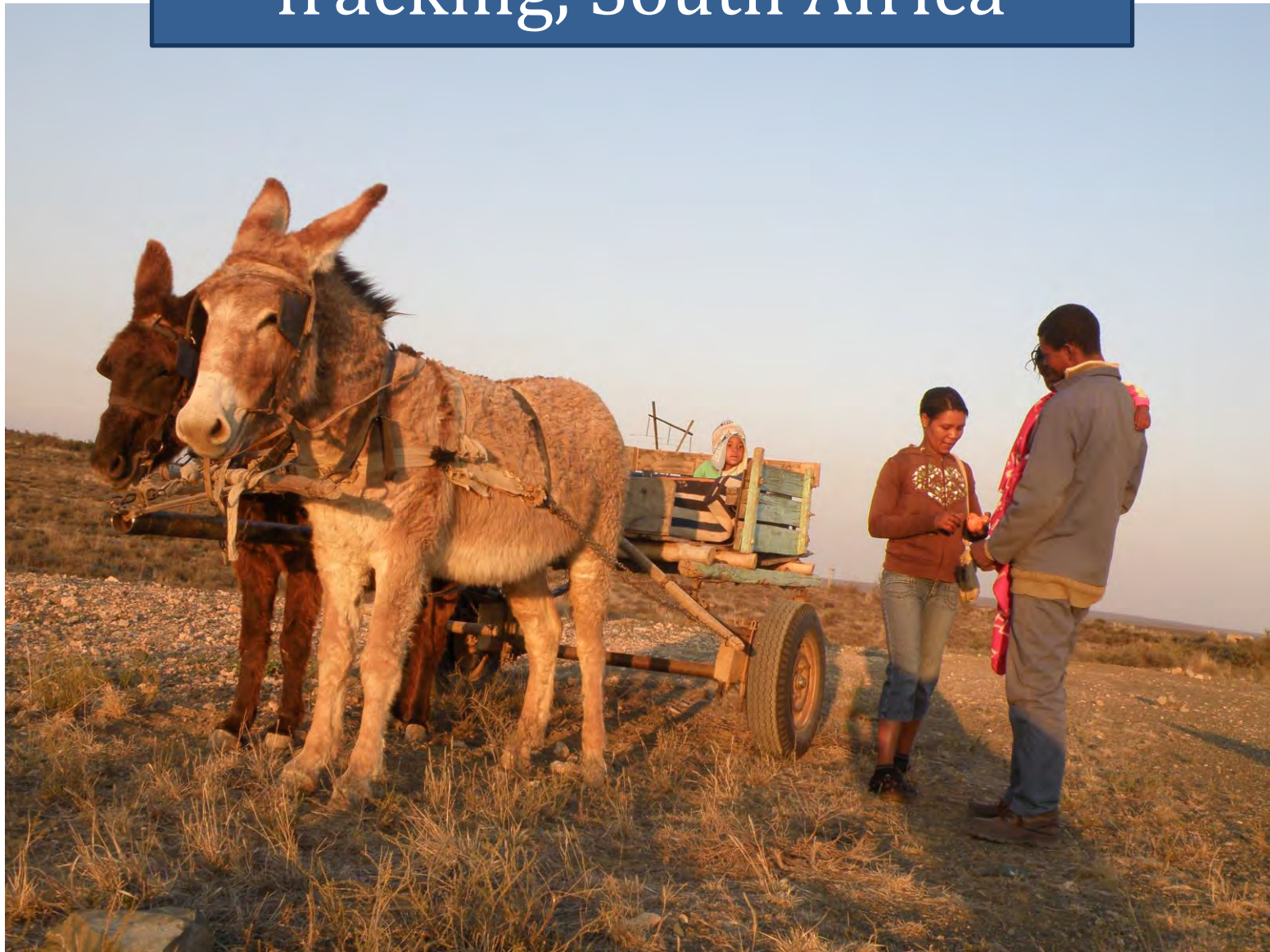


Health risk perception of Karoo residents related to fracking, South Africa



Mini-dissertation submitted to the Faculty of Health Sciences, University of Cape Town, in partial fulfilment of the requirements for the degree of Master in Public Health, 2015

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Master in Public Health (General track) Mini-Dissertation

I, Mieke Willems (WLLMIE001), declare that the work that I have submitted is my own and where the work of others has been used (whether quoted verbatim, paraphrased or referred to) it has been attributed and acknowledged.

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Signed by candidate

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22April 2015



PART 0: Preamble



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Dedication Page

I would herewith like to dedicate this thesis to South Africa, our country whom I love far and wide. I wish that decisions will be made and based on long term vision and not economic gain. I hope that one day we will look back at the struggles we all faced and cherish the value of our efforts as we drink clean water, we roam the barely trodden beaches, the vast plains of grass, sand and rock and enjoy the infinity of our Karoo night sky.

Abstract

Shale gas exploration by means of Hydraulic Fracturing (fracking) has been on the South African (SA) energy agenda since 2010 as a potential alternative energy source to coal mining. Internationally, the desirability of fracking is debated due to increasing evidence of the environmental and health risks fracking poses. However, experts favouring fracking propose this technology as a greener alternative to conventional energy sources such as coal. Limited scientific evidence is available internationally related to knowledge and risk perceptions of fracking and evidence is limited to studies conducted in the United States (US). South African risk perception studies relates to mining, farming, travelling in SA as a foreigner and sexual behaviour. The president of SA called fracking a 'Game-Changer' using industry jargon in the 2014 presidential address. However, SA has failed to produce exploration regulations to date despite oil and gas companies pushing their agendas. Public participation in the process thus far has been limited.

This cross sectional study explored the knowledge, health risk perceptions and information sources related to fracking amongst 102 Central Karoo residents through a household survey. Beaufort West municipality was selected as the study site as this is one of the closest areas to Cape Town demarcated for fracking exploration.

This study found that 40% of Central Karoo residents do not know what fracking is or the potential risks and benefits thereof. Media is the main information source of 59% of participants. Only half of participants trust their information sources. Those with more trust in their information sources perceived fracking as posing a greater risk. In contrast those believing fracking to pose a low risk were more likely to trust the government and oil and

gas companies. More than half of participants (53%) believe that fracking poses an extreme health risk and 78% thought fracking will harm their health. Most commonly listed causes why fracking will make Karoo residents sick includes water pollution (47.4%) and air pollution (19.6%). Higher education was found to have an inverse relationship with trust in the national government.

A limitation of this study was that farms could not be randomly selected, affecting the representativeness of the sample. There is a major lack of knowledge pertaining to fracking among those living in the Central Karoo which has important implications for managing the process of public participation in the approval of shale gas exploration.

Acknowledgements

I would herewith like to thank my family for their support on all spheres during my masters, especially my mother who proved to be the best fieldworker imaginable.

I am indebted to Professor Jan Glazewski from University of Cape Town's Marine Environmental Law faculty and Professor Mohamed Aqiel Dalvie from the Department of Public Health and Family Medicine for sponsoring the fieldwork of my research.

Further I would like to thank my Professors for their continued input and support throughout 2014 and early 2015. My Supervisor, Professor M.A. Dalvie especially assisted me during the start of the literature review, to refine the study objectives and during protocol development as well as feedback throughout the process. I thank my Co-Supervisor, Professor Hanna-Andrea Rother for sharing my structured approach and all her input into the risk component of the literature review, questionnaire development and analysis and tabulation of open-ended questions. Her approach to my work was very encouraging and I value this support. Lastly, my other Co-Supervisor, Professor Leslie London who definitely deserves to be called the backbone of my thesis-writing process as his unfailing support and constructive feedback was noteworthy. Professor London helped to guide the analysis process, guided the tabulation in the results section of the manuscript and the oversight of my work in order to ensure that I formulate my arguments as a coherent whole. He was quick to respond to emails and his thorough approach is highly valued.

Further I want to thank Jordache Ramjith for extensive assistance with the use of Stata and one emergency Cappuccino.

PART A: Protocol



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List of Abbreviations

Beaufort West	BW
Benzene, Toluene, Ethyl-benzene and Xylene	BTEX
Central Karoo	CK
Confidence Interval	CI
Concerned Health Professionals of New York	CHPNY
Endocrine Disrupting Chemicals	EDC
Environmental Impact Assessments	EIA
Maximum Contamination Limit	MCL
New York	NY
Non-Government Organisation	NGO
Pennsylvania	PA
Petrol Agency of South Africa	Petro-SA
Prevalence Odds Ratio	POR
Reconstruction and Development Programme	RDP
South Africa	SA
Treasure the Karoo Action Group	TKAG
United Kingdom	UK
United States	US
University of Cape Town	UCT
Western Cape	WC
Volatile Organic Compounds	VOC

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1 Introduction

1.1 Background

1.1.1 Fracking –General

Conventional modes of energy production are failing to supply the global surge in the energy demand (Korfmacher, Jones, Malone, Vinci, et al. 2013). South Africa (SA), as the rest of the world has to look to alternative energy sources in order to satisfy energy needs (Shell exploration company, 2011). There is an estimated reduction of 30-60% in carbon emissions by retrieving natural gas, compared to energy produced by current means such as coal - and oil mining (Considine et al., 2009). With the widespread concern about global warming, carbon emission is becoming increasingly considered in ensuring sustainable power solutions (Considine et al., 2009).

Shale gas extraction (fracking), developed as a means of subsidising current energy sources mentioned above, was initially pioneered in the US in the 1940's (Korfmacher, Jones, Malone, Vinci, et al. 2013). Fracking is the process where natural gas, predominantly methane, confined in underground rock formations are released and retrieved as an energy source (Jackson et al., 2012; Miller and Robert, 2011; Swiss Centre for Applied Ecotoxicology et al., 2013). Fracking wells are drilled to a depth of one to three kilometres from the surface to reach the shale rock which embeds the gas (Swiss Centre for Applied Ecotoxicology et al., 2013). The rock formations have to be cracked to release gas, and this is done through injecting a combination of water, sand and chemicals into wells at pressures ranging between 345 and 1000 bar (Swiss Centre for Applied Ecotoxicology et al., 2013). This high pressured injections crack the shale rock formations, release the natural gas and

allow it to escape the shale and be captured at surface level (Fisk 2013; Korfmacher, Jones, Malone, Vinci, et al. 2013).

Experimentation with different types of gas extraction has resulted in the development of horizontal drilling, known as 'Unconventional Hydraulic Fracturing' in Texas in 1991 and has expanded internationally since (Considine et al., 2009; Miller and Robert, 2011). Horizontal drilling extends between 600 and 1200 metres from the drill shaft (Swiss Centre for Applied Ecotoxicology et al., 2013). Since 1996, fracking methods changed to using slick water fluid to drill for gases and crack layers of shale rock in order to release gases trapped in tight formations deep below the surface of the earth (Considine et al., 2009).

As demonstrated in Figure 1, drinking water aquifers are closer to the earth's surface than horizontal drill shafts (Swiss Centre for Applied Ecotoxicology et al., 2013) and numerous US studies related to fracking have found water in proximity to fracking activities to be contaminated with harmful chemicals (Collins, 1971; Hayes, 2012; Osborn et al., 2011). These chemicals include hydrocarbons (Collins, 1971; Osborn et al., 2011), benzene, radioactive materials, carcinogens banned from drinking water due to the health risks posed (Hayes, 2012) and methane reported to have been found in households' drinking water (Osborn et al., 2011).

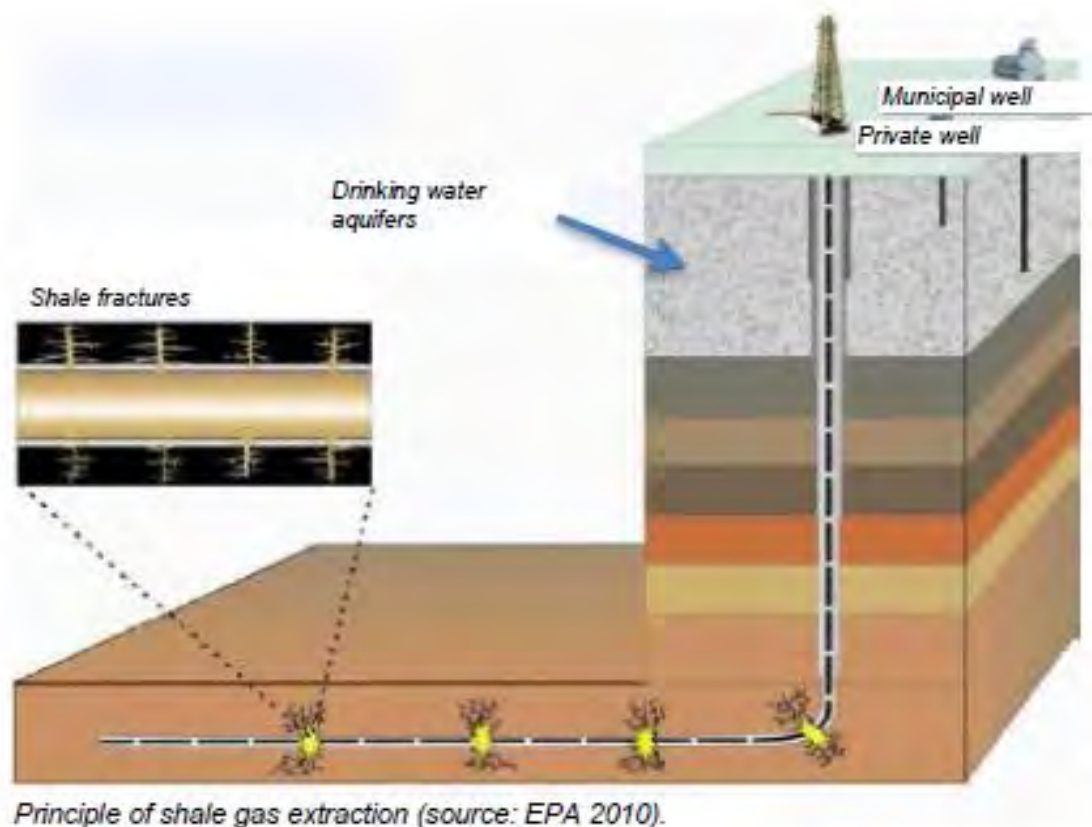


Figure 1: Principles of Shale gas extraction, Source (Swiss Centre for Applied Ecotoxicology et al., 2013).

To inhibit gas migration from the wells to the subsurface drinking water aquifers, wells are cased with steel and cement (Considine et al., 2009). In the literature there seems to be controversy over the efficacy of these barriers and the monitoring and regulatory efficacy of pollution prevention (Brown et al., 2014). This is emphasised by Bulgaria, France, Ireland, Tunisia, Luxembourg, Netherlands, Romania and Czech republic banning or placing moratoriums on fracking or any fracking related activities (Blaine, 2014; Unknown, 2014).

1.1.2 Fracking and South Africa

International fracking experts estimate that South Africa is situated on the fifth largest gas reservoir in the world (Jackson et al., 2012; Smith, 2013). Due to our growing economy, SA is more dependent on energy than other developing countries (South African Energy Department, 2013). Currently SA utilises predominantly coal and nuclear power and has a

large coal mining industry with 28% of all mined coal, exported (South African Energy Department, 2013). Energy generated through coal mining has high carbon emissions compared to other energy sources (Department of Energy, 2010). Due to greenhouse gasses and global warming, SA has ratified carbon credit targets and climate change policies thus pressurising government to find more environmentally friendly sustainable energy solutions (South African Energy Department, 2013). Furthermore, health risks associated with nuclear power substantiates the need to look for alternative energy sources (Jackson et al., 2012).

Due to alternative energy options being limited and costly (South African Energy Department, 2013), the renewable energy market specialising in solar and wind energy is fast expanding (Jackson et al., 2012), however still not satisfying the current need.

As fracking is a solution which some deem feasible, the SA government is in the negotiation process with gas companies who are avid to start drilling in the Karoo (Johnathan Deal, 2014). Grass roots information and perceptions from the population who are most at risk in SA are absent and would aid in steering risk communication. The latest government gazette related to mineral resources, published regulations related to fracking in October 2013 (Department of Mineral Resources, 2013) and provided one month for public input. The regulations include guidelines through the whole process from general provisions and site selection and preparation, to well suspension and abandonment when fracking has been completed and wells depleted of their gas reserves (Department of Mineral Resources, 2013). The amendments to the latest bill allow the government to buy up to 100% of the gas development from the oil companies (Johnathan Deal, 2014). Next, the bill will be voted on by the National Council of Provinces and following this, the president could choose to sign the bill off as the law (Johnathan Deal, 2014).

In 2011, the Petrol Agency of South Africa (Petro-SA) granted Shell, Bundu, Falcon and Sasol and later Anglo permits for gas exploration in the Karoo (du Toit, 2014; Ground Work, 2013; Jackson et al., 2012). Sasol has since retracted its application (Ground Work, 2013). Following this, the SA minister of mineral resources announced a two year moratorium on all fracking and fracking related activities in February 2011 to ensure that regulations governing fracking are scientifically based to ensure environmental sustainability of the gas extraction (Blaine, 2014). The moratorium was concluded in September 2012, however no fracking permitted until the regulations are updated (du Toit, 2014). At the 2014 State of the Nation Address in the South African parliament, president Jacob Zuma stated that the risks and benefits of fracking has been assessed and regulations will be announced and licences issued to oil companies in 2014 (Forde, 2014). The SA government has further announced that exploratory fracking may commence, after the release of the regulations prior to the national election on the 7th of May 2014 in order to accurately establish the amount of retrievable shale gas (Blaine, 2014). Exploration will be followed by Environmental Impact Assessments (EIA) to further evaluate the feasibility of fracking as a long term energy solution for South Africa (Janse van Vuuren, 2012). Commercial fracking may follow.

1.1.3 The Karoo

The Karoo stretches over four of the nine provinces in SA and comprises 40% of the total South African land mass (du Toit, 2014; Shell exploration company, 2011). The South African meat and wool industry relies heavily on Karoo produce for international export markets (du Toit, 2014). Arid Karoo ecosystems host an alternative biodiversity with half of all the plant species endemic to the Karoo (du Toit, 2014). Farming procedures rely heavily on ground water for survival (du Toit, 2014).

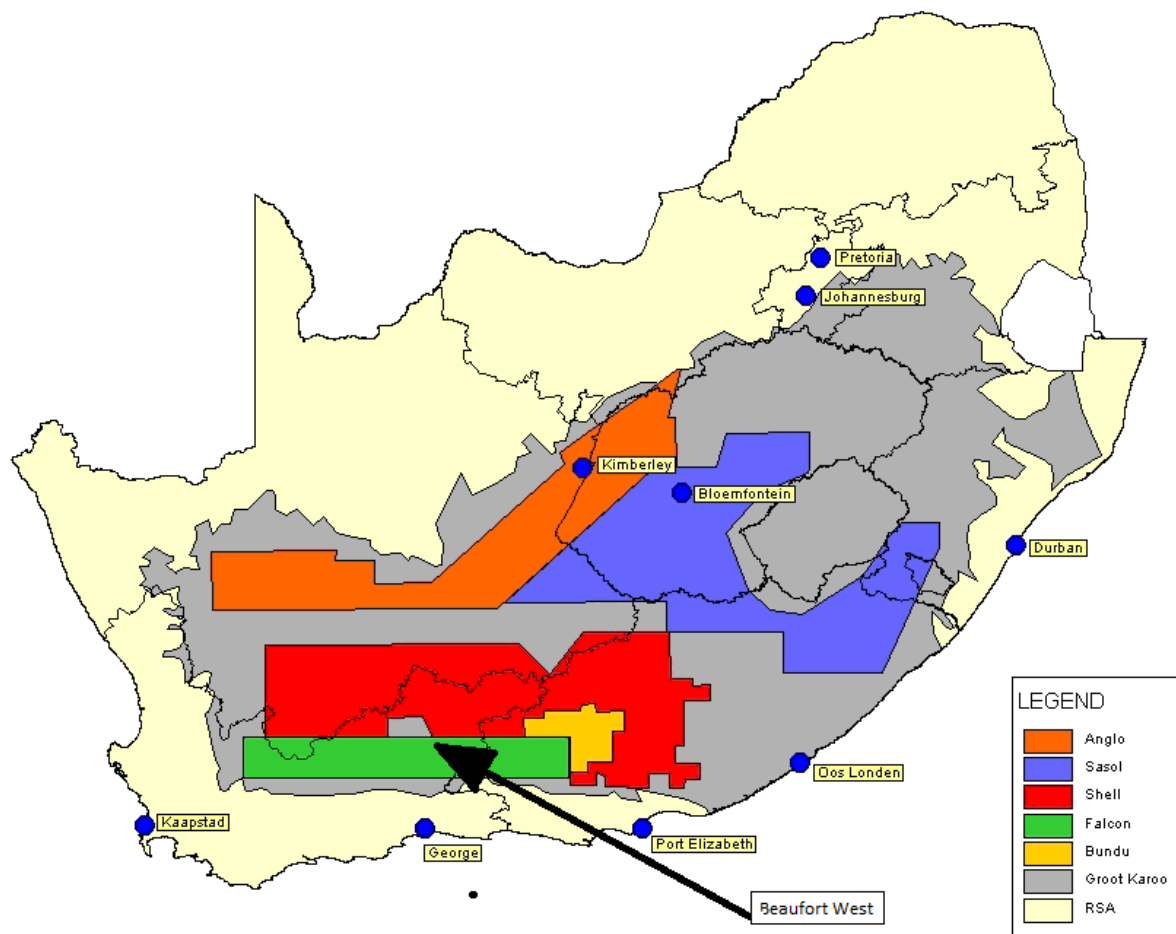


Figure 2: Areas where gas companies applied to drill for shale gas in the Karoo basin indicating Beaufort West in the Central Karoo, Source (Steyl and Van Tonder, 2013).

1.1.4 Fracking and Health

Internationally the safety and feasibility of fracking is controversial and parties in favour of and against fracking are strongly divided (Fisk, 2013). Common arguments in favour of fracking include the reduction of oil and gas prices, economic development and reductions in carbon emission (Shell exploration company, 2011) compared to traditional modes of energy generation such as coal mining (Jackson and Twine, 2012). Parties in opposition to fracking highlight the challenges of fracking regulation and monitoring and use evidence of water and air pollution as well as the adverse health impacts associated with these pollution

types to substantiate arguments (Davis et al. 1989; Adgate et al. 2014; Kovats et al. 2014; Mackie et al. 2013; Korfmacher, Jones, Malone, Vinci, et al. 2013; Fisk 2013).

Fracking has been found to have a variety of health impacts as a result of increased air and ground water pollution, increased psychosocial stressors as a result of drilling in the proximity of residential areas and farms, traffic and noise pollution as a result of rapid area development and the necessity to transport large water quantities needed during drilling procedures (de Rijke, 2013; Korfmacher et al., 2013a; Kovats et al., 2014). In the US, self-reported health consequences related to fracking encompass a range of conditions from psychosocial stressors to physical health symptoms such as headaches and nausea (Ferrar et al., 2013). Key studies related to fracking and the health implications thereof, follow:

1.1.4.1 Health Effects

Firstly, Bamberger (2012) investigated the emerging health impacts on humans and their livestock living in the proximity of fracking sites in six US states. Toxins found in human urine living in the proximity of fracking sites in those six states included phenol (metabolized benzene) and arsenic (Bamberger and Oswald, 2012). Study participants reported symptoms pertaining to the vascular system, respiratory tract, dermatological abnormalities, gastrointestinal problems, fatigue and headaches. One case of arsenic poisoning required hospitalization as a result (Bamberger and Oswald, 2012).

Secondly, Hill (2012) found that there are 25% more infants born with low birth weight due to maternal exposure to fracking compared to infants born of mothers who live far away from fracking activities.

1.1.4.2 Water Pollution

As evidence of water and air pollution as a result of fracking and the long term detrimental impacts thereof increases, scientists increasingly focus resources on studying these phenomena and their associated health impacts. A recent compendium compiled by Concerned Health Professionals of New York (CHPNY) summarized evidence from current published literature on fracking and surmised that ground water contamination occurs as a result of fracking in the proximity of fracking sites and threaten the safety of our drinking water (Concerned health professionals of New York, 2014; Vengosh et al., 2014) Increasing evidence support surface water pollution as a result of well leaks, accidents and well blow outs (Concerned health professionals of New York, 2014).

Literature further reveals that radium, a known carcinogen, was found in some of the frack waste water (Vengosh et al., 2014). In addition a study 100 water samples from private drinking water wells within a three kilometre radius of the Barnett Shale in the USA, found that Arsenic, Selenium, Strontium, and Barium were present in the samples at levels exceeding the Maximum Contamination Limit (MCL) suitable for drinking water (Fontenot et al., 2013). Methanol and Ethanol were present in 29% of these drinking water samples (Fontenot et al., 2013).

1.1.4.3 Air Pollution

The CHPNY reviewed air monitoring studies related to fracking and found that areas with high fracking activities are associated with poor ambient air quality and raised ozone levels (Concerned health professionals of New York, 2014). Some of the studies reviewed found raised rates of health problems associated with contaminated air, in fracking areas (Concerned health professionals of New York, 2014).

Preproduction	Production	Transmission, Storage and Distribution	Use	Well Production End-of-Life
Methane	Methane	Methane	Methane	Methane
BTEX	BTEX		CO ₂	
Non-Methane Volatile Organic Compounds	Non-Methane Volatile Organic Compounds		NO _x	
NO _x				
PM _{2.5}				
Hydrogen Sulfide				
Silica				

Figure 3: Potential emissions into the atmosphere during the life cycle of a fracking well, Source (Moore et al., 2014).

Another review of 20 years of literature relating to air emissions as a result of fracking found that higher quantities of methane are leaking than anticipated through reporting showed in Figure 3 (Moore et al., 2014). Air pollution measures are not based on standardised scientific tools and thus fugitive emissions from the industry could be dwarfed by truck traffic emissions and other forms of air pollution. Methane concentrations of 28.5 ppm has been found to leak from 3400 fracking pipelines in Boston, USA, compared to the global background of 1.8 ppm (Moore et al., 2014). Thus methane emissions in areas where fracking is done are higher than the global average of methane emissions which is concerning due to the environmental concerns surrounding high methane concentration in the ambient air.

1.1.4.4 Chemicals

Coffman (2009) used data sheets with drilling companies' documentation and found that 48 hazardous chemicals, of which some are known carcinogens, are used in the fracking process. Apart from cancer, other health effects associated with these fracking chemicals

include problems of the visual -, respiratory -, nervous -, neural - and hepatic systems (Coffman, 2009). Limited details pertaining to the types of chemicals are provided in this paper and the researchers did not extend their inquiry into the actual associated health effects as a result of fracking, but merely concentrated on the chemicals and their known health effects.

Furthermore, Colborn (2011) found that three quarters of chemicals used for fracking could be harmful to the hepatic, sensory, respiratory and gastrointestinal systems and half of the chemicals cause known adverse neurological and neural symptoms. Of the chemicals used in the fracking process which experts were able to identify, 47% were endocrine disrupting chemicals (The Endocrine Disruption Exchange, 2014). These endocrine disrupting chemicals (including oestrogenic and anti-androgenic chemicals) have been found in the fracking fluid, spill water and waste water as well as boreholes in areas surrounding fracking activities and are commonly known to lead to birth defects or infertility (The Endocrine Disruption Exchange, 2014).

In addition, Garrison (2011) identified three groups of volatile organic compounds harmful to human health, identified the way in which they are used and produced in the gas industry as well as the resultant adverse health effects to humans (Garrison et al., 2011). These include: ozone, hydrogen sulphide and BTEX (benzene, toluene, ethyl-benzene and xylene) (Garrison et al., 2011).

1.1.4.5 Regulation

Furthermore, Schmidt (2011) found that the lack of regulation and the enforcement thereof, are daunting experts who are trying to establish causal pathways between fracking, pollution and health (Schmidt, 2011). Despite one study mentioning that there are stringent

fracking regulations in the first world, there is agreement in the literature over how challenging it proved to be, to effectively regulate fracking (de Rijke, 2013). This lack of regulation, have resulted in oil companies discarding harmful chemicals and radioactive elements into water suitable for human consumption (Fisk, 2013). This results in water pollution causing population health problems (Fisk, 2013).

