Hydraulic fracturing is a process used throughout the world to access natural gas reservoirs that would otherwise be uneconomic or technically impossible to recover. It involves pumping fluid under high pressure through deep, heavily encased wells into ‘tight’ low permeable oil and gas bearing rock formations.

The process produces fine fissures in the target rock. When the pressure is released, ‘proppant’ (sand or ceramic beads) remains in the fissures to prop them open and provide pathways for the trapped natural gas and oil to flow up the well to the surface.

Todd Energy designs and constructs its wells to the highest international industry standards, with multiple layers of steel cemented in place.

The target formations in Taranaki are thousands of metres below the surface, and separated from any freshwater resources by multiple layers of impermeable rock.

Hydraulic fracturing is a sophisticated technology subject to intense R&D development, including a shift towards the use of 100% environmentally benign fluids.

What are the risks?

Like all industrial processes, hydraulic fracturing does involve some risks, and these are detailed overleaf. These risks are present with all drilling operations and are effectively managed through adherence to industry best practice and New Zealand’s rigorous regulatory regime. The recent increase in the use of hydraulic fracturing in shale gas and coal seam gas internationally has drawn attention to these risks and the possible environmental effects of hydraulic fracturing. Much of the concern has however been based on misunderstanding and lack of factual information.

The main concern raised is the risk of contaminating freshwater aquifers. International studies have concluded that faulty wells or surface spills are the most likely way hydraulic fracturing could cause contamination of freshwater aquifers. However, in line with similar international studies, Taranaki Regional Council and GNS Science have found no evidence of environmental problems arising from hydraulic fracturing activities in New Zealand.
Why is hydraulic fracturing used?

Hydraulic fracturing is used to tap into New Zealand’s abundant ‘tight’ gas resources, such as sandstone, that have accumulated natural gas and condensate over millions of years.

In rocks with high permeability the oil and natural gas flows easily through the pore spaces. Tight rocks with low permeability require fracture stimulation to produce commercial flow rates. The process achieves the same benefits produced by natural fractures, commonly found in oil and gas-bearing rock, which enable fluids to seep from the rock and pool in the crevices.

Hydraulic fracturing techniques

The type of hydraulic fracturing used depends on the geology of the target formation. The main types are:

- **Conventional fracturing** (used in New Zealand) is typically used in low permeability ‘tight’ reservoirs (such as sandstone), generally below 3,000 metres. A water-based gel fluid is used with a medium proppant loading and 4 to 5 pumps operating at a combined rate of up to 5 cubic metres of water per minute. This creates long, very fine fractures. The volume of fluid is usually less than 1,000 cubic metres per fracture treatment.

- **High-volume water fracturing** (used in the United States for shale gas extraction) is typically used in very low permeability reservoirs (shale and coal) at various depths, usually below 800 metres. Large volumes of water with a low proppant loading are used, with over 20 pumps operating at a combined rate of 24 cubic metres of water per minute. This produces very long, fine fractures. It is often used in conjunction with horizontal drilling for shale gas extraction.

- **Skin fracturing** is used for small scale fracture operations to bypass near wellbore damage, typically in high permeability reservoirs. It produces short, wide fractures.

- **Acid fracturing** is used in limestone formations with a mild acid-based fluid that etches the rock and does not require a proppant.

History of hydraulic fracturing

- **1860s** – ‘Shooting’ wells with nitroglycerin in the United States. Very effective, but very hazardous!

- **1930s** – ‘Pressure parting’ by pumping acid into reservoirs.

- **1947** – First primitive hydraulic fracturing operation, using gelled gasoline and sand, by Stanolind Oil in Kansas.

- **1949** – First commercial operation, ‘Hydrafac’, in Oklahoma. A further 332 wells treated that year, using gelled gasoline, crude oil or kerosene, with an average 75% increase in well productivity.

- **1950s** – Over 3,000 treatments per month. Water-based fluids introduced with various gelling agents and other additives.

- **1960s** – Computer modelling introduced to predict fracture growth.

- **1970s** – Hydraulic fracturing becomes the conventional technique in the United States for accessing tight formations.

- **1977-1985** – Introduced in Western Europe, the United Kingdom, Eastern Europe and North Africa.

