

## Responsible Natural Gas Development

The world economy is growing, driving increased demand for all forms of energy. Demand is centered on Asia as people strive for a better quality of life. Achieving this requires stable, secure, and affordable energy supplies.

Natural gas is an efficient energy source, and the cleanest-burning fossil fuel. Natural gas from shale and tight rock formations has emerged as a significant energy source, and can be accessed safely and economically in quantities that are changing the B.C. and global energy supply landscape.

Natural gas from shale is being developed safely and responsibly in B.C. using technologies that have been proven over decades of use. Producing natural gas from shale is made possible

by extended-reach horizontal drilling to access the natural gas resource, and hydraulic fracturing to fracture the rock and release the trapped gas. Once completed, these natural gas wells are expected to produce for many decades.

Technological advances in horizontal drilling and multi-stage hydraulic fracturing have made shale, tight gas and other unconventional gas supplies commercially possible. Shale and tight resources are a game changer in B.C., offering greater energy supplies and valuable resources to B.C.'s economy. Markets for this natural gas include customers in B.C., Canada and the United States, and potential customers in Asia.

## What is Horizontal Drilling?

Extended reach horizontal drilling allows wells to be drilled horizontally to access far more of the rock formation that contains natural gas than a vertically drilled well would be able to. This technology dramatically reduces the amount of surface land disturbance to extract natural gas. For example,

a 20-well horizontal pad site disturbs just 9 percent of the local area that comparable vertical wells would use to access the same volume of natural gas. In addition, the horizontal well will access more of the productive formation, resulting in greater natural gas recovery compared to a vertical well.



## Did you know?

Since hydraulic fracturing was developed in the 1940s, it has been applied in more than two million wells worldwide.

## What is Hydraulic Fracturing?

Hydraulic fracturing is a process where water, a small amount of additives, and sand or another proppant are pumped down a well at high pressure to a targeted formation. The pressure causes the rock in that formation to fracture. When the pumping pressure is relieved, the water flows back up the well to surface, and leaves the sand behind to prop open the cracks or fractures. This process allows the natural gas to escape from these formations, and flow to the surface where it is processed and shipped by pipeline to market.

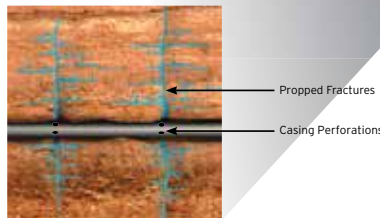
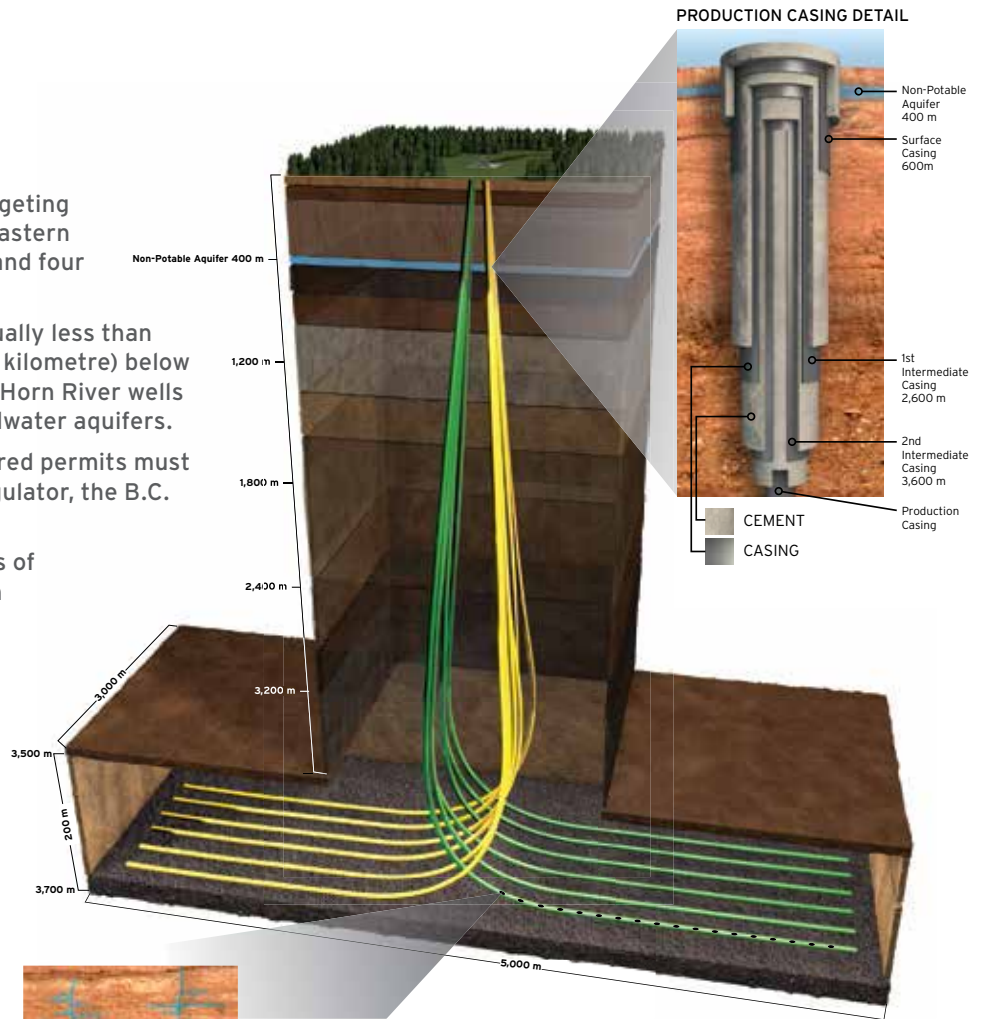
Hydraulic fracturing is not new; in fact, this technique has been safely used in British Columbia since the 1960s. Today, more than 60 percent of all the natural gas that moves through pipelines from Northern B.C. into homes in the province has been extracted by using hydraulic fracturing.



