Unconventional GAS PRODUCTION

FIRST NATIONS
LNG ALLIANCE

Unconventional gas resources

Source: BCOGC

Canada has large reserves of unconventional natural gas resources. These account for nearly 30% of the country's natural gas production. That contribution is expected to grow. Unconventional resources are located mostly in Alberta and British Columbia (BC), and some in Saskatchewan.

Conventional deposits of natural gas are found in porous sandstone or limestone formations. The gas deposit (called a reservoir) is accessed by drilling a vertical gas well. Once a well is established, the gas in these reservoirs will flow freely to the surface.

Unconventional gas is held in porous, low-permeability geological formations that cannot be as easily accessed using conventional natural gas production processes.

In an unconventional source the natural gas is located in small pores in sedimentary rock, including sandstone, shale and coal. In these formations, natural gas does not flow easily through the rock. This makes it more difficult to produce gas and requires the use of innovative tools.

Based on the type of natural gas bearing formation, unconventional resources can be divided into three types: tight gas, shale gas, and coalbed methane.

Tight gas is the natural gas found in low-permeability rock, including sandstone, siltstones, and carbonates. **Shale gas** is the natural gas trapped in fine-grained, organic-rich rock; and **coalbed methane** is the natural gas contained in coal deposits.

Shale gas is the natural gas trapped in fine-grained rock.

Unconventional natural gas production requires more complex technologies like **hydraulic fracturing** (commonly called **fracking**) and horizontal drilling.

In BC, unconventional natural gas production has been distributed within several major **shale plays**, the most important plays include the Horn River Basin of Northern BC, and the adjacent Montney Basin which spans the BC and Alberta border.

The term **play** refers to natural gas resource, sometimes also called a **prospect**, located within the same region and within the same geological formation.

Producing natural gas

Getting to unconventional gas involves creating pathways to allow it to move through the rock to a well so it can be pumped to the surface. This can be done by the combined use of horizontal drilling and hydraulic fracturing. The images on this page show what the process looks like.

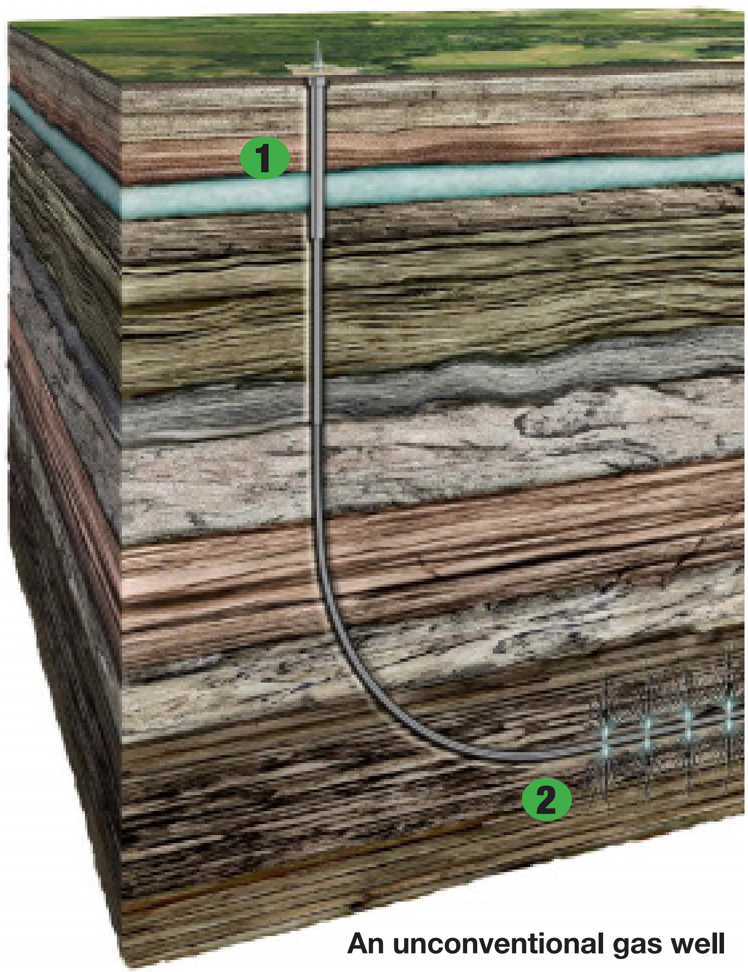
Horizontal drilling

Horizontal drilling is a form of directional drilling in which the wells are drilled at multiple angles, not just vertically, to better reach reserves and produce gas.

