
mean:	0.5580
stdev:	0.8370
a=b/e eur:	1.3590
transform:	1.3627
$E[x x > a]$:	2.5219
$Pr[x > a]$:	8.6%
$Q[R a]$:	0.2181

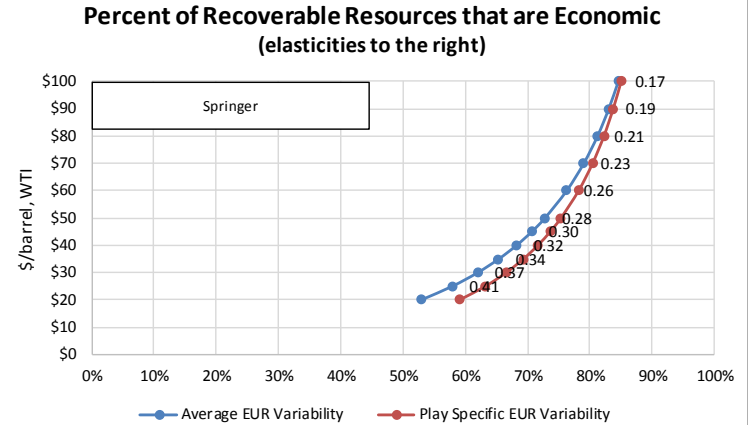
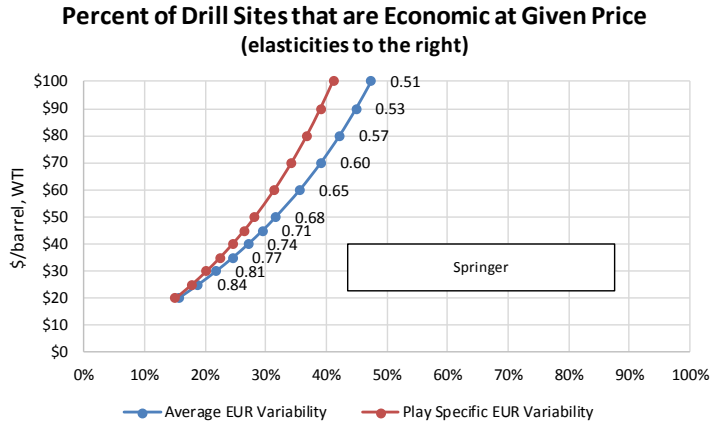


Bakken Non Core Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
1.61	\$20	1,552	1.49	2.798	7%	34%	0.88	1.37	\$20	1,552	1.44	3.195	7%	43%	0.65
1.41	\$25	1,255	1.29	2.372	10%	42%	0.74	1.22	\$25	1,255	1.27	2.719	10%	49%	0.55
1.26	\$30	1,064	1.14	2.095	13%	48%	0.63	1.10	\$30	1,064	1.14	2.407	13%	55%	0.48
1.15	\$35	931	1.01	1.900	16%	53%	0.55	1.00	\$35	931	1.04	2.187	15%	59%	0.42
1.08	\$40	833	0.91	1.755	18%	57%	0.50	0.95	\$40	833	0.95	2.023	17%	62%	0.39
1.00	\$45	756	0.82	1.640	21%	60%	0.45	0.89	\$45	756	0.87	1.893	19%	65%	0.35
0.93	\$50	695	0.75	1.549	23%	63%	0.41	0.83	\$50	695	0.80	1.789	21%	68%	0.32
0.84	\$60	602	0.61	1.409	27%	68%	0.35	0.76	\$60	602	0.69	1.628	25%	72%	0.27
0.75	\$70	535	0.50	1.307	31%	72%	0.30	0.69	\$70	535	0.60	1.511	28%	75%	0.24
0.73	\$80	485	0.41	1.231	34%	75%	0.28	0.67	\$80	485	0.52	1.423	30%	77%	0.23
0.65	\$90	444	0.33	1.168	37%	77%	0.24	0.61	\$90	444	0.45	1.350	33%	79%	0.20
0.65	\$100	412	0.26	1.119	40%	79%	0.24	0.61	\$100	412	0.39	1.293	35%	81%	0.20

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Springer

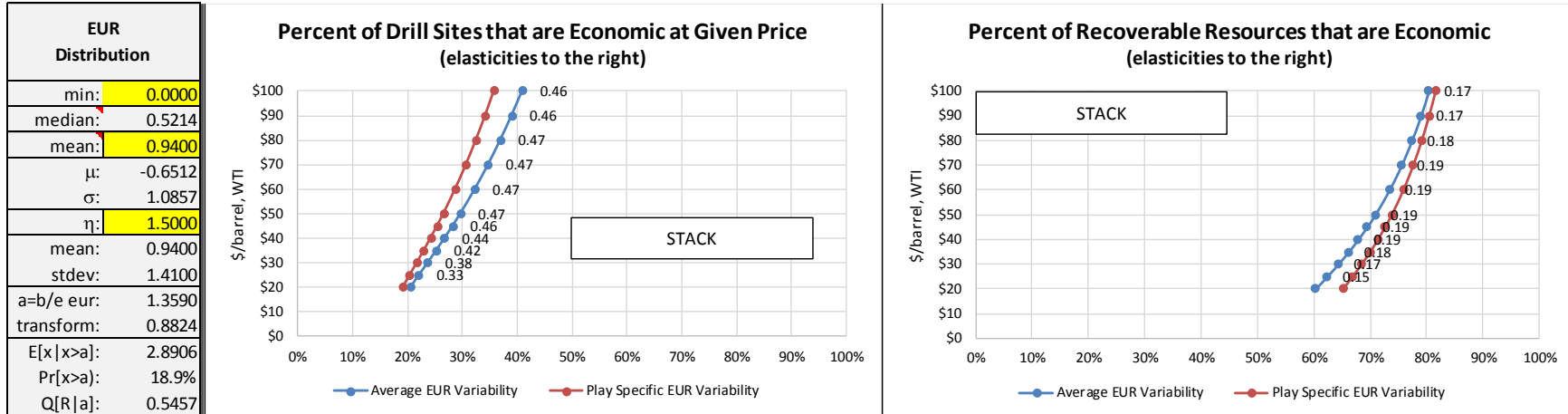
EUR Distribution	
min:	0.0000
median:	0.5014
mean:	0.9040
μ :	-0.6903
σ :	1.0857
η :	1.5000
mean:	0.9040
stdev:	1.3560
a=b/e eur:	1.3590
transform:	0.9183
$E[x x>a]$:	2.8572
$Pr[x>a]$:	17.9%
$Q[R a]$:	0.5121



Springer Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.84	\$20	1,504	1.01	3.071	16%	53%	0.41	0.74	\$20	1,504	1.04	3.556	15%	59%	0.31
0.81	\$25	1,311	0.89	2.786	19%	58%	0.37	0.71	\$25	1,311	0.93	3.230	18%	63%	0.28
0.77	\$30	1,169	0.78	2.574	22%	62%	0.34	0.69	\$30	1,169	0.84	2.988	20%	67%	0.26
0.74	\$35	1,060	0.69	2.411	25%	65%	0.32	0.66	\$35	1,060	0.76	2.800	22%	69%	0.25
0.71	\$40	973	0.61	2.279	27%	68%	0.30	0.64	\$40	973	0.69	2.649	24%	72%	0.23
0.68	\$45	902	0.54	2.172	29%	71%	0.28	0.62	\$45	902	0.63	2.525	26%	74%	0.22
0.65	\$50	843	0.48	2.082	32%	73%	0.26	0.60	\$50	843	0.58	2.420	28%	75%	0.20
0.60	\$60	749	0.37	1.938	36%	76%	0.23	0.56	\$60	749	0.48	2.253	31%	78%	0.18
0.57	\$70	678	0.28	1.829	39%	79%	0.21	0.54	\$70	678	0.41	2.125	34%	81%	0.15
0.53	\$80	622	0.20	1.743	42%	81%	0.19	0.51	\$80	622	0.34	2.023	37%	82%	0.14
0.51	\$90	577	0.13	1.674	45%	83%	0.17	0.49	\$90	577	0.28	1.941	39%	84%	0.14
0.51	\$100	539	0.07	1.615	47%	85%	0.17	0.49	\$100	539	0.22	1.871	41%	85%	0.14

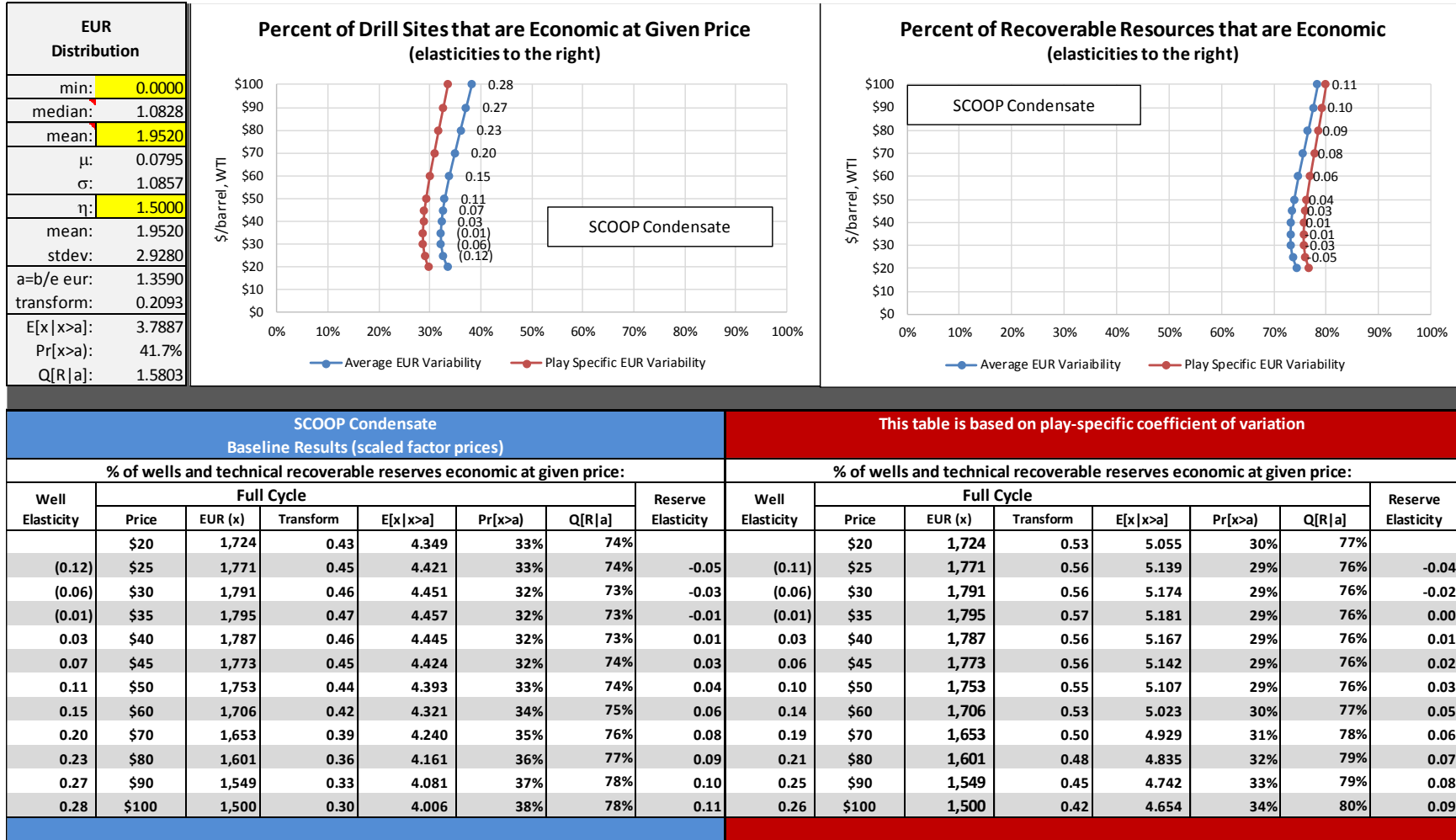
Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

STACK



STACK								This table is based on play-specific coefficient of variation							
Baseline Results (scaled factor prices)															
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
0.33	\$20	1,274	0.82	2.764	21%	60%	0.15	0.29	\$20	1,274	0.87	3.207	19%	65%	
	\$25	1,202	0.77	2.656	22%	62%	0.15	0.34	\$25	1,202	0.83	3.084	20%	67%	0.11
0.38	\$30	1,136	0.72	2.557	24%	64%	0.17	0.39	\$30	1,136	0.78	2.970	22%	69%	0.13
0.42	\$35	1,076	0.67	2.467	25%	66%	0.18	0.43	\$35	1,076	0.74	2.866	23%	70%	0.14
0.44	\$40	1,023	0.62	2.387	27%	68%	0.19	0.47	\$40	1,023	0.70	2.774	24%	71%	0.15
0.46	\$45	975	0.58	2.314	28%	69%	0.19	0.43	\$45	975	0.66	2.690	25%	73%	0.15
0.47	\$50	932	0.53	2.249	30%	71%	0.19	0.43	\$50	932	0.63	2.615	27%	74%	0.15
0.47	\$60	859	0.46	2.138	32%	73%	0.19	0.43	\$60	859	0.56	2.486	29%	76%	0.15
0.47	\$70	799	0.39	2.046	35%	76%	0.19	0.43	\$70	799	0.50	2.379	31%	78%	0.15
0.47	\$80	749	0.33	1.970	37%	77%	0.18	0.43	\$80	749	0.45	2.289	33%	79%	0.14
0.46	\$90	706	0.28	1.904	39%	79%	0.17	0.43	\$90	706	0.41	2.212	34%	80%	0.14
0.46	\$100	669	0.23	1.847	41%	80%	0.17	0.43	\$100	669	0.36	2.144	36%	82%	0.13

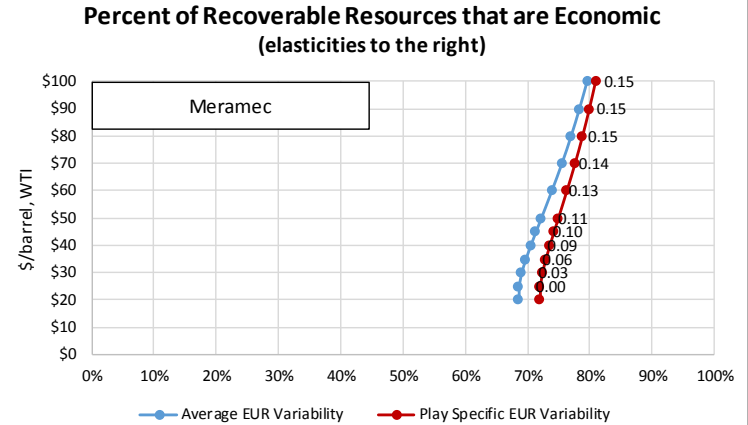
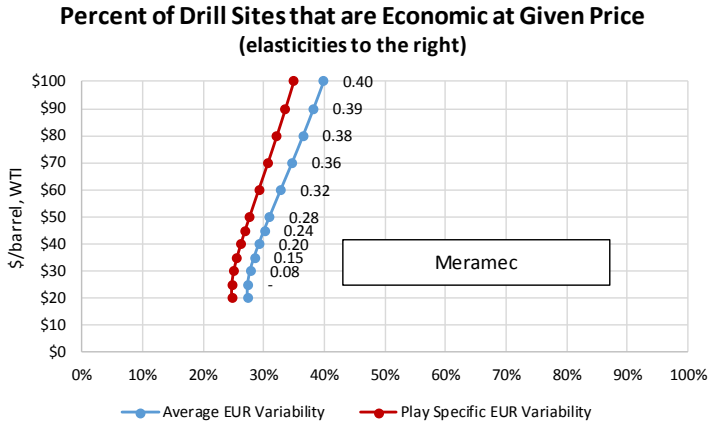
SCOOP Condensate



Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Meramec

EUR Distribution	
min:	0.0000
median:	0.7422
mean:	1.3380
μ :	-0.2982
σ :	1.0857
η :	1.5000
mean:	1.3380
stdev:	2.0070
a=b/e eur:	1.3590
transform:	0.5572
$E[x x > a]$:	3.2507
$Pr[x > a]$:	28.9%
$Q[R a]$:	0.9385

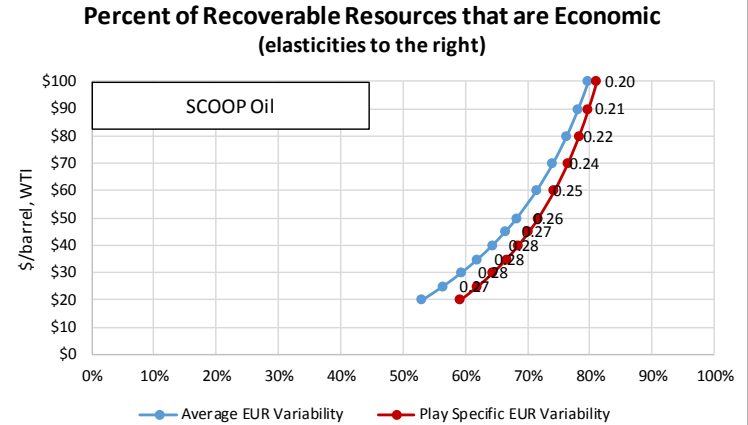
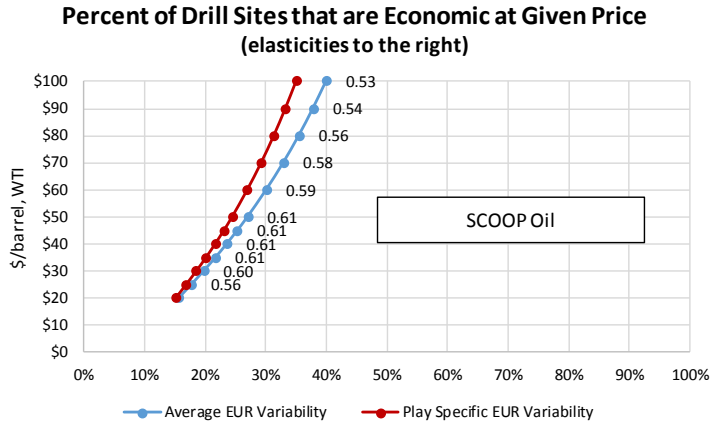