Similarly, another study states that weak international fracking regulations leave influential decision makers with a lack of evidence from which to inform costly long term decisions related to fracking, and the associated health effects (Penningroth et al., 2013).

1.1.4.6 Occupational Health

Added to the risk posed by fracking due to exposure to harmful chemical toxins and carcinogens, further health risks described by Adgate (2014) include a seven times higher rate of mortality in the workplace, when compared to other industries (Adgate et al., 2014; Concerned health professionals of New York, 2014). Other health risks associated with being a professional in the fracking industry include burns, toxic chemical exposure, head injuries, road traffic injuries, heat associated conditions and lack of sleep (Concerned health professionals of New York, 2014).

1.1.4.7 Summary

Notwithstanding the studies with documented chemicals and their effects described above, literature pertaining to fracking and the health risks thereof seems to be largely anecdotal. Long term prospective scientific evidence showing causal disease trends related to fracking do not exist. Researchers are challenged by the absence of pre-fracking water and air samples and the non-disclosure agreements which the oil industry seems to be using in order to pay their way out of challenging situations where constitution and human rights

are violated. These measures impede scientific inquiries and decreases the public awareness of the magnitude of the problem (Concerned health professionals of New York, 2014).

1.1.5 Community Attitudes and Fracking

Surveys assessing public opinion provide valuable insight into the perceptions of communities related to fracking (Boudet et al., 2013; Brasier et al., 2013). The USA national surveys show that the majority of individuals are aware of fracking and the economic and secondary benefits thereof (Boudet et al., 2013). Boudet's study further provides evidence related to the public's perception on fracking; it assessed familiarity and support levels towards fracking and found that older-aged university graduates with conservative political views favour fracking due to its perceived economic growth potential. Females who reported informing themselves on news and current affairs, demonstrated more resistance to fracking than males due to the common association between fracking, pollution and other harmful environmental impacts (Boudet et al., 2013). Due to the lack of public understanding and to enhance community involvement and improve fracking safety monitoring, a community based risk assessment tool was used in New York, in combination with voluntary localised water sampling to provide communities access to water data (Penningroth et al., 2013). Findings of this study suggested that baseline water samples taken by citizens are deemed effective information for assessing later contamination and thus protecting water resources in New York state (Penningroth et al., 2013). Taking these measurements empowered locals to contribute to sustainable water management and aided in informing their perceptions and opinions related to fracking through their self-collected evidence (Penningroth et al., 2013).

Another scientist, studied how the perceptions of the community from rural New York state towards fracking and the infrastructure and other changes it imposes on an area, steers social action of that particular community (Simonelli, 2014). In this study it was found that the first drive towards change happens through orderly collaboration of individuals in the

community (Simonelli, 2014). In rural New York, this structured approach was followed by civil disobedience during the time of their moratorium on fracking (Simonelli, 2014).

1.1.6 Risk Perception and Fracking

Slovic, 1987 describes risk perception as originating in order to understand behaviour of individuals related to environmental - and technological hazards (Slovic, 1987). Risk perceptions stem from a multitude of factors including socio-cultural variables, familiarity with the risk and level of knowledge, personal relationships, power relations and the catastrophic potential of the risk (Slovic, 1987). The literature further suggests that preformed opinions about risk is not necessarily changed with the evolution of new, reliable evidence, but on the other hand, un-opinionated individuals can effortlessly be swayed in either direction (Slovic, 1987). Lay persons' perception of risk is sometimes deemed richer than experts' opinions and thus a combination approach of castes in society and their risk perception is crucial (Slovic, 1987).

New technologies and their risks are increasingly studied by social scientists. These could be favourable for the population or specified individuals, however also harm or burden others (Brasier et al., 2013). Fracking, with its benefits and risks is an example of such a technology and experts argues in favour of and against it. Similarly to Slovic's descriptions, British research has shown that the structured way in which oil companies and environmental organisations advocate for or against fracking influences public opinion and whether individuals deem fracking to pose a high risk or be beneficial (Jones et al., 2013). Anecdotal studies related to risk perception and fracking in the USA found that individuals with poor health lacked trust in regulatory authorities compared to those with good health (Adgate et al., 2014; Ferrar et al., 2013).

In 2013, Brasier conducted research about risk perception related to fracking in the USA. This research gave voice to the individuals in the study and some parallels can be drawn between the proposed research in this protocol and Brasier's work. Brasier concluded that technological risk perceptions can be categorized into three: firstly institutional trust, secondly perceived knowledge related to the activity and the effects thereof and lastly the unique environmental or demographic variables (Brasier et al., 2013). Other studies related to risk and general perception towards fracking have incorporated some but not all of these categories (Korfmacher, Jones, Malone, Vinci, et al. 2013; Boudet et al. 2013).

Technological risk perception relating to topics such as fracking, can be defined as technologies which could be favourable for the population, however also harm or burden groups or individuals in the population (Brasier et al., 2013). Social scientist increasingly study technological risk perceptions of technologies such as fracking (Brasier et al., 2013).

Further risk analysis literature found an inverse relationship between the perceived risk and the perceived advantages of a technological activity such as fracking (Slovic et al., 2004).

In South Africa the evidence available on public perception and risk is limited to risk perception studies related to farming and pesticides (Rother, 2000). One such study, conducted among individuals working in the cotton industry in northern Kwazulu-Natal related to women and children's exposure to pesticides and the associated risks (Rother, 2000). This particular study found that the opinions of the individuals in the study, related to the known health hazards associated with pesticides are invalid (Rother, 2000).

Further an unpublished qualitative study from the mining industry (Muntingh, 2011) also relates to risk perception. The risk perception mining investigation described South Africa as

having a dramatic mineral history with recurring conflict between mining advocates, environmentalist and local or rural communities (Muntingh, 2011). This study found that the community of the western part of North West Province had a positive perception towards mining (Muntingh, 2011). No published literature supports Muntingh's Master's Thesis on the perceptions of farming communities towards proposed mining developments in South Africa or their knowledge and perceptions related to the health impacts thereof.

1.2 Research Justification and Rationale

Internationally fracking has caused much controversy and debate among economists in the oil- and gas- industries favouring gas extraction, (de Rijke, 2013) in opposition to environmentalist and public health specialists, concerned about the pollution and the resultant adverse health impacts associated with fracking-pollution (Korfmacher, Jones, Malone, Vinci, et al. 2013). Fracking has been banned in France and states in the US and moratoriums on the process of fracking and exploration have been called for elsewhere (de Rijke, 2013; Miller and Robert, 2011). Despite these international debacles, South Africa is about to embark on an exploratory phase of fracking in the Karoo (Janse van Vuuren, 2012).

Quantitative studies conducted in the USA have explored the risk perceptions related to fracking by means of national surveys and found that the general public lack information related to fracking (Boudet et al., 2013; Brasier et al., 2013).

South Africa is currently in the process of introducing fracking, (Janse van Vuuren, 2012) despite scientific evidence highlighting the risk of water and air pollution as a result of fracking. (Adgate et al., 2014; Kovats et al., 2014; McKenzie et al., 2012) In current South African media, parties in favour of and in opposition to fracking are forcefully advocating for their causes (Bryer, 2014; Cropley, 2013; Donnelly, 2013; SAPA, 2013) and controversy

relating to government's personal gain in this venture is debated. Jolynn Minnaar, Karoo resident and film maker, has started exploring the public's perception related to fracking through informal interviews in her documentary, *Unearthed*, released in 2014 in South Africa (Minnaar, 2014). Shell, Bundu and Falcon lobbying for exploration licences in various parts of South Africa (du Toit, 2014) have investigated and interviewed farm dwellers in the Karoo in order to better understand their attitude towards fracking, their willingness to allow drilling on their farms and to relay social and economic feasibility of fracking to the people of the Karoo (Jackson and Twine, 2012; Shell exploration company, 2011). South African literature related to public risk perception excludes the topic, fracking.

No studies related to public's perception of risk and health impacts related to fracking in SA have been conducted to date. The justification for carrying out this research is to investigate the public perception of the risks of hydraulic fracturing and the perceived health impacts thereof as well as informing the researcher of the factors associated with certain risk perceptions in the Karoo, SA.

To date there are no local scientific studies providing the public with a voice in national fracking discussions.

1.3 Problem Statement

Fracking or the extraction of natural gas from shale rock has been prevalent in the US since the 1940's and has expanded significantly in the international realm since then (Korfmacher, Jones, Malone, Vinci, et al. 2013). Fracking is considered a good alternative energy source to the fossil fuel industry (Penning et al., 2014). Oil and gas companies argue that fracking has a low carbon footprint, compared to other known forms of energy extraction such as coal mining (Considine et al., 2009). In the United States, fracking has proliferated rapidly, raising major questions about environmental pollution and the long term associated health effects (Penning et al., 2014). This has elicited strong public opinion for and against fracking.

Similarly to the rest of the developing world, SA is considering fracking as an alternative energy source to supply the growing energy demand (Shell exploration company, 2011). SA is in the final decision making stages in formulating the regulatory laws related to Shale gas exploration and extraction (Forde, 2014). During the presidential address by President Jacob Zuma in February 2014, the president announced fracking as a “game changer”, a commonly used phrase by oil and gas industry (News 24, 2014). During his address the president stated that regulations pertaining to fracking would have been published by May 2014 (News 24, 2014). To date only draft regulations have been published.

In SA, environmental NGO's (such as Treasure the Karoo Action Group (TKAG) and AfriForum) are advocating against fracking and lobbying to see effective regulatory policies in place prior to exploration commencing (South African Press Association, 2014), however public consensus and public voice in the matter is limited.

This research is needed to establish the health risk perception of individuals living in the Karoo related to fracking, explore their information sources the trust therein as well as in

the government. Providing these individuals with public voice will aid in allowing environmental justice to these individuals as their 'home' and lives will be affected by the potential fracking exploration despite their perception related to the matter.

1.4 Research Questions

- i. What is the Karoo public's perception of hydraulic fracturing and what perceived health risks do fracking pose to the people living in the Karoo if any?
- ii. Where do Karoo citizens get information related to fracking?
- iii. Do the people of the Karoo trust their information sources?
- iv. Do the people of the Karoo trust the government related to fracking?
- v. Is there a relationship between health risk perception related to fracking in the Karoo and variables such as gender, age, level of education, demographic environment and socio-economic status?
- vi. Is there a relationship between health risk perception related to fracking in the Karoo and information sources and trust in government?

1.5 Research Objectives

The aim of the proposed study is to examine the public's health risk perceptions related to hydraulic fracturing in the Karoo, South Africa as well as the factors shaping these risk perceptions among inhabitants in the Karoo basin.

1.5.1 Subsidiary Objectives

- i. To describe the population profile of Karoo residents in terms of location, demography and socio-economic status.
- ii. To ascertain the perception of Karoo residents related to fracking.
- iii. To ascertain the health risks Karoo residents perceive as associated with fracking.
- iv. To characterise how risky Karoo residents perceive fracking to be from a health point of view.
- v. To determine the variables which influences Karoo residents' health risk perception related to fracking
- vi. To establish what the people of the Karoo deem as their main information sources related to fracking
- vii. To establish whether the people of the Karoo trust their information sources
- viii. To establish whether the people of the Karoo trust the government in relation to fracking

2 Methods

2.1 Study Design

A descriptive study investigating the health risk perception related to the intended fracking in the Central Karoo of a representative sample of individuals residing in Beaufort West municipality will be conducted. Please refer to Figure 2 for map indicating Beaufort West. Data will be gathered by means of household surveys in the formal town area, Reconstruction and Development Programme (RDP) housing as well as farms randomly selected from the Beaufort West municipal area. As the Karoo stretches over four provinces in South Africa and comprises approximately a third of the South African land mass, it is not feasible in terms of time, cost and the project scale to draw a sample representative of the entire Karoo for this study. Beaufort West municipality was selected as this municipal area is large enough to stratify in terms of household types and still draw a sample representing the Central Karoo (Karoo situated in the Western Cape). Furthermore the distance to travel from the University of Cape Town (UCT) to the Central Karoo being the shortest compared to other Karoo provinces where fracking exploration is proposed, makes this area, the most feasible on a limited budget.

2.2 Study Setting

The Karoo situated in a semi-desert, is renowned for hosting the largest number of succulent species in the world (Department Provincial and Local government of South Africa, 2005). Due to the scarce water sources, agricultural opportunities are limited in the Karoo, thus prohibiting large scale development and economic growth (Department Provincial and Local government of South Africa, 2005).

The Central Karoo forms part of the greater Karoo, is situated in the Western Cape Province, is a central district municipality, encompassing three local municipalities namely: Beaufort West, Prince Albert and Laingsburg (Department Provincial and Local government of South Africa, 2005). This arid, fossil rich region is sparsely populated with a density of 1.6 people per square kilometre (Department Provincial and Local government of South Africa, 2005). The population of the Central Karoo is approximately 80% urban and 20% rural (Department Provincial and Local government of South Africa, 2005). Beaufort West municipality is deemed the most feasible area for conducting this study due to its size compared to the other two smaller municipalities. The population size of the Beaufort West municipality is estimated at 37 107 (Department Provincial and Local government of South Africa, 2005). The town Beaufort West town is the economic centre of the Central Karoo due to the amalgamation of the N1 (national road connecting Cape Town and Johannesburg) and the N12 (Department Provincial and Local government of South Africa, 2005).

The predominant language in the Central Karoo is Afrikaans (89.3%) (Department Provincial and Local government of South Africa, 2005). The Central Karoo is an impoverished area with only 35.2% of the population employed in 2004 (Department Provincial and Local government of South Africa, 2005). Sheep farming is the leading economy in the Central Karoo and other forms of agriculture are restricted by the lack of water in the area, as well as the soil's inability to retain water (Department Provincial and Local government of South Africa, 2005). Other economic opportunities in the Central Karoo include tanning leather, tourism and large scale herb growing projects (Department Provincial and Local government of South Africa, 2005).

2.3 Population and Sampling

2.3.1 Population

Adults equal to or exceeding the age of 18 years living in the Beaufort West municipality in the Central Karoo (Western Cape), will be eligible for inclusion in this study. Individuals who are unable to speak Afrikaans or English will be excluded from this study. As 89% of the people living in the Central Karoo speak Afrikaans, this exclusion criterion is not anticipated to subject the study to selection bias.

2.3.2 Sampling Method

On the basis that similar studies have been conducted in the US using household survey data to inquire about risk perception related to fracking (Boudet et al., 2013; Brasier et al., 2013), this research will be conducted by means of cross sectional household surveys. Individuals from a representative randomly selected sample of households will be surveyed. A multi-tiered stratified random sampling strategy as described in the Epidemiology Research Manual for South Africa, will be used (Joubert and Ehrlich, 2007).

The study area, namely Beaufort West municipality, will be stratified into three categories according to types of housing. Firstly the town area with formal housing, secondly the less formal settlement with predominantly RDP-housing and some informal and thirdly farm dwellers (owners and labourers) recruited by visiting selected farms in the area.

2.3.2.1 Recruitment Procedures

Due to this study being conducted by means of a household survey, individuals from randomly selected households will be approached, and invited to participate in the study on the day that fieldwork will be conducted for the town areas and prior to the fieldwork period for the farms as explained in Section 2.3.2.3 and 2.3.2.4. Where participants refuse to consent or do not wish to participate, the same procedures will be followed as when

finding a vacant house, as described in Section 2.3.2.3 until the required sample size was interviewed. The researcher and trained fieldworker, responsible for conducting the interviews, are bilingual (Afrikaans and English) and therefore will be able to elicit the necessary information to thoroughly complete the survey in either of the mentioned languages. Where participants are unable to speak Afrikaans or English, they will be thanked for their time and it will be explained that they are not eligible to participate and the researcher will proceed to the house adjacent, to the right and follow procedures as described in Section 2.3.2.3, under the Sampling Method.

The primary researcher or trained fieldworker will explain the participation requirements to each participant. Participants will be informed that they have the right to withdraw at any given time during the study, without penalties or consequences. Those participants wishing to proceed will be required to sign informed consent in order to partake in the study. A pen cross next to their name, thumb print or the signature of a literate witness will be accepted for non-literate participants, permitted they are able to communicate in Afrikaans or English and have verbally agreed to partake.

2.3.2.2 Sample Size

The formula used for calculating the sample is: $n = \frac{p(1-p)z^2}{d^2}$

Where: n = Sample size

p = Anticipated population proportion, 50% is used as there is a lack of context specific evidence

d = Desired precision (10%) due to budget constraints $\alpha = (0.1)$

z = value corresponding with a 95% confidence interval = 1.96

Therefore: $n = \frac{0.5(1-0.5)(1.96)^2}{(0.1)^2} = \frac{0.9604}{0.01} = 96.4 = 97$ participants

The number of individuals in each stratum will be based on the number of households per strata in the population, to ensure that the sample is representative of the area. Beaufort West municipality has a total number of 130 89 houses.

Formal residential is 10923 (83.45%) and farms tally to 2082 (15.9%). According to the formal classification by Stats SA, there is no informal housing in the Beaufort West Municipality. Thus formal housing will be further stratified into non-RDP and RDP-housing.

Beaufort West old town has 5309 formal houses (non-RDP) and the sum total of the various RDP-areas (Kwa-Madlenkosi - 1491, New Town - 173 and Rustdene - 1884), totals to 3548 RDP-houses.

Thus for the sample of 97 individuals, rounded to 100 individuals to be representative of the types of households in the Beaufort West municipality, 84 candidates must be surveyed living in formal residential areas and 16 farm dwellers. Formal residential must contain 40% RDP and 60% non-RDP households, thus amounting to 34 and 50 households respectively.

2.3.2.3 Sampling of Town- And RDP-Housing

Multi-level cluster sampling will be used to sample households within the three strata. The sample size and the number of household per strata are described in section 2.3.2.2, namely Sample Size. In order to select street blocks in the town areas, the aid of municipal aerial maps in combination with consultation of the local police station will be used. The town will be divided into suburbs. All suburbs will be numbered and duplicates thereof placed in a hat. Six numbers will be drawn from the hat for the formal and four for the RDP-area signifying the areas that households will be selected from in the respective strata. Within the selected neighbourhoods, systematic sampling will be used to select the participating households. This means that after the selection of a random starting point, every third house will be contacted to find someone eligible to conduct the survey with, until a suitable number of participants from each area have completed the survey. In such a case where the house is found vacant, the house on the right hand side (when facing the front of the house), adjacent to the actual identified house will be tried, until a suitable household is found where the survey can be completed. In the case where there is no house on the right of the selected house, the house opposite the selected house will be tried and where there is none available, the house to the left of the original house will be attempted.

In households where there is only one eligible participant to be questioned, that person will be invited to participate in the study. In the case where there is more than one candidate meeting the inclusion criteria at the selected household, the family can indicate their preferred individual to answer the survey questions. The survey will be conducted only if the appointed person consents to participate. Where someone refuses consent, the next eligible person in the same household will be invited to participate. This will continue until someone suitable is recruited. In such case where nobody in the household consents to

participate, the same procedure will be followed as when nobody was found to be present in the home, i.e. proceed to the house on the right.

2.3.2.4 Sampling of Farms

For the farm strata sixteen farm dwellers must be selected. One member of the owning household (or farm management in such case where the farm manager lives on the farm and the owners are located elsewhere) as well as one member of the farm work force living on the same farm will be included in the study. This method is done to include both the perspectives of the land owners and the labourers of farms. Eight farms will need to be visited as explained in Section 2.3.2.2, Sample Size. For feasibility reasons and due to large distances between farms (60-70 km on average) farms will be sampled in combination with the assistance of Mr Gous, principle of the Central Karoo District Agricultural Union. Mr Gous has provided a list of farms broken down into municipal areas, containing farmers contact details. In total the Central Karoo surrounding Beaufort West comprises of six areas. The farm closest to and third closest to Beaufort West town will be contacted via e-mail to establish their willingness to participate as well as fix an appointment time to prevent unnecessary driving. An appointment will only be made with the first eight farmers who consent to participate.

2.4 Measurement

2.4.1 Instruments - Questionnaire

A survey, designed for the purposes of this research in English, adapted from Kathryn Brasier and Katrina Korfmacher's work related to risk perception and fracking in the USA will be used to adapt survey instrument from. Further risk perception surveys, not restricted to fracking, were also taken into consideration (McKenzie et al., 2012; Rother, 2000; Shepherd et al., 2012; Stinson et al., 2008). Questions from these surveys answering the study

objectives of this study were incorporated and adapted to the South African context for the purposes of this research.

Due to the data being collected in a predominantly Afrikaans community as mentioned previously, the survey will be professionally translated into Afrikaans in order to conduct interviews in the first language of participants. The Afrikaans version will be back translated to English and correlated with the original version to ensure that the meaning of the Afrikaans and English versions, match. A pilot study will determine the accuracy and acceptability of the questions and allow for the necessary changes to be made to the tool, prior to the actual data collection. Due to budget constraints the pilot will not be conducted in the actual study field; however participants representing the research sample will be surveyed for the pilot. The primary researcher and a trained field worker will be conducting all surveys. Data will be analysed by the primary researcher using Stata version 12.1 (2011).

Surveys will be conducted in the participants' preferred language between Afrikaans and English (Appendix B).

The questionnaire originated with seven subsections which corresponded with the study objectives and was then reworked into a more comprehensive shorter document for practicality and efficiency. Questions include demographic and geographic characteristics of the participants. Education, financial and household information is also asked in the initial part of the survey. Further knowledge related to fracking is queried as well as the perception of the health and general benefits and risks thereof. Information sources related to fracking are explored. The last section of the survey questions participants' trust in institutions and agencies such as trust in government related to fracking decisions.

A combination approach of Google Forms and hard copies of the survey will be used, dependant on the safety in the area as well as the access to the internet in the field. The survey was initially compiled as a Microsoft Word document and redone as a google form. The online and printed forms are identical. The primary researcher is the only person with access to the google drive where forms are stored and data compiled.

2.4.2 List and Definition of Variables

Table 1: Dummy table of independent variables and measurement.

VARIABLE	SURVEY QUESTION	CODE OPTIONS
1. SECTION 1: FRACKING KNOWLEDGE		
Knowledge of fracking	Do you know what fracking is? Is fracking exploration proposed in Beaufort West municipality?	Binary Variable Nominal Variable
2. SECTION 2: GENERAL AND DEMOGRAPHIC INFORMATION		
Age bands	In what year were you born?	Open ended, will be categorized as Ordinal Categorical variable
Gender	The gender of the participant is:	Binary variable
Education	What is the highest level of education you have successfully completed?	Open ended Will be analysed as Ordinal variable
Employment	What describes your current work situation best? What work do you do?	Nominal Variable Open ended
Duration lived in Karoo	How many years have you lived in the Karoo?	Open ended Will be analysed as Ordinal variable
Karoo property owner	Do you or your direct family own this house or another in the Karoo?	Nominal Variable
Household income	What was the monthly income of your household last year (before tax)?	Ordinal Variable
Housing type	The type of housing	Nominal Variable
3. SECTION 3: PERCEPTION TOWARDS FRACKING – GENERAL		
Perception of fracking	I would work in the fracking industry (for an oil company) in the Karoo if the opportunity presents itself. If I could choose, I would not allow fracking in the Karoo. Fracking will boost tourism in the Karoo Fracking will be beneficial to the people of the Karoo. Probe: If agreed, why do you think fracking will be beneficial or if you disagreed why?	Ordinal Variable Open ended
Sources of Information	What information sources do you base these answers on?	Nominal Variables Open ended Nominal Variables
4. SECTION 4: PERCEIVED HEALTH RISK OF FRACKING		
Health risk	From a health perspective, how much risk do you think fracking holds?	Ordinal Variable
Health perception	Fracking will make people living in the	Ordinal Variable

Sources of Information	<p>Karoo sick.</p> <p>Do you agree that fracking can potentially harm the health of unborn children from mothers living in fracking areas?</p> <p>Do you agree that fracking can be to harmful to your own health?</p> <p>If you are of opinion that fracking can cause disease, why did you say fracking can make people sick?</p> <p>What type diseases do you anticipate in the short term?</p> <p>What type diseases do you anticipate in the short term?</p> <p>Where did you get this information from?</p> <p>Did you see it on TV, hear at the hospital etc.?</p>	<p>Open ended</p> <p>Nominal Variable</p> <p>Open ended</p> <p>Nominal Variable</p> <p>Open ended</p> <p>Nominal Variable</p> <p>Open ended</p> <p>Nominal Variables</p>
5. SECTION 5: TRUST IN INSTITUTIONS AND AGENCIES		
Trust in Information sources	How much trust do you have in the accuracy of your information about to fracking?	Ordinal variable
Trust in fracking companies	How much trust do you have in fracking companies who applied for fracking licences in the Karoo?	Ordinal variable
Trust in scientist	How much trust do you have in what the scientists say with respect to fracking?	Ordinal Variable
6. SECTION 6: TRUST IN GOVERNMENT DECISIONS		
Trust in government	<p>I trust the national government?</p> <p>The government will not be effective in regulating the fracking industry.</p> <p>Why did you agree or disagree?</p>	<p>Ordinal Variable</p> <p>Ordinal Variable</p> <p>Open ended</p> <p>Nominal variables</p>

2.4.3 Validity and Reliability of Measurement Instruments

This study will not be subject to inter observer bias due to the standardized outcome options provided by the questionnaire (predominantly closed ended questions). The primary researcher will train the fieldworker on the informed consent, random participant selection and survey conduction. Proposal writing, planning as well as frequent correspondence with the study supervisors during data collection will ensure timeous identification of errors in the research process.

2.5 Pilot Study

Due to the survey not being pre-standardized or externally validated, it will be piloted on 5% of the study sample prior to actual data collection. Pilot participants will be matched as closely as possible to the study sample stratum in order to ensure that the pilot represents the actual sample. Questionnaire revision will be based on feedback from the pilot surveys. The pilot will be conducted in the Boland area where there is a variety of households matching the study sample households.

3 Analysis Plan

Stata version 12.1 (2011) in combination with Google Drive and Microsoft Excel will be used to clean, analyse and present the data.

Descriptive statistics of the knowledge and perceptions of the people of the Central Karoo related to fracking, as well as their sources of information and trust in government and other institutions will be done.

Furthermore a variety of associations will be explored from the data. Shapiro-Wilk test will indicate whether the data are normally distributed or non-normally distributed. In the latter case the data will be transformed to ensure normality and where not possible, non-parametric means of analysis will be used. Where data are normally distributed, chi-square test or Mc-Nemar's test will be applied to establish the association between variables.

The following associations will be explored:

- Gender and knowledge of fracking
- Income level and trust in government
- Level of education and health risk perception of fracking
- Number of years resident in the Central Karoo and the health risk perception of fracking
- Type of housing (of the three stratifications) and the health risk perception of fracking
- Owning property in the Central Karoo and health risk perception related to fracking

4 Ethics

The study protocol and all appendices will undergo approval as stipulated in the University of Cape Town's (UCT) research guidelines by the UCT Research Ethics Committee. To maintain confidentiality, only researchers involved in the study will have access to data. Surveys will have unique participant identifiers. No personal particulars will be collected during this study that could reveal the participant's identity. Furthermore the researcher will publish or report on group level results and not exempt individual participants. From a choice of Afrikaans or English, surveys will be conducted in the participants' favoured language. See appendix B.

4.1 Autonomy

Due to the involvement of human subjects in the inquiry, this research will be conducted according to the 64th revision of the Declaration of Helsinki. (World Medical Association, 2013). Individuals participating in this study will remain anonymous through the use of unique personal identifiers instead of identification details.

4.1.1 Informed Consent:

Field workers conducting the surveys will be trained to obtain written informed consent from each participant and where participants are unable to sign, a thumb print will be accepted (Appendix A). The informed consent process will include discussing the purpose of the research, the potential benefits and known participation risks, to all individuals in their choice of Afrikaans or English.

Furthermore, it will be explained that participation is voluntary, declining will have no censure and that consent can be withdrawn at any stage during the study with no

repercussions. Study participants will be able to ask the principle investigator for more extensive study details should it be of interest. Confidentiality will be maintained throughout the study and dissemination will occur on group level and not pertain to individual survey answers. The researcher and her three supervisors will be the only individuals enjoying access to the raw data.