- **1989** – Hydraulic fracturing first used in New Zealand.

- **1990s** – Texas ‘wildcatter’ George Mitchell first uses horizontal drilling with hydraulic fracturing in the Barnett shale field.

- **1993** – Hydraulic fracturing first used by Shell Todd Oil Services (STOS) in New Zealand.

- **By 2011** – Over a million treatments performed in the United States alone. A total of 65 treatments in 39 onshore New Zealand wells, including 12 by Todd, mainly in the Mangahewa field, with no significant adverse environmental effects.

Hydraulic fracturing is now the standard treatment for improving flow rates in deep natural gas wells in Taranaki. To date it has not been used in New Zealand for shale gas.
2. Operations and planning
Planning includes a comprehensive assessment of safety, environmental and commercial factors alongside the technical preparations required to undertake the fracturing successfully.

The design of fracture treatments varies between rock types, locations and well geometry. Computer modelling is used to optimise the design.

Hydraulic fracturing is not in itself an exploration technique. It is only used once detailed information about the rock and reservoir properties are available.

3. Fracture fluid composition
Fracturing fluids typically contain 97% to 99% water and proppant (sand or ceramic beads). Additives are necessary to prevent bacterial build up, clay hydration, and corrosion of the well equipment. A gelling agent, such as guar gum, transports the proppant into the fractures.

The types of chemicals used have changed substantially over the last 20 years. Most are now environmentally benign and are found in common household and food products. Todd uses Baker Hughes’ Spectra Frac G fracture fluid for most Mangahewa operations. Todd does not use radioactive tracers in its fracturing operations.

Fracture fluid compositions are fully disclosed in resource consents and on many company websites.

4. Well design and construction
High quality well construction is central to successful oil and gas operations, including hydraulic fracturing.

Several layers of steel casing and cement isolate the well from the surrounding rock and aquifers. Stringent standards apply to the selection and construction of steel and cement.

Continuous monitoring and pressure testing ensures ongoing well integrity and the protection of freshwater aquifers. The operation is stopped immediately if any problems are encountered. This effectively eliminates the risk of injecting contaminants into fresh-water sources.

5. Well perforation
Before the fracture fluids are injected, the steel casing of the well is perforated to create a series of holes linking the well and the target reservoir formation. In Taranaki this is generally 3-4,000 metres below the surface and far beneath freshwater resources.

6. Pumping
Pump trucks supply the pressure needed to pump the fracturing fluid down the well and create the fractures. The fluids from each pump truck are combined at a treatment manifold and directed down the well.

The pumping operation is controlled onsite.

7. Fracture formation
The growth of the fractures is controlled by the geology of the target formation and the surrounding layers of impermeable rock, the amount of fluid and pressure used, and the stresses within the formation.

Various tools are used to monitor fracture growth and dimensions.

A typical conventional fracture in Taranaki will be a few millimetres wide, 30 to 40 metres in height and extend a few hundred metres laterally from either side of the well.

This picture represents a bird’s eye view of the well and the fractures.

8. Proppant
When the hydraulic pumping stops and the pressure is released, the fractures will close due to the forces acting on the formation. The proppant ‘props’ the fractures open creating a narrow path for the natural gas or oil to flow into the well.

The most common proppant is sand, sieved to the required size, although manufactured ceramic beads are increasingly used due to superior strength, size and shape properties.

9. Returned fluids
The well is then flowed back to the surface where the spent fracturing fluids are recovered, usually in lined pits or steel tanks. The fluids are then safely disposed of, as described in box 10.

Between 25 and 75% of the fracture fluids will be recovered immediately. The remaining fluid will be slowly recovered during the production life of the well or remain in the rock. Any fluids not recovered are trapped in the rock unable to reach the surface.

The natural gas associated with the returned fluids is separated and flared in lined flare pits.

10. Disposal of returned fluids
Returned fluids are disposed of via land farming or deep well injection in full compliance with resource consent conditions.

Land farming involves spreading returned fluids and drilling wastes onto unproductive land. The land is covered with topsoil and treated with fertiliser. Microbes in the soil break down the waste, converting the land into pasture for grazing.