Meramec Baseline Results (scaled factor prices)							This table is based on play-specific coefficient of variation								
% of wells and technical recoverable reserves economic at given price:							% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
-	\$20	1,425	0.60	3.351	27%	69%	0.00	-	\$20	1,425	0.68	3.894	25%	72%	0.00
0.08	\$25	1,425	0.60	3.351	27%	69%	0.03	0.07	\$25	1,425	0.68	3.894	25%	72%	0.03
0.15	\$30	1,407	0.59	3.323	28%	69%	0.06	0.14	\$30	1,407	0.67	3.863	25%	72%	0.06
0.20	\$35	1,378	0.57	3.280	28%	70%	0.09	0.18	\$35	1,378	0.66	3.812	26%	73%	0.09
0.24	\$40	1,344	0.55	3.228	29%	70%	0.11	0.22	\$40	1,344	0.64	3.752	26%	74%	0.11
0.28	\$45	1,309	0.52	3.175	30%	71%	0.10	0.26	\$45	1,309	0.62	3.691	27%	74%	0.10
0.32	\$50	1,273	0.50	3.120	31%	72%	0.11	0.29	\$50	1,273	0.59	3.627	28%	75%	0.11
0.36	\$60	1,204	0.45	3.015	33%	74%	0.13	0.33	\$60	1,204	0.55	3.505	29%	76%	0.13
0.38	\$70	1,139	0.39	2.916	35%	76%	0.14	0.35	\$70	1,139	0.51	3.389	31%	78%	0.14
0.39	\$80	1,081	0.35	2.827	36%	77%	0.15	0.36	\$80	1,081	0.46	3.285	32%	79%	0.15
0.40	\$90	1,029	0.30	2.747	38%	78%	0.15	0.38	\$90	1,029	0.43	3.191	34%	80%	0.15
0.40	\$100	982	0.26	2.675	40%	80%	0.15	0.38	\$100	982	0.39	3.106	35%	81%	0.15

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

SCOOP Oil

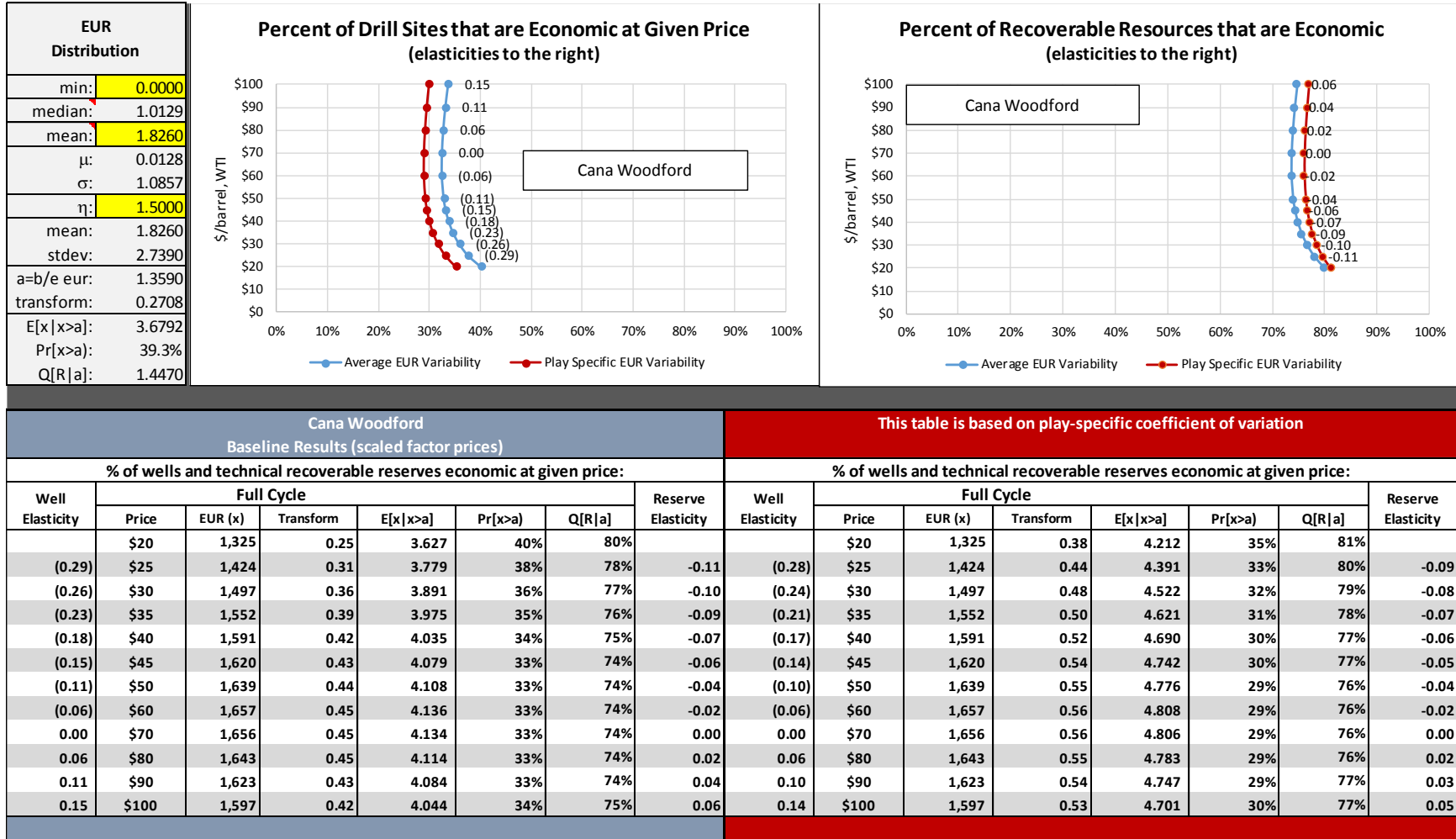
EUR Distribution	
min:	0.0000
median:	0.5431
mean:	0.9790
μ :	-0.6106
σ :	1.0857
η :	1.5000
mean:	0.9790
stdev:	1.4685
a=b/e eur:	1.3590
transform:	0.8449
$E[x x>a]$:	2.9266
$Pr[x>a]$:	19.9%
$Q[R a]$:	0.5826



SCOOP Oil Baseline Results (scaled factor prices)							This table is based on play-specific coefficient of variation								
% of wells and technical recoverable reserves economic at given price:							% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	1,624	1.01	3.319	16%	53%		0.49	\$20	1,624	1.03	3.843	15%	59%	
0.56	\$25	1,483	0.93	3.111	18%	56%	0.27	0.52	\$25	1,483	0.96	3.605	17%	62%	0.20
0.60	\$30	1,366	0.85	2.937	20%	59%	0.28	0.52	\$30	1,366	0.90	3.407	19%	64%	0.21
0.61	\$35	1,268	0.78	2.791	22%	62%	0.28	0.54	\$35	1,268	0.84	3.240	20%	67%	0.21
0.61	\$40	1,186	0.72	2.668	24%	64%	0.28	0.54	\$40	1,186	0.78	3.098	22%	68%	0.21
0.61	\$45	1,116	0.66	2.562	25%	66%	0.27	0.55	\$45	1,116	0.74	2.977	23%	70%	0.21
0.61	\$50	1,055	0.61	2.470	27%	68%	0.26	0.55	\$50	1,055	0.69	2.871	24%	72%	0.20
0.59	\$60	956	0.52	2.320	30%	71%	0.25	0.54	\$60	956	0.61	2.697	27%	74%	0.19
0.58	\$70	877	0.44	2.200	33%	74%	0.24	0.53	\$70	877	0.55	2.557	29%	76%	0.19
0.56	\$80	813	0.37	2.102	36%	76%	0.22	0.52	\$80	813	0.49	2.443	31%	78%	0.17
0.54	\$90	760	0.31	2.021	38%	78%	0.21	0.50	\$90	760	0.43	2.348	33%	80%	0.17
0.53	\$100	715	0.25	1.952	40%	80%	0.20	0.49	\$100	715	0.38	2.267	35%	81%	0.16

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

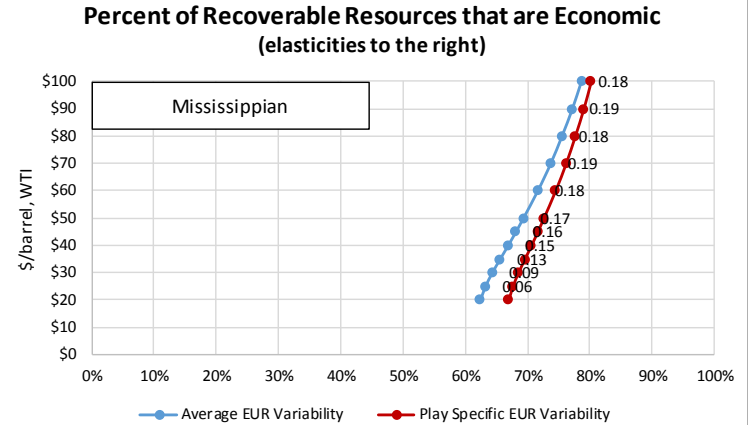
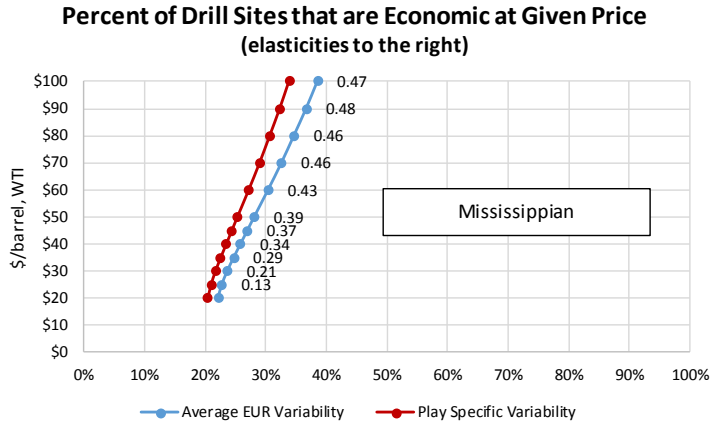
Cana Woodford



Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Mississippian

EUR Distribution	
min:	0.0000
median:	0.2274
mean:	0.4100
μ :	-1.4809
σ :	1.0857
η :	1.5000
mean:	0.4100
stdev:	0.6150
a=b/e eur:	1.3590
transform:	1.6466
$E[x x > a]$:	2.3654
$Pr[x > a]$:	5.0%
$Q[R a]$:	0.1178

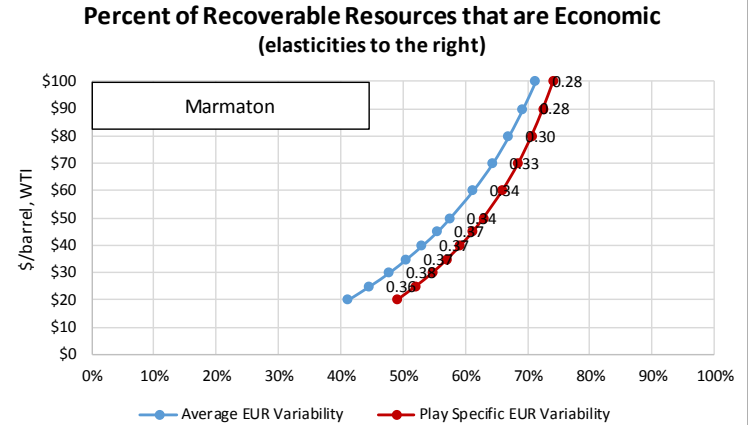
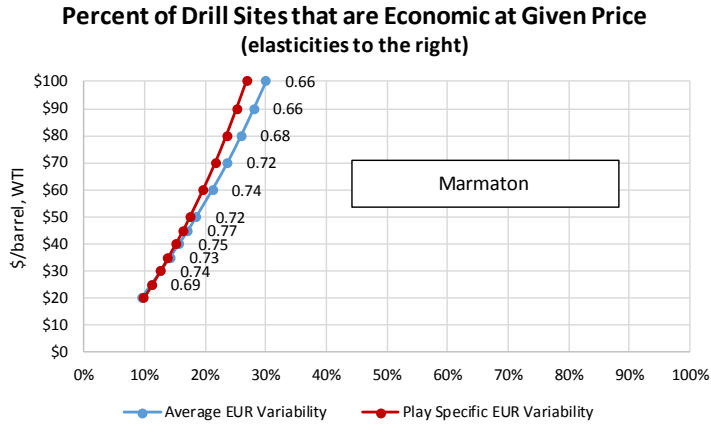


Mississippian Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
0.13	\$20	524	0.77	1.158	22%	62%	0.06	0.11	\$20	524	0.83	1.345	20%	67%	0.04
0.21	\$25	512	0.75	1.140	23%	63%	0.09	0.19	\$25	512	0.81	1.324	21%	68%	0.07
0.29	\$30	496	0.72	1.116	24%	64%	0.13	0.25	\$30	496	0.78	1.296	22%	69%	0.10
0.34	\$35	478	0.68	1.089	25%	66%	0.15	0.30	\$35	478	0.75	1.265	23%	70%	0.11
0.37	\$40	460	0.65	1.062	26%	67%	0.16	0.33	\$40	460	0.72	1.234	23%	71%	0.12
0.39	\$45	443	0.61	1.036	27%	68%	0.17	0.35	\$45	443	0.69	1.204	24%	72%	0.13
0.43	\$50	427	0.58	1.012	28%	69%	0.18	0.39	\$50	427	0.66	1.176	25%	73%	0.14
0.46	\$60	397	0.51	0.967	30%	72%	0.18	0.42	\$60	397	0.61	1.124	27%	74%	0.14
0.46	\$70	371	0.45	0.927	33%	74%	0.19	0.42	\$70	371	0.55	1.078	29%	76%	0.15
0.48	\$80	349	0.39	0.893	35%	76%	0.18	0.44	\$80	349	0.51	1.038	31%	78%	0.14
0.47	\$90	329	0.34	0.863	37%	77%	0.19	0.44	\$90	329	0.46	1.003	32%	79%	0.15
0.47	\$100	312	0.29	0.837	39%	79%	0.18	0.44	\$100	312	0.42	0.972	34%	80%	0.14

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Marmaton

EUR Distribution	
min:	0.0000
median:	0.1115
mean:	0.2010
μ :	-2.1938
σ :	1.0857
η :	1.5000
mean:	0.2010
stdev:	0.3015
a=b/e eur:	1.3590
transform:	2.3032
$E[x x > a]$:	2.1114
$Pr[x > a]$:	1.1%
$Q[R a]$:	0.0225

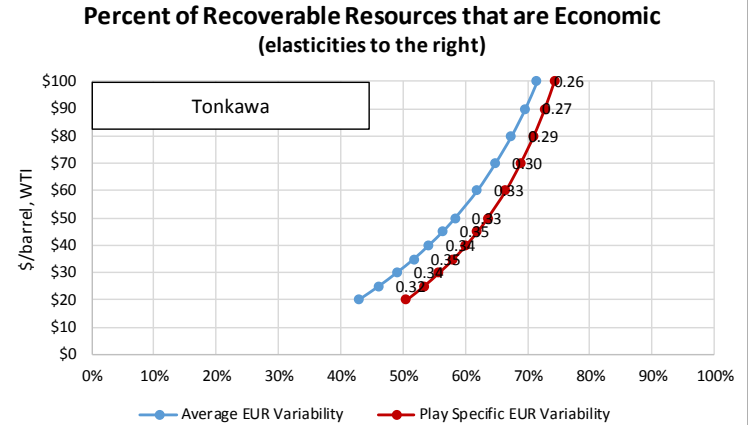
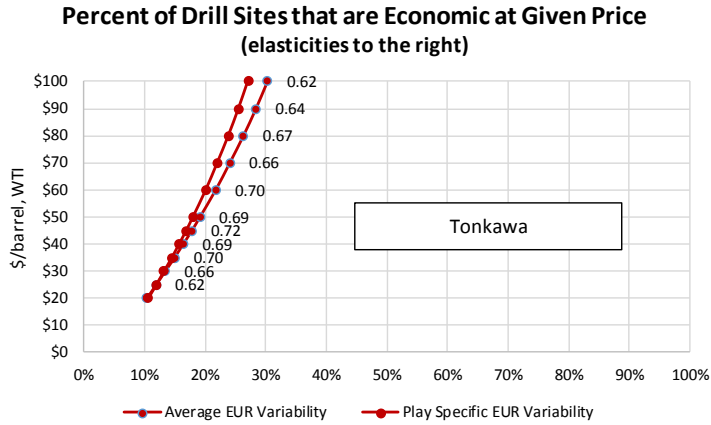


Marmaton Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
0.69	\$20	462	1.31	0.869	10%	41%	0.36	0.59	\$20	462	1.29	1.001	10%	49%	0.27
0.74	\$25	420	1.22	0.808	11%	45%	0.38	0.63	\$25	420	1.22	0.932	11%	52%	0.28
0.73	\$30	385	1.14	0.757	13%	48%	0.37	0.63	\$30	385	1.15	0.875	13%	55%	0.28
0.75	\$35	357	1.07	0.716	14%	51%	0.37	0.65	\$35	357	1.09	0.828	14%	57%	0.27
0.72	\$40	333	1.01	0.681	16%	53%	0.37	0.67	\$40	333	1.03	0.788	15%	59%	0.28
0.74	\$45	312	0.95	0.650	17%	55%	0.34	0.65	\$45	312	0.98	0.753	16%	61%	0.26
0.72	\$50	295	0.90	0.625	19%	58%	0.34	0.64	\$50	295	0.94	0.724	17%	63%	0.26
0.74	\$60	266	0.80	0.581	21%	61%	0.33	0.64	\$60	266	0.85	0.675	20%	66%	0.25
0.72	\$70	243	0.72	0.547	24%	64%	0.33	0.61	\$70	243	0.78	0.635	22%	69%	0.23
0.68	\$80	225	0.65	0.520	26%	67%	0.28	0.60	\$80	225	0.72	0.604	24%	71%	0.22
0.66	\$90	210	0.58	0.497	28%	69%	0.28	0.60	\$90	210	0.67	0.578	25%	73%	0.22
0.66	\$100	197	0.52	0.477	30%	71%	0.28	0.60	\$100	197	0.62	0.555	27%	74%	0.21

