# Scoping Study of the Impacts of Fracking on Indigenous Reservations in Alberta using the Mauri Model Decision Making Framework

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NGĀ PAE O TE MĀRAMATANGA

## EXECUTIVE SUMMARY

An assessment of the impacts of hydraulic fracturing on the Blood Reserve in Alberta was carried out using the Mauri Model Decision Making Framework. The key findings of the assessment are as follows:

- A five-year deal between the Blood Tribe and Murphy Oil and Bowood Energy was signed allowing hydraulic fracturing to be carried out on approximately 50% of the Blood Reserve.
- Blood Tribe members are concerned about the adverse environmental impacts associated with hydraulic fractruing as well as the lack of communication during the consultation and negotiation of the deal.
- Hydraulic fracturing has scientifically proven to have large-scale adverse impacts on the environment, even in New Zealand.
- The economic and employment benefits of hydraulic fracturing are creating stability in the energy industry.
- The results of the Mauri Model unweighted data is that the environment or ecosystem mauri is effected the most by the operation. It has a diminishing mauri currently and in the long-term. The other three dimensions point towards a slightly diminishing or maintaining value on the Mauri-ometer.
- When the data is weighted for various stakeholders, the results still indicate a negatively affected mauri. This indicates the option is unsustainable, even with the large scale economic and employment benefits.
- If hydraulic fracturing was to expand in New Zealand, large scale economic benefits will not increase the mauri, as the impacts to the environment and indigenous Maori culture would outweigh any benefits realised.

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# 1. INTRODUCTION

Hydraulic fracturing or ‘fracking’ is emerging as the future of global energy. Fracking operations are increasing at an alarming rate throughout North America and the rest of the world. However, the process of fracturing fuel-rich subterranean rock deep below the surface to extract oil and gas has great uncertainty surrounding it. Many countries have banned or enforced moratoriums as controversy rises over the environmental costs (Macfie, 2012). There are numerous allegations linking fracking to contaminated groundwater, earthquakes, and air pollution. The science is beginning to confirm these cases however greater depth of science is still required into the direct impacts of this practice to society and the environement (Mooney, 2011; Macfie, 2012).

The aim of this study is to use the Mauri Model Decision Making Framework to investigate the impacts of fracking on an indigenous reservation in Alberta, Canada. The Mauri Model framework could give insights into the costs and benefits of fracking on the reservation. The results of this study will hopefully aid in improving the decision-making process of oil and gas exploration (especially fracking) in New Zealand.

## 1.1 Background

In 2010, Kainaiwa Resources Inc (KRI), a company owned by the indigenous Blood Tribe of Alberta, Canada, signed an agreement with Murphy Oil and Bowood Energy. In exchange for access to oil and gas exploration within approximately 50% of Blood Tribe land (129 Ha, 280 acres), the tribe gained $50 million in royalties and potentially greater revenue in the future. The deal is a five-year lease allowing enough time for the impacts to be generated in the short and long term. The type of drilling being carried out is hydraulic fracturing, commonly referred to as fracking. Members of the Blood Tribe are concerned about this controversial oil and gas extraction technique, with many believing it has the capacity to cause irreversible damage to the environment on the Blood Reserve and surrounding areas. They are also worried about human health, wildlife and livestock. The second issue they have is the way the deal between the oil companies and Blood Tribe council was carried out. They believe they were not consulted on the issue even though they are the residents living on the lands (www.potectbloodland.ca).

The abundance of natural gas is a significant driver of Canada’s economy. In 2008, approximately 600,000 Canadians worked in jobs supported by natural gas, contributing in excess of $106 billion to the nation’s GDP. The industry is particularly important in Alberta with over 16% of the provinces jobs in the field. Alberta also has the largest financial stake in natural gas, which supports 27.7% of the province’s total GDP (www.nrcan.gc.ca/energy/sources/). The importance of the industry to Alberta needs to be taken into account when completing the Mauri Model assessment.

### 1.2 The Blood Tribe

The Kainai or Blood Tribe are indigenous people from Southern Alberta, Canada. They are members of the Blackfoot Confederacy which also includes the Peigan, Siksika and South Peigan (Blackfeet). The Blood Tribe peoples number over 10,000 and occupy approximately 550 square miles of land making it the largest indigenous reserve in Canada. Three rivers, the Old Man, St. Mary and Belly Rivers border the Blood Reserve (bloodtribe.org).

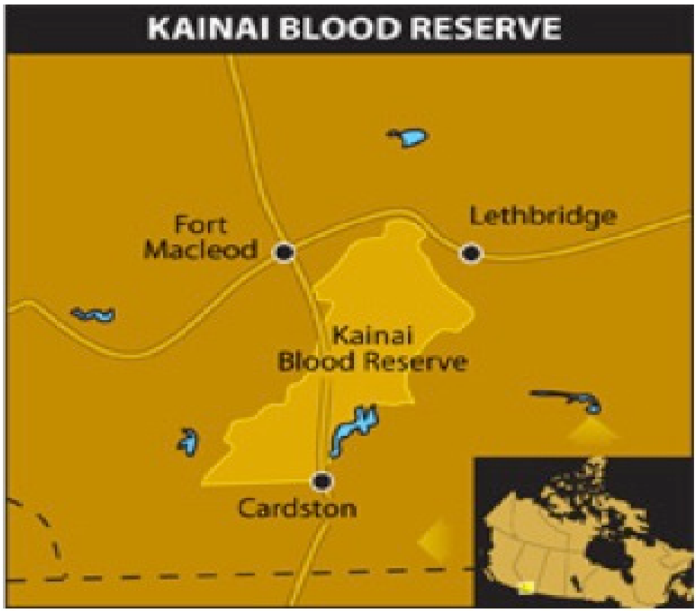


Figure 1. Map outlining the location of the Blood Reserve (www.protectbloodland.ca).

Archaeologists believe the plains of the reserve have been hunted for over 11,000 years. The Blood Tribe during this traditional period were a vibrant and self-sufficient society. The area was rich in natural resources, supplying all the necessary needs of the people. The Tribe had a developed social structure, cultural and political systems making it a well-ordered society. The Blood Tribes alignment with the Blackfoot Confederacy resulted in a territory bordered on the north by the North Saskatchewan River, south by the Yellowstone River in Montana, west by the Rocky Mountains, and east by the Sand Hills in Saskatchewan. The Blackfoot people were one of the last First Nations to enter into treaty with the Americans in 1855. An additional peace treaty was signed by the British Crown in 1877 with the intention of sustaining a peaceful co-existence.  To compensate for the sharing of land and destruction of the buffalo, the Blood Tribe were to receive certain benefits. This initially involved an area of 50,000 square miles of land, located north of their traditional lands. As a result, Chief Red Crow of the Bloods, selected the land between the Waterton River and the St Mary's River back to the Rocky Mountains and as far south as the Canada – United States International Boundary. In 1882, the Blood Tribe reserve was surveyed comprising 708.4 square miles . However the following year the reserve was resurveyed and reduced to 547.5 square miles, without explanation (bloodtribe.org).

Following the formation of the Blood Reserve, the Blood Tribe cultivated its own land and remained independent. They took pride in their identity as Kainai. As a result, they successfully resisted the efforts of governments, churches, and other groups whose aim was to breakdown their cultural identity and legal rights. In April, 2011 the Blood Tribe through its company Kainaiwa Resources Inc., announced the formation of Kainai Energy. The firm was established as an attempt to capitalize on their petroleum reservoir which could generate jobs and capital. Recent science had demonstrated that the Blood Reserve was sitting on the Alberta Bakken, a large reservoir of oil and gas. Kainai Energy was formed in partnership with Native American Resource Partners LCC (NARP); that specializes in developing natural resources projects with indigenous people in Canada and the United States. NARP assisted with a $100 million financial commitment, as well as technical and commercial oil and gas expertise (Muise, 2011). Although the tribe continues to draw on the past, the introduction of oil and gas exploration and large scale economic benefits has divided this once unified tribe.

Figure 2. The Blood Reserve looking towards the Rocky Mountains (www.cbc.ca).

### 1.3 Relevance to New Zealand

Oil and gas companies have been undertaking hydraulic fracturing operations in Taranaki since 1993 with increased activity occurring since 2007. During this time more than 43 hydraulic fracturing activities have been undertaken in 28 wells. The depth of these wells varies between 1.15km and 4km underground. A report carried out by the Taranaki Region Council (TRC) in 2011 into the fracking of the region during 2000-2011, found no evidence that groundwater was contaminated. They concluded the operations posed little risk and could be managed by best practice and tight regulatory control (TRC, 2011). However, up until recent years, fracking operations were not required to gain resource consent. This suggests that the quality of regulation in the past was questionable (Macfie, 2012).

