Ministry of Business, Innovation & Employment

East Coast Oil and Gas Development Study

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City of Napier
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Hawke's Bay Regional Council

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Executive Summary

Purpose of the Study

A1. This Study is intended to support informed dialogue between councils, communities and iwi about the potential benefits, impacts and risks of petroleum (oil and gas) development across the East Coast of the North Island, if such a development were to eventuate.

A2. It represents a very first step. It is intended to stimulate discussion, and provide information.

A3. As such, it does not present any recommendations. Rather it identifies the issues that will need to be addressed and considers mechanisms by which they may be resolved.

A4. The Study is a collaboration between the Ministry of Business, Innovation and Employment (**MBIE**) and the Mayors of Gisborne, Tararua, Central Hawke's Bay, Hastings, Napier and Wairoa, and the Chairs of Horizons and Hawke's Bay Regional Councils (the **East Coast Mayors and Chairs**) with support from the regional economic development agency Business Hawke's Bay.

A5. Iwi have expressed a strong interest in the subject of this report, and have a perspective and knowledge to bring across the environmental, economic, social and cultural dimensions. They also have their own way of assessing impacts across these dimensions for the areas of which they are kaitiaki. Mātauranga Māori (knowledge and wisdom) can be used alongside community-based and scientific knowledge to provide a fuller and richer assessment of potential development and impacts.

A6. This report provides a set of possible development scenarios, their implications, and supporting economic data, that may support the full dialogue that will be required on all the environmental, economic, social and cultural dimensions, should the prospect of development become more certain.

The petroleum resource potential in the East Coast Region

A7. There is significant interest in exploring the onshore East Coast Basin and a real prospect that this could lead to some form of petroleum development. The geology of the East Coast of the North Island has two extensive formations, Waipawa and Whangai, which have generated petroleum. It is known that they have generated petroleum because oil has seeped to the surface at a number of locations.

A8. Little exploration of the Waipawa and Whangai formations has taken place, so our current knowledge of the productive potential of these formations is limited. Until exploratory wells are drilled to directly access these formations there is a wide range of uncertainty about whether recovery would be economic and about what the potential impacts would be.

A9. To address this uncertainty this report presents a range of scenarios. These scenarios are intended to illustrate the range of outcomes that might result from petroleum exploration and possible subsequent development. They are not intended to be forecasts. They are based on the level of information that currently exists about the resource, and have been developed on behalf of MBIE and Councils by independent experts.

A10. The scenarios are:

- **Scenario 1: quickly abandoned exploration** after 1–2 years of exploration
- **Scenario 2: some more exploration but no development** as production would be uneconomic, taking place over 4–6 years
- **Scenario 3: small-scale production**, with oil produced in three areas of the East Coast over 21 years
- **Scenario 4: large-scale production** over a period of 41 years that would have a significant impact on both the regional and the national economy
- **Scenario 5: large-scale, high-volume production**, modelling a scenario at the very upper end of what may be plausible, but with potential transformative implications and production over a period of 64 years.

A11. If the initial drilling proves that the formations are productive at commercially viable rates, and if subsequent exploration shows that this is true over a large area, there is a potential for a significant oil boom. Such a boom could transform the economy of the entire region – and in the larger scenarios could even be game changing for New Zealand as a whole.

Economic impacts

A12. The study included the use of a computable general equilibrium (**CGE**) model to estimate the long run impact of the three possible "development" scenarios indicated above. This provided the following findings at the national and regional level.

A13. The headline impacts at the national level are summarised in Table 1.

Table 1: Summary of national results

% change versus baseline; annual average; $NZ million

Scenario	3: Small-scale		4: Large-scale		5: Large-scale, high-volume	
Metric	%	$m	%	$m	%	$m
GDP[1]	0.18%	$360	2.7%	$5,300	9.3%	$18,000
GNDI[2]	0.14%	$270	2.2%	$4,000	7.5%	$14,000

1 Gross Domestic Product

2 Gross National Disposable Income (**GNDI**) is a measure of how well-off New Zealand residents are.

Consumer welfare	0.14%	$160	2.0%	$2,300	6.8%	$7,800
Real wage	0.13%		1.4%		4.6%	
Real exchange rate	0.15%		1.7%		5.5%	
Crown revenue		$90		$2,000		$7,700

Source: NZIER

A14. The New Zealand economy is considerably better off under all scenarios. GDP increases by 0.18% if there is a small-scale development, by 2.7% in scenario 4 (a large-scale development) and by 9.3% in the most ambitious scenario. To put this in perspective, scenario 4 is equivalent to two and half times the GDP impact of the petroleum industry in Taranaki.

A15. There is strong growth in employment in the oil and gas industry and supporting supply and investment sectors. From 200 to over 2,300 jobs could be created in the region (see Table 2 below, which covers regional impacts and employment gains). Of the jobs created in the oil and gas industry in the region, it is assumed that initially 50% would go to locally based employees, but over time the proportion of locally based workers would increase to 95%.

A16. Households also benefit through higher real wages. This reflects the higher effective productivity of labour in the oil and gas and supporting sectors. The overall net economic impact is overwhelmingly positive, leading to growth not just for the oil and gas industry but for supporting sectors such as mining and engineering services. In the case of a major find, there are some potential offsetting effects as the currency appreciates reducing export returns to some sectors.

A17. In all cases, there is a significant increase in Crown revenue, from $90m with a small-scale development, $2bn in a large-scale development, or up to $7.7bn in the large-scale, high-volume scenario.

A18. These fiscal impacts are significant under the larger-scale development scenarios. This provides a range of opportunities to the government including: increasing services; reducing debt which improves disposable incomes; or reducing taxation. It also means that the precise nature of the long run impacts of petroleum development will depend on key fiscal choices, ie what the Crown does with the increased revenue.

A19. For the East Coast region, where the oil and gas developments are to be located, the key impacts are summarised in Table 2:

Table 2: Summary of Regional impacts

% change versus baseline; $NZ million

Scenario	3: Small-scale		4: Large-scale		5: Large-scale, high-volume	
GNDI	**%**	**$m**	**%**	**$m**	**%**	**$m**
East Coast Study Region	2%	160	15%	1,400	39%	3,600
Rest of NZ	0.1%	100	1.5%	2,630	5.9%	10,500

Employment gains (employee counts)			
Oil and gas	177	978	1,804
Other industries	22	185	543
Total	**199**	**1,163**	**2,347**

Source: NZIER

A20. The oil and gas developments would improve the economic diversity of the East Coast and deliver strong economic gains to a region that currently has lower economic, employment and population growth than the national average.

A21. There would be flow-on implications to a range of industries that benefit from the increased economic activity within the East Coast, such as heavy construction, engineering, retail, and property.

A22. The highly capital-intensive nature of the oil and gas industry means that the employment and transformational benefits of developments would be small relative to the GDP gains. Nonetheless, average employment gains of between 0.2% and 1.4%, depending on the scale of the development, would improve employment opportunities in the East Coast where employment growth is low relative to the rest of New Zealand.

A23. Because the oil and gas industry is capital rather than labour intensive, uses foreign investment and is a previously untapped resource, there is little crowding-out of resources used by other industries within the economy.

Development impact and environmental footprint

A24. As with any land use development, developing petroleum resources has an impact on the environment and those living in the area.

A25. Any petroleum development will bring with it a range of environmental impacts, and challenges that would need to be managed effectively. In this case, the development could involve pockets of what is known as “conventional” resource, such as the sandstones found in Taranaki. More likely it would involve so-called “unconventional” resource, in this case shales (soft clay-based rock that splits into layers) and less permeable formations, which would likely require a more significant environmental footprint to develop.

A26. On 27 November 2012, the Parliamentary Commissioner for the Environment (**PCE**) issued her interim report on hydraulic fracturing[3]. The PCE’s high level conclusion is that the environmental risks associated with hydraulic fracturing can be effectively managed provided operational best practices are implemented and enforced through regulation. While it is *likely* that if there is potential for petroleum development on the East Coast, it will involve hydraulic fracturing, it is not yet *certain* that this will be the case.

[3] *Evaluating the environmental impacts of fracking in New Zealand, An interim report*, Parliamentary Commissioner for the Environment, November 2012

A27. The Study report sets out the scale of potential impact, indicating that this varies directly with the scenarios. It covers the physical infrastructure such as drilling sites, production stations, the potential impact on local ports, and environmental impacts.

A28. As a particular concern is the potential impact on aquifers, this report identifies the major aquifers in the region, sets out the issues and presents the measures used to protect them. These include legislative provisions that provide for the appropriate management and protection of the region's water sources and significant aquifers such as the Heretaunga and Ruataniwha Plains.

Risks and risk management

A29. The petroleum industry has been particularly active in Taranaki. The study notes the strong safety record of the petroleum industry throughout New Zealand over the past 40 years. It also discusses how risks can be mitigated through good operational practice, and sets out the regulations in place to govern such activity, which are designed to ensure any future development maintains a high environmental and safety record.

Shaping development in practice and ensuring robust planning for future development

A30. Any significant development would take place over a prolonged timeframe – there will be no change overnight. Rather, development would take a number of years to eventuate. As exploration goes ahead and proves successful, more substantive choices would follow. Such a timeframe provides opportunities to consider and manage the impacts.

A31. The more optimistic scenarios would, if pursued, have a major impact on the region, but there would be choices about how the East Coast community explores and develops the resource. Because the resource is region wide and the impact is region wide, it makes sense for any discussion to take place at the regional level.

A32. Councils in the region already have a range of tools for consulting with communities regarding resource issues, and have developed specific arrangements to engage with Māori.

A33. The impact of large-scale petroleum development is such that there would likely be a need for Regional and/or District Plan changes. The Study sets out what would be involved in plan changes under the Resource Management Act 1991 (**RMA**).

A34. The Study does not aim to prejudge any such changes. It explains the significant choices that may need to be made and the existing mechanisms for the people of the East Coast to provide input into any decisions. In the event that significant commercial development is likely, it may be appropriate to develop specific mechanisms for dialogue between iwi, councils and communities, for example by preparing a petroleum management strategy, which would then inform the development of statutory plans.

A35. The role of the East Coast Oil and Gas Development Study and how development may play out in practice are summarised in Figure 1 below.

Oil and Gas in Taranaki: A Regional Success Story

Resource exploration has safely and successfully sat alongside agriculture and tourism to drive the Taranaki economy

The oil and gas industry in Taranaki makes a significant contribution to the regional and national economy – over half a century after the first modern development. Petroleum development in Taranaki dates back to the discovery of the onshore Kapuni field in 1959. This was sufficient to invest in the North Island gas transmission network. It was notably followed by the discovery of the giant Maui field in 1969.

Today, the industry is estimated to contribute $2.2 billion[4] to GDP. This is 40% of the estimated impact of Scenario 4 (or six times Scenario 3). It is estimated that the region has the highest average labour productivity and the highest level of output per capita in New Zealand[5]. Mining was estimated to contribute 23% of regional GDP in 2011.

[4] 2009 figure, direct, indirect and induced impacts

[5] This estimate is based on regional estimates provided by BERL. Note that these estimates are less reliable for small regions such as Taranaki.

These benefits are realised in a number of ways:

- The industry accounts for 4,200 jobs in the region and an additional 1,800 nationally.
- The industry is the basis of a number of the region's major commercial operators including Shell Todd Oil Services, Fitzroy Engineering Group, and Transfield Worley
- It has presented a significant opportunity for local contractors to upskill from other industrial sectors. Upskilling means greater productivity and value added.
- It has fostered a diversity of support industry roles including: entry strategies, land access, professional services, seismic information, district planning, environmental advice, health and safety training, engineering, design, electrical and mechanical work, and transport.
- Significant regional companies, Methanex and Balance Agri-nutrients, are viable because of feedstock provided by the industry.
- Flow on effects reach such sectors as retail and housing, supporting additional jobs.
- Royalty payments from petroleum are around $400 million per annum.
- Other less tangible, but important benefits have emerged. Hosting a global industry has brought vibrancy to the region, attracting skilled workers and their families. The industry has catalysed advancements in technology and fostered a greater understanding of our natural resources, careers, science, and research. Exploration and production companies have contributed to the region by supporting social and environmental activities.

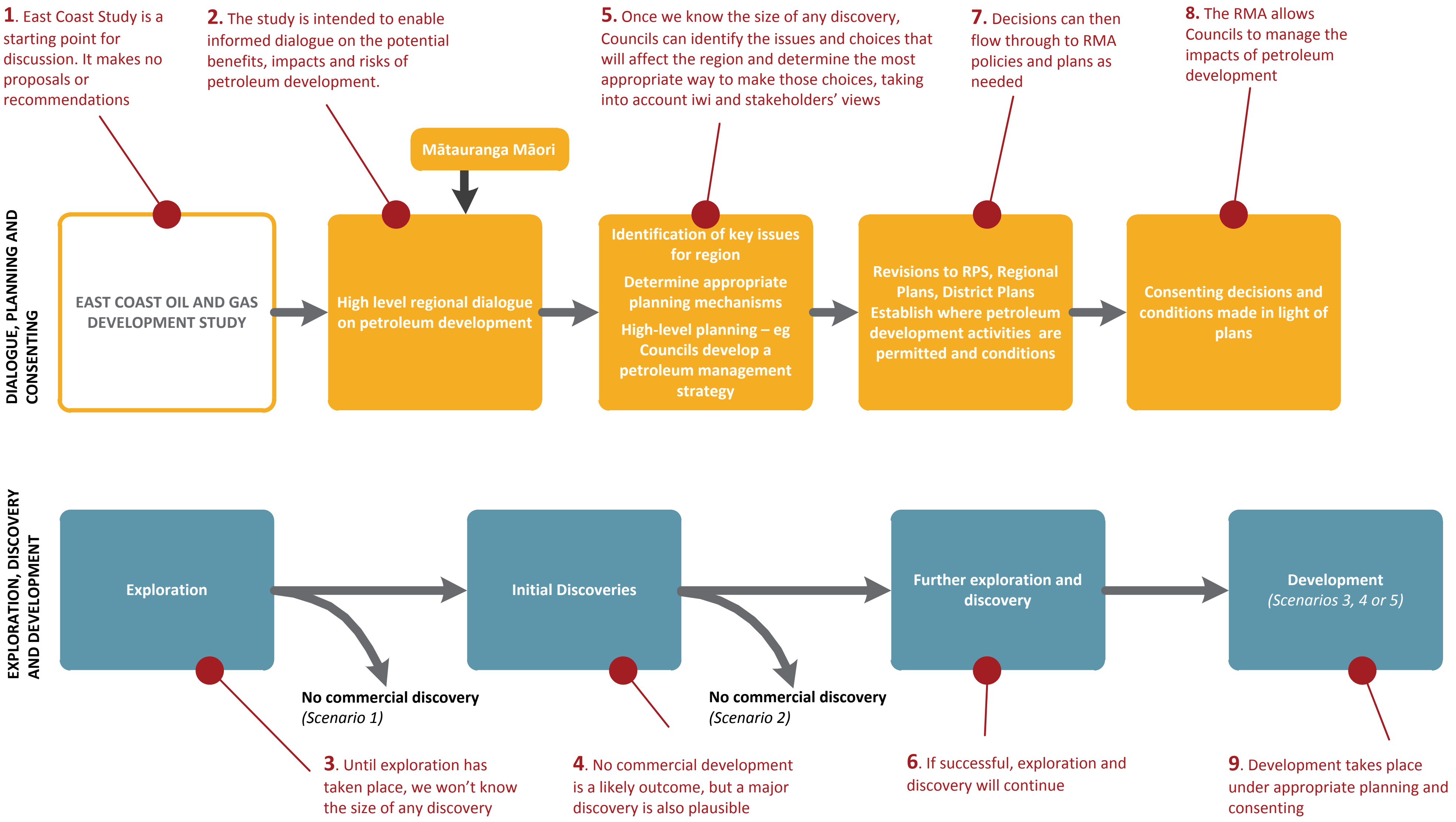
The Taranaki oil and gas industry is now seen as a platform for further development in the region and elsewhere in the country. It has opportunities to participate in development overseas, and can support further diversification.

Sources: *The Wealth Beneath our Feet*, Venture Taranaki 2010;
Economic contribution and potential of New Zealand's oil and gas industry, MBIE, August 2012

Figure 1: How development might play out in practice

EAST COAST OIL AND GAS DEVELOPMENT STUDY AS THE START OF A DIALOGUE

- The East Coast Oil and Gas Development Study is one input at the start of a set of dialogue, planning and consenting processes.
- These processes take place alongside initial exploration and discovery – unless and until there are initial discoveries it will not be clear what planning is needed.
- There are numerous linkages between: dialogue, planning and consenting; and exploration, planning and consenting. These linkages are considered in this report.



1. Introduction

1. Earlier this year, the Mayors of Gisborne, Tararua, Central Hawke's Bay, Hastings, Napier and Wairoa, and the Chairs of Horizons and Hawke's Bay Regional Councils (the **East Coast Mayors and Chairs**) and the Ministry of Business, Innovation and Employment (**MBIE**) expressed an interest in knowing more about the economic potential for the region of possible oil and gas development, as well as the potential footprint.

2. As a result, the East Coast Mayors and Chairs and MBIE, with support from the regional economic development agency, Business Hawke's Bay, agreed to carry out a joint study of the possible strategic impact that a v ariety of different development scenarios may have on the region.

3. This report is the outcome of that study. It is intended to support informed dialogue between iwi, councils and communities about the potential benefits, impacts and risks of petroleum development across the East Coast of the North Island, if such a development were to become a realistic prospect.