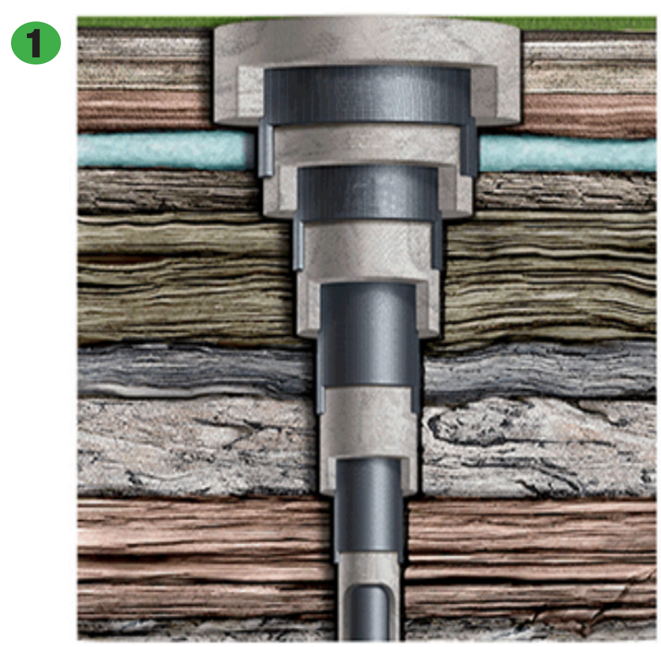
The construction of a directional well often costs two to three times as much as a conventional well. But this can be worth it because initial gas production is often three to four times that of a conventional well. Horizontal drilling can reach gas-bearing formations that cannot be accessed by traditional vertical drilling and it can improve the productivity of wells in a fractured reservoir. This makes directional drilling very useful in unconventional gas production.

Just as in a typical well, horizontal drilling begins with a vertical shaft, but once it approaches the depth of the targeted gas reservoir (in BC this is about 1.5 to 3 km) the shaft bears off at an arc. This is so it can intersect the reservoir at a near-horizontal angle. It continues horizontally through the reservoir until the needed length is reached.

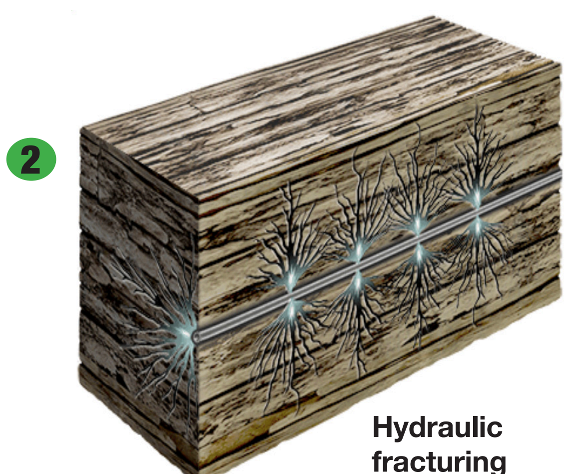
Horizontal wells are designed to increase the production of a well by offering better contact with the reservoir. After the horizontal well has been drilled, a well casing is constructed. This stage uses steel and cement to keep the well intact and stable, and to protect aquifers of groundwater that are closer to the surface.