4.2 Benefit

4.2.1 Social Value

Direct benefits to participants include broadening uninformed participants' knowledge by introduction to the concept of fracking, a potential future reality in the Karoo. No financial incentives will be awarded to individuals participating in this research. To acknowledge the time participants took to participate in the study, an informative leaflet will be provided about fracking to increase their knowledge of fracking, benefits and risks thereof (Appendix C). The participants will be provided with the opportunity to participate and thus contribute to building knowledge with prospective value of which they themselves as well as the larger Beaufort West municipality will be beneficiaries. This study will provide individuals voice to raise their opinions and concerns and contribute to a scientific perspective.

4.2.2 Collaborative Partnerships

This research will enable individuals living in the Beaufort West municipality to develop partnerships with the researcher. Partnerships will enable access to valuable information through the academic institution that the researcher is affiliated with. The researcher and trained field worker will ensure that the cultures and traditions and values of the community is respected by researching the community in advance and being cognisant of subtleties during interview and consent processes. If possible, a community member will be recruited to introduce potential of being surveyed to the community.

Larger scale benefits include that the study will provide a forum for participants to provide feedback or the opportunity to have public voice in national fracking debate.

This could influence policy processes and thus have significant long term benefits for the community as their collaborative voice could help regulate or ban shale gas development, in their area.

4.2.3 Respect for Recruited Participants and Community

Research results will be made available to the participants or the wider community through their local municipality.

4.3 Harm

The proposed study is considered to have a low risk to participants. The participants' opportunity cost of taking time to answer the survey could be considered most detrimental, however it holds no direct risk to individuals as each participant has the right to withdraw at any stage should they so wish.

4.4 Justice

Due to the various applications for exploratory fracking licences in the Karoo, this particular site was selected as participants in the study will be directly affected by the proposed developments. Study findings will be published in a peer review journal, available in UCT's Health Science Library at the medical faculty and provided to the Beaufort West municipality for participants to access the information directly if required.

4.4.1 Fair Selection of Study Population

Beaufort West municipality was selected for feasibility and practicality reasons as there are many sites in South Africa where fracking exploration is proposed. Within this municipality, a sample representing the municipality (or community) was chosen randomly to ensure that a fair selection of individuals is attained. In order to enhance public voice, the sample was stratified to give voice to castes of the community (for e.g. the farm workers) who might lack opportunities and access to amenities that others are commonly exposed to.

4.4.2 Scientific Validity

The scientific design of this research is in alignment with the research objectives. In lieu of the current controversy in South Africa related to permitting fracking and the regulation thereof, this research is certainly feasible in the current political, social, and health contexts. This research will add social value by giving 'voice' to the study participants.

5 Logistics

This research will be completed in 10 months during 2014. The Gantt chart with intermediate goals and the time line for this study are displayed below in Table 2.

5.1 Time Table

Table 2: Time schedule for dissertation on Health Risk Perception related to fracking.

TASKS	Month in 2014									
	3	4	5	6	7	8	9	10	11	
Protocol development										
Protocol approved by UCT Ethics Committee and Public Health faculty										
Thesis Literature review										
Data Collection										
Data analysis and cleaning										
Write up and tidy findings and compose thesis into a coherent document										
Write Journal article										
Submit thesis										

5.2 Budget

This budget (Table 3) for the data collection phase of this research, expressed in South African Rand and amounts to a total of R 23 714.

Table 3: Break down of budget for Karoo field trip for MPH fracking study.

ITEM	Number of units	Cost per unit	Total	Comment
Personnel *				
Principal investigator	23	-	-	MPH Student
Fieldworker	7	R 500	R 3500	7 days of field work assistance needed @ R500 per day
Total personnel	7 (+23)	R 500	R 3500	
Equipment †				
Information sheets and consent forms	105	4	R 420	Printing 105 consent forms (4 pages per document)
Survey: Risk perception related to fracking	105	12	R 1260	Printing 105 surveys (12 pages per document)
Total equipment	105	4	R 1680	
Other				
Translation services	2	R 500	R 1000	UCT School of African Languages and Literature (tutor rate)
Total other	2	R 500	R 1000	
Accommodation				
Accommodation	30	R 300	R 9000	R 300 day x 30 days
Total accommodation	30	R 300	R 9000	
Travel				
Transport Cape Town Beaufort return	930 km	R 3.27	R 3041	AA rates Opel Corsa Light
Transport in and around Beaufort West	560 km	R 3.27	R 1831	40 km per day x 14 days
Transport to farms	1120 km	R 3.27	R 3662	70 km from one farm to the next x 16 farms
Total travel			R 8534	
Dissemination				
Publication fees				
Community meeting				Rental, materials, refreshments
Total dissemination				
TOTAL			R23714	

6 Protocol Sources

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PART B: Literature Review



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1 Introduction

1.1 Background

South Africa (SA), similar to other developing countries, is considering fracking as an alternative energy source to supply the growing energy demand (De Wit, 2011). Yet in countries like the US with proliferation of the fracking industry, there is strong public divide regarding fracking as it raises questions about environmental pollution and potential health risks (Penning et al. 2014).

Conventional extraction of natural gas from shale rock from vertical gas wells, has been prevalent in the (United States) US since the 1940's and has expanded significantly in the international realm since then (Korfmacher et al., 2013). Due to the more recent decline of the conventional natural gas supply and the growing global energy demand, the oil and gas industry has turned their resources to unconventional natural gas extraction in 2005 through refining horizontal hydro fracking (Canadian society for unconventional gas, 2014). This unconventional process of gas extraction is known to be highly specialized and incur greater costs than conventional drilling (Canadian society for unconventional gas, 2014) but also has a higher profit margin. Some believes fracking to be a better alternative energy source to other fossil fuels such as coal because of lower carbon emissions (Penning et al., 2014) however this is disputed depending on how you estimate the life cycle of a fracking well (Sovacool, 2014).

SA is in the final decision making stages in formulating the regulatory laws related to Shale gas exploration and extraction (Forde, 2014). During the presidential address by President

Jacob Zuma in February 2014, the president announced fracking as a “game changer”, a commonly used phrase by oil and gas companies (News 24, 2014) suggesting a high level of support for fracking exploration. According to the local media, it was anticipated that regulations pertaining to fracking would have been published by May 2014 prior to the national elections (News 24, 2014). To date only draft regulations have been published.

In SA, environmental Non-Government Organisations (NGOs) are advocating against fracking and lobbying to see effective regulatory policies in place prior to exploration commencing (South African Press Association, 2014), however public consensus and public voice in the matter is limited.

Literature pertaining to risk perception and fracking is limited and varies from the SA context. No studies related to health risk perception and fracking have been conducted. International inquiries were done in areas where fracking is already prevalent. Thus, research is needed to establish the health risk perception of individuals living in the Karoo related to fracking, explore their trust in government and their information sources. Providing Karoo residents with public voice could promote environmental justice.

1.2 Objective

This review critically summarises the relevant literature pertaining to fracking and health risk perceptions. Fracking in SA is targeting the Karoo, a unique environment from a lifestyle and biodiversity perspective. As the study is set in the Karoo, background related to this area is provided. Then the review discusses the known and potential health impacts of fracking categorized according to water pollution -, air pollution -, and environmental health – and occupation health studies and studies pertaining to regulation of fracking. Literature

pertaining to risk perception and community attitudes towards fracking follows, highlighting the gap in the current literature related to risk perception and fracking in SA. The research could inform future risk communication strategies and aid in identifying communication channels between stakeholders and the population.

1.3 Search Strategy

Data were gathered from a variety of peer reviewed online sources and relevant media. Only English publications were included, however German and Afrikaans media served as leads to recently published accredited English sources.

A summary of the published fracking literature from 2012 was used as a starting point providing an oversight as to the type of, magnitude and quality of evidence available on fracking. Google Scholar was used extensively with weekly alerts to new articles and key word searches were also conducted in PubMed, Medline and Scopus and the Zotero¹ databases. Key word search terms used include (Fracking) OR (Hydraulic fracturing) OR (Hydro fracking) OR (Shale gas extraction) and (Attitude to Health [Mesh]) OR (Attitude to health) OR (Risk [Mesh]) OR (Perceived risk) OR (Risk perception) OR (Safety attitudes) OR (Health, Knowledge, Attitudes, Practice [Mesh] OR (Community understanding). The searches were restricted to the availability of an English abstract.

Fracking meetings and sustainable energy forums I have attended served as a platform to discuss and learn about new developments related to fracking in SA through a multidisciplinary team of academics. Reports from such events were reviewed as sources for

¹ Zotero database (https://www.zotero.org/groups/pse_study_citation_database/items)

this literature review. Academics at these meetings would share new publications and relevant fracking literature via email.

2 Literature

2.1 Fracking – General

Natural gas extraction is the process where gas, predominantly methane, confined in underground shale rock formations is released, often through the process of hydraulic fracturing (fracking) and retrieved as an energy source (Miller & Robert, 2011; Swiss Centre for Applied Ecotoxicology et al., 2013).

Conventional fracking wells are drilled to a depth of one to three kilometres from the surface to reach the shale rock (Swiss Centre for Applied Ecotoxicology et al., 2013). The rock formations are cracked to release gas, through the injection of a combination of water, fine sand and chemicals into wells at pressures ranging between 345 and 1000 bar (Swiss Centre for Applied Ecotoxicology et al., 2013). These brine injections crack the shale, release the natural gas and allow it to be captured at surface level (Fisk, 2013; Korfmacher et al., 2013a).

Following the initial era of conventional gas extraction led by the US since the 1940's, experimentation with different types of gas extraction has resulted in the development of unconventional gas extraction by means of horizontal drilling initiated in Texas in 1991 (Considine et al., 2009; Miller and Robert, 2011). Horizontal drilling extends laterally between 600 and 1200 metres from the drill shaft (Swiss Centre for Applied Ecotoxicology et al., 2013).

Since 1996, slick water fluid has been used to crack layers of rock in order to release gasses trapped in deep shale formations (Considine et al., 2009). Despite the existence of other technologies and extraction techniques, these new technologies increased economic viability of gas extraction (Sovacool, 2014). This resulted in rapid expansion of fracking operations internationally due to the potential yields and the large anticipated profit margin to oil and gas companies (Sovacool, 2014).

As demonstrated in Figure 1 below, drinking water aquifers are closer to the earth's surface than the horizontal drill shafts used to hydraulically fracture the shale (Swiss Centre for Applied Ecotoxicology et al., 2013). Pollution of drinking water aquifers as a result of fracking through leaks in vertical wells as well as accidents have been documented, however pollution as a result of flow back water or upward migration of chemicals is still uncertain (Vengosh et al., 2014).

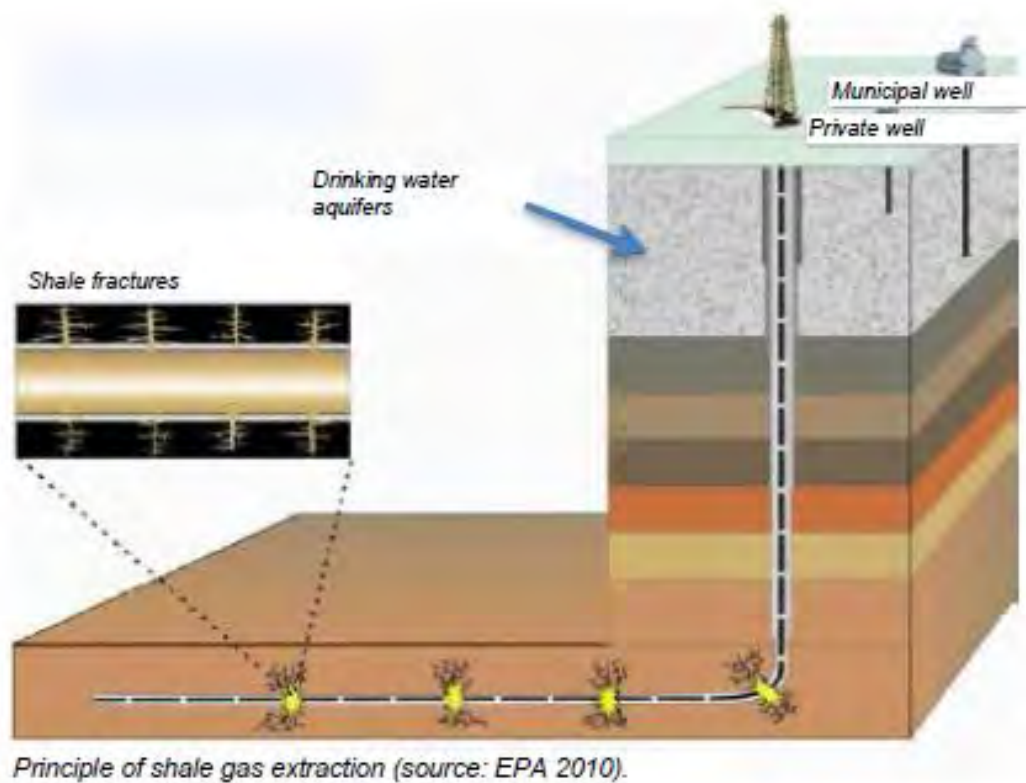


Figure 1: Principles of Shale Gas Extraction (Source: Facts Sheet, Eawag Aquatics Research 2013).

To inhibit gas migration from the wells to the subsurface drinking water aquifers, wells are cased with steel and cement. Castings are intended to seal the well and prohibit migration of fluids between the well and the surrounds (Considine et al., 2009). The efficacy of these barriers and regulatory efficacy of the industry are contested in the literature (Phillips et al., 2013; Vengosh et al., 2014).

SA, as the rest of the world has to look to alternative energy sources in order to satisfy energy needs (Cohen and Winkler, 2014). With the widespread concern about global warming, carbon emission is becoming increasingly considered in ensuring sustainable power solutions (Considine et al., 2009). Experts argue whether fracking is a more suitable energy source than coal mining and supporting evidence in the literature is contrasting.

According to Considine, using natural gas for energy production results in an estimated 30-60% reduction in carbon emissions, compared to coal and oil mining (Considine et al., 2009). In contrast, the Swiss Centre for Applied toxicology (2013) modelled carbon dioxide emissions during various types of energy extraction, and found fracking to potentially be more hazardous to the climate than oil extraction.

Internationally an ever expanding number of countries are banning fracking. Seemingly bans are as a result of countries not deeming fracking to be feasible, firstly due to the potential risks involved in the process and secondly due to their ability and capacity to upscale alternative energy solutions effectively (Environmental Systems Research Institute and ArcGIS, 2014). The following countries have banned or suspended all fracking related activities: Bulgaria, France, Northern Ireland, Germany, Luxembourg, Netherlands, Romania and Czech republic (Environmental Systems Research Institute and ArcGIS, 2014)(Refer to 6.1).

2.2 Fracking in South Africa

Oil and gas experts estimate that SA is situated on the fifth largest shale gas reservoir in the world (Jackson et al., 2012; Smith, 2013). Due to our growing economy, SA is more dependent on energy than other developing countries (South African Energy Department, 2013). SA utilises predominantly coal and nuclear power and has a large coal mining industry, exporting 28% of mined coal (South African Energy Department, 2013). Energy generated through coal mining has high carbon emissions compared to other energy sources (Department of Energy, 2010). Refer to Table 1 below for details.

Table 1: Relative emissions from different carbon energy sources in South Africa.

Fuel	Units	PM10	SO ₂	NO _x	Benzene
Coal	kg/ton	6.6	19S	5.5	0.00065
Anthracite	kg/ton	0.04A	19.5S	4.5	
Coke	kg/ton	6.6	25.5	9	0.00065
HFO	kg/kL	3.3712	18.84S	6.6	0.0000257
Diesel	kg/kL	0.96	8	8.49	
Paraffin	kg/kL	0.24	1.22	2.4	
Wood	kg/ton	2.6316	0.18275	3.5819	0.030702
Wood Waste	kg/ton	2.6316	0.18275	3.5819	0.030702
LPG	kg/kL	0.072	0.0108S	2.52	
Waste	kg/ton	6.3	1.73	1.83	
Diesel/paraffin	kg/kL	0.96	8	8.49	
Natural Gas	Kg 10 ³ /m ³	0.0304	0.0096	1.6	0.0000336
Abbreviations: TOC: total organic compounds, NMTOC: non-methane total organic compounds A: represents the ash content of the fuel (as %). The ash content of the anthracite was assumed to be 15% where unspecified. S: Sulphur content of the fuel (as %). The sulphur content of coal and anthracite was taken to be about 1% and the sulphur content of HFO circa 3.2% where not specified. Emission factors are provided in kg of pollutant emitted as a result of unit fuel burned Table replicated from (Scorgie, 2012)					

In response to global efforts to reduce greenhouse gasses and control global warming, SA has ratified carbon emission reduction targets and adopted climate change policies thus pressurising government to find more environmentally friendly sustainable energy solutions (South African Energy Department, 2013). The SA energy department is of opinion that due to alternative energy options currently being limited and costly (South African Energy

Department, 2013), alternative energy is still not able to satisfy the current SA energy need. Due to the SA energy department potentially benefiting from fracking developments, this information may be bias.

Fracking has increased US energy independence with the abundant gas supply and decreased energy prices making it an obvious choice (Sovacool, 2014). Due to the large estimated gas pool below the Karoo, the SA government and oil and gas companies are eager to take advantage of this resource as an alternative to current energy sources dominated by coal (81%) (Jackson et al., 2012). Due to the large profit margins associated with fracking (Sovacool, 2014), the SA government is commonly accused of exploring fracking for economic reasons. According to a report by Shell, extracting gas from the Karoo basin will reduce the current carbon emissions and aid in a more sustainable distribution of energy production (Jackson et al., 2012).

In 2011, the Petrol Agency of SA (PetroSA) granted Shell, Bundu, Falcon and Sasol and later Anglo permits for gas exploration in the Karoo as indicated below in Figure 2 (du Toit, 2014; Ground Work, 2013; Jackson et al., 2012). Sasol has since retracted its application as they feel that fracking is no longer financially viable for them. (Ground Work, 2013). A public outcry resulted in the SA minister of mineral resources announcing a six month moratorium on all fracking and fracking related activities in February 2011 to ensure that regulations governing fracking are scientifically based and gas extraction would be done in an environmentally sustainable way (Blaine, 2014).

Following the abolition of the moratorium in September 2012, the government published their gazette related to mineral resources in October 2013 (Department of Mineral

Resources, 2013). This gazette provided draft regulations for fracking (Department of Mineral Resources, 2013) and provided one month for public comment. The regulations included fracking guidelines through the whole fracking process (Department of Mineral Resources, 2013).

The perception of strong and partisan support for fracking is illustrated in President Jacob Zuma's description in 2014 of fracking as a "game changer," using the jargon of the oil and gas industry. The SA government has further announced that exploratory fracking may commence, after the release of the regulations prior to the national election on the 7th of May 2014 in order to accurately establish the amount of retrievable shale gas (Blaine, 2014).

In August 2014, the next set of draft regulations related to fracking was published by the government. However, no conclusive decisions have been taken on the matter to date. The bill will still be voted on by the National Council of Provinces and following this, the President can sign it off as the new law (Deal, 2014). Exploration will be followed by environmental impact assessments (EIA) to further evaluate the feasibility of fracking as a long term energy solution for SA and aid experts in taking informed decisions related to fracking (Janse van Vuuren, 2012). If approved, commercial fracking can commence afterwards.

Shell exploration company conducted desktop studies relating to the Karoo with some consultation with Karoo land owners (Shell exploration company, 2011). Further a series of meetings were hosted by the oil and gas industry in the Karoo, which Karoo citizens were free to attend (Shell exploration company, 2011). Fracking matters were discussed in these meetings.

Due to the short periods provided for public input by the Department of Mineral Resources and the lack of agreement over whether fracking should commence in SA or not, it is imperative to establish what the perceptions of Karoo residents are related to fracking.

2.3 The Karoo

Due to shale gas reservoirs in SA being largely situated in the Karoo basin, Oil and gas companies are targeting the Karoo as a starting point for exploratory fracking. The Karoo-area has unique demographic and geographic characteristics and thus this background information related to the Karoo should facilitate a better understanding of the context of this study.

The Karoo stretches over four of the nine provinces of SA namely: Western Cape (WC), Northern Cape, Eastern Cape and the Free State Province and comprises 40% of the SA land mass (du Toit, 2014; Shell exploration company, 2011). Afrikaans is spoken by 80% of the CK population and 10% are Xhosa (Beaufort West Municipality, 2014).

The Karoo relies largely on sheep farming to sustain its economy (Beaufort West Municipality, 2014; Moore et al., 2014). Central Karoo (CK), formerly the economic centre of SA, situated in the WC now relies heavily on international export markets to sustain their meat and wool industry (du Toit, 2014). Farming in this region is reliant on ground water, despite the limited amounts available (du Toit, 2014). Beaufort West (BW) municipal area has a population density of 0.3 individuals/km² (Beaufort West Municipality, 2014), an extremely low proportion when compared to the provincial average of 45 individuals/km² in the Western Cape Province.

2.3.1 Gender and Migration Patterns

The rural Karoo population has decreased significantly between the 1960's and 2004 while the urban population grew approximately 240% in the last century (Nel and Hill, 2008). There were more women than men in the CK according to 1996 and 2011 census data (Statistics South Africa and Lehohla, 2012).

2.3.2 Education and Employment

Evidence indicates that there was a significant decline in the proportion of individuals with no schooling and an increase in the proportion which completed secondary education between 1996 and 2011 (Statistics South Africa and Lehohla, 2012). However, in 2011 a meagre 28% of the Western Cape population aged 20 years and above have completed Grade 12 (secondary school) (Statistics South Africa and Lehohla, 2012). The CK Municipality shared the highest unemployment rate in the WC of 23% with the City of Cape Town (Statistics South Africa and Lehohla, 2012).

2.3.3 Household Size and Type

According to a Stats SA report, the average household size in the CK declined from 4.3 in 1996 to 3.6 in 2011 (Statistics South Africa and Lehohla, 2012). An estimated 97% of Karoo households are classified as formal (Statistics South Africa and Lehohla, 2012).

2.3.4 Average Household Income

The average household income in the Central Karoo almost doubled between 2001 and 2011. In 2011 the average annual household income in the Central Karoo was R77 979 and in the Western Cape Province, R143 461 (Statistics South Africa and Lehohla, 2012).

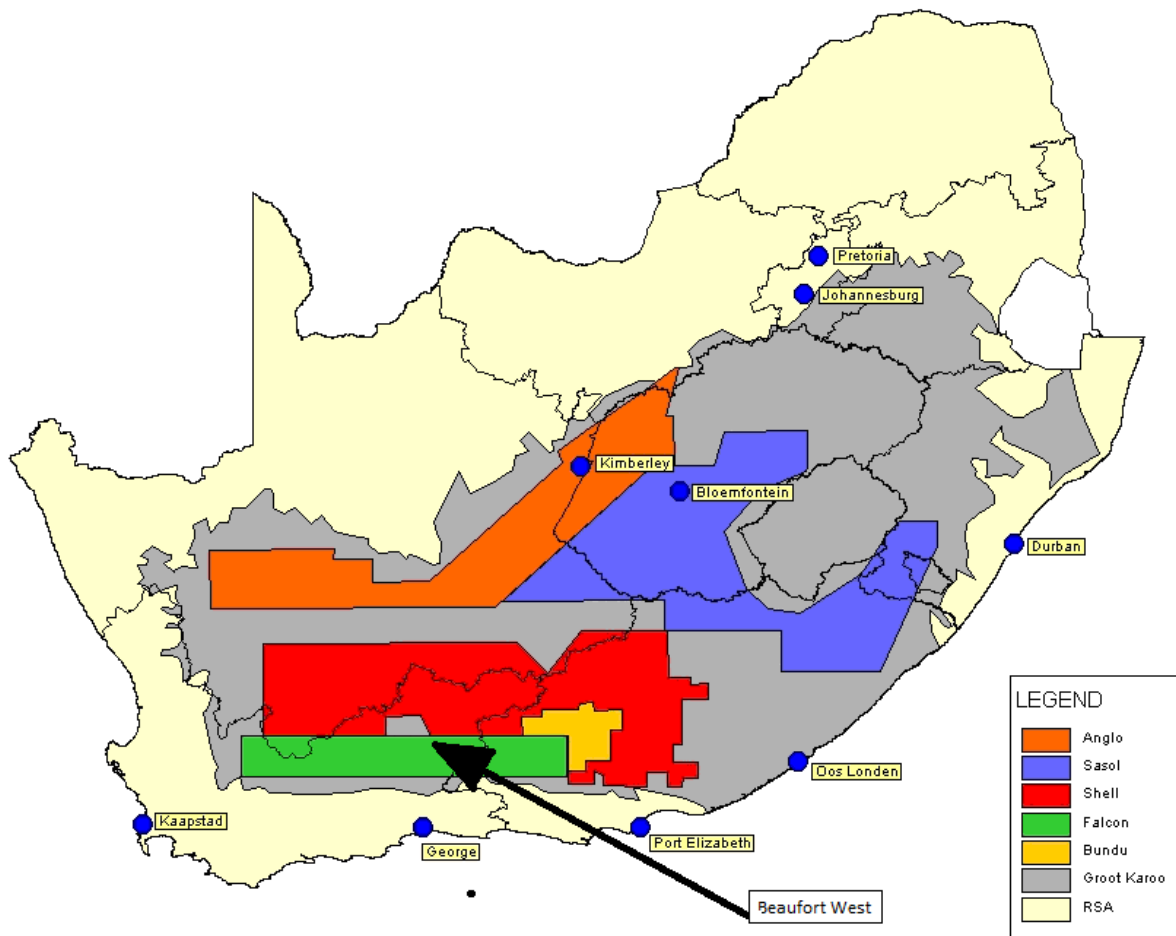


Figure 2: Areas Where Gas Companies Applied To Drill For Shale Gas In The Karoo Basin Indicating Beaufort West In The Central Karoo. Source: Steyl & Van Tonder 2013.

2.4 Fracking and Human Health

Reviews of current literature related to fracking and health repeatedly emphasize the lack of epidemiological evidence in this field (Concerned health professionals of New York, 2014; Penning et al., 2014). In the US, non-disclosure agreements between land owners and oil and gas companies have made it difficult to study fracking. Likewise the combinations of chemicals used in the fracking industry vary between different companies and is said to be proprietary information and therefore remain undisclosed. This results in weak epidemiological studies due exposure characterisation often being based on estimation.

Nonetheless, evidence related to health impacts due to fracking drawn from studies on water pollution, air pollution, health effects due to environmental exposures and occupational health follow (Addendum B: Tables Summarising Literature Pertaining to Fracking, Environment and Health: Table 2 to Table 9).

2.4.1 Water Pollution Studies

Numerous scientific studies have investigated and documented the potential means of water pollution through all phases in the fracking process (Table 2 & Table 3).

Various researchers have drawn water samples from drinking wells and or other water sources in the proximity of fracking operations to study water and chemical composition (Fontenot et al., 2013; Osborn et al., 2011; Warner et al., 2012). A large number of chemicals with known health effects have been detected in water samples drawn from fracking sites including: Arsenic, Methanol, Ethanol, Selenium, Strontium, Barium, Total Dissolved Solids (TDS) and Volatile Organic Compounds (VOC) (Fontenot et al., 2013; Osborn et al., 2011).

One highly technical study by Warner et al. (2012) studied 426 water samples to ascertain migration patterns of water and brine and found that the Marcellus Shale is at an increased risk for shallow water contamination as a result of fracking due to the subsurface rock fissures. Further, deep brine compositions suggest that brine was mixed with ground water (Warner et al., 2012). Surface water is at risk of chemical pollution as a result of well leaks, accidents and well blow outs (Concerned health professionals of New York, 2014).