# How does it work?

## Drilling the well

- Unconventional natural gas resources targeting the Liard and Horn River basins in northeastern B.C. are typically located between three and four kilometres below the earth's surface.
- The deepest drinkable groundwater is usually less than 150 metres (approximately one tenth of a kilometre) below the surface. To date, Chevron's Liard and Horn River wells have not encountered any potable groundwater aquifers.
- Before any well work can begin, the required permits must first be granted by B.C.'s independent regulator, the B.C. Oil and Gas Commission.
- As the well is being drilled, multiple layers of steel casing are inserted and cemented in place creating solid barriers between the well and any potential underground freshwater sources.
- Horizontal drilling techniques extend the well up to 3.5 kilometres into the formation to maximize production and allow more natural gas to be extracted from each well, and reducing the development footprint at surface.
- Before hydraulic fracturing begins, and throughout its life, the well is tested for integrity and to ensure that the casings and sealing cement will prevent fluids or gas from migrating.
- After the well has been drilled and the casings installed, cemented and tested, the hydraulic fracturing process can begin.



HYDRAULIC FRACTURING DETAIL

## Hydraulic Fracturing Steps:

- Prior to fracturing, small holes, or perforations, are made in the well casing to access the natural gas formation and provide an entry point for the natural gas to flow through.
- Then a mixture of water, additives, and sand or "proppant" is pumped into the well under high pressure to fracture the rock containing the natural gas. These fractures extend outwards from the horizontal section of the well.
- The pumped fluid is allowed to flow back into the well and to surface, leaving the sand to prop open the fractures and provide a pathway for the natural gas to flow into the well more easily.



## Did you know?

- Fracturing fluid is a mixture consisting of 98.5% water and sand with the remainder comprised of additives, many of which are found in everyday household products.
- On average, the hydraulic fracturing process takes 3 to 10 days.
- Once the hydraulic fracturing stage is completed, the well will produce natural gas for several decades.

## An Experienced Developer of Natural Gas Resources

In 2014, Chevron was the first company in the United States to receive the Centre for Sustainable Shale Development's full certification for meeting 15 stringent performance standards. These standards, which focused on protecting air and water, were evaluated and verified by an independent third party.

## Safety and Environmental Protection

B.C.'s natural gas industry has strict regulations and laws that have been developed over many decades to minimize impacts, protect fresh water aquifers and to ensure safe and responsible development.

For example, the provincial government issues water licenses and permits for fresh water use that strictly regulate how much water is used and how it is disposed.

- More than 175,000 wells have been hydraulically fractured in B.C. and Alberta over the past 60 years without a documented case of harm to drinking water.
- Over 7,500 wells have been safely hydraulically fractured in B.C.

