# Introduction

This document provides answers to many of the more detailed questions that are asked of EnCana regarding CBM development. It is not intended to be an introductory explanation of CBM development but focuses on providing more details regarding many of the 'technical' questions regarding this type of development.

For additional questions or introductory material, please contact EnCana.



# Drilling and Completions

Horseshoe Canyon CBM wells are drilled in the same way as SE Alberta shallow gas wells. The industry has over 30 years experience drilling these types of wells with 10's of thousands drilled without incident.

The wells are typically drilled in 2 stages. In the first stage 'conductor casing' or 'surface casing' is placed. This shallowest casing layer is constructed by drilling the hole and then placing a steel pipe that is cemented into the ground around its outside from the bottom of the hole to the surface. The second stage is the drilling of the 'production hole'. Steel pipe 'casing' is also placed in this hole and the pipe cemented from bottom to top around the outside of pipe. The cement prevents fluids (gas or water) from flowing up (or down) the outside of the pipe thereby containing vertical flow to the inside of the 'production casing'.

## Lost Circulation Events

Lost circulation events are events where some of the water used for drilling a well (drilling mud) does not flow back to surface during a rotary drilling operation, but instead is sidetracked into a highly permeable underground zone. Lost circulation can occur at shallow depths and happens during drilling of water wells in addition to hydrocarbon wells.

EnCana places surface casing over the zones where lost circulation is most likely to occur to reduce the possibility of lost circulation while drilling the production wellbore. When a lost circulation event occurs, corrective actions are taken and if required Loss Control Materials, typically cellophane or cellulose material, is placed in the drilling fluids to stop the leak off. It should be noted that drilling fluid losses with lost circulation events are very small relative to the size of the zone and it is highly unlikely for the drilling fluids to penetrate an area further away then a few metres from the well being drilled. EnCana has drilled thousands of shallow gas wells in southern Alberta and is unaware of ever having had a lost circulation event that caused any type of impact on an aquifer.

## Drilling and Completions Fluids

For CBM and shallow gas operations, drilling fluids, which are often referred to as 'drilling mud', is most often simply available surface water. In many cases, this water will 'mud up' naturally from bentonite and other clays that are encountered in the ground as the well bore is drilled. If not enough clay is encountered to create the correct fluid density, bentonite clay is added to the water on the drilling rig. In some cases materials such as lime or sodium-hydroxide are added to control pH.

Drilling fluids for CBM and shallow gas wells are normally disposed of through land spreading. After being tested to meet Alberta Environment requirements and with approval from the affected landowner, the fluids are spread over a cultivated field and worked so as to have no negative impacts on the land.

Horseshoe Canyon CBM wells are fracture stimulated with commercial nitrogen. Most of the nitrogen is recovered and vented in the first day, while the remainder of the nitrogen displaces some of the natural gas in the coal bed and is produced back out over the production life of the well.

Aquifers are actively avoided in Horseshoe Canyon type CBM developments since any zone that produces enough non-saline water to be considered an aquifer is unlikely to produce commercial quantities of gas and would jeopardize production from the other gas bearing coals encountered in the well. Small amounts of water production, even amounts below the water required for an average household, can be enough water to stop the gas flowing in a typical Horseshoe Canyon type CBM well, so avoiding water production is key to the success of these types of CBM wells.

Electronic well logs and experience in the area allows EnCana to avoid aquifers. If an 'aquifer' was encountered in a completion operation, the zone would be abandoned by being cemented off in the wellbore before fracture stimulation. If through some combination of events, an aquifer was infiltrated by the 'fracture fluid' (nitrogen), the nitrogen is diluted by the vast quantity of water in the aquifer relative to the quantity of the nitrogen and no long term change would be discernable in the aquifer water.

# Groundwater Concerns

EnCana acknowledges that protection of groundwater is a primary concern for industry. This is not a new concern – the AEUB has had rules in place since its inception that protects ground water. Alberta Environment also enforces strict regulations in this area. Industry, including EnCana has followed drilling and completions practices for decades that protect groundwater, modifying the practices appropriately as new technology and hydrocarbon development types come along. The AEUB has 5 recorded incidents of ground water contamination as a result of hydrocarbon development while more than 175,000 hydrocarbon wells have been drilled in the province. All 5 were successfully resolved.

## Water well testing

EnCana customizes its water well testing approach dependent on the area being developed. Factors we consider include:

- Local hydrogeology
- Availability of existing data on ground water
- Type of development  and the depth of the zones to be developed for hydrocarbons
- EnCana's drilling and completion experience in the area; and
- Local community concerns

At a minimum we encourage individuals with water wells within 200 m of a proposed well to have their water well tested at EnCana's expense. EnCana also makes testing available to anyone within 400 m of a proposed gas well. The sampling of water wells further away are considered on a case-by-case basis.