Another study analysed 100 water samples from private drinking wells within 3kms of fracking wells in Barnett shale, Texas and found chemical compositions raised compared to control sites (more than 3kms from active wells) and exceeding the US Maximum Contamination Limits (MCL) for safe drinking water (Fontenot et al., 2013). Arsenic was found in 98.9% of the samples (Fontenot et al., 2013). The prevalence of this known carcinogen, exceeded historic data and 32.2% of samples exceeded the MCL of 10 µg/L for drinking water (Fontenot et al., 2013). Methanol and Ethanol, for which exposure is linked to visual deficits, blindness, headaches, nausea and even death were present in 29% of these drinking water samples (Fontenot et al., 2013). However, because participants in this study were volunteers, the study is subject to selection bias.

Further in the Marcellus Shale, Pennsylvania (PA) and the Utica Shale in New York (NY), 60 water samples from private drinking water wells within 1km of active fracking wells were analysed and it was found that active wells had 17-times higher average methane concentrations compared to drinking wells from areas without active wells (Osborn et al., 2011). Historic water samples were used as a proxy to compare water samples taken during this study. These historic samples were collected during oil extraction periods and thus

potentially the purity of the water may have been influenced due to the oil drilling operations. Further it was unclear whether all the wells in the region were sampled or how the final 60 were selected, thus potentially subjecting the study to selection bias.

Reviews concluded that baseline information related to water quality in fracking areas are scanty, making it difficult to assess the extent of fracking pollution (Concerned health professionals of New York, 2014; Finkel and Hays, 2013; Ong, 2014; Penning et al., 2014; Vengosh et al., 2014).

Literature confirms that ground water is at risk of contamination in the proximity of fracking sites and that fracking can threaten the safety of drinking water (Concerned health professionals of New York, 2014; Vengosh et al., 2014). Approximately 30-70% of fracking fluid will resurface during the fracking process, exposing the toxic chemicals used (Finkel and Hays, 2013). Of the chemicals used in the fracking process, three quarters potentially has an impact on breathing and airways, the digestive system, skin and vision and a quarter of the chemicals are known carcinogens (Ong, 2014). Elements found in the ground water and associated with the fracking process include Hydrocarbons (gas form) and radioactive elements, known to cause cancer and other adverse health impacts (Vengosh et al., 2014). Fracking is known to cause salinization of the ground water due to high salt content of the produced water, small spills or amounts cyphering into the surface water (typically TDS < 1000 mg/L) (Vengosh et al., 2014). Fracking sites in Colorado, showed elevated levels of benzene, toluene, ethyl benzene, and xylene (BTEX) in groundwater where spills of fracking fluid occurred (Vengosh et al., 2014). Exposure to BTEX can result in carcinogenic and non-carcinogenic health effects including neurological deficits, foetal development problems,

reproductive problems, hearing loss, eye-, skin-, throat-, liver-, kidney- and respiratory problems have been documented (Durmusoglu et al., 2010).

Although all the reviews included a large body of literature, individual studies were seldom critiqued for methodology and limited information was provided regarding the inclusion criteria for studies into the reviews, which means that poor quality studies or those with sampling bias could have been included in the review and equally weighted.

2.4.2 Air Pollution Studies

Evidence for air pollution pertaining to fracking is also lacking (Table 4 & Table 5). Air emissions occur during fracking due to a combination of gas leaks and through the normal course of the fracking process as well as secondary pollution arising because of gas flaring (gas combustion in an industrial site), site construction, increased truck traffic and generator use.

McKenzie et al. (2012) collected 163 air samples in fracking areas in Colorado in order to estimate cancer and other health risks and found proximity to fracking operations to be an indicator for health risk with those being closer than half a mile to the gas extraction being more at risk. Benzene exposure is the main contributor to cancer risk and non-cancer risks are as a result of exposure to Ethyl benzene, Tri-methyl-benzenes, Xylenes, Toluene, Propylene and Aliphatic Hydrocarbons (McKenzie et al., 2012). Data for this study was collected over a three year period and used to estimate 30-year risks thus the risk may be over or under representative. The authors repeated their calculations using three different distances from fracking wells and comparing the results with distances further away from the specified distance. The shortest distance (half a mile), on which the most significant

study findings were based could have led to exposure misclassification because of the differing topography of the study site.

Furthermore, vertical air samples taken from the Utah basin found alarming amounts Volatile Organic Compounds (VOC), Alkane Hydrocarbons, Benzene and Toluene in ambient outdoor air and estimated the VOC emitted by the gas industry to equal that of 100 million cars (Helmig et al., 2014).

Rich et al. (2014) collected 50 air samples from 6 urban residential areas in the proximity to fracking operations confirming that the toxins in ambient air samples (listed above), significantly exceeded concentrations found in areas without fracking. Methane concentrations, found in 98% of air samples (1.8-2.0ppm), exceeded background levels (Rich et al., 2014). This study was subject to convenience sampling. Also despite the study being conducted in an urban area, other sources of air pollution potentially confounding the results of this study were not fully considered. The authors failed to disclose the distances samples were taken from fracking operations.

Also, air samples in the proximity of fracking sites captured in various US states had elevated levels and combinations of Benzene, a known carcinogen, hydrocarbons, ethyl benzene, toluene and xylene (linked to neurological and respiratory problems) as well as increased levels of Ozone, particulate matter and ozone precursors such as Volatile Organic Compounds (VOCs) in the ambient air (Concerned health professionals of New York, 2014).

Another potential cause of air pollution the fracking industry face is the reticulation of gas to urban areas. The increased availability to natural gas may lead to increased problems in the distribution of gas and Moore's review (2014) of 20 years literature, is an example of

documentation of methane leakages from fixed gas pipelines with concentrations exceeding that which is commonly reported. Methane concentrations of 28.5 ppm has been found to leak from 3400 fracking pipelines in Boston, USA, compared to the global background methane concentrations of 1.8 ppm (Moore et al., 2014).

2.4.3 Environmental Epidemiological Studies

Limited epidemiological studies investigating health effects from exposures resulting of fracking activities on nearby communities has been found in the literature (Hill, 2012) (Table 6 & Table 7.) The literature includes studies pointing to the risk of explosions associated with fracking, spreading chemicals in an uncontrolled manner polluting air, water and soil (Finkel and Hays, 2013). Furthermore, illegal and legal dumping of untreated and half treated fracking waste water into rivers and being sprayed onto roads amongst other, have been documented (Finkel and Hays, 2013).

Colborn et al. (2011) formulated a list of the known chemicals used in the fracking process and conducted general literature searches to find the known health effects of exposure to these specific chemicals and elements. Potential health impacts due to exposure to fracking chemicals include harm to the hepatic, sensory, respiratory and gastrointestinal systems (Colborn et al., 2011). Furthermore half of the chemicals used in the fracking process can result in problems of the neurological and cardiovascular systems, the immune system, nervous systems and the kidneys (Colborn et al., 2011). Exposure to 25% of the fracking chemicals places one at greater risk for developing cancer and mutations (Colborn et al., 2011). Of the chemicals used in the fracking process which experts were able to identify, 37% were endocrine disrupting chemicals (EDC) (Colborn et al., 2011). EDC are known to lead to birth defects or infertility (The Endocrine Disruption Exchange, 2014).

Bamberger and Oswald (2012) interviewed and took urine samples from 24 farmers in six US states in the proximity of fracking operations and found arsenic and metabolized benzene in the urine. Moreover, apart from an individual admitted to hospital due to arsenic poisoning, anecdotally reported health problems include “upper respiratory, dermatological, neurological, and gastrointestinal health impacts” as well as general exhaustion and headaches (Bamberger and Oswald, 2012). Supporting evidence used in this study was mainly anecdotal and not based on air and water samples in order to establish direct links to the fracking chemicals. Sampling bias was introduced due to researchers including volunteers and shale gas activists in the study. No rigorous explanation was provided for the sample selection and distances between farm and fracking operations were not disclosed in the article.

Hill (2012) studied maternal exposure to fracking and infant health of 1 069 699 infants born in Pennsylvania state in proximity to fracking sites between 2003 and 2009. Maternal exposure to fracking was defined as living within 1.5 miles of an active fracking well (Hill, 2012). It was found that maternal exposure to fracking increases low birth weight by 25% and small for gestational age by 17% (Hill, 2012). McKenzie et al., (2014) further found that maternal exposure to fracking defined as more than 125 fracking wells per mile increases the odds of giving birth to an infant with neural tube defects twofold (OR=2; 95% CI: 1.0, 3.9) and coronary heart disease by 1.3 (OR=1.3; CI: 1.2, 1.5) (Mckenzie et al., 2014). Due to the researchers in this study using secondary data for their analysis, the researchers made assumptions about the whereabouts of mothers in the various trimesters of their pregnancies which could have affected the results. This study did not adjust for socio-

economic status or nutrition which could also affect the infant's growth and health outcomes thus possibly inflating the odds ratio.

A review of anecdotal evidence related to fracking reports the most common problems to include fatigue, dry eyes, skin irritation, headaches, endocrine disruption and hormonal changes as well as lifestyle and stress related problems (McDermott-Levy et al., 2013). Other cases documented include benzene in blood tests as well as familial problems of nose bleeds and skin rashes which appeared shortly after fracking commenced in the proximity of these landowners' private property (McDermott-Levy et al., 2013). However, the authors failed to describe their review methodology and thus the inquiry will not be easily replicated. A different study reviewing the potential health risks posed by chemicals used in the process of fracking, found fracking to pose a risk of health problems including respiratory problems, sleep apnoea, headaches, vomiting, visual - and smell problems, cardiovascular problems as well as leukaemia and other cancers confirming McDermott's findings (Garrison et al., 2011).

A further review included case studies with anecdotal evidence pertaining to health issues reported after exposure to fracking (Brown et al., 2014). Health problems included dermatological, neurological, respiratory and gastrointestinal problems (Brown et al., 2014).

Another major concern related to the fracking industry in the literature is influx of people causing rapid bursts of industrial urbanisation. This urbanisation places strain on public services due to the competition for access to basics such as health care, accommodation and recreation (Penning et al., 2014). Furthermore urbanisation and resource shortages increase the risk of infectious disease outbreaks which may not have previously been a

health challenge in specified areas. Practitioners are also seen as unable to warn and educate those working in the fracking industry about the potential risks they face at work and in their immediate environments due to the already mentioned lack of transparency, related to chemical composition (Penning et al., 2014).

2.4.4 Occupational Health Studies

A review related to the health risks of fracking found that vocational stressors in the fracking industry include a high risk of exposure to chemicals, death and accidents in the industry (Adgate et al., 2014) (Table 8 & Table 9).

Silica is used during the fracking process as part of the injection cocktail (Penning et al., 2014). In a study of 111 workers at 11 fracking sites in the US, breathing samples were taken from all of the employees (Esswein et al., 2013). It was found that of those who worked their full shift, 68% had silica exposures that surpassed the US Health and Safety Regulations exposure limit of 0.05 mg/m^3 . Silica is a known increase risk of Silicosis, a severe form of occupational lung disease as well as lung cancer, kidney disease, autoimmune diseases and an increased risk of tuberculosis (Esswein et al., 2013). Silica exposure in mining is long recognised as a cause of occupational lung disease and, more recently, associated with lung – and other cancers (Penning et al., 2014).

Furthermore, another review have found that the US Bureau of Labour Statistics calculated that the mortality rate is 2.5 times higher in the oil and gas industry than in the notorious building industry and 7 times higher than in other industries using data from 2005-2009 (Concerned health professionals of New York, 2014; Witter et al., 2014). Close to 30% of

deaths were as a result of road crashes and approximately 20% of deaths were as a result of acute injuries (Witter et al., 2014).

Occupational risks in the fracking industry include burns, toxic chemical exposure, head injuries, road traffic injuries, heat associated conditions and sleep disturbances (Concerned health professionals of New York, 2014). Light and noise pollution, which experts claim may be linked to breast cancer, cardiovascular disease and cognitive impairment are also potential exposure risks of the fracking industry (Concerned health professionals of New York, 2014).

As fracking has not commenced yet, there is no SA data substantiating the US occupational health risks in the fracking industry.

2.4.5 Regulation

Internationally, the lack of regulation and the enforcement has been identified as a major challenge in the fracking industry (de Rijke, 2013; Schmidt, 2011). This leaves influential decision makers with a lack of evidence from which to inform costly long term decisions related to fracking (Penningroth et al., 2013). Poor regulation of fracking results in oil companies discarding harmful chemicals and radioactive elements into drinking water which poses public health challenges (Fisk, 2013).

To highlight the severity of concern related to the potential health and social problems to communities as a result of fracking, Pennsylvania reacted on a political level and instituted a special tax to make provision to compensate communities, who suffered as a result of fracking (Korfmacher et al., 2013).

2.5 Risk Perception and Fracking

2.5.1 Definition

“Risk perceptions encompass cognitive evaluations of the likelihood of harm as well as related emotional responses” (Penning et al., 2014). Perception of risk is formed by individual personalities, levels of knowledge, power relations and socio-cultural variables (Renn and Benighaus, 2013; Schmidt, 2004).

2.5.2 Evidence and risk

Within the risk analysis literature, an inverse relationship was found between the perceived risk and the perceived advantages of technological activities such as fracking (Slovic et al., 2004).

Lay persons’ perception of risk is sometimes deemed richer than experts’ opinions and thus a combination approach of the lays’ risk - and experts perceptions are crucial (Slovik, 1987). Furthermore lay persons have been said to have a broad perspective of risk compared to field experts (Schmidt, 2004). The lay would typically include aspects such as their amount of control over a risk, equity of risk distribution and long term effects on generations to come essentially based on their personal beliefs and attitudes (Schmidt, 2004). Experts basing their risk perceptions of scientific findings, have a more simplified approach to risk due to the nature of the evidence that they base their risk perceptions on (Schmidt, 2004).

2.5.3 Media and Risk Perception

British research has shown that the structured way in which oil and gas companies and environmental organisations state their cases for or against fracking, influences public opinion (Jones et al., 2013) and shape individuals’ risk perception related to fracking. Bussotti, (2014) claimed that media polarizes arguments relating to risk without providing

necessary details to lay persons. Apart from the media, technological risks related to technologies such as fracking or the use of nuclear energy has been documented to divide societies (Renn and Benighaus, 2013) which is evident in the SA media related to fracking.

Risk perception literature from Mozambique suggests that in developing countries such as Mozambique, the government often regulates the media and that risk communication can be manipulated to favour government priorities (Bussotti, 2014). Communities understanding of the risk can inform which information sources they choose (Penning et al., 2014). This has been said to help ascertain whether the information sources need substantiation with credible sources or whether they are deemed credible (Penning et al., 2014).

It has been argued that African countries face further challenges with risk communication due to their financial dependency on international donors (Bussotti, 2014). An example of this practice is the international company Shell and the SA government liaising and the collaboration will benefit the government as fracking developments will be a major source of revenue for the SA government (Bussotti, 2014).

Internationally, the study of environmental risk perceptions have grown significantly during the last three decades, however in Sub-Saharan Africa risk perception is not yet classified as a crucial study field (Bussotti, 2014). Local evidence still lack.

2.5.4 Risk and trust

When risks are not voluntary or uncertain, it is perceived as being amplified compared to when someone chooses to expose themselves or they carry knowledge of the extent of the risk (Schmidt, 2004). In some instances where individuals are unable to control a risk due to

their lack of expertise, then trust in the relevant authorities responsible for risk regulation, predicts how risky the action is perceived to be (Schmidt, 2004).

Brasier, (2013) studied risk perception related to fracking in the US and concluded that technological risk perceptions are influenced by three categories: firstly institutional trust, secondly perceived knowledge related to the activity and the effects thereof and lastly the unique environmental or demographic variables (Brasier et al., 2013). Fracking is an intricate process which few individuals seem to fully grasp.

Löfstedt's work on the collaboration of state regulators and the industry working together with the civilians found that collaboration between the state, the people and the industry is one of the most critical variables to increase the public's trust in authorities (Löfstedt et al., 2001).

Studies related to fracking found that individuals living in fracking areas, who trust authorities in relation to fracking, seem to have better health outcomes compared to those who do not trust authorities. (Adgate et al., 2014; Ferrar et al., 2013)

2.5.5 Risk in South Africa

In SA, evidence available on public perception and risk is limited to risk perceptual studies related to farming and pesticides (Rother, 2000, 2008). One such study was conducted among individuals working in the cotton industry in northern Kwazulu-Natal and related to women and children's exposure to pesticides and their associated risks (Rother, 2000). This particular study found that the grass roots perception of pesticides are not aligned with actual scientific risks to human health (Rother, 2000).

Further, an unpublished qualitative study from the mining industry aimed to explore what the perceptions of the rural SA farming community in the Northern Province were related to the possibility of a new mine in the area where they lived (Muntingh, 2011). The author found that the community had an overall positive perception towards mining (Muntingh, 2011). However, this research was conducted on behalf of a mining exploration company potentially subjecting the study to bias. No other published South Africa literature has supported Muntingh's findings.

2.5.6 Risk and Inequity

When individuals experience a risk to be distributed fairly amongst everyone, then the risk is not rejected as much as when it was unequally spread amongst the population (Schmidt, 2004). Schmidt (2004) describes the 'risk-benefit-ratio' as being the least acceptable when the risk is only posed to a specific group of individuals and those are not the ones benefitting from the risk or technology. This theory can be applied to fracking in the Karoo. Due to the gas reserves being situated under the Karoo basin, any detrimental effects as a result of fracking could potentially impact those living in the Karoo, despite the rest of South Africa and or the government potentially benefitting from fracking. This highlights the importance of the proposed study in order to establish the perceptions of those who are at risk of being affected by fracking, were it to materialize in the Karoo.

2.6 Community Attitudes and Fracking

In the USA national surveys show that the majority of individuals living in active fracking areas, are aware of fracking and the economic and secondary benefits thereof (Boudet et al., 2013; Brasier et al., 2013). Boudet (2014) found that older persons with university level of education with conservative political views favour fracking due to its perceived economic growth potential. Females who reported informing themselves on news and current affairs, demonstrated more resistance to fracking than males due to the potential pollution and other harmful environmental impacts (Boudet et al., 2013). To enhance community involvement and improve fracking monitoring, a community based risk assessment tool was used in NY, in combination with voluntary localised water sampling to provide communities access to water data (Penningroth et al., 2013). The study found that baseline water samples taken by NY citizens are effective to use as baseline samples in order to compare future samples against in order to establish whether water has been contaminated (Penningroth et al., 2013). This local data collection helped to protect water resources and empowered locals to contribute to sustainable water management (Penningroth et al., 2013).

3 Discussion

Internationally, fracking has caused much controversy and debate among economists in the oil- and gas- industries favouring gas extraction, (de Rijke, 2013) in opposition to environmentalist and public health specialists, concerned about the pollution and the resultant adverse health impacts associated with fracking-pollution (Korfmacher et al., 2013). Despite the lack of clarity about the risks of fracking, SA is about to embark on an exploratory phase of fracking in the Karoo (Janse van Vuuren, 2012).

Quantitative studies conducted in the US have explored the risk perceptions related to fracking by means of national surveys and found that the general public lack information related to fracking (Boudet et al., 2013; Brasier et al., 2013).

SA is currently in the process of introducing fracking, (Janse van Vuuren, 2012) despite scientific evidence highlighting the risk of pollution it poses. (Adgate et al., 2014; Kovats et al., 2014; McKenzie et al., 2012) In current SA media, parties in favour of and in opposition with fracking are forcefully advocating for their cases (Bryer, 2014; Cropley, 2013; Donnelly, 2013; SAPA, 2013) and controversy relating to government's personal gain in this venture is debated. Jolynn Minnaar, Karoo resident and film maker, has started exploring the public's perception related to fracking through interviews in her documentary, *Unearthed*, released in 2014 (Minnaar, 2014). Shell, Bundu, Anglo and Falcon are companies that seek exploration licences for various parts of SA (du Toit, 2014). Shell has done desktop investigations, substantiated by some interviews with farmers in the Karoo in order to relay social and economic feasibility of fracking (Shell exploration company, 2011). SA literature

related to public risk perception is limited and addresses perceptions of risk related to mining (Muntingh, 2011), pesticide exposure of rural South African women and children (Rother, 2000), crime affecting tourists visiting SA and condom use amongst married and co-habiting couples in Kwazulu-Natal, SA (Maharaj and Cleland, 2015).

4 Conclusion

Notwithstanding the studies with documented chemicals and their effects described above, literature pertaining to fracking and the health risks thereof seems to be in its infancy with results based largely on modelled data and cross sectional readings. Long term prospective scientific evidence showing causal disease trends related to fracking are lacking. Despite current evidence raising numerous questions about the health risks posed by gas extraction, literature exploring the relationships between public health challenges and fracking have limitations including small samples, volunteer based sampling, lack of baseline information related to air and water samples, lack of temporality of evidence and limited exposure data or the lack of consistently collected data related to health effects in fracking areas. Non-disclosure agreements between oil and gas companies in the US and citizens living in fracking areas further increase uncertainty. Not knowing the full extent of the chemicals results in exposure misclassification and likely under-estimation of the extent of the possible risks and harms fracking may pose.

Literature related to risk perception and fracking is limited to the US. To my knowledge there have been no studies conducted in the Karoo related to fracking knowledge or health risk perception. This baseline information regarding knowledge and perceptions towards fracking is essential if the SA government is to consider proceeding with fracking exploration for better management of the risks fracking poses to the Karoo community once it is introduced. This research will increase the scientific understanding of risk perception of Central Karoo residents related to fracking and fill the gap in the literature pertaining to risk perception in a the Sub-Saharan African context. Providing Karoo locals with public voice will

aid in allowing environmental justice to these individuals as their 'home' and lives will be affected by the potential fracking exploration irrespective of their perception related to the matter. The knowledge gained through this research related to their information sources will inform future risk communication strategies and important communication channels.

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6 Addenda

6.1 Addendum A: Map showing International Resistance to Fracking



Figure 3: Map Showing International Resistance To Fracking (Environmental Systems Research Institute and ArcGIS, 2014).

6.2 Addendum B: Tables Summarising Literature Pertaining to Fracking, Environment and Health

6.2.1 Primary Water Pollution Studies Pertaining to Fracking

Table 2: Summary of Primary Studies Pertaining to Water Pollution Resulting From Fracking.

Primary studies related to water pollution and fracking				
Author , year	Methods	Quality of Evidence	Chemicals/ hazard	Findings
(Fonte not et al., 2013)	Chemical analysis of water samples collected from 100 private drinking water wells within 3km of the Barnett shale (USA)	<p>Although the researchers did not take pre and post fracking water samples to compare, access to historical water data from the study area allowed for comparison with the water samples that was collected for the study. Historical data did not include Methanol and Ethanol levels thus no comparison was possible.</p> <p>This study could potentially be subject to selection bias as</p>	<p>Arsenic, Methanol, Ethanol, Selenium, Strontium, Barium</p> <p>Total Dissolved Solids (TDS)</p> <p>Volatile Organic Compounds (VOC)</p>	<p>Drinking water contained chemicals exceeding the safe Maximum Contamination Limit (MCL) for drinking water.</p> <p>The concentrations of chemicals were raised when compared to control sites outside of fracking areas.</p> <p>Methanol and ethanol were present in 29% of all the drinking water samples.</p> <p>Arsenic was found in 98.9% of all the samples drawn from drinking water wells in the proximity of active fracking sites which exceed historic data. 32.2% of samples exceeded the MCL of 10 µg/L for drinking water.</p> <p>Selenium was found in 11.1% of samples (n = 90) with 2</p>

		<p>participants were recruited by means of volunteering to a press release. Thus those who suspect or know that their water is contaminated could have been more willing to participate in the study, compared to those who are not concerned about their water quality. To highlight this point, no participants signed up for the study from the area where fracking was not prevalent, despite the call for volunteers.</p>		<p>samples exceeding the MCL of 50 µg/L.</p> <p>Strontium was detected in 98.9% of samples with 17 exceeding the recommended limit of 4000 µg/L for drinking water.</p> <p>Barium was detected in 98.9% of samples with none exceeding the MCL. Levels were said to be significantly higher than historic data.</p> <p>54.9% samples exceeded TDS MCL of 500 mg/L.</p> <p>Methanol, ethanol and volatile organic compounds (VOCs) were also present in the drinking water samples</p>
(Osborn et al., 2011)	<p>This study evaluated the impacts of fracking on ground water systems in the Marcellus Shale in Pennsylvania (PA) and the Utica Shale in New York (NY) by analysing water samples</p>	<p>Historic water samples used as a proxy to compare water samples taken during the study may be dated and influenced by other industries such as oil and or natural tectonic movements influencing the findings of this research.</p> <p>Limited evidence is provided related to the sampling of the wells from which measurements</p>	Methane in ground water	<p>The authors found methane leakages in the ground water systems in three areas of the studied region.</p> <p>The shorter the distance to an active gas well, the higher the methane concentrations found in this study (Paper indicates prevalence on Figure 3 on Journal page 8173).</p> <p>Active wells had 17-times higher methane concentration averages compared to inactive wells.</p> <p>Ethane and other hydro-carbons were found in 80% of active wells compared to the 9% prevalence in in-active</p>

	<p>from 68 private water wells. Water samples were taken in a 1km radius from active fracking wells and compared to historical samples further than 1km from active fracking wells. 60 samples were analysed for hydrocarbons and methane.</p>	<p>were taken. It is unclear whether all the wells in the region were included in the sample or how they were selected. This makes the research process less transparent and reduces validity.</p> <p>The writing style of this paper is extremely technical, thus not suitable for widespread dissemination or will challenge the widespread public.</p>		<p>wells.</p> <p>In the comparison of the 68 water samples to historical water samples of the same region, there is no evidence to substantiate that fracking fluid enters the ground water systems.</p>
(Warner et al., 2012)	<p>This study analysed 109 new water samples, 49 samples from a previous study as well as 268 wells for which data has been published previously. This study aided in</p>	<p>Also a very technical paper strewn with jargon. Methods and results are described and argument well grounded.</p>	<p>Salinization of fresh water aquifers</p>	<p>It was found that ground water had varying levels of salinity prior to fracking commencing and thus that not all salinity can be ascribed to fracking.</p> <p>The composition of deep brine samples and ground water aquifer composition suggest that deep and shallow water mix underground. The geological and chemical compositions of fracking areas and pathways across rock formations connecting deep and shallow aquifers, places areas such as Marcellus Shale in PA area</p>

	understanding and trying to establish migration patterns of brine and saline water from deep shale layers to shallow ground water.			<p>at great risk of shallow water contamination.</p> <p>Another potential hazard is gas leaking into ground water through existing rock fractures. This type of gas migration is predicted to be possible in less than twelve months.</p>
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6.2.2 Water Pollution Reviews Pertaining To Fracking

Table 3: Summary of Reviews Pertaining to Water Pollution as a Result of Fracking.