4. There is a real possibility of such development. The geology of the East Coast of the North Island has two extensive formations, the Waipawa and Whangai, and some less widespread sandstone and limestone formations which are potential sources of petroleum. It is known that they generate petroleum because there are over 300 mapped oil and gas seeps across the East Coast.

5. As a r esult, there is interest in exploring for petroleum in the area and MBIE's New Zealand Petroleum & Minerals branch (**NZP&M**) has issued a num ber of exploration permits. One is held by TAG Oil, which is planning to drill four exploratory wells to help them determine the likelihood of development being commercial.

6. There has been little exploration of the Waipawa and Whangai formations as they have historically been considered to have productive capacities well below the commercial thresholds accessible using conventional development technologies, so our current knowledge of the geology of these formations is limited. Until exploratory wells are drilled, there is a great deal of uncertainty about whether petroleum recovery would be either possible or economic and about the potential impacts.

7. To address this uncertainty, this report presents a range of scenarios. These scenarios are intended to illustrate the range of outcomes that might result from petroleum exploration and development. They are not intended to be forecasts or predictions. They are based on the level of information that currently exists about the resource, and have been developed on b ehalf of MBIE and the East Coast Mayors and C hairs by independent experts.

8. The scenarios range from exploration uncovering dry wells or extraction of the resource being found to be u neconomic, through to scenarios where petroleum development is economic, and very significant.

STUDY PURPOSE

The purpose of the study is to:

- **Support informed dialogue on the exploration of oil and gas resources in the East Coast region**

- **Place the dialogue at a regional level**

To do this, the report provides:

- An understanding of the potential regional and national economic impacts, placed in the perspective of the regional and national economy: What will be the impact on jobs? What will be the impact on wealth? Which industries gain and which might lose? What is the impact on the Government's books?

- A perspective on the footprint of petroleum development and the risks: What would it be like to have petroleum development in one's midst? Just how serious are the risks? How can they be managed?

Scope

9. The scope of the study is the entire East Coast excluding the Wellington region (ie the Wairarapa is excluded[6]). That means that it is broadly the area of Hawke's Bay and Gisborne Regions and Tararua District, as shown in Figure 2 (the **Study Region**). The Study Region departs from these administrative boundaries in that:

   - it has been extended marginally so that permit areas that extend slightly beyond these boundaries have been included

   - sensitive public conservation land listed in Schedule 4 of the Crown Minerals Act 1991 (**CMA**)[7] has been excluded – principally Urewera National Park, but also Huramua Nature Reserve, an area of 0.3 ha north west of Wairoa

   - an area where it is thought that there are no geological formations likely to bear petroleum has been excluded.

10. This does not mean that the whole Study Region is open to potential activity. Actual activity typically involves much smaller areas. Before any activity can occur, permits

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6 Active exploration is taking place in the Wairarapa region, with three core holes drilled in 2012 and two exploration wells planned for 2013. As these are based on the same formation found in the Study Region, this activity is likely to further the understanding of prospectivity in the Study Region.

7 Schedule 4 covers Crown-owned areas of particular conservation significance and includes national parks and nature reserves. Under section 53 of the CMA, if a permit relates to Schedule 4-listed land, the permit holder may exercise the permit only in accordance with an access agreement agreed in writing between the permit holder and the appropriate Minister.

under the CMA, consents under the RMA, and land access agreements with landowners are required.

11. Areas of particular natural significance listed in Schedule 4 of the CMA, including national parks and nature reserves, would not be considered for development (and in any case, are excluded from the Study Region as noted in paragraph 9 above).

12. Sites of local, cultural and historical significance are protected in legislation, which ensures the appropriate management and protection of the region's water sources and significant aquifers such as the Heretaunga and Ruataniwha Plains.

13. The findings of this study are not sensitive to marginal changes in the Study Region boundaries.

Approach

14. This report draws on:

- **information provided by current permit holders** that has been subject to peer review
- **specially commissioned reports by independent experts** that assess the potential for oil and gas development and the resultant economic impact
- **a specially commissioned compilation of available information on the aquifers of the region** in order to provide a high level indication where the potential oil resource overlaps with aquifers
- **third party reports** that describe the footprint and risks of unconventional oil development
- **the experience and knowledge of the East Coast councils and the Ministry of Business, Innovation and Employment** regarding planning, consenting and permitting.

15. The specially commissioned reports are available for download from the MBIE website[8]. A full list of these reports is provided in Appendix 1.

16. Terms of reference for the Study are attached at Appendix 2.

8 http://www.med.govt.nz/sectors-industries/natural-resources/oil-and-gas/petroleum-expert-reports/east-coast-oil-and-gas-development-study

Figure 2: Map of Study Region

Petroleum development, energy security and climate change

17. This report sets out a range of scenarios that at the higher end involve an increase in our oil, and potentially gas, production. Such a development would potentially bolster New Zealand's energy security (ie with local oil and gas development New Zealand would become less reliant on imports).

18. Petroleum plays a vital role in transport and many other sectors, and is likely to continue to do so for many decades as measures are undertaken to adapt both domestic and international economies for a future where carbon resources are more constrained. For the next few decades at least, the world and New Zealand will need oil and gas for secure and affordable energy that is needed to maintain our economic performance and social well-being.

19. Developing the country's diverse resources in a responsible manner will enable New Zealand to deal with these energy challenges while minimising the costs to our households and businesses and ensuring we remain in step with the international community. It will also reduce our exposure to the impacts of an international energy price shock.

20. An important incentive to move to renewable energy sources comes from the Emissions Trading Scheme which adds the cost of carbon emissions into non-renewables.

The Parliamentary Commissioner for the Environment's Report on Fracking

21. On 27 November the Parliamentary Commissioner for the Environment (**PCE**) issued her interim report on fracking[9]. While it is *likely* that if there is potential for petroleum development on the East Coast, it will involve hydraulic fracturing, it is not yet *certain* that this will be the case. As paragraph 45 below explains, this is because of uncertainty about the nature of the resource.

22. The PCE's high-level conclusion is that the environmental risks associated with hydraulic fracturing "*can be effectively managed provided, to quote the United Kingdom Royal Society, 'operational best practices are implemented and enforced through regulation'*".

23. As Chapter 6 sets out, the petroleum industry is subject to strong health & safety, and environmental regulation that requires industry to adopt best operational practice. This allows regulators in New Zealand to address common concerns raised regarding hydraulic fracturing, such as ground water contamination and earthquakes. With regard to water contamination, the PCE noted that there is no evidence that hydraulic fracturing has caused groundwater contamination in New Zealand, and at the current scale of operations the risk appears low.

24. With regard to earthquakes, the PCE noted that hydraulic fracturing creates tiny earthquakes, generally less than magnitude 2 and which cannot be felt at the surface. The PCE references in her report a study undertaken by GNS Science which concluded that "*prior to 2012, there is no evidence that fracking in Taranaki has caused earthquakes*

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9 *Evaluating the environmental impacts of fracking in New Zealand, An interim report*, Parliamentary Commissioner for the Environment, November 2012

that could be felt at the surface." The measures that ensure safe procedures are undertaken are described in paragraphs 258 to 266 below.

25. The issues of ground water contamination and earthquakes are considered in more detail in this report with similar findings.

26. The PCE posed a number of questions in relation to development on the East Coast. These are:

- Given that the area is particularly seismically active, what are the implications for well integrity and the injection of wastewater?
- Has the folding and faulting of the rock layers meant that contamination of groundwater is more likely?
- Will the drilling be vertical or horizontal, as a horizontal well has a much greater likelihood of intercepting vertical faults?
- What does the depth of the shale layers mean for proximity to groundwater and aquifers?
- Given that the East Coast is much drier (and frequently suffers from summer drought), where will the water required for fracking be taken from?
- How well would the main waste disposal methods used in Taranaki (land farming and wastewater injection) translate to the East Coast?

27. These are valid questions. They are most appropriately answered during the detailed investigation and planning that will follow once the existence of a commercially viable petroleum resource is confirmed and the technology required to mine that resource is clearer.

Petroleum development and Māori

28. Natural resources are taonga for Māori because they are part of Papatūānuku (earth mother), and also because they provide food, water and even warmth. Māori interpreted the existence of gas seepages as a connection to atua and so regarded them as tapu. A gas seep near Te Puia Springs north of Gisborne is named Te Ahi o te Atua – the fire of the gods.

29. Iwi and hapū are kaitiaki of resources provided to them by atua and take this role seriously.

30. Māori have long had many uses for oil and gas, including lighting and as a dye. Seepages known to Māori were the first places Europeans targeted in developing petroleum. Gas bubbling to the surface on the New Plymouth foreshore led to the digging of a well in 1865.

31. Iwi have expressed a strong interest in the subject of this report, and have an important perspective and knowledge to bring across the environmental, economic, social and

cultural dimensions. They also have their own ways of assessing impacts across these dimensions for the areas of which they are kaitiaki.

32. This report is intended to provide a starting point for further input and consideration based on the potential development scenarios. As such, it is acknowledged that if development of a prospective area becomes commercially viable, any subsequent planning and strategising will need to take into account thorough consideration of all of these dimensions with full input from iwi. Mātauranga Māori (Māori knowledge and wisdom) can be used alongside community-based and scientific-based knowledge to provide a fuller and richer assessment of potential development and impacts.

33. Statutory and possible non-statutory mechanisms for consulting with iwi are discussed in this report, particularly in Section 7.

Remainder of this Report

34. The remainder of this report is set out as follows:

Section 2: Petroleum Prospectivity sets out what is currently known (and not known) about the prospect for petroleum development in the Study Region.

Section 3: Introducing the Scenarios provides a description of each development scenario, including how they might play out over time.

Section 4: Economic Opportunities and Impacts summarises the assessment of the impact of each of the economic scenarios on the national and regional economy.

Section 5: Development Impact and Environmental Footprint provides a description of what it would be like to have oil and gas development taking place in the East Coast.

Section 6: Risks, Risk Management and the Regulation of Petroleum Development gives perspectives on the main risks of petroleum development, the options to manage those risks and the regulatory arrangements to make sure they are indeed managed diligently.

Section 7: Shaping Development in Practice sets out the tools available to the communities of the East Coast to exercise choices about petroleum development and examines how they might be used in the scenarios.

2. Petroleum Prospectivity

35. This section considers the prospects for commercially viable petroleum finds in the East Coast region. Whether there is commercially viable petroleum depends on:

    a. the extent to which there is oil present and recoverable

    b. the cost of recovery.

36. Consideration of these draws extensively on two of the reports commissioned as part of the Study:

    a. *East Coast North Island – Oil Resource Play – Development Scenario Models* by Michael Adams Reservoir Engineering

    b. *Geological Input into the Evaluation of a Potential East Coast Resources Play*, by GNS Science.

37. A number of non-geological considerations also have an important bearing on prospectivity, and will be taken into account by an investor before commencing exploration. These include:

    - the fiscal regime – how much of the gross revenue is paid in tax and royalties?
    - the regulatory regime – how stable is it; how clear are the requirements; how much compliance burden does it generate; how quickly will decisions be made; how predictable are the outcomes?
    - market access – are mechanisms in place to deliver petroleum to market; are there potential political barriers?
    - infrastructure – is there adequate infrastructure to support a petroleum industry?
    - local support – to what extent is there local support for petroleum development?

38. Most of these factors are considered at the level of New Zealand generally and are not East Coast specific. New Zealand scores well across most of these dimensions, except that the geographic isolation and scale of the industry means that the cost of petroleum development can be r elatively high. Within parts of the East Coast this issue is exacerbated by the terrain and relative isolation of a number of locations.

Geological Considerations

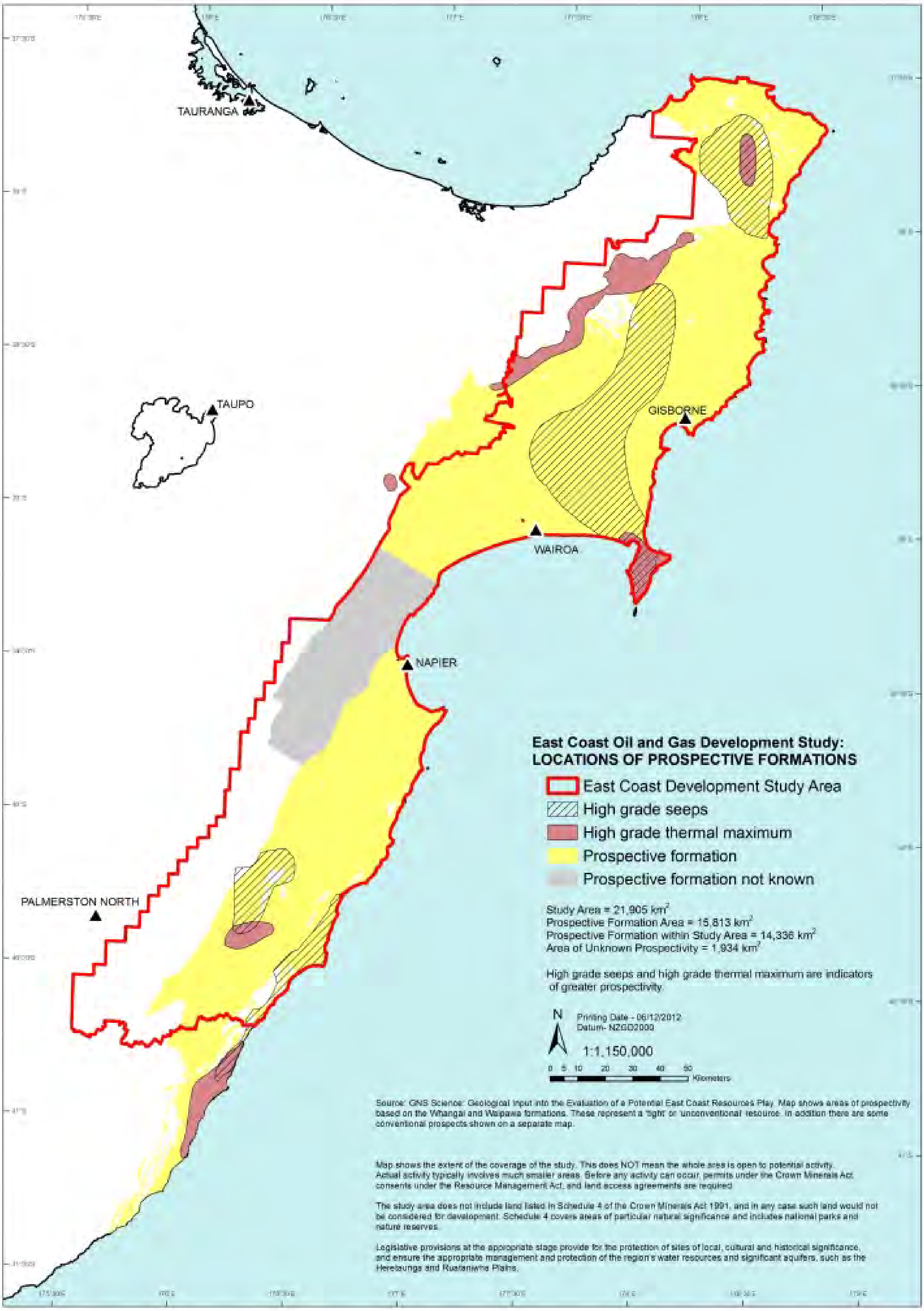
39. Although the East Coast region is geologically complex, it has tantalised oil and gas explorers since the 1850's. More than 300 known oil and gas seeps are present, and this attracted early interest in the area. Indeed small volumes of oil were produced from shallow wells and pits near surface seeps at Waingaromia and Rotokautuku. More than 40 wells have been drilled onshore in the East Coast Basin. Among the late 19th century

"successes" was Waingaromia-1, which produced 20 to 50 barrels of oil per day (**bopd**) until the rig burnt down in 1870. Most wells drilled since then have had shows of oil and/or gas. Offshore there were strong gas shows in the three offshore wells as well as gas finds in the onshore Wairoa area. These and other small finds have maintained exploration interest, although finding any sizeable accumulations has been problematic.

The Whangai and Waipawa Formations

40. The onshore interest of industry participants includes both the less extensive sandstone and limestone formations as well as the extensive Whangai mudstone and Waipawa black shale. The latter are Mid and Late Cretaceous marine formations deposited around 100 million years ago. GNS Science has mapped the horizontal extent of these formations as shown in Figure 3. Its work also included an estimation of the vertical extent of the formations. Figure 3 is based on currently available information. New Zealand Energy Corp advises that work on the Ranui permit extends the prospective area to the south west (ie outside the Study Region).

Figure 3: Extent of Waipawa and Whangai formations



41. There are a number of grounds to believe that the Whangai and Waipawa formations potentially hold oil volumes. Geochemical analyses of oil seeps in the region confirm their genesis in these formations.

42. But Michael Adams describes any oil as presently ‘undiscovered’. The main reason for this is that only three wells have reached these formations and only two of these provide good data. Most importantly, no oil or gas has ever been produced directly from them. Seismic surveys have been acquired in some areas, but much of the data is older and coupled with difficult terrain and complex geological structuring makes interpreting it over wide areas impossible. Other information on the target formations is gleaned by geologists from where they outcrop, but these points are at the edges of the basin and have been exposed to the elements, which makes inferring their rock properties at depth subject to uncertainty. These difficulties are compounded by the complex geological history of the region. Oil will only be present if the formations are at sufficient depth (and therefore had sufficient heat and pressure) to generate it. The current depth places the formations outside or just inside the oil generation window. However, the geological history suggests that they will have been substantially deeper in the recent past and will have produced oil at that time – as evidenced by the seeps.