Deep well injection washes pumping returned fluids into a sealed rock formation several thousand metres underground. Todd uses the watered-out McKee oil reservoir for this purpose.

11. Remediation
Hydraulic fracturing production activity is brief, and once the well is in production the site is remediated and the visual impact is minimal.

12. Natural gas to you
Once the natural gas has been extracted, it is processed and transported to the end user.

Natural gas:
- meets 19% of NZ’s primary energy needs
- provides 18% of our electricity - the second most important source of electricity generation after hydro
- delivers flexible and reliable energy supply to backup electricity generation
- serves thousands of households and businesses that rely on natural gas for heating and cooking, and hospitals and dairy factories, who depend on it for onsite electricity and steam generation
- is vital to the NZ farming sector as the feedstock for Area Fertiliser
- provides the feedstock for countless products made from methanol used around the home and in every aspect of our lives, including paint, insulation, laminates and even medication.
How do we know it’s safe?

Many of the environmental risks raised as concerns relating to hydraulic fracturing apply to all exploration and production drilling. These are understood by the industry and managed through adherence to high quality well construction and best practice in all operations. The most common questions are:

Can chemicals or hydrocarbons leak into drinking water supplies?

In Taranaki, freshwater aquifers are protected by both man-made and natural barriers. In Todd’s operations, state-of-the-art well construction and fracture monitoring procedures prevent the escape of fluids through the well, and the thousands of metres of impermeable overburden rock mean the possibility of fractures extending up into freshwater aquifers is virtually non-existent.

What about spills at the surface?

Although chemicals are diluted and fracture fluids are of very low toxicity, accidental surface spillage of these fluids is a potential risk. This is managed through strict adherence to high quality health, safety and environmental management procedures and compliance with the Hazardous Substances and New Organisms Act 1996 and other regulatory controls.

Could hydraulic fracturing cause a major earthquake?

Micro-seismic events (ie vibrations) caused by hydraulic fracturing are smaller than those caused by a passing truck and are highly unlikely to be felt at the surface. A review of the GeoNet earthquake database by GNS Science found no recorded seismic events related to hydraulic fracturing in Taranaki.

Could hydraulic fracturing activate an existing fault?

The risk of this occurring in Taranaki is very remote. Part of the normal risk assessment in planning hydraulic fracturing includes identifying the presence of any faults using seismic surveys. Avoiding these faults is good operating practice, as a fault tends to act as a ‘thief’ zone and compromise the objectives of the hydraulic fracturing operation.

Flaring is wasteful and produces harmful emissions. Why is it permitted?

The ability to flare gas in a controlled environment is essential for safety reasons, and may be required to obtain critical data on the reservoir. Todd keeps flaring to a minimum, to minimise the environmental effects, including noise, and to avoid waste.

The Taranaki Regional Council undertook a study of the effect of emissions from flaring on ambient air quality. Findings were consistent with an earlier study and confirmed that there were minimal effects in the vicinity of the flare.

Regulatory environment

The Resource Management Act 1991 (RMA)

The RMA provides New Zealand with a rigorous regulatory framework that ensures hydraulic fracturing operations meet appropriately high environmental standards. In New Zealand, the Taranaki Regional Council has the most experience regulating hydraulic fracturing under the RMA.

The Taranaki Regional Council reviewed and extended its regulation of hydraulic fracturing in 2011, adding a requirement for specific resource consents and additional compliance and public disclosure requirements. The council can set additional safeguards in the form of further risk control or safety conditions.

Testing and monitoring

To ensure compliance with consent conditions and requirements, the Taranaki Regional Council undertakes extensive independent monitoring of wellsites, water, soil, physiochemical and biological sampling. In the past 10 years, the Council has conducted over 700 freshwater bio-monitoring surveys, and 30,000 parameter analyses of over 4,600 water and soil samples.

None of this testing has indicated any adverse environmental effects, including any effects on water quality in freshwater aquifers caused by drilling or hydraulic fracturing.

Handling of chemicals

The transport, handling, storage and use of chemicals at wellsites is tightly regulated by the Hazardous Substances and New Organisms Act 1996 in conjunction with resource consents. The Act requirements include preparation of a hazardous chemicals register, and detailed Spill Contingency Plans.