Reviews related to water pollution and fracking				
Author s, year	Methods	Quality of Evidence	Chemicals/ hazard	Findings
(Vengosh et al., 2014)	Critical Review of predominantly US Case studies related to fracking and the impacts thereof on a variety of water forms to which humans are exposed.	High quality review.	Methane, Propane, Ethane, Helium Salinity 1500 mS/cm	<p>Fugitive gas contamination of shallow water aquifers can be associated with the fracking industry e.g. In North Eastern Pennsylvania (PA) elevated levels of Methane, Propane, Ethane and Helium was found in drinking water wells, compared to expected 'background' gas standards for those wells. Stray gas contamination occurs in a 1km radius from fracking wells in PA.</p> <p>Fracking is known to cause salinization of the ground water due to high salt content of the produced water, small spills or amounts cyphering into the surface water (typically TDS < 1000 mg/L). Salts and dissolved elements leak into and pollute ground water by means of spills as well as inadequate wastewater treatment. This could result in raised PH (10-11), raised chloride (exceeding EPA threshold for drinking water wells) >250mg/L and toxic metals such Arsenic. Chloride levels as high as 3000mg/L has been measured in drinking water wells.</p>

			<p>Radium and toxic waste</p> <p>TDS</p> <p>Hydrocarbons, Radioactive elements</p> <p>BTEX</p>	<p>Raised levels of radium and toxic waste were found in the ground and riverbeds in proximity to fracking activities in Marcellus Shale, PA.</p> <p>The total dissolved salts (TDS) content of water produced during the fracking process ranges from salt concentrations below seawater (25 000 mg/L) to concentrations seven times more saline than seawater, depending on the specific shale formation. In PA fracking waste water contain high levels of salinity TDS (120 000 mg/L), toxic metals such as strontium, barium and radioactive elements as well as organic constituents such as benzene and toluene. Also river water chlorine concentrations increased by 6000-fold and bromine 12000-fold when compared to background concentrations.</p> <p>Other elements found in the ground water and associated with the fracking process include Hydrocarbons (gas form) and radioactive elements, known to cause cancer and other adverse health impacts.</p> <p>Fracking sites in Colorado, showed elevated levels of benzene, toluene, ethyl benzene, and xylene (BTEX) in groundwater where spills occurred.</p>
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(Ong, 2014)	This review discussed the potential impact of fracking on water resources and agriculture.	Despite this article being published in the European Journal for Sustainable Development, the referencing style is inconsistent. The author has an emotive writing style and makes unsubstantiated claims. No methodology is reported related to search terms or inclusion criteria in the review. Poor evidence.	Chemicals not listed	Water quality could be compromised throughout the fracking process. Of the chemicals used in the fracking process, three quarters potentially has an impact on breathing and airways, the digestive system, skin and vision. A quarter of the chemicals could lead to cancer. Radioactive material exceeding measured background levels have been measured in water near fracking sites.
(Concerned health professionals of New York, 2014)	A group of scientist and experts compiled this review of current literature related to fracking with a focus on health. Peer reviewed and journal articles were included in the	This document summarises the available literature on fracking according to various categories, to describe what is available. Study findings are stated; however this compendium lacks reporting the types of evidence or combination of studies in order to strengthen arguments. Instead they merely presented the study findings.	Radium in drinking water Endocrine Disrupting Chemicals (ECD) pollute water	Research conducted by Oil and Gas companies involved in fracking found that on average one fracking-chemical leaks daily in Colorado. Recent evidence found toxic radiation levels in treated fracking wastewater. Marcellus Shale in PA contains water radium levels 3600 times exceeding the safe drinking water limit stipulated by the environmental protection agency of the US. Studies in Colorado found high levels of oestrogen and androgen disrupting chemicals in water samples in sites where frack fluid spill was reported. Another study found endocrine disrupting chemicals (EDCs) in water samples

	review. This review is published biannually and serves as a working document essentially summarising the literature relating to a subjects.		sources Methane, Ethane, Propane Barium, strontium, bromides, chlorides and benzene	<p>drawn near drilling and fracking sites match the chemicals used in fracking fluid. EDCs are associated with reproductive, neurobehavioral, and metabolic problems.</p> <p>A study conducted in 2013 found raised metal and arsenic levels from drinking water wells within a 5km radius of Barnett Shale. The concentrations of these elements were not disclosed in the review or compared to safe drinking water levels.</p> <p>Evidence substantiates raised levels of methane, ethane and propane in groundwater in proximity to fracking sites in PA.</p> <p>Barium, strontium, bromides, chlorides and benzene exceeding levels known to cause health impacts to humans has been measured in wastewater by the University of Pittsburgh. Actual levels not stated in this compendium.</p>
(Pennin g et al., 2014)	Penning et al. (2014) reviewed the current literature pertaining to fracking and the public health	Penning et al. (2014) described their inclusion criteria for including studies into this review and only included peer reviewed literature. The quality of evidence included in this review was not discussed thus	Benzene, Xylene, Volatile Organic Carbons, Hydrocarbons	<p>This review highlighted that due to the lack of baseline information related to water and air content in fracking areas, it is challenging to prove that the pollution is as a direct result of fracking or draw comparisons between before and after air and water samples.</p> <p>In Wyoming it was found that groundwater in 169 wells above fracking pits was contaminated with benzene,</p>

	risks it potentially poses, from a water pollution perspective.	poor quality evidence and highly rigorous research carried the same weight in the review.		<p>xylenes, total volatile hydrocarbons, and gasoline and diesel-type organics matching the composition of chemicals used in the fracking process. Due to the lack of baseline water samples, fracking could not be blamed directly for this pollution. There is debate about the radioactive materials found and whether those are naturally occurring or as a result of fracking.</p> <p>Wells closer to active fracking sites contained raised hydro-carbon levels compared to water wells far from fracking sites.</p>
(Finkel and Hays, 2013)	Finkel and Hays reviewed literature related to fracking and health to establish the implications of drilling for gas from a public health perspective.	The authors did not mention their methodology or research approach. Due to this, the study cannot be replicated and this reduces the validity of review findings.	Toxic chemicals	<p>Thirty to seventy percent of fracking fluid will come back to the surface at some stage during the fracking process, exposing the toxic chemicals used in the process.</p> <p>Numerous instances of environmental harm have been documented as a result of fracking. Explosions, illegal and legal dumping of waste water and half treated water into rivers are some of the documented instances that have happened.</p>

6.2.3 Primary Air Pollution Studies Pertaining To Fracking

Table 4: Summary of Primary Studies Pertaining To Air Pollution and Fracking.

[illegible]

	grid formation where researchers drove in different directions and took samples at set distances from the starting point, to establish areas with high mixed alkane levels.			
(McKenzie et al., 2012)	This study collected air samples in Colorado to measure emissions and estimate cancer and other health risks as a result of exposure.	Although air samples were collected for this study through the use of standard US EPA methods, most of the risks are estimated through the use of a Hazard Index and could thus be under or over estimations of the real risk. Data collected over a three year period was used to estimate 30-year risks thus it may not be accurate. The half	Benzene, Ethyl benzene, Tri-methyl-benzenes, Xylenes, Toluene, Propylene, Aliphatic Hydrocarbons	<p>Air monitoring data has shown that proximity to fracking operations is an indicator of the health risks with those living closer being more at risk. Furthermore it was stated that these risks need further study.</p> <p>Cancer risk is 10 in a million for residents living within half a mile from fracking sites. When living further away from the site than half a mile, the risk is reduced to 6 in a million. Benzene used in the fracking industry (generators and trucks) is a major contributor to cancer risk for those living in proximity to the industry. Exposure to chemicals used in</p>

	Air samples were collected following the US Environmental Protection Agency's (EPA) standard protocol for collection and laboratory analysis of the samples. 163 samples were collected in the proximity of an active fracking site and 24 in the proximity of completed wells run by a variety of gas companies.	mile on which most of the study findings are based can have a significant impact on the results depending on the topography of the study sight and is thus not constantly contextually relevant.		the fracking industry such as: tri-methyl-benzenes, xylenes and aliphatic hydrocarbons are the main non-cancer threats to health.
(Helmig et al.,	In this study surface and		Volatile Organic Compounds,	Although VOC is usually negligible during the winter months, this study found that there is a link between oil and

2014)	vertical profile observations of VOC from the Utah Basin were taken to establish the ozone composition of in these fracking sites. Samples were collected in winter in the beginning of 2012 and 2013 from sampling inlets located on a 2-m tower.		Alkane Hydrocarbons, Benzene, Toluene	<p>gas emissions and ozone damage. Measurements taken from air samples reveal that “highly elevated levels of atmospheric alkane hydrocarbons with enhancement rates of C2– C6 non-methane hydrocarbon (NMHC) mean mole fractions during temperature inversion events in 2013 at 200-300 times above the regional and seasonal background.” The total mass of VOC produced each year by the industry equals the emissions of a 100 million cars.</p> <p>“Total annual fugitive emission of the aromatic compounds benzene and toluene, considered air toxics, were estimated at $1.6 \pm 0.4 \times 10^6$ kg yr⁻¹ and $2.0 \pm 0.5 \times 10^6$ kg yr⁻¹ respectively.”</p>
(Rich et al., 2014)	Ambient air samples from 6 residential areas in proximity of fracking sites were collected	The authors mentioned their small sample size as being a limiting factor in this study. Various locations where air sampling was done were as per clients’ requests. This could subject the results to a form of	Methane	<p>This study found that gas and chemical prevalence exceeded that which is found in the ambient air samples of areas where no fracking occurs.</p> <p>Methane was found in 98% of the air samples in amounts (1.8-2.0 ppm_v) exceeding background concentrations.</p>

	<p>and analysed to determine if chemical prevalence and which combination of chemicals can be associated with fracking. Samples were collected by means of 24 hour passive air sampling. 50 samples were taken from 39 areas.</p>	<p>selection bias where only those noticing or anticipating gaseous changes would volunteer to partake in the study. Thus all the homes where there are no gas leaks or problems will remain unmonitored, potentially skewing the results.</p> <p>Furthermore the study was conducted in urban areas and researcher did not account for pollution as a result of traffic for e.g.</p>	<p>Xylene, Ethyl-benzene, Tri-methyl-benzene, Toluene, Benzene</p> <p>And 95 other chemicals are present in the residential fracking area where the study was conducted</p>	<p>Chemicals associated with compression include various combinations of xylene, ethyl-benzene, tri-methyl-benzene, toluene, benzene and was found in air samples in proximity to fracking sights. This paper stipulated the prevalence of these chemicals but did not specify the whether the concentrations were below or above the background levels.</p>
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6.2.4 Air Pollution Reviews Pertaining to Fracking

Table 5: Summary of Reviews Pertaining to Air Pollution and Fracking.

Reviews related to air monitoring and fracking				
Authors, year	Methods	Quality of Evidence	Chemicals/ Hazard/ problem	Findings
(Penning et al., 2014)	Penning et al. (2014) reviewed the current literature pertaining to fracking and the public health risks it potentially poses, from an air pollution perspective.		Diesel fumes	<p>It has been found that ambient air pollution is associated with intensive fracking through numerous pathways. Causes of air pollution ranges from silica dust used to fill fractures to diesel fumes caused by trucks and generators. Inhalation of diesel fumes is associated with increased lung cancer prevalence.</p> <p>PM_{2.5} is released as part of diesel exhaust and can potentially result in lung problems and even cancer. More than 2200 trucks are needed per well head for the fracking process.</p>
(Concerned)	A group of scientist and	This document summarises the available literature on fracking		Literature increasingly provides evidence of the air pollution associated with fracking. Studies related to air pollution and

health professionals of New York, 2014)	experts compiled this review of current literature related to fracking with a focus on health. Peer reviewed and journal articles were included in the review.	according to various categories, to describe what is available. Study findings are stated; however this compendium lacks reporting the types of evidence or combination of studies in order to strengthen arguments. Instead they merely presented the study findings.	<p>Raised levels of air particulate matter</p> <p>Ozone</p> <p>Benzene, Ethyl benzene, Toluene, Xylene</p>	<p>fracking cover a range of information. Some highlight the types of air pollutants as a result of fracking and the potential or anticipated health impacts thereof. Others document the actual increases in health problems associated with air pollution as a result of the fracking industry. This review found that:</p> <p>Fracking contributes to levels of air pollution known to be associated with higher disease and fatality rates. Spikes in airborne particulate matter commonly measured in homes in the proximity of drilling sites, can cause acute health impacts. Infant mortality has increased six-fold in Utah in the last three years likely as a result of the high concentrations of air particulate matter associated with the fracking industry.</p> <p>Ozone production was found to be associated with fracking in Colorado. In Texas, fracking was shown to emit large amounts of Volatile Organic Compounds (VOC) into the air, known to cause respiratory -, neurological problems and cancer. Furthermore, ozone levels in Utah considered dangerous for human inhalation were reported with the main contributor being the fracking industry.</p> <p>Toxins found in the air associated with fracking in the region of Colorado include benzene, ethyl benzene, toluene and xylene and can be linked to neurological problems,</p>
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				respiratory problems as well as cancer.
(Moore et al., 2014)	The authors have reviewed 20 years' literature on air emissions of methane due to fracking. Furthermore they examined fracking regulations. Lastly they reviewed and grouped case studies of air impacts resulting from fracking.	The authors commented on the lack of baseline information related to air emissions and air composition prior to fracking commencing. Thus most of the interpretations in this study is based on estimates and not actual readings and data changes. The lack of evidence is highlighted by this review.	Ozone, Particulate matter, Toxic air pollutants, Methane, BTEX, Non-methane Volatile Organic Compounds (VOC), NO _x , PM _{2.5} , Hydrogen Sulphide, Silica, Carbon Dioxide	<p>The authors of this review stated that there is a gap in the literature pertaining to air pollution as a result of fracking. Literature provides evidence that effective evaluation and program regulation can decrease emissions (and thus decrease the carbon footprint). The available literature substantiates the following conclusions:</p> <p>Air emissions from the natural gas life cycle include greenhouse gases, ozone precursors (volatile organic compounds and Nitrogen oxides), air toxics, and particulates.'</p> <p>A review of methane leakages from the past 20 years' literature found that leakages due to fracking in the USA may be more than expected. State regulatory air emission inventories rely on limited, incomplete and outdated emission factors. Data on the potential polluting activities is not based on standardised measurements.</p> <p>Evidence substantiates that methane concentrations of 28.5ppm were measured in 3400 leaking fracking pipelines in Boston, compared to and exceeding the global background methane concentrations of 1.8 ppm.</p> <p>Chemicals used in the fracking process and thus potentially leaking into the atmosphere include methane, BTEX, Non-</p>

				methane Volatile Organic Compounds (VOC), NO _x , PM _{2.5} , Hydrogen Sulphide, Silica and Carbon Dioxide.
(Brown et al., 2014)	The authors of this paper reviewed literature pertaining to air pollution impacts as a result of fracking, using material available to public as well as journal and peer reviewed articles.	<p>Estimations of the safety of exposure to certain chemicals are not based on actual (real-time) information which is a limitation of many of the studies included in the review.</p> <p>This review holds a lot of value. Methodology is clearly described and justified.</p>	Similar to previous studies and reviews listed above	<p>The authors of the paper stated that the way in which fracking emissions polluting the air is monitored, is insufficient. These monitoring processes fail to measure the exposure time, the interactions with ambient elements or chemical intensities. Average pollutants measured in daily air samples are said to be an underestimate of the prevalence of air toxins in reality.</p> <p>Literature fails to comprehensively address the health risks posed by fracking operations due to the industries not being obliged to state all the chemicals used in the fracking process. Further health concerns stem due to the standards which are set to curb air pollution, failing to consider the health effects as a result of the combinations of pollutants in the air.</p> <p>The weather plays a pertinent role in the extent of chemical air exposure.</p>

6.2.5 Primary Environmental Health Studies Pertaining to Fracking

Table 6: Summary of Primary Studies Pertaining To Environmental Health and Fracking.

Primary studies related to environmental health and fracking				
Authors, year	Methods	Quality of Evidence	Chemicals/ Hazard/ problem	Findings
(Hill, 2012)	Hill explores the effect of the introduction of fracking to an area in Pennsylvania (PA) and the subsequent deterioration of air and water quality, on infant health. Secondary data was used for the analysis of this study. The	<p>In the paper there are typing errors such as “Please see tables ?? and 1”.</p> <p>An inherent bias of Difference in difference methodology such as used in this study are reversion to the mean and must be accounted for in analysis. In this study it was done by means of having a suitably matched control group.</p> <p>The article provides only estimates of the effects of fracking on infant health.</p>	Maternal exposure to fracking during pregnancy	<p>No studies have made any direct links between fracking and health.</p> <p>Hill (2012) found that maternal exposure to fracking within 1.5 miles of active fracking well, is harmful to the development of babies in utero. “These results suggest that natural gas wells close to pregnant mothers’ residences increased LBW by 25%, increased small for gestational age by 17% and reduced 5 minute APGAR scores, when compared to pregnant mothers’ residences that are close to a future well (permit)” Living close to gas wells constituted living within a 1.5 mile radius of an active fracking well which was compared to living within 1.5 miles of a spot which has been allocated to drill wells but operations have not started yet.</p>

	<p>difference in difference (DD) research design was used.</p> <p>Fracking data from the PA Department of Environmental Protection provided information related to well locations of the 2459 wells used in the analysis of this study. Wells where permits have been attained but wells not drilled yet, served as controls. Neonatal records of</p>			
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	<p>infant births between 2003 and 2010 from clinics were the main data source with 1069699 infants included. To be exposed, an infant had to live within 2.5km from a fracking well. The author looked at four health outcomes routinely collected by clinics to ascertain whether there is an association between distance from</p>			
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	fracking site and prevalence of adverse infant health outcomes.			
(Colborn et al., 2011)	The authors of this paper ascertained the chemicals used in the fracking process. Then literature searches were conducted to establish the health effects of these chemicals. Waste water residuals from evaporation pits were used as an example for the	These findings are based on modelling and not empirical evidence.	There are 944 products used in the fracking process containing 632 chemicals BTEX	Colborn (2011) found that chemicals used in the fracking process could have long term public health implications that are seldom disclosed. Health impacts due to exposure to fracking chemicals include: three quarters of chemicals used for fracking could be harmful to the hepatic, sensory, respiratory and gastrointestinal systems. Furthermore half of the chemicals used in the fracking process can result in problems of the neurological and cardiovascular systems, the immune system, nervous systems and the kidneys. Exposure to 25% of the fracking chemicals places one at greater risk for developing cancer and mutations. Of the chemicals used in the fracking process which experts were able to identify, 37% were endocrine disrupting chemicals. These endocrine disrupting chemicals (including oestrogenic and anti-androgenic chemicals) have been found in the fracking fluid, spill water and waste water as well as boreholes in areas surrounding fracking activities and are commonly known to lead to birth defects or infertility (The Endocrine Disruption Exchange, 2014)

	discussion purposes of the paper.			
(Bamberger and Oswald, 2012)	Bamberger and Oswald interviewed 24 farmers living in proximity to the fracking operations and are animal owners, using a standard series of questions. Laboratory results of ground, water and air samples were used where available.	<p>This study failed to sample air, water and tissue in order to establish direct links to the fracking industry.</p> <p>Supporting evidence was mostly anecdotal.</p>	Petroleum hydrocarbons, Quaternary ammonium compounds, Phenol, Arsenic	<p>This study found that farmers living in fracking areas commonly report sudden death and other impacts on their livestock as well as human health issues. One case of human arsenic poisoning required hospitalization was reported. Commonly reported health problems include upper respiratory, dermatological, neurological, and gastrointestinal health impacts, nosebleeds, fatigue and headaches.</p> <p>Furthermore the findings highlight the concern about meat and animal products entering the human food supply chain in the form of meat and other produce, not undergoing safety checks related to chemical exposure.</p> <p>Toxins found in human urine living in the proximity of fracking sites in those six states included phenol (metabolized benzene) and arsenic.</p>
(McKenzie et al., 2014)	McKenzie et al. (2014) conducted a	Researchers assumed that the mothers in the study lived in the same area during the first	Maternal exposure to fracking was	With every tertile decrease in the total 10 mile radius to wells, the prevalence of infants born with Coronary Heart Defects (CHD) increased. In the highest tertile the Odds

	<p>retrospective cohort study in order to establish the association between maternal exposures to fracking due to distance lived from active fracking wells, and infant health outcomes. Logistic and Linear regression was used to establish associations. 124,842 infants from Colorado were included in the study.</p>	<p>trimester of the pregnancy as during the last trimester, which is not necessarily the case. The data used in this paper resulted in researchers not including diagnoses incident later in the infant's life such as after the age of three. Miscarriages and still births were not included in the study due to these records being separated from other maternal and infant records, which could potentially mean that the results are under-represented. Researchers tried to match cases and controls; however factors such as nutrition and socio-economic status, playing an important role in infant health outcomes were not adjusted for subjecting the results to confounding.</p>	<p>found to be associated with infant neural tube defects and coronary heart defects</p>	<p>Ratio (OR) was 1.3 (95% CI: 1.2, 1.5). Neural Tube Defects (NTD) was associated with the first tertile (OR = 2.0; 95% CI: 1.0, 3.9, based on 59 cases) compared to areas where there were no wells within a 10 mile radius.</p> <p>"Exposure was negatively associated with preterm birth and positively associated with foetal growth, although the magnitude of association was small."</p>
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6.2.6 Environmental Health Reviews Pertaining to Fracking

Table 7: Summary of Reviews Pertaining to Environmental Health and Fracking.

Reviews related to environmental health and fracking				
Authors, year	Methods	Quality of Evidence	Chemicals/ Hazard/ problem	Findings
(Garrison et al., 2011)	The authors set out to explain fracking and the potential health risks thereof using a variety of both qualitative and quantitative sources and through expert consultation.	<p>The arguments in this paper are built through the use of emotive language.</p> <p>There is no mention in this publication of the methods that were used in including articles and whether there were exclusion criteria such as published prior to a certain date. Thus the quality of evidence was not really discussed or addressed meaning low quality studies may have been included and used to build arguments. Garrison (2011)</p>	Harmful chemicals identified and used in the fracking process include: ozone, hydrogen sulphide and BTEX (benzene, toluene, ethyl-benzene and xylene). Water used in the fracking industry has been seen to	<p>The authors concluded that fracking threatens human health from a population perspective and has the potential to impede on the health and well-being of communities where gas is being extracted.</p> <p>Furthermore three groups of volatile organic compounds potentially released into the air due to fracking were identified and classified harmful to human health and in the way in which they are used and produced in the gas industry as well as their adverse health effects to humans. Exposure can induce health problems including respiratory problems, sleep apnoea, headaches, vomiting, visual - and smell problems, cardiovascular problems as well as places one at risk of leukaemia and other cancers.</p> <p>According to the authors, gas extraction is known to cause</p>

		failed to substantiate why both qualitative and quantitative evidence was included in this study and how this was beneficial or necessary.	contain suspensions of cadmium, arsenic, mercury, copper, lead, hydrocarbons, hydrogen sulphide and natural gas.	the 'boom-town' effect. Boom towns result in resource shortages such as medical care and schooling as well as other problems like violence according to experts.
(Concerned health professionals of New York, 2014)	A group of scientist and experts compiled this review of current literature related to fracking with a focus on health. Peer reviewed and journal articles were included in the review.	This document summarises the available literature on fracking according to various categories, to describe what is available. Study findings are stated; however this compendium lacks reporting the types of evidence or combination of studies in order to strengthen arguments. Instead they merely presented the study findings.	<p>Infant congenital heart defect</p> <p>Low birth weight babies</p>	<p>Literature increasingly provides evidence of health problems related to the environment and fracking. This review found that:</p> <p>A longitudinal study in Colorado found that there is an association between infant congenital heart defects and density and proximity of fracking sites (10 mile radius of mothers' homes) due to the air emissions caused by fracking. Further evidence supports that mothers living in proximity of fracking areas are more likely to deliver underweight babies than those who live far from fracking sites (numerous studies supports this argument).</p> <p>In Texas, fracking was shown to emit large amounts of Volatile Organic Compounds (VOC) into the air, known to cause respiratory -, neurological problems and cancer.</p>

			Air polluted with Volatile Organic Compounds	Furthermore, in Canada, it was found that there is a higher incidence of hematopoietic cancer in males living in proximity of fracking facilities and dangerous levels of VOCs in the same areas.
(Penning et al., 2014)	Penning et al. (2014) reviewed the current literature pertaining to fracking and the public health risks it potentially poses in order to advise on the scope of future research needed from a public health perspective. Other studies were thus reviewed.	Penning et al. (2014) described their inclusion criteria for including studies into this review and only included peer reviewed literature. The quality of evidence included in this review was not discussed thus poor quality evidence and highly rigorous research carried the same weight in the review.	Congenital heart problems	<p>The lack of baseline data related to the environment makes it impossible for researchers to conduct high quality epidemiological studies related to fracking and the environment.</p> <p>“An association between well density and proximity of natural gas wells within a 10-mile radius of maternal residence with prevalence of congenital heart defects in new-borns was observed” Methodology of this study was not provided in this review but was reviewed in the section related to primary studies.</p>

(McDermott-Levy et al., 2013)	This article reviewed the available literature on fracking and included a variety of sources related to health, air and water pollution as well as some anecdotal accounts from case studies of individuals residing in fracking areas.	The authors did not mention their methodology or research approach. Due to this, the study cannot be replicated and this reduces the validity of the findings.	Health problems affecting multiple systems	<p>The authors of this paper found that common symptoms experienced by people living close to fracking sites include exhaustion, dry eyes, irritable skin, and headaches.</p> <p>The following health problems were reported: respiratory, musculoskeletal, gastrointestinal, immunologic, neurological, sensory, bone marrow, vascular, endocrine, urologic, Changes in lifestyle and stress patterns. Participants living in fracking areas report severe nose bleeds and rashes developed in more than one family member shortly after fracking commenced.</p> <p>Another family experienced severe headaches, nausea, nose bleeds and fatigue following fracking commencing on their property and tested positive for benzene in their blood (known human carcinogen). It is recommended that the 'precautionary principle' be employed when it comes to fracking due to the lack of information relating to the health and long term impacts thereof.</p>
(Finkel and Hays, 2013)	Finkel and Hays reviewed literature related to fracking and health to	The authors did not mention their methodology or research approach. Due to this, the study cannot be replicated and this reduces the validity of review findings.	Lack of evidence	The authors have found that there are no epidemiological studies directly addressing exposure-related health effects as a result of fracking. Due to non-disclosure agreements in the USA as well as the oil and gas companies rights to privacy of their fracking cocktail, the lack of knowledge of the composition of the fracking fluid, further challenge

	establish the implications of drilling for gas from a public health perspective.			researchers.
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6.2.7 Primary Occupational Health Studies Pertaining to Fracking

Table 8: Primary Studies Pertaining to Occupational Health and Fracking and the Associated Health Impacts.

Primary Studies related to Occupational Health and Fracking				
Authors, year	Methods	Quality of Evidence	Chemicals/ Hazard/ problem	Findings
(Esswein et al., 2013)	In this article, the authors discussed the occupational health risk of the exposure to respirable crystalline silica which is used during the fracking process. The national institute for Occupational Health and	The methods of this study were clearly stipulated. The author recruited volunteers into the study thus results could be subject to volunteer or selection bias and not a representation of general workers in the fracking industry.	Crystalline silica exposure	<p>Work in the fracking industry leads to exposure to levels of crystalline silica exceeding the Occupational Health guidelines.</p> <p>According to this study: “Inhalation of crystalline silica can cause silicosis, lung cancer, autoimmune disorders, kidney disease, and an increased risk of tuberculosis”. 68% of workers evaluated who worked a full shift from all sites, surpassed the silica exposure limit of $0.05\text{mg}/\text{m}^3$ recommended by the United States National Institution for Safety and Health, sometimes tenfold. For this intensity of exposure, protective masks and respirators are not deemed sufficient.</p> <p>The authors further found there is no other evidence pertaining to occupational silica exposure in the fracking</p>

	Safety took breathing samples from 111 workers to ascertain exposure to silica in 11 sites in 5 different states in the US.			industry, nor evidence providing information relating to where in the fracking process, workers could be at risk of exposure.
(Environmental Leader, 2014) (not peer reviewed)	In April 2014 there was an earthquake in Ohio, unusual for the area and in proximity to fracking operations. The Department of Natural Resources in Ohio suspended all	This is not an academic article. No references were mentioned in the article and thus following up the quality of the material is challenging.	Earth quake hazard	Ohio Department of Natural Resources (ODNR) stated that water and sand pumped into fracking wells increases the underground pressure potentially resulting in earthquakes which has significant occupational health impacts. Fracking poses earth quake hazard to those working in the industry as well as the surrounding neighbourhoods

	fracking operations in the proximity of the earthquake. Thereafter, this article featured in an online environmental newspaper.			
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6.2.8 Occupational Health Reviews Pertaining to Fracking

Table 9: Summary of Reviews Pertaining To Occupational Health and Fracking and the Associated Health Impacts.