43. All these factors mean the real productive and commercial potential of these formations is unknown, and requires more wells and modern seismic investigation to commercially appraise it.

44. An accepted method for assessing the prospects of making petroleum finds is to compare an area with known analogues. TAG has used the Bakken Shale in North America. If this is a valid analogy, then taking into account the fact that the East Coast formations are thicker, this may make them highly productive with the estimated ultimate recovery per well (a key driver of commercial viability) potentially very high – ie assumed to be of the order of 1 million barrels of oil equivalent (**BOE**). This is the figure that has driven TAG’s own development scenarios.

45. Michael Adams and GNS Science consider the Waipawa and Whangai formations not to be true shales in the manner of the North American analogues, instead being sequences of inter-bedded sands, silts and carbonaceous clay/silt stones. Oil and gas generated in the formations will likely migrate into the adjacent silts and sands and these will be the permeable sources of oil or gas, assuming the formation seals remain intact. However, industry operator sources quote field examination of Whangai Formation outcrops revealing a massive (poorly bedded), indurated, siliceous mudstone up to 500m thick with higher porosity than those of the Bakken shales. In both scenarios the hydrocarbons may flow more easily than true “shale” plays and require less drilling/fracturing to obtain commercial rates of flow. A better analogy for these formations may be one based on conventional so-called ‘tight’ oil or gas plays. If this is the case it is possible, but not certain, that recovery of the resource would involve less intensive development than assumed in the scenarios in this report – ie fewer wells and fracture stimulations, albeit with lower total petroleum volumes in place than in the Bakken analogy and hence lower total petroleum recoverable volumes.

Conventional prospects

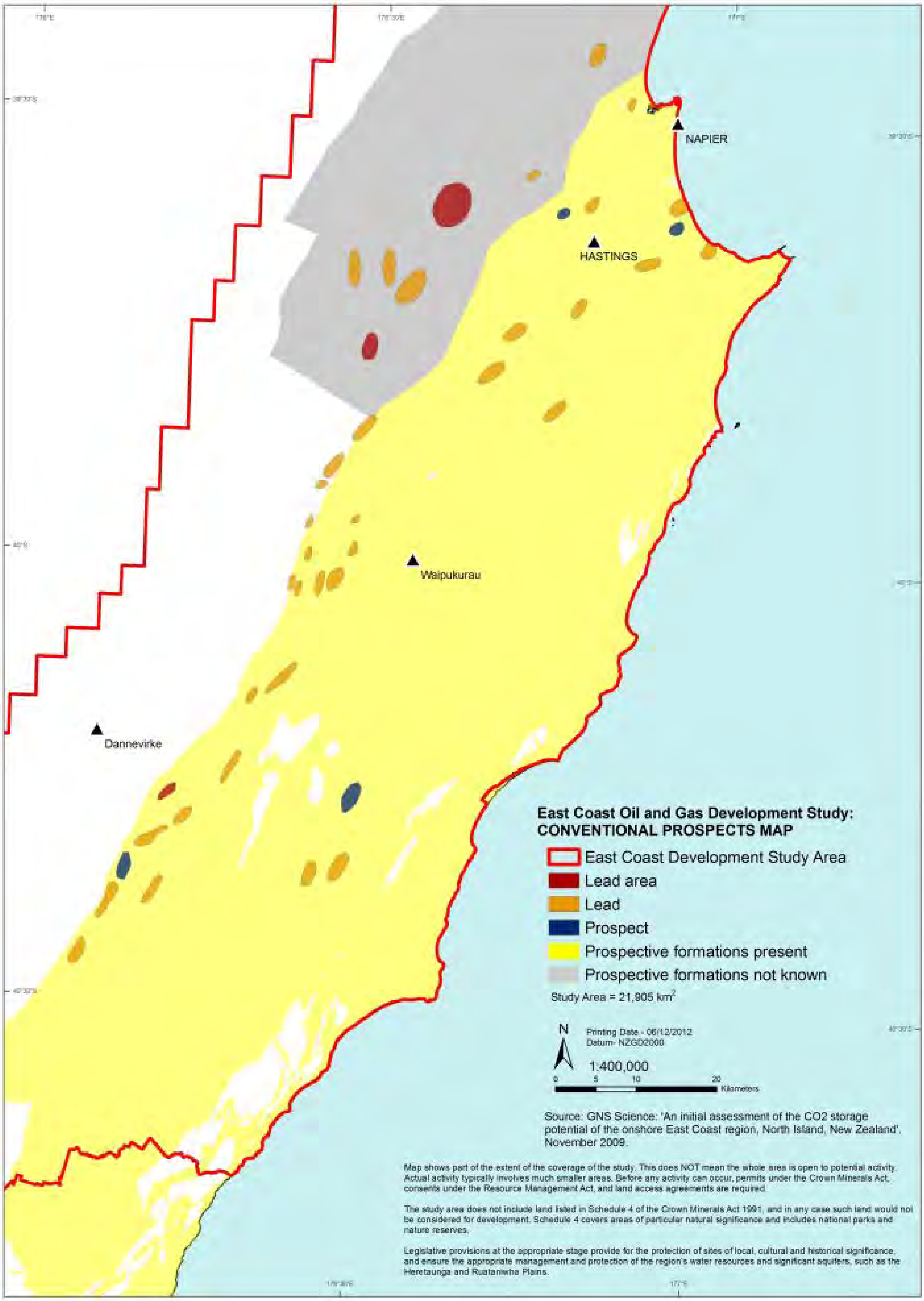
46. In addition to the unconventional prospects considered in detail in this Study, there are also conventional prospects. Earlier work by GNS Science has identified a number of areas where there could be conventional recoveries for part of the Study Region. This work was done as part of an assessment of CO_2 storage potential[10]. These are shown in Figure 4. There is continuing interest in exploring these prospects and one permit holder is actively considering conventional prospects north of the area shown in Figure 4.

47. For simplicity, the conventional prospects have not been factored into the scenarios, but this does not significantly affect the extent to which the scenarios illustrate the broad range of plausible outcomes.

48. In Figure 4, a ‘lead area’ is an area identified for consideration; a ‘lead’ merits more detailed examination, typically a formation that may act as an oil trap. Leads are matured into a drillable ‘prospect’ through detailed seismic or other investigation.

10 Petroleum reservoirs are potential CO_2 storage sites (when the petroleum has been removed), as they managed to hold hydrocarbons over geological time so they should also manage to hold CO_2. The study was Bland, K, Griffin, A, Doody, B and Field, B, 2010, *An initial assessment of the CO_2 storage potential of the onshore East Coast region, North Island, New Zealand*, Cooperative Research Centre for Greenhouse Gas Technologies, Canberra, Australia, CO2CRC Publication Number RPT09-1531, available at https://extra.co2crc.com.au/pts/index.php/extDown/getFile/1775

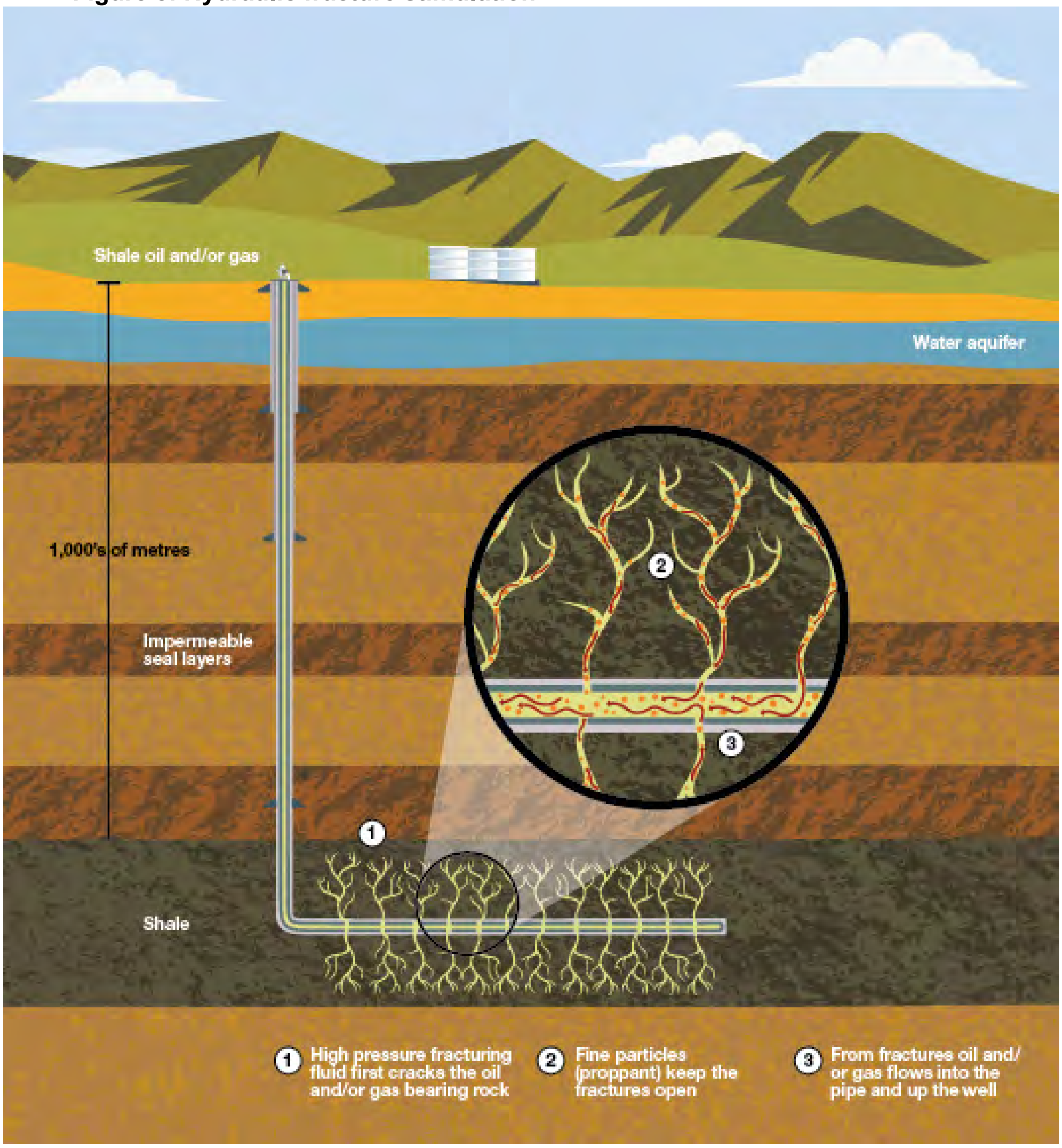
Figure 4: East Coast conventional prospects map



Production technology

49. Whether the resource is a true shale or not, the primary approach to the recovery of any finds is expected to use horizontal and/or high angle wells, most likely with hydraulic fracture stimulation at intervals within these wells (commonly referred to as 'fracturing', 'fracking' or sometimes 'hydrofracking'). As discussed in paragraph 45 above the need for and intensity of any fracture stimulation is uncertain. Fracture stimulation is shown schematically in Figure 5.

Figure 5: Hydraulic fracture stimulation



50. Fracture stimulation is a process whereby cracks are created in underground rock strata by injecting large volumes of water into the rock under extremely high pressure. The cracks open up the rock and this improves flow by increasing the area of rock available for petroleum to flow from.

51. To prevent the cracks closing up under the weight of rock above them, sand or ceramic beads known as ‘proppants’ are added to the water to keep the cracks from closing. Other chemicals are used to enable the water and proppant to temporarily remain suspended in the injected water and to assist the mixture to penetrate the hairline fractures naturally present in most rocks.

52. Fracture stimulation in shales is typically associated with horizontal drilling. This allows a large area of stratum to be penetrated from one production site. The underground area covered can typically be 3 x 3 kilometres.

53. Fracture stimulation is a relatively mature technology. It was first used in the United States in 1949. Worldwide its use has increased in recent years as a result of improved drilling technology allowing horizontal drilling, and increases in the international price of oil to date. It is estimated that over 2.5 million wells worldwide have been hydraulically fractured. Although more expensive than conventional approaches, it does increase the flow from petroleum bearing strata. This makes it commercially viable to mine resources that would otherwise be uneconomic to develop. The Government is aware of at least 55 wells that have been fractured in New Zealand.

54. The cost of petroleum development will depend on the availability and accessibility of potential well sites. In relatively benign topography with reasonable road access the costs will be lower and therefore any finds are more likely to be commercial. In more mountainous country, costs will be greater, and greater volumes will be needed to make development commercially viable.

55. More information about hydraulic fracturing can be found on the New Zealand Petroleum & Minerals website[11].

Production scenarios

56. Michael Adams considered three production scenarios in detail. Each is based on different well by well performance and recoveries and cost scenarios. Each of these is based on discovery in one permit area initially.

- *Well production based on GNS Science-supported estimates of rock properties and associated tight-oil derived production forecasts*: Oil recovery per well is presumed to be 0.45 million BOE, which is about 20% less than a typical Bakken shale well. The financial performance of this scenario just passes the petroleum industry’s typical investment hurdle. That is, this outcome is commercially viable, but only just.

- *Bakken Shale-type recoveries of 0.55 million BOE*: This is commercially viable and would be a successful outcome.

- *Recoveries based on TAG’s modelling of 1 million BOE*: Commercially, this would be a very successful outcome.

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11 http://www.nzpam.govt.nz/cms/petroleum/overview/hydraulic-fracturing

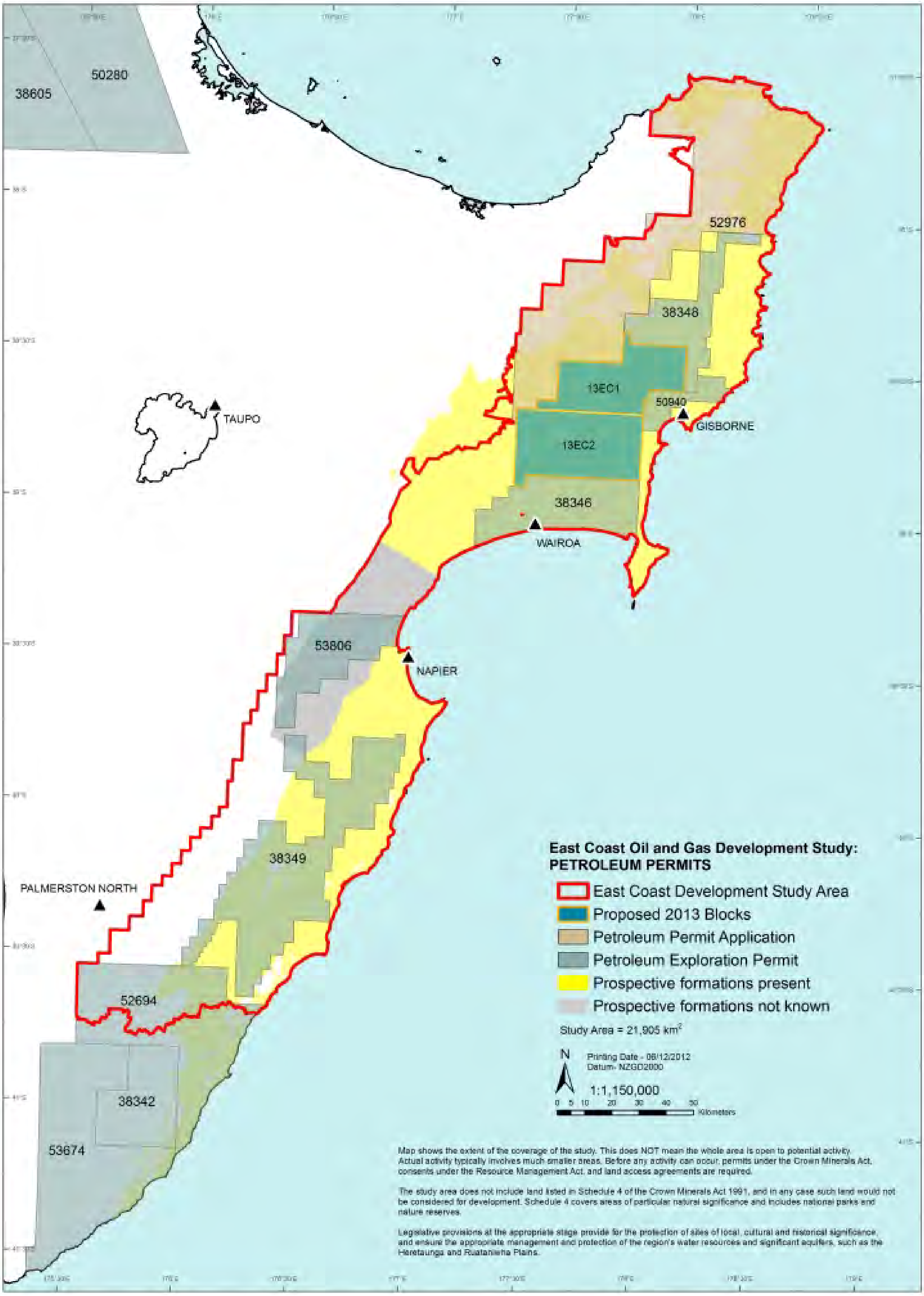
57. A number of factors that will not be determined until exploratory drilling has been done, but will determine which of these applies in practice, including:
- actual thickness of the petroleum bearing formation at the well site
- oil content and porosity
- pressure.