The Environmental Protection Agency (EPA) has overall responsibility for ensuring compliance with these requirements.

Industry best practice

Todd applies international industry best practice in all of its operations. This includes meeting industry standards set by the American Petroleum Institute (API) and strict adherence to world-class health, safety and environmental management systems.

Incident and risk management

Todd applies a systematic approach to the identification, assessment and control of risk that commences with hazard identification and analysis at the design phase. It fosters an open and positive incident reporting culture, geared towards learning and continuous improvement.

Training and competency

Todd’s safety and environmental record has also been achieved through employing the highest quality staff and industry contractors, and investing heavily in the training, development and safety of its people.

Note: all of the Taranaki Regional Council’s reports and investigations on hydraulic fracturing operations are publicly available on its website www.trc.govt.nz
Todd Energy

Todd Energy is a 100% New Zealand owned and operated company and one of the country’s leading energy explorers and producers.

It owns or has interests in six producing fields responsible for over 80% of New Zealand’s annual hydrocarbon energy production, and holds ten petroleum exploration permits.

It is a highly competent operator with extensive international experience and expertise in upstream petroleum operations, including hydraulic fracturing.

Todd Energy is a significant and growing contributor to the Taranaki and national economies and currently employs 438 staff in its upstream and downstream operations around the country.

Todd Energy’s ongoing projects centred on further development of the Mangahewa gas field will see it invest $800 million in New Zealand over the next few years, including drilling natural gas wells and a substantial expansion of Todd’s production facilities in Taranaki.

As a major energy producer with substantial experience in hydraulic fracturing, Todd Energy wants to contribute to public understanding of the process and its use in New Zealand. We want to dispel confusion over issues arising in other countries, and provide assurance to our communities about the safety, care and high standards involved in our operations.

Benefits to Taranaki and New Zealand

Economic benefits

The oil and gas sector generates significant economic benefits for the Taranaki region and New Zealand, providing export revenue, jobs, taxes and royalties ($2.1 billion in the last five years), as well as being a major supplier of primary energy and reliable electricity generation.

Since 2008/09 the Crown has received more cash as royalty payments from the oil and gas industry than it has received as ordinary dividends from its entire State Owned Enterprises portfolio.

The sector contributes $2.2 billion to national Gross Domestic Product (GDP) annually and provides, directly or indirectly, approximately 6,000 jobs. Labour productivity is very high, at $525,000 per worker, which is five times the national average.

In Taranaki the oil and gas sector is responsible for 32% of regional GDP and has played a large role in making New Plymouth New Zealand’s fastest growing city.

Natural gas – the ideal transitional fuel

Todd supports the move to more sustainable energy sources. It is likely however that fossil fuels will continue to play an important role in New Zealand’s energy mix for the foreseeable future.

Natural gas is not weather dependent and can be quickly fed into the electricity network when needed via peaker power stations ensuring consistent, reliable electricity supplies.

Natural gas is the cleanest-burning source of energy after renewables. It emits about half the carbon dioxide emissions of coal.

Unlike coal, hydro and wind energy, hydraulic fracturing does not involve large scale landscape disruption. Producing natural gas through hydraulic fracturing reduces the number of wells needed and their cumulative surface footprint.

In 2011, Todd’s Mangahewa field alone produced as much energy as around 90% of New Zealand’s 456 wind turbines.

As production from the large Maui and Kapuni fields winds down, tight gas resources are required to secure New Zealand’s long term gas production and energy supply, and their production necessitates the use of hydraulic fracturing.

Community benefits

The Taranaki and wider New Zealand communities benefit from the millions of dollars the oil and gas sector spends each year supporting community events, initiatives, infrastructure and services.

For example, Todd Energy contributed $227,000 towards the Taranaki Coastguard’s new rescue vessel, Todd Energy Rescue, and has committed $3 million towards the Len Lye Centre. Todd Energy supports the WOMAD (World of Music and Dance) festival, the Todd Energy Aquatic Centre, the Taranaki Kart Club’s raceway facility, and sponsors many community projects.

For further information you can visit our website www.toddenergy.co.nz or download our submission to the Parliamentary Commissioner for the Environment from the following link: toddenergy.co.nz/operations/production/hydraulic-fracturing