Reviews related to Occupational Health and Fracking				
Authors, year	Methods	Quality of Evidence	Chemicals/ Hazard/ problem	Findings
(Adgate et al., 2014)	This review assesses the health risks of fracking by looking at harmful chemicals used and discarded in the process as well as the social implications of shale gas development.	<p>Mortality rates are averages across the oil industry and the gas industry and thus not merely related to hydraulic fracturing.</p> <p>* In this review the means of establishing this association is not stated. The original source referenced is discussed in the next row.</p>	Increased mortality risk in the workplace in Oil and gas industry	<p>No population based studies exist outlining the public health risks associated with fracking.</p> <p>The authors found that vocational stressors associated with the fracking industry include a high risk of exposure to chemicals, death and accidents in the industry.</p> <p>When studying data from 2005 to 2009 it was established that the mortality rate in the fracking industry is seven times higher in this workplace than in other industries.*</p> <p>Truck traffic has also significantly increased with the average number of trucks accessing in Bradford County in PA, being 40% higher now than a five year average prior to fracking in the area.</p>

(Witter et al., 2014)	This article is a review of literature pertaining to Occupational fatality and injury rate data, the causes of these injuries as well as potential solutions relating to the occupational risks.	The review does not have a methodology section where search methods and inclusion and exclusion criteria were discussed. The quality of evidence in the review is also not discussed in the review thus it is likely to comprise of a combination of credible and poor sources.	Increased mortality risk in the workplace in Oil and gas industry. One third of Oil and Gas industry deaths as a result of Road traffic Accidents (RTA)	The authors have found that the US Bureau of Labour Statistics calculated that the mortality rate is 2.5 times higher in the oil and gas industry than in the building industry and 7 times higher than in other industries. The fatal injury rate of the industry is calculated measuring the number of active wells. Close to 30% of these deaths were as a result of road traffic accidents (RTA) and approximately 20% of deaths were as a result of acute injuries such as being struck by objects.
(Concerned health professionals of New York, 2014)	A group of scientist and experts compiled this review of current literature related to fracking with a	This document summarises the available literature on fracking according to various categories, to describe what is available. Study findings are stated; however this compendium lacks reporting the types of evidence or combination of studies in order to strengthen arguments.	Lack of basic services such as health care Light and Noise pollution	From the review it seems that individuals working in the fracking industry lack access to basic health care and insurance. Chronic light and noise pollution linked to the fracking industry may be detrimental to population health and cause a range of health effects including breast cancer, cardiovascular disease, cognitive impairment and sleep disturbance.

	focus on health. Peer reviewed and journal articles were included in the review.	Instead they merely presented the study findings.		
(Penning et al., 2014)	Penning et al. (2014) reviewed the current literature pertaining to fracking and the public health risks it potentially poses from an occupational health perspective.	Penning et al. (2014) described their inclusion criteria for including studies into this review and only included peer reviewed literature. The quality of evidence included in this review was not discussed thus poor quality evidence and highly rigorous research carried the same weight in the review.	<p>Lack of basic services</p> <p>Population influx</p> <p>Poor health care services related to fracking</p>	<p>In the review, one study showed that two small communities suffered as a result of fracking due to the migratory patterns of lay workers, moving to fracking areas, in search of employment opportunities. This results in public services unable to meet the demand and thus a general deterioration in waste management and access to health care.</p> <p>Another conclusion of this review was that general practitioners practicing in fracking areas, not trained to deal with specialist chemical exposure cases, are not equipped to effectively treat and educate families about the exposure risks in their immediate environments. Furthermore they are unable to warn and educate those working in the fracking industry about the potential risks they face at work and in their immediate environments due to the lack of transparency related to chemicals used in the process.</p>

PART C: Manuscript

Environmental Practice



This article has been prepared for submission to the Environmental Practice Journal. Author instructions for the journal have been attached (Appendix F and G). Further correspondence with the Journal editor confirmed that single line spacing may be used for the tables of the manuscript. Page numbers in this document are subject to thesis requirements.

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Health Risk Perception related to Fracking in the Karoo, South Africa

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Risk Perception, Air pollution, Water pollution, Urban, Rural, Environmental health, Hydraulic Fracturing, Shale gas, Trust, Public awareness

Abstract

Shale gas exploration by means of Hydraulic Fracturing (fracking) has been on the South African (SA) energy agenda since 2010 as a potential alternative to coal. Internationally, the desirability of fracking is debated due to increasing evidence of the environmental and health risks fracking poses. Limited scientific evidence is available internationally related to knowledge and risk perceptions of fracking; none from SA. This cross sectional study explored the knowledge, health risk perceptions and information sources related to fracking amongst 102 Central Karoo residents through a household survey. The study found that 40% of Central Karoo residents do not know what fracking is or the potential risks and benefits thereof. Media is the main information source of 59% of participants. Only half of participants trust their information sources. Those with more trust in their information sources perceived fracking as posing a greater risk. In contrast those believing fracking to pose a low risk were more likely to trust the government and oil and gas companies. More than half of participants (53%) believe that fracking poses an extreme health risk and 78% thought fracking will harm their health. Most commonly listed causes why fracking will make Karoo residents sick includes water pollution (47.4%) and air pollution (19.6%). Higher education was found to have an inverse relationship with trust in the national government.

Introduction

There is intense interest by International Oil and Gas Companies in the application of Shale Gas Extraction by means of horizontal Hydraulic Fracturing (Fracking) in South Africa (SA). Fracking is a technique, commonly used in the United States (US) to retrieve natural gas from shale rock found three to five kilometres below the ground (Swiss Centre for Applied Ecotoxicology et al., 2013; Vengosh et al., 2014). However, in SA it is unknown what people know and think about fracking and there is a gap in how public opinion can inform decision-making related to fracking. Therefore this research is critical in providing public with a platform to collectively raise their voice. Government will benefit as public knowledge and opinion should direct their focus regarding public opinion on the fracking.

The SA economy is highly dependent on coal for its energy and fracking has been presented as an attractive alternative energy source with lower greenhouse gas emissions (South African Energy Department, 2013). Evidence suggesting that fracking may have a number of health impacts is increasing (Adgate et al., 2014; Bamberger and Oswald, 2012; Kovats et al., 2014); however, much of this is based on modelling and risk assessment approaches whereas limited epidemiological evidence is available at present. Studies have suggested that fracking results in elevated methane emissions (Concerned health professionals of New York, 2014; Osborn et al., 2011; Vengosh et al., 2014) and potential increases in Volatile Organic Compounds (VOC) (Fontenot et al., 2013; Helmig et al., 2014; Penning et al., 2014) many of which are known to be carcinogenic (Colborn et al., 2011; McKenzie et al., 2012; Penning et al., 2014). Water contamination with methane as a result of poor containment by well casings has been found in Pennsylvania (PA) (Helmig et al., 2014; Katzenstein et al.,

2003; Vengosh et al., 2014) and risks from direct contamination of water from fracking fluids are of concern (Finkel and Hays, 2013). As a result, some countries have initiated national bans on fracking (Environmental Systems Research Institute and ArcGIS, 2014).

SA hosts approximately the 5th largest Shale gas reserve in the world, situated in the Karoo basin (Jackson et al., 2012). The Karoo is a semi-arid region and comprises 40% of the SA land mass (du Toit, 2014). This environment hosts a rich biodiversity of endemic succulent species. Sheep farming is the economic driver and main source of agriculture in the Karoo (Beaufort West Municipality, 2014).

In 2011, five companies, Shell, Bundu, Falcon, Anglo and Sasol, were given permits to start fracking exploration in the Karoo. Sasol has since retracted their application. However, the SA Department of Mineral Resources announced a moratorium on fracking, which ran from February 2011 to September 2012 to allow for passing regulations to ensure environmentally sustainable practices pertaining to fracking. These draft regulations were published in October 2013 and revised and re-published in August 2014 (Department of Mineral Resources, 2013). Although President Zuma used the language of the Oil and Gas industry when he stated that fracking is a 'Game Changer' for SA during his 2014 presidential address, to date, final decisions and regulations related to fracking in SA are still pending.

In the United States (US), studies have quantified risk perceptions related to fracking and identified critical factors shaping such perceptions (Brasier et al. 2013; H. Boudet et al. 2014) in order to inform risk communication and policy decisions. In SA, risk perception studies have examined risks in mining and agriculture related to pesticides (Muntingh, 2011;

Rother, 2000, 2008); however, no scientific inquiries have been made into fracking and health risk perception in the Karoo, SA. This research informed important areas of knowledge distribution and thus have given a small number of individuals from the Central Karoo (CK) a voice relating to fracking. This study elicited perceptions of participants local to an area where fracking exploration is planned. The findings serve as a valuable starting point for future larger studies giving marginalized communities potentially affected by fracking a communal voice.

Objectives

This study investigated the knowledge and health risk perceptions of Central Karoo residents related to fracking and determined factors associated with these perceptions in order to increase scientific understanding of the risk perception of CK residents. This information is essential if the SA government decides to proceed with fracking to better manage anticipated risks and further to fill the gap in the Sub-Saharan African literature related to risk perception.

It also described information sources related to fracking for CK residents and their levels of trust in these sources, the government, oil and gas companies and independent scientists.

Methods

Study Site

Beaufort West (BW) Municipality in the CK in SA was selected as the study site for this research because this is one of the sites selected for fracking exploration and the closest part of the Karoo to the Cape Town; a limited budget precluded travelling further. The population of BW municipality are predominantly Afrikaans speaking, followed by Xhosa and English (Department Provincial and Local government of South Africa, 2005). BW is the district capital. The CK region is internationally renowned for sheep farming often marketed as 'Karoo Lamb'. Four different household types are found in BW municipality namely: formal urban; urban Reconstruction and Development Program (RDP) housing; farmer houses; and farm workers' housing. Formal urban could be described as housing owned or rented in urban areas. RDP housing refers to state-provided housing for previously disadvantaged South Africans. Farmer and farm worker housing are both located on farms but the latter are generally of poorer quality and owned by the employer. Statistics SA population estimates for each household type in the area were used to determine the size of the sample in each housing type stratum.

Population and study design

An analytical cross sectional study was conducted. In the absence of contextually relevant evidence, a sample size of 97 was calculated using an anticipated population proportion of 50% with a desired precision of 10% and rounded up to 100 participants. The study recruited 102 participants and data were collected by means of household surveys. Subjects

unable to fluently communicate in either Afrikaans or English or being 17 years or younger were excluded from this study.

To select the urban households, a proportional stratified sample was used. With assistance from the BW police as well as maps from the National Geospatial Institute (NGI), neighbourhoods within the greater BW municipality were divided into urban town - and urban RDP housing; all of the six urban town neighbourhoods were included in the study; of the eight RDP neighbourhoods, four were randomly sampled – the ratio being based on proportional CK population estimates. Within each household, interviews were conducted with one adult meeting the inclusion criteria. In the rare case where there was more than one adult willing to participate, the household members were told what the study was about and given the opportunity to appoint the most suited candidate. Visitors were excluded. In each of the selected urban areas, a random starting point was selected on a map; every third house was included in the study thereafter until desired study numbers were attained.

For rural households, a cluster sampling method was used. Information provided by the Central Karoo Agricultural Society divided farms in the Central Karoo into six geographical areas. Due to large distances between farms, it was not feasible to randomly select farms. In each area, 2 farms were selected - the farm closest to BW and third closest to BW. Because it was common for family members to farm adjacent to each other, non-contiguous farms (1st and 3rd) were chosen rather than contiguous farms (1st and 2nd). On each selected farm, interviews were conducted with one farmer or member of farming household and one farm worker per farm. At 6 of the 8 farms, farmers invited farm workers to participate in the

study prior to the appointment time with the researcher. In two cases, the researcher joined the farmer in the field and sheering pen, respectively, and asked the workers who of them were willing to participate; thus two volunteers were included.

This multistage sampling procedure aimed to achieve a sample representative of the composition of the Central Karoo population.

The questionnaire was piloted in the Western Cape with 7 individuals representing different strata in this study. The survey was shortened and language simplified after the pilot study. Housewife was added as an employment category and 'Don't know' was added as a fifth choice to the multiple choice questions.

Survey Instrument

A face-to-face questionnaire was used to explore fracking knowledge (section 1), socio-demographic information (section 2), perceptions of fracking (section 3), health risk perception (section 4), and trust of fracking information sources, oil and gas companies, independent scientists (section 5) and government (section 6).

Because the research aimed to establish the perceptions of a representative sample of the Central Karoo population related to fracking, those who said that they did not know what fracking was, were included in this study but were given the following standardized explanation of fracking:

“Fracking is a method of attaining gas from deep rock layers two to five kilometres under the ground. This gas is valuable like petrol and diesel and could lower energy prices and create jobs. The exploitation of such gas requires the use of large amounts of water. Experts

claim that fracking can cause air and water pollution. Internationally, there are contrary opinions about the cost-benefit ratio of fracking. South Africa is considering fracking in the Karoo as a means to provide for the country's increasing energy demands. With this questionnaire we would like to establish your opinion on fracking.”

To increase validity of the questionnaire by demonstrating neutrality in the research process, some questions were asked in ways that appeared to favour fracking and others in ways that appeared to oppose fracking. Refer to Surveys in Appendix B.

The perception questions related to fracking were adapted from other instruments: questionnaires used in US studies on fracking perception (Brasier et al., 2013; Ford et al., 2013), a SA pesticide risk perception study (Rother 2000; 2008) and a survey by the Centre for Environmental Rights on Social Justice related to environmental rights designed in and for SA (Personal communication, Mr James Irlam, date 5/6/2014).

English surveys were translated to Afrikaans and back translated to English in order to check translation accuracy. Face-to-face interviews were conducted in participants' language preference (Afrikaans or English) by the principle researcher or trained fieldworker.

During the capturing of the data it became evident that the question: 'The government will not be effective in regulating the fracking industry' was not answered consistently due to the negative sentence construction which confused respondents. This was evident from the researchers' understanding of the position the participant took towards fracking as well as the inconsistency of the answer to this question compared to other answers. Thus, this question was omitted from analysis as the answers to this question were deemed to be an inaccurate representation of participants' opinions.

Participants were asked about the duration they have been living in the Karoo and this was expressed as a proportion expressed in relation to their age¹.

Outcome variables

There were 5 outcome variables pertaining to health risk: (a) perceived health risk ‘From a health perspective, how much risk do you think fracking holds?’; (b) whether fracking in the Karoo will make people living in the Karoo sick; (c) whether fracking will harm participant’s own health; (d) whether maternal exposure to fracking will harm infant health and, (e) whether the participant will work in the fracking industry if the opportunity presented itself. The outcome variables were rated on a four-point Likert scale with ‘Don’t know’ as a fifth option.

Statistical analysis

Google forms were used to capture the surveys into electronic format. Microsoft Excel and Stata edition 12.1 was used for data analysis.

Univariate Analysis

Exploratory data analysis included univariate – and bivariate analysis of all quantitative variables as well as the analysis of open ended questions. For bivariate and multivariate analysis, variables were dichotomized combining ‘Agree strongly’/‘Agree’ and ‘Disagree strongly’/‘Disagree’; ‘Don’t know’ responses were omitted. Health risk perception was dichotomized into ‘Some to Moderate Risk’ and ‘Extreme Health Risk’. No respondents gave answers indicating that fracking poses ‘no risk’ from a health perspective.

¹ *Proportion of life lived in the Karoo* = $\frac{\text{Median Duration lived in Karoo}}{\text{Median Age}}$

Post-coding was used to categorize the answers to open-ended questions into relevant themes based on Hennink's Textual Data Analysis (Hennink et al., 2011). Open-ended questions related to fracking information sources, why participants think that fracking will make people sick and types of diseases that participants associate with fracking and responses were tabulated into themes and quantified. Responses to the question: 'Why did you agree that fracking will make people living in the Karoo sick?' were categorized into Direct Health Effects, Indirect Health Effects and responses not directly associated with health, but with potential long term health impacts. Participants' answers when asked about their information sources related to fracking were categorized as Media if they said any of the following: Television, newspaper, radio, internet, magazines and documentaries and Personal Opinion where they stated that answers were based on 'common sense', 'own experience' or 'personal opinion.' 'Gas can make people sick' was selected as a category due to the large number of participants stating this directly or in a more roundabout way.

Bivariate Analysis

For bivariate analysis of dichotomous variables, the Chi-square or Fischer's exact test was used depending on the size of the expected frequencies. Pearson's correlation coefficient was used to ascertain the strength of correlation between two continuous variables.

Multivariate Analysis

Multivariate logistic regression was used to establish factors associated with risk. Independent variables considered in the model included: gender, language, education, age and four trust variables (trust information sources, trust oil and gas companies, trust independent scientists and trust in government). Because of co-linearity, the following variables were excluded from the logistic regression: household income, employment,

housing type, property owners and duration lived in the Karoo. First a forced model was constructed where all the above mentioned variables were included in the model. Following this, a manual model was built through ordinal logistic regression by means of stepwise selection of variables to include in the model in order to identify variables associated with the outcome - risk.

For the bivariate and multivariate analysis, statistical significance was taken as a p-value < 0.05 but note was taken of p-values <0.1 as being of borderline significance in discussion.

Results

Participation

The sample realized was 102, which was slightly higher than the planned sample of 100 participants. Ages ranged from 19 – 84 years. Table 1 reflects the demographics of participants as well as the sample categorized according to housing types. Farm residents and workers were recruited from 8 farms. Completeness of responses varied across different questions from 91-98% for 7 questions and 100% for the remaining 31 questions.

Univariate Analysis

Demographic and socio-economic information of participants

The median age of participants was 48.5 years and 60% were female (Table 1). Afrikaans was the home language of 85% of the study participants. For 34% of the participants, monthly household income did not exceed R3000 (approximately 265 US\$) per month. On average, the proportion of their lifetime that study participants lived in the Karoo was 74%². Further 87% of participant's reported that their immediate families own property in the Karoo. These findings suggest that the sample found residents with longevity and who are rooted in the Karoo as most of the participants spent most of their lives in the Karoo and also own property there.

²Proportion of life lived in Karoo = $\frac{\text{Median Duration lived in Karoo}}{\text{Median Age}} = \frac{36}{48.5} = 74.2\%$

Table 1: Demographics and fracking knowledge of study participants (n=102).

Characteristics	Median (IQR)	n (%)
Gender		
Male		41 (40.2)
Female		61 (59.8)
Age (in years)	48.5 (32.0-61.0)	
Home Language		
Afrikaans		87 (85.3)
English		3 (2.9)
Xhosa		12 (11.8)
Education		
None		9 (8.8)
Completed Primary School		38 (37.3)
Completed Secondary School		33 (32.4)
Completed Diploma		15 (14.7)
Completed Degree		7 (6.9)
Annual household Income		
< R3000 per month		35 (34.3)
R3001 – R6000 per month		21 (20.6)
R6001 – R10 000 per month		11 (10.8)
R10 001 – R50 000 per month		19 (18.6)
> R50 000 per month		5 (4.9)
Don't know		11 (10.8)
Employment		
Generating any income [*]		71 (69.6)
Employment not generating an income		31 (30.4)
Housing type		
Town House		52 (50.5)
RDP ^{**} House		34 (36.1)
Farmer's House		8 (8.2)
Farm Worker's House		8 (8.2)
Duration lived in Karoo (in years)	36 (22.0-55.0)	
Family Own Property in the Karoo		89 (87.3)
Fracking knowledge		
Knows what fracking is		61 (59.8)
Does not know what fracking is		41 (40.2)
Is fracking proposed for Beaufort West?		
Yes		41 (40.2)
No		10 (9.8)
Don't know		51 (50.0)

Note:

* Employment generating any income refers to those individuals who have any form of income irrespective whether it is their occupation or a government – or disability grant.

** Reconstruction and Development Program Housing

General Fracking perceptions

A slight majority of participants (54%) responded that they would not permit fracking in the Karoo (Table 2). A nearly equal proportion of participants agreed (27%) and strongly disagreed (28%) that fracking will increase tourism in the Karoo. Nearly half of the participants (48%) agreed or strongly agreed that 'Fracking will be beneficial to Karoo residents'.

Risk perceptions related to fracking

More than half of the participants (52%) said that they would not work in the fracking industry if the opportunity presented itself (Table 2). Two thirds of participants said that fracking will make Karoo residents sick (67%) and a quarter (24.5%) of the participants said that they did not know. This is the highest proportion of 'Don't know' responses of all the questions in the survey. The majority (72%) believed that maternal exposure to fracking is detrimental to foetal health and 78% of participants believed fracking will harm their own health. When asked how much risk participants think fracking holds from a health perspective, no-one said that fracking holds no risk and 53% of participants thought fracking poses an extreme health risk.

Table 2: Risk perception and trust related to fracking of Central Karoo Survey Residents (n = 102).

Variable	Agree Strongly n (%)	Agree n (%)	Disagree n (%)	Disagree Strongly n (%)	Don't Know n (%)
General perception of – and attitudes towards fracking					
I would not allow fracking in the Karoo	42 (41.2)	13 (12.8)	21 (20.6)	14 (13.7)	12 (11.8)
Fracking will increase tourism in the Karoo	13 (12.8)	28 (27.5)	23 (22.6)	29 (28.4)	9 (8.8)
Fracking will be beneficial to Karoo residents	14 (13.7)	35 (34.3)	16 (15.7)	29 (28.4)	8 (7.8)
Health risk perception related to Fracking					
I would work in the fracking industry (for an oil company) in the Karoo if the opportunity presented itself	18 (17.7)	28 (27.5)	23 (22.6)	30 (29.4)	3 (2.9)
Fracking will make Karoo residents sick	30 (29.4)	38 (37.3)	7 (6.9)	2 (2.0)	25 (24.5)
Maternal exposure to fracking will be detrimental to fetal health	36 (35.3)	37 (36.3)	10 (9.8)	2 (2.0)	17 (16.7)
Fracking will harm personal health	44 (43.1)	36 (35.3)	14 (13.4)	1 (1.0)	7 (6.9)
Perception of extent of Health Risk	No risk	Minimal risk	Moderate Risk	Extreme risk	Don't Know
From a health perspective, how much risk do you think fracking holds?	0 (0.0)	12 (11.8)	21 (20.6)	54 (52.9)	15 (14.7)
Extent of Trust in different sources	No trust	Some trust	Fair amount of trust	Great trust	Don't Know
Trust in the accuracy of information I have related to fracking	6 (5.9)	12 (11.8)	23 (22.6)	51 (50.0)	10 (9.8)
Trust Fracking companies	43 (42.2)	20 (19.6)	19 (18.6)	14 (13.7)	6 (5.9)

who applied for licenses to frack in the Karoo					
Trust independent scientists regarding fracking	12 (11.8)	14 (13.7)	24 (23.5)	44 (43.1)	8 (7.8)
Trust in government	Agree Strongly	Agree	Disagree	Disagree Strongly	Don't Know
I trust the government	7 (6.9)	18 (17.7)	15 (14.7)	47 (46.1)	15 (14.7)

Note: n = number of participants

Trust in fracking authorities and information

Half of all the participants (50%) have great trust in their information sources related to fracking (Table 2). Over a third of participants (42%) have no trust in oil and gas companies who applied for licenses to start fracking in the Karoo. In contrast, 43% of participants have great trust in independent scientist regarding fracking. When asked if participants trust the government in relation to fracking, 46% said that they disagree strongly. Interestingly also, 15% of participants said that they do not know whether they trust the government.

Summary of open-ended questions on health risks and information source

Respondents were asked for more details in the form of open-ended questions explaining some of their responses.

Why will fracking make people sick

Table 3 presents CK Residents' rationales (n=97) for why they think fracking will make people in the Karoo sick.

The most common direct health effects singled out by participants was: 'Gas can make you sick' (17.5%). The most commonly listed indirect health problems as a result of exposure to fracking included: water pollution (47.4%) and air pollution (19.6%).

An important reason not directly associated with health but which had potential long-term health impacts was a lack of knowledge pertaining to fracking (17.5%). One tenth of the participants (10.3%) answered that they 'Don't know' why they said that fracking will make Karoo residents sick and only 3.1% said that they base their answers on international fracking evidence.

Table 3: Respondent's motivations for why they think Fracking will make people in the Karoo sick. n=102

Participant Responses	%
Direct Health Effects	
Gas can make people sick <ul style="list-style-type: none"> - The gas [referring to shale gas] will make the people living in the Karoo sick. - If we extract this gas and bring it to the surface it can cause disease. 	17.5
Chemical exposure <ul style="list-style-type: none"> - Accidents in the fracking industry results in chemical spills. - Different types of chemicals and materials are used in the fracking process. We do not have knowledge about how these chemicals will impact our bodies. 	8.2
Health problems [specifically mentioned] <ul style="list-style-type: none"> - People could get potential lung problems and asthma from fracking. - Lungs will be affected. Gas will attack the lungs and people can get asthma attacks [as a result of fracking]. 	7.2
Indirect Health Effects	
Water pollution <ul style="list-style-type: none"> - International evidence about fracking supports water pollution which can make people exposed to this water sick. - Water pollution and chemicals used in the process will impact those drinking the water. 	47.4
Air pollution <ul style="list-style-type: none"> - Fracking will cause air pollution and people will get sick due to all the gas in the air. - It will [make people in the Karoo sick] as there are very few factories here polluting the air and fracking will pollute the air and cause lung problems. Air pollution as a result of fracking can cause global warming which will also affect health. 	19.6
Social problems/Social influx <ul style="list-style-type: none"> - Social problems such as HIV, alcohol abuse and housing shortages will be evident [as a result of fracking]. Long term food insecurity will cause hunger, malnutrition, poverty and infectious diseases. - A larger concentration of people who will flow into our area as a result of potential working opportunities, results in hygiene problems and a greater incidence of infectious diseases. 	7.2
Detrimental to agriculture <ul style="list-style-type: none"> - Livestock will get sick from drinking the polluted water and thus the meat will no longer be fit for human consumption. 	5.2
Noise pollution <ul style="list-style-type: none"> - It [fracking] will result in noise pollution. 	1.0

Responses Not Directly Or Indirectly Associated With Health, However With Potential Long Term Health Impacts	
Lack of evidence/knowledge <ul style="list-style-type: none"> - We do not have knowledge about how these chemicals [referring to those used in the fracking process] will impact our bodies. - Nobody knows what the real impact [of fracking] will be. 	12.4
Don't know	10.3
Mining comparison <ul style="list-style-type: none"> - My family in law lived and worked in Kuruman at Asbestos mine. One son obtained Asbestosis and passed away. During their time in the mine they did not immediately become sick or show signs of contamination, the problems only started many years later. Thus Fracking can also hold long term health risks which we currently do not know about. - Anywhere where people mine, health problems are prevalent. Maybe they will not experience problems right now, but the next generation will suffer. 	4.2
Fracking will not make one sick <ul style="list-style-type: none"> - Other mines do not make people sick. There are fracking mines elsewhere where we can learn what to do and what not to do. 	4.1
Long term problems <ul style="list-style-type: none"> - Anywhere where people mine, health problems are prevalent. Maybe they will not experience problems right now, but the next generation will suffer. - Long term food insecurity will cause hunger, malnutrition, poverty and infectious diseases. 	4.1
Lack of water <ul style="list-style-type: none"> - In Beaufort West we already have to reuse sewage water for drinking due to the terrible lack of water we have in the town for consumption. The fracking process needs a lot of water and thus this will endanger and potentially pollute the little bit of water that we currently have. 	3.1
International evidence <ul style="list-style-type: none"> - Internationally where the people are fracking, there are many health problems. In US water had to be brought in to farmers in large amounts as all the naturally occurring water on the farms were contaminated by fracking. 	3.1
Poor management <ul style="list-style-type: none"> - Plants and livestock that are consumed as food products can make people sick, but this is merely if there are accidents, spillages or poor management. 	1.0

Note:

- Respondents had the opportunity to provide multiple responses.
- Bulleted points are direct quotations from participants.
- [] indicate where the researcher added to the quotes to provide context as quotes are only snippets of participants' statements.

Health risks people perceive to be as a result of fracking

Of short-term health risks identified by respondents, the most common were stomach problems (32%) and respiratory problems (25%). Notably, more than a third of the participants (36%) did not have an opinion of the short term health risks associated with fracking.

The long term perceived health risk of fracking was dominated by cancer (29%). More than a quarter of participants (26%) believe that fracking may cause asthma, lung and respiratory diseases and a quarter of participants said TB. Interestingly 13% of participants said that HIV/AIDS is a long term health risk of fracking. Other long term health risks included alcohol related diseases hypertension, infertility, neurological damage and joint diseases. One fifth of participants said that they are not familiar with the long term risks or diseases as a result of fracking.

Information Sources related to fracking

Study participants were asked about their source of information. (Table 4) The media was the information source reported by most participants (59%). More than half of the study participants (56%) said that they based their answers on their personal opinion. About a fifth (19%) of participants said that the researcher or fieldworker was their only fracking information source. Other information sources include meetings in local community including municipal and agricultural society meetings (17%) and mining comparison with other mining towns (16%).