EnCana uses 3rd party, accredited labs for water well testing. Water samples are obtained by qualified 3rd party contractors, typically a provincially certified water well drilling company or a hydrogeology consulting company.

At a minimum, EnCana tests for routine potability parameters (major ions).

EnCana does not routinely perform flow tests on water wells for several reasons including: the results are significantly affected by seasonal and usage variations, and water well construction and maintenance; it is inconvenient to well owners and wastes water; and there is a considerable risk to the water well and its equipment. EnCana's experience with drilling and completions operations indicates that most reported water well concerns involve changes in water quality, not quantity.

EnCana does not routinely test for dissolved hydrocarbons, including methane or aromatics (i.e. benzene, toluene, etc). The presence or absence of methane by itself in a water well is not an useful indicator of gas migration resulting from hydrocarbon development activity because of the variable presence of free methane that comes from the aquifer itself in many parts of Alberta.

Aquifer methane that is naturally present will tend to 'come and go' in water wells that make use of the aquifer. When aquifers are drawn down, the methane gas in an aquifer will tend to collect in the water well due to the low pressure area created in the immediate vicinity of the water well; when aquifer water levels are higher, the methane gas in the aquifer will not be generated as free gas. Methane can also be generated by biological activity in the aquifer and water well. This variation in methane production in water wells and the fact that methane can and very often is sourced from the aquifer or water system itself is what causes the presence of methane to not be an useful indicator of impact on the well from hydrocarbon development.

Free gas testing may be done as part of the investigation of a water well complaint since the presence of hydrocarbon gases other than methane (e.g. pentane) could indicate gas migration. However no ‘baseline sample’ is necessary for this indicator to be useful since in most of the province it would be very unusual for heavier hydrocarbons to be present in the aquifer without having migrated up a nearby gas or oil well.

As a general practice, EnCana does not perform ongoing sampling of private water wells or use ground water monitoring well networks. Our experience after testing 1000s of water wells, many of them multiple times, is that the effects of water usage; ground water sources; water well maintenance and construction; and seasonal and rainfall variances have a much greater impact on water quality and quantity that what our operations can reasonably affect. In the very few cases in Alberta where hydrocarbon development has been shown to have affected ground water, the affects were readily apparent. Most water well owners are very familiar with the performance of their water wells, pay close attention to any changes and are willing to contact us if changes are observed.

If a concern with a water well is received by EnCana and the person believes it might be associated with our activities, EnCana will investigate. If water supply is a concern, EnCana will supply necessary water. Our investigations go through a series of steps that starts with some basic questions and may ultimately end with a formal investigation by a 3rd party, professional hydrogeologist. EnCana shares all investigations and their results with Alberta Environment, and will often keep Alberta Environment informed throughout the investigation.

Water well investigations are expensive – usually considerably more than the cost of settling a typical damage claim. Therefore it had become a fairly common practice for industry to settle damages on a water well issue without an investigation. However this practice has led to misunderstanding regarding the frequency of industry impact on water wells and therefore the practice of settling for damages without investigation is not permitted within EnCana and we actively encourage other operators to thoroughly investigate claims as well.

## Methane Migration Experience

EnCana is not aware of any problem with methane migration into water wells as a consequence of its CBM activity in Alberta. Although there has been a suggestion reported in the press that EnCana’s CBM activity is associated with methane migration into water wells, no requests have ever been directly received by EnCana to investigate methane migration in association with CBM activity.

Methane is a non-toxic gas that is commonly found in aquifers in Alberta and its presence in water wells varies predominantly with season and groundwater usage. In aquifers that are naturally bearing methane, the gas that is present has either naturally migrated from ultra-shallow gas-bearing zones or been generated in the aquifer itself, particularly if the aquifer is a coal bed. Of course in areas where ultra-shallow gas and coal beds are present, there is also nearly always deeper gas-bearing zones and coals which can be commercially developed for gas. This proximity of gas development to groundwater that contains naturally occurring methane can cause people to conclude, incorrectly, that it is the gas development causing the methane in the groundwater, when really it simply a fact that if there is methane gas present at groundwater depths, there is almost always deeper gas suitable for commercial development. Adding to the confusion is the tendency for free gas to appear and disappear in a water well as the pressure in the aquifer changes in response to the water usage and recharge.

The type of CBM development that EnCana is doing in Alberta has no greater risk of causing gas migration into aquifers then conventional shallow gas development. Specifically, within the Horseshoe Canyon coals, the methane gas is trapped in the coal by cap rocks – this is exactly the same way conventional gas is trapped in conventional reservoirs. The initiation of gas production from these coals cannot cause vertical gas migration – except through the inside of the well bore. This is fundamentally different from much of the CBM produced in the US where the gas in the coal seams is held in place by water instead of cap rock and the dewatering performed as part of production can, at least in theory, release the gas permitting it to migrate up existing natural fractures.