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Tonkawa

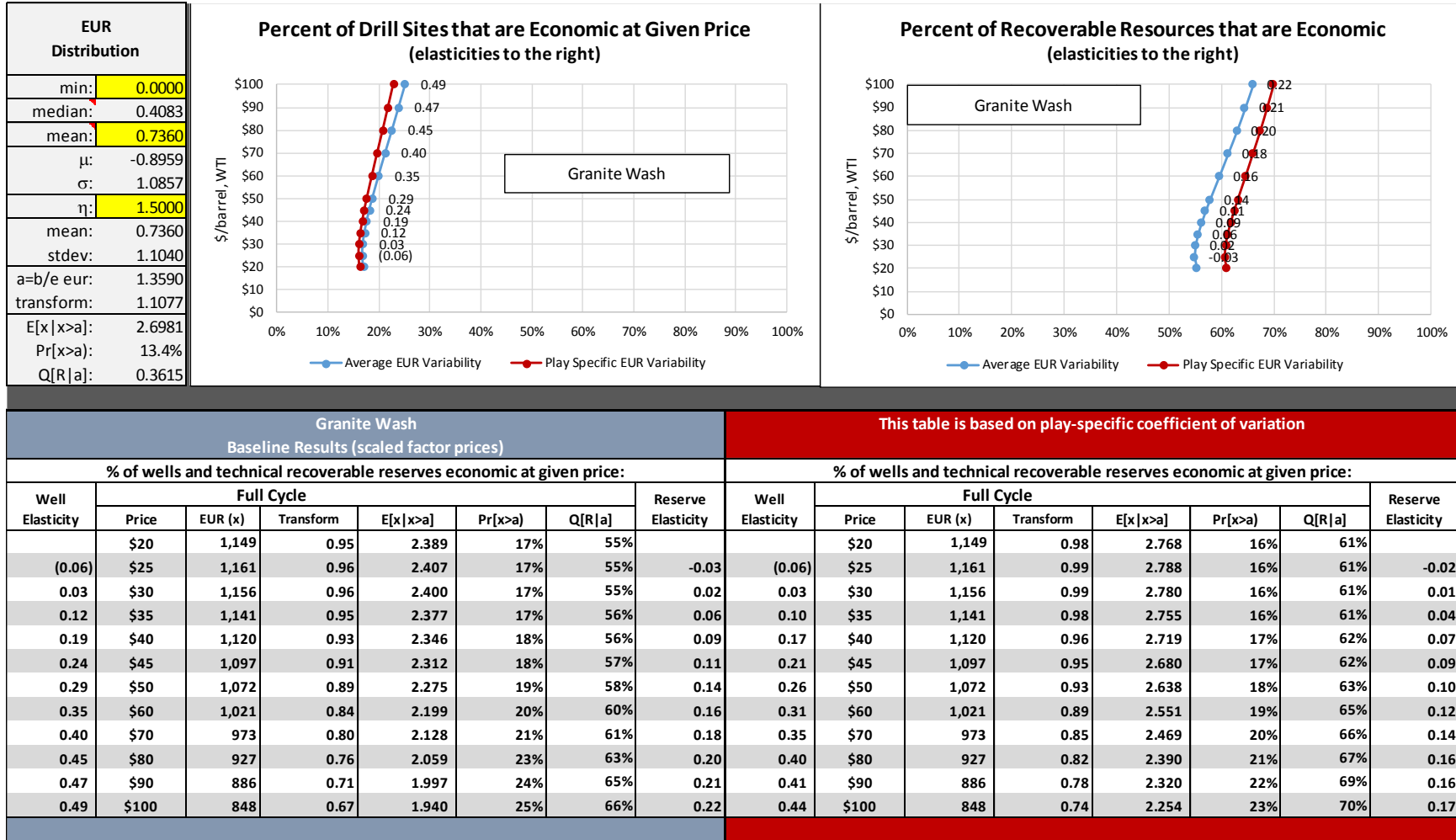
EUR Distribution	
min:	0.0000
median:	0.1381
mean:	0.2490
μ :	-1.9796
σ :	1.0857
η :	1.5000
mean:	0.2490
stdev:	0.3735
a=b/e eur:	1.3590
transform:	2.1060
$E[x x>a]$:	2.1754
$Pr[x>a]$:	1.8%
$Q[R a]$:	0.0383



Tonkawa Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.62	\$20	545	1.26	1.037	10%	43%	0.32	0.53	\$20	545	1.25	1.195	11%	51%	0.24
0.66	\$25	499	1.18	0.970	12%	46%	0.34	0.57	\$25	499	1.18	1.120	12%	53%	0.25
0.70	\$30	461	1.11	0.915	13%	49%	0.34	0.57	\$30	461	1.12	1.057	13%	56%	0.25
0.70	\$35	428	1.04	0.866	15%	52%	0.35	0.61	\$35	428	1.06	1.002	14%	58%	0.26
0.69	\$40	401	0.98	0.826	16%	54%	0.34	0.60	\$40	401	1.01	0.957	16%	60%	0.25
0.72	\$45	377	0.92	0.791	18%	56%	0.35	0.63	\$45	377	0.96	0.917	17%	62%	0.26
0.69	\$50	357	0.87	0.761	19%	58%	0.33	0.60	\$50	357	0.92	0.883	18%	64%	0.25
0.70	\$60	323	0.78	0.711	22%	62%	0.33	0.62	\$60	323	0.84	0.825	20%	67%	0.25
0.66	\$70	297	0.71	0.672	24%	65%	0.30	0.59	\$70	297	0.77	0.780	22%	69%	0.23
0.67	\$80	275	0.63	0.638	26%	67%	0.29	0.60	\$80	275	0.71	0.742	24%	71%	0.23
0.64	\$90	257	0.57	0.611	28%	70%	0.27	0.58	\$90	257	0.66	0.710	26%	73%	0.21
0.62	\$100	242	0.52	0.588	30%	72%	0.26	0.56	\$100	242	0.61	0.684	27%	74%	0.20

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

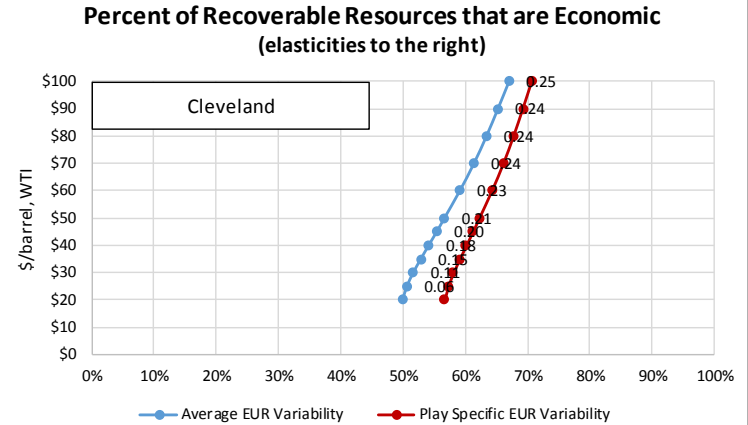
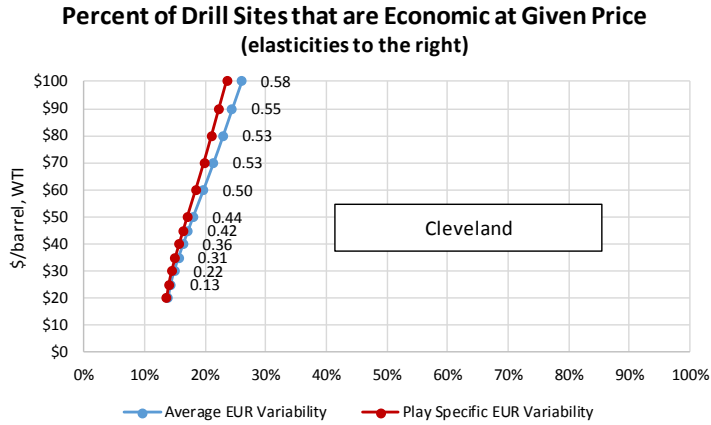
Granite Wash



Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Cleveland

EUR Distribution	
min:	0.0000
median:	0.1287
mean:	0.2320
μ :	-2.0503
σ :	1.0857
η :	1.5000
mean:	0.2320
stdev:	0.3480
a=b/e eur:	1.3590
transform:	2.1711
$E[x x>a]$:	2.1533
$Pr[x>a]$:	1.5%
$Q[R a]$:	0.0322

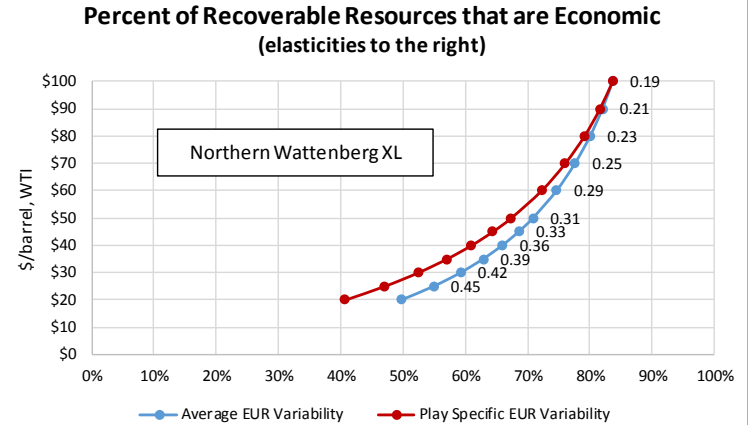
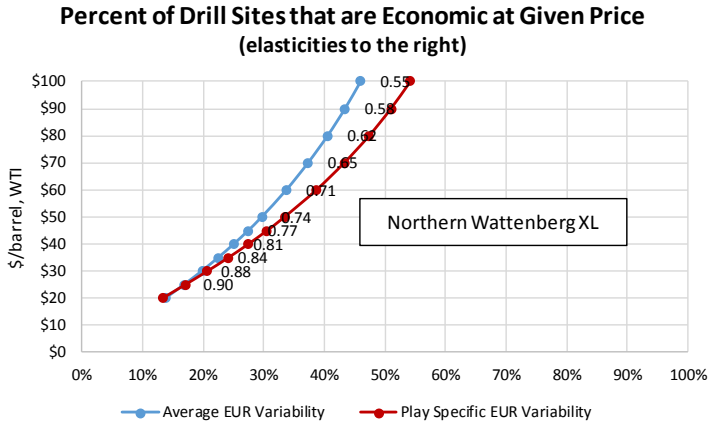


Cleveland Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.13	\$20	418	1.09	0.835	14%	50%	0.06	0.11	\$20	418	1.10	0.966	14%	57%	0.05
0.22	\$25	410	1.07	0.824	14%	51%	0.11	0.19	\$25	410	1.08	0.953	14%	57%	0.08
0.31	\$30	399	1.04	0.807	15%	52%	0.11	0.19	\$30	399	1.06	0.934	14%	58%	0.08
0.36	\$35	386	1.01	0.788	16%	53%	0.15	0.27	\$35	386	1.04	0.913	15%	59%	0.11
0.42	\$40	373	0.98	0.769	16%	54%	0.18	0.31	\$40	373	1.01	0.891	16%	60%	0.13
0.44	\$45	360	0.95	0.750	17%	55%	0.20	0.36	\$45	360	0.98	0.869	16%	61%	0.15
0.50	\$50	348	0.92	0.732	18%	57%	0.21	0.38	\$50	348	0.95	0.849	17%	62%	0.16
0.53	\$60	325	0.85	0.698	20%	59%	0.23	0.44	\$60	325	0.90	0.810	18%	64%	0.18
0.53	\$70	305	0.79	0.668	21%	61%	0.24	0.46	\$70	305	0.85	0.775	20%	66%	0.18
0.53	\$80	288	0.74	0.643	23%	63%	0.24	0.47	\$80	288	0.80	0.746	21%	68%	0.18
0.55	\$90	273	0.69	0.620	24%	65%	0.24	0.49	\$90	273	0.76	0.720	22%	69%	0.19
0.58	\$100	259	0.64	0.599	26%	67%	0.25	0.52	\$100	259	0.72	0.696	24%	71%	0.20

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Northern Wattenberg XL

EUR Distribution	
min:	0.0000
median:	0.4033
mean:	0.7270
μ :	-0.9082
σ :	1.0857
η :	1.5000
mean:	0.7270
stdev:	1.0905
a=b/e eur:	1.3590
transform:	1.1190
$E[x x>a]$:	2.6894
$Pr[x>a]$:	13.2%
$Q[R a]$:	0.3538

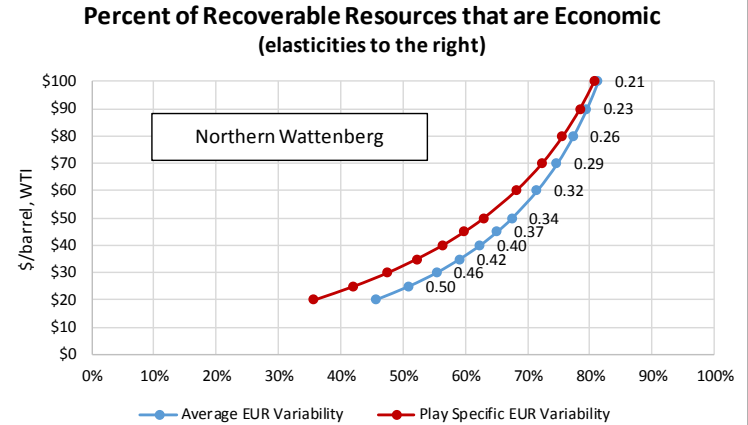
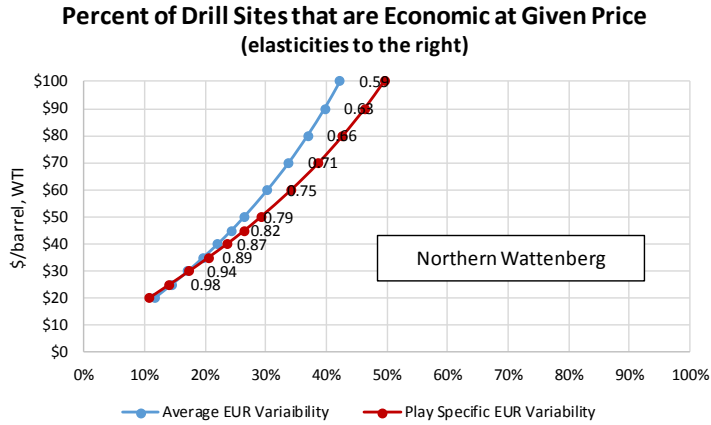


Northern Wattenberg XL Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.90	\$20	1,318	1.09	2.629	14%	50%	0.45	1.12	\$20	1,318	1.12	2.237	13%	41%	0.65
0.88	\$25	1,144	0.96	2.373	17%	55%	0.42	1.07	\$25	1,144	0.96	2.014	17%	47%	0.60
0.84	\$30	1,015	0.85	2.182	20%	59%	0.39	1.01	\$30	1,015	0.82	1.848	21%	52%	0.55
0.81	\$35	916	0.76	2.034	22%	63%	0.36	0.96	\$35	916	0.70	1.720	24%	57%	0.51
0.77	\$40	837	0.67	1.915	25%	66%	0.33	0.91	\$40	837	0.60	1.618	27%	61%	0.46
0.74	\$45	773	0.60	1.819	27%	69%	0.31	0.86	\$45	773	0.51	1.536	31%	64%	0.43
0.71	\$50	720	0.53	1.738	30%	71%	0.29	0.80	\$50	720	0.43	1.468	33%	67%	0.39
0.65	\$60	636	0.42	1.610	34%	75%	0.25	0.73	\$60	636	0.29	1.360	39%	72%	0.33
0.62	\$70	573	0.32	1.514	37%	78%	0.23	0.68	\$70	573	0.17	1.279	43%	76%	0.30
0.58	\$80	523	0.24	1.437	41%	80%	0.21	0.62	\$80	523	0.07	1.216	47%	79%	0.26
0.55	\$90	483	0.17	1.375	43%	82%	0.19	0.58	\$90	483	-0.02	1.166	51%	82%	0.24
0.55	\$100	450	0.10	1.324	46%	84%	0.19	0.58	\$100	450	-0.10	1.124	54%	84%	0.24

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Northern Wattenberg

EUR Distribution	
min:	0.0000
median:	0.1980
mean:	0.3570
μ :	-1.6193
σ :	1.0857
η :	1.5000
mean:	0.3570
stdev:	0.5355
a=b/e eur:	1.3590
transform:	1.7741
$E[x x>a]$:	2.3059
$Pr[x>a]$:	3.8%
$Q[R a]$:	0.0877

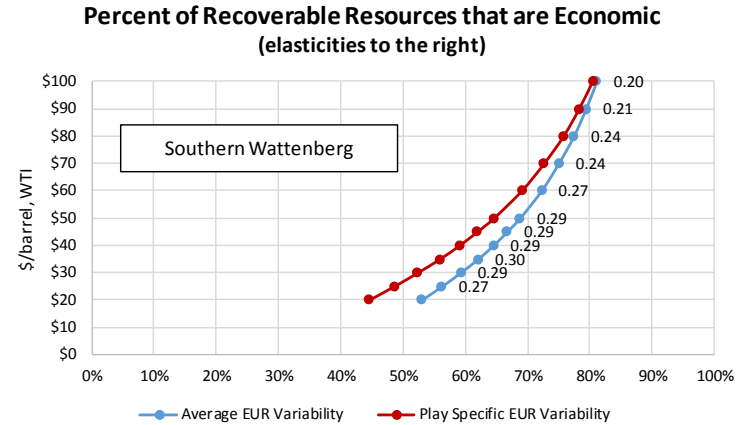
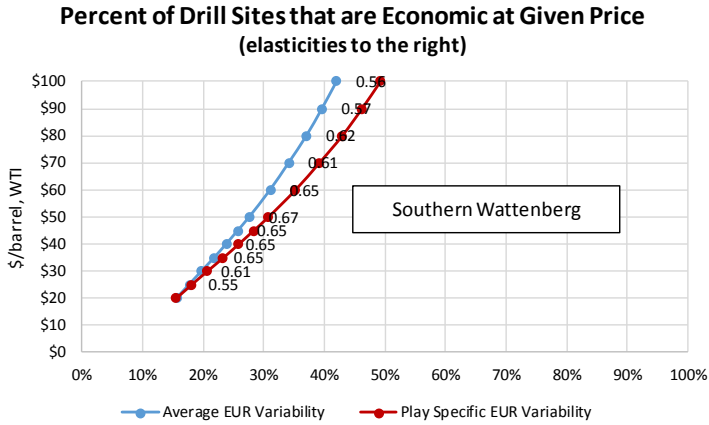