Table 4: Respondent's information sources related to Fracking. n=102

Participant Responses	%
Media (Including TV, Newspaper, radio, internet, magazines, documentaries, e-mail) <ul style="list-style-type: none"> - A lawyer in Graaff-Reinet who is knowledgeable about fracking talks on the radio often. - I read about American diseases due to Fracking in the newspaper. - Saw videos on You Tube about fracking. [Internet] - TV (50/50). 	59
Personal Experience / Own opinion <ul style="list-style-type: none"> - I use my healthy mind and common sense. - By looking at nature and knowing the Karoo inside out since his youth... Nature will not be able to handle this thing. - I have lived through changes such as proposed with fracking and saw the impact it has had on my community. 	56
Hearsay / Word of mouth / Family <ul style="list-style-type: none"> - My son worked at the Agricultural research Centre in Pretoria and he provided useful information [about fracking]. - My husband is involved in fracking talks and meetings and relay the plans, advantages and disadvantages thereof to me. My husband reads a lot about fracking as he is constantly talking to the farmers in his work and thus he is up to date. He tells me what is going on. - My cousin's child is currently of school going age. Someone came to the school she is attending and explained about fracking. My cousin told me about it. Truck drivers passing through Beaufort West carry some of the equipment for the wind farms. I have had interaction with them from time to time and we have discussed various energy options and alternatives. 	20
From Researcher <ul style="list-style-type: none"> - From the information the fieldworker provided me with 	19
Community meetings (includes Agricultural society - and Municipal meetings) <ul style="list-style-type: none"> - Attend community and Agriculture meetings [where fracking is discussed]. 	17
Mining comparison <ul style="list-style-type: none"> - I know people who worked at a mine and got sick from working there and I compare this to what will or could happen in the fracking industry. - I come from the Kuruman region so have seen the effects of the mines there. I have witnessed some of these court cases related to mining pollution in that area and I base my answers on that. - People become sick in towns where there are mining activities. 	16
Other <ul style="list-style-type: none"> - My medical background as Doctor. - Prophetic insight translated from Afrikaans: "The Lord laid it on my heart". - Lack credible information [pertaining to fracking]. 	9
From Clinic <ul style="list-style-type: none"> - Talk about fracking at the clinic. - [According to Nelspoort clinic] TB was associated with all the trucks on the national road. Therefore I think Fracking can result in similar conditions due to the amount of water needed in the process that will be transported here with trucks. 	8
From School or teaching institution <ul style="list-style-type: none"> - I learnt about the mines and their impacts during school. - I learnt in school in Geography about fracking. Further we had a debate at one of our schools about fracking. 	6

Meetings with Oil and Gas companies <ul style="list-style-type: none"> - Chevron came to tell the farmers about the [fracking] process and was honest about advantages and disadvantages thereof. - Community meetings hosted by Shell. 	5
From Employer <ul style="list-style-type: none"> - I used to work on a farm and learn quite a bit there about the long term effects of fracking. - Informative emails we get at work related to tourism and Beaufort West. 	4
Don't know	2

Note:

- Respondents had the opportunity to provide multiple responses; responses are therefore not mutually exclusive.
- Bulleted points are direct quotations from participants.
- [] indicate where the researcher added to the quotes to provide context as quotes are only snippets of participants' statements.

Bivariate Analysis

Relationship between Trust and Demographic Variables

There were no associations found between demographic variables and (i) trust in fracking information sources, (ii) trust in independent scientists and (iii) trust in oil and gas companies, except for variations in housing type. Those living on farms (farmer or farm worker houses) were more likely to have little to no trust in oil and gas companies compared to those living in urban (urban formal or RDP) houses (93% versus 61% respectively; $p=0.01$).

A number of statistically significant associations were found between demographic variables and trust in the government (expressed as agree/disagreement with the statement 'I trust the national government'). Respondents who were better educated (82% Grade 12 and above versus 56% amongst those with less than Grade 12 education; $p=0.01$) of higher socio-economic status (82% for monthly household income $> R3000$ versus 48% for monthly household income $\leq R 3000$; $p=0.01$) and reported paying employment (80% versus 52% of respondents with no income-generating employment; $p=0.01$) were more likely to disagree or disagree strongly. Those who had little or no trust in government tended to be older than those who reported some trust (mean 49 years versus 42 years; $p=0.10$) but the difference was not statistically significant. (Detailed tables are available from author.)

Relationship between Risk and Demographic Variables

Although no-one perceived fracking to hold no health risk, there were no associations between demographic variables and (i) perception of health risk; (ii) perception of risk to the unborn foetus as a result of maternal exposure to fracking; (iii) perception that fracking is detrimental to personal health and (iv) that fracking is detrimental to the health of those living in the Karoo.

A number of statistically significant associations were found between demographic variables and reported willingness to work in the fracking industry. Respondents who were less educated (58% of respondents with education up to Grade 11 versus 37% of respondents with Grade 12 and higher) of lower socio-economic status (70% of respondents with household income of \leq R3000 per month versus 36% of respondents with household income of $>$ R3000 per month; $p=0.01$), had no paying employment (68% of respondents with no income generating employment versus 37% of respondents who held any income generating employment; $p=0.01$) and respondents who lived in urban housing (54% of those in formal houses (formal urban and RDP) versus 0% of those living in houses on a farm (farmer and farm worker housing); $p<0.001$) reported that they were willing to work in the fracking industry. Again, as for trust, those reporting unwillingness to work in the fracking industry were slightly older than those expressing willingness (mean age 51 years, versus 44 years; $p=0.06$) but the difference was only marginally significant. (Detailed tables are available from author.)

Relationship between Risk and Trust

Those who disagreed with the statement “I trust the government” are 4.3 (95% CI: 1.4-14.1) times more likely to believe that fracking poses an extreme health risk and 5.0 (95% CI: 1.2-20.1) times as likely to believe that fracking will be detrimental to their own health. Conversely, those who agreed that they trust the government are 6 times more likely to agree to work in the fracking industry (Table 5).

Those who have no/little trust in oil and gas companies are 10.5 (95% CI: 3.3-34.4) times more likely to believe that fracking poses an extreme health risk, and 6.7 (95% CI: 1.2-44.8) times more likely to agree that fracking is detrimental to others health. Those with moderate to great trust in oil and gas companies are 10.5 (95% CI: 3.5-33.4) times more likely to agree to work in the fracking industry.

Table 5: Odds Ratios¹ showing relationship between risk and trust variables.

	Risk variables ³				
Trust variables ² (Predictors)	Health Risk Perception ⁴	Detrimental to Fetus	Detrimental to own health	Detrimental to other's health 'Fracking will make Karoo residents sick'	Willingness to work in fracking industry
Trust Information Sources	1.03 (0.27-4.37)	0.45 (0.10-2.42)	0.24 (0.06-1.02)	0.56 (0.08-6.45)	1.05 (0.32-3.65)
Trust Oil and Gas Companies	10.45 (3.27-34.44)	2.19 (0.47-9.71)	3.14 (0.86-11.51)	6.67(1.21-44.75)	10.45 (3.47-33.41)
Trust Scientists	1.73 (0.57-5.69)	1.71 (0.30-17.80)	1.04 (0.26-5.02)	-	1.83 (0.65-5.38)
Trust Government Case: Agree Control: Disagree	4.33 (1.37-13.97)	4.93 (0.98-26.61)	4.95 (1.24-20.06)	5.24 (0.86-36.94)	6.00 (1.93-19.72)

Note: ¹Prevalence Odds Ratio (95% Confidence Interval)

²Trust defined as 'Moderate to great trust' versus 'No to little trust'

³Risk (except Health Risk perception) defined as 'Agree' versus 'Disagree'

⁴Health risk perception defined as 'Some to moderate risk' versus 'Extreme risk'

Relationship between Sources of Information and Trust Information Sources

No associations were found between different types of Information sources and Trust in Information Sources.

Associations with Risk Perception: Multivariate Analyses

Each risk outcome was modelled on potential predictors (gender, age, language, education and 4 trust variables: in information sources, in oil and gas companies, in independent scientists and in government), as described in the methods. The results of the forced modelling did not identify predictors associated with the respective outcomes different to those generated from stepwise modelling; only the latter are presented in Table 6 (full result tables available from the author).

For general health risk perception, only trust in Oil and Gas companies was significantly associated. Those with moderate to great trust in Oil and Gas companies, were 85% less likely (POR 0.15; 95% CI 0.05-0.47) to believe that fracking poses an 'Extreme Health Risk', compared to those with no or little trust in the Oil and Gas companies.

For the belief that maternal exposure to fracking is detrimental to foetal health, those with moderate to great trust compared to those with no or little trust in their sources of information, were 5.07 times (95% CI 0.94-27.44) more likely, and those who trust government compared to those with no or little trust were 86% less likely (POR 0.14; 95% CI 0.03-0.69) to believe that maternal exposure to fracking is detrimental to foetal health.

Those with moderate to great trust compared to those who do not trust or have minimal trust in their sources of information are 7.26 times (95% CI 1.49 - 35.31) more likely to perceive that fracking is detrimental to one's own health; and those with moderate to great trust compared to those with no or minimal trust in Oil and Gas companies are 81% less likely (POR 0.19; 95% CI 0.01-0.48) to believe that being exposed to fracking is detrimental to personal health.

With every additional year of age, the participant's likelihood of believing fracking was a risk to others' health declined by 6% (POR 0.94; 95% CI 0.87-1.01) (Table 6). Additionally, those with moderate to great trust compared to those with no or minimal trust in Oil and Gas companies are 96% less likely (POR 0.04; 95% CI 0.01-0.48) to believe that being exposed to fracking is detrimental to others' health.

Reported willingness to work in the fracking industry was strongly related to two trust variables. Those with moderate to great trust in Oil and Gas companies compared to those with no or little trust were 14.85 times (95% CI 3.73-59.16) more likely, and those who trust the government compared to those who do not trust government, were 9.00 times (95% CI 2.13 - 38.10) more likely to report that they would work in the fracking industry if the opportunity were to present itself.

Table 6: Multivariate regression: Summary of Prevalence Odds Ratios (POR) through stepwise models.

VARIABLE¹ POR (95% CI)	Health Risk Perception²	Risk to foetal health³	Risk to one's own health³	Risk to Others' health³	Willingness to work in fracking industry³
Gender	-	-	-	-	-
Age	-	-	-	0.94 (0.87 - 1.01)	-
Home Language	-	-	-	-	-
Education	-	-	-	-	-
Trust Information Sources ⁴	-	5.07 (0.94 - 27.44)	7.26 (1.49 - 35.31)	-	-
Trust Oil and Gas companies ⁴	0.15 (0.05 - 0.47)	-	0.19 (0.04 - 0.87)	0.04 (0.01 - 0.48)	14.85 (3.73 - 59.16)
Trust Independent Scientist ⁴	-	-	-	-	-
Trust Government ⁴	-	0.14 (0.03 - 0.69)	-	-	9.00 (2.13 - 38.10)

Note: ¹Prevalence Odds Ratio (95% Confidence Interval)

²Health risk perception defined as 'Some to moderate risk' versus 'Extreme risk'

³Risk (except Health Risk perception) and Trust Government defined as 'Agree' versus 'Disagree'

⁴Trust defined as 'Moderate to great trust' versus 'No to little trust'

Discussion

Fracking knowledge and information sources

The low levels of knowledge related to fracking were found: 40% of participants did not know what fracking was and 25% did not know the potential detrimental health impacts thereof. The Low levels of education and literacy among participants may explain these findings as few study participants had access to the internet and some were non-literate. Similar low levels of knowledge about fracking were found in a recent study amongst a nationally representative sample of Americans (H. Boudet et al., 2014).

Half of the participants in this study indicated that they have great trust in their information sources. Those trusting their information were more likely to believe that fracking is detrimental to foetal and personal health (Table 6). The media, comprising 59% of the Central Karoo residents' fracking information sources, could be a useful tool in educating the population as suggested by Boudet (2014) and ensuring scientific risk communication to the population in future. Further research into information sources could explore whether the media is relaying predominantly information from the government, sponsored by the oil and gas industry or independent researchers as this output may impact on the populations risk perception.

Previous research indicated that the effect of media coverage on risk inflation or mediation, depends on the way messages are relayed, the contents as well as the receivers (H. Boudet et al., 2014). In this study, more than half of the participants (56%) said that they base their answers to the study survey on personal opinion or common sense. However, it is plausible

that participants received information without recognizing the information source. The data substantiates this argument as close to half (40.2%) of the participants said that they do not know what fracking is, but only a fifth of participants (19%) named the researcher or fieldworker as their information source. Participants' actual information sources are thus likely to be under represented. Thus, opinions could have been formed and risks potentially amplified or reduced by participants without acknowledging whether information was biased or who was disseminating the information.

Trust and Risk

Trust is described in the literature as a strong predictor of being in favour of or opposing technologies such as fracking (H. Boudet et al., 2014).

Close to two thirds of the participants (60.8%), predominately those with better education, paid employment and higher socio-economic status, stated that they do not trust the government. These participants were more likely to believe that fracking will be detrimental to personal health and pose extreme health risks (Table 6). Conversely, those who trust government were more likely to agree to work in the fracking industry and less likely to say fracking is detrimental to foetal health (Table 6). Distrust of government appears correlated with opposition to fracking exploration (Table 6). This may be as a result of inequity in SA as those with higher socio-economic status, education and employment are likely less desperate for jobs and thus less dependent on developments such as fracking. These individuals are likely to have increased ownership over their selection of information sources to ensure scientifically based perceptions as opposed to those exposed only to mainstream media potentially funded by the oil and gas industry.

This study confirmed previous findings that established that a lack of trust in oil and gas companies results in the perception that fracking is more risky (Brasier et al., 2013), as in this study those who do not trust oil and gas companies were more likely to believe that fracking will be detrimental to other's health and pose an extreme health risk. Furthermore the results of this study showed that those who trust oil and gas companies are less likely to report risks. These finding suggest that trust in oil and gas companies may result in a general perception that a technology is safe or poses minimal risk.

People living on farms were more likely not to trust oil and gas companies (93% versus 61%) and this is likely as a result of them feeling that they will be adversely affected the most as oil and gas companies are targeting rural areas. Due to the farms' dependency on water and water scarcity in the Karoo, pollution in one aquifer could wipe out an entire farmer's livelihood which increases the unequal distribution of risk amongst the local residents. This unequal distribution of risk should be further explored by studying the perceptual differences between those South Africans living in areas where fracking is proposed and those not living in such areas.

The 'Social Amplification of Risk Framework' suggests that people processing knowledge of risks usually enlarge the threatening aspects or down play the less threatening risks (Renn, 2011). When combining the health risk questions, 72.6% of participants believe that fracking poses some health risks. Considering that 40% of participants did not know what fracking was to start with, three quarters of participants perceiving fracking to pose health risks is a large number and it may suggest that perceptions related to the extent of the health risks are amplified meaning that they may perceive more risks than there are in reality or they

may perceive the risks that there are to be more significant than in reality. Furthermore, Renn (2011) claimed that these explanations are commonly disseminated to others which could explain why Central Karoo residents deem fracking to be so risky from a health perspective, despite lack of credible information sources highlighted by numerous participants.

Lung diseases were listed as a common type of sickness participants believe the fracking industry would cause. This is potentially as a result of perceptions related to previous exposures in the large mining industry in SA (16% of participants stated that their information source is the mining industry). In contrast to this, it was found that the risk perception of those who previously worked in any form of mining industry in the US, did not differ significantly from perceptions of those doing other types of work (Brasier et al., 2013).

Further, 13% of participants said that a long term health risk of fracking is contracting HIV/AIDS. In the SA context with the large communicable disease burden this finding is relevant. It may indicate that in BW residents, situated along the primary national highway connecting the SA economic capital, Johannesburg, with Cape Town, could be aware of HIV incidence in relation to truck drivers in their town. Literature substantiates that truck drivers are at an increased risk of contracting and spreading HIV (Pandey et al., 2008; Ramjee and Gouws, 2001).

Study Limitations

The sampling of the farm strata (farmer housing and farm worker housing) could not be done randomly and thus affected the representativeness of the sample. Further, farmers invited those working on their farm to partake thus there may be some bias in whom they have selected depending on personal fracking perceptions, talkativeness or education levels of the farm workers. Another limitation of the study is that individuals who were not familiar with fracking were included in the study and thus their perceptions were mainly based on the information the researcher or fieldworker provided them with.

Recommendations

Future research into the misconceptions among Karoo residents related to fracking and the potential health impacts thereof is necessary. Further this study also highlighted the importance of further exploring the health risk perceptions of residents of the Greater Karoo in order to ascertain whether the perceptions of those in the Central Karoo differ from the perceptions of those in the Greater Karoo region when it comes to fracking. The data collected in this study should be further analysed according to participants with knowledge of fracking and those who stated that they did not know what fracking was in order to observe differences between these groups.

Conclusion

There is a major lack of knowledge related to fracking under those living in the CK. Lower health risk was perceived by participants who trust the government and oil and gas companies while greater trust in information sources correlated with perceiving fracking as posing a higher risk. These findings have important implications for managing the process of public participation in the approval or disapproval of shale gas exploration in South Africa.

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PART D: Appendices



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Appendix A: Informed Consent Form

Consent To Participate In A Study Of Health Risk
Perception Related To Fracking In The Karoo

INFORMED CONSENT

12/8/2014

MIEKE WILLEMS



UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

This document outlines the consent procedure to participate in a household survey to investigate the health risk perception of the Karoo population related to 'fracking'.

Title of research project

Health Risk Perception related to 'fracking' in the Karoo, South Africa.

Names of the researchers

Primary Researcher: Mieke Willems (B. Occupational Therapy)

Supervisor: Mohamed Aqiel Dalvie (BSc, Honours, MSc, PhD)

Purpose of research

The University of Cape Town is conducting this survey to find out what you and other people living in the Central Karoo think about fracking and the potential benefits and or problems it could cause. Further, with this study is aimed at giving you and other participants a chance to raise your voice about fracking, through a scientific study.

This research will contribute towards Miss Willems's Master's Degree in Public Health.

Description of the research project

Your household has been selected from the Central Karoo, using random (every household has the same chance of being chosen to participate) sampling. If your household is selected, you are invited to participate in the survey. I will ask you some questions from a questionnaire and fill out the answers. Apart from answering the questions as best you can, nothing else will be expected from you.

Questionnaire

I will interview you in the privacy of your home or where suitable to fill out the questionnaire. You will be asked questions about: general personal information, as well as questions pertaining to fracking and your opinion thereof.

Risks and discomforts of the research

There are minimal risks associated with completing this questionnaire. The only known risk is providing personal details such as income. However, the only people seeing this information will be I or the person collecting the data and possibly my university supervisors. You will not be asked for your name, ID numbers or contact details and thus nobody will have any way of knowing who you are, from your answers. In the presentation of the final study results all the data will be presented as averages and what you answered will not be identifiable. There are no other known risks associated with this study.

Expected benefits to you and others

This research will help you and others living in the Karoo to say whether you would like fracking to happen or not and why or why not (provide public voice). I will put together all the answers I get from you and other participants into a formal scientific article, thus your valuable opinion will be part of the findings. Taking part in this study will not benefit you directly on an

individual basis, apart from possibly teaching you more about fracking and some of the advantages and disadvantages thereof.

In South Africa, there are no official research studies published on fracking yet, thus your participation in this study will help to start building some formal evidence about fracking, which is necessary for politicians, oil companies, environmentalist and farmers in order to make the right decisions about fracking and effectively regulate it.

Costs to you resulting from participation in the study

You will receive no remuneration for taking part in this study.

Confidentiality of information collected

Your name or details will not be mentioned in any reports published on this study. Your answers will be kept confidential as stipulated in the ethical guidelines provided by the University of Cape Town. After the results have been analyzed, your questionnaire and all the others used in the study will be shredded. Online surveys will be password protected.

Documentation of the consent

Please will you sign two copies of this informed consent that we are discussing now. One copy is for you to keep and the other copy will be filed by the University of Cape Town with the final study report.

Contact details

You may contact the following people if you have any further questions about this research or anything that you feel is related to this study.

Contact:	Mieke Willems (Principal investigator)	084 6233 644
	Prof. Aqiel Dalvie (Principal Supervisor)	021 406 6610

You may contact the Human Research Ethics Committee (HREC) of the University of Cape Town should you have any queries related to your rights or welfare as participant in this study.

Contact:	Faculty of Health Sciences HREC	021 404 6338
	http://www.health.uct.ac.za/fhs/research/humanethics/about	

Voluntary nature of participation

Your participation in this interview is voluntary. After you gave consent to participate, you may withdraw from the study at any time. If you withdraw from the study or refuse from the start you will not incur a penalty and you are likely to still benefit from the study as if you participated.

Consent of the participant

Please sign below to confirm that you have read and understood this document and that you agree to participate in this study.

2	0	1	4				
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Name of participant (print)

Signature

Date

2	0	1	4				
---	---	---	---	--	--	--	--

Interviewer (print)

Signature

Date

2	0	1	4				
---	---	---	---	--	--	--	--

Witness (print)

Signature

Date

Study Number

Appendix B: Surveys

Appendix B1: English Survey

HEALTH RISK PERCEPTION RELATED TO FRACKING

Master's in Public Health Questionnaire - University of Cape Town 2014

Has this participant signed the consent form?

☐ Yes

What is the date today?

--	--	--	--	--	--	--	--

What is your home language?

☐ Afrikaans

☐ English

☐ Other:

In what language is the survey conducted?

☐ Afrikaans

☐ English

This questionnaire has 6 sections and will take approximately 15 minutes to complete. My first questions will relate to your knowledge about fracking.

SECTION 1: FRACKING KNOWLEDGE

Do you know what fracking is?

- ☐ Yes
- ☐ No

(If participant answered NO, please read the following)

Fracking is a method of attaining gas from deep rock layers 2 – 5 km under the ground. This gas is valuable like petrol and diesel and could lower energy prices. The exploitation of such gas requires the use of large amounts of water. Experts claim that fracking can cause air and water pollution. Internationally, there are contrary opinions about the cost-benefit ratio of fracking. South Africa is considering fracking in the Karoo as a means to provide for the country's increasing energy demands. With this questionnaire we would like to establish your opinion on fracking. (Skip the next question and proceed.)

(If participant answered YES to the previous question, then ask him/her)

"Please explain what fracking is?"

(Please tick the answers listed by the participant - no cuing allowed)

- ☐ Gas mining
- ☐ An energy source
- ☐ A means to stimulate the economy
- ☐ Waste of time
- ☐ Detrimental to the environment
- ☐ Threat to tourism
- ☐ Detrimental to farming in the Karoo
- ☐ Don't know
- ☐ Other:

Is fracking exploration proposed in Beaufort West municipality?

- ☐ Yes
- ☐ No
- ☐ Don't know

SECTION 2: GENERAL AND DEMOGRAPHIC INFORMATION

Now I will ask you some questions about yourself.

In what year were you born?

What is the highest level of education you have successfully completed?

(Please specify grade in school complete, graduate degree or post graduate qualification)

What describes your current work situation best?

- ☐ Self employed
- ☐ Employed full time
- ☐ Employed part time
- ☐ Not employed (actively seeking work)
- ☐ Not employed (not seeking work))
- ☐ Pensioner
- ☐ Housewife
- ☐ Other:

What work do you do?

How many years have you lived in the Karoo?

Do you or your direct family own this house or another in the Karoo?

- ☐ Yes
- ☐ No
- ☐ Don't know

What was the monthly income of your household last year (before tax)?

- ☐ < R3000 per month
- ☐ R3001 – R6000 per month
- ☐ R6001 – R10 000 per month
- ☐ R10 001 – R50 000 per month
- ☐ > R50 000 per month
- ☐ Don't know

SECTION 3: PERCEPTION TOWARDS FRACKING – GENERAL

Now I will ask you questions about your opinion of fracking. Please indicate whether you agree or disagree with the following statements.

I would work in the fracking industry (for an oil company) in the Karoo if the opportunity presents itself.

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

If I could choose, I would not allow fracking in the Karoo.

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

Why did you say this?

Is your answer based on information obtained from the media, from the internet and/or from public meetings (opinion)?

Fracking will boost tourism in the Karoo.

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

Comments: (no cuing)

Fracking will be beneficial to the people of the Karoo.

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

If you agreed, why do you think fracking will be beneficial? (no cuing)

Possible POSITIVE long term impacts

- ☐ Employment opportunities (economic growth)
- ☐ Decreased energy prices
- ☐ Improved health care
- ☐ Improved education
- ☐ General development, housing improvement
- ☐ Decrease in living cost
- ☐ Improved overall life quality
- ☐ Other:

If you disagreed, why did you say that fracking will not be beneficial? (no cuing)

Possible NEGATIVE long term impacts

- ☐ Housing Shortages, Increased rent prices
- ☐ Strains on public services (water, transport)
- ☐ Health Problems (STI, HIV)
- ☐ Pollution (traffic, air, water, noise)
- ☐ Crime and Violence increase
- ☐ Loss of land for future generations
- ☐ Other:

You said you feel that fracking will be beneficial or harmful, where did you get this information from?

Did you get this information from a specific source or is it a general opinion or feeling?

SECTION 4: PERCEIVED HEALTH RISK OF FRACKING

I am now going to ask you about the risk you think fracking has for good health.

From a health perspective, how much risk do you think fracking holds?

- ☐ No risk
- ☐ Low risk
- ☐ Moderate risk
- ☐ Extreme risk
- ☐ Don't know

Fracking will make people living in the Karoo sick.

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

In case you are of the opinion that fracking can cause disease, why did you say fracking can make people sick?

What type of diseases in the SHORT term?

What type of diseases in the LONG term?

Where did you get this information from? Did you see it on TV, hear at the hospital etc.?

Do you agree that fracking can potentially harm the health of unborn children from mothers living in fracking areas?

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

Do you agree that fracking can be to harmful to YOUR own health?

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

SECTION 5: TRUST IN INSTITUTIONS AND AGENCIES

Definition: Trust is a firm belief in the reliability of something or the truth about something or someone.

How much trust do you have in the accuracy of your information about fracking?

- ☐ No trust
- ☐ Some trust
- ☐ Moderate trust
- ☐ Great trust
- ☐ Don't know

How much trust do you have in fracking companies who applied for fracking licences in the Karoo?

- ☐ No trust
- ☐ Some trust
- ☐ Moderate trust
- ☐ Great trust
- ☐ Don't know

How much trust do you have in what the scientists say with respect to fracking?

- ☐ No trust
- ☐ Some trust
- ☐ Moderate trust
- ☐ Great trust
- ☐ Don't know

SECTION 6: TRUST IN GOVERNMENT DECISIONS

Please indicate whether you agree or disagree with the following statements.

I trust the national government (when it comes to fracking)?

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

Please specify why you agree or disagree?

The government will not be effective in regulating the fracking industry

- ☐ Agree strongly
- ☐ Agree
- ☐ Disagree
- ☐ Disagree strongly
- ☐ Don't know

Please specify why you agree or disagree?

Thank you for taking time to answer my questions. Here is a flyer which provides more information about fracking. The findings of this paper will be available from your local municipality in December 2014 or early 2015, should you be interested you are welcome to attain it there.

END OF SURVEY

DO NOT ASK THE FOLLOWING QUESTIONS

Complete after questionnaire.

The gender of participant was:

- ☐ Male
- ☐ Female

Tick type of housing of participant:

- ☐ Formal Beaufort-West town area
- ☐ Formal RDP-housing (Kwa-Madlenkosi or Newtown)
- ☐ Farm (Farmer house)
- ☐ Farm (Farm worker housing)

Questionnaire completed by:

- ☐ Researcher: Mieke Willems
- ☐ Research assistant / Field worker

Appendix B2: Afrikaans Survey

BEWUSTHEID OOR DIE GESONDHEIDSRISIKO VAN SKALIE BREKING (FRACKING)

Meerstersgraad in Publieke Gesondheid Vraelys – Universiteit van Kaapstad 2014

Is geskrewe toestemming verleen vir deelname aan die studie?

☐

Ja

Wat is vandag se datum?

--	--	--	--	--	--	--	--

Wat is u moedertaal?