Permit arrangements

58. There are currently six exploration permits in the Study Region; one block is the subject of applications, and two further blocks are included in NZP&M's 2013 block offer. The block offer is a competitive tender process by which exploration permits are awarded. New Zealand Petroleum & Minerals selects the blocks in the offer in consultation with iwi and local authorities. Permits granted as a result of Block Offer 2013 are expected to be awarded at the end of 2013.

59. The permits are shown in Figure 6 with additional details provided in Appendix 3.

Figure 6: Permits in the East Coast Region



3. Introducing the Scenarios

60. Given the uncertainty of what will be found once exploratory drilling takes place this Study has developed 5 s cenarios. These scenarios represent the full spectrum of plausible outcomes for the region that could be the end result of exploration. They take into account the geology, economics (notably the potential level of investment by permit holders) and the response of the East Coast Community.

61. The scenarios are:

- Scenario 1: Quickly abandoned exploration
- Scenario 2: Explore but no development
- Scenario 3: Small-scale production
- Scenario 4: Large-scale production
- Scenario 5: Large-scale high-volume production.

62. Scenarios 1 and 2 represent instances where exploration wells are dry or not economic to develop, which is a common outcome in the oil and gas industry.

63. Scenarios 3, 4 and 5 are estimated by Michael Adams to pass conventional financial thresholds for commercial viability. They are based on the three scenarios referred to in paragraph 56 in the previous section adjusted to reflect that commercial viability in one area is likely to attract further exploration and signal likely success in other areas.

64. Scenario 3 could be described as a mid-point best estimate based on present information and assumes moderate success in three areas.

65. Scenario 4 is an optimistic scenario between Scenarios 3 and 5. It also assumes success in three areas, but uses the more favourable cost assumptions of Scenario 5.

66. Scenario 5 represents the upper end of what is plausible. It assumes success in six areas. For it to happen would require both potential recovery per unit of rock and the extent of mature rock volumes at the upper end of their likely ranges. It would also require the support of the East Coast community. In this case, a constraint is likely to be capital inflows into development for New Zealand – at least initially. As a result the development would take place over a long timeframe. Scenario 5 is plausible but unlikely, though finds on this scale do happen from the current level of prospectivity – the Bakken Shale in North America being an example.

67. A description of each scenario is provided below, with more details of the assumptions, costs and revenues set out in *Table 3: Key metrics of the scenarios* on page 36.

68. In each of the commercial scenarios (3, 4 and 5) the main product is oil, but there are also quantities of gas produced.

Scenario 1 – Quickly abandoned exploration

69. In this first scenario, TAG executes the currently planned 4 well campaign on the East Coast. Results are so poor that they leave and the results discourage any further exploration. There will be a short-term economic boost locally for a year in terms of non-technical jobs such as seismic crew work, site preparation works and supply of food/fuel/accommodation but crews and rigs will be predominantly from bases in Taranaki, with geoscience/engineering support provided from there or Houston/Calgary head offices.

Key facts

Spend $ billion	**Max production** bopd	**Time period** years
0.1	Nil	1 - 2

Scenario 2 – Explore but no development

70. A step up from Scenario 1, Scenario 2 sees encouraging enough results to inspire additional exploration work along the East Coast basins over a number of years, and additional investigations by other permit holders. It is assumed this will involve some 12 wells and a proportionate increase in spend. On completion of the programmes there is deemed to be insufficiently economic resources for commercial development. All well sites are remediated and permits handed back. As for Scenario 1 there will be short-term East Coast benefits in terms of roading and civil works and goods supply. Due to the longer-term nature of the activity there would be more opportunity for East Coast locals to take on skilled technical jobs on drilling rigs and for service companies (cementing, fracturing, completion, well logging, well testing etc). At the end of activities, local people who wish to continue using these new skills would have to move or take up 'fly in fly out' roles further afield.

Key facts

Spend $ billion	**Max production** bopd	**Time period** years
0.3	Nil	4 - 6

Scenario 3 – Small-scale production

71. This scenario represents a likely development if commercially viable discoveries are made.

72. Scenario 3 sees economic oil production being established in 3 areas of the East Coast in a staggered manner. Each area would have around 5 drilling pads (each with around 6 wells) of 1 to 2 ha each. Different combinations of numbers of pads and wells can also be envisaged. There would be a total of 6 exploration wells and 90 production wells, with a total area drained of 300km^2. The wells would use horizontal drilling and stimulation techniques to attain economic oil rates. Reservoir recovery for this scenario is based on the small amount of geological information available for the basin. The estimate in this

scenario for recovery is some 20% less than the average in the Bakken Shales[12] of North Dakota and only 45% of the high end of the range.

73. The scenario assumes that there would initially be one rig drilling production wells, but that after a three-year lag, a second rig is brought in – though it may be difficult to raise the capital for this. Oil in each area would be gathered by buried gathering pipelines, and collected to a central processing facility for stabilisation – removal of volatile gases methane, ethane, propane, butane. This scenario envisages that crude oil would initially be trucked to New Plymouth for export, which would have transport costs. It is likely that following an early stage of testing, port facilities would be set up locally, reducing the need for long distance trucking. It is assumed that oil would be a light sweet crude based on information from seep data, and that this will sell into Asian markets.

74. Following initial flaring, to prove volumes and test reservoir potential, gas would be sold into the existing East Coast market and should enable further demand creation through pricing pressure on current supplies from further afield. The existing pipelines currently providing gas to the East Coast could have their flows reversed, allowing additional volumes to be sold into West Coast markets.

75. Given the duration of the work there will be opportunities for contracting for both the exploration and construction phases in terms of site preparation, pipeline and facility construction, provision of transport, food and accommodation. As drilling activity will be longer, involving larger numbers of more complex wells than the exploration only scenarios, there will be many more opportunities to directly work in skilled oil field occupations in the drilling phase. Even after drilling is completed the wells will require on-going maintenance (workovers), and the facilities will require technically skilled operation and maintenance. The downstream process to export will require management, and the fields must be nurtured by skilled engineers and scientists to ensure optimal extraction.

Key facts

Spend $ billion	**Max production** bopd	**Time period** years
11	15,000	21

Scenario 4 – Large-scale Production

76. As with Scenario 3, economic oil production is established in 3 areas of the East Coast in a staggered manner. However each area drained is larger than in Scenario 3 and each well is more productive. It is assumed that each well is as productive as the Bakken Shale average in the United States. Each area is some 260 km^2. This is an optimistic, commercially attractive scenario with a big step up in production.

77. The total area drained (780 km^2) is just over 4% of the potentially prospective area in the East Coast (under 4% of the Study Region).

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12 The Bakken shales have been used by the permit holder as an analogue in its analysis of the prospectivity of the East Coast.

78. Drilling starts with some 10 exploration wells in the first 3 years followed by another 1,800 wells over the next 28 years, initially using 5 rigs and ramping up after 11 years as additional prospective area is included. The production wells would be drilled directionally from pads of 12 wells, to reduce impacts to other land users. As in Scenario 3, oil and gas would flow through underground gathering pipelines to central processing facilities. Here fluids would be separated, crude oil would be stabilised and gas conditioned for onward sales.

79. It is possible that this level of recovery could be achieved with less intensive development. This would occur in the event that petroleum has migrated into silts and sands (as suggested in paragraph 45 above). However, if that is the case, the chances of recoveries reaching the level envisaged for this scenario are lower.

80. Crude oil volumes are assumed high enough to justify cross country pipeline connection to a port terminal, located on the East Coast. At the port receiving terminal, storage tanks and tanker loading facilities would be constructed, and upgrading/dredging operations would be undertaken to allow an Aframax (700,000 barrel) oil tanker access.

81. In this scenario, it may become attractive to adapt the Marsden Point refinery for a diet of East Coast crude via shuttle tanker or pipeline. This would be an economic decision related to transport costs versus refinery upgrade costs and has not been considered in this analysis as it would not significantly alter the project economics. However, it would be an opportunity if the scenario played out.

82. It is envisaged that gas would be sold into the local East Coast market, pipeline upgrade works would be undertaken to move gas to market both through the northern and western reticulation routes, and a power plant could be constructed locally to utilise gas. In the short term some gas flaring may be required[13] to prove up sufficient volumes for the capital intensive works involved in commercialising the produced gas.

83. As with the previous scenario there would be both short- and long-term employment opportunities. These opportunities would increase at least in proportion to the increase in activity levels, possibly more so due to the multiplying effect of "downstream" activities such as power production, long-term infrastructure enhancement (roads, port etc), and the setting up of bases for management of service and oil company operations near population centres.

Key facts

Spend $ billion	**Max production** bopd	**Time period** years
85	150,000	41

13 Thermal oxidation technology which combusts gas without flaring is now available in New Zealand and so flaring may not be required.

Scenario 5 – Large-scale high-volume production

84. This scenario is at the upper end of what is plausible and could be described as a 1% chance. It also represents the upper end of potential impact in terms of the infrastructure required.

85. In this scenario the unconventional reservoirs the East Coast Basin are found to be at the upper end of the range found in the Bakken (ie well above the Bakken average). This is possible, because the formations are thicker than found in the Bakken. This would provide nation-changing economic returns. The area drained (1,600 km^2) is 9% of the potentially prospective area in the East Coast (and 7.3 % of the Study Region).

86. As with Scenario 4, in the event that petroleum has migrated into silts and sands (as suggested in paragraph 45), the recoveries would remain as Scenario 5, but the development would be less intensive.

87. Drilling starts with some 10 exploration wells in the first 3 years, followed by another 3,600 production wells over the subsequent 49 years, initially using 1 rig and ramping up after 11 years of production as additional prospective area is proved. This continues for the next 38 years. The production wells would be drilled directionally from pads of 12 wells, to reduce impacts to other land users. As in Scenarios 3 and 4, oil and gas would flow through underground gathering pipelines to central processing facilities. Here fluids would be separated, crude oil would be stabilised and gas conditioned for onward sales.

88. Crude oil volumes are assumed to be high enough to justify cross country pipeline connection to a port terminal, located on the East Coast. At the port receiving terminal storage tanks and an offshore loading system would be implemented in deep enough water to allow a Suezmax (1.2 million barrel) access. Consideration would need to be given to the appropriate port and shipping lanes to accommodate oil tankers. A pipeline to Marsden Point and upgrade of this refinery to accept East Coast crude feed would be even more attractive in this case due to the long term nature of the production scheme, but as in the previous case this was not deemed significant in evaluating the impacts of this scenario.

89. As in the previous scenario gas would be sold into the local East Coast market, pipeline upgrade works would be undertaken to move gas to market both through the northern and western reticulation routes, with a large local power plant to utilise the produced gas and raise steam for other industrial users (eg pulp and paper, dairy). Further volumes would be subject to a capital intensive conversion project to monetise the gas. This may be in the form of Gas to Liquids, LNG, or large-scale power generation. The scenario has simply assumed a low sales price for the gas that would allow such a large capital intensive project to be economic. In the short term some gas flaring would be required to prove up sufficient volumes for the capital intensive works involved in commercialising the produced gas.

90. Again there will be both short- and long-term employment opportunities. These opportunities will increase at least in proportion to the increase in activity levels, in this scenario even more so due to the multiplying effect of “downstream” activities such as power production, long-term infrastructure enhancement (roads, port etc), and the setting

up of bases for management of service and oil company operations near population centres.

Key facts

Spend $ billion	Max production bopd	Time period years
284	225,000	64

Comparison of the scenarios with Taranaki

91. Comparison of the scenarios with Taranaki is not straightforward because:

- differences in the nature of the resource: the output of Taranaki measured in energy comprises two-thirds gas and one-third oil, but the modelling carried out for the study assumes the price of oil is around five times that of gas gigajoule for gigajoule
- comparisons are between projected future prices and fluctuating past prices
- the scenarios assume a steady build up to maximum output and then a decline; the use of averages over the development cycle masks this
- costs on the East Coast are likely to vary considerably according to scale.

92. The following comparison should therefore be considered indicative only. The energy output from Taranaki in 2011 is of the same order as scenario 4. However, because of the high proportion of gas produced in Taranaki, the gross revenue is around half scenario 4. The average annual gross revenue of scenario 4 is around $5.1 billion. Although this puts the economic impact of Taranaki below scenario 4, it is still more akin to scenario 4 than scenario 3, for which the average annual gross revenue is around $390 million.

Table 3: Key metrics of the scenarios

	Units[3]	*Scenario 1* **Quickly abandoned exploration**	*Scenario 2* **Explore but no more**	*Scenario 3* **Small-scale production**	*Scenario 4* **Large-scale production**	*Scenario 5* **Large- scale high-volume production**
Duration	years	1 - 2	4 - 6	21	41	64
Estimated ultimate recovery/well	mmBOE	N/A	N/A	0.45	0.55	1
Max rigs in operation	#	1	1	2	5	10
Exploration wells	#	4	12	6	10	10
Production wells	#	0	0	90	1,800	3,600
Well sites	#			19	156	306
Max number new wells per year	#	4	4	10	80	80
Year of last new well		2014	2019	2025	2044	2065
Max wells concurrently in production		0	0	60	1,200	2,000
Area drained	km^2	0	0	300	780	1,600
Processing plants	#, capacity	N/A	N/A	3 X 5,000 bopd	3 X 100,000 bopd	6 X 100,000 bopd
Locations (oil fields)	#	1	1	3	3	6
Maximum production	000 bbl/day			15	150	225
Export route		N/A	N/A	Truck to New Plymouth	150km pipleline to port then Afromax-type tanker to Asia	400km pipelines to deepwater port then Suezmax-type tanker to Asia
Investment 2012 prices[1]	NZ$bn	0.1	0.3	11	85	284
Max net revenue 2012 prices[2]	NZ$bn/year	0	0	0.7	12	36

Notes:
1: Investment is made by the commercial operator
2: Net revenue is revenue to the commercial operator, after operating and capital costs, before royalties and tax
3: # = number

Source: Michael Adams Reservoir Engineering

4. Economic Opportunities and Impacts

93. This section considers the economic impact of petroleum mining in the East Coast region. It draws extensively on a report '*Economic Potential of Oil and Gas Development*' prepared especially for this study by NZIER.

Scope of the analysis

94. Time and data constraints have meant that NZIER's analysis has been based on baseline data at the administrative region level. This means that aggregate data below on the current economy and demography of the Study Region relate to Hawke's Bay and Gisborne Region combined. Technically, this includes areas outside the Study Region (notably within Hawke's Bay Region) and excludes Tararua District. In aggregate, these overs and unders provide a reasonable proxy baseline on which to base the economic impact assessment.

95. The impact is reported at the Study Region level. It has not been disaggregated at the administrative region or district level because it is not known where petroleum development would take place. The more positive scenarios assume that development would take place in a number of areas across the region.

96. The analysis was undertaken using a static CGE model. Broadly, this allows the first round effects of petroleum development (increased production and increased investment and returns within the oil and gas industry) to be translated into the broader impact on the New Zealand economy. To capture intuitively the effect of petroleum mining on the region and country, NZIER has reported its findings in terms of a representative year during mining operations.

97. NZIER notes some limitations to this approach could be overcome using a dynamic modelling approach. This would have taken more time than available and it is not clear that this would have added significantly to the understanding of economic impacts given that the scenarios are not predictions but intended to illustrate the range of possible outcomes from petroleum development.

Current economy and prospects

98. The Study Region was home to 201,900 people in 2011, which was 4.6% of the total New Zealand population. The rate of population growth (1.9% since 2006) is significantly lower than for New Zealand as a whole (5.3%). One factor is outmigration from Gisborne and Hawke's Bay. (There was also outmigration from Manawatu-Whanganui.) The median age is 38.1 years, older than 36.8 nationally.

99. The Study Region's GDP is estimated to be $8 billion a year with total employment of 97,000. These figures are both around 5% of their national equivalents. There is a strong emphasis (in absolute terms and also relative to the national picture) on primary industry. Employment growth has been negative in recent years, declining by 0.5% a year between 2006 and 2011.

100. These aggregate figures mask diversity within the Study Region, which has areas that are relatively dynamic and fast growing with low rates of unemployment and sound growth prospects. Elsewhere the reverse is true.

Hawke's Bay

101. Hawke's Bay generates an estimated 3% of national GDP. The Hawke's Bay economy is dominated by primary and manufacturing industries. The region is a nationally significant producer of meat, wood and horticultural products, with equally significant processing facilities for these products. While these industries are high value and high volume, over the last 10 years, primary production has been static and the manufacturing sector has shrunk.

102. The availability of water is a critical issue for growth of agriculture and horticulture. The Ruataniwha Water Storage project[14] has the potential to double the area of irrigated land in Hawke's Bay.

103. Like other non-main centres, the region faces many demographic and skill challenges – a limited and slow growing population, an ageing population, net losses of families and young adults, low labour force participation and high unemployment.

104. There do not seem to be major infrastructure constraints in the region (other than in relation to fresh-water management), nor do there seem to be specific capital access issues. Economic growth will depend on further value add and diversification of the economic base.

Gisborne

105. Gisborne generates an estimated 1% of national GDP. The economy is concentrated in agriculture, forestry and fishing shaped by the small population base, rural geographically isolated location and significant natural resources.

106. Gisborne's natural resources are its key assets, but its biggest exports (meat, logs and wood products, and vegetables and fruit) are largely processed in other parts of New Zealand or overseas. There is scope for more 'value added' manufacturing and services in the region.

107. GDP growth was ahead of New Zealand as a whole in 2009 and 2010, but more recently is in line with the national average.