An unconventional gas well



Well casing and cementing



Hydraulic fracturing

Source: BCOGC/FracFocus

Source: Shell

Drill threads at Groundbirch, BC

Well casing

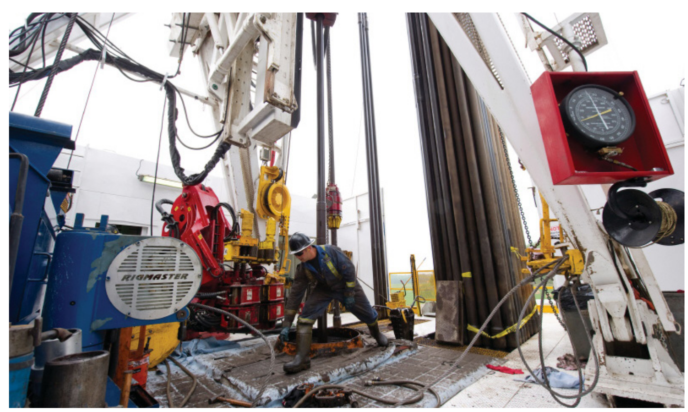
Casing is pipe or tubing made to support the sides of a well hole and to prevent the walls of the well from collapsing.

This also prevents the loss of drilling mud into the rock around it, and it helps prevent other fluids from entering or leaking into the well.

Typically, surface casing must be set below the base of all strata where we know we'll find groundwater, or we might expect to find it. This is especially important for protecting groundwater quality.

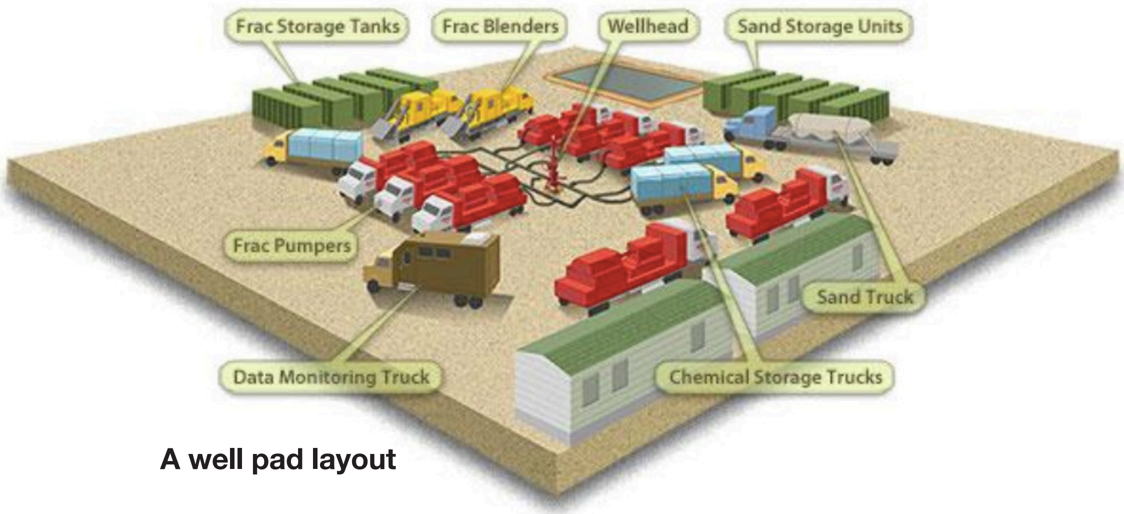
A space called the annulus, located between the wellbore and the steel casing string, must be also filled with cement all the way to the surface.

Cementing is the process of permanently securing the casing to the wellbore or plugging and sealing it after the well is no longer needed.



Drilling operation

Source: Shell



A well pad layout

Source: BCOGC

Fracking

Fracking is an important technique used in unconventional gas production. Fracking is carried out after horizontal wells have been drilled, cased and cemented. Fracking creates cracks and fissures. This increases permeability of the gas bearing formation.