Furthermore the gas being produced from Horseshoe Canyon coal beds is at unusually low pressures in the reservoir. Because of the low pressure, there is little energy in the reservoir (the coal beds) to push the gas out. To get gas in significant quantities to move out of the coal at all requires the large opening and low pressure that is made available in the inside of the production casing in the gas well. The low reservoir pressure makes Horseshoe Canyon CBM gas even less likely to migrate up the outside of the casing then with conventional gas where reservoir pressures are usually higher.

EnCana receives relatively few complaints regarding methane migration in water wells. Of the 30 complaints on file that have been investigated in the last 7 years, two of the complaints were for perceived methane migration issues. In neither case did investigations by 3rd party hydrologists conclude there was methane migration as a result of industry activity. Furthermore, the AEUB has provided at EnCana's request information on water well complaints that it has on record. In the last 7 years there has been 4 confirmed water well gas migration problems that were linked with industry activity – these problems were all found to be associated with poor cement in the space between the casing and the outside of the wellbore in older, deeper conventional wells.

In the 2 investigations conducted on EnCana's behalf into methane migration complaints the independent hydrogeogists concluded that the methane originated naturally from the aquifers. Coal beds that exist at the ultra-shallow depths, typically less than 150 m deep, often serve as aquifers. These coal bed aquifers are not commercially produced for gas in the 'Horseshoe Canyon' area because they do not contain commercial quantities of natural gas. However, these coal beds are often used as water sources for water wells. Because they are coal beds these aquifers contain methane gas and in fact continue to 'manufacture' methane gas through natural processes. Water wells completed in coal bed aquifers are essentially very low producing 'wet coal' type CBM wells – when the water is removed for usage by the owner, the coal becomes depressured and produces methane. The low volume of methane produced by these water wells is insufficient to be of commercial interest to gas production companies but is definitely detectable by the water well owner. If the coal bed aquifer is recharged with water either from reduced water usage or recharge, the methane production will decrease or even stop since the water level in the coal bed aquifer will restore the pressure to a level where the gas in the coal will no longer be liberated from the coal.

## Flaring, Venting and Incineration

For CBM and shallow gas development, EnCana typically has pipeline in place before the well is completed and flowed. Although this reduces the need for disposal of 'waste gas' by flaring, venting or incineration, it does not eliminate it. CBM wells are stimulated using nitrogen and as a result the gas that first flows back from the well contains a large amount of nitrogen. The nitrogen reduces the 'heat content' of the gas so that it does not work correctly for furnaces and other natural gas uses and so it is not permitted to be sold. This requires that the first gas flowed back from a well be disposed of using flaring, incineration or venting. That being said, waste gas from a CBM well flows at a very low rate and disposal is required for only a few days, so despite the large number of CBM wells drilled they are a very small contributor to the venting and flaring volumes in the province.

EnCana uses flaring, venting and incineration in its CBM operations. As mentioned previously, nitrogen is used to fracture the coal beds to stimulate production and the first gas flowed back from the well is very high in nitrogen content. This gas is incapable of combustion, so it is vented for several hours until combustion is possible. After this phase, the gas is combustible but still contains too much nitrogen to be sold – the energy content is too low. EnCana preferentially flares this gas. Occasionally EnCana will incinerate the gas.

The CBM gas from the Horseshoe Canyon coals is 'cleaner' then commercial sales gas – the gas has less heavy hydrocarbons and no $H_2S$. It is a different gas then 'solution gas' which has been the basis for nearly all of the published flared gas emission studies. Therefore EnCana sponsored a study by Dr. Kostiuk on the flaring of CBM gas at different nitrogen levels and under different wind conditions. The study concluded that flaring of the gas from CBM wells did not result in detectable level of 'toxic' emission substances (e.g. benzene, PAHs) due to the lack of heavier hydrocarbons in the gas. High nitrogen content and high winds could reduce the efficiency of flaring resulting in some methane not being combusted. However, methane is not toxic and the issue of it not being converted to water and $CO_2$ through combustion is in EnCana's opinion a greenhouse gas issue, not a toxic emission issue.

Due to the low heat content of the CBM gas that is burned as waste gas, incinerators require ‘propane assist’ to function correctly. The addition of propane to the gas stream not only increases the amount of energy being consumed in disposal of the waste gas, but also increases the possibility of complex emissions such as PAHs, since propane includes the heavier hydrocarbon molecules that lead to increased emissions of this type. However, incineration would ensure the combustion of virtually all of the methane and reduce the ‘greenhouse gas’ contribution. From an esthetics perspective, incinerators have a tendency to be louder then flares, whereas the light of a flare is usually more visible.