Northern Wattenberg Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.98	\$20	725	1.20	1.405	12%	46%	0.50	1.22	\$20	725	1.24	1.198	11%	36%	0.73
0.94	\$25	627	1.06	1.262	14%	51%	0.46	1.16	\$25	627	1.08	1.073	14%	42%	0.67
0.89	\$30	555	0.95	1.155	17%	55%	0.42	1.08	\$30	555	0.94	0.980	17%	48%	0.60
0.87	\$35	501	0.85	1.075	20%	59%	0.40	1.05	\$35	501	0.83	0.911	20%	52%	0.57
0.82	\$40	457	0.77	1.010	22%	62%	0.37	0.98	\$40	457	0.72	0.854	24%	56%	0.52
0.79	\$45	422	0.70	0.957	24%	65%	0.34	0.93	\$45	422	0.63	0.809	26%	60%	0.48
0.75	\$50	393	0.63	0.913	26%	68%	0.32	0.87	\$50	393	0.55	0.771	29%	63%	0.44
0.71	\$60	347	0.52	0.844	30%	72%	0.29	0.81	\$60	347	0.41	0.712	34%	68%	0.39
0.66	\$70	312	0.42	0.790	34%	75%	0.26	0.73	\$70	312	0.29	0.667	39%	72%	0.34
0.63	\$80	285	0.34	0.749	37%	77%	0.23	0.64	\$80	285	0.18	0.633	43%	76%	0.30
0.59	\$90	263	0.26	0.715	40%	80%	0.21	0.64	\$90	263	0.09	0.605	46%	78%	0.27
0.59	\$100	245	0.20	0.687	42%	81%	0.21	0.64	\$100	245	0.01	0.582	49%	81%	0.27

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Southern Wattenberg

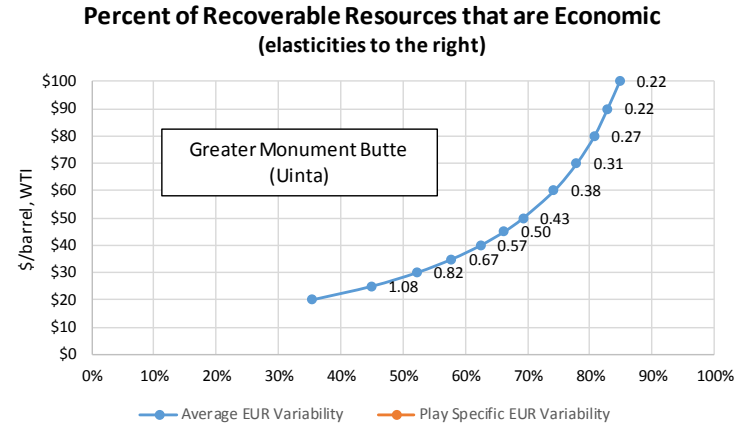
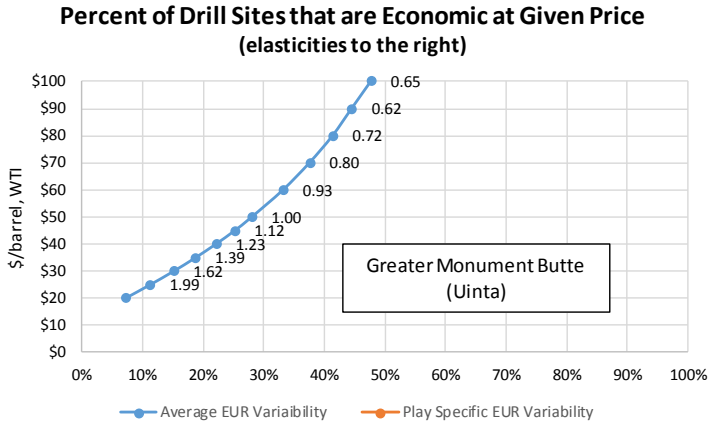
EUR Distribution	
min:	0.0000
median:	0.2191
mean:	0.3950
μ :	-1.5182
σ :	1.0857
η :	1.5000
mean:	0.3950
stdev:	0.5925
a=b/e eur:	1.3590
transform:	1.6810
$E[x x>a]$:	2.3488
$Pr[x>a]$:	4.6%
$Q[R a]$:	0.1089



Southern Wattenberg Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	656	1.01	1.340	16%	53%		\$20	656	1.02	1.138	15%	45%		
0.55	\$25	600	0.93	1.258	18%	56%	0.27	0.68	\$25	600	0.92	1.066	18%	49%	0.39
0.61	\$30	552	0.85	1.186	20%	59%	0.29	0.74	\$30	552	0.82	1.005	21%	52%	0.41
0.65	\$35	510	0.78	1.124	22%	62%	0.30	0.79	\$35	510	0.73	0.950	23%	56%	0.43
0.65	\$40	475	0.71	1.071	24%	65%	0.29	0.78	\$40	475	0.65	0.905	26%	59%	0.41
0.65	\$45	445	0.65	1.026	26%	67%	0.29	0.77	\$45	445	0.58	0.867	28%	62%	0.40
0.67	\$50	418	0.59	0.985	28%	69%	0.29	0.79	\$50	418	0.50	0.832	31%	65%	0.40
0.65	\$60	375	0.49	0.920	31%	72%	0.27	0.74	\$60	375	0.38	0.777	35%	69%	0.37
0.61	\$70	342	0.41	0.870	34%	75%	0.24	0.69	\$70	342	0.28	0.734	39%	73%	0.33
0.62	\$80	314	0.33	0.827	37%	77%	0.24	0.69	\$80	314	0.18	0.699	43%	76%	0.32
0.57	\$90	292	0.26	0.793	40%	79%	0.21	0.62	\$90	292	0.10	0.671	46%	78%	0.28
0.56	\$100	273	0.20	0.764	42%	81%	0.20	0.61	\$100	273	0.02	0.647	49%	81%	0.26

Greater Monument Butte

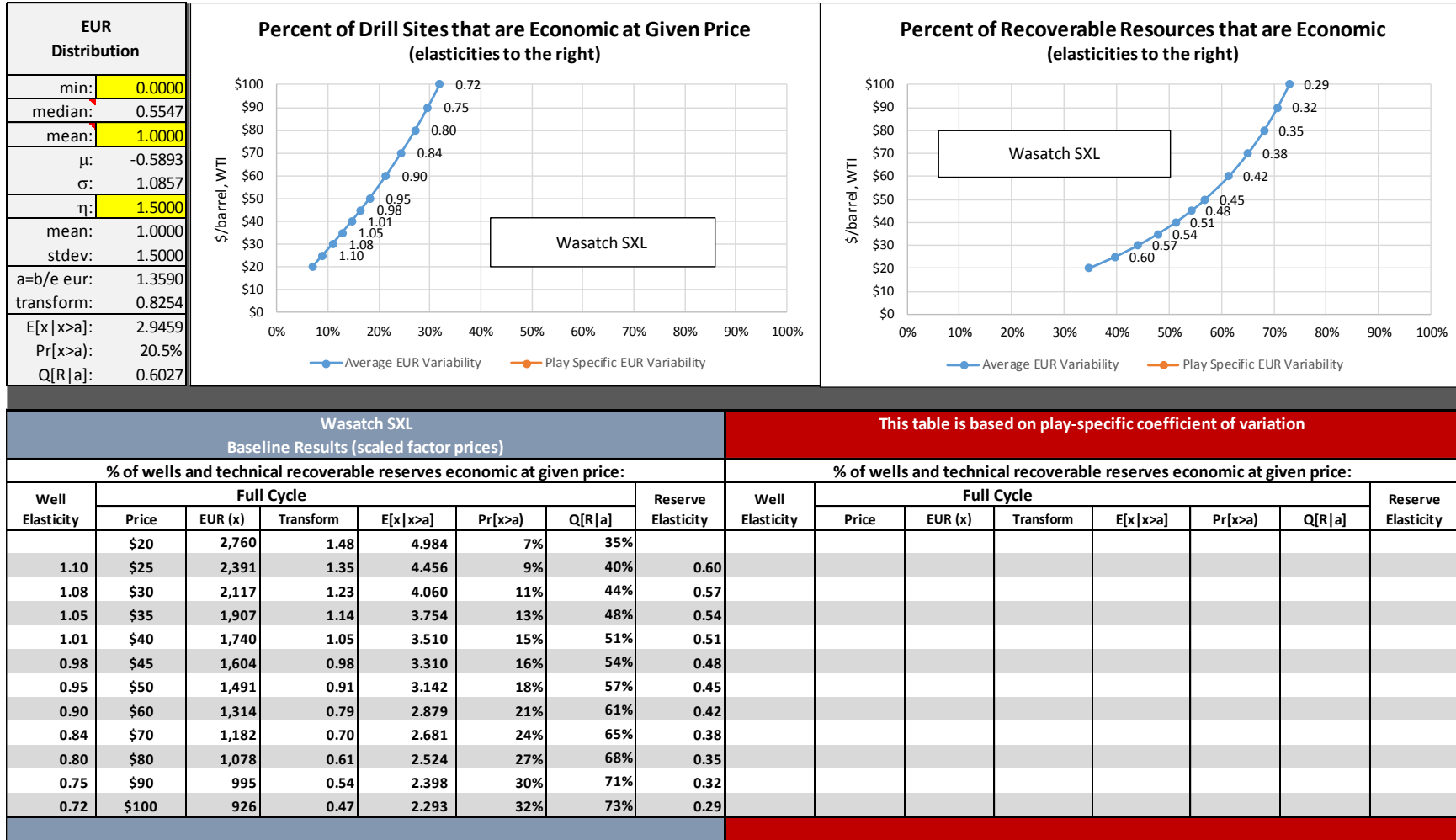
EUR Distribution	
min:	0.0000
median:	0.1043
mean:	0.1880
μ :	-2.2606
σ :	1.0857
η :	1.5000
mean:	0.1880
stdev:	0.2820
a=b/e eur:	1.3590
transform:	2.3648
$E[x x>a]$:	2.0932
$Pr[x>a]$:	0.9%
$Q[R a]$:	0.0189



Greater Monument Butte (Uinta) Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation							
% of wells and technical recoverable reserves economic at given price:								% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	510	1.46	0.924	7%	35%									
1.99	\$25	389	1.21	0.750	11%	45%	1.08								
1.62	\$30	319	1.03	0.648	15%	52%	0.82								
1.39	\$35	273	0.89	0.580	19%	58%	0.67								
1.23	\$40	240	0.77	0.531	22%	62%	0.57								
1.12	\$45	215	0.67	0.493	25%	66%	0.50								
1.00	\$50	196	0.58	0.464	28%	69%	0.43								
0.93	\$60	167	0.43	0.420	33%	74%	0.38								
0.80	\$70	147	0.32	0.390	38%	78%	0.31								
0.72	\$80	132	0.22	0.367	41%	81%	0.27								
0.62	\$90	121	0.14	0.350	45%	83%	0.22								
0.65	\$100	111	0.06	0.334	48%	85%	0.22								

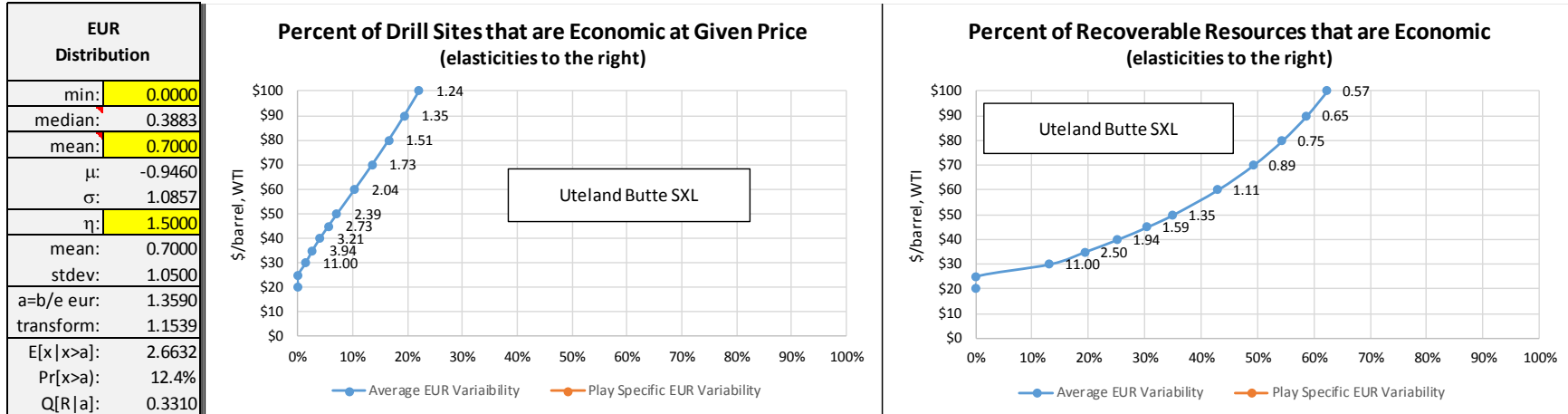
Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Wasatch SXL



Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Uteland Butte SXL

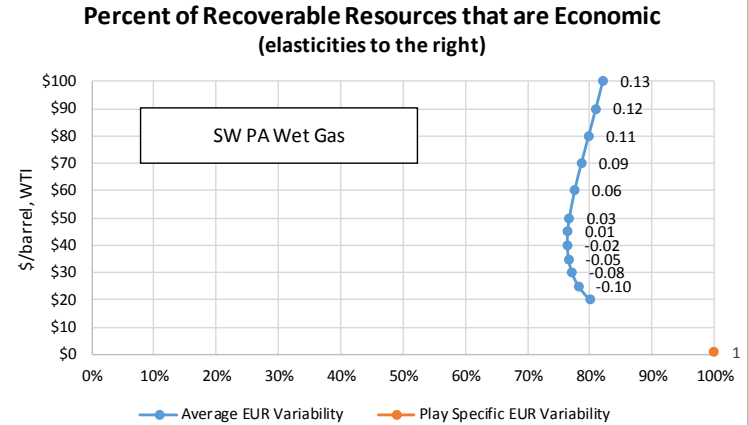
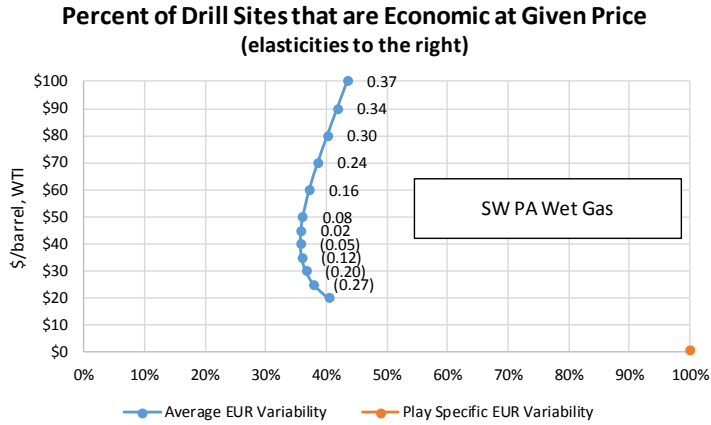


Uteland Butte SXL Baseline Results (scaled factor prices)								This table is based on play-specific coefficient of variation									
% of wells and technical recoverable reserves economic at given price:									% of wells and technical recoverable reserves economic at given price:								
Well Elasticity	Full Cycle						Reserve Elasticity	Well Elasticity	Full Cycle						Reserve Elasticity		
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$			
	\$20	13,112	3.24	18.313	0%	0%	11.00										
	\$25	6,360	2.58	9.529	0%	0%											
11.00	\$30	4,245	2.20	6.693	1%	13%											
3.94	\$35	3,214	1.95	5.283	3%	19%		2.50									
3.21	\$40	2,604	1.75	4.437	4%	25%		1.94									
2.73	\$45	2,200	1.60	3.869	6%	30%		1.59									
2.39	\$50	1,913	1.47	3.462	7%	35%		1.35									
2.04	\$60	1,531	1.26	2.913	10%	43%		1.11									
1.73	\$70	1,287	1.10	2.558	13%	49%		0.89									
1.51	\$80	1,118	0.97	2.310	17%	54%		0.75									
1.35	\$90	993	0.86	2.124	19%	59%	0.65										
1.24	\$100	896	0.77	1.980	22%	62%	0.57										

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

SW PA Wet Gas

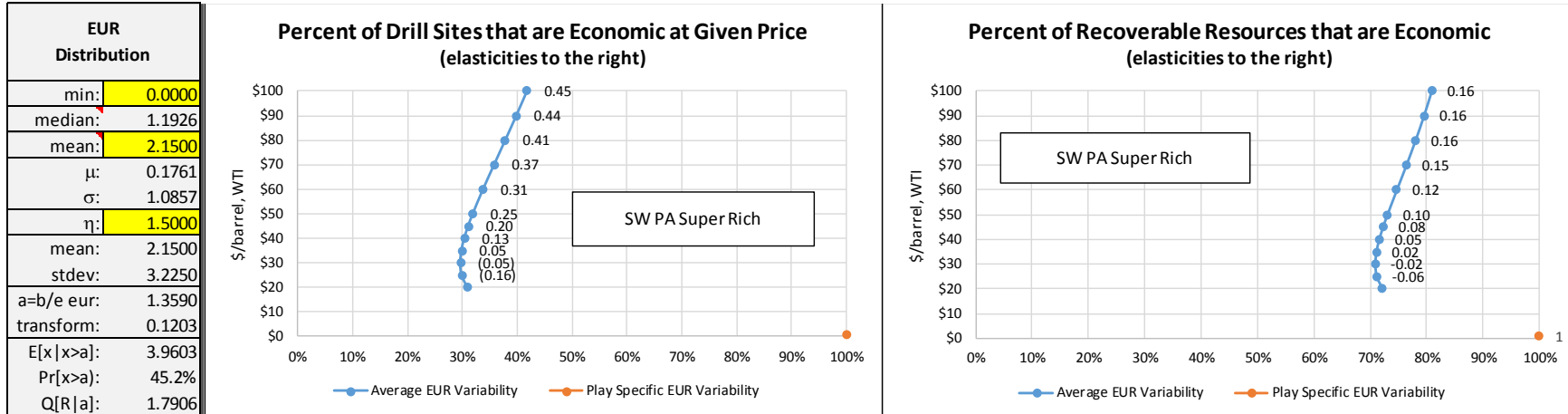
EUR Distribution	
min:	0.0000
median:	1.6269
mean:	2.9330
μ :	0.4867
σ :	1.0857
η :	1.5000
mean:	2.9330
stdev:	4.3995
a=b/e eur:	1.3590
transform:	-0.1658
$E[x x > a]$:	4.6373
$Pr[x > a]$:	56.6%
$Q[R a]$:	2.6239



SW PA Wet Gas							
Baseline Results (scaled factor prices)							
% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
	\$20	2,119	0.24	5.811	40%	80%	
(0.27)	\$25	2,266	0.31	6.037	38%	78%	-0.10
(0.20)	\$30	2,356	0.34	6.176	37%	77%	-0.08
(0.12)	\$35	2,403	0.36	6.248	36%	77%	-0.05
(0.05)	\$40	2,419	0.37	6.272	36%	76%	-0.02
0.02	\$45	2,413	0.36	6.263	36%	77%	0.01
0.08	\$50	2,391	0.35	6.229	36%	77%	0.03
0.16	\$60	2,319	0.33	6.119	37%	78%	0.06
0.24	\$70	2,228	0.29	5.979	39%	79%	0.09
0.30	\$80	2,131	0.25	5.830	40%	80%	0.11
0.34	\$90	2,036	0.21	5.684	42%	81%	0.12
0.37	\$100	1,944	0.16	5.542	43%	82%	0.13

