Summary of Dave Cox Testimony

Exhibit C1: Curriculum Vitae for Dave Cox

Occupation: Petroleum Engineer

Qualifications: BS and MS, Petroleum Engineering from the Colorado School of Mines, with 28 years experience in the oil and gas industry, including working on coalbed methane projects since 1981 in all the major CBM basins of the US as well as other international basins.

Exhibit C2: Presentation and Exhibits for the San Juan Basin Coalbed Methane Spacing Study

This material was excerpted from a presentation by the San Juan Basin Coalbed Methane Committee at an NMOCD Examiner hearing on Feb. 21, 1991. It provides a short review of several key points regarding coalbed methane production. Diagrammatic production decline curves show the differences between a conventional decline curve and a coalbed methane decline curve. Coalbed methane production curves incline for a period (in some cases for several years), before they peak and begin to decline, in contrast to conventional sandstone gas reservoir decline curves which commonly decline throughout most of their lives. This exhibit also shows an adsorption isotherm, which relates the amount of gas stored on a coal to the pressure on the coal. Mr. Cox will discuss the condition known as "undersaturated", and its impact on CBM production.

Exhibit C3: Adsorption Isotherms

This exhibit presents two isotherms reported by the San Juan Coal Company from coreholes in or near the application area, and compares them to an average San Juan Basin isotherm. Mr. Cox will use this exhibit to describe why the desorption testing conducted by San Juan Coal Company was erroneous.

BEFORE THE
OIL CONSERVATION COMMISSION
Case No. 12734
Exhibit # C-1
Submitted By:Richardson Oper.Co.
Hearing Date:October 28 & 30, 2002

Exhibit C4: Initial Pressure Data in and Near the Richardson Application Area

Pressure data from five wells in and near the application area are shown on this exhibit. From these data, it is concluded that the average initial potentiometric surface level in the Fruitland Coal in the application was about 5100 ft above sea level or higher.

Exhibit C5: Gas Content Based on the Isotherm

The gas content of the Fruitland Coal in the application area is assessed in this exhibit, based on the initial pressures computed for various depths and the average initial potentiometric surface level in the coal. The average gas content based on the isotherm is about 250 scf/ton, with a range in the area from 178 to 281 scf/ton. By bringing reservoir pressure down to 25 to 75 psia, the remaining adsorbed gas in the reservoir is reduced to 32 to 90 scf/ton.

Exhibit C6: Fruitland CBM Recovery Based on the Adsorption Isotherm

The average isotherm presented in Exhibit C-5 was used with various assumed abandonment pressures to determine the amount of gas recoverable from the Fruitland Coal. After adjusting for a higher indicated ash content in the Upper Coal, the average gas in place per 320-acees in the application area was determined to be about 3.8 Bcf. An average of about 2.6 Bcf should be recoverable to 50 psia abandonment pressure from each 320-acre drilling and spacing unit in the coal. This corresponds to about 68% of the average initial gas in place.

Exhibit C7: Typical Pictured Cliffs Gas in Place and Recovery Efficiency

Using typical values for Pictured Cliffs reservoir properties, this exhibit shows that each 160-acre drilling and spacing unit in the Pictured Cliffs contains 0.05 to 0.26 Bcf recoverable, depending mainly on net pay thickness.

Exhibit C8: Russell Federal No. 2 Production Curve

The Russell Federal No. 2 is a well to the east of the application area. Mr. Richardson's examination of the historical production from this well was the cause of his exploration for CBM in this area. The production curve and ultimate recovery from the Russell

Federal No. 2 indicate most of its production came from the Fruitland Coal, instead of the Pictured Cliffs Sandstone.

<u>Exhibit C9: Total Production from Richardson Wells in the Application Area</u>

This chart shows how production has increased dramatically over the last several years from the Richardson wells in the Application Area. Cumulative production from the Richardson wells in the Application Area is **<u>2.5 Bcf</u>** of gas in less than 3 years, with aggregate production now exceeding **<u>4 MMcfd</u>**.

<u>Exhibit C10: Production Summary for Application Area</u>

This table summarizes the production by well within the application area. Cumulative production per well ranges from virtually nothing to 337 MMcf from the Bushman 6-1 well. Most of the wells show increases in production over time similar to the increases seen in the aggregate curve.

<u>Exhibit C11: Bushman 6-1 Decline Curve</u>

The Bushman 6-1 was Mr. Richardson's first well in the Application Area. The production curve for this well indicates it is producing from a good permeability interval in the Fruitland Coal, in addition to the Pictured Cliffs Sandstone. The production behavior shows the early incline curve, rising to a peak rate of 350 to 400 Mcfd per well. A linear scale was chosen for these next several wells to highlight the increases in production that have been observed.