Fracking involves injecting millions of litres of **fracking fluid** at high pressure into rock formation. Fracking typically starts at the end of the horizontal well and works back to the vertical part of the well. Fracking fluid consists of water and chemicals. **Water makes up most of the fracking fluid.** Another major substance in the fluid is proppant (made of grains of sand, ceramic, or other similar materials). Other chemicals used in the process are described below.

Fracking fluid is injected into the well at high pressure. The resulting build-up in pressure causes the formation to fracture. The proppant fills the fractures to keep them from resealing. This allows the natural gas trapped in the formation to flow into the well. Then the gas can be collected.

Since the fractures will close over time, most wells will be fractured repeatedly over the course of well operation.

The process is referred to as **multi-stage hydraulic fracturing**. The number of stages depends on the lateral length of the well. Commonly, it takes an average of 10 to 15 stages to ensure adequate treatment of the reservoir in order to take out a good portion of the gas it contains.

Once the well is in operation, it may produce natural gas for several years.

The fracture-fluid composition varies based on the nature of the rock formation, the wellbore, and the location. Fracturing fluid is produced on the wellsite by mixing the water, proppant, and other chemicals together.

The components of a typical hydraulic fracturing wellsite, also called a **frack pad** (or well pad), are shown in the figure on this page.

FRACKING STAGES

Spearhead stage: also referred to as an acid stage, it uses a mix of water with diluted acid, typically hydrochloric acid, to clear debris that may be present in the wellbore created by horizontal drilling, providing a clear pathway for fracturing fluids to access the formation.

Pad stage: A batch of carrying fluid without proppant that is used to initiate fractures in the target formation.

Proppant stage: During this stage, the proppants will be carried by the fracturing fluid into the formation and deposited. The proppant will remain in the fractures once the pressure is reduced and keep the fractures open.

Flush stage: Fresh water will be pumped down the wellbore to flush out any excess proppant in the wellbore.

Flowback

Completing a single fracturing usually takes about 3 to 4 days. Then the equipment is removed from the wellsite and flow-testing or production equipment is installed. Following fracking, fluids will return to the surface; this is called **flowback**.

The flowback can be made up of as little as 3% and as much as 80% of the total amount of water and other material actually used to fracture the well. In addition to the original fluid used for fracking, the flowback can also contain other new chemicals that come naturally from the fractured rock in the ground. Flowback fluids require proper temporary storage, treatment, and safe disposal.

Temporary storage in BC is in above-ground tanks or artificial ponds lined with a material used to prevent leaking. The majority of flowback fluids are eventually disposed of in underground injection wells.

Advances in flowback fluid treatment technologies, such as filtration, reverse osmosis, and ion exchange, enable the recycling of flowback fluid for subsequent fracturing operations, or possibly for other uses such as irrigation.

Consumptive use water licenses in northeast BC

Source: BCOGC

*20.0 million m^3/yr
Oil & gas

15.1 million m^3/yr
Domestic & waterworks

12.6 million m^3/yr
Mining

9.8 million m^3/yr
Forestry

3.6 million m^3/yr
Agriculture & Range

The actual withdrawal for oil and gas activities is 2.8 million m^3/yr

Water use

Water and proppants can make up about 99.5% of the fracturing fluid. Water acts as the primary carrier fluid for fracking.

A multi-stage fracturing of a single horizontal shale gas well can use up to several million litres of water. The amount of water needed for fracturing vary significantly from place to place. Small volume fracturing could be 500 to 2500 cubic metres (m^3) per well; while moderate volume fracturing might be 10,000 to 50,000 m^3. High volume fracturing might need between 50,000 to 100,000 m^3 per well.

A significant volume of flowback occurs in the first week after fracking is complete. Other flowback can continue for several months. Flowback fluid is recovered and held temporarily at the wellsite in containment tanks.

Ongoing gas production from a well may also con-tinue to yield fluid. This is called **produced fluid** and it is made up of water-based geological mate-rial that exists naturally within the rock formation.

The quality of the water is very important because impurities can reduce the efficiency of the chemical additives used in the process. Most water used in hydraulic fracturing originates from surface water sources such as lakes and rivers. Wells in BC may also use salty water extracted from deep underground.