108. Half the population is under 25, but many young people leave the region for lack of a job or to take up study/training opportunities. A shortage of technical skills and motivated young workers appears to be holding back Gisborne's businesses.

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14 The Ruataniwha Water Storage project, led by Hawke's Bay Regional Council, is a long-term sustainable water supply solution for Central Hawke's Bay. If approved, the storage dam with a potential capacity of 90 million cubic metres will provide certainty of supply for irrigators and other water users.

Horizons

109. The Horizons region generates an estimated 4% of New Zealand's GDP. It has a relatively balanced and diverse economy, with fairly good growth rates across a number of industries.

110. It has a substantial primary industries base focussed on sheep (meat and wool) and beef farming, and dairy farm expansion and intensification. Around 40% of New Zealand's commercial sheep farms are located in the region, particularly in the western districts.

111. Public administration and safety is a major component of the regional economy, particularly within the education, health and defence sectors. Agricultural strengths in the wider region drive the strong agritech research & development and educational presence in Palmerston North and Manawatu, with Massey University, three Crown Research Institutes and Ohakea Air Base.

112. Manufacturing has been in decline, but is dominated by food processing and metal fabrication for use in the agricultural sector. Meat processing is a significant part of the regional economy.

113. Strengths exist in related engineering such as boat building, aviation and pharmaceuticals with some high-performing niche businesses emerging from these sectors.

114. The region faces some significant demographic challenges. It has a relatively small, slow growing and older population (median age of 39.1 years against a national median of 36.8 years), and there are concerns about maintaining labour force capacity and skills. Labour force participation is the same as the national average (68%). Recent employment growth has focussed in finance & insurance and transport.

115. Only a small part of Horizons is within the Study Region – Tararua District. The extent to which the wider region benefits from petroleum development to any greater extent than New Zealand as a whole is likely to depend on the location of development and the relative strengths of links between Tararua District and Hawke's Bay versus those with the remainder of the Horizons region.

Tararua District

116. Tararua District was estimated to have a population of 17,700 in June 2011[15]. The population is declining.

117. The district has a substantial primary industries base focused on sheep (meat and wool) and beef farming, dairy farm expansion and intensification, and exotic forestry. Wind energy generation is a key feature of the district, including New Zealand's largest wind farm, TrustPower's Tararua wind farm. Further wind farm development is underway.

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15 Statistics New Zealand medium forecast based on 2006 census

Prospects

118. NZIER reports a number of indicators that do not bode well for the Study Region's growth potential:

- The East Coast is one of the least economically complex regions in New Zealand. Broadly this means that there are a relatively limited number of distinctive capabilities – ie specialised businesses. This has been linked in the literature to lower growth potential.

- The East Coast has exhibited modest performance measures of economic dynamism. During 2011, the East Coast had a significantly lower than average number of new businesses: -29% for Gisborne and -15% for Hawke's Bay. The number of employees generated by new businesses was also lower than the national average.

119. Caution should be exercised in basing projections on these indicators, but they suggest that the prospects for the Study Region are for growth below the national rate.

Impacts of petroleum development

Direct effects

120. The direct effects of petroleum development are those on the oil and gas industry itself. They flow from the revenue from petroleum sales and the investments made. These flows pay for operating costs and capital expenditure, much of which is spent within the region. A number of people are employed by the permit holder either directly or through contractors. Related taxes and royalties are paid to the Crown and the balance is profit for the investor.

121. These direct effects are summarised in Table 4. To put these figures in context, the total revenue line, which is assumed to be the result of exporting all the petroleum, can be compared with the total value of New Zealand's exports in 2011 of $58,000 million.

Table 4: Average annual commercial and direct employment impacts

$NZ million

Scenario	3: Small-scale	4: Large-scale (4)	5: Large-scale, high-volume
Total revenue	**390**	**5,100**	**17,000**
Less			
Operating costs	110	850	2,300
Capital expenditure	170	1,300	2,300
Royalties	26	600	2,500
Taxes	23	700	3,000
Profit	**54**	**1,600**	**6,900**
Direct employment (FTE)	158	587	899

Source: NZIER based on Michael Adams Reservoir Engineering. Differences are due to rounding

122. In Table 4:

- revenue is assumed to be from export of the oil and gas
- operating costs are assumed to be spent within the Study Region and overseas
- capital expenditure is assumed to be provided by overseas investment
- royalties are payments to the Crown for the right to extract petroleum
- profits are corporate profits
- the profit is assumed to be exported as the investment is from overseas.

123. The relative profitability of petroleum development increases with the more optimistic scenarios. The main drivers of this are economies of scale (for example by building pipelines to transport petroleum to ports) and the greater recovery per well.

124. Of the jobs created in the oil and gas industry in the region, it is assumed that initially 50% would go to locally based employees, with the balance going to skilled workers moving in from other parts of the country. However, the proportion of locally based workers would increase to 95% over time.

Indirect Effects

125. There are flow-on effects to a range of industries. The nature of these effects varies according to the relationship of the industry to the petroleum sector.

a. **Supplying industries** – industries that supply the extraction sector with intermediate inputs. For example the mining services industry experiences strong growth as its engineering services are used more heavily.

b. **Household expenditure industries** – industries that households spend money on. The incomes are clearly positive for industries which rely on household expenditure. Higher returns to capital and land boost households' incomes, leading to increased spending in industries such as retail, property and other service sectors.

c. **Investment industries** – industries that are used for investment and c apital creation, such as heavy construction grow as the industry builds and maintains capital stocks to sustain production.

d. **Export competing industries** – industries that suffer from the appreciation of the exchange rate as oil and gas exports expand. The value of exports such as dairy and horticulture decline as a consequence.

126. These gains and losses are illustrated in Table 5.

Table 5 Industry impacts

Percentage change in value added, selected industries[16]

Industry	Type	3: Small-scale	4: Large-scale	5: Large-scale, high-volume
Mining services	Supplying	2.5%	18%	48%
Residential property	Household expenditure	0.16%	2.6%	8.9%
Supermarkets	Household expenditure	0.10%	1.3%	4.5%
Heavy construction	Investment/ Supplying	0.22%	1.7%	4.7%
Dairy	Competing exporter	-0.23%	-2.6%	-8.2%
Horticulture	Competing exporter	-0.18%	-1.9%	-6.1%

Source: NZIER

127. As discussed below, the net indirect effects are strongly positive. However, these gains and losses are reflected by significant shifts in total employment in each sector. Overall NZIER has assumed that aggregate employment grows only at population growth rate. It is possible however, that employment increases and/or there becomes a significant flow of population into the Study Region reflecting the improved economy.

128. There is a rise in the average real wage of 0.13%, 1.4% and 4.7% for scenarios 3, 4 and 5 respectively.

National effects

129. The economy benefits from the wealth generated by utilising previously dormant resources, resulting in increasing wages and returns to capital for the natural resource sector. The increase in exports generates higher income for New Zealanders, which leads to an increase in our wealth and thus living standards.

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16 The table shows impacts on a selection of industries to illustrate the range of categories in paragraph 125. They provide a good indication of the impact of various types of flow-on effects.

130. GDP grows by 0.18%, 2.7%, and 9.3% across scenarios 3, 4 and 5. GNDI, which is a measure of how well-off New Zealand residents are, grows by 0.14%, 2.2% and 7.5% across scenarios 3, 4 and 5. This equates to increases of $61, $910 and $3,183 respectively in per capita incomes.

131. National economic effects are summarised in Table 6.

Table 6 Summary of national results

% change versus baseline; annual average; $NZ million

Scenario	3: Small-scale		4: Large-scale		5: Large-scale, high-volume	
Metric	**%**	**$m**	**%**	**$m**	**%**	**$m**
GDP	0.18%	360	2.7%	$5,300	9.3%	18,000
GNDI	0.14%	270	2.2%	$4,000	7.6%	14,000
Consumer welfare	0.14%	160	2.0%	$2,300	6.8%	7,800
Exports (volume)	0.29%		4.6%		16%	
Imports (volume)	0.11%		1.2%		3.7%	
Nominal balance of trade		160		$2,600		9,000
Real wage	0.13%		1.4%		4.6%	
Real exchange rate	0.15%		1.7%		5.5%	
Capital stock	0.29%		2.4%		5.6%	
Crown revenue						
Indirect taxation		43		650		2,300
Royalties		22		600		2,500
Direct corporate tax		23		700		3,000
Total Increase		88		2,000		7,700

Source: NZIER. Differences are due to rounding

132. The development leads to a rise in Crown revenue from increased royalties, direct taxes, corporate taxes on the oil and gas industry and further tax revenue increases resulting from increased economic activity. The amounts are modest in Scenario 3, rising in Scenario 5 to nearly $8 billion. This is equivalent to around 13% of current core Crown revenue. Looked at another way, it is around 56% of the amount we currently spend on health. In practice, governments would have a choice as to whether to use such additional income to increase the level of services, meet the increased cost of providing services due to demographic and other changes, reduce net debt thereby increasing the safety net to international shocks, invest in infrastructure and initiatives to support economic development, or reduce taxation.

133. The national gains to employment are a function of the macro-economic assumptions in the modelling. In this case, it has been assumed that national employment levels grow with population – which is the long-run trend. This means the national employment gains are assumed to be zero. In practice any net employment impacts

will depend on a number of key policy settings, and Government spending and investment decisions made in the light of increased income.

Regional Impacts

134. The majority of economic gains from development flow to the Study Region. (Benefits flow beyond the region because oil and gas development is likely to use some inputs from other regions, some of the income generated is spent on goods from other parts of New Zealand, and benefits from royalties are likely to be widely distributed.) The Study Region benefits from 'regional multipliers' which mean that it benefits over and above the direct gain from oil and gas developments.

135. The aggregate impact on the Study Region is reported in terms of Gross Regional Disposable Income (**GRDI**). This is calculated as the estimated portion of GNDI relating to the region. GRDI excludes income that flows out of the region in the form of Crown taxes and royalties. The region would in addition benefit from any additional Crown expenditure. GRDI amounts must be treated with caution as income flows across the country are difficult to ascertain.

Table 7 National and Regional GNDI impacts

% change versus baseline; $NZ million

Scenario	3: Small-scale		4: Large-scale		5: Large-scale, high-volume	
	%	$m	%	$m	%	$m
East Coast Study Region	2%	$164	15%	$1,414	39%	$3,613
Rest of NZ	0.1%	$106	1.5%	$2,631	5.9%	$10,542

Source: NZIER

136. Employment gains range from 177 to 2,347 jobs. While these numbers are significant, they are relatively modest for the scale of development due to the high capital intensity of the oil and gas industry.

Table 8 Average East Coast employment impacts

Employee counts

Scenario	3: Small-scale	4: Large-scale	5: Large-scale, high-volume
Employment gains (employee counts)			
Oil and gas	177	978	1,804
Other industries	22	185	543
Total	199	1,163	2,347

Source: NZIER

137. Gains from 'other industries' are induced effects such as may result from increased household expenditure. There is the prospect of some of these gains flowing to those

who are currently unemployed. The requirement of any construction phase for unskilled labour to be taken on will provide opportunities to gain work experience.

138. Within these net gains are gains in the oil and gas industry and a mixture of gains and losses according to industry. Retail, service and property industries in particular benefit from increased incomes within the region. In the case of a large-scale, high-volume development, some export-based industries, including primary industries, are likely to face some adverse impact due to the increased strength of the dollar.

Table 9 East Coast industry impacts
Percentage change in value added, selected industries for the East Coast region

Industry	Type	3: Small-scale	4: Large-scale	5: Large-scale, high-volume
Heavy construction	Investment/ Supplying	0.22%	1.7%	4.7%
Residential property	Household expenditure	0.5%	5.1%	16%
Real estate	Household expenditure	1.3%	9.6%	26%
Supermarkets	Household expenditure	0.6%	7.2%	23%
Food outlets	Household expenditure	0.5%	5.3%	17%
Local government	Services	7.7%	20%	28%
Horticulture	Competing exporter	-0.2%	-1.9%	-6.1%
Dairy	Competing exporter	-0.2%	-2.6%	-8.2%

Source: NZIER

139. The development of a drill site can lead to increased income for the land owner, due to access fees. However, there can sometimes be depreciation in land value on neighbouring properties.

Implications across the scenarios

140. As noted, the East Coast is underperforming compared to the rest of New Zealand for economic growth, employment and population. Oil and gas development would deliver economic gains. The scale of the gains depends on the scenario. The scenarios do no more than illustrate the range of possibilities. The ones modelled in this Section assume that there are commercially viable petroleum deposits, but this cannot be assumed.

141. In other words, the economic impacts could be smaller than for Scenario 3, or anything in the range spelt out by Scenario 3 to Scenario 5. In the circumstances of the East Coast the impact of the scenarios could be interpreted as follows:

- Scenario 3 makes a welcome contribution to the economy of the region. For the period of petroleum mining, it could be seen as potentially offsetting the risk of economic decline. The impact on the national economy would be negligible.

- Scenario 4 would see a step change in the economy of the region and would see a decent increase in real wages (1.4%). This would benefit the welfare of the region's residents. A similar benefit might result from large increases in world prices of the region's primary produce. The impact on tax and royalty receipts to the government is slightly less than the total increases of spending in 2012 and forecast for 2013 combined. This would present the government with some significant choices for fiscal management.

- Scenario 5 would transform the Study Region's economy and see a step change in the nation's economy. While Scenario 5 is at the upper end of what is plausible, these observations would still be true if the outcome was intermediate between Scenarios 4 and 5.

142. The modelling doesn't attempt to predict what happens beyond the period of petroleum development. In Scenarios 4 and 5 these periods are already long. What happens beyond then will depend on a number of factors, including choices made regarding the expenditure and investment of the additional income. There is prospect that petroleum development will create a critical mass of capability which will be the basis for later diversification and/or export. As the Box: *Oil and gas in Taranaki: a regional success story* on page 10 shows, there is evidence of this happening in Taranaki.

143. Because petroleum development makes use of an untapped resource, involves overseas investment, and is capital rather than labour intensive, there is very little displacement of current activity. The gains discussed are net gains. Within this, however, there will be some movement between industries and sectors. While there is a risk that an oil boom creates pressures on housing supply and on other infrastructure, the numbers and the timeframe over which development is likely to ramp up, mean that there are opportunities to manage these pressures.

144. In all cases, a significant portion of the benefits go to an increase in Crown revenue. The fiscal impacts are significant in Scenario 4 and very large in Scenario 5. This means that the precise nature of the impacts of petroleum development will depend on key fiscal choices.

5. Development Impact and Environmental Footprint

145. As with any land use development, development of petroleum resources has an impact on the environment and potentially those living in neighbouring areas.

146. The scale of potential impact varies directly with the scenarios and the scale is therefore unknown at this stage. The actual impacts would also depend on the result of established planning processes that would be worked through should there be significant petroleum finds. These are discussed more fully in Section 7.

147. The main impacts resulting from petroleum development are:

- the presence of drill pads: these can be intrusive visually during the drilling phase, and can be responsible for noise, light and dust. These effects are significantly reduced or eliminated once the production phase is entered
- other physical infrastructure, including production stations, roading and pipelines
- traffic during development
- possible impacts from the water abstraction and the disposal of waste water
- limited methane emissions and the effects of flaring.

148. This section explains these impacts and why they occur. There is always a risk that impacts are greater than expected. These risks are considered in (Section 6).

Physical infrastructure

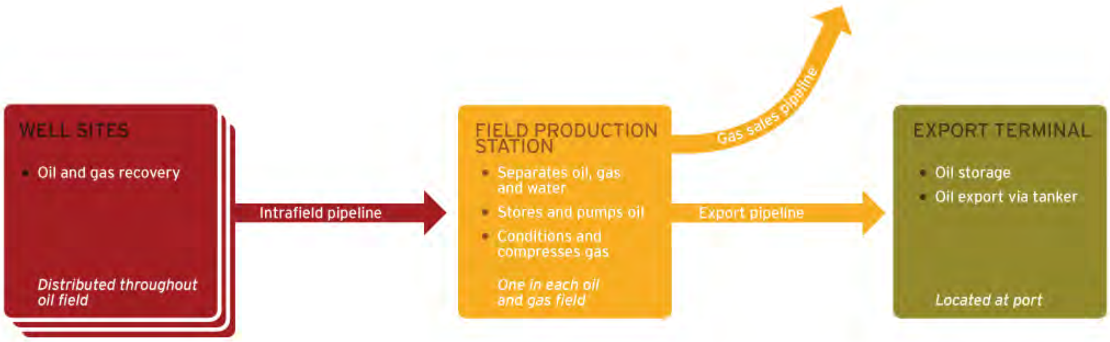
149. The most obvious impact of petroleum development is the development and presence of physical infrastructure.

150. A characteristic of unconventional petroleum development is that it requires a lattice of drill sites. Each drill site has a number of wells – the assumption in this case is that there will be six wells, but practice varies. Wells are connected by intra-field pipelines to processing facilities that separate gas, oil and any water before the gas and oil is prepared for export. In the more optimistic scenarios, gas may also be processed and sold locally.

151. Depending on volumes, petroleum may be trucked to a port out of the region or a port in the region may be developed to become an export terminal. For higher volumes, it will be efficient to build a pipeline from the field to the export terminal.

152. This arrangement is shown functionally in Figure 7.

Figure 7: Schematic of crude oil processing infrastructure



153. The following describes the physical infrastructure in more detail – what neighbours would expect to see, and what would be involved in its development.