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

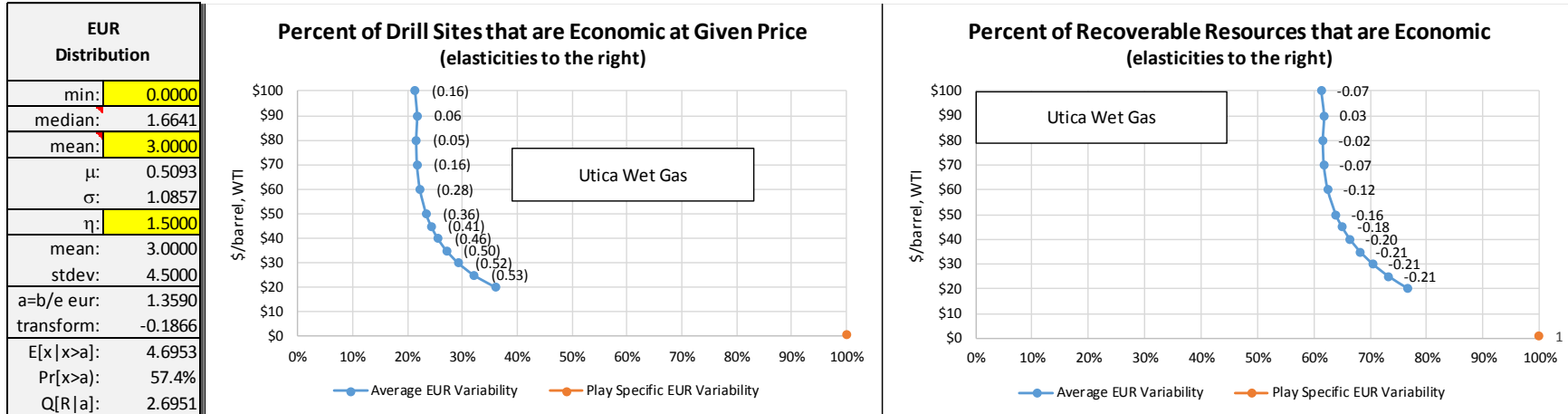
SW PA Super Rich



SW PA Super Rich Baseline Results (scaled factor prices)							
% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x > a]$	$Pr[x > a]$	$Q[R a]$	
	\$20	2,044	0.50	5.011	31%	72%	
(0.16)	\$25	2,112	0.53	5.115	30%	71%	-0.06
(0.05)	\$30	2,130	0.53	5.142	30%	71%	-0.02
0.05	\$35	2,116	0.53	5.121	30%	71%	0.02
0.13	\$40	2,083	0.51	5.070	30%	72%	0.05
0.20	\$45	2,038	0.49	5.002	31%	72%	0.08
0.25	\$50	1,987	0.47	4.924	32%	73%	0.10
0.31	\$60	1,879	0.42	4.760	34%	75%	0.12
0.37	\$70	1,772	0.36	4.596	36%	76%	0.15
0.41	\$80	1,672	0.31	4.442	38%	78%	0.16
0.44	\$90	1,580	0.26	4.301	40%	80%	0.16
0.45	\$100	1,497	0.21	4.173	42%	81%	0.16

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

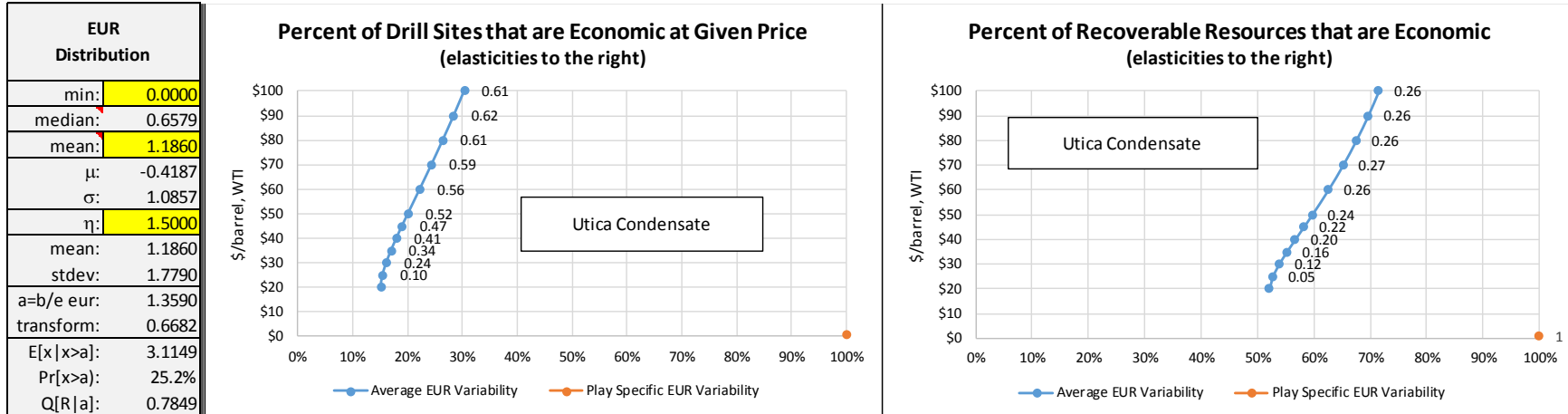
Utica Wet Gas



Utica Wet Gas							
Baseline Results (scaled factor prices)							
% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	2,447	0.36	6.374	36%	77%	
(0.53)	\$25	2,754	0.46	6.843	32%	73%	-0.21
(0.52)	\$30	3,013	0.55	7.237	29%	71%	-0.21
(0.50)	\$35	3,229	0.61	7.564	27%	68%	-0.21
(0.46)	\$40	3,408	0.66	7.834	25%	66%	-0.20
(0.41)	\$45	3,552	0.70	8.051	24%	65%	-0.18
(0.36)	\$50	3,667	0.73	8.224	23%	64%	-0.16
(0.28)	\$60	3,822	0.77	8.457	22%	63%	-0.12
(0.16)	\$70	3,898	0.78	8.570	22%	62%	-0.07
(0.05)	\$80	3,917	0.79	8.599	22%	62%	-0.02
0.06	\$90	3,896	0.78	8.567	22%	62%	0.03
(0.16)	\$100	3,948	0.80	8.645	21%	61%	-0.07

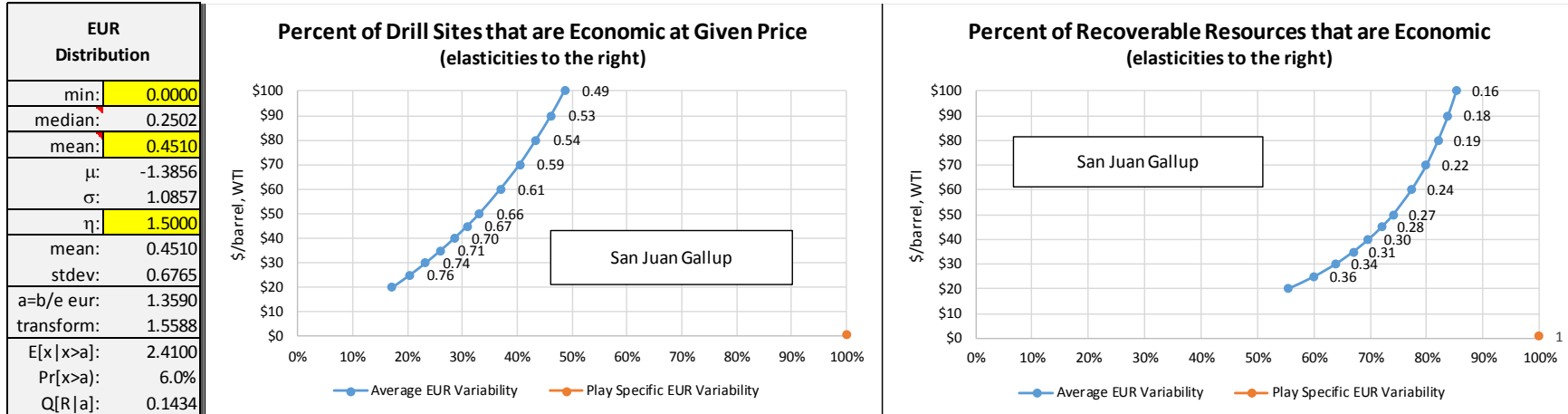
Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Utica Condensate



Utica Condensate							
Baseline Results (scaled factor prices)							
% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
0.10	\$20	2,015	1.03	4.091	15%	52%	0.05
0.24	\$30	1,924	0.99	3.957	16%	54%	0.12
0.34	\$35	1,853	0.95	3.852	17%	55%	0.16
0.41	\$40	1,779	0.92	3.743	18%	57%	0.20
0.47	\$45	1,706	0.88	3.634	19%	58%	0.22
0.52	\$50	1,636	0.84	3.530	20%	60%	0.24
0.56	\$60	1,509	0.76	3.340	22%	63%	0.26
0.59	\$70	1,399	0.69	3.175	24%	65%	0.27
0.61	\$80	1,305	0.63	3.033	26%	68%	0.26
0.62	\$90	1,223	0.57	2.909	28%	70%	0.26
0.61	\$100	1,152	0.52	2.802	30%	72%	0.26

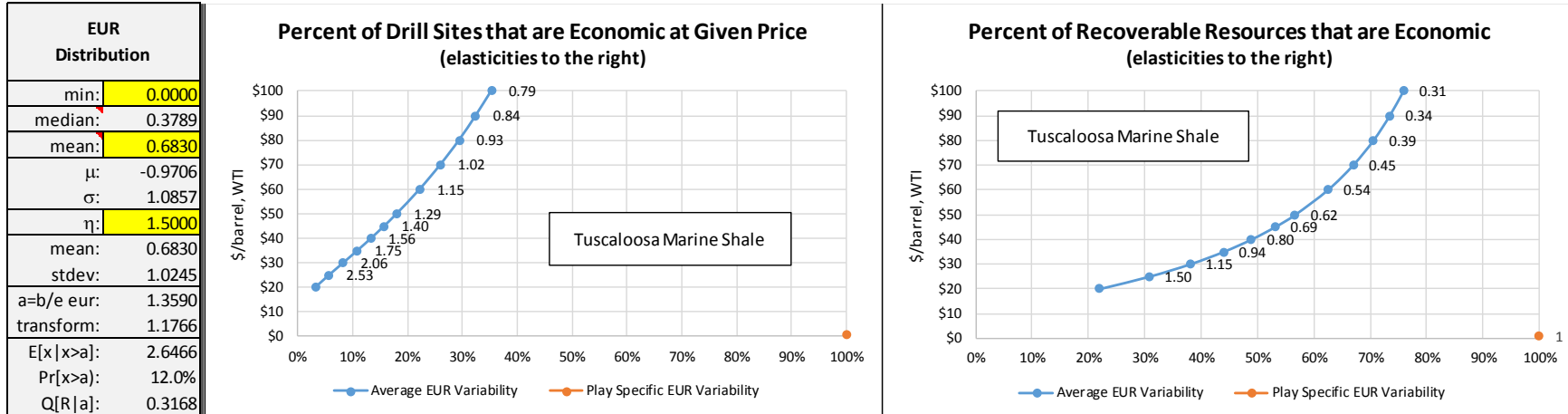
San Juan - Gallup



San Juan Gallup							
Baseline Results (scaled factor prices)							
% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x x>a]$	$Pr[x>a]$	$Q[R a]$	
	\$20	700	0.95	1.458	17%	55%	
0.76	\$25	616	0.83	1.333	20%	60%	0.36
0.74	\$30	553	0.73	1.239	23%	64%	0.34
0.71	\$35	504	0.65	1.165	26%	67%	0.31
0.70	\$40	464	0.57	1.105	28%	70%	0.30
0.67	\$45	431	0.50	1.055	31%	72%	0.28
0.66	\$50	403	0.44	1.012	33%	74%	0.27
0.61	\$60	360	0.34	0.946	37%	77%	0.24
0.59	\$70	326	0.24	0.894	40%	80%	0.22
0.54	\$80	300	0.17	0.854	43%	82%	0.19
0.53	\$90	278	0.10	0.820	46%	84%	0.18
0.49	\$100	260	0.04	0.792	49%	85%	0.16

Appendix D: Reserve Elasticity & Drill Site Elasticity, Dynamic Cost Scenario, Alternative Coefficients of Variation.

Tuscaloosa Marine Shale



Tuscaloosa Marine Shale							
Baseline Results (scaled factor prices)							
% of wells and technical recoverable reserves economic at given price:							
Well Elasticity	Full Cycle						Reserve Elasticity
	Price	EUR (x)	Transform	$E[x > a]$	$Pr[x > a]$	$Q[R a]$	
	\$20	2,844	1.86	4.751	3%	22%	
2.53	\$25	2,118	1.59	3.735	6%	31%	1.50
2.06	\$30	1,711	1.39	3.155	8%	38%	1.15
1.75	\$35	1,450	1.24	2.779	11%	44%	0.94
1.56	\$40	1,266	1.11	2.511	13%	49%	0.80
1.40	\$45	1,130	1.01	2.311	16%	53%	0.69
1.29	\$50	1,024	0.92	2.155	18%	57%	0.62
1.15	\$60	870	0.77	1.925	22%	63%	0.54
1.02	\$70	763	0.64	1.764	26%	67%	0.45
0.93	\$80	683	0.54	1.643	29%	71%	0.39
0.84	\$90	622	0.46	1.550	32%	74%	0.34
0.79	\$100	572	0.38	1.474	35%	76%	0.31

Midland Basin Spraberry					
Midland Basin: Spraberry					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 128.41	\$ 70.41	55%	-45%	
500	\$ 70.69	\$ 41.68	59%	-41%	
750	\$ 51.47	\$ 32.14	62%	-38%	
1,000	\$ 41.87	\$ 27.37	65%	-35%	
mean→	753	\$ 51.32	\$ 32.06	62%	-38%
median→	418	\$ 82.00	\$ 47.31	58%	-42%

Northern Delaware Bone Spring					
Northern Delaware Basin: Bone Spring					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 142.12	\$ 77.29	54%	-46%	
500	\$ 77.54	\$ 45.13	58%	-42%	
750	\$ 56.05	\$ 34.45	61%	-39%	
1,000	\$ 45.31	\$ 29.11	64%	-36%	
mean→	676	\$ 60.75	\$ 36.79	61%	-39%
median→	375	\$ 99.05	\$ 55.84	56%	-44%

Southern Delaware Wolfcamp

Southern Delaware Basin: Wolfcamp					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
EUR	minimum price		ratio	reduction	
	full cycle	DUC			
250	\$ 189.06	\$ 100.24	53%	-47%	
500	\$100.70	\$ 56.29	56%	-44%	
750	\$ 71.28	\$ 41.67	58%	-42%	
1,000	\$ 56.58	\$ 34.38	61%	-39%	
mean→	883	\$ 62.42	\$ 37.28	60%	-40%
median→	490	\$102.50	\$ 57.18	56%	-44%

Culberson LL Wolfcamp

Culberson LL: Wolfcamp					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
EUR	minimum price		ratio	reduction	
	full cycle	DUC			
250	\$ 681.34	\$ 342.86	50%	-50%	
500	\$ 345.30	\$ 176.06	51%	-49%	
750	\$ 233.29	\$ 120.46	52%	-48%	
1,000	\$ 177.28	\$ 92.66	52%	-48%	
mean→	1,955	\$ 95.20	\$ 51.92	55%	-45%
median→	1,084	\$ 164.26	\$ 86.20	52%	-48%

Midland Basin Wolfcamp					
Midland Basin: Wolfcamp					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 155.05	\$ 83.88	54%	-46%	
500	\$ 84.25	\$ 48.66	58%	-42%	
750	\$ 60.68	\$ 36.95	61%	-39%	
1,000	\$ 48.90	\$ 31.11	64%	-36%	
mean→	746	\$ 60.93	\$ 37.08	61%	-39%
median→	414	\$ 98.94	\$ 55.96	57%	-43%

Southern Midland Basin Wolfcamp					
Southern Midland Basin: Wolfcamp					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 138.81	\$ 75.68	55%	-45%	
500	\$ 75.97	\$ 44.41	58%	-42%	
750	\$ 55.07	\$ 34.02	62%	-38%	
1,000	\$ 44.62	\$ 28.84	65%	-35%	
mean→	500	\$ 75.97	\$ 44.41	58%	-42%
median→	277	\$126.55	\$ 69.57	55%	-45%

Eagle Ford Condensate

Eagle Ford: Condensate Region					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 170.66	\$ 92.76	54%	-46%	
500	\$ 93.14	\$ 54.19	58%	-42%	
750	\$ 67.33	\$ 41.37	61%	-39%	
1,000	\$ 54.44	\$ 34.96	64%	-36%	
mean→	801	\$ 64.05	\$ 39.74	62%	-38%
median→	444	\$102.91	\$ 59.05	57%	-43%

Eagle Ford Oil

Eagle Ford: Oil Region					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 117.81	\$ 66.37	56%	-44%	
500	\$ 66.58	\$ 40.86	61%	-39%	
750	\$ 49.52	\$ 32.39	65%	-35%	
1,000	\$ 41.01	\$ 28.15	69%	-31%	
mean→	515	\$ 65.08	\$ 40.12	62%	-38%
median→	286	\$104.90	\$ 59.94	57%	-43%

Eagle Ford Combo

Eagle Ford:Combo Region					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	EUR	minimum price		ratio	reduction
		full cycle	DUC		
	250	\$ 241.13	\$ 123.02	51%	-49%
	500	\$ 123.38	\$ 64.34	52%	-48%
	750	\$ 84.21	\$ 44.86	53%	-47%
	1,000	\$ 64.64	\$ 35.14	54%	-46%
mean→	898	\$ 71.31	\$ 38.45	54%	-46%
median→	498	\$ 123.85	\$ 64.58	52%	-48%

Bakken Core

Bakken: Core					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	EUR	minimum price		ratio	reduction
		full cycle	DUC		
	250	\$ 165.49	\$ 89.80	54%	-46%
	500	\$ 90.30	\$ 52.46	58%	-42%
	750	\$ 65.25	\$ 40.30	62%	-38%
	1,000	\$ 52.73	\$ 33.81	64%	-36%
mean→	725	\$ 66.98	\$ 40.88	61%	-39%
median→	402	\$ 108.62	\$ 61.55	57%	-43%