<u>Exhibit C12: Pittam Pond Production Curve</u>

The production curve for this Fruitland Coal/Pictured Cliffs well near the southwest corner of the Application Area indicates its production is still climbing. It started at only about 1 Mcfd, and has now reached about 70 Mcfd.

Exhibit C13: State 36-3 Production Curve

This Fruitland Coal well is very close to the mining activities near the southwest corner of the Application Area. Although this well is extremely shallow, its production has been steadily rising, and was recently more than 100 Mcfd.

Exhibit C14: State 16-1 Production Curve

The production curve for this Fruitland Coal/Pictured Cliffs well near the northeast corner of the Application Area also demonstrates substantially increasing production over time. It started at only 3-5 Mcfd, and has since reached well over 100 Mcfd.

Exhibit C15: State 32-1 PC Production Curve

The production curve for this Pictured Cliffs well started at about 45 Mcfd and has since declined to about 30 Mcfd. The low rate and steady decline denote the type of performance that can be expected from a low permeability sandstone reservoir like the Pictured Cliffs.

Exhibit C16: Location of Nearby Fruitland Coal Wells

Most of Mr. Richardson's Fruitland Coal wells are still in the production incline phase of their life. In order to evaluate the how much further production can be expected to increase, the performance of nearby Fruitland Coal wells was examined. This exhibit shows the locations of nearby Fruitland Coal wells. Most of the closest wells have only a few years of production. Fifty-one of the wells on this exhibit had 5 years or more of production. Out of those, 28 wells (or 55%) showed inclines, 16 wells (31%) showed high initial rates above 300 Mcfd with subsequent declines and little or no incline period, while the remaining 7 wells (14%) had lower initial rates and held steady or declined.

Exhibit C17: Ropco Fee 6 #001 Production Curve

The Ropco Fee 6 No. 1 is completed in both the Upper and Lower Fruitland Coal. Gas production from this well grew from a few Mcf per day to over 1.2 MMcfd over 7 years.

Exhibit C18: San Juan Federal #002 Production Curve

The San Juan Federal #002 is also completed in both the Upper and Lower Fruitland Coal. Following an early decline lasting several years and leading to a minimum rate of about 40 Mcfd, gas production from this well then inclined and reached 500 Mcfd almost 9 years after initial production.

Exhibit C19: Gilbreath #001 Production Curve

Gas production from the Gilbreath #001 began at about 100 Mcfd for about 2 years, before inclining to over 600 Mcfd after 8 years of production.

Exhibit C20: Gallegos 421 Production Curve

The production from the Gallegos 421 is representative of the low rate, flat or declining production class, with little or no production incline period yet observed.

Exhibit C21: Gallegos 382 Production Curve

The production from the Gallegos 382 is representative of the high initial rate, declining production, with little or no production incline period.

Exhibit C22: Performance of Nearby Wells with At Least 5 Years of Production

Each of the 51 nearby wells with at least 5 years of production history were categorized into one of the three types described above:

1. Inclining Production
2. Low Initial Rates and Steady or Declining Production
3. High Initial Rates and Declining Production

This table summarizes other relevant information that were examined assess the reasons the three different types are present. Possible differences in coal thickness and coal depth were considered. No obvious differences were found that were correlated to measured properties. Accordingly, an attempt was then made to evaluate the range of performance particularly for the inclining wells, which appear to have similar production behavior as the wells in the Application Area. For the inclining wells, the mean incline period was 5.1 years from initial production to peak rate, and the average peak rate was 644 Mcfd.

Exhibit C23: Correlation between Depth and Peak Gas Rate

This exhibit showed that there was essentially no correlation between peak gas rate and depth for the Fruitland Coal wells with inclining production. In theory, peak rate should correlate to permeability, pressure and other factors. Because there is no correlation to depth, it is inferred that any increase in average pressure with depth is probably offset by lower average permeability associated with greater confining pressure on the coal.

Exhibit C24: Correlation between Thickness and Peak Gas Rate

This exhibit showed that there was essentially no correlation between peak gas rate and coal thickness for the Fruitland Coal wells with inclining production. In theory, peak rate should be proportional to thickness if all other factors are equal. Because there is no correlation with thickness, it is inferred that variability in other factors, such as permeability, are much greater than the variability in thickness.