The Kapuni gas field of Taranaki is one of New Zealand's oldest gas fields. Fracking has been occurring at this site since 1993, with future expansion of operations in the area confirmed by Shell Todd Oil Services (STOS) general manager Rob Jager (Maetzig, 2011). However, there is evidence of long-standing contamination of groundwater caused by well fluids seeping through unlined storage pits. In a report published by the TRC in June 2011, groundwater beneath blow down pits at several Kapuni well sites was described as unsuitable for drinking, stock use, and irrigation. The toxic chemicals benzene, ethyl benzene, xylene and petroleum hydrocarbons were present at levels exceeding Ministry for the Environment guidelines at many sites. Many of these locations were in close proximity to houses (Macfie, 2012).

Figure 3. A Tag Oil hydraulic fracturing operation in Taranaki (Macfie, 2012).

Expansion of fracking operations within New Zealand is on many oil and gas companies agenda. The Canadian-based Tag Oil is aggressively expanding its operations in Taranaki, and has gained permits over the North Island's East Coast, stretching from Te Puia Springs to southern Hawke's Bay. They have joined with Apache Corporation in conducting seismic surveys (Gullery, 2011) Exploration of the area using unconventional fracking methods could generate at least $600 million into the country's economy. The joint-venture would pay 5 percent of the value of each barrel in royalties, with 12 billion barrels expected to be extracted in the reservoir. However there are many people adverse to the idea of exploration of this magnitude. Opponents claim it increases seismic instability and threatens water sources with chemical pollution (Reid, 2012). People are not concerned with economic benefits, but want assurances over the long-term health of the environment.

Wellington-based L& M Energy, have indicated that they plan to explore shale gas reserves in Canterbury and Southland. They believe there is significant shale gas potential, similar to that in North America. With Canterbury having water management issues and suffering from devastating earthquakes, the region is against mining in the area (Macfie, 2012).The

New Zealand Government wants to become a net exporter of oil and gas by 2030 with hydraulic fracturing playing a large role in this. But many councils are adverse to the idea, and have demanded the government impose a moratorium. The Kaikoura District, Christchurch City, and Selwyn District Councils want the practice to be fully investigated with all potential risks identified (Macfie, 2012; Reid, 2012).

## 2.0 DESCRIPTION OF HYDRAULIC FRACTURING (FRACKING)

Hydraulic fracturing, commonly referred to as fracking, is increasingly being used to extract gas from shale deposits and coal beds. The gas in such deep reservoirs (2-3 km deep) has been described as 'unconventional' gas due to low porosity and was long thought to be too difficult and expensive to extract (TRC, 2011). The basic 'conventional' technique of hydraulic fracturing has been used since the late 1940s. Traditionally, the vertical well shaft is drilled until it hits the target formation. Chemically treated water and sand are pumped at high pressure to fracture open the rock to release the natural gas. Over the past 15 years, new methods have advanced the ability to extract gas. The first of these is precision drilling which allows horizontal drilling along the contour of the geological layer. The well may follow along the contour of a shale layer for three kilometres or more after an initially vertical drill of two kilometres (Mooney, 2011). Secondly, large volumes of high-pressure water with additives have been applied to increase the fissures in the formations. These two new technologies were first experimented in Texas, however have spread to much of the United States, and now the rest of the world (Howarth et al., 2011).

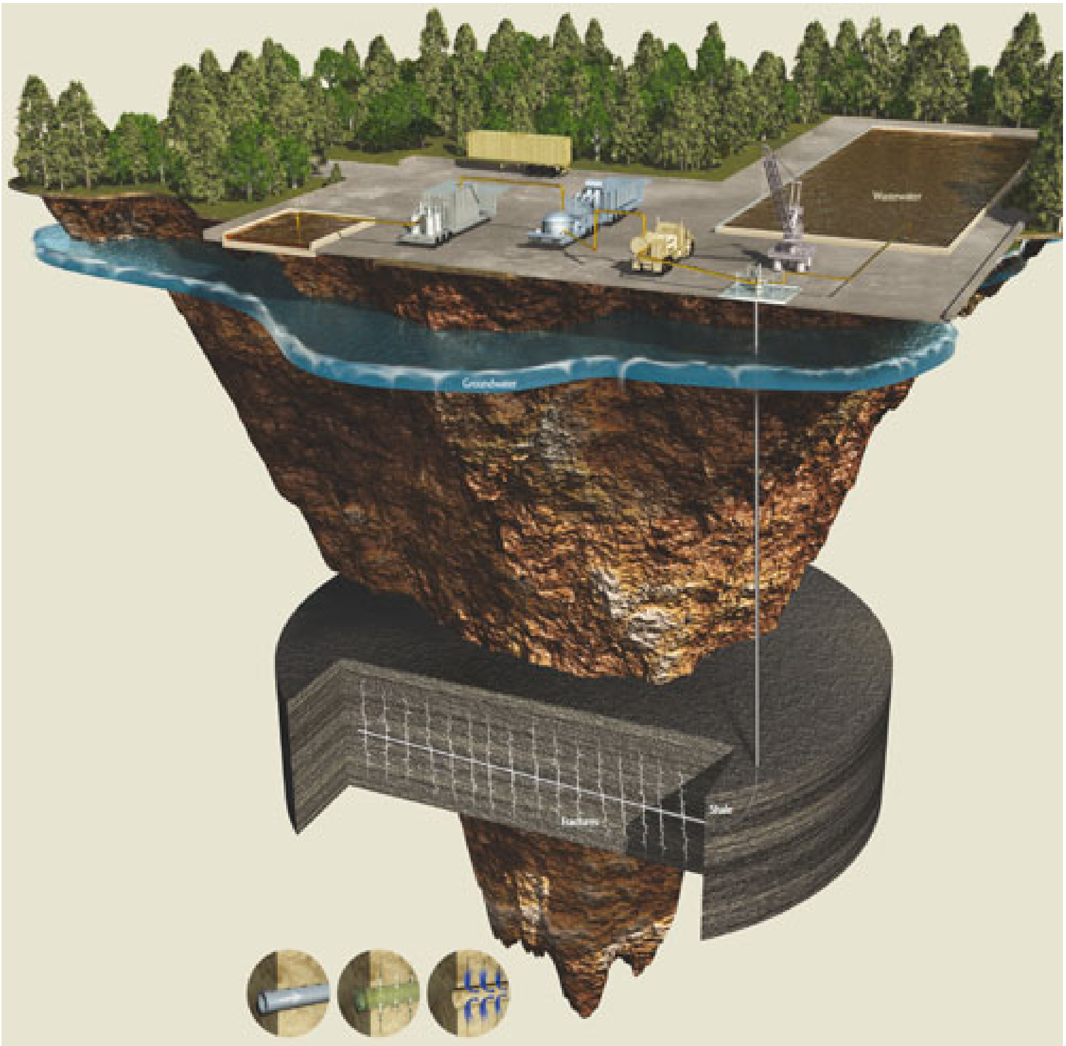

Figure 4. An overview of the key processes involved in hydraulic fracturing (Mooney, 2011).

The success of this unconventional gas extraction has transformed the gas industry. The United States is estimated to have 827 trillion cubic feet of unconventional gas within reach, stored in large shale formations. This has transitioned the nation away from importing natural gas. It is also believed that fracking has strongly effected world energy trade, geopolitics and climate change (TRC, 2011) However, the process has received significant media attention in the recent past. Most of this coverage has been negative due to the large scale environmental impacts evident from the process, as seen in the film 'Gasland' (Howarth et al., 2011). Even though much is still unkown into the impacts of fracking, the signs are not promising.

### 2.1 The Hydrauic Fracturing Process

Hydraulic fracturing is a process that results in the creation of small fissures or fractures in reservoir rocks, enhancing oil and gas recovery. The fracking process is initiated by the drilling of a well which is then lined with steel casing. The steel casing is held in place with cement and is installed in numerous tubular sections. The cement secures the steel casing to the hole walls thus sealing the entire outer annulus (TRC, 2011). The following step involves perforating the steel casing within the target depths that contain oil and gas. Fracturing fluids consisting of freshwater, fracture chemicals and proppant (usually sand or small ceramic pallets) is injected into the well at high pressure into the reservoir rock through the perforated casing. The fluid pressure exceeds the fracture strength of the reservoir rock resulting in artificial hydraulic fractures forming. The fracturing fluid pressure and period of application depends on the fracture design engineer. The fractures only occur in the target formation thus not penetrating overlaying geological layers (TRC, 2011).

The fractures created depend on the geological formations but are generally in the order of millimetres wide and metres long. The proppant which is added to the fracturing fluid, remains in the fractures to hold them open when pumping is halted and the fracture fluid withdrawn. Often cross-linked gels are used alongside the proppant to transport it into the target formation. Once in the formation, these gels have the ability to transform back to a liquid state so they can return to the surface without effecting the proppant (TRC,2011).

Once the fractures have been created and injection ceased, the fracking fluids begin to flow back to the surface. This is driven by the high pressure in the reservoir which forces the fluid to the surface. The flow back fluids generally consist about 30-80% of the original fluid injected. These wastes are stored in open pits or tanks on site before being disposed of. The remaining fluid stays within the target formation, with some of these gradually leached out (TRC, 2011).