Bakken Non-Core

Bakken: Non Core					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 144.77	\$ 81.51	56%	-44%	
500	\$ 81.92	\$ 50.29	61%	-39%	
750	\$ 60.99	\$ 39.90	65%	-35%	
1,000	\$ 50.52	\$ 34.71	69%	-31%	
mean→	558	\$ 75.40	\$ 47.05	62%	-38%
median→	310	\$120.43	\$ 69.41	58%	-42%

Springer

Springer					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 192.87	\$ 101.40	53%	-47%	
500	\$101.86	\$ 56.13	55%	-45%	
750	\$ 71.56	\$ 41.07	57%	-43%	
1,000	\$ 56.42	\$ 33.55	59%	-41%	
mean→	904	\$ 61.24	\$ 35.95	59%	-41%
median→	501	\$101.68	\$ 56.04	55%	-45%

STACK

STACK					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	minimum price				
	EUR	full cycle	DUC	ratio	reduction
	250	\$ 259.67	\$ 127.71	49%	-51%
	500	\$128.02	\$ 62.04	48%	-52%
	750	\$ 84.24	\$ 40.25	48%	-52%
	1,000	\$ 62.37	\$ 29.38	47%	-53%
mean→	940	\$ 66.55	\$ 31.46	47%	-53%
median→	521	\$122.72	\$ 59.40	48%	-52%

SCOOP Condensate

SCOOP Condensate					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	minimum price				
	EUR	full cycle	DUC	ratio	reduction
	250	\$ 670.07	\$ 322.26	48%	-52%
	500	\$323.69	\$ 149.79	46%	-54%
	750	\$208.44	\$ 92.51	44%	-56%
	1,000	\$150.86	\$ 63.91	42%	-58%
mean→	1,952	\$ 66.65	\$ 22.11	33%	-67%
median→	1,083	\$137.62	\$ 57.34	42%	-58%

Meramec

Meramec					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 373.15	\$ 184.84	50%	-50%	
500	\$ 185.82	\$ 91.67	49%	-51%	
750	\$ 123.48	\$ 60.71	49%	-51%	
1,000	\$ 92.32	\$ 45.24	49%	-51%	
mean→	1,338	\$ 68.71	\$ 33.52	49%	-51%
median→	742	\$ 124.82	\$ 61.38	49%	-51%

SCOOP Oil

SCOOP Oil					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 263.10	\$ 133.23	51%	-49%	
500	\$ 133.87	\$ 68.93	51%	-49%	
750	\$ 90.86	\$ 47.57	52%	-48%	
1,000	\$ 69.36	\$ 36.90	53%	-47%	
mean→	979	\$ 70.75	\$ 37.58	53%	-47%
median→	543	\$ 123.65	\$ 63.86	52%	-48%

Cana Woodford

Cana Woodford					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 722.20	\$ 346.16	48%	-52%	
500	\$ 347.95	\$ 159.93	46%	-54%	
750	\$ 223.41	\$ 98.06	44%	-56%	
1,000	\$ 161.18	\$ 67.16	42%	-58%	
mean→	1,826	\$ 76.74	\$ 25.25	33%	-67%
median→	1,013	\$ 158.78	\$ 65.98	42%	-58%

Mississippian

Mississippian					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 116.90	\$ 60.29	52%	-48%	
500	\$ 60.58	\$ 32.27	53%	-47%	
750	\$ 41.84	\$ 22.97	55%	-45%	
1,000	\$ 32.48	\$ 18.32	56%	-44%	
mean→	410	\$ 72.92	\$ 38.40	53%	-47%
median→	227	\$ 128.35	\$ 66.00	51%	-49%

Marmaton

Marmaton					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 76.44	\$ 41.59	54%	-46%	
500	\$ 41.60	\$ 24.19	58%	-42%	
750	\$ 30.03	\$ 18.43	61%	-39%	
1,000	\$ 24.26	\$ 15.56	64%	-36%	
mean→	201	\$ 93.48	\$ 50.14	54%	-46%
median→	112	\$162.95	\$ 85.12	52%	-48%

Tonkawa

Tonkawa					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 92.08	\$ 48.85	53%	-47%	
500	\$ 48.89	\$ 27.29	56%	-44%	
750	\$ 34.55	\$ 20.15	58%	-42%	
1,000	\$ 27.38	\$ 16.59	61%	-39%	
mean→	249	\$ 92.42	\$ 49.02	53%	-47%
median→	138	\$162.53	\$ 84.20	52%	-48%

Granite Wash

Granite Wash					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	EUR	minimum price		ratio	reduction
		full cycle	DUC		
	250	\$ 327.26	\$ 161.16	49%	-51%
	500	\$ 161.67	\$ 78.64	49%	-51%
	750	\$ 106.57	\$ 51.22	48%	-52%
	1,000	\$ 79.04	\$ 37.54	47%	-53%
mean→	736	\$ 108.67	\$ 52.27	48%	-52%
median→	408	\$ 198.98	\$ 97.21	49%	-51%

Cleveland

Cleveland					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	EUR	minimum price		ratio	reduction
		full cycle	DUC		
	250	\$ 97.98	\$ 48.90	50%	-50%
	500	\$ 48.90	\$ 24.39	50%	-50%
	750	\$ 32.60	\$ 16.28	50%	-50%
	1,000	\$ 24.47	\$ 12.23	50%	-50%
mean→	232	\$ 105.61	\$ 52.73	50%	-50%
median→	129	\$ 190.66	\$ 95.48	50%	-50%

Northern Wattenberg XL					
Denver Julesburg Basin: Northern Wattenberg XL					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	minimum price				
	EUR	full cycle	DUC	ratio	reduction
	250	\$ 159.01	\$ 86.86	55%	-45%
	500	\$ 87.28	\$ 52.21	60%	-40%
	750	\$ 63.40	\$ 39.35	62%	-38%
	1,000	\$ 51.47	\$ 33.43	65%	-35%
mean→	727	\$ 64.91	\$ 40.10	62%	-38%
median→	403	\$104.53	\$ 59.78	57%	-43%

Northern Wattenberg					
Denver Julesburg Basin: Northern Wattenberg					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	minimum price				
	EUR	full cycle	DUC	ratio	reduction
	250	\$ 93.78	\$ 54.33	58%	-42%
	500	\$ 54.47	\$ 34.75	64%	-36%
	750	\$ 41.40	\$ 28.25	68%	-32%
	1,000	\$ 34.87	\$ 25.01	72%	-28%
mean→	357	\$ 70.20	\$ 42.58	61%	-39%
median→	198	\$114.48	\$ 64.66	56%	-44%

Southern Wattenberg

Denver Julesburg Basin: Southern Wattenberg					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 102.28	\$ 58.46	57%	-43%	
500	\$ 58.60	\$ 36.71	63%	-37%	
750	\$ 44.08	\$ 29.49	67%	-33%	
1,000	\$ 36.83	\$ 25.88	70%	-30%	
mean→	395	\$ 70.19	\$ 42.48	61%	-39%
median→	219	\$114.68	\$ 64.65	56%	-44%

Greater Monument Butte

Uinta Basin: Greater Monument Butte/Uinta					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 55.34	\$ 39.29	71%	-29%	
500	\$ 39.41	\$ 31.38	80%	-20%	
750	\$ 34.09	\$ 28.74	84%	-16%	
1,000	\$ 31.44	\$ 27.42	87%	-13%	
mean→	188	\$ 65.88	\$ 44.53	68%	-32%
median→	104	\$100.45	\$ 61.85	62%	-38%

Wasatch SXL

Uinta Basin: Wasatch SXL					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 306.52	\$ 160.93	53%	-47%	
500	\$161.72	\$ 88.92	55%	-45%	
750	\$113.48	\$ 64.96	57%	-43%	
1,000	\$ 89.37	\$ 52.98	59%	-41%	
mean→	1,000	\$ 89.37	\$ 52.98	59%	-41%
median→	555	\$147.37	\$ 81.80	56%	-44%

Uteland Butte SXL

Uteland Butte SXL					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 239.37	\$ 138.77	58%	-42%	
500	\$139.36	\$ 89.07	64%	-36%	
750	\$106.04	\$ 72.52	68%	-32%	
1,000	\$ 89.39	\$ 64.25	72%	-28%	
mean→	700	\$110.80	\$ 74.89	68%	-32%
median→	388	\$168.22	\$ 103.41	61%	-39%

SW PA Wet Gas

Appalachia Basin: SW PA Wet Gas					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
	EUR	full cycle	DUC	ratio	reduction
	250	\$ 581.60	\$ 299.23	51%	-49%
	500	\$ 301.10	\$ 159.92	53%	-47%
	750	\$ 207.66	\$ 113.54	55%	-45%
	1,000	\$ 160.94	\$ 90.35	56%	-44%
mean→	2,933	\$ 68.56	\$ 44.50	65%	-35%
median→	1,627	\$ 106.92	\$ 63.54	59%	-41%

SW PA Super Rich

Appalachia Basin: SW PA Super Rich					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
	EUR	full cycle	DUC	ratio	reduction
	250	\$ 466.02	\$ 240.91	52%	-48%
	500	\$ 242.44	\$ 129.88	54%	-46%
	750	\$ 167.94	\$ 92.91	55%	-45%
	1,000	\$ 130.70	\$ 74.42	57%	-43%
mean→	2,150	\$ 70.93	\$ 44.75	63%	-37%
median→	1,193	\$ 112.62	\$ 65.45	58%	-42%

Utica Wet Gas

Appalachia Basin: Utica Wet Gas					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 1,173.57	\$ 591.03	50%	-50%	
500	\$ 593.96	\$ 302.73	51%	-49%	
750	\$ 400.95	\$ 206.80	52%	-48%	
1,000	\$ 304.48	\$ 158.88	52%	-48%	
mean→	3,000	\$ 111.67	\$ 63.14	57%	-43%
median→	1,664	\$ 189.05	\$ 101.55	54%	-46%

Utica Condensate

Appalachia Basin: Utica Condensate					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
minimum price					
EUR	full cycle	DUC	ratio	reduction	
250	\$ 377.08	\$ 195.49	52%	-48%	
500	\$ 196.38	\$ 105.61	54%	-46%	
750	\$ 136.21	\$ 75.70	56%	-44%	
1,000	\$ 106.14	\$ 60.76	57%	-43%	
mean→	1,186	\$ 92.00	\$ 53.74	58%	-42%
median→	658	\$ 153.04	\$ 84.06	55%	-45%

San Juan - Gallup

Other Regions: San Juan - Gallup					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	EUR	minimum price		ratio	reduction
		full cycle	DUC		
	250	\$ 98.69	\$ 54.48	55%	-45%
	500	\$ 54.61	\$ 32.51	60%	-40%
	750	\$ 39.96	\$ 25.22	63%	-37%
	1,000	\$ 32.64	\$ 21.59	66%	-34%
mean→	451	\$ 59.39	\$ 34.89	59%	-41%
median→	250	\$ 98.69	\$ 54.48	55%	-45%

Tuscaloosa Marine Shale

Other Regions: Tuscaloosa Marine Shale					
Baseline Results (2014 factor prices)					
minimum (breakeven) price for the given EUR:					
	EUR	minimum price		ratio	reduction
		full cycle	DUC		
	250	\$ 186.63	\$ 105.07	56%	-44%
	500	\$ 105.62	\$ 64.84	61%	-39%
	750	\$ 78.63	\$ 51.44	65%	-35%
	1,000	\$ 65.14	\$ 44.74	69%	-31%
mean→	683	\$ 83.93	\$ 54.07	64%	-36%
median→	379	\$ 131.48	\$ 77.68	59%	-41%

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Midland Basin Spraberry

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	77%	85%	90%	92%	94%	95%	96%	97%	98%
	250	93%	96%	98%	99%	100%	100%	100%	100%	100%
	500	98%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	188	153	128	108	91	77	64	53	43
	250	100	65	39	19	2	0	0	0	0
	500	33	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
2,000	0	0	0	0	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Northern Delaware Bone Spring

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	76%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	76%	83%	87%	89%	91%	93%	94%	94%	95%
	250	91%	94%	96%	97%	97%	98%	98%	99%	99%
	500	96%	98%	99%	99%	99%	100%	100%	100%	100%
	750	98%	99%	100%	100%	100%	100%	100%	100%	100%
	1,000	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Northern Delaware Basin: Bone Springs										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	216	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	216	192	173	158	146	135	126	117	110
	250	146	122	103	88	76	65	56	47	40
	500	93	69	50	35	23	12	3	0	0
	750	62	38	19	4	0	0	0	0	0
	1,000	40	16	0	0	0	0	0	0	0
	1,250	23	0	0	0	0	0	0	0	0
	1,500	9	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Southern Delaware Wolfcamp

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	73%	81%	86%	89%	91%	93%	94%	95%	96%
	250	92%	95%	97%	98%	99%	100%	100%	100%	100%
	500	98%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Southern Delaware Basin: Wolfcamp										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	199	169	145	126	110	97	84	74	64
	250	106	76	52	33	17	4	0	0	0
	500	36	5	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Culberson LL Wolfcamp

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	68%	80%	89%	96%	100%	100%	100%	100%	100%
	250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	146	100	60	25	0	0	0	0	0
	250	0	0	0	0	0	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Midland Basin Wolfcamp

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	76%	84%	88%	91%	93%	95%	96%	97%	97%
	250	93%	96%	98%	99%	100%	100%	100%	100%	100%
	500	99%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	189	156	131	110	94	79	66	55	45
	250	95	62	37	17	0	0	0	0	0
	500	25	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Southern Midland Basin Wolfcamp

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	82%	86%	90%	92%	94%	95%	96%	97%
	250	93%	96%	98%	99%	100%	100%	100%	100%	100%
	500	99%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Southern Midland Basin: Wolfcamp										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	191	160	136	116	100	85	73	62	51
	250	92	62	38	18	2	0	0	0	0
	500	18	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Eagle Ford Condensate

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	70%	79%	84%	88%	90%	92%	93%	94%	95%
	250	90%	94%	96%	97%	98%	99%	99%	100%	100%
	500	97%	98%	99%	100%	100%	100%	100%	100%	100%
	750	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Eagle Ford: Condensate Region										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	10	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	216	186	163	145	130	117	106	96	87
	250	131	102	79	61	46	33	21	11	2
	500	68	38	15	0	0	0	0	0	0
	750	30	0	0	0	0	0	0	0	0
	1,000	4	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Eagle Ford Oil

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	73%	82%	86%	89%	91%	93%	94%	95%	95%
	250	90%	94%	96%	97%	98%	98%	99%	99%	99%
	500	96%	98%	99%	99%	100%	100%	100%	100%	100%
	750	98%	99%	100%	100%	100%	100%	100%	100%	100%
	1,000	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	

Eagle Ford: Oil Region										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	219	191	170	154	141	129	119	110	102
	250	146	118	97	81	68	56	46	37	29
	500	90	63	42	26	13	1	0	0	0
	750	58	31	10	0	0	0	0	0	0
	1,000	35	8	0	0	0	0	0	0	0
	1,250	18	0	0	0	0	0	0	0	0
	1,500	3	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
2,000	0	0	0	0	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Eagle Ford Combo

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	72%	77%	80%	83%	85%	87%	88%	89%	90%
	250	90%	92%	93%	94%	95%	95%	96%	96%	97%
	500	95%	96%	97%	98%	98%	98%	99%	99%	99%
	750	97%	98%	99%	99%	99%	99%	100%	100%	100%
	1,000	98%	99%	99%	100%	100%	100%	100%	100%	100%
	1,250	99%	99%	100%	100%	100%	100%	100%	100%	100%
	1,500	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	1	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	228	214	203	193	184	176	169	162	156
	250	159	146	134	124	116	108	101	94	88
	500	108	94	83	73	64	56	49	42	36
	750	77	64	52	42	34	26	19	12	6
	1,000	56	42	31	21	12	4	0	0	0
	1,250	39	26	14	4	0	0	0	0	0
	1,500	26	12	1	0	0	0	0	0	0
	1,750	14	1	0	0	0	0	0	0	0
2,000	4	0	0	0	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Bakken Core

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	73%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	73%	84%	90%	94%	96%	98%	100%	100%	100%
	250	95%	100%	100%	100%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	174	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	174	126	91	63	40	20	3	0	0
	250	50	2	0	0	0	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Bakken Non-Core

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	75%	85%	90%	93%	96%	97%	99%	100%	100%
	250	94%	98%	100%	100%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
Bakken: Non Core										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	177	133	100	75	54	36	20	6	0
	250	67	22	0	0	0	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Springer

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	77%	85%	89%	92%	93%	95%	96%	96%	97%
	250	93%	96%	98%	99%	99%	100%	100%	100%	100%
	500	98%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	193	161	138	119	104	90	79	69	59
	250	108	77	53	35	19	6	0	0	0
	500	44	13	0	0	0	0	0	0	0
	750	7	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

STACK

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	72%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	72%	80%	85%	88%	90%	92%	94%	95%	96%
	250	92%	95%	97%	99%	100%	100%	100%	100%	100%
	500	99%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	195	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	195	167	144	125	109	95	82	71	61
	250	96	67	44	25	9	0	0	0	0
	500	20	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
2,000	0	0	0	0	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

SCOOP Condensate

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	70%	75%	79%	82%	84%	86%	88%	89%	91%
	250	93%	95%	96%	97%	98%	99%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	192	175	161	148	136	125	115	106	97
	250	81	64	50	36	25	14	4	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
2,000	0	0	0	0	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Meramec

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	71%	77%	81%	84%	87%	89%	91%	92%	94%
	250	93%	96%	97%	99%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	-	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	188	166	147	131	116	103	92	81	71
	250	74	51	33	16	2	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

SCOOP Oil

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	73%	82%	87%	90%	93%	95%	96%	97%	98%
	250	93%	97%	99%	100%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	-	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	185	149	122	99	81	64	50	37	26
	250	76	40	12	0	0	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Cana Woodford

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	77%	79%	81%	83%	84%	85%	87%	88%
	250	93%	94%	95%	96%	96%	97%	98%	98%	98%
	500	99%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	-	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	187	177	169	161	153	146	139	133	127
	250	87	77	68	60	53	46	39	33	27
	500	11	1	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
2,000	0	0	0	0	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Mississippian

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	82%	86%	90%	93%	95%	96%	98%	99%
	250	97%	100%	100%	100%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	-	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	162	132	108	86	68	52	37	23	11
	250	28	0	0	0	0	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Marmaton