Exhibit C25: Palmer and Mansoori Paper

After reviewing the performance of the wells in the Application Area and other nearby wells, several possible explanations for inclining production were considered. Dewatering causes increasing gas saturation, and therefore increasing effective permeability to gas, which leads to inclining production in the classical CBM conceptual analysis as described in the Presentation and Exhibits for the San Juan Basin Coalbed Methane Spacing Study. This explanation probably accounts for part of the increase in production, but the low observed water rates suggest that water saturation (and therefore gas relative permeability) would change little after a few years of production in this area. Another possibility would be removal of formation damage caused by stimulation fluids, but it seems unlikely that this would occur so consistently over so many wells. A more likely cause of the production is found in a paper by Palmer and Mansoori, which indicates that with production, the coal matrix can actually shrink in some cases. This can allow the natural fractures or cleats in the coal to become more open, leading to large increases in permeability by a factor of 5 or more. This occurs as a result of the gas production from the coal, so the limited water production would not adversely affect this explanation. In fact, the low water production numbers are consistent with the matrix shrinkage explanation, because matrix shrinkage effects are more pronounced at low cleat porosity levels in the coal, which would also lead to low volumes of water available to be produced.

Exhibit C26: Application Area EUR

A simulation model was prepared to evaluate the ultimate recovery per well under current conditions, and with an additional Fruitland Coal well in each unit. The model was originally based on the area within the current mine plan, and was subsequently scaled up to include the entire application area. Mr. Hively's geological maps were used for thickness and structure. The analysis assumed that 80% of the wells within the area would follow the inclining type of behavior, with an average combined peak rate from Upper and Lower Fruitland Coal of 500 Mcfd after 5 years of production. All wells were allowed to produce to an economic limit.

Using this approach, an ultimate recovery of 0.91 Bcf per 320 acres was computed for recovery from the Lower Fruitland coal using existing wells and completions. With two wells per 320-acre spacing unit, ultimate recovery reached 1.56 Bcf per 320 acres from the Lower Coal. The Upper Coal was found to add 0.38 to 0.65 Bcf per 320 acres for 1 and 2 wells per 320, respectively. Thus, a total additional recovery of 0.92 Bcf per 320 acres can be achieved by adding a second well in each 320-acre spacing unit, leading to a total incremental recovery of 27 Bcf from the application area through additional completions and drilling.

Most of these wells are already in place, so the additional cost to complete the Fruitland Coal will be small. The total working interest net economic benefit based on recent prices and costs is more than $1 per Mcf, indicating a future working interest net income of more than **$39 million** from wells as currently completed, or more than **$66 million** total from existing and proposed completions.

The above analysis assumes that Richardson's wells will be allowed to produce until they reach an economic limit, and are not adversely affected by excessive drainage from adjacent tracts. If the wells are prematurely abandoned as a result of mining, or if the mining activity causes a larger drawdown (and thus greater drainage across the lease lines) than an offset well would have done, then the EUR and future net income from CBM wells would be impaired.

Exhibit C27: Map of All Penetrations

This exhibit shows all existing Fruitland penetrations in the Application Area as large red circles, with proposed new wells as yellow circles. As shown on this map, there are more than 70 penetrations of the Fruitland Coal in the Application Area that will need to be accounted for in the mining plans.

Exhibit C28: Underground Observations of Mined-Through Stimulation Treatments of Coalbeds, by William P. Diamond

This paper is provided to demonstrate the compatibility of coalbed methane production with underground mining for coal. This paper reports on 22 government-sponsored stimulation treatments that were mined through to determine the effects of hydraulic fracture treatments on the coalbeds and roof strata. These "minebacks" were conducted in varied settings in Alabama, Pennsylvania, Virginia, West Virginia, Illinois and Utah. The last sentence of the abstract summarizes the results of this paper:

> "No roof falls or adverse mining conditions were encountered that could be attributed to the stimulations."

In addition, numerous CBM wells have been mined through especially in Alabama and Virginia that were not documented to this extent. In fact, Black Warrior Methane, the largest coalbed methane producer in Alabama, is jointly owned by Jim Walter Resources (one of the largest coal mining companies in Alabama with 3 longwall mines) and El Paso Production Company. Their web site notes that they are "The World Leader in The

Capture and Sale of Methane Gas Generated by Underground Coal Mining". Black Warrior Methane has produced more than 260 Bcf of coalbed methane, and is currently producing about 50 MMcfd of CBM. Furthermore, Consol Energy, who is the largest producer of coal from underground mines in the US primarily with longwall operations, also produces 130 MMcfd of CBM from conventional and gob wells in southwestern Virginia.