Although water based fracture techniques appear common place, there are other ways to fracture wells. Oil based fracturing, which was widely used in Taranaki fracking operations, uses petroleum based medium such as diesel oil. However, diesel oil contains a mixture of organic compounds including the hazardous mixture of benzene, ethylbenzene, toluene, and xylene (BTEX). For example, Benzene is highly carcinogenic and found in many toxic products (TRC, 2011). Fractures are also created by injecting gases such as propane or nitrogen.

### 2.2 Environmental Issues

Although industry claim that fracking has been around since the late 1940s, it has only been in the past 15 years that new techniques have altered the whole fracking process. The approach is far bigger and riskier than the conventional fracking of earlier years. As a result scientific literature of the environemental impacts is scarce (Howarth et al., 2011).

It has been estimated by the United States Environmental Protection Agency (EPA) that an average of 20 million litres of freshwater are forced under pressure into each well. This large scale extraction for industry purposes has raised concerns about the depletion of freshwater resources and the ecological impacts. Although many fracking location have an abundance of water resources there are others located in semi-arid locations, putting greater pressure on the management of water. The large quantities of water pumped at high pressure are combined with large volumes of sand or other material to keep the fractures open. 200,000 litres of acids, biocides, scale inhibitors, friction reducers and surfactants are added to each frack. Many of these fracking additives are toxic, carcinogenic or mutagenic. Due to the Halliburton loophole, the United States exempts fracking from many of the major federal environmental-protection laws, including the Safe Drinking Water Act (Howarth et al., 2011).

The biggest concern with fracking is the impact it has on surface water and groundwater resources. Evidence is mounting linking methane contamination in groundwater from fracking. Osborne et al. (2011) found that about 75% of wells sampled within 1 kilometre of gas drilling in the Marcellus Shale, Pennsylvania were contaminated with methane from deep shale formations. Fracking fluids have also contaminated drinking water however no peer-reviewed literature has demonstrated this. Concerns regarding the potential impact of hydraulic fracturing on drinking water resources are the subject of current research being undertaken by the U.S. Environmental Protection Agency (TRC, 2011).

It has been proposed that methane and fracking fluid have four potential routes to reaching overlying freshwater aquifers: leakage from the well casing due to defective installation or a broken seal in the cement casing; leakage through hidden routes upwards such as old abandoned gas wells, natural fissures, or new fissures created by repeated fracturing; leakage from improper handling of wastewater; a well blowout resulting in underground leakage into aquifers or surface recharge via spillage. Well blow outs have occurred in many operations around the world (TRC, 2011). Also the impact of earthquakes in seismically active zones has not been examined however the integrity of the cement casing and overlying geology could facilitate contamination.


Figure 5. Opponents to Fracking (Mooney, 2011).


Figure 6. Household tap water ignited from methane contamination (www.wilderutopia.com).

Other concerns are related to public health and air pollution. Huge diesel pumps are used to inject the chemically treated water creating local air pollution, often at dangerous levels. Volatile organic compounds (VOCs) such as benzene have been measured in the air at dangerous levels near wells. In Texas, for example, benzene concentrations exceeded acute toxicity standards (Texas Commission in Environmental Quality, 2010). VOCs can cause symptoms such as headache, loss of coordination,  and damage to liver. Chronic exposure also increases the risk of cancer as benzene is a carcinogen (Brown, 2007).

Natural gas is seen as the 'bridging' fuel towards a lower greenhouse gas emission economy. However, a study carried out at Cornell indicated that extracting gas could do more to accellerate global warming than mining other fossil fuels such as coal. Natural gas has been portrayed as a clean-burning fuel that produces less carbon dioxide than coal but natural gas is mostly methane, which is a more potent greenhouse gas. In the short term, methane has 105 times more warming impact than carbon dioxide. Although the influence of methane lessens over longer timeframes, the footprint of natural gas remains comparable to that of oil and coal. It has been estimated that between 3.6 – 7.9%of the methane in shale gas leaks during the lifetime of a fracking well with a significant amount lost during flaring. The unconventional process lends itself to more leaking because it takes longer to drill the well, requires more venting and produces more flow back waste (Howarth et al., 2010). Venting and leakage can be decreased by upgrading pipelines and storage systems, and by applying better technology for capturing gas from flow back, however the economic incentives are not yet sufficient to drive these changes (Howarth et al., 2011).

A large concern from the public is that fracking causes earthquakes. There have been no confirmed cases in which hydraulic fracturing has triggered an earthquake. This was recently investigated by GNS New Zealand who found no evidence that fracking in Taranaki had resulted in seismic activity in the region (Reid, 2012). However, many companies inject their wastewater into disposal wells which has been linked to earthquakes, as large as a magnitude 5. Many injection wells in the United States have been shut down while geologists examine the link to recent quake activity around the location of the wells (Jones, 2011).

### 2.3 Benefits of Hydraulic Fracturing

Fracking has proven to be crucial to global economic stability. Many believe the large economic benefits of the industry outweigh the unproven and uncertain environmental risks. With an estimated 42 trillion cubic metres of recoverable gas from fracking, the United States has enough domestic gas to meet their needs for the foreseeable future. The total is equivalent to about 65 times the current United States annual consumption. During the past three years, 50 billion barrels of oil from shale deposits have been extracted using fracking. This has the effect of offsetting one-third of current United States oil imports (Engelder, 2011).

The role of natural gas will continue to grow in the near future when greenhouse gas emissions are constrained. Natural gas has the lowest carbon intensity among the fossil fuels, emitting less carbon dioxide per unit of energy generated than other fossil fuels. In a carbon-constrained world, a carbon dioxide emissions price for all fuels without subsidies or other preferential policy treatment, will maximise the value to society of natural gas (MIT, 2011). Fracking is therefore viewed as a bridging energy source to a low-carbon future. It is vital to global economic stability until renewable or nuclear energy can carry more of the workload. A study completed by Jiang (2011), concluded that replacing coal with natural gas in power plants could reduce the plant’s greenhouse gas emissions by up to 50%. As mentioned in 2.3 however, natural gas from fracking could be more harmful than coal, an issue which needs further research.

The gas industry in the North America is worth billions of dollars and accounts for millions of jobs. In the United States gas is worth US$385 billion in direct economic activity and nearly three million jobs. Approximately 600,000 Canadians work in jobs supported by natural gas, contributing US$106 billion to the nation’s GDP. The potential gains to employment, economics, and national security alongside the potential to reduce global greenhouse gas emissions (if managed effectively), make for a compelling case (Howath et al., 2011).

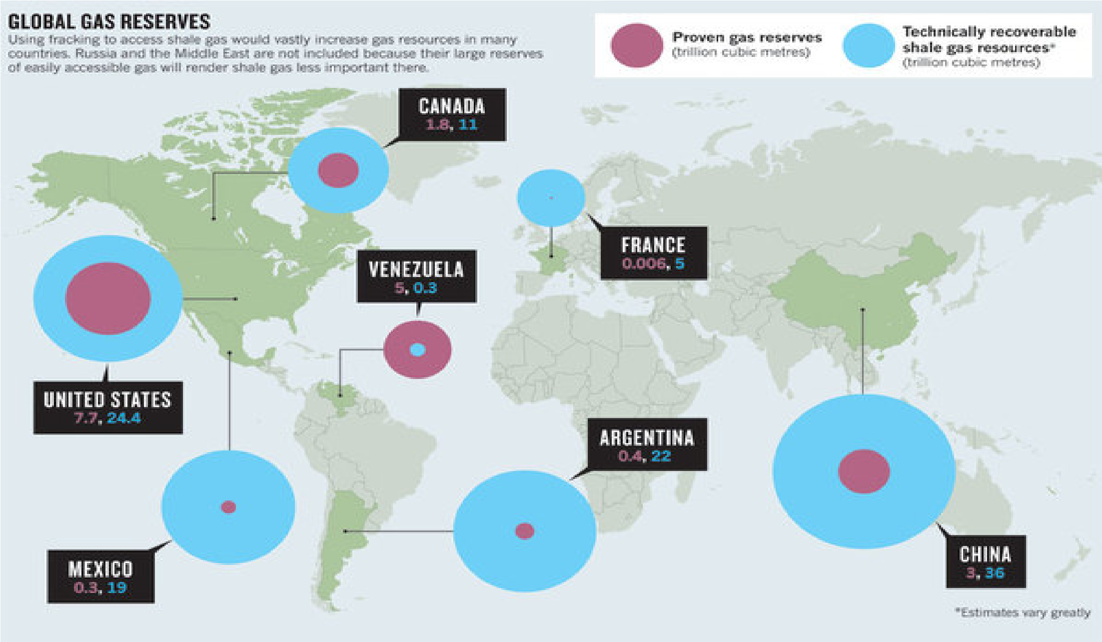

Figure 7. Global gas reserves of proven and recoverable reserves (Howarth et al., 2011).