Due to the reasons outlined above, EnCana does not take a strong position on flaring versus incineration for disposal of waste gas from CBM wells. Incineration requires additional fuel, can result in more complex emissions and is usually louder. Flaring increases the amount of methane not combusted in high winds and/or high nitrogen conditions and has a more visible flame. In our opinion there is no clear environmental advantage to using one over the other and incineration ‘wastes’ more hydrocarbon energy because of the need to add fuel gas to operate – therefore we recommend flaring for these types of wells. That being said, EnCana will incinerate when local residents express a strong preference towards it.

EnCana does not routinely perform air monitoring associated with CBM wells. The gas content of the wells, low flow rates, low operating pressures and low flaring emissions associated with a short flaring period makes the measurement of air quality impact impractical against back ground levels.

## Facilities Associated with CBM (and Shallow Gas) Development

Both CBM and conventional shallow gas development require similar well densities and equipment. Horseshoe Canyon CBM development typically requires wells, pipeline, compression and dehydration. There are no physical ‘batteries’ and no well site separators required. Well densities are typically from 2 to 4 wells per section with some pilots currently being performed at 8 wells in a section. Some Horseshoe Canyon CBM wells are initially used to produce conventional gas before being used for CBM, these wells may have a separator package on them during the period the well is used for conventional gas.

Occasionally lay persons will suggest that the final well density will likely be much higher then what is stated here – EnCana has heard numbers reported as high as 128 wells in a section. Such large numbers usually arise from one or both of two improperly used sources. The first is a misuse of the meaning of ‘well spacing’ orders (well density orders approved by the AEUB). ‘Well Spacing’ approvals are granted on a ‘per pool’ basis for the purposes of managing mineral ownership. Because there are multiple stacked pools involved with CBM, some persons will take the number of pools and multiply it times the number of wells approved ‘per pool’ to arrive at very large ‘potential’ well densities. In reality CBM and the associated conventional shallow gas pools are ‘commingled’ so as to use a single well to produce from all the pools. For CBM development, using one well per pool would be both uneconomic and impractical. For the current price and cost predictions, general expectation for Horseshoe Canyon CBM development continues to be from 4 to 8 surface locations in a section. The second misused data source is comparisons to potential well densities reported for US CBM developments. Most of the CBM in the US has much higher gas content then Alberta coals and this higher gas content allows more wells in a section to be supported. All of the Horseshoe Canyon Coals and the great majority of other Alberta coals simply do not contain enough gas to be capable of supporting the same level of well density as the US coals. In general US examples make very poor analogues for Alberta coals and CBM development because the geology and reservoir characteristics of the coals are markedly different. Alberta Horseshoe Canyon CBM is much more similar to Southern Alberta Shallow Gas then it is to US CBM.

Coal Bed Methane systems operate at very low pressures, typically as close to atmospheric pressure at the wellhead as possible. In general CBM developments require more compression horsepower then conventional gas developments, although many conventional gas systems require similar levels of compression in the last few years of gas production in order to maximize gas recovery.

Coal Bed Methane does not require any ‘gas processing’ except for dehydration. Dehydration involves the removal of water vapor from the gas to prevent water from condensing in pipelines. Dehydration is typically carried out at the sales compressor station – the last compressor station between the well and the gas transmission line.

## Noise Control

EnCana includes some form of noise control or ‘noise attenuation’ package as part of facility design. In new facilities, these packages are always designed to significantly exceed the requirements of Guide 38 from the AEUB. In EnCana’s experience this approach provides for some variance in atmospheric and ground conditions that can change noise characteristics and provides flexibility to ourselves and landowners for future changes.

In most situations in which we operate, Guide 38 requires nighttime levels of 40 dBA at the nearest dwelling, regardless of the distance from the location. Since EnCana CBM gas facilities run 24 hours per day, daytime noise levels at the nearest dwelling is also typically less than 40 dBA. This sound level (40 dBA) is approximately equivalent to a ‘quiet office, library’.

Actual sound levels (attenuation) are determined using a noise study for each individual site since these levels depend on the type and orientation of equipment at the site and local ground conditions. Noise levels at different distances from a site can only be determined on a specific site basis.

If EnCana receives a noise complaint, the initial response is to have an operator visit the site and ensure no unusual conditions exist and all the noise attenuation features at the site are in place. This resolves most noise complaints. Persistent noise complaints are investigated by having a qualified 3rd party noise specialist measure noise in the vicinity and provide a report. If the study indicates excessive noise and especially if noise levels from the facility exceed the requirements of Guide 38, EnCana undertakes facility modifications to reduce the noise level. As a result of this process, noise control has been improved at a number of EnCana's older facilities, many of which were still meeting the minimum requirements of Guide 38 but did not have modern noise control packages installed. As mentioned earlier, new facilities exceed Guide 38 requirements.