The experience of Consol and Black Warrior Methane with CBM wells in conjunction with coal mining demonstrates that CBM wells are not inherently incompatible with longwall mining. However, in those cases the mining companies own a major position or the entirety of the CBM operations. In this case, there are different owners for the different rights. As the mining progresses, much of the CBM gas that would otherwise be recovered from Richardson's wells will be vented to the atmosphere. The gas that is vented is not available to Richardson, and will obviously reduce his ultimate recovery.

DAVE O. COX, M.S., P.E.

QUALIFICATIONS SUMMARY

Twenty-five plus years of diverse experience in well testing, enhanced oil recovery, unconventional and low permeability reservoirs, and property evaluations.

- Coalbed methane
- Oil and gas property evaluation
- Well testing
- Reservoir engineering
- Reservoir simulation
- Adjunct professor, Colorado School of Mines
- Short course instructor
- Author of more than 35 technical papers

PROFESSIONAL EXPERIENCE

Numerous assignments in a broad range of settings, covering 31 states of the US and 20 other countries. Organized and taught industry short courses on Coalbed Methane, Tight Gas Sands, Type Curve Methods, and Thermal Recovery. Experience in conventional and unconventional oil recovery includes primary recovery, waterflooding, gas flooding, carbon dioxide flooding, steam soak and drive methods, *in-situ* combustion, tar sands and oil shale. Gas reservoir experience includes dry gas reservoirs, overpressured gas reservoirs, gas condensate fields, low permeability and unconventional coal and shale reservoirs. Has testified on numerous occasions as a Coalbed Methane expert at Oil and Gas Commission hearings.

1997-Present: Questa Engineering Corporation, Golden, Colorado; Vice President of Reservoir Engineering

Projects included:

- Project manager on the 3M Coalbed Methane Project, involving simulating all CBM wells on the Colorado portion of the San Juan Basin
- CBM evaluation projects in San Juan, Powder River, Raton, and Sand Wash Basins
- Short courses:
  - Produced water in the oil and gas industry
  - Coalbed methane reservoir engineering
  - Maximizing coalbed methane asset value
  - Tight gas production in the Green River Basin.

1991-Present: Colorado School of Mines, Golden, Colorado; Adjunct Professor of Petroleum Engineering

- Classes Taught:
  - Coalbed Methane
  - Waterflooding
  - Graduate and Undergraduate Well Testing
  - Reservoir Studies
  - Unsteady Flow Problems In Porous Media
  - Advanced Decline Curve Analysis.

Exhibit #
C-1-A

1992-1997: Advanced Resources International, Inc., Lakewood, Colorado, Vice President of Reservoir Engineering and other positions

Projects included:

- Prepared reservoir performance models to analyze production of 10,000 natural gas fields in the US
- Analyzed more than 200 CBM well tests
- Simulated coalbed methane reservoir performance for more than 50 projects in San Juan, Warrior, and Appalachian Basins
- Analysis of gas seepage from coal beds
- Short courses on petroleum reservoir engineering, well testing, tight gas sands, coalbed methane, and gas shales.

1990-1991: Cox Engineering Corporation, Golden, Colorado, President and Owner

- A short course on type curve analysis of fractured wells
- Evaluation of CBM properties in San Juan Basin
- Directional planning for a thirty-well urban drilling program in California
- Reserves analysis of a 25 MMcfd gas field in the Arkoma basin, Oklahoma
- Testified at lawsuits and hearings in California, Texas and Nebraska.

1984-1989: ANGUS Petroleum Corporation, Golden, Colorado, Vice President, Engineering and other positions

- VP of the independent oil production affiliate of Pacific Gas & Electric Company (the largest public utility in the US)
- Responsible for acquisitions, engineering, development and reservoir management
- Evaluated CBM properties containing more than 4 Tcf of gas in place
- Evaluated 300 properties in Texas, the Rockies and California, leading to offers for over $100 million of producing properties
- ANGUS operated 400 wells in 8 fields in California, Colorado and Texas.

1981-1994: E&P Petroleum Consultants, Inc., Denver, Colorado, Vice President

- Prepared and presented a short course on thermal recovery
- Provided all engineering services for a 46,000-acre Raton Basin coalbed methane leasehold
- Analyzed coalbed methane projects in the Raton, Piceance and Warrior Basins
- Determined the impact of oil shale mining on the Natural Buttes gas field.