## 3.0 MAURI MODEL: AN INDIGENOUS DECISION MAKING FRAMEWORK

In New Zealand, sustainability assessment focuses upon the four dimensions: environmental, cultural, economic, and social well-being. Limitations become evident when the decision making process for sustainability is dominated by economic factors that tends to result in an undervalueing of the three other dimensions. Indigeneity is described in Durie (2005) as: Unity with the environment (holistic); Geographic relationship and belonging (relevance); Survival over many generations (time); Development of a distinctive culture (identity); System of knowledge; and encourages sustainability. This definition of indigeneity highlights the key aspects of sustainability which may be what is missing from current sustainability thinking in the western world (Morgan, 2009). With this knowledge, the Mauri Model Decision Making Framework was developed over a period of five years. It was trialed in a range of contexts relevant to engineering decision making, especially within Maori communities of New Zealand.

The suitability and adaptability of the mauri principle as a measure of sustainability is the concept that encapsulated the decision making framework. Mauri is a concept used by Māori, the indigenous peoples of NZ, who believe the land, forests, waters, all the life they support, together with natural processes, all possess mauri. It is a holistic concept central to Māori thinking due to its representation in the genealogy of creation (Morgan, 2011). Barlow (1991) describes mauri as being the binding force between the physical and the spiritual. When this bond is broken down the result is death of a living organism or alternatively the loss of capacity to support life in material such as water or soil. The Mauri Model Decision Making Framework incorporates this mauri concept into a series of steps to determine whether the mauri of each dimension is being fully restored, enhanced, maintained, diminished, or destroyed. Thus the use of mauri rather than money as the measure of sustainability avoids the constrained economic analysis, instead taking a holistic approach (Morgan, 2009).

Thus, the central theme of this analysis is that mauri is the binding force, the fusion that makes it possible for everything to exist. When actions have a negative impact upon the mauri of something, this essential bond is weakened, and can potentially result in the separation of the physical and spiritual elements resulting in the death of a living thing or alternatively the loss of something's capacity to support other life. If the mauri of a forest or river is not respected it will not flourish, but rather it will lose its vitality and fruitfulness. The life of the forest or river must not constantly be dominated by that of humankind. The natural, healthy and proper state is one of balance (Morgan, 2009).

Mauri is a pervasive sustainability performance indicator so that the results of the Mauri-ometer assessment are universally understood, robust and difficult to challenge. While mauri is a concept from Maori culture, it is easily understood by people from all cultures, as it is the difference between life and death both individually and in terms of our future survival (Morgan, 2011)

The framework comprises a sequence of eleven steps that work together in a holistic manner by producing an integrated sustainability assessment. The steps have been developed to accommodate all stakeholders and worldviews while drawing on the most effective scientific techniques. Transparency in the decision making process is retained by reducing the dependence on computer analysis. The sequence of steps are as follows;

1. Correlate legislated sustainable development definition with mauri dimensions.
2. Use pair-wise comparisons to determine relative ranking of dimensions.
3. Normalise the ranking results and convert to percentage weightings for sustainability.
4. Select case studies for assessment using modal analysis.
5. Select performance indicators for each dimension of sustainability.
6. Sustainability assessment of each indicator using the MauriOmeter.
7. Calculate the scores for indicators, dimensions, and overall sustainability.
8. Calculate the weighted scores for indicators, dimensions, and sustainability.
9. Sensitivity assessment to identify most significant sustainability performance modifiers.
10. Evaluation of options against indigenous sustainability time scales and against each other.
11. Select the most sustainable development option available.

***Step 1.***

Sustainable development should be holistic and promote social, economic, environmental, and cultural well-being. To assess each of these well-being criteria using mauri as the measure of sustainability, it is vital to identify representations of those dimensions for which the impact upon mauri can be evaluated. These representations have been determined as the mauri of the community (social), whanau or family unit (economic), ecosystem (environmental), and hapū/clan (cultural). The correlation of well-being criterion to mauri dimension is demonstrated in figure 8.

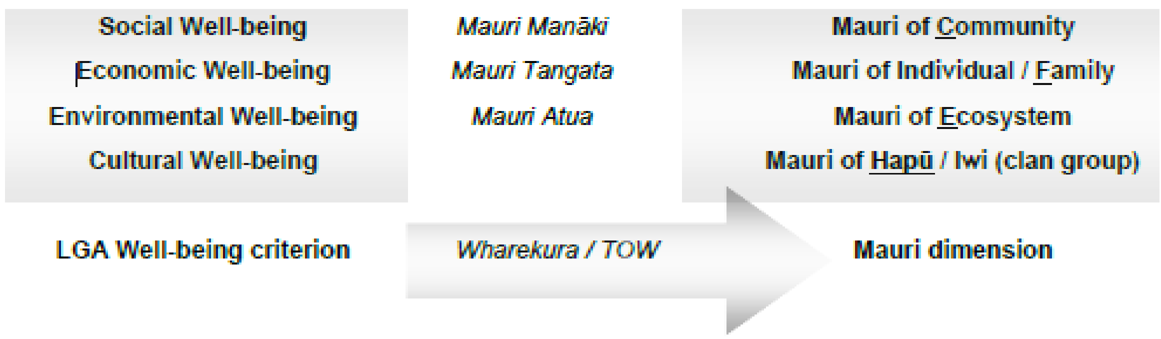


Figure 8. New Zealand Local Government Act 2002 and Mauri Dimensions.

***Step 2.***

It is necessary to apply the appropriate weighting to each of the four mauri dimensions. Weightings reflect the relative importance given to social, economic, environmental, and cultural indicator performance. An equal weighting has little validity in the real world due to the lack of bias between the dimensions. Although it may be a defendable legal position based on legislation, it is not a valid assumption in the real world. The weightings are important to identify bias and acknowledge the various worldviews and how they impact upon the choices made and the reasons for these choices (Morgan, 2011).

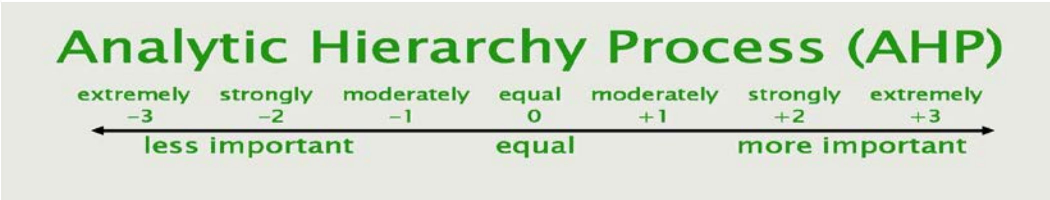


Figure 9. Scale for determination of relative importance of mauri dimensions (Saaty, 1980).

The Analytical Hierarchy Process (AHP) devised by Saaty (1980), is used to assess the relative importance of the mauri dimensions. The AHP is the pair-wise comparison of mauri dimensions using the Likert Scale, as shown in figure 9. The approach is simple in that the relative importance of each pair of mauri dimensions. An example is shown in Table 1, which explains that the mauri of the ecosystem is strongly more important than the mauri of the community. This is displayed with a pair-wise comparison result of +2 (Morgan, 2007).

Table 1. Pair-wise comparison of a Mauri Dimension example.

| Mauri | Ecosystem | Hapū | Community | Whanau | Sum |
|---|---|---|---|---|---|
| Ecosystem | 0 | 0 | +2 | +2 | +4 |
| Hapū | 0 | 0 | +3 | +3 | +6 |
| Community | -2 | -3 | 0 | -1 | -6 |
| Whanau | -2 | -3 | +1 | 0 | -4 |

***Step 3.***

The next step is the normalization of the AHP results and conversion to percentage weightings, as shown in table 2. The results are normalized by by adding nine, which determines the percentage weightings for the four mauri dimensions. Dimension weightings vary across a range of projects, and woeldviews.

Table 2. Percentage Weighting of Mauri Dimensions.

| Mauri | Hapū | Ecosystem | Whanau | Community |
|---|---|---|---|---|
| Score | +6 | +4 | -4 | -6 |
| Normalised | 15 | 13 | 5 | 3 |
| Percentage | 42% | 36% | 14% | 8% |

***Steps 4 and 5.***

Performance indicators for each dimension (usually at least three each) of sustainability are identified. The usual method is to list all the performance indicators and debate their relative merits until a consensus is made (Morgan, 2007).

***Step 6.***

The sustainability assessment can now be carried out using the mauriOmeter. It is based on whether the option identified is fully restoring, enhancing, maintaining, diminishing, or denigrating the mauri of the dimension being considered. The result is a long term indication of an options viability and sustainability. There are only five ratings available as shown in figure 10.

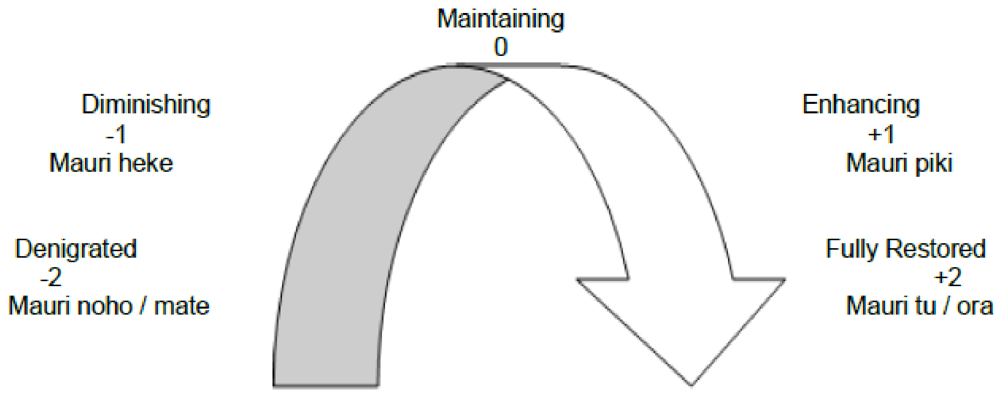


Figure 10. Sustainability assessment using the Mauri Barometer (Morgan, 2010).