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	94%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	82%	86%	89%	91%	92%	93%	94%	95%
	250	91%	94%	95%	97%	97%	98%	98%	99%	99%
	500	97%	98%	99%	99%	100%	100%	100%	100%	100%
	750	98%	99%	100%	100%	100%	100%	100%	100%	100%
	1,000	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	110	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	214	189	170	155	142	131	121	113	105
	250	139	114	96	80	68	57	47	38	30
	500	82	58	39	24	11	0	0	0	0
	750	49	25	6	0	0	0	0	0	0
	1,000	26	1	0	0	0	0	0	0	0
	1,250	8	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
2,000	0	0	0	0	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Tonkawa

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	96%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	76%	82%	87%	89%	91%	93%	94%	95%	95%
	250	92%	95%	96%	97%	98%	99%	99%	100%	100%
	500	97%	99%	100%	100%	100%	100%	100%	100%	100%
	750	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	72	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	201	176	155	139	125	113	103	93	85
	250	120	94	74	57	44	32	21	12	3
	500	58	32	12	0	0	0	0	0	0
	750	22	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Granite Wash

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	98%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	76%	79%	82%	84%	85%	87%	88%	89%
	250	89%	91%	92%	93%	94%	95%	95%	95%	96%
	500	95%	96%	96%	97%	97%	98%	98%	98%	98%
	750	97%	97%	98%	98%	98%	99%	99%	99%	99%
	1,000	98%	98%	99%	99%	99%	99%	99%	99%	99%
	1,250	98%	99%	99%	99%	99%	99%	100%	100%	100%
	1,500	99%	99%	99%	99%	100%	100%	100%	100%	100%
	1,750	99%	99%	99%	100%	100%	100%	100%	100%	100%
2,000	99%	99%	100%	100%	100%	100%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	99	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	236	231	222	214	207	201	195	190	185
	250	183	173	164	157	150	143	138	133	128
	500	140	130	121	113	106	100	94	89	84
	750	114	104	95	87	81	74	69	63	59
	1,000	96	86	77	69	62	56	51	45	41
	1,250	82	72	63	55	48	42	37	31	27
	1,500	71	60	52	44	37	31	25	20	15
	1,750	61	51	42	34	27	21	15	10	5
2,000	53	42	34	26	19	13	7	2	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Cleveland

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	93%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	79%	82%	85%	87%	88%	89%	90%	91%
	250	90%	92%	93%	94%	95%	96%	96%	97%	97%
	500	95%	96%	97%	98%	98%	98%	99%	99%	99%
	750	97%	98%	98%	99%	99%	99%	99%	99%	100%
	1,000	98%	99%	99%	99%	99%	100%	100%	100%	100%
	1,250	99%	99%	99%	100%	100%	100%	100%	100%	100%
	1,500	99%	99%	100%	100%	100%	100%	100%	100%	100%
	1,750	99%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	99%	100%	100%	100%	100%	100%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	151	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	232	219	208	198	190	183	176	170	165
	250	172	158	147	138	130	122	116	110	104
	500	126	113	102	92	84	77	70	64	59
	750	99	86	75	66	57	50	43	37	32
	1,000	80	67	56	47	38	31	24	18	13
	1,250	65	52	41	32	24	16	10	4	0
	1,500	53	40	29	20	12	4	0	0	0
	1,750	43	30	19	10	1	0	0	0	0
2,000	34	21	10	1	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Northern Wattenberg XL

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	75%	83%	88%	91%	93%	95%	96%	97%	98%
	250	93%	97%	99%	100%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Denver Julesburg Basin: Northern Wattenberg XL										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	-	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	185	149	122	101	83	67	54	41	31
	250	83	48	21	0	0	0	0	0	0
	500	6	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Northern Wattenberg

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	97%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	82%	87%	90%	92%	93%	94%	95%	96%
	250	92%	95%	97%	98%	99%	99%	100%	100%	100%
	500	98%	99%	100%	100%	100%	100%	100%	100%	100%
	750	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Denver Julesburg Basin: Northern Wattenberg										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	57	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	202	172	149	131	115	102	91	80	71
	250	117	86	64	45	30	17	5	0	0
	500	52	22	0	0	0	0	0	0	0
	750	14	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Southern Wattenberg

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	96%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	81%	85%	88%	90%	91%	92%	93%	94%
	250	91%	94%	95%	97%	97%	98%	98%	99%	99%
	500	97%	98%	99%	100%	100%	100%	100%	100%	100%
	750	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Denver Julesburg Basin: Southern Wattenberg										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	82	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	210	187	169	154	141	130	120	112	104
	250	131	108	90	75	62	51	42	33	25
	500	71	48	30	15	3	0	0	0	0
	750	36	13	0	0	0	0	0	0	0
	1,000	12	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Greater Monument Butte

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	97%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	75%	87%	93%	97%	99%	100%	100%	100%	100%
	250	98%	100%	100%	100%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	27	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	159	104	64	33	7	0	0	0	0
	250	24	0	0	0	0	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Wasatch SXL

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	99%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	77%	83%	87%	89%	91%	92%	93%	94%	95%
	250	91%	94%	95%	96%	97%	97%	98%	98%	98%
	500	96%	97%	98%	98%	99%	99%	99%	99%	99%
	750	97%	98%	99%	99%	99%	99%	100%	100%	100%
	1,000	98%	99%	99%	99%	100%	100%	100%	100%	100%
	1,250	99%	99%	99%	100%	100%	100%	100%	100%	100%
	1,500	99%	99%	100%	100%	100%	100%	100%	100%	100%
	1,750	99%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	99%	100%	100%	100%	100%	100%	100%	100%	100%	

Uinta Basin: Wasatch SXL										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	60	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	233	214	199	187	178	169	162	155	149
	250	177	158	144	132	122	114	106	100	94
	500	135	116	102	90	80	72	64	58	52
	750	111	92	77	65	56	47	40	33	27
	1,000	93	74	60	48	38	30	22	16	10
	1,250	80	61	46	34	25	16	9	2	0
	1,500	69	50	35	23	14	5	0	0	0
	1,750	59	40	26	14	4	0	0	0	0
2,000	51	32	18	6	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Uteland Butte SXL

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	98%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	93%	93%	93%	93%	93%	93%	93%	93%	93%
	250	93%	93%	94%	95%	96%	96%	97%	97%	97%
	500	93%	96%	97%	97%	98%	98%	98%	98%	99%
	750	71%	97%	98%	98%	98%	99%	99%	99%	99%
	1,000	51%	98%	98%	99%	99%	99%	99%	99%	99%
	1,250	40%	98%	99%	99%	99%	99%	99%	99%	99%
	1,500	32%	99%	99%	99%	99%	99%	99%	99%	100%
	1,750	26%	99%	99%	99%	99%	99%	100%	100%	100%
2,000	22%	99%	99%	99%	99%	99%	100%	100%	100%	

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	192	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	243	236	236	236	236	236	236	236	236
	250	259	236	233	227	222	218	214	210	207
	500	270	219	211	205	200	196	192	189	186
	750	280	206	199	193	188	183	179	176	173
	1,000	289	197	190	184	179	174	170	167	164
	1,250	296	190	183	177	171	167	163	160	157
	1,500	302	184	177	171	166	161	158	154	151
	1,750	307	180	172	166	161	157	153	149	146
2,000	311	175	168	162	157	152	148	145	142	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

SW PA Wet Gas

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	62%	68%	72%	76%	79%	82%	84%	86%	87%
	250	92%	94%	96%	98%	99%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Appalachia Basin: SW PA Wet Gas										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	-	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	204	187	171	157	144	133	122	112	103
	250	73	55	40	26	13	1	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

SW PA Super Rich

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	64%	71%	76%	80%	83%	86%	88%	90%	92%
	250	94%	96%	98%	100%	100%	100%	100%	100%	100%
	500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

Appalachia Basin: SW PA Super Rich										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	-	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	195	173	153	136	121	107	94	82	71
	250	58	35	16	0	0	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Utica Wet Gas

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	76%	77%	79%	80%	81%	82%	83%	84%
	250	90%	91%	92%	92%	93%	93%	93%	94%	94%
	500	96%	96%	96%	97%	97%	97%	97%	98%	98%
	750	97%	98%	98%	98%	98%	98%	99%	99%	99%
	1,000	98%	98%	99%	99%	99%	99%	99%	99%	99%
	1,250	99%	99%	99%	99%	99%	99%	100%	100%	100%
	1,500	99%	99%	99%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	

Appalachia Basin: Utica Wet Gas										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	0%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	228	223	218	214	210	206	202	198	195
	250	164	159	154	150	145	141	138	134	131
	500	115	110	105	101	97	93	89	85	82
	750	87	82	77	72	68	64	60	57	54
	1,000	67	62	57	52	48	44	40	37	33
	1,250	51	46	41	37	32	28	25	21	18
	1,500	38	33	28	24	20	16	12	8	5
	1,750	27	22	17	13	9	5	1	0	0
2,000	18	13	8	4	0	0	0	0	0	

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Utica Condensate

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	99%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	76%	80%	83%	86%	87%	89%	90%	91%	92%
	250	91%	93%	94%	95%	95%	96%	97%	97%	97%
	500	96%	97%	97%	98%	98%	98%	99%	99%	99%
	750	98%	98%	99%	99%	99%	99%	99%	100%	100%
	1,000	98%	99%	99%	99%	100%	100%	100%	100%	100%
	1,250	99%	99%	99%	100%	100%	100%	100%	100%	100%
	1,500	99%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	99%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%

		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	46	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	226	213	202	192	184	177	170	164	159
	250	164	151	140	131	122	115	108	102	97
	500	117	104	93	84	75	68	61	55	50
	750	89	77	66	56	48	41	34	28	23
	1,000	70	57	46	37	29	21	15	9	3
	1,250	55	42	31	22	13	6	0	0	0
	1,500	43	30	19	9	1	0	0	0	0
	1,750	32	19	8	0	0	0	0	0	0
	2,000	23	10	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

San Juan - Gallup

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	99%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	74%	83%	87%	91%	93%	94%	96%	96%	97%
	250	92%	96%	98%	99%	100%	100%	100%	100%	100%
	500	99%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
Other Regions: San Juan - Gallup										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	28	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	193	160	135	114	98	83	70	59	49
	250	100	66	41	21	4	0	0	0	0
	500	29	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix F: Tail-End Economics, 2016 Cost Scenario.

Tuscaloosa Marine Shale

		Table Showing Tail End Recovery Factor								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	100%	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	78%	86%	91%	93%	95%	96%	97%	98%	98%
	250	94%	97%	99%	100%	100%	100%	100%	100%	100%
	500	99%	100%	100%	100%	100%	100%	100%	100%	100%
	750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,250	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,500	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1,750	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2,000	100%	100%	100%	100%	100%	100%	100%	100%	100%
Other Regions: Tuscaloosa Marine Shale										
		Table Showing Months of Lost Production								
		Oil Price (\$/barrel)								
EUR (1000 barrels/well)	-	\$20	\$30	\$40	\$50	\$60	\$70	\$80	\$90	\$100
	100	183	146	119	98	81	66	54	42	32
	250	93	56	29	8	0	0	0	0	0
	500	25	0	0	0	0	0	0	0	0
	750	0	0	0	0	0	0	0	0	0
	1,000	0	0	0	0	0	0	0	0	0
	1,250	0	0	0	0	0	0	0	0	0
	1,500	0	0	0	0	0	0	0	0	0
	1,750	0	0	0	0	0	0	0	0	0
	2,000	0	0	0	0	0	0	0	0	0

Appendix G: Notes on the Lognormal Distribution

Here we set forth the basic facts concerning the lognormal distribution that we have relied on to characterize the variation in well productivity within the population of drill sites located within each individual shale oil play.

Two-parameter lognormal distribution, $\Lambda(\mu, \sigma)$

It is assumed that EUR follows a lognormal distribution that ranges from zero to infinity. The distribution is completely determined by two parameters: $\mu = E[\ln EUR]$ and $\sigma = st. dev[\ln EUR]$. By definition, the random variable $\ln EUR$ itself follows a normal distribution with mean μ and standard deviation σ . The following facts are well known:¹

$$\text{mode}(EUR) : \quad e^{\mu - \sigma^2}$$

$$\text{median}(EUR) : \quad e^{\mu}$$

$$\text{mean}(EUR) : \quad e^{\mu + \sigma^2/2} \quad [\text{denoted } \alpha]$$

Note: median = mean $\times e^{-\sigma^2/2}$

$$\text{variance}(EUR) : \quad e^{2\mu + 2\sigma^2} - e^{2\mu + \sigma^2} = \alpha^2(e^{\sigma^2} - 1) \quad [\text{denoted } \beta^2]$$

$$\text{coef. of var.} : \quad \frac{\beta}{\alpha} = \sqrt{e^{\sigma^2} - 1} \quad [\text{denoted } \eta]$$

Note: the coefficient of variation depends only on the variance.

Quantiles: lognormal distribution $\Lambda(\mu, \sigma)$ versus std. normal distribution $N(0,1)$ ²

Let f_q and v_q be quantiles of order q of $\Lambda(\mu, \sigma)$ and $N(0,1)$, respectively.

Then $f_q = e^{\mu + v_q \sigma}$.

Proof: $\text{prob}(x < f_q) = \text{prob}(x < e^{\mu + v_q \sigma}) = \text{prob}(\ln(x) < \mu + v_q \sigma)$

$$= \text{prob}\left(\frac{\ln(x) - \mu}{\sigma} < v_q\right). \text{ QED}$$

¹ J. Aitchison and J.A. C. Brown, *The Lognormal Distribution*, Cambridge Univ. Press, 1966, p. 8.

² J. Aitchison and J.A.C. Brown op. cit., p. 9.

Three-parameter (shifted) lognormal distribution, $\Lambda(\tau, \mu, \sigma)$

The entire lognormal distribution will be shifted to the right if it is believed that EUR is bounded away from zero. The USGS follows this approach, assuming that the minimum EUR is approximately 20,000 barrels for all shale oil plays.³

If $x' = x - \tau \sim \Lambda(\mu, \sigma)$, then $x \sim \Lambda(\tau, \mu, \sigma)$

If τ is known, the variate x' is immediately known and we have all the properties of the two variate $\Lambda(\mu, \sigma)$ and no new theory arises:

$$\Lambda(x|\tau, \mu, \sigma) = \Lambda(x - \tau|\mu, \sigma) \text{ for } x > \tau$$

Because USGS treats τ as a known parameter, this formulation guides their analysis.

Location parameters are each increased by τ :⁴

$$\begin{aligned} \text{mean:} & \quad \tau + e^{\mu + \sigma^2/2} \\ \text{median:} & \quad \tau + e^{\mu} \\ \text{mode:} & \quad \tau + e^{\mu - \sigma^2} \end{aligned}$$

Also quantiles of order q are displaced from f_q to $\tau + f_q$.

All moments around the mean are unchanged.

$$\text{coef. of var:} \quad \eta' = \frac{\alpha \sqrt{e^{\sigma^2} - 1}}{\alpha + \tau} = \frac{\sqrt{e^{\sigma^2} - 1}}{1 + \tau/\alpha} = \frac{\eta}{1 + \tau/\alpha}$$

Estimation of μ and σ^2 , given τ :

Expert judgement provides:

$$f_{50} = \tau + e^{\mu} \quad (\text{median})$$

$$f_{99,9} = \tau + e^{\mu + v_{99,9}\sigma}$$

Thus,

$$f_{50} - \tau = e^{\mu}$$

$$f_{99,9} - \tau = e^{\mu + v_{99,9}\sigma}$$

and

³ USGS, Oil and Gas Assessment Team, "Variability of Distributions of Well-Scale Estimated Ultimate Recovery for Continuous (Unconventional) Oil and Gas Resources in the United States, Open-File Report 2012-1118.

⁴ J. Aitchison and J.A.C. Brown, op. cit., p. 15.

$$\frac{f_{99.9} - \tau}{f_{50} - \tau} = e^{v_{99.9}\sigma}$$

from which it follows:

$$\ln \left[\frac{f_{99.9} - \tau}{f_{50} - \tau} \right] = v_{99.9}\sigma.$$

Thus:

$$\hat{\sigma} = \frac{\ln \left[\frac{f_{99.9} - \tau}{f_{50} - \tau} \right]}{v_{99.9}} = \frac{\ln \left[\frac{f_{99.9} - \tau}{f_{50} - \tau} \right]}{3.09}.$$

Estimation of μ and σ^2 , given τ (general quantile approach):

Expert judgment provides:

$$f_{q_1} = \tau + e^{\mu + v_{q_1}\sigma}$$

$$f_{q_2} = \tau + e^{\mu + v_{q_2}\sigma}$$

Thus:

$$\frac{f_{q_1} - \tau}{f_{q_2} - \tau} = e^{(v_{q_1} - v_{q_2})\sigma}$$

$$\ln \left[\frac{f_{q_1} - \tau}{f_{q_2} - \tau} \right] = (v_{q_1} - v_{q_2})\sigma,$$

thus:

$$\hat{\sigma} = \frac{\ln \left[\frac{f_{q_1} - \tau}{f_{q_2} - \tau} \right]}{v_{q_1} - v_{q_2}}.$$

But, how to estimate the mean (μ)? You need expert judgment regarding either the mean, mode, or median of the lognormal distribution:

Ex. #1: Given the mode = $\tau + e^{\mu - \sigma^2}$, it follows that:

$$\ln(\text{mode} - \tau) = \mu - \sigma^2, \text{ which gives: } \hat{\mu} = \ln(\text{mode} - \tau) + \hat{\sigma}^2.$$

Ex. #2: Given the mean = $\tau + e^{\mu + \sigma^2/2}$, it follows that:

$$\ln(\text{mean} - \tau) = \mu + \sigma^2/2, \text{ which gives: } \hat{\mu} = \ln(\text{mean} - \tau) - \hat{\sigma}^2/2.$$

Ex. #3: Given the median = $\tau + e^{\mu}$, it follows that: $\hat{\mu} = \ln(\text{median} - \tau)$.

The third method, based on expert judgment of the median, is how USGS estimates μ .⁷

⁵ This corresponds to the estimation equation for σ found in USGS, op. cit., p. 2.

⁶ This is the general form of Eq. 6.21 in J. Aitchison and J.A.C. Brown, op. cit., p. 58.

Parameters of the “shifted truncated” lognormal distribution

USGS makes various calculations based on a finite, discretized spreadsheet representation of the estimated lognormal distribution. For that purpose, it is necessary for them to impose an upper bound on EUR, which they refer to as EUR_{max} . Their distribution is therefore truncated at the upper bound, and probability densities are recalibrated to ensure that the truncated density function still integrates to unity. The mean and variance of this truncated distribution deviate from the mean and variance of the non-truncated distribution. These transformations are described in Aitchison and Brown, and have been adopted by USGS.⁸

Our calculations are not based on a discretized spreadsheet representation of the estimated lognormal distribution. Rather, we integrate over the full range of the distribution and do not apply the truncation transformations. We also do not impose a lower bound on the estimated lognormal distribution—assuming instead that EUR at a given drill site may approach arbitrarily close to zero (albeit with miniscule probability). In practice, whether the lower bound is assumed to be zero or 20,000 barrels has negligible effect on the results, and the analytics are greatly simplified if the lower bound is assumed to be zero, as explained in the next section.