If there is not enough surface water, groundwater can be used to support surface water supplies. The amount of water used in fracking may appear substantial, but it may be smaller than other water uses within a region; such as agriculture, manufacturing and municipal uses.

In order to get water for fracking, a company must have the right approvals and permits from the BC government. The BC government regulates the allocation of water for industry and other users.

Chemicals

Various chemicals are added to fracturing fluids to ensure the fracturing job is effective and efficient. The chemicals used are called **additives**.

Additives serve many functions, such as preventing corrosion of well casing, limiting the growth of undesired microbes, improving the transport of proppants, and reducing the friction of fracturing fluid.

In Canada, the chemicals used in hydraulic fracturing are regulated under the Hazardous Material Information Review Act. A chemical use database, the **FracFocus Chemical Disclosure Registry,** which is called **FracFocus**, has been launched to record the information about the ingredients used in hydraulic fracturing fluids at individual wells.

FracFocus is publicly accessible on the internet (see *www.fracfocus.ca*). All provinces and territories can participate, and provide public access to data regarding the location of oil and gas activities. The website allows individual jurisdictions to upload data provided to them by industry about hydraulic fracturing fluids.

However, some ingredients or fluid formulations, which represent a unique or competitive advantage to owner of the intellectual property, may not be disclosed to FracFocus to protect confidential business information (CBI).

For hazardous chemicals, companies wishing to protect their CBI need to show that an ingredient or the formula is a trade secret. To do this they need to apply to the **Hazardous Material Information Review Commission** to claim an exemption under the Hazardous Material Information Review Act.

REASONS FOR ADDITIVES

Chemical additives can be divided into several functional categories, including friction reducers, corrosion inhibitors, biocides, breakers, clay stabilizers, cross-linkers, gelling agents, iron control agents, surfactants, demulsifiers, scale inhibitors, and pH adjusters.

The number of chemical additives required for a fracturing treatment depends on the conditions of the specific well that is being fractured. Typically, a fracking treatment uses 3 to 12 different chemical additives.

The chemical additives accounts for only a small fraction (about 0.5 to 2%) of the total volume of a fracturing fluids. Based on the chemical compositions, water-based fracturing fluids can generally be divided into two types of fluid: slickwater and gelled fracturing fluid.

Slickwater is the term for fluids that are thin and flow easily. These are easier to pump, and they can be pumped at high rates to generate complex narrow fractures in formations while working with low amounts of proppants. The most critical chemical additive for slickwater fracking is the friction reducer. This can significantly reduce the friction pressure of the fluids to help achieve high pumping rates.

Gelled fracturing fluids are thicker because they use relatively high concentrations of gelling agents. The gelled fracturing fluids have a better performance in transporting proppants, and they do this using less water.

Environmental concerns

As unconventional gas production in BC increases, so does public concern about its potential effects on human health and the environment.

The major concerns include impacts on fresh-water resources, water quantities used, land use changes, air pollution, and fracking-induced earthquakes.

Although the technology for fracking has been around for over 50 years, its use on a large scale still largely recent. It is only over the last 20 years that it has been applied to a large number of locations in the US and Canada. This means that our understanding of the impacts of fracking is also growing.

There are many uncertainties about what the long-term effects of fracking will be on water and land resources. In many places fracking may have few or no significant effects over time, and in others we may not see or understand the impacts for many years.

WATER

Muncho Lake in northeastern BC

Large amounts of water are used in hydraulic fracturing. An average well can require 11 to 30 million litres of water over its lifetime.

In BC, water supplies cannot be taken for granted. One challenge in coming years may be the impacts of climate change on water supplies, and this could pose a challenge for some fracking operations. However, local impacts vary with water availability and other competing demands (such as for towns, agriculture, hydropower or industry).