***Steps 7, 8 and 9.***

The rating or raw score for each performance indicator is then multiplied by the relative dimension weighting, summed, and then divided by the number of indicators used in each dimension, to indicate the sensitivity of the result to the various worldviews. Greater insight can be gained by performing sensitivity assessment to identify the most significant potential sustainability score modifiers.

***Step 10.***

There is the opportunity to evaluate options against themselves using indigenous sustainability time scales in terms of generations to reflect the concept of inter-generational equity commonly refered to in sustainability. The long-term planning timeframe has been suggested to be six generations (150 years). An analysis of this allows long-term trends to be identified and can strongly influence selection of sustainable development options that at face value appear weaker choices but are actually the most sustainable approach (Morgan, 2007).

# 4.0 Application of Mauri Model Decision Making Framework

## 4.1 Step One: Correlate to Local Sustainable Development Legislation

The following descriptions were presented by Morgan (2007) to explain the mauri of each dimension:

1. Mauri of the Ecosystem – Māori believe that the physical and spiritual integrity of the ecosystem is reflected by its mauri and the state of the environment. This includes all land, air, flora and fauna, and water. Consideration of the mauri in terms of environmental well-being is related to the geographic boundaries established by a watershed, the region of a specific hapū, and the related impacts on estuaries, harbours and the ocean.

2. Mauri of the Hapū – The well-being of a particular environment, in particular the qualities of water within a watershed, and how well managed this is, impacts on the identity, standing and authority of the hapū in a variety of ways. These include: reinforcing the ability to continue in a guardianship role; the prestige associated with caring for visitors; maintenance of the hapū knowledge base through active reinforcement; the effective dissemination of knowledge to successive generations and the integrity of all these practices. These metrics among others impact directly on the mauri of the hapū and are relevant in any assessment of cultural well-being as a dimension of sustainability.

3. Mauri of the Community – The community at large includes non-Māori, Māori from other regions, and the hapū of that place. The community well-being dimension includes their collective general health and safety, and includes the ability to accommodate future community needs such as land and water resources to satisfy housing demand or the creation of employment oportunities. Community well-bein also includes most aspects of day-to-day life such as recreational access to parks, forests, beaches, reserves, rivers, lakes, estuaries and the ocean or opportunities for employment.

4. Mauri of the Whanau – Economic well-being is assessed in terms of the impact upon the mauri of the whanau (family unit). The family unit is chosen because ultimately it is at this level that economic decisions impact upon people. The impact upon the mauri of the whanau is a measure of the direct personal cost or benefit that accrues to a whanau as a result of a choice of action.

## 4.2 Step Two and Three: Stakeholder Mauri Dimension Priorities

There are three key stakeholders involved in the hydraulic fracturing operations on the Blood Reserve, who all have varying priorities. Their priorities were calculated by applying the AHP and are expressed as percentage weights for each well-being criterion or mauri dimension. Firstly, the Indigenous Blood Tribe weights for the mauri dimensions were; 39% ecosystem (environmental), 28% hapū (cultural), 19% whanau (economic), 14% community (social). Secondly, the Oil Companies scored; 44% whanau, 25% ecosystem, 25% community, 6% hapū. Finally, the local Alberta Government weights were; 39% whanau, 31% ecosystem, 19% community, 11% hapū.

### 4. 3 Step Four and Five: Performance indicators for each dimension

1. SOCIAL- Mauri Manaki/Community

(i) *Public health and safety* – The fracking operations on the reserve pose a large threat to public health and safety. Although there is a large gap in science into this area, the initial signs are not good. Human exposure to toxic chemicals can occur by ingesting chemicals that have been spilled and entered drinking water sources, through direct skin contact (eg. workers), or by inhaling vapours from the flow back stored in the tanks or pits. Colborn et al. (2010) summarised the toxicity of the fracking chemicals which have the ability to effect the skin, eyes, respitatory system, liver, brain, nervous system, immune system, kidneys, blood, and heart. They are carcinogenic, mutagenic, endocrine disruptive chemicals. Water contamination from the wells also pose a large threat. It has been well documented that methane has leaked into freshwater aquifers with many cases of household tap water being ignited. Methane being highly flamable poses a grave risk to households (Howarth et al., 2011). Noise and air pollution are additional adverse effects which will negatively impact on the public. With the addition of new wells on the reserve, new roads were constructed to handle the constant flow of traffic. This large rise in the vehicle movements around the reserve is of concern.

(ii) *Mauri of land* – The suitability of the land in the reserve has been altered. Once the five year lease has ended there will be long term effects. Firstly, the infrastructure such as roads and wells used will remain. The improved roading on the reserve has the effect of creating better access within the reserve. However there are a number of adverse effects which will decrease the future suitability of the Blood Lands. In an email from Mike Bruised Head (a local in the Blood Reserve), previous mining has contaminated the groundwater and soil with tests proving this. As a result, a number of his cattle have died, affecting the agricultural industry. This has the flow-on effect of decreasing the value of the land, its mauri (life supporting capacity) and utility for other purposes.

(iii) *Employment* – The Blood Tribe has a high unemployment rate. The oil and gas exploration on the reserve opens up the possibility of creating jobs and training opportunities for tribe members (Muise, 2011). However the question remains of what happens to these workers once operations have ceased. Many of these jobs are in the lowly-skilled category, meaning future employment is uncertain.

(iv) *Access to reserve* – Due to the fracking operations, about 50% of the Blood Tribe land (129, 280 acres) has been blocked to the public and tribe members. These lands have been used for centuries for hunting, gathering, and exploring. The restriction of access also to

Blood Tribe members has prohibited them from carrying out traditional practices on their own lands (www.protectbloodland.ca).

2. ECONOMIC – Mauri Tangata/Whanau

(i) *Economic incentives* – The Blood Tribe will receive at least $50 million in royalties, with potentially more in the future. However there is the risk that the long term adverse effects to the environment will end up costing the tribe and tribe member's vast sums of money. This has already been seen in many locations around the United States who now have to use water tankers for water supply.

(ii) *Formation of Kainai Energy* – Kainai Energy was formed in 2011 from Kainaiwa Resources Inc..According to a release from KRI "The formation of Kainai Energy strategically positions the Blood Tribe to fully capitalize on its oil and gas participation rights designated in two recent joint ventures agreements with leading oil and gas operating companies and enable the Blood Tribe to secure both the expertise and investment capital necessary to evaluate and fund associated exploration and development costs (www.protectbloodland.ca)." In forming Kainai Energy, the Blood Tribe has retained all of its rights to royalty payments from development of its reserve land by industry partners Murphy Oil and Bowood Energy, while securing needed capital to participate in its own resource development. Kainai Energy will continue to focus on developing the emerging Alberta Bakken and other potential oil and gas formations in the future, with a long-term goal of expanding outside the Blood Tribe Reserve (www.protectbloodland.ca). The cultural implications of these actions aspirations have not been considered here.

(iii) *Agricultural practices* – Due to the restiction of 50% of the Blood Reserve, there is a reduction in land available for agricultural production. There is also the issue of water and soil contamination both currently and in the long-term. There have already been cattle affected on the reserve and there is reason to suggest that it will continue in the future.

(iv) *Eco-tourism* – Although eco-tourism is not prominent in the Blood Reserve, drilling in the area has taken away many future eco-tourism options. Eco-tourism has proven to be successful and sustainable with other indigenous people on their traditional lands.

3. ENVIRONMENTAL – Mauri Atua/Ecosystem

(i) *Life supporting capacity of water* – the capacity of water to support the Blood Reserve and the people living in it. The surface water and groundwater have already been effected by previous drilling operations. Water testing has revealed that one resident living on the reserve, has household water that is contaminated. Uranium and fracking fluids (benzene and vinyl chloride) were identified, caused from fracking done by Bonvista Oil Company in 2002. There are no reassurances that this will not occur again. There are numerous other cases of contaminated water, with scientific literature beginning to make these links between fracking and contaminated water supplies. Osborn et al. (2011) have demonstrated that methane contamination of drinking water accompanies hydraulic fracturing. With this evidence clearly presented, the future of water supplies on the reserve does not look promising.