Calibrating the Variance to Match Expert Judgment:

Our procedure involves identifying the mean EUR of the lognormal distribution based on expert industry judgment (we could use the USGS estimate, but it is dated) and estimating the coefficient of variation (which is independent of the mean) based on the data provided by USGS. The remaining parameter of interest (standard deviation) can then be deduced. With the two-parameter distribution (zero lower bound), this is trivial. We have already shown:

$$\eta = \sqrt{e^{\sigma^2} - 1},$$

from which it follows:

⁷ Their estimating equation is presented in USGS, op. cit., p. 2 (top).

⁸ See Eq. 9.3 of J. Aitchison and J.A.C. Brown, op. cit., p. 87, which is the source of the two equations presented in USGS, op. cit., p. 2.

$$\hat{\sigma} = \sqrt{\ln(1 + \eta^2)}.$$

For a shifted lognormal distribution with positive threshold ($\tau > 0$), this problem entails the solution of two nonlinear equations in μ and σ , which are derived in the next section. As mentioned previously, however, because the USGS lower bound is close to zero, the resulting difference is negligible so we have applied the simpler method shown above. A comparison of the results of the two methods is tabulated later.

Calibrating the moments of a “shifted lognormal” distribution:

Objective: Given the minimum value (τ), median value (med), and coefficient of variation (η) of a lognormal distribution, find the mean and standard deviation.

We know: $med = e^\mu + \tau$

And: $mean = e^{\mu+\sigma^2/2} + \tau$

Also, by definition: $stdev = e^{\mu+\sigma^2/2} \times \sqrt{e^{\sigma^2} - 1} = \eta \times (e^{\mu+\sigma^2/2} + \tau)$

Divide through by $e^{\mu+\sigma^2/2}$ to obtain:

$$\begin{aligned} \sqrt{e^{\sigma^2} - 1} &= \eta \times \left(1 + \frac{\tau}{e^{\mu+\sigma^2/2}}\right) \\ &= \eta \times \left(1 + \frac{\tau}{mean-\tau}\right) \end{aligned}$$

Thus:

$$e^{\sigma^2} - 1 = \eta^2 \times \left(\frac{mean}{mean-\tau}\right)^2$$

Which implies:

$$\sigma^2 = \ln \left[1 + \eta^2 \times \left(\frac{mean}{mean-\tau}\right)^2\right]. \quad (I)$$

Since we have two unknowns ($mean$ and σ^2), we need another equation to complete the solution.

Start from the identity:

$$mean - med = \tau + e^{\mu+\sigma^2/2} - \tau - e^\mu = -e^\mu(1 - e^{\sigma^2/2})$$

From which:

$$e^{\sigma^2/2} = 1 + \frac{mean-med}{e^\mu}$$

And

$$\frac{\sigma^2}{2} = \ln\left(1 + \frac{\text{mean} - \text{med}}{e^\mu}\right)$$
$$\sigma^2 = 2 \times \ln\left(1 + \frac{\text{mean} - \text{med}}{e^\mu}\right) \quad (\text{II})$$

Now, equate the two expressions for sigma (I and II):

$$2 \times \ln\left(1 + \frac{\text{mean} - \text{med}}{e^\mu}\right) = \ln\left[1 + \eta^2 \times \left(\frac{\text{mean}}{\text{mean} - \tau}\right)^2\right]$$
$$\left(1 + \frac{\text{mean} - \text{med}}{e^\mu}\right)^2 = 1 + \eta^2 \times \left(\frac{\text{mean}}{\text{mean} - \tau}\right)^2$$

After substituting for e^μ :

$$\left(\frac{\text{med} - \tau + \text{mean} - \text{med}}{\text{med} - \tau}\right)^2 = 1 + \eta^2 \times \left(\frac{\text{mean}}{\text{mean} - \tau}\right)^2$$
$$\left(\frac{\text{mean} - \tau}{\text{med} - \tau}\right)^2 = 1 + \eta^2 \times \left(\frac{\text{mean}}{\text{mean} - \tau}\right)^2$$

Finally:

$$(\text{mean} - \tau)^4 = (\text{med} - \tau)^2 (\text{mean} - \tau)^2 + \eta^2 (\text{med} - \tau)^2 \text{mean}^2$$

This is one equation in one unknown (*mean*) that must be solved numerically. Having solved for mean, the *stdev* is found through the relation:

$$\text{stdev} = \eta \times \text{mean}$$

The parameters of the corresponding normal distribution (μ and σ^2) are then obtained from (I) and (II).

Estimated Coefficients of Variation: Comparison of Methods⁹

Table G1: Estimates of the non-shifted, non-truncated lognormal distribution.

AU Name	Province		USGS estimates			Normal Distribution		Shifted Lognormal		
			min	med	max	μ	σ	mean	stdev	coef var.
1 Eastern Expulsion Threshold	Williston Basin	2008	0.000	0.120	5.000	-2.120	1.207	0.249	0.451	1.814
2 Nesson-Little Knife Structural	Williston Basin	2008	0.000	0.090	4.000	-2.408	1.228	0.191	0.359	1.875
3 Cane Creek Shale Oil	Paradox Basin	2011	0.000	0.080	3.000	-2.526	1.173	0.159	0.274	1.720
4 Northwest Exclusion Threshold	Williston Basin	2008	0.000	0.065	4.000	-2.733	1.333	0.158	0.350	2.217
5 Elm Coulee-Billings Nose	Williston Basin	2008	0.000	0.080	2.000	-2.526	1.042	0.138	0.193	1.400
6 Marias River Shale Continuous Oil	Montana Thrust Belt	2002	0.000	0.080	1.600	-2.526	0.969	0.128	0.160	1.249
7 Niobrara Continuous Oil	Southwestern Wyoming	2002	0.000	0.080	1.600	-2.526	0.969	0.128	0.160	1.249
8 Niobrara Continuous Oil	Hanna, Laramie, Shirley	2005	0.000	0.040	1.600	-3.219	1.194	0.082	0.145	1.777
9 Central Basin-Poplar Dome	Williston Basin	2008	0.000	0.025	2.000	-3.689	1.418	0.068	0.174	2.543
10 Gothic, Chimney Rock, Hovenweep	Paradox Basin	2011	0.000	0.030	1.500	-3.507	1.266	0.067	0.133	1.991
11 Woodford Shale Oil	Anadarko Basin	2010	0.000	0.030	1.500	-3.507	1.266	0.067	0.133	1.991
12 Deep Uinta Overpressured Cont. Oil	Uinta-Piceance	2000	0.000	0.045	0.450	-3.101	0.745	0.059	0.051	0.862
13 Spraberry Continuous Oil	Permian Basin	2007	0.000	0.045	0.400	-3.101	0.707	0.058	0.047	0.805
14 Eagle Ford Shale Oil	Gulf Coast Mesozoic	2010	0.000	0.030	1.000	-3.507	1.135	0.057	0.093	1.620
15 Austin Pearsall-Giddings Area Oil	Gulf Coast Mesozoic	2010	0.000	0.040	0.500	-3.219	0.817	0.056	0.054	0.975
16 Niobrara Continuous Oil	Powder River Basin	2002	0.000	0.028	0.500	-3.576	0.933	0.043	0.051	1.178
17 Mowry Continuous Oil	Powder River Basin	2002	0.000	0.025	0.350	-3.689	0.854	0.036	0.037	1.036
18 Mowry Fractured Shale Cont. Oil	Big Horn Basin	2008	0.000	0.025	0.350	-3.689	0.854	0.036	0.037	1.036
19 Fractured Niobrara Limestone (Silo)	Denver Basin	2001	0.000	0.022	0.400	-3.817	0.939	0.034	0.041	1.189
20 Niobrara-Cedell (Wattenberg Area)	Denver Basin	2001	0.000	0.008	0.100	-4.828	0.817	0.011	0.011	0.975
								mean =		1.475
								st.dev. =		0.495

Table G2: Estimates of the shifted, non-truncated lognormal distribution.

AU Name	Province		USGS estimates			Normal Distribution		Shifted Lognormal		
			min	med	max	μ	σ	mean	stdev	coef var.
1 Eastern Expulsion Threshold	Williston Basin	2008	0.002	0.120	5.000	-2.137	1.212	0.248	0.450	1.815
2 Nesson-Little Knife Structural	Williston Basin	2008	0.002	0.090	4.000	-2.430	1.235	0.191	0.358	1.876
3 Cane Creek Shale Oil	Paradox Basin	2011	0.002	0.080	3.000	-2.551	1.181	0.159	0.273	1.719
4 Northwest Exclusion Threshold	Williston Basin	2008	0.002	0.065	4.000	-2.765	1.343	0.157	0.350	2.224
5 Elm Coulee-Billings Nose	Williston Basin	2008	0.002	0.080	2.000	-2.551	1.049	0.137	0.192	1.397
6 Marias River Shale Continuous Oil	Montana Thrust Belt	2002	0.001	0.080	1.600	-2.538	0.973	0.128	0.159	1.247
7 Niobrara Continuous Oil	Southwestern Wyoming	2002	0.001	0.080	1.600	-2.538	0.973	0.128	0.159	1.247
8 Niobrara Continuous Oil	Hanna, Laramie, Shirley	2005	0.001	0.040	1.600	-3.244	1.202	0.081	0.144	1.777
9 Central Basin-Poplar Dome	Williston Basin	2008	0.002	0.025	2.000	-3.772	1.445	0.067	0.174	2.578
10 Gothic, Chimney Rock, Hovenweep	Paradox Basin	2011	0.002	0.030	1.500	-3.576	1.288	0.066	0.132	2.000
11 Woodford Shale Oil	Anadarko Basin	2010	0.003	0.030	1.500	-3.612	1.299	0.066	0.132	2.004
12 Deep Uinta Overpressured Cont. Oil	Uinta-Piceance	2000	0.003	0.045	0.450	-3.170	0.765	0.059	0.050	0.847
13 Spraberry Continuous Oil	Permian Basin	2007	0.001	0.045	0.400	-3.124	0.713	0.058	0.046	0.801
14 Eagle Ford Shale Oil	Gulf Coast Mesozoic	2010	0.002	0.030	1.000	-3.576	1.156	0.057	0.092	1.617
15 Austin Pearsall-Giddings Area Oil	Gulf Coast Mesozoic	2010	0.002	0.040	0.500	-3.270	0.833	0.056	0.054	0.964
16 Niobrara Continuous Oil	Powder River Basin	2002	0.002	0.028	0.500	-3.650	0.955	0.043	0.050	1.164
17 Mowry Continuous Oil	Powder River Basin	2002	0.002	0.025	0.350	-3.772	0.879	0.036	0.037	1.020
18 Mowry Fractured Shale Cont. Oil	Big Horn Basin	2008	0.002	0.025	0.350	-3.772	0.879	0.036	0.037	1.020
19 Fractured Niobrara Limestone (Silo)	Denver Basin	2001	0.002	0.022	0.400	-3.912	0.968	0.034	0.040	1.172
20 Niobrara-Cedell (Wattenberg Area)	Denver Basin	2001	0.003	0.008	0.100	-5.298	0.960	0.011	0.010	0.892
								mean =		1.469
								st.dev. =		0.510

⁹ AU (Assessment Unit) names, provinces, plus min, med, and max of the respective lognormal distributions are as given in USGS, op. cit., p. 7.

Table G3: Estimates of the shifted, truncated lognormal distribution (USGS method).

AU Name	Province	USGS estimates			μ	σ	Truncation		Lognormal		Shifted Truncated Lognormal			
		min	med	max			factor 1 ^a	factor 2 ^b	E[x]	E[x ²]	mean	stdev	coef var.	
1 Eastern Expulsion Threshold	Williston Basin	2008	0.002	0.120	5.000	-2.137	1.212	0.971	0.748	0.239	0.197	0.241	0.374	1.552
2 Nesson-Little Knife Structural	Williston Basin	2008	0.002	0.090	4.000	-2.430	1.235	0.969	0.733	0.183	0.120	0.185	0.294	1.591
3 Cane Creek Shale Oil	Paradox Basin	2011	0.002	0.080	3.000	-2.551	1.181	0.973	0.768	0.152	0.076	0.154	0.230	1.487
4 Northwest Expulsion Threshold	Williston Basin	2008	0.002	0.065	4.000	-2.765	1.343	0.961	0.658	0.149	0.096	0.151	0.272	1.800
5 Elm Coulee-Billings Nose	Williston Basin	2008	0.002	0.080	2.000	-2.551	1.049	0.980	0.840	0.133	0.046	0.135	0.169	1.258
6 Marias River Shale Continuous Oil	Montana Thrust Belt	2002	0.001	0.080	1.600	-2.538	0.973	0.984	0.875	0.125	0.036	0.126	0.144	1.144
7 Niobrara Continuous Oil	Southwestern Wyoming	2002	0.001	0.080	1.600	-2.538	0.973	0.984	0.875	0.125	0.036	0.126	0.144	1.144
8 Niobrara Continuous Oil	Hanna, Laramie, Shirley	2005	0.001	0.040	1.600	-3.244	1.202	0.972	0.755	0.078	0.021	0.079	0.121	1.526
9 Central Basin-Poplar Dome	Williston Basin	2008	0.002	0.025	2.000	-3.772	1.445	0.951	0.580	0.062	0.020	0.064	0.127	1.979
10 Gothic, Chimney Rock, Hovenweep	Paradox Basin	2011	0.002	0.030	1.500	-3.576	1.288	0.965	0.698	0.062	0.015	0.064	0.106	1.659
11 Woodford Shale Oil	Anadarko Basin	2010	0.003	0.030	1.500	-3.612	1.299	0.964	0.690	0.061	0.015	0.064	0.105	1.654
12 Deep Uinta Overpressured Cont. Oil	Uinta-Piceance	2000	0.003	0.045	0.450	-3.170	0.765	0.991	0.943	0.056	0.005	0.059	0.047	0.807
13 Spraberry Continuous Oil	Permian Basin	2007	0.001	0.045	0.400	-3.124	0.713	0.992	0.953	0.056	0.005	0.057	0.044	0.768
14 Eagle Ford Shale Oil	Gulf Coast Mesozoic	2010	0.002	0.030	1.000	-3.576	1.156	0.975	0.783	0.053	0.009	0.055	0.078	1.410
15 Austin Pearsall-Giddings Area Oil	Gulf Coast Mesozoic	2010	0.002	0.040	0.500	-3.270	0.833	0.989	0.925	0.053	0.005	0.055	0.050	0.909
16 Niobrara Continuous Oil	Powder River Basin	2002	0.002	0.028	0.500	-3.650	0.955	0.985	0.883	0.040	0.004	0.042	0.045	1.073
17 Mowry Continuous Oil	Powder River Basin	2002	0.002	0.025	0.350	-3.772	0.879	0.988	0.911	0.033	0.002	0.035	0.034	0.954
18 Mowry Fractured Shale Cont. Oil	Big Horn Basin	2008	0.002	0.025	0.350	-3.772	0.879	0.988	0.911	0.033	0.002	0.035	0.034	0.954
19 Fractured Niobrara Limestone (Silo)	Denver Basin	2001	0.002	0.022	0.400	-3.912	0.968	0.984	0.878	0.031	0.002	0.033	0.036	1.077
20 Niobrara-Cedell (Wattenberg Area)	Denver Basin	2001	0.003	0.008	0.100	-5.298	0.960	0.986	0.886	0.008	0.000	0.011	0.009	0.821

a. Factor 1 = $\Phi((\ln \max - \mu - 2\sigma^2)/\sigma)/\Phi((\ln \max - \mu)/\sigma)$, where $\Phi(\cdot)$ represents the standardized Normal distribution function.

b. Factor 2 = $\Phi((\ln \max - \mu - \sigma^2)/\sigma)/\Phi((\ln \max - \mu)/\sigma)$.

mean = 1.278
st.dev. = 0.363

Derivation of the Percentage of Drilling Sites and Resources that are Economically Viable

The portion of technically recoverable resources that constitute reserves at any given price level is composed of the reserves of all drill sites that are economically viable; i.e., where $EUR > EUR_p$. This is quantified by integrating the recoverable resource over all drill sites that exceed the threshold:

$$N \times \int_{EUR_p}^{\infty} x \cdot f(x) dx, \quad (G1)$$

where N represents the number of potential drilling sites in the play and $f(\)$ represents the lognormal density of EUR .

The volume of technically recoverable resources is found by integrating over all drill sites:

$$N \times \int_0^{\infty} x \cdot f(x) dx. \quad (G2)$$

Reserves as a percentage of the potentially recoverable resource base is given by the ratio:

$$\%resources = \frac{\int_{EUR_p}^{\infty} x \cdot f(x) dx}{\int_0^{\infty} x \cdot f(x) dx} \quad (G3)$$

We multiply and divide the numerator by the term $1 - F(EUR_p)$ to obtain:

$$\%resources = \frac{\int_{EUR_p}^{\infty} x \cdot \frac{f(x)}{1-F(EUR_p)} dx \times [1-F(EUR_p)]}{\int_0^{\infty} x \cdot f(x) dx}, \quad (G4)$$

where $F(EUR_p) = \int_{EUR_p}^{\infty} f(x) dx$.

Equation (G4) can be written equivalently as:

$$\%resources = \frac{E[EUR|EUR > EUR_p]}{E[EUR]} \times \%wells, \quad (G5)$$

where:

$$\%wells = 1 - F(EUR_p).$$

Since EUR follows a lognormal distribution, the conditional mean is given by:¹⁰

$$E[EUR|EUR > EUR_p] = E[EUR] \times \frac{\Phi\left(\frac{\sigma - \ln EUR_p - \mu}{\sigma}\right)}{\Phi\left(\frac{-\ln EUR_p - \mu}{\sigma}\right)}. \quad (G6)$$

¹⁰ J. Aitchison and J.A.C. Brown, op.cit., Eq. 9.3, p. 87.

After substituting this into (G5), and observing that $\Phi\left(-\frac{\ln EUR_p - \mu}{\sigma}\right) = 1 - \Phi\left(\frac{\ln EUR_p - \mu}{\sigma}\right) = \%wells$,

we have: $\%resources = \Phi\left(\sigma - \frac{\ln EUR_p - \mu}{\sigma}\right).$ (G7)