The possible impacts of fracking on **groundwater** are being studied, but there is uncertainty about the potential for fracking fluid or natural gas to migrate into groundwater supplies. For deep wells (common in BC) the likelihood seems small, but for shallow wells there may be greater risks. Impacts may also not show up until well after fracking has begun, or even after a well is closed and is no longer producing gas.

The BC Oil and Gas Commission says BC groundwater has never been contaminated by fracking. But more research and data are needed, and we need to guarantee best practices in fracking.

It is also important that companies and regulators provide timely and open information about their efforts to monitor groundwater quality, the status of water quality, and the precautions being taken to reduce the possibility of impacts.

GROUNDWATER

A recent comprehensive study by the US Environmental Protection Agency examined scientific evidence about circumstances where fracking activities can impact drinking water resources. The study identifies certain conditions under which impacts from hydraulic fracturing activities can be more frequent or severe:

- Water withdrawals for hydraulic fracturing in times or areas of low water availability, particularly in areas with limited or declining groundwater resources;
- Spills during the handling of hydraulic fracturing fluids and chemicals or produced water that result in large volumes or high concentrations of chemicals reaching groundwater resources;
- Injection of hydraulic fracturing fluids into wells with inadequate mechanical integrity, allowing gases or liquids to move to groundwater resources;
- Injection of hydraulic fracturing fluids directly into groundwater resources;
- Discharge of inadequately treated hydraulic fracturing wastewater to surface water; and
- Disposal or storage of hydraulic fracturing wastewater in unlined pits resulting in contamination of groundwater resources.

(US EPA, 2016)

Drilling rig in the Peace River district

Ian King/Photo

Impacts on water

Many fracturing fluid chemicals are known to be toxic to humans and wildlife, and some are linked to cancer. The fracturing fluids and flowback waters can enter into the environment if surface spills occur as a result of equipment failure or other errors.

Volatile chemicals held in flowback water storage ponds can evaporate into the atmosphere, or overflow. If flowback leaks from a storage area then it might end up in groundwater systems.

Surface and groundwater may become contaminated by trucks carrying hydraulic fracturing chemicals and wastewater if they are involved in accidents on the way to hydraulic fracturing sites or disposal locations.

Much of the natural gas developed in the North America was largely formed at the site of ancient seas. Thus, the gas deposits can contain salty brine. Along with other minerals, radioactive radionuclides may be dissolved in the brine. The particular radionuclides and their concentrations are going to be different depending on the nature of the geological formation. These substances are considered naturally occurring radioactive materials. These can separate and settle out in wastes at the surface.

Generally, the radioactivity levels observed in fracking wastewater in North America are low. In northern BC it might be considered a workplace issue for some sites and needs observation management, but it is not considered a public health issue.

There is not too much information about the impacts on environmental health posed by fracking wastewater disposal in Canada. Two studies carried out in Canada in 2014 analyzed the current scientific evidence on hydraulic fracturing: one by the Council of Canadian Academies' Environmental Impacts of Shale Gas in Canada, and another is the Report of the Nova Scotia Independent Review Panel on Hydraulic Fracturing.

The studies have concluded two major uncertainties that are key concerns for water use management and hydraulic fracturing: 1, uncertainty regarding contamination risks; and 2, uncertainty regarding water use volume-related effects. For ex-ample, the Council of Canadian Academies report notes: "the data are commonly limited and do not support definitive conclusions … little attention has been paid to monitoring surface water quality."

Much of the work on water-related risks was done in the US. Given differences in physical geography and the geology of the formations, findings from US-based studies may not be easily transferable to the BC setting.

Ian King/Photo

Tight gas operation in northeastern BC

Natural gas may be released into the air from well site operations and from old well sites. This is called **gas migration**. The amounts released will vary in quantity depending on the site and the reason for gas migration. In 2013, a **gas migration** study was undertaken by the BC Oil and Gas Commission (OGC) to better research the frequency, causes and impacts of gas migration.

The study found instances of gas migration, but none of the wells inspected or on record to have gas migration are in close proximity to domestic water wells.