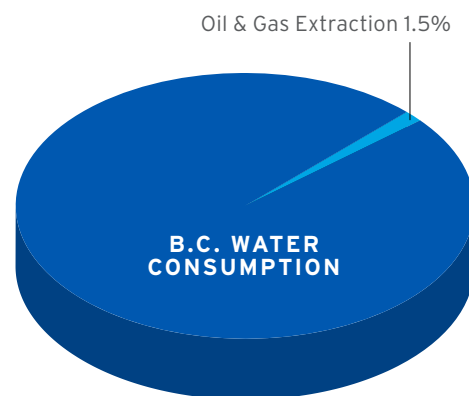
Chevron believes natural gas can be extracted safely while protecting people and the environment, and this is our

highest priority. We are committed to ongoing community consultations, engagement with First Nations and participation in industry groups that promote best practices as part of our operations.

Source: BC Oil & Gas Commission (OGC), Alberta Energy Regulator (AER)

## Protecting and conserving water

- Chevron designs its wells with industry best practices and puts in place rigorous standards and processes to prevent ground water impact.
- All Chevron operations place a high value on the responsible use of water, and protecting water sources and air quality. Chevron has the capability and technology to manage hydraulic fracturing fluids in a safe and environmentally responsible manner.
- Where possible, Chevron strives to recycle and reuse all well-flow back and produced water during the development phase. When this is not feasible, Chevron disposes all flow-back and produced water in accordance with government regulations at designated facilities.
- In British Columbia, companies are required to publicly disclose hydraulic fracturing fluid additives on [FracFocus.ca](http://FracFocus.ca)



## Managing induced seismicity events

Hydraulic fracturing is a controlled process that injects pressurized fluids to the geological formation where natural gas is locked in dense rock, such as shale. The pressurized fluid cracks the rock. The energy released in this process causes micro-seismic activity. Documented scientific evidence indicates that any micro-seismic activity associated with hydraulic fracturing is rarely felt on the surface, and has not caused any injury to property or posed any risk to the public or environment.

- Chevron complies with all government regulations and follows industry best practices as laid out by the independent B.C. Oil and Gas Commission in order to minimize the risk of any significant induced seismicity.
- Before any operations begin, Chevron does a thorough assessment of the potential for induced seismic activity related to hydraulic fracturing. This includes geological, geophysical, completion engineering, geo-mechanical and regional seismicity data.
- Chevron creates detailed fault maps based on 3-D seismic data, which are critical in determining the risk of induced seismicity. We identify faults with higher risk of reactivation. We also consult historical National Resources Canada seismicity catalogs to determine any seismicity risk that may already be present. Real-time seismicity monitoring information is accessed daily and maps are updated with any new activity.
- During operations, Chevron installs additional seismicity monitoring equipment to improve the fidelity of induced seismicity monitoring in the vicinity of our operations.
- Chevron has a protocol in place to respond to induced seismicity that is the result of operations on a Chevron well site. Permit conditions dictate that operations are shut down immediately if induced seismicity occurs beyond a certain threshold.

## Did you know?

- The amount of water used for hydraulic fracturing varies across northeast B.C. The varying water requirements are largely dependent on the geology of the underground formation.
- Actual water use in B.C. for natural gas development during 2012 was less than 0.075 % of mean annual runoff in all rivers and basins.\*

\*Source: BC Oil & Gas Commission





## Unlocking Cleaner Burning Energy

The world needs more energy and a cleaner environment too. Natural gas is the cleanest burning hydrocarbon, and can be used in a variety of ways to help reduce GHG emissions, including in the transportation and electricity generation sectors.

As the third-largest producer of natural gas globally, Canada has enough supply to last over 100 years. With this abundance of natural gas, opportunities exist to broaden the use of cleaner-burning natural gas domestically as well as globally, and at the same time reducing GHG emissions.

Through the safe and responsible development of our valuable natural gas resources, Kitimat LNG will help meet the world's growing demand for clean, reliable energy.

### For more information about the Kitimat LNG Project:

Visit our website: [chevron.ca/KitimatLNG](http://chevron.ca/KitimatLNG)  
Email us at [KitimatLNGFeedback@chevron.com](mailto:KitimatLNGFeedback@chevron.com)  
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