Well sites

154. One of the main impacts of petroleum development is the process of drilling itself, and the land required for such development to occur (each drill pad typically occupies an area of 1 to 2 hectares). Typically this involves a burst of activity in developing the drill site and wells, which is the most visible and disruptive part of the development, before activity stabilises during the production phase.

Figure 8: Well site during drilling phase

155. Developing a site involves a drilling rig, associated equipment, and pits to store drilling fluids and waste. Roads and pipelines may need to be built. Setting up drilling in a new location can involve between 100 and 200 truck movements. There can also be intensive activity during the hydraulic fracturing operations.

Figure 9: Hydraulic fracturing operations underway in Taranaki

156. The site becomes less visible after drilling has finished and production starts. A "Christmas Tree" of valves, typically one metre high, is left on top of the well, with petroleum being piped to processing facilities that usually serve all the wells in an oil field.

Figure 10: Taranaki well site

157. The overall level of impact will depend on the scale of development, including whether there will be several drill sites under development concurrently. The extent of this is likely to be dependent on what is consented under planning rules, as well as the number of rigs the developer has commissioned. In the scenarios developed for this

study, the maximum number of rigs in operation across the East Coast varies from 2 in Scenario 3, to 10 in Scenario 5.

Processing facility

158. Most oil and gas production wells are initially free flowing: the underground pressures drive the liquid and gas up the well bore to the surface. When the oil cannot reach the surface unaided, some form of additional lift is required, such as a pum ping mechanism.

159. The processing facility processes the hydrocarbon fluids and separates oil, gas and water. Any water produced is treated before disposal, which can be sent to a treatment plant, re-used, or injected deep underground.

Pipelines

160. Infield pipelines carry fluids from a cluster of wells on a drilling pad to a processing facility. They are relatively small in diameter (c 100mm) and are buried in a trench to a depth that allows local activity (for example ploughing) to be carried out.

161. Export pipelines take petroleum from the oil field to a port terminal. These are larger sized pipelines, specifically sized for the expected rates of flow through them. The gas pipeline will be designed to meet the long distance existing transmission pipeline pressure rating. Additional allowances are made for safety, and valves are installed at specific points to isolate the pipeline if required.

Roading

162. It is expected that for most locations in the East Coast, roads of some sort will be available near the location of any drilling site. New roads may need to be constructed on private land to get to the drill site. In the exploration phase, roads will be upgraded where necessary to enable to mobilisation and demobilisation of crew and equipment to carry out exploratory drilling.

163. In the development and production phase of a project, roading works may be more extensive and permanent. Roads that will require daily travel may be upgraded to all weather bitumen, with appropriate widening and straightening to ensure safe use for all travellers. Roads to drilling pads may remain unsealed.

164. Roads built for petroleum development can typically provide improved long term access for farmers.

Export terminal

165. All products need a market and to get to markets outside New Zealand they need to be shipped. Oil produced on the East Coast would be no different. An export terminal would need to be developed near a port with deep water access. (An exception may

be in the case of Scenario 3, where oil produced may be trucked to Taranaki for export – at least in the first instance.)

166. An export terminal is connected to the export pipeline from an oil field. The terminal would require storage sufficient to fill an oil tanker. (Again in Scenario 3, there may not be an export pipeline, but trucks might be used).

167. Oil tankers come in "standard" international sizes based on tonnage. In this study, it was assumed that where production rates are high enough to justify building an export terminal, then an "Aframax" tanker (700,000 bbl) or "Suezmax" (1.2 million bbl) could be used. Aframax tankers are used to bring Middle Eastern crude oil into Marsden Point refinery approximately once per week, so it is possible that this same now empty tanker could be back loaded with crude oil for Asian refineries. The schedule of tanker loadings would be dictated by production rate from the field.

168. If it was determined to use one of the East Coast ports, dredging works would be required to deepen and maintain access from open ocean to the loading wharf for a fully laden tanker. It has been assumed that the dredge will operate some three months per year. In addition, two tugs will be required, and it has been assumed that the tugs operate for three days per tanker visit.

Decommissioning and abandonment

169. At the end of their useful life, wells must be safely abandoned. The HSE (Petroleum Exploration and Extraction) Regulations provisions include requirements with regard to the safe abandonment of wells. These Regulations are currently under review, with proposed changes intended to come into effect in mid-2013 that include an obligation that a well is designed and constructed so it can be suspended or abandoned safely, and there can be no unplanned escape of fluids. It is usual practice for resource consent conditions to require structures to be removed and the site remediated, and a bond might be required to ensure this occurs.

170. Because the more economic scenarios are played out over a long timeframe, many wells will have reached the end of their useful life (typically 20 – 30 years) before wells later in the development cycle have been drilled. The maximum number of well sites estimated to be in play at any one time is consistent with these scenarios and this is shown in Table 10. In interpreting Table 10 it should be remembered that any actual development pattern is likely to be different to that in the scenario. For that reason, Table 10 should be considered illustrative.

Table 10: Max number of well sites active at any one time

Scenario	3	4	5
Max active well sites	10	100	170

Source: Michael Adams Reservoir Engineering

171. Planning for decommissioning is an integral part of the overall management process and is considered at the beginning of the development during design. The aim of decommissioning is to generally revert the land to its original condition and use

permanently, unless otherwise agreed with a land holder and consented under the RMA (for example a concrete production pad being left and used as floor of a shed).

172. By their nature, most exploration wells will be unsuccessful and will be decommissioned after the initial one-to-three months of activity. Decommissioning of onshore production installations occurs at the end of their commercial life, typically 20–40 years, and involves the removal of buildings and equipment, restoration of the site and continued monitoring of the site after closure.

Environmental Impacts

173. The expected environmental impacts from the development – other than those relating to the development of infrastructure – relate to water use and disposal, and the effects of flaring and venting. Risks that arise from petroleum development, how these are mitigated, managed and regulated, is discussed in the following section.

Water use

174. Water use in hydraulic fracturing has not been an issue of significance in New Zealand. However, the development scenarios involving shale or tight resources could make more extensive use of water than developments that have occurred in Taranaki.

175. The likely source of water depends on the location of the drill site. Options include surface water sources (such as rivers, lakes or the sea), from groundwater, or trucked in from further afield.

176. Examples of water use in Taranaki include 7 cubic metres for the Cheal A7 well[17] to 1,500 cubic metres for the Mangahewa-6 well. Overseas, a well might require between a few thousand and 20,000 cubic metres of water. Recycling water has helped to reduce water demand. In some cases overseas, grey water has been used.

177. The need for water in water-scarce areas has driven technological development in the United States where fracturing operations are commonly carried out in arid areas. Various techniques for cleaning produced water to allow it to be reused in fracturing or for other purposes are entering service.

178. Water use is allocated under the RMA through regional plan provisions and the resource consenting regime. Regional Councils manage water use, and they may adopt provisions in their plans to permit and restrict these activities. These controls typically use measurable thresholds, beyond which a resource consent will be required.

179. In relation to truck movements to transport water if required, Councils often require a traffic management plan to minimise any inconvenience or risks to public safety or to the roading network that truck movements could cause.

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17 *Hydrogeologic Risk Assessment of Hydraulic Fracturing for Gas Recovery in the Taranaki Region,* Taranaki Regional Council, 2012

Methane and other air emissions

180. This sub-section considers the *direct* impact of production on the atmosphere and the implications for neighbours of venting and flaring[18]. The global warming implications of the *use* of the produced petroleum for energy are considered in Section 1.

181. Unconventional development generally has higher production-related greenhouse-gas emissions than conventional development:
    - More wells and more hydraulic fracturing are needed per unit of output. This uses energy typically coming from diesel motors, which have CO_2 emissions.
    - More venting or flaring during well completion because the flow-back phase represents a larger percentage of total recovery.

182. Venting and Flaring are regulated under the Crown Minerals Act and associated regulatory regime (**CMA Regime**) and the RMA, and climate change considerations through the Emissions Trading Scheme. The Minerals Programme for Petroleum issued under the CMA discourages venting and flaring setting out the Government's expectations that permit holders should implement practical and economic options to collect and use gas. It is also in the operator's interest to minimise venting and flaring.

183. Venting of methane can be prevented in most cases by diverting it for sale. If this is not economic it can be flared, though there remains a risk that venting is required in an emergency to prevent a blowout or for equipment maintenance. Operators are required to offset emissions through the Emissions Trading Scheme.

Access to Land

184. Petroleum development requires access to land for drilling pads. For private land, this requires the negotiation of an access agreement with the landowner or occupier. Typically this can provide an attractive return to the landowner for the area occupied.

185. A permit holder generally doesn't need an access arrangement for minimum impact activities on the land under a permit, except for special classes of land. However, 10 working days' notice of entry must be given to each landowner and occupier, or iwi authority in the case of Māori land.

186. Where the land is Crown land, the access arrangement is with the appropriate minister (usually the Minister of Conservation).

[18] Flaring is burning off natural gas as a waste product when it is uneconomic to sell or conserve, or in emergency situations when accumulations of gas become a safety concern. Venting is the direct release of natural gas into the atmosphere.

6. Risks, Risk Management and the Regulation of Petroleum Development

187. The petroleum industry has been operating effectively for over 40 years in New Zealand, and over that time there has been a strong safety record. The Government is conscious of the need to protect New Zealand's environment and deliver economic outcomes that are consistent with good environmental practice.

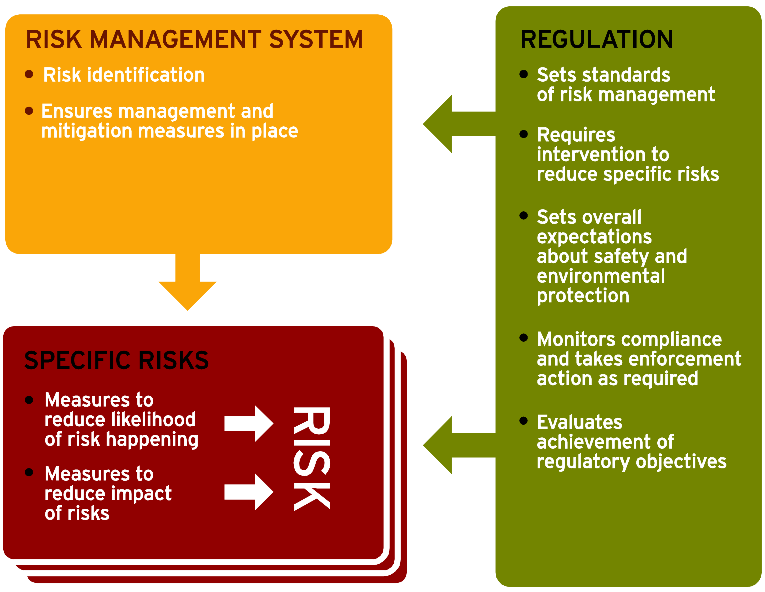
188. There are a number of risks associated with petroleum development, as with any economic activity, and this section explains what some of these risks are, how they are managed and the regulatory framework governing such activity. The sector is heavily regulated and there are detailed planning processes under which development is undertaken (see section 7 of this report). Given that, the picture emerges of any development only taking place on a controlled basis.

189. Much public focus has related to the practice of hydraulic fracturing, but hydraulic fracturing is just one aspect of the petroleum development process and many of the issues raised relate to petroleum development more generally.

Risk management and regulation

190. An important element in assessing whether risks are acceptable is whether they are well managed. Managing risks is a multi-layered matter as shown in the following diagram.

Figure 11: Risk management layers



191. The layers are:

- **Specific responses to individual risks:** The sub-sections below consider specific responses to specific risks. Such responses are designed to reduce the likelihood of the incident occurring, reduce the impact if it does, and facilitate remediation. For example, channelling hazardous chemicals through armoured hoses reduces the risk of a rupture. Placing a facility over a contained paved area reduces the extent to which chemicals filter into the environment in the event there is a spill. Having clean up material accessible facilitates remediation.

- **Risk management:** The oil extraction technologies set out envisaged for the region are relatively mature. This means that risks have been identified and suitable responses developed. Nevertheless as technology evolves and circumstances change it is important to have mechanisms in place to constantly identify risks and ensure that suitable responses are indeed in place. This process is known as risk management, and is primarily the responsibility of operators.

- **Regulation:** This refers to the use of a range of legal instruments to achieve social and economic policy objectives. A common reason for regulation is to ensure that operators do not compromise public or environmental safety for their own gain. In this regard, a well designed and implemented regulatory system ensures that operators manage risks at an acceptable level.

192. The primary aim of the risk management regime is to prevent any harm occurring in the first place. The liability regime complements this by ensuring that there are strong incentives on operators to avoid harm.

193. Regulation is the key tool by which central and local government make sure that risks are properly managed to avoid unnecessary harm resulting from petroleum development.

The New Zealand regulatory regime for petroleum development

194. The government has been working to ensure New Zealand has a world-class regulatory environment for the safe and environmentally responsible exploration, production and transportation of our petroleum resources.

195. The process by which the government manages petroleum development is shown in Figure 12 below. It provides for a number of 'gates' that provide assurance that land access, exploration, resource access, environment, and health and safety will be appropriately managed.

Figure 12: Government management of onshore petroleum

The processes for the government management of petroleum provide for a number of risk mitigation gates

RISK MITIGATION GATE		CMA PERMITS
1 Land allocation gate	**ASSESSMENT** **LOOKING AT THE LAND** • Research based on historical and available technical data • Some land excluded for conservation and cultural considerations	
2 CMA gate (explore and access)	**EXPLORATION** **GETTING A PERMIT** • Competitive tenders through block offers • Permits issued based on proposed work programme, technical and financial capability • Consultation with iwi and councils	**Permit for up to two five-year terms** • Seismic surveys • Sampling • Aeromagnetic surverys • Exploratory drilling • Geological studies • Data analysis
3 RMA gate (environment)	**ENVIRONMENTAL CONSENTS** • Resource consents from local authorities under RMA	
4 H&S gate (health and safety)	**HEALTH AND SAFETY** • Health and Safety in Employment Act, and Petroleum regulations administered by MBIE's High Hazards Unit	
5 CMA gate (production and access)	**PRODUCTION** **GETTING A PERMIT** • Permits can be awarded once a discovery made • NZP&M assesses work programme • Consultation with iwi • Royalties paid to the Crown	**Permit for up to 40 years** • Development to produce the resource • Well drilling • Production facilities • Infrastructure eg pipelines
6 RMA gate (environment)	**ENVIRONMENTAL CONSENTS** • Resource consents from local authorities under RMA	
7 H&S gate (health and safety)	**HEALTH AND SAFETY** • Health and Safety in Employment Act, and Petroleum regulations administered by MBIE's High Hazards Unit	
8 Land restoration gate (HSE)	**RESTORING THE SITE** **DECOMISSIONING AND RESTORATION** • Restoration as required under RMA • Abandoned wells must be plugged under the Health and Safety in Employment Act	

Diagram applies to on-shore exploration and development only. Additional requirements apply to off-shore exploration and development.

For more information see:
http://www.nzpam.govt.nz/cms/petroleum/publications#guide

196. The government has been, and is, undertaking a number of initiatives currently to strengthen the overall regulatory regime for petroleum activity and ensure an appropriate balance between economic benefits and health, safety and environmental concerns. In relation to onshore activity in particular, this involves changes to the CMA; and strengthening the health and safety regime which collectively impose obligations on duty holders in relation to the design, construction, operation, maintenance, suspension and abandonment of all petroleum and related well-drilling operations.

197. The Royal Commission on the Pike River Coal Mine Tragedy has recommended that the CMA Regime should be changed to ensure that health and safety is an integral part of permit allocation and monitoring. In response the Government is taking steps to amend the CMA Regime accordingly[19].

198. Stronger health and safety tends to support environmental protection. For example, integrity of a bore is critical in protecting workers from the risk of a blowout and also protects any ground water through it passes.

199. The regime has many of the features of modern regulatory systems including:

- **A focus on risk management:** A focus on risk management ensures that operators have appropriate robust risk management systems in place. This approach contrasts with a prescriptive approach that ensures that specific responses are taken to specific risk. A regime focused on risk management is more amenable to the introduction of the advantages of new technology and processes than one that is more prescriptive.

- **A graduated approach:** While the concept of implementation of regulation is sometimes conflated with that of enforcement, a graduated approach includes measures to inform operators of requirements and support them in implementation as well as penalties for breaches. This is a constructive approach to ensuring compliance.

- **Gatekeeping:** This refers to the use of mechanisms to ensure that operators are not allowed to carry out activities until they have demonstrated that they are able to meet regulatory requirements.

Crown Minerals Act 1991 and the Issue of Permits

200. The right to develop minerals resources is controlled and allocated through a permit system operated under the CMA.

201. Decisions made under the CMA are typically required to have regard to the efficient allocation of rights in respect of Crown owned minerals; and to the obtaining by the Crown of a fair financial return from its minerals.

19 For more information see: http://beehive.govt.nz/release/changes-cma-bill-reflect-pike-river-report.

202. It is not therefore a primary instrument for constraining petroleum development. However, it may potentially do so through limiting new exploration permits and allowing extensions to permits where a more extended development period is indicated.

203. The CMA also provides opportunities to decline permit applications by operators that do not have the capability to manage health, safety and environmental impacts. The Crown Minerals (Permitting and Crown Land) Bill proposes to amend the CMA by introducing an initial assessment of operators' health and safety and environmental capability, as well as improving the regulatory co-ordination relating to a permit holder's activity through annual review meetings.