(ii) *Air pollution* – local air quality and greenhouse gas emissions are two side-effects of fracking operations. The biggest concern to residents of the reserve is the air pollution created from trucks, diesels pumps, and wastewater. A large number of trucks are needed to transport the water, chemicals, sand, and wastewater to and from the wells on the reserve. This heavy traffic will likely create an increase in local air pollution. The diesel pumps used in the process also effect local air quality. Cancer causing chemicals have been identified near fracking wells in the United States. Methane collected from fracking has been found by Cornell University to have a large GHG footprint than coal.

(iii) *Water usage* – There is a large concern over the amount of water used in the fracking process and how the flow back is disposed off. The water is collected from outside the Blood Reserve and the flowback waste is disposed off the reserve as well. An average of 20 million litres of water is forced under pressure into each well. Even though this water is not sourced from the reserve it will be diminishing supplies elsewhere. The large amount of flow back generated from wells also extracts natural salts, heavy metals, hydrocarbons and radioactive materials. These along with fracking fluids have the potential to spill into surface water or leak into groundwater, especially if it is not stored and disposed of effectively.

(iv) *Toxic chemicals* and disposal of waste/biproducts– There are numerous toxic chemicals used in fracking that all have the potential contaminate water supplies and surrounding geology. These chemicals are known to be toxic to humans and wildlife. It has been estimated that 200,000 litres of acids, biocides, scale inhibitors, friction reducers and surfactants are used per well. Although many of these chemical are disclosed by industry many are toxic, carcinogenic or mutagenic.

4. CULTURAL – Mauri Hapū/Iwi: Blood Tribe

(i) *Water management* – The Blood Reserve's groundwater supply is under threat from the oil and gas exploration. Groundwater mapping of the reserve has not been carried out. Additionally, the oil companies are carrying out the water testing around the wells.

(ii) *Traditional knowledge and practices* – The Blood Tribe's culture is based upon traditional practices such as drumming and praying. There has already been an incident with a prayer gathering on the Blood Lands on the October 1st, 2011. Blood Tribe members were forced off land by fracking operations as they were about to carry out a day of prayers and traditional drumming. In effect they were prohibited from carrying out traditional practices. There is also the potential loss of traditional knowledge through the interruption of active reinforcement.

(iii) *Tribal leadership* – There is widespread conflict in the way the consulting process was carried out. The contract between Kainaiwa Resources Inc., Murphy Oil, and Bowood Energy did not involve any Blood Tribe members during the negotiations even though drilling was to be carried out on their land. KRI and the Blood Tribe Chief and Council failed to maintain any degree of transparency during and after the negotiations, leading to a majority of members unaware of the proceedings. This whole process has divided the Blood Tribe and with many losing faith in the direction the tribe is heading towards (www.protectbloodland.ca).

(iv) *Manawhenua (Relationships)* – Mutual respect between the Blood Tribe and the oil companies over the management of the lands is important. However through the blocking of access to 50% of the reserve, the Blood Tribe are restricted from carrying out traditional practices such as drumming and prayers. They are been dictated to by non-natives on their own lands.

### 4.4 Steps 5 and 6: Performance Indicators Assessment using the Mauri-ometer

Table 3. Sustainability assessment of the performance indicators.

| Performance Indicators | | Pre-Fracking | | Current Situation | | Future (150yr) | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Table 7. Raw Data | | | | | | | |
| **ID** | **Indicator Description** | **Past** | **Avg** | **Current** | **Avg** | **Future** | **Avg** |
| **Ecosystem** | Life supporting capacity of water | 2 | | -1 | | -2 | |
| | Air Quality | 2 | | -1 | | -1 | |
| | Water Usage | 2 | | -1 | | -1 | |
| | Toxic Chemicals | 2 | | -1 | | -1 | |
| | | | **2** | | **-1** | | **-1.25** |
| | | | | | | | |
| **Hapū** | Water Management | 2 | | -1 | | 0 | |
| | Manawhenua | 2 | | -1 | | 1 | |
| | Traditional knowledge and practices | 2 | | -1 | | 0 | |
| | Tribal Leadership | 2 | | -1 | | -1 | |
| | | | **2** | | **-1** | | **0** |
| | | | | | | | |
| **Whanau** | Economic Incentives | -1 | | 2 | | 1 | |
| | Formation of Kainaiwa Energy | 0 | | 1 | | 1 | |
| | Agricultural Practices | 2 | | -1 | | -1 | |
| | Eco-tourism | 0 | | 0 | | -1 | |
| | | | **0.25** | | **0.5** | | **0** |
| | | | | | | | |
| **Community** | Public health and safety | 2 | | -1 | | -1 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Community Access | 2 | | -1 | | 1 | |
| | Suitability of land | 2 | | 0 | | -1 | |
| | Creation of employment | 0 | | 1 | | 1 | |
| | | | **1.5** | | **-0.25** | | **0** |

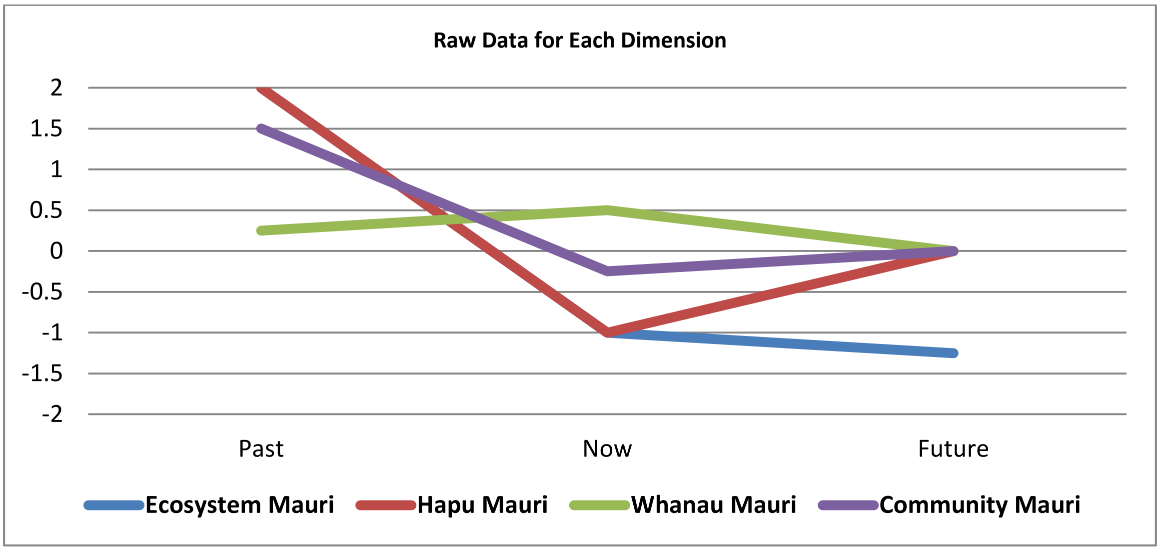


Figure 11. The raw data for sustainability for each Mauri Dimension.

The raw data analysis for each of the four mauri dimensions has indicated that there is large-scale variance between each dimension. The Ecosystem (environmental) dimension data indicates that before hydraulic fracturing operations were carried out on the Blood Reserve ecosystem mauri was fully restored (+2). With the addition of hydraulic fracturing in recent years the ecosystem mauri diminished dramatically to a score of -1 or diminishing mauri. There is a current situation on the reserve where fracking fluids (benzene and vinyl chloride) have been found during the course of water testing near households. In addition to fracking fluids, there is a strong possibility that methane has already entered groundwater which poses a threat in the near future. Air quality has transitioned from a clean environment with minimal air pollution to a current situation of constant air pollution being generated from trucks and diesel pumps. The future in 150 years time has an even lower mauri score of -1.25. This is heading towards the denigrated end of the Mauri Barometer. The reason for this is that there is a high possibility of water contamination on the reserve from either methane or fracking fluids leaking into the groundwater or surface water. Toxic chemicals will remain in subterranean rock for a long period with the chance of migrating upwards towards aquifers and soil. The reason that air quality remains at -1 is that although the trucks and pumps have disappeared, the air pollution created from methane leaking into the atmosphere will leave a legacy aiding global warming.

The hapū or cultural dimension is initially similar to that of the ecosystem however the long-term increases the position of the dimension. The hapū dimension has a pre-fracking value of +2 however the current situation has reduced this to -1. The Blood Tribe's culture is being affected by the mining in numerous ways. Tribal leadership which is carried out by a chief who represents the members is now under threat. Tribal members are unsatisfied with the way the exploration deal was carried out and the blatant lack of consultation between the parties. As a result, members are divided about the leadership regime within the tribe. Traditional practices such as drumming and praying have been restricted on the reserve reducing the strong relationship the Blood Tribe have with their lands. In the long-term, the diminished mauri stabilises, a situation that is unlikely to improve without specific external intervention. Access to 50% of the Blood Reserve will be returned once the five year lease is up, helping to restore many cultural practices. Also, with the oil companies off the land, the tribe will have greater control over the lands and how they are managed.