☐

Afrikaans

☐

Engels

☐

Ander:

In watter taal is die opname onderhoud gevoer?

☐

Afrikaans

☐

Engels

Hierdie vraelys het 6 onderafdelings en behoort ongeveer 15 minute te neem om te voltooi.
My eerste vrae aan u sal gaan oor u kennis van skalie-breking (fracking).

AFDELING 1: KENNIS VAN SKALIE-BREKING (FRACKING)

Weet u wat skalie-breking (fracking) is?

- ☐ Ja
☐ Nee

(Indien die deelnemer se antwoord NEE was, lees asseblief die volgende inligting aan hom/haar voor.)

“Skalie-breking (fracking) is ’n manier van aardgas ontginning uit skalierots wat diep onder die grond (2 tot 5 kilometer) voorkom. Aardgas is ’n waardevolle natuurlike hulpbron soortgelyk aan petrol en diesel wat sou kon dien as ’n goedkoop alternatiewe bron van energie. Om gas op hierdie manier te ontgin word baie water benodig. Sommige kundiges beweer dat skalie-breking kan aanleiding gee tot lug- en waterbesoedeling. Daar is internasionaal teenstrydige sienings oor die voordeel/koste verhouding van skalie-breking. Suid Afrika oorweeg skalie-breking in die Karoo om in die stygende vraag na energie van ons land te voorsien. Met hierdie vraelys wil ons graag u mening oor skalie-breking bekom.”

(Slaan nou die volgende vraag oor en gaan voort.)

(Indien die deelnemer se antwoord JA was op die vraag hierbo gestel, vra hom/haar:)

“Verduidelik asseblief wat u onder skalie-breking (fracking) verstaan?”

(Merk die antwoord van die deelnemer hieronder – geen leidrade, wenke of voorsê toegelaat.)

- ☐ Gas ontginning
☐ ’n Bron van energie
☐ ’n Manier om die ekonomie te stimuleer
☐ Mors van tyd
☐ Nadelig vir die omgewing
☐ Bedreiging vir toerisme
☐ Dit sal boerdery in die Karoo nadelig beïnvloed
☐ Ek weet nie
☐ Ander:

Is daar planne om skalie-breking eksplorاسie werk in die Beaufort-Wes Munisipale gebied te doen?

- ☐ Ja
- ☐ Nee
- ☐ Ek weet nie

AFDELING 2: ALGEMENE DEMOGRAFIESE INLIGTING

Ek gaan nou vir u 'n paar vrae omtrent uself vra.

Wat is u geboorte datum? (Teken slegs jaar aan)

Wat is u hoogste vlak van skoling geslaag?

(Spesifiseer asseblief die Graad voltooi in skool of tersiere opleiding of nagraadse studies)

Watter van die volgende beskryf u werksituasie die beste?

- ☐ Werk vir myself
- ☐ Voltydse werknemer
- ☐ Deeltydse werknemer
- ☐ Werkloos maar soek aktief werk
- ☐ Werkloos maar soek nie werk nie
- ☐ Pensioenaris
- ☐ Huisvrou
- ☐ Ander:

Watter werk doen u?

Hoeveel jaar is u al in die Karoo woonagtig?

Besit u of u naaste familie hierdie huis of ander eiendom in die Karoo?

- ☐ Ja
- ☐ Nee
- ☐ Ek weet nie

Wat was u gesin se maandelikse inkomste verlede jaar (voor belasting)?

- ☐ < R3000 per maand
- ☐ R3001 – R6000 per maand
- ☐ R6001 – R10 000 per maand
- ☐ R10 001 – R50 000 per maand
- ☐ > R50 000 per maand
- ☐ Ek weet nie

AFDELING 3: PERSEPSIE OOR SKALIE-BREKING (FRACKING) – ALGEMEEN

Hierdie afdeling handel oor u siening ten opsigte van skalie-breking. Dui asseblief aan of u saamstem met die volgende stellings.

Ek sou belangstel in werk in die skalie-breking industrie (vir 'n oliemaatskappy) in die Karoo as die geleentheid hom voordoen.

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

As ek kon kies, sou ek nie skalie-breking in die Karoo toelaat nie.

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

Waarom sê u so?

Baseer u, u antwoord op inligting verkry uit die media, internet en/of openbare vergaderings?

Skalie-breking sal toerisme in die Karoo vermeerder.

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

Kommentaar: (geen leidrade, wenke of voorsê toegelaat)

Skalie-breking sal tot voordeel wees vir die inwoners van die Karoo.

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

As u saamstem, waarom dink u dat skalie-breking voordelig sal wees? (geen leidrade,wenke of voorsê word toegelaat nie)

Moontlike POSITIEWE langtermyn impakte

- ☐ Werkskepping (ekonomiese groei)
- ☐ Afname in energie pryse
- ☐ Beter gesondheidsorg
- ☐ Beter opvoeding
- ☐ Groei in algemene ontwikkeling en beter behuising
- ☐ Laer lewenskoste
- ☐ Verhoging in algemene lewenskwaliteit
- ☐ Ander:

Indien u nie saamstem nie, waarom dink u dat skalie-breking nie voordelig sal wees nie?
(geen wenke, leidrade of voorsê toegelaat nie)

Moontlike NEGATIEWE langtermyn impakte

- ☐ Behuisingstekorte sal ontstaan en toename in huishuurpryse
- ☐ Oorbelasting van openbare dienste (water, vervoer)
- ☐ Gesondheidsprobleme (seksueel oordraagbare siektes, HIV)
- ☐ Besoedeling (verkeer, lug, water en geraas)
- ☐ Toename in misdaad en geweld
- ☐ Verlies aan grond en hulpbronne vir toekomstige generasies
- ☐ Ander:

Waar het u inligting gekry waarop u antwoorde gegrond is?

Kom u inligting vanaf 'n spesifieke bron of is dit u algemene mening of gevoel?

AFDELING 4: BEGRIP BETREFFENDE DIE GESONDHEIDSRISIKO VAN SKALIE-BREKING

Ek gaan vir u nou vra oor watter gesondheids-risikos u dink skalie-breking kan inhou.

Vanuit 'n gesondheids perspektief, hoe baie risiko dink u hou skalie-breking in?

- ☐ Geen risiko
- ☐ Lae risiko
- ☐ Gematigde risiko
- ☐ Groot risiko
- ☐ Ek weet nie

Skalie-breking sal mense wat in die Karoo woon siek maak.

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

Waarom het u gesê dat skalie-breking mense sal siek maak?

Watter soort siektes verwag u oor die KORT-termyn?

Watter soort siektes verwag u in die LANG-termyn?

Van waar kry u die inligting waarop u hierdie stellings baseer? Het u dit op televisie gesien of by 'n hospitaal ontvang?

Stem u saam dat skalie-breking die gesondheid van ongebore babas van moeders wat in aardgas ontginningsareas woon, nadelig kan beïnvloed.

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

Stem u saam dat skalie-breking nadelig sal wees vir u EIE gesondheid?

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

AFDELING 5: VERTRoue IN INSTASIES EN AGENTS KAPPE

Definisie: Vertroue weerspieël geloofwaardigheid in die korrektheid of betroubaarheid van inligting, en opregtheid van betrokkenes daaromtrent.

Hoe baie vertroue het u in die inligting waarom u beskik omtrent skalie-breking?

- ☐ Geen vertroue
- ☐ Bietjie vertroue
- ☐ Matige vertroue
- ☐ Baie vertroue
- ☐ Ek weet nie

Hoe baie vertroue het u in die maatskappye wat om lisensies aansoek gedoen het om skalie-breking in die Karoo te doen?

- ☐ Geen vertroue
- ☐ Bietjie vertroue
- ☐ Matige vertroue
- ☐ Baie vertroue
- ☐ Ek weet nie

Hoe baie vertroue het u in wetenskaplike sienings betreffende skalie-breking?

- ☐ Geen vertroue
- ☐ Bietjie vertroue
- ☐ Matige vertroue
- ☐ Baie vertroue
- ☐ Ek weet nie

AFDELING 6: GELOOFWAARDIGHEID IN DIE BESLUIE DEUR ONS REGERING GENEEM

Dui asseblief aan of u saamstem of nie met die volgende stellings.

Ek vertrou die nasionale regering (betreffende skalie-breking)?

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

Verduidelik asseblief u antwoord?

Die regering sal nie effektief wees in die regulering van die skalie-breking industrie nie.

- ☐ Stem volkome saam
- ☐ Stem saam
- ☐ Stem nie saam nie
- ☐ Stem glad nie saam nie
- ☐ Ek weet nie

Verduidelik asseblief u antwoord?

U word bedank vir u tyd en bereidwilligheid om my vrae te beantwoord. Die bevindings van die vraelys sal gedurende Desember 2014 of vroeg in 2015 by u munisipaliteit ter insae beskikbaar wees. Ontvang asseblief hierdie inligtingspamflet wat vir u meer inligting rakende skalie-breking verskaf.

EINDE VAN OPNAME ONDERHOUD

MOENIE DIE VOLGENDE VRAE IN DIE ONDERHOUD VRA NIE.

Voltooi na afloop van die onderhoud.

Die geslag van die deelnemer was:

- ☐ Manlik
- ☐ Vroulik

Merk die tipe behuising van die deelnemer:

- ☐ Formele Beaufort Wes Dorp area
- ☐ Formele RDP-behuising (Kwa-Madlenkosi or Newtown)
- ☐ Plaas (Herehuis)
- ☐ Plaas (Werkers behuising)

Vraelys is voltooi deur:

- ☐ Navorser: Mieke Willems
- ☐ Navorsingsassistent / veldwerker

Appendix C: Fracking Information Leaflets

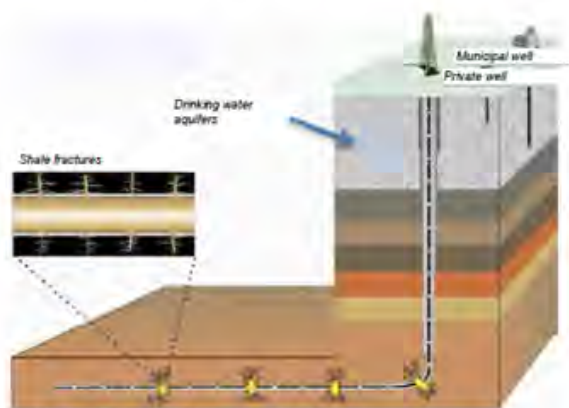
Appendix C1: English participant leaflet

WHAT IS SHALE GAS?

Shale gas is an unconventional fossil fuel (natural gas) trapped between pores of rock particles in shale rock layers deep in the earth.

WHAT IS FRACKING?

The shale gas mining process is called “high volume, slick water, horizontal hydraulic fracturing” or “fracking”. During the fracking process, vertical wells are drilled between two and five kilometres underground. At such depths the drill bit is turned sideways to continue drilling in a horizontal direction. During the process, water, sand and some toxic chemicals are pumped into the shaft at high pressure which fractures the rock and releases the valuable gas.



Principle of shale gas extraction (source: EPA 2010).

MORE THOUGHTS RELATED TO FRACKING:

- Fracking wells are enclosed by cement and metal casings to prevent gas and chemicals from escaping into drinking water as wells are drilled through drinking water aquifers.
- In the fracking process, 20 million litres of water is used per fracking well.
- Experts in favour of fracking argue that it will boost economic development and decrease energy cost in South Africa.
- In America, there is evidence substantiating that fracking has led to water and air pollution in areas where there are active fracking industries.
- Environmentalists are concerned that damage to the environment in the forms of noise -, air - and water pollution will not be reversible.
- Further concerns relate to the potential health impacts of fracking and the lack of scientific evidence to inform long term decisions related to the expected impact of the industry.

Thank you for your participation.

Contact: Mieke Willems miekelie@yahoo.com

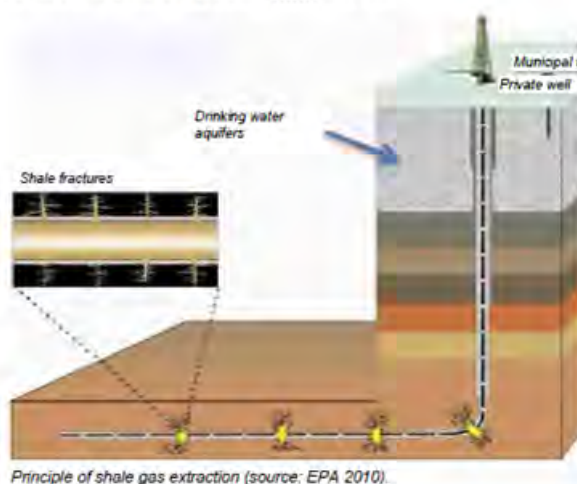
Appendix C2: Afrikaans participant leaflet

WAT IS SKALIE-GAS?

Skaliegas is 'n fossielbrandstof in die vorm van aardgas wat versprei is deur rotslae diep onder die aardoppervlak.

WAT IS SKALIE-BREKING (FRACKING)?

Die myntegniek wat gebruik word om skaliegas te ontgin staan bekend as hidrouliese rotsbreking, skalie-breking of "fracking". 'n Vertikale boorgat word in die grond geboor, waarna die boor op dieptes van twee tot vyf kilometer onder die grond draai om horisontaal in die skalierotslaag te boor. Gedurende die proses word water, sand en chemikalieë word onder hoë druk in die grond en rots lag ingepomp om die rotse te kraak sodat die gas vrygestel kan word.



GEDAGTES AANGAANDE SKALIE-BREKING:

- Skalie-gas putte word deur drink water lae onder die aarde se oppervlak geboor. Putte word omhul deur sement en metaal omhulsels om te verhoed dat chemikalieë, gebruik in die brekings proses, nie in die drinkwater ontsnap nie.
- Een skalie-gas put gebruik nagenoeg 20 miljoen liter water om gas te ontgin.
- Kundiges ten gunste van skalie-gas ontginning meen dat die ontginning sal lei tot 'n verlaging in energie pryse en ekonomiese groei in Suid-Afrika.
- In Amerika is daar bevind dat Skalie-breking in sekere gebiede water – en lugbesoedeling veroorsaak het in area waar gas ontgin word.
- Omgewings deskundiges is bekommerd oor potensiele lug -, geraa – en waterbesoedeling die omgewing sal beïnvloed en waarskynlik onomkeerbaar sal wees.
- Verdere bekommernisse sluit gesondheidsrisikos in en die tekort aan wel nagevorsde wetenskaplike bewyse aangaande die potensiele lang termyn skade.

Dankie vir u deelname.

Kontak: Mieke Willems miekelie@yahoo.com

Appendix D: Ethics clearance



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee



Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492 • **Facsimile** [021] 406 6411
Email: Sumayah.ariefdien@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

14 August 2014

HREC/REF: 564/2014

A/Prof A Dalvie
School of Public Health & Family Medicine
Falmouth Building
FHS

Dear A/Prof Dalvie

Project Title: HEALTH RISK PERCEPTION OF KAROO RESIDENTS RELATED TO FRACKING, SOUTH AFRICA (Masters candidate-Mieke Willems)

Thank you for your response letter dated 11 August 2014, addressing the issues raised by the Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above mentioned study.

Approval is granted for one year until the 30 August 2015.

Please submit a progress form, using the standardised Annual Report Form, if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

We acknowledge that the following student:-M Willems is also involved in this project.

Please note that the on-going ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.

Institutional Review Board (IRB) number: IRB00001938

Hrec/ref:564/2014

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Hrec/ref:564/2014

Appendix E: Instructions for Authors

Environmental Practice Journal

INFORMATION FOR CONTRIBUTORS

Environmental Practice is an English-language journal published quarterly by the National Association of Environmental Professionals. It serves an international audience of environmental professionals in practice and research. *Environmental Practice* is peer reviewed and accepts original manuscripts that have not previously been published in whole or in part in a peer-reviewed journal or in a widely available publication, either print or electronic. The general philosophy of the journal is outlined in the Mission Statement, which is reproduced in full after the Table of Contents in each issue.

Priority for publication is given to manuscripts that offer clear, insightful views on an environmental problem from an interdisciplinary perspective. *Environmental Practice* seeks especially to publish studies that link data and findings in science and technology with issues of public policy, health, environmental quality, law, political economy, management. Because the readership of *Environmental Practice* is very broadly based, manuscripts should not be burdened by extensive, unexplained, technical language familiar only to a small group of specialists.

Manuscripts are accepted throughout the year.

Kinds of Manuscripts Sought

Environmental Practice publishes several categories of manuscripts as described below. Two of these categories, Research Articles, and Environmental Reviews and Case Studies, are peer reviewed.

Research Articles: manuscripts that report the results of systematic study on an environmental problem. Typically, research articles will (a) report the results of formal research or (b) summarize systematic analysis of one or more case studies of particular interest. Environmental professionals in academic or research laboratory settings

may be more likely to submit formal research manuscripts. Professionals in consulting practice, agencies, or other organizations may be more likely to submit manuscripts based on case studies. Under most circumstances, Research Articles will not be over 5000 words of text. Most will be substantially shorter. Tables, figures, and reference lists need not be included in the word count. All Research Articles are peer reviewed.

Environmental Reviews and Case Studies: manuscripts that organize and summarize a research literature similar to a meta-analysis. These manuscripts help clarify a problem, illustrate policy-making processes, or assist in pointing out discrepancies in the research of the topic over time, with greater emphasis placed on the details of a project than on data analysis. Case study oriented manuscripts provide readers with a unique insight on a development in the professional field using a case as an example or illustration; simple project reports will not be accepted. *Environmental Reviews and Case Studies* will generally be about 6000 words of text. Tables, figures, and reference lists need not be included in the word count. All Environmental Reviews and Case Studies are peer reviewed.

Reviews: manuscripts that portray the content, quality, and significance of books or films of wide interest to environmental professionals and their practices. Reviews should normally not exceed 750 words, but with the approval of the editor may reach 1500 words.

Perspectives from the Field: statements of informed opinion intended to provoke discussion and debate on particular issues. These manuscripts will generally range from 500 to 1000 words. Such manuscripts will not be subject to peer review, because they are personal opinion; however, the editor may seek advice on matters of tone and fairness.

Dialogue: responses to other manuscripts or controversies within the professional or academic discipline. These manuscripts will generally range from 50 to 500 words, and take the form of a letter to the editor. Dialogues will not be peer reviewed, but they may be used to solicit responses from others for simultaneous publication.

The editors welcome inquiries about manuscript ideas. You may also contact the editors to request exceptions to the word count limits given above. Contact information can be found at the end of these instructions.

Manuscript Preparation and Submission

1. Membership in the National Association of Environmental Professionals is not a requirement for publication in *Environmental Practice*.

2. Only electronic submittals will be accepted. Authors should either send via email their work to the managing editor listed at the end of these instructions. Please indicate in your electronic submittal which section the work should be considered under: Research Articles, Environmental Reviews and Case Studies, Reviews, Perspectives from the Field, or Dialogue. Also, in email, please put in the subject line, Environmental Practice Submittal. All manuscripts will be accepted in Word or Excel software.

3. Manuscripts should be organized as follows:

Cover sheet: Attach a cover sheet including manuscript title, author name(s); title or position; institutional affiliation; corresponding author address, telephone number, fax number, and e-mail address. All pages should be numbered, with the cover sheet as page 1. To facilitate blind peer reviews, author names and affiliations should appear *only* on the cover sheet.

Acknowledgments: Place on a separate sheet, located after the cover sheet. The study sponsors, if any, should be included in the acknowledgments.

Abstract: Research Articles, Environmental Reviews and Case Studies should be accompanied by an abstract of no more than 225 words on a separate sheet. Abstracts should be a stand-alone summary of the manuscript's central findings and argument, not an overview of the manuscript's outline. The title of the manuscript should appear at the top of the abstract page.

Text: Research Articles and Environmental Reviews and Case Studies will typically have separate sections for Introduction, Methods, Results, Discussion, and Conclusions. In all cases, use appropriate section headings to help guide the reader.

All text, including references, tables, legends, and quotations, should be typed, double-spaced, on one side of white paper with margins of at least one inch on all sides and without right-hand justification.

Documentation and references: Authors may use either author-date notation or endnotes.

Author-date notation is widely used in the natural and social sciences. References are cited in text like so: "Smith (1990) showed. . ." or "as seen elsewhere (Smith, 1990)." References cited in text are listed alphabetically in a References section at the end of the manuscript. The following examples illustrate an appropriate style for most kinds of documents listed in the References section:

Article in journal

Author, A.B., and C.D. Author. 1997. Title of Article. *Name of Journal* Volume(Issue): starting page number-ending page number.

Article or chapter in book

Author, A.B., C.D. Author, and E.F. Author. 2000. Title of Article or Chapter. In *Title of Book*, G.H. Editor and I.J. Editor, eds., 4th edition. Publisher, Place of Publication, starting page number-ending page number.

Book

Author, A.B., and C.D. Author. 2001. *Title of Book*. Publisher, Place of Publication, total pages in book.

Edited book

Editor, A.B., and C.D. Editor, eds. 1999. *Title of Book*. Publisher, Place of Publication, total pages in book.

Dissertation or thesis

Author, A.B. 1998. *Title*, (PhD Dissertation) OR (Master's Thesis). University, City, State, total pages in document.

Reports by author

Author, A.B. 1993. *Title of report*. Report Number, Agency, City, State, total pages in report.

Reports by agency

Name of agency. 1995. *Title of report*. Report Number, City, State, total pages in report.

Personal communication (e.g. letter, telephone, e-mail, interview)

Person, A.B. 1999. Personal communication. Person's title or position, Person's agency or organization, City, State. Day-Month.

Web sites

Name of Site/Subsection of Site. Year posted on site. *Title of subsection*. URL address of site. Day-Month-Year of access to site.

Endnotes consist of a superscript number in the text and a corresponding, numbered list of citations placed at the end of the text. This method of documentation is frequently used in historical, legal, or humanistic writing, and it is useful for citations that must contain more than one reference. Endnotes with more than one reference should be separated by semi-colons. Avoid, if possible, the use of endnotes simply to further explain the text rather than to provide documentation. Subsequent references to a source should give the last name of the author(s), shortened title, and relevant page(s). Do not use op. cit., ibid, idem, infra, or supra. See *The Chicago Manual*

of Style for details not addressed here. The following examples illustrate proper style for endnotes:

Article in journal

A.B. Author and C.D. Author, 2000, "Title of Article," *Name of Journal* Volume(Issue): starting page number-ending page number.

Article or chapter in book

A.B. Author, C.D. Author, and E.F. Author, 1998, "Title of Article or Chapter," in *Title of Book*, G.H. Editor and I.J. Editor, eds., 4th edition, Publisher, Place of Publication, starting page number-ending page number.

Book

A.B. Author and C.D. Author, 1999, *Title of Book*, Publisher, Place of Publication, total pages in book.

Edited book

A.B. Editor and C.D. Editor, eds., 2001, *Title of Book*, Publisher, Place of Publication, total pages in book.

4. Authors are strongly encouraged to illustrate their work with tables, figures, maps, and photographs. Authors should submit any figures in electronic form, preferably TIF (line drawings should be at least 600 ppi; halftone or gray-scale figures should be at least 300 ppi) or EPS (with fonts embedded) format. Color figures must be at least 300 ppi CMYK, although authors will be charged for the production cost of printing any four-color figures (a color figure costs \$450; additional color figures in the same article will cost \$250). Provide figure captions together on a separate page. Tables (in Word or Excel that the editorial office will be able to manipulate for formatting purposes) should not duplicate data also provided in figures or in the text. For tables of data that might be of value only to a few readers, authors should consider indicating that the data is available on request from the author. Table and figure captions/legends should make them understandable without reference to the text. Tables and figures must be referred to in the text.

5. This journal resists the use of acronyms and other forms of abbreviation. As a general rule, an acronym is appropriate only (a) if it is used frequently in a portion or all of a manuscript or (b) if the acronym itself has entered common usage in everyday conversation (e.g., "USEPA" for "United States Environmental Protection Agency"). The use of more than two different acronyms in one manuscript is unlikely to be acceptable.

6. Use the International System of Units (SI) or metric units. If necessary for clarity or common usage, other units may be included in parentheses immediately following the acceptable units.

7. *Environmental Practice* uses a double-blind peer review process. The reviewer will not know the identity or location of the author(s), and the author(s) will receive reviewer's comments without the reviewer's identity or location. Authors are invited to submit names of appropriate reviewers, but the final choice of reviewers lies with the editor. Authors will be notified of the disposition of their manuscript as soon as possible. The goal of this journal is to have a decision to the author(s) within 90 days of receipt of manuscript.

8. Upon acceptance of manuscripts, authors will be requested to send the editorial office an electronic version of the manuscript. Please contact the editorial office for exceptions: an author's access to computing equipment will not be a factor in the publication of a manuscript.

9. The final version of the manuscript should include a short biographical sketch of each author (150 words or less per author).

10. All authors must sign the "Transfer of Copyright Agreement" and a disclosure of commercial interests before the manuscript can be published. The Transfer Agreement enables the National Association of Environmental Professionals to protect the copyrighted material for the authors, but authors do not thereby relinquish proprietary rights or rights to use their work in the future. The copyright transfer covers the exclusive rights to reproduce and distribute the manuscript, including reprints, photographic reproduction, microfilm, electronic versions, and all other reproduction methods, plus translations into languages other than English.

11. The corresponding author will receive page proofs for final proofreading shortly before the article is scheduled for publication. Authors bear full responsibility for accuracy and completeness of their material. Any corrections (not revisions) should be made at this time, and the page proofs must be returned to the publisher within 48 hours of receipt. Extensive revisions are strongly discouraged at this stage of the publication process and, if permitted by the editor and publisher, are likely to result in special charges to the author.

12. It is a condition of publication that manuscripts submitted to this journal have not been published previously, in part or

in whole, in a print or electronic publication. All prior presentations of the manuscript material must be disclosed to the editor at the time of initial manuscript submission. It is also a condition of publication that the author(s) will not simultaneously submit or publish the material elsewhere.

13. Authors will receive a reprint order form when they are sent page proofs. A PDF of the article will be provided free of charge to the lead author. If additional reprints are desired, the completed form along with payment must be returned to the publisher at the same time page proofs are returned.

Revised September 2011

Electronic Submission Required (See "Manuscript Preparation and Submission" above)

Send electronic manuscripts to:

Dan Carroll
Managing Editor, *Environmental Practice*
DePaul University
2312 N. Clifton Ave, Room 130
Chicago, IL 60614
Telephone: 773-325-2298
(e-mail) dcarro17@depaul.edu

Appendix F: Journal Correspondence

The instructions for authors specify that the journal ready manuscript must 5000 words and be typed in double line spacing and this includes all text, tables and references. Below is the email correspondence with the editor specifying that submitting an article of 6000 words is acceptable and that tables can be formatted with single line spacing to increase legibility.

**Mieke Willems** <miekewillems1@gmail.

6 Feb (3 days ago) ☆



to dcarro17 ▾

Dear Dan

I am in the final stages of drafting an article on fracking which I aim to Publish in the Environmental Practice Journal if accepted. The article is about risk perception related to fracking in the Karoo, South Africa.

It is one of the requirements of my Masters thesis (University of Cape Town) that I write a manuscript of the findings of my article in journal format according to a specific journal thus i have closely followed the guidelines to authors stipulated by the Environmental Practice Journal.

I have some questions pertaining to this:

1. In the instructions to authors document it is specified that all text and tables must be double line spaced. The tables in this format is very lengthy and some of my tables stretches over three pages which is impractical for the reader... May I please format the tables and their captions single spaced or at 1.15?
2. Further I see the guidelines recommends sticking to 5000 words. My article is currently around 6000... Shall I finalize it and send it through to you or first try to scrape away another 1000 words (which I find utterly challenging)?

Kind Regards,

Mieke Willems
miekewillems1@gmail.com
 084 6233 644

**Carroll, Daniel** <DCARRO17@depaul.e

6 Feb (3 days ago) ☆



to me ▾

Mieke,

- 1) That's no problem.
- 2) 6,000 is fine. It's more of a guideline than a hard limit, because if we don't put a number, we start getting 20,000-word papers.

Looking forward to it!

Thanks,