204. The two key instruments are Minerals Programme for Petroleum and Minerals Permits.

Minerals Programme for Petroleum

205. The Minerals Programme for Petroleum[20] sets out how the government will interpret and apply the CMA in relation to petroleum. It is not a programme of activity, but rather a framework by which activities will be assessed, consulted, and managed. This makes it a basis for the issue of permits and the conditions attached to those permits. The programme is revised from time to time through a consultative process. A draft is currently out for consultation and the comments here are based on that draft – which is subject to change in response to feedback.

206. The programme provides opportunities for engagement with the East Coast community through the following:

- consultation with iwi on permits and permit rounds in land identified as wāhi tapu or of cultural significance to iwi (such land may be excluded or protected within a permit area)
- consultation with local councils on the timing and location of blocks on offer in permit rounds (such consultation is not mandatory but is established practice).

Minerals (Petroleum) Permits

207. The right to explore for and mine petroleum is controlled by permits issued under the CMA in accordance with the Programme. The two main relevant types of permit are the exploration permit and the mining permit. Exploration permits give exclusive rights to pre-determined blocks. They are issued following competitive tender. A key factor in evaluating the tender is the bidder's proposed work programme. Holders of exploration permits have first rights to a mining permit for their block as a return for the investment they put into investigation.

208. Current permits in the Study Region are set out in Figure 6 on page 29.

20 A revised Programme is currently under consultation and is referred to as the 'Petroleum Programme'.

Environmental Regulation

209. The environmental regulation of petroleum development in New Zealand is primarily the responsibility of local authorities under the RMA. Under the RMA councils prepare district and regional plans that regulate, among other matters, land use and water use. Depending on the planning provisions, a resource consent is required to construct infrastructure (well pads, roads, pipelines, etc), to abstract water for a hydraulic fracturing operation, to discharge contaminants to air, and to discharge water and contaminants to land or water.

210. Effects of climate change cannot be considered under the RMA[21]. As noted in paragraph 19, the Emission Trading Scheme is the mechanism for dealing with climate change in New Zealand.

211. Hazardous substances are subject to the Hazardous Substances and New Organisms Act 1996, administered by the Environmental Protection Authority.

212. More detail on environmental regulation and planning in practice is covered in Section 7 of this report.

Health and safety regulation

213. Health and safety regulation of petroleum activities, including well integrity is regulated by the Safety and Regulatory Practice Group in MBIE under the Health and Safety in Employment (Petroleum Exploration and Extraction) Regulations 1999 (**HSE(PEE) Regulations**) issued under the Health and Safety in Employment Act 1992 (**HSE Act)**. MBIE's Labour and Commercial Environment Group is responsible for health and safety policy. The HSE(PEE) Regulations cover the design, construction, operation, maintenance, suspension and abandonment of wells.

214. In 2012, the government sought feedback from the public on proposed changes to HSE(PEE) Regulations[22] and will introduce new regulations to be implemented in June 2013. The new regulations will seek aim to ensure that health and safety regulation of petroleum exploration and extraction activities in New Zealand — both onshore and offshore — is more consistent with best practice in the UK and Australia and developments in light of recent, high-profile major accidents overseas.

215. Five key changes are proposed:

    a. Operators (both onshore and offshore) will be required to prepare a safety case and submit it to the regulator for acceptance before the commencement of operations.

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21 Pursuant to section 104E of the RMA, when considering applications for discharges of greenhouse gases into the air, local government must not have regard to the effects on climate change.

22 http://www.dol.govt.nz/consultation/petroleum-regulations/

b. Operators of smaller-scale, lower-risk onshore production installations will be required to prepare an overview of the measures in place to protect the health and safety of those at, or near, the installation in lieu of a safety case.

c. All operators will have to report 'near miss' incidents that could have led to a major accident – this will ensure the regulator has sufficient data to inform the targeting of its regulatory interventions.

d. The regulatory regime will focus on the whole lifecycle of the well.

e. All operators will be required to implement arrangements for independent and competent persons to examine the design, construction, and maintenance of all wells within their inventory.

216. Under the new regulations operators will still be required to notify the regulator before the commencement of well operations.

217. A key finding of the UK Royal Society report on shale gas extraction is that well integrity is the highest priority for environment protection, as faulty wells are a more likely cause of contamination.[23] Consequently, these changes aimed at health and safety improvements also serve to strengthen our regulatory regime in the environmental protection area.

218. Another important development is the establishment of the High Hazards Unit in the Safety and Regulatory Practice Group[24] with a m arked increase in the number of inspectors and the appointment of a Chief Inspector Petroleum and Geothermal.

Risks and risk management

219. The four areas that typically cause the main concern with onshore petroleum development are blowouts; ground water contamination; spills of hazardous chemicals and petroleum; a concern that naturally occurring earthquakes may rupture well bores; and a concern that hydraulic fracturing may cause earthquakes. Note that only the last of these is specific to hydraulic fracturing. Each of these is considered in turn below.

220. This consideration is intended to give an appreciation of the key risks. It is not intended to be a comprehensive description of all of the risks associated with petroleum development.

Risk: Blowout

How could this happen, and how likely is it?

221. A blowout occurs when the drill hits a higher pressure than anticipated and prepared for, causing a sudden release of oil and/or gas. Normally such a pressure increase (or

23 www.raeng.org.uk/news/publications/list/reports/Shale_Gas.pdf

24 The High Hazards Unit was established in late 2011 to improve leadership, planning and relationship management in MBIE's inspection and enforcement work in the mining, petroleum, and geothermal industries.

'kick') is managed using the multiply redundant failsafe blowout preventers (**BOP**s). These would have to fail for a blowout to occur.

222. A scenario could involve:
   - drilling mud being expelled, requiring soil to be disposed and replaced
   - hydrogen sulphide being released (this occurs naturally but is toxic; it is not normally present in New Zealand reservoirs)
   - the oil/gas stream being ignited
   - in an extreme case, loss of life or serious injury to operators.

223. What data is available indicates that the probability of a blowout has decreased as oil and gas industry operational methods, equipment and training have improved over the years[25]. Nevertheless, blowouts still occur. General statistics for oil and gas production in the central valley of California indicate that the rate of blowouts for the period 2001-2008 in which 16,400 wells were drilling was very low both in terms of the number of well years (ie 1 per 5,200 wells) and drilling distances (1 per 13 million feet)[26].

224. The applicability of these statistics to the circumstances of the drilling, hydraulic fracturing, and production of wells in the East Coast is uncertain. There has only been one blowout in New Zealand (at McKee-13 in Taranaki in 1995). No one was injured, but contaminants were discharged into the Mangahewa Stream. The stream was fully recovered in less than 18 months at the cost of the operator (around $1m). The operator was also prosecuted under the HSE Act and the RMA.

How do we make sure that good practice is followed?

225. The principal regulation regarding blowouts is the HSE(PEE) Regulations, which, as indicated above, is currently under review.

Risk: Water contamination

How could this happen and how likely is it?

226. There are three main ways that this might happen:
   - spill of oil or chemicals on the surface at the well site
   - leak from the well bore as it passes through an aquifer
   - flow of chemicals up through fractures.

227. There is also a risk from inappropriate waste water disposal.

228. The impact depends on the extent of any the leak, the toxicity of the chemicals involved, and the extent to which the aquifer is in use as a freshwater supply. While the unintentional discharge of toxic chemicals into groundwater is a serious matter, there are mechanisms to mitigate the impacts. Untapped aquifers have little or no flow, so the contaminant disperses very slowly if at all. This means there are options

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25 Jordan PD, Benson SM, *Well blowout rates and consequences in California Oil and Gas District 4 from 1991 to 2005: implications for geological storage of carbon dioxide*, Environmental Geology, 2009; 57:1103–1123

26 ibid

to remediate the water. Contamination of surface waters can have a more immediate effect, depending on the contaminant.

229. It is possible that accidental spills occur on a well site, but the risk can be reduced with good practice and procedures. Spills can also occur through the transport of chemicals or petroleum to and from the site, through the rupture of a pipeline or from an oil tanker foundering at sea.

230. In general, these risks already exist in New Zealand, and there is established experience in managing them. The risk of a leak from the well bore passing into an aquifer is minimised through ensuring well integrity.

231. The likelihood of petroleum or fluids reaching an aquifer through a fracture depends on the geology and the distance between the petroleum layer and the aquifer. It is extremely unlikely and is considered only theoretically possible given the vertical separation and the presence of seals. Shale and tight gas production is usually very deep below aquifers, and will be separated by several impermeable layers, called geological seals. These seals stop oil and gas from naturally making their way to the surface and will also stop hydraulic fracturing fluids from migrating towards the surface.[27]

232. Waste fluids include hydraulic fracturing fluid that has returned to the surface. Inappropriate storage or treatment of waste fluids could contaminate nearby ground or surface water.

How do we manage the risk and ensure good practice is followed?

233. There are robust mechanisms to minimise these risks. Concerns raised about water contamination from hydraulic fracturing in Taranaki have not been upheld by independent scientific analysis[28], nor in a study of 16,000 horizontally fractured wells in Texas[29].

234. It is standard practice for operators to assess seismic risk in an area before they drill. Taranaki Regional Council requires applicants in their resource consent applications to provide information on active faults in the area, assess the risks of inducing seismic activity, and provide details of any seismic or vibration monitoring to be carried out. It is expected that all Councils will follow this approach.

235. The risk of a spill can be minimised by ensuring that chemicals are stored appropriately (eg in double-walled or corrosion-resistant containers), through having good procedures and training, and by having contingency measures in the case of a

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27 See International Energy Agency, *Golden Rules for a Golden Age of Gas*, 2012, p37.

28 See Taranaki Regional Council. *Hydrogeologic Risk Assessment of Hydraulic Fracturing for Gas Recovery in the Taranaki Region*, 2012.

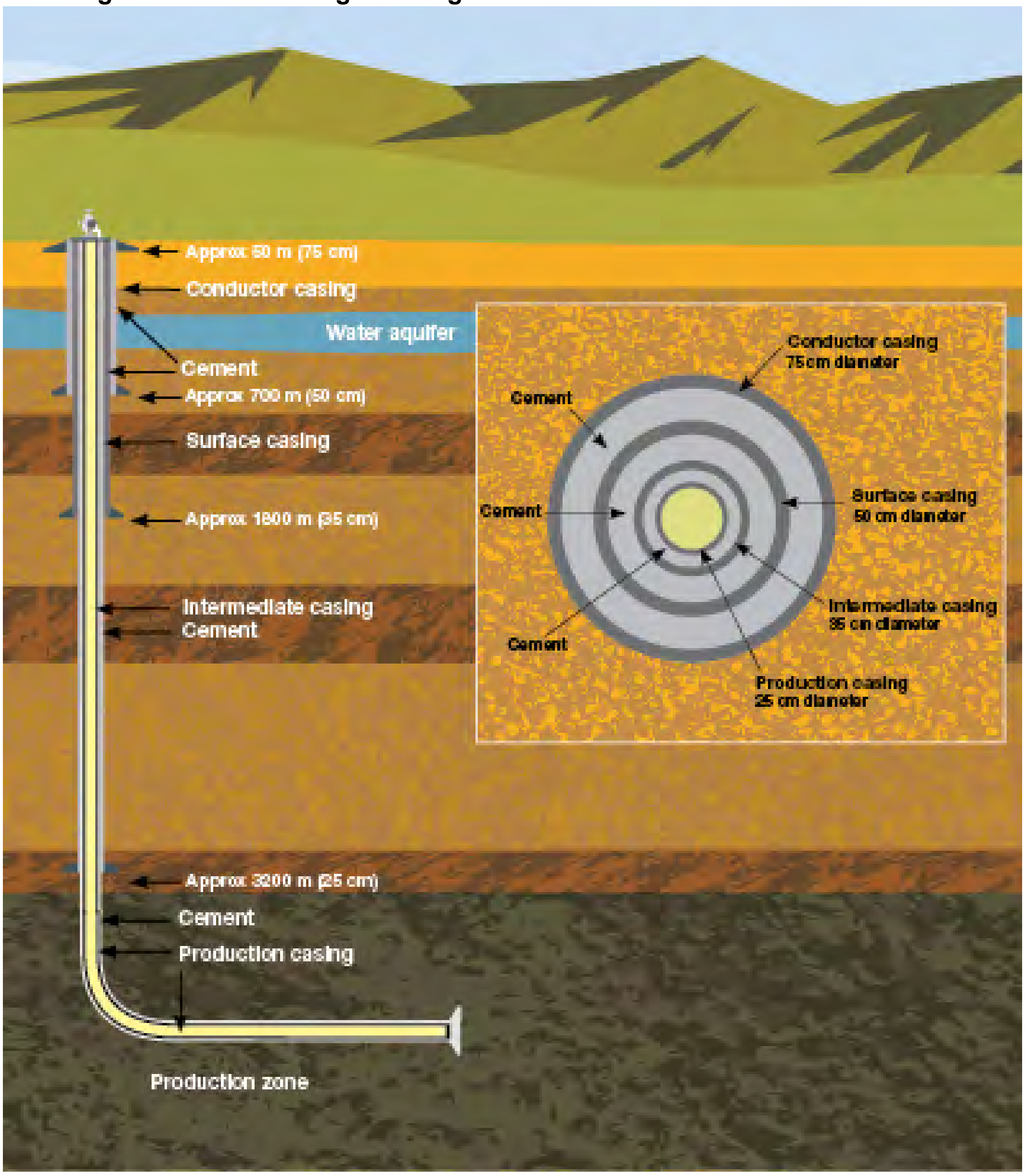
29 See Kell, S: *State Oil and Gas Agency Groundwater Investigations and Their Role in Advancing Regulatory Reforms, A Two-State Review: Ohio and Texas*, August 2011, Ground Water Protection Council, available at: http://www.gwpc.org/sites/default/files/State%20Oil%20%26%20Gas%20Agency%20Groundwater%20Investigations.pdf.

spill (for example, the use of an enclosure, known as a 'bund' – or 'bunding' - to contain a spill).

236. Well bores contain multiple steel casings, which are cemented together and act as a barrier between the well and the surrounding rock. A typical bore casing is illustrated in Figure 13.

237. In her interim report, the PCE concluded that there is no evidence that hydraulic fracturing has caused groundwater contamination in New Zealand, and at the current scale of operations the risk appears low (see paragraphs 21 to 27 above for more detail on the PCE's report).

Figure 13: Bore casing showing extent and cross section



238. Waste fluids can be recycled (ie used for subsequent hydraulic fracturing operations), treated on land or reinjected underground. Any storage at the surface should be in

water tanks or lined pits to avoid leaks. The treatment of waste fluids may be the subject of a resource consent – depending on the disposal method.

239. Monitoring water quality will indicate if contamination is occurring. It is best practice for monitoring to take place before any drilling activity so that a baseline standard can be established and regional councils can require monitoring as a c ondition of resource consent, if consent is required. In the event of contamination, the aquifer can be remediated by removing the contaminated water volume.

240. Several statutes protect ground water:

- The **RMA** allows conditions to be applied to resource consents to minimise the risks to groundwater. The RMA also regulates the treatment of waste fluids at the surface to avoid contamination of water sources. For example, conditions placed on a resource consent may require only certain approved substances are used onsite, and that containment systems are in place to minimise the effects of accidental spills.

- The **HSE(PEE) Regulations** (1999, currently in revision) require operators to take all practical steps to prevent spills of hazardous liquids, vapours or gases. They also specifically require wells to be constructed "with sufficient casing to prevent the uncontrolled release of fluid to or from formations".

- The storage, use and disposal of hazardous chemicals are covered by the **Hazardous Substances and New Organisms Act** (1996). Regulations made under the Act control how hazardous substances are to be disposed of, and users of hazardous chemicals are required to have response plans to address all reasonably likely emergencies that may arise.

- Should contamination occur, councils have a responsibility to remediate the site in accordance with the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health[30]. Councils will place conditions on consents requiring that any contamination is cleaned up by the operator, and may impose a bond.

- The transport of dangerous goods (including hazardous substances) must comply with the **Land Transport Rule: Dangerous Goods 2005** and the relevant Maritime Rules and Marine Protection Rules.

Risk: Chemical spill

How could this happen and how likely is it?

241. Chemicals are used in petroleum development as:

- 'mud' used as part of the drilling process
- hydraulic fracturing fluids
- cleaning products on rigs and other equipment
- antifreeze to control gas hydrates
- 'depressants' to allow waxy crude to flow.

30 www.mfe.govt.nz/laws/standards/contaminants-in-soil

242. The use of chemicals has proved to be a controversial element of hydraulic fracturing, though it is important to emphasise that the chemicals in fracturing fluids are only one component of those used in petroleum development. Water and sand (used as a proppant) make up between 98 and 99.5 per cent of the fluid used for hydraulic fracturing. Chemicals are used to prevent bacterial growth and corrosion (which if untreated could lead to the well's integrity failing) and to ensure the hydraulic fracturing job is effective and efficient.

243. The chemicals used include some that are classified as hazardous substances. They are generally transported to sites in an unmixed form before being diluted to make up the fluid used in hydraulic fracturing ('frac fluid'). The actual toxicity depends on the substance and its concentration. Some of the chemicals that have been used in hydraulic fracturing fluids internationally are extremely toxic undiluted (eg biocides), but in diluted form are commonly found in industrial and domestic use, for example as components of cleaning products and shampoo.

244. The trend internationally has been to reduce the number of chemicals and move to chemicals of lower toxicity. For example, in Germany, ExxonMobil has used 150 different chemicals in the past, but is now planning to use only five[31].