Contrastingly, the whanau or economic dimension behaves differently. Prior to the fracking, the Blood Reserve was struggling economically. They relied on agriculture for an income. The deal between the oil companies and the Blood Tribe netted them over $50 million, providing a much needed economic boost to the region. The formation of Kainai Energy has provided the Tribe with the corporate stability needed to take advantage of oil and gas resources. The mauri score improves from 0.25 to a current score of 0.5. The reason that it does not increase steeply is due to the fact that agricultural practices on the reserve are hindered by fracking. Half of the land has been restricted as well as contamination already evident. One farmer on the reserve has noted that stock have been dying under mysterious circumstances recently, likely from fracking wells contaminating the soil or water reserves. In the long-term economic incentives may decrease due to the environmental costs of fracking, which will cost the tribe. Eco-tourism which is one way the tribe can improve its economic stability will be diminished with known fracking wells remaining on the reserve.

Finally, the community or social mauri dimension changes over time. Public health and safety and access to the lands were considered to be adequate on the reserve aiding in a high mauri score. However there is a high unemployment rate on the reserve, especially with the youth. The mauri score diminishes from 1.5 to a current score of -.25. The reason for this is blocking of 50% of the Blood Reserve restricts community access. Also the health and safety of tribal members will diminish. Increase in traffic around the reserve create dangers for members. Air pollution and a reduction in water quality currently have the same effect. In the long-term community mauri stabilises, with no further decline identified.

### 4.5 Step Seven, Eight & Nine: Weighted Average Scores for each Stakeholder

The averaged impacts upon mauri for the three stakeholders considered are presented in figure 11. The sensitivity adjusted results using the worldwide priorities determined in steps 2 and 3 are applied to the scores to give a weighted average.

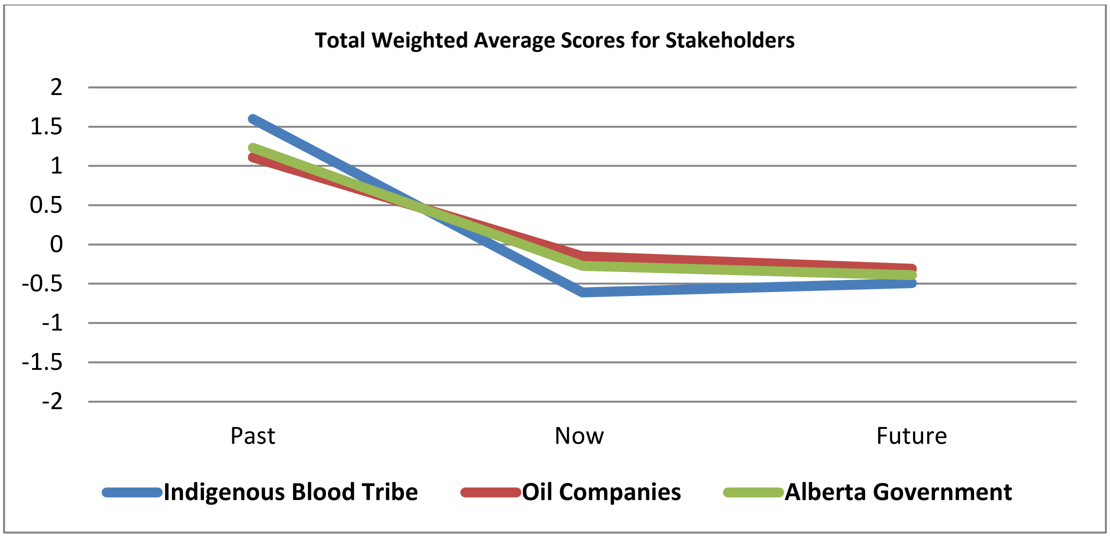

Figure 11. Summaried Mauri Results for different Stakeholders after sensitivity adjusted.

The cummulative position of all three stakeholders when weighted is that of a dimishing mauri. The indigenous Blood Tribe has a worldview with higher weighting placed upon the mauri of the ecosystem (39%) and hapū (28%). Thus, due to raw data supporting a diminishing mauri in these dimensions, the weighted average of the indigenous Blood Tribe (-0.61) is lower than both the Oil Companies (-0.15) and the Alberta Government perspectives (-0.27). The Oil Companies and Alberta Government place a much greater weighting on economic outcomes and therefore the whanau dimension. However their weighting bias is not sufficient enough to alter the Mauri-ometer result to be interpreted as enhancing mauri.

In the distant future, the three stakeholders position begin to converge. This is due to firstly the increase in the mauri of the hapū dimension which increases the indigenous Blood Tribe mauri position (-0.49). Both the Oil Companies and Alberta Government do not place great weighting on the environment forcing the mauri to decline to values of -0.31 and -0.39 respectively.

## 5.0 DISCUSSION AND CONCLUSIONS

The analysis clearly demonstrates that the mauri of the Blood Reserve is diminishing as a result of the hydraulic fracturing operations being carried out over the five year period. The negative impacts upon the mauri outweight the benefits resulting in negative mauri values both currently and in the long-term. The desired outcome of the drilling is for the averaged result on the mauri-ometer to be positive and enhancing mauri. For this to occur, the adverse impacts on the mauri of performance indicators needs to be addressed and economic benefits need to be applied to mitigating adverse effects. Even if by increasing the economic gains of the tribe, the total mauri is enhanced, additionally, the negative impacts to the Blood Reserve environment and Blood Tribe culture will need to be addressed in order to enhance the mauri.

The importance placed on economic outcomes is generally over-stated, with the negative impacts of drilling on the environment and cultures diminishing the mauri. Even large scale economic benefits struggle to produce an overall enhanced mauri to people and place. Currently, New Zealand is planning on expanding its hydraulic fracturing operations combined with deep sea oil drilling and exploration. The government has identified that the significant economic royalties will benefit the country, however, as demonstrated by this study, even these large-scale economic gains are not sustainable. In order for the mauri to be enhanced, it is clear that the environmental and cultural wellbeing impacted by the fracking exploration activities needs to be minimised so that only minor reversible impacts are evident. If this can occur, sustainability could potentially be achieved.

In conclusion, the assessment carried out is holistic in its approach and forward looking rather than based upon the present and immediate economic returns. It takes into account the various stakeholders involved in the hydraulic fracturing operations on the reserve and their respective world-views. The Mauri Model Decision Making Framework has produced results that are robust and clear. The findings from the study are consistent considered both in terms of separate mauri dimensions and also when considered together.

The results of investigations into the impacts of hydrauic fracturing on the Blood Reserve, Alberta indicate that:

- The current situation on the reserve is diminishing the mauri making the fracking operation unsustainable.
- The environmental impacts from fracking on the reserve need to be eliminated or mitigated and then closely monitored.
- Increasing the economic benefits solely will not significantly alter the assessment and the mauri will continue to be diminished.
- The long-term impacts remain negative as the mauri is still diminishing.

- If this type of drilling was to occur in New Zealand, large economic gains to the economy will not equate to sustainable development if the impacts to ecosystem mauri and the mauri of effected hapū are genuinely taken into account.

## 6.0 REFERENCES


Author unknown (2011) About protectbloodlands. Available at www.protectbloodland.ca

Barlow, C. 1991. Tikanga Whakaaro: Key Concepts in Maori Cuture. Auckland: Oxford University Press.

Blood Tribe Tribal Government and External Affairs. About the Blood Tribe. Available at www.bloodtribe.org

Brown, V. J. 2007. Putting the Heat on Gas. *Environemntal Health Perspectives* 115(2): 76.

Durie, M. 2005. Ngai Tai Matatu: Tides of Maori Endurance. Melborne: Oxford University Press.

Gullery, L. 2011. Fracking still on oil companies agenda. Hawke's Bay Today, available at www.nzherald.co.nz/news/print=10771906

Howarth, R. W., Santoro, R., Ingraffea, A. 2010. Natural Gas. *Climate Change* 106: 679-690.

Howarth, R. W., Ingraffea, A., Engelder, T. 2011. Comment – Should Fracking Stop. *Nature* 477: 271-275.

Jiang, M. 2011. *Environ. Res. Lett*. 6: 034014.

Jones, N. 2011. United States investigates fracking safety – Energy department to scrutinize hydraulic fracturing for natural gas. Nature News, available at www.nature.com/news/2011/110512

Macfie, R. 2012. Fracture Friction. New Zealand Listner January 14-20 2012. Pg 22-27.

Maetzig, R. 2011. Concern as gas drilling intensifies. Available at www.taranaki-daily-news/5379486

MIT, 2011. The Future of Natural Gas – An Interdisciplinary MIT Study. Pg 1-285.

Mooney, C. 2011. Energy – The Truth about Fracking. *Scientific America* 305: 62-67.

Morgan, T. K. K. B. 2009. 'Exploring Knowledge System Synergies for Integrated Decision Making', *Journal of Australian Indigenous Issues*, 12 (1): 299-308.

Morgan, T. K. K. B. 2007. 'Traditional Approaches to Forest Management and the Mauri Model'. Sharing Indigenous Wisdom International conference, Green Bay, Wisconsin, 11-15 June, 2007.

Morgan, T. K. K. B. 2011. Mauri Model Decision Making Framework based Cultural Impact Assessment. Mahi Maioro Professionals, Pg 1-27.