The OGC has introduced measures to better identify and track such events, and to provide guidance to industry and outline requirements for tracking and better managing gas migration, especially for old well sites that are no longer used. This includes a recent helicopter survey of abandoned wells to determine if methane emissions are occurring. As of mid-2017, gas migration had been observed at 144 wells in northeast BC. The OGC has required risk assessment reports for some sites, and the preparation of groundwater monitoring for some others. Reports are available from the BC Oil and Gas Commission website, including annual summaries and statistics.

Other air pollutants from unconventional gas production includes particulate matter and dust, ground level ozone, smog, nitrogen oxides, carbon monoxide, benzene, toluene, xylene, and ethyl benzene (called BTEX for short), formaldehyde, and metals or other pollutants contained in diesel fuel combustion from running machinery at the frack pad site.

Exposure to these pollutants may cause short-term illness; longer-term expose may cause chronic damage to human health. Crystalline silica, in the form of sand, is the main proppant in fracking. When inhaled by workers it may lead to silicosis, a form of lung disease. But with the right workplace precautions, impacts from these pollutants can be managed and prevented.

Flaring is the controlled burning of natural gas that cannot be processed, and it is sometimes done at well sites. There are circumstances where it may not be economic, practical, or safe to use the natural gas. However, flaring wastes potentially valuable resources and produces emissions that can affect human health, livestock, and the environment. All flaring in BC must be conducted in accordance with government regulations and air quality standards.

Venting is the release of natural gas directly without flaring. Venting may occur during well testing and in the operations of wells. Industry and governments have sought to reduce flaring and venting. The practice has declined over the last 10 years.

LAND USE

Road near Dawson Creek, BC

Source: Shell

Cummulative impacts

Hydraulic fracturing also has impact on the land and wildlife. The average land impact per gas well is small, roughly about 3 hectares. But there are also roads, exploration activities, pipelines, work camps and other activities needed to serve the industry. This can result in a much changed countryside.

If there are many well sites developed over time across a region then natural gas development will create cumulative impacts on the landscape. Cumulative impacts, or cumulative effects, are changes to the environment caused by a project in combination with other past, present and future projects.

The roads needed to service each site and the traffic that will come along with fracking have impacts such as dust and noise. New roads will allow more access to areas that were previously not easy to get to without hiking in, using an ATV, coming in on horseback, or by snowmobile.

The new access provided by roads can have impacts on animals and other environmental qualities such as streams and lakes. Access may also create risks from forest fires caused by human activities. But they can also improve access for firefighting when forest fires occur, or for other emergencies.

Earthquakes

Hydraulic fracturing can cause induced seismicity, also called micro-seismic events or micro earthquakes. These micro-seismic events are often used to map the horizontal and vertical extent of the fracturing. Fracking triggers movement along pre-existing stressed faults, leading to an induced seismic event.

We do not have sufficient information and data about these geological formations to predict the likelihood or magnitude of seismic events prompted by fracking. The magnitude of these events is usually too small to be detected at the surface. There is a history of moderate seismic events in BC from waste-water disposal and fracking. There is also a possibility that triggered events could be large enough to cause damage, but to date there have been no reports of injury or major structural damage related to induced seismicity in northeast BC.

The BC Oil and Gas Commission reports that less than 0.2% of fracking operations cause seismic events that could be felt at the surface. The intensity of felt events has been moderate and the associated vibrations are not expected to be great enough to cause damage. The risk of damage to property or injury from induced seismicity is seen as very low.

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Cover photo source: Shell

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The Information Series is produced by the First Nations LNG Alliance in collaboration with the Centre for Environmental Assessment Research at UBC. The series provides information for individuals and communities interested in learning about the nature, structure, operation and impacts of the LNG industry and natural gas resource development in British Columbia. Where possible the information sheets are developed using sources available online. This is so readers can more easily access the sources used by the author. Information sheets may be updated periodically. Please check the date of issue for the most current version.

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Natural Gas
Unconventional Gas Production
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