1975-1980: Energy Consulting Associates, Inc., Denver, Colorado, Manager of Reservoir Engineering and other positions

- Evaluated primary and secondary operations in oil fields in Texas, Wyoming, Oklahoma, Colorado, North Dakota, Montana and California
- Prepared field studies of tight gas wells and Devonian Shale wells for the Department of Energy
- Prepared geology and reservoir engineering sections of a basic petroleum technology course presented to over 20,000 people
- Performed hydrologic modeling, well testing and permit applications for mine dewatering and water disposal for oil shale projects.

EDUCATION

1977: MS Petroleum Engineering, Colorado School of Mines
1974: BS Petroleum Engineering, Colorado School of Mines

PROFESSIONAL SOCIETIES

Society of Petroleum Engineers of AIME
Society of Petroleum Evaluation Engineers
Colorado Registered Professional Engineer No. 17831
Society of Professional Well Log Analysts

CBM-RELATED PUBLICATIONS

Cox, D., Onsager, P., Thomson, J., Reinke, R., Gianinny, G., Vliss, C., Hughes, J., and Janowiak, M., "San Juan Basin Ground Water Modeling Study: Ground Water – Surface Water Interactions Between Fruitland Coalbed Methane Development and Rivers", Prepared for the Groundwater Protection Research Foundation, Oct., 2001.

"Maximizing CBM Asset Value", a One-Day Seminar presented by Questa Engineering Corporation, Golden, Colorado, Oct. 19, 2001.

"Different Viewpoints for CBM Asset Values

"CBM Reservoir Engineering", a Two-Day Seminar presented by Questa Engineering Corporation, Golden, Colorado, June 2001.

"Coalbed Methane in the Rockies: Christmas Past, Present and Future", Presented to the Denver Chapter of the Society of Petroleum Evaluation Engineers, Jan. 10, 2001.

"The 3M CBM Final Report, Volume I: Analysis and Results", Prepared for the Southern Ute Indian Tribe, the Colorado Oil and Gas Conservation Commission, and the U.S. Bureau of Land Management, Dec. 14, 2000.

"3M CBM Model Status and Future Runs", Presented to the 3M Technical Peer Review Team, July 25, 2000.

"3M CBM Model Seepage and Infill Results", Presented to the Colorado Oil and Gas Conservation Commission, June 5, 2000.
"3M CBM Model Supplemental Information", Prepared for the 3M Technical Peer Review Team, June 5, 2000.

"Aquifer Recharge Issues in the Basin: Will the Water Come Back? An Investigation of What Will Happen after Coalbed Methane Production in the Powder River Basin," presented at the CBM Fair II, Sheridan Wyoming, Nov. 19-20, 1999.

"Updated Information Regarding Gas Seepage in the Pine River Area, La Plata County, Colorado," a Presentation prepared for the Colorado Oil and Gas Conservation Commission, October 1998.

"Options to Reduce Gas Seepage in the Pine River Area, La Plata County, Colorado," a Presentation prepared for the Colorado Oil and Gas Conservation Commission, Sep. 3, 1996.

"Gas Seepage in the Pine River Area, La Plata County, Colorado," a Presentation prepared for the Colorado Oil and Gas Conservation Commission, May 21, 1996.

"Gas Seepage in the Pine River Area, Colorado," prepared for the Pine River Fruitland Coal Investigative Team, Nov. 1994.

"Well Testing in Coalbed Methane (CBM) Wells: An Environmental Remediation Case History," SPE Paper No. 30578, SPE Annual Technical Conference, Dallas, Texas, Oct. 22-25, 1993. (Co-author)

"Coal Seam Water Production Disposal, San Juan Basin," in *Quarterly Review of Methane from Coal Seams Technology*: 11(2), Dec. 1993.

"Water Disposal from Coalbed Methane Wells in the San Juan Basin," SPE 26384, 1993 SPE Annual Technical Conference, Houston, Texas, Oct. 3-6, 1993. (Co-author)

Analysis of Fruitland Water Production, Treatment and Disposal, San Juan Basin, Topical Report, Prepared for the Gas Research Institute, Report No. 93/0288, June 1993. (Co-author)

"Analysis of Fruitland Water Production, Treatment, and Disposal, San Juan Basin," Coalbed Methane Forum, Denver, Colo., June 1993.

"A Modeler's View of Critical Coalbed Methane Reservoir Parameters," Natural Gas Supply Project Advisor Group Meeting: Coalbed Methane Project Area, Colorado Springs, Colo., Sep. 1992.