Muise, L. 2011. Reservation Road: The Blood Tribe looks to Alberta's Bakken – A joint gamble on an unproven play could be a ticket to economic development. Alberta Oil Magazine July 01, 2011.

Osborn, S. G., Vengosh, A., Warner, N. R., Jackson, R. B. 2011. Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proc. Natl Acad. Sci.* 108: 8172-8176.

Reid, N. 2012. Oil strike could be worth $600m. Sunday Star Times February 26, 2012. Pg. 10.

Taranaki Regional Council (TRC), 2011. Hydrogeological Risk Assessment of Hydraulic Fracturing for Gas Recovery in the Taranaki Region. Pg 1-30.

Texas Commission on Environmental Quality. 2010. Barnett Shale Formation Area Monitoring Projects. Available at www.nature.com/v7k4re

## APPENDIX I: Stakeholder Mauri Dimension Priorities

| | | | | | |
|---|---|---|---|---|---|
| Table 1. Pair-wise comparison of Mauri Dimensions (Indigenous Blood Tribe) | | | | | |
| Mauri | Ecosystem | Hapū | Community | Whanau | Sum |
| Ecosystem | 0 | 1 | 2 | 2 | 5 |
| Hapū | -1 | 0 | 1 | 1 | 1 |
| Community | -2 | -1 | 0 | -1 | -4 |
| Whanau | -2 | -1 | 1 | 0 | -2 |
| | | | | | |
| Normalization of the AHP Results | | | | | |
| Table 2. Percentage weighting of Mauri Dimensions | | | | | |
| Mauri | Ecosystem | Hapū | Whanau | Community | |
| Score | 5 | 1 | -2 | -4 | |
| Normalised | 14 | 10 | 7 | 5 | |
| Percentage | 39% | 28% | 19% | 14% | |
| | | | | | |
| Table 3. Pair-wise (Oil Companies) | | | | | |
| Mauri | Ecosystem | Hapū | Community | Whanau | Sum |
| Ecosystem | 0 | 2 | 0 | -2 | 0 |
| Hapū | -2 | 0 | -2 | -3 | -7 |
| Community | 0 | 2 | 0 | -2 | 0 |
| Whanau | 2 | 3 | 2 | 0 | 7 |
| | | | | | |
| Table 4. Percentage weightings Oil Companies | | | | | |
| Mauri | Ecosystem | Hapū | Whanau | Community | |
| Score | 0 | -7 | 7 | 0 | |
| Normalised | 9 | 2 | 16 | 9 | |
| Percentage | 25% | 6% | 44% | 25% | |
| | | | | | |
| Table 5. Pair-wise Alberta Government | | | | | |
| Mauri | Ecosystem | Hapū | Community | Whanau | Sum |
| Ecosystem | 0 | 2 | 1 | -1 | 2 |
| Hapū | -2 | 0 | -1 | -2 | -5 |
| Community | -1 | 1 | 0 | -2 | -2 |
| Whanau | 1 | 2 | 2 | 0 | 5 |
| | | | | | |

| Table 6. Percentage weightings Alberta Government | | | | | |
|---|---|---|---|---|---|
| Mauri | Ecosystem | Hapū | Whanau | Community | |
| Score | 2 | -5 | 5 | -2 | |
| Normalised | 11 | 4 | 14 | 7 | |
| Percentage | 31% | 11% | 39% | 19% | |

## APPENDIX II: Weighted Average Scores of the Three Stakeholders

| Table 7. Indigenous Blood Tribe | | | | | | | |
|---|---|---|---|---|---|---|---|
| **ID** | **Indicator Description** | **Past** | **Avg** | **Current** | **Avg** | **Future** | **Avg** |
| **Ecosystem** | Life supporting capacity of water | 2 | | -1 | | -2 | |
| **39%** | Air Quality | 2 | | -1 | | -1 | |
| | Water Usage | 2 | | -1 | | -1 | |
| | Toxic Chemicals | 2 | | -1 | | -1 | |
| *Raw Data* | | | 2 | | -1 | | -1.25 |
| *Weighting* | | | 0.78 | | -0.39 | | -0.49 |
| **Hapū** | Water Management | 2 | | -1 | | 0 | |
| **28%** | Manawhenua | 2 | | -1 | | **1** | |
| | Traditional knowledge and practices | 2 | | -1 | | 0 | |
| | Tribal Leadership | 2 | | -1 | | -1 | |
| | | | 2 | | -1 | | 0 |
| | | | 0.56 | | -0.28 | | 0 |
| **Whanau** | Economic Incentives | -1 | | 2 | | 1 | |
| **19%** | Formation of Kainaiwa Energy | 0 | | 1 | | 1 | |
| | Agricultural Practices | 2 | | -1 | | -1 | |
| | Eco-tourism | 0 | | 0 | | -1 | |
| | | | 0.25 | | 0.5 | | 0 |
| | | | 0.05 | | 0.1 | | 0 |
| **Community** | Public health and safety | 2 | | -1 | | -1 | |
| **14%** | Community Access | 2 | | -1 | | 1 | |
| | Suitability of land | 2 | | 0 | | -1 | |
| | Creation of employment | 0 | | 1 | | 1 | |
| | | | 1.5 | | -0.25 | | 0 |
| | | | 0.21 | | -0.04 | | 0 |
| **Total Weight** | | | **1.6** | | **-0.61** | | **-0.49** |

| Table 8. Oil Companies | | | | | | | |
|---|---|---|---|---|---|---|---|
| **ID** | **Indicator Description** | **Past** | **Avg** | **Current** | **Avg** | **Future** | **Avg** |
| **Ecosystem** | Life supporting capacity of water | 2 | | -1 | | -2 | |
| **25%** | Air Quality | 2 | | -1 | | -1 | |
| | Water Usage | 2 | | -1 | | -1 | |
| | Toxic Chemicals | 2 | | -1 | | -1 | |
| *Raw Data* | | | 2 | | -1 | | -1.25 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Weighted* | | | 0.5 | | -0.25 | | -0.31 |
| **Hapū** | Water Management | 2 | | -1 | | 0 | |
| **6%** | Manawhenua | 2 | | -1 | | **1** | |
| | Traditional knowledge and practices | 2 | | -1 | | 0 | |
| | Tribal Leadership | 2 | | -1 | | -1 | |
| | | | 2 | | -1 | | 0 |
| | | | 0.12 | | -0.06 | | 0 |
| **Whanau** | Economic Incentives | -1 | | 2 | | 1 | |
| **44%** | Formation of Kainaiwa Energy | 0 | | 1 | | 1 | |
| | Agricultural Practices | 2 | | -1 | | -1 | |
| | Eco-tourism | 0 | | 0 | | -1 | |
| | | | 0.25 | | 0.5 | | 0 |
| | | | 0.11 | | 0.22 | | 0 |
| **Community** | Public health and safety | 2 | | -1 | | -1 | |
| **25%** | Community Access | 2 | | -1 | | 1 | |
| | Suitability of land | 2 | | 0 | | -1 | |
| | Creation of employment | 0 | | 1 | | 1 | |
| | | | 1.5 | | -0.25 | | 0 |
| | | | 0.38 | | -0.06 | | 0 |
| **Total** | | | **1.11** | | **-0.15** | | **-0.31** |
| Table 9. Alberta Government | | | | | | | |
| **ID** | **Indicator Description** | **Past** | **Avg** | **Current** | **Avg** | **Future** | **Avg** |
| **Ecosystem** | Life supporting capacity of water | 2 | | -1 | | -2 | |
| **31%** | Air Quality | 2 | | -1 | | -1 | |
| | Water Usage | 2 | | -1 | | -1 | |
| | Toxic Chemicals | 2 | | -1 | | -1 | |
| ***R**aw Data* | | | 2 | | -1 | | -1.25 |
| *Weighted* | | | 0.62 | | -0.31 | | -0.39 |
| **Hapū** | Water Management | 2 | | -1 | | 0 | |
| **11%** | Manawhenua | 2 | | -1 | | **1** | |
| | Traditional knowledge and practices | 2 | | -1 | | 0 | |
| | Tribal Leadership | 2 | | -1 | | -1 | |
| | | | 2 | | -1 | | 0 |
| | | | 0.22 | | -0.11 | | 0 |
| **Whanau** | Economic Incentives | -1 | | 2 | | 1 | |
| **39%** | Formation of Kainaiwa Energy | 0 | | 1 | | 1 | |
| | Agricultural Practices | 2 | | -1 | | -1 | |
| | Eco-tourism | 0 | | 0 | | -1 | |
| | | | 0.25 | | 0.5 | | 0 |
| | | | 0.1 | | 0.2 | | 0 |
| **Community** | Public health and safety | 2 | | -1 | | -1 | |
| **19%** | Community Access | 2 | | -1 | | 1 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Suitability of land | 2 | | 0 | | -1 | |
| | Creation of employment | 0 | | 1 | | 1 | |
| | | | 1.5 | | -0.25 | | 0 |
| | | | 0.29 | | -0.05 | | 0 |
| **TOTAL** | | | **1.23** | | **-0.27** | | **-0.39** |