245. In New Zealand, in the past, oil-based hydraulic fracturing fluids were used in Taranaki (from 2001 to 2005). Taranaki Regional Council has since indicated that it will now only grant consent for 'water-based fracturing fluids' (ie those in which water and proppant compose at least 95 per cent of the fluid).

246. One concern has been the lack of disclosure of what chemicals are used. In the past, companies have withheld this information on commercial grounds, but there now is a strong trend towards disclosure driven awareness of the need to respond to public sensitivity. For example, details of the five chemicals ExxonMobil proposes to use in Germany are publicly available.

How do we manage the risk and ensure good practice is followed?

247. The risk of an accidental spill can be minimised through the appropriate storage of chemicals. Regulations under the Hazardous Substances and New Organisms Act 1996 referred to at paragraph 240 above, and the Hazardous Substances (Emergency Management) Regulations contain provisions for emergency response plans to address all reasonably likely emergencies that may arise from the failure of controls on hazardous substances on site.

248. The HSE(PEE) Regulations require operators to take all practical steps to prevent spills of hazardous substances. Councils also have a strong interest in preventing accidental spills due to adverse effects on the environment. The transport of hazardous substances is also regulated by the relevant transport agency.

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31 *Hydrofracking Risk Assessment*, Panel of Experts, April 2012. http://dialog-erdgasundfrac.de/sites/dialog-erdgasundfrac.de/files/Ex_HydrofrackingRiskAssessment_120611.pdf

Risk: An earthquake caused by mining operations

How could this happen and how likely is it?

249. Concern has been expressed that hydraulic fracturing causes earthquakes. It is extremely unlikely that hydraulic fracturing would lead to a damage-causing earthquake.

250. The potential concern arises from injecting fluids under pressure deep underground. This can lead to 'induced seismicity' – a term that refers to human-induced micro-earthquakes.

251. The issue of seismicity is the subject of a n umber of reports that this study have drawn on. These include:
   - UK Royal Society and Academy of Engineering: *Shale gas extraction in the UK: a review of hydraulic fracturing*, June 2012
   - US National Science Council: *Induced Seismicity Potential in Energy Technologies*, prepublication version, 2012
   - GNS Science: *An Assessment of the Effects of Hydraulic Fracturing of Seismicity in the Taranaki Region*, February 2012.

252. The likelihood (and magnitude) of an induced micro-earthquake depends on the nature of water injection. Injection for a short period, such as is the case for hydraulic fracturing, is considered to be relatively low risk. According to the US National Science Council (NSC), there has only been one case where a c onclusive relationship between hydraulic fracturing and seismicity has been reported. This was in Blackpool England in April and May 2011 when micro-earthquakes of magnitude 2.3 and 1.5 were reported. A specific study of that event[32] concluded that the events were quite exceptional and seismic events induced by these fracture treatments normally have a magnitude much lower than 0 on the Richter scale.

253. In addition, there are three cases where hydraulic fracturing is suspected as a cause of seismicity. These were in Oklahoma in 1978 and 1979. The NSC has concluded that the process of hydraulic fracturing as presently implemented for shale gas recovery does not pose a high risk for inducing felt seismic events.

254. GNS, looking at events between 2000 and 2011, concluded there was no evidence that hydraulic fracturing has caused earthquakes or affected volcanic activity in Taranaki.

255. The UK Royal Society and Royal Academy of Engineering have noted that there is an emerging consensus that the magnitude of seismicity induced by hydraulic fracturing would be no greater than magnitude 3 (felt by few people and resulting in negligible, if any, surface impacts).

256. The largest known example of induced seismicity in New Zealand was the 4.6 magnitude earthquake caused by the filling of Lake Pukaki in 1978. The use of the

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32 www.cuadrillaresources.com/wp-content/uploads/2012/02/Geomechanical-Study-of-Bowland-Shale-Seismicity_02-11-11.pdf

Rotokawa geothermal field near Taupo has caused 70 micro-earthquakes between magnitude 2 and 2.9, and two of magnitude 3 or larger since 2000.

257. The PCE's interim report on fracking concluded that the practice can create tiny earthquakes, generally less than magnitude 2 and which cannot be felt at the surface. Injecting fluid into a well can trigger a more significant earthquake if the fluid finds its way into an active fault.

How do we manage the risk and ensure good practice is followed?

258. Risks can be mitigated though an understanding of the geology. The area should be properly surveyed, with faults identified and the stress regime of any faults understood. Activities such as micro-seismic monitoring (to monitor the fracture size and direction) and low pressure 'mini' fracture jobs provide additional assurance on managing any risks.

259. The RMA allows for resource consent conditions to set requirements for monitoring before and after any hydraulic fracturing. The precise requirements are determined by the regional council on a case-by-case basis.

260. As an example, Taranaki Regional Council requires applicants for resource consents to provide an analysis of the active faults, assess the risk of seismic activity and provide details of any monitoring to be carried out in the Assessment of Environmental Effects. In addition, Taranaki operators are required to provide the regional council a 'Pre-Fracturing Discharge Report' at least 14 days before the discharge is proposed to commence.

Dealing with East Coast seismicity and geology

261. The East Coast is an area of relatively high seismicity, which causes complexity in the geological structure, including the presence of faults. This raises the question as to whether earthquakes pose a threat to the integrity of petroleum exploration and mining operations.

262. It should be noted that petroleum development has been carried out safely for many years in areas of high seismicity including in Japan, Italy, California, Columbia, Peru, Chile and Russia.

263. Major faults subject to movement can be detected during seismic surveying prior to drilling. Minor faults that are below the threshold for detection in this manner can be detected from drill logs once drilling takes place. The requirement to detect faults is part of the consenting process. Operators also have strong incentives to avoid medium and large faults because of the potential to disrupt operations. Minor faults can be drilled through, but operators will only want to do this where they are confident that the fault is sealed. They will avoid hydraulic fracturing near a minor fault as its presence can lead to pressure loss and lower recovery.

264. In the event that a well bore pipe passes through a fault that is subject to movement, the likely outcome is that the bore will be deformed, but without loss of integrity. The worst case scenario is that a bore is severed near an aquifer. This risk is managed by

installing an automatic shut off valve (Subsurface Safety Valve) below the level of the aquifer.

265. The presence of over 300 mapped oil and gas seeps on the East Coast indicates that there are natural faults allowing petroleum to come to the surface. These are a natural source of potential contamination. In these cases, petroleum development can reduce the natural seepage by reducing underground pressure and flow to the surface.

266. In the same way that the complex folding of the East Coast can provide opportunities for the conventional petroleum development, it can provide suitable reservoirs for wastewater disposal or indeed long term CO_2 sequestration[33].

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[33] Bland, Griffin, Doody, and Field, *An initial assessment of the CO2 storage potential of the onshore East Coast region, North Island, New Zealand*, Nov 2009, CO2CRC report number RPT09-1531

7. Shaping Development in Practice

267. The geology determines the potential for petroleum development, but many other factors will shape any development that does eventuate if exploration shows significant amounts of recoverable petroleum.

268. If the potential for petroleum development proves to be along the lines of the more economically optimistic scenarios set out in this report (ie scenarios 4 and 5) a number of social, cultural and environmental issues will arise. For example: petroleum development is a land use that competes, and sometimes conflicts, with other land uses. Social issues can arise from large-scale economic transformation. For example; experience with the Bakken formation in North Dakota, suggests there can be significant pressures on housing resulting from an influx of workers that needs to be managed.

269. East Coast communities will want to make choices about the extent and pace of development and how a range of issues will be managed. The more petroleum that is found, the more important these choices will be. As a minimum, Scenarios 4 and 5 would likely require changes to the Regional Policy Statements (**RPSs**), Regional Plans and District Plans. Changes to RMA plans and policy statements involve a process of public consultation under Schedule 1 of the RMA. Councils in the region have already indicated a willingness to work together to address issues where it makes sense to do so.

270. Fortunately, there is a range of statutory (for example District Plans) and non-statutory tools (for example specific strategies) that allow central and local government to actively make these choices. Statutory tools must be developed in consultation with iwi and communities, and similar consultation is the accepted norm for non-statutory tools as well. A strategy could be a suitable vehicle for harmonising approaches across the East Coast region if petroleum development becomes a reality in future.

271. To support consultation, councils in the region have developed specific arrangements to engage with Māori. For example, Hawke's Bay Regional Council has a non-statutory joint planning committee (JPC) with 9 iwi represented alongside key stakeholders across the region for their water catchment/management issues. There are opportunities to extend this model to petroleum issues.

272. This section sets out the tools available to manage the main issues that are likely to arise, how they might be used in practice, and what consultation will be involved.

Formal tools to manage development

273. The formal tools to manage development are summarised in the following table and discussed in more detail below (except for those under the CMA, which are discussed above in Paragraphs 200 to 208).

Table 11: Tools to manage petroleum development

<table>
<tr><th>Instrument</th><th>Comment</th></tr>
<tr><td colspan="2">Resource Management Act 1991</td></tr>
<tr><td>Regional Policy Statement (RPS)</td><td>Establishes high-level policies, objectives and methods for resource use in the region. Does not include rules. Has potential to identify petroleum as a significant resource management issue and proactively plan for the effects of development of petroleum on the East Coast.</td></tr>
<tr><td>Regional Plan</td><td>Sets out objectives, policies and rules for matters that a regional council is responsible for, including soil conservation, water, natural hazards, hazardous substances, discharge of contaminants, biodiversity, and aquatic ecosystems. Must give effect to RPS.</td></tr>
<tr><td>District Plan</td><td>Sets out objectives, policies and rules regarding land use. Must give effect to RPS and cannot be inconsistent with regional plans.</td></tr>
<tr><td>Resource Consent</td><td>Must be issued by the relevant Local Authority before any significant resource development takes place if the activity is not permitted in a plan. It is the primary mechanism for regulating specific petroleum development proposals. Some aspects of petroleum development will be consented by the regional council, others by the district council. Decisions made in accordance with frameworks set out by District and Regional Plans and in accordance with the RMA.</td></tr>
<tr><td colspan="2">Land Transport Management Act 2003</td></tr>
<tr><td>Regional Land Transport Strategy</td><td rowspan="2">Together these documents provide the mechanism for planning enhancement of the road network in response to direct and indirect impacts of development: such as the development and maintenance of access roads, and the upgrading and increased maintenance of arterial roads in response to economic growth.</td></tr>
<tr><td>Regional Land Transport Plan</td></tr>
<tr><td colspan="2">Crown Minerals Act 1991</td></tr>
<tr><td>Minerals Programme for Petroleum</td><td>Establishes the framework by which petroleum permits will be offered, assessed, consulted and managed.</td></tr>
<tr><td>Minerals Permits</td><td>Mechanism for controlling in which areas petroleum exploration and mining can take place, and setting out a range of conditions.</td></tr>
<tr><td colspan="2">Other</td></tr>
<tr><td>Growth Plans</td><td>Ad hoc plans, for example a petroleum management strategy, that are not required by statute but can provide a good mechanism for consulting and coordinating statutory plans across the Study Region.</td></tr>
</table>

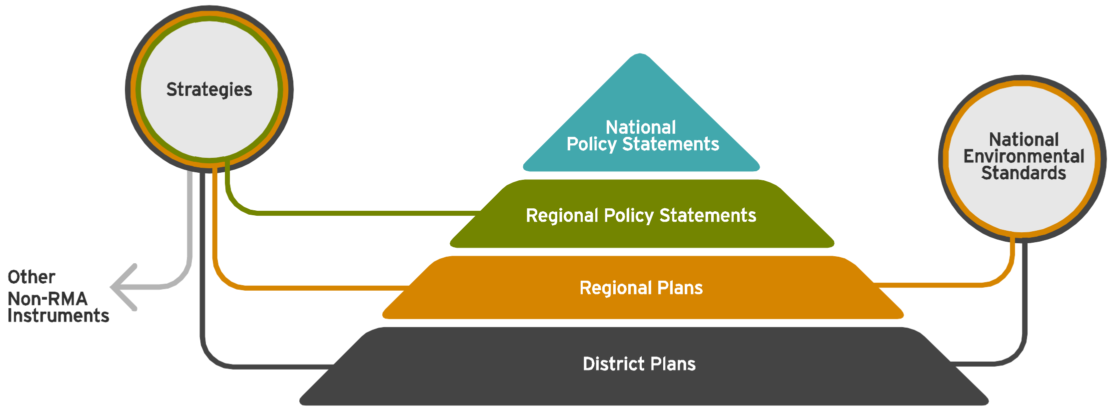
Resource Management Act Instruments

Hierarchy of planning under the RMA

274. The RMA establishes the principal mechanisms for managing resource use and addressing potential conflict in resource use.

275. It also establishes a hierarchy of management tools (as shown in Figure 14). Resource consents are then considered against criteria set out in Regional Plans and District Plans.

Figure 14: Hierarchy of RMA plans and other management tools



276. **National Policy Statements** set out policies where there are potentially trade-offs between national and local objectives to be taken into account. There are none existing or currently proposed that relate specifically to petroleum development. However, the National Policy Statement on Freshwater Management and the New Zealand Coastal Policy Statement may apply.

277. **National Environmental Standards** are regulations that set standards that councils need to reflect in Regional and District Plans. Currently there are three National Environmental Standards that are directly relevant to petroleum exploration and development on:

- sources of human drinking water
- air quality standards
- assessing and managing contaminants in soil to protect human health: this standard specifically addresses petroleum contamination.

278. A National Environmental Standard on ecological flows and water levels is also in development.

279. The remaining elements of Figure 14 would likely be significantly developed at the Study Region or local authority level to address issues arising from significant petroleum discoveries and are described in more detail below.

Regional Policy Statements

280. Regional Policy Statements (**RPS**s) establish a council's broad direction and framework for resource management within their respective region. The statements play a key role as Regional and District Plans must include actions to give effect to them. They can also influence regional land transport strategies and any non-statutory growth strategies.

281. In the event of there being significant petroleum development (ie Scenarios 4 or 5), it is likely to be appropriate for the RPSs to be updated. For example, the Hawke's Bay Regional Council's RPS currently does not make any reference to petroleum development (though it does recognise the need to manage conflicts that may arise between alternative forms of land use). In contrast, the Taranaki Regional Council recognises the development of petroleum as a particular issue that needs to be managed and sets out a number of policies in response, including, for example, mechanisms to consult with iwi and the desirability of avoiding subdivision in areas of potential petroleum mining.

282. RPSs themselves are only finalised following consultation with iwi and publicly notified consultation.

Regional Plans

283. While there is no statutory requirement for a 'regional plan' (aside from a regional coastal plan), regions typically develop one or more plans covering matters specifically under their responsibility (as opposed to matters under the districts' responsibility). Regional plans can cover:
    - soil conservation
    - water quality, quantity and usage
    - hazardous substances
    - natural hazards
    - discharge of contaminants
    - biodiversity.

284. Petroleum development potentially affects all these matters to some degree, and some significantly so.

285. In practice the scope and nature of plans varies from region to region. Whatever their form, the plans establish the criteria by which resource consents are issued by the council.

286. Regional Plans must give effect to the policies in the RPS that fall under the regional council's remit. As with the RPS, Regional Plans are only finalised following consultation with iwi and publicly notified consultation.

District Plans

287. District plans establish policies and regulations for land use, and the environmental effects arising from land use. District plans must give effect to the RPS and cannot be inconsistent with regional plans.

288. Typically, district plans include a zoning of the district that sets out what activities are permitted where, and under what conditions. As part of the zoning, areas of particular significance are identified. For example, the Central Hawke's Bay District Plan identifies sites of cultural significance to tangata whenua, areas of significant nature conservation value, and areas of outstanding landscape views. District plans may set out the circumstances under which notification of resource consent is required, but ordinarily councils rely on the thresholds in the RMA and make notification decisions on each individual application[34].

289. District plans have significant potential to shape petroleum development throughout the region – building on the policies set out in the RPS. Specifically, they have the potential to substantially affect locations where petroleum development can take place. Where petroleum development is allowed, they can set out the criteria development must meet before it is allowed.

290. By way of an ex ample, the South Taranaki District Plan provides for petroleum activities in the Rural Zone as follows[35]:

- **Discretionary activities** (which means that the council has absolute discretion as to whether to grant a consent and unrestricted discretion to impose conditions): petroleum production stations and well heads

- **Limited discretionary activities** (which means that the council must take into account identified matters in deciding whether to issue a consent but has the ability to either grant or decline limited discretionary consents): petroleum exploration and production testing which cannot meet one or more of the performance standards as a controlled activity

  Council retains discretion over:
  - noise
  - landscaping
  - access
  - heavy vehicle movements
  - duration of activity.

- **Controlled activities** (which means that the council cannot withhold a consent but may impose conditions): petroleum exploration and production testing

  Council may impose conditions relating to:
  - noise
  - landscaping
  - appearance
  - access
  - heavy vehicle movements

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34 Notified consents have associated appeals rights for submitters. This can have time and cost implications for the submitters. This is also true for notified plan changes.

35 In addition to the categories set out here, the RMA provides for activities to be permitted, non-complying and prohibited. For more information see: http://www.rmaguide.org.nz/rma/resourceconsents/typesofactivities.cfm

- o duration of production testing.

291. Again, District Plans are only finalised following consultation with iwi and publicly notified consultation.

Local government capability under the RMA

292. The effectiveness of the RMA tools is contingent on the capability of local government to undertake the necessary planning, and assess resource consent applications.

293. Planning is a time-bound activity and it is straightforward to engage the necessary expertise required. Local government already has the capability to manage many of the consenting aspects of petroleum development, simply because many aspects are held in common with other developments: noise, dust, traffic implications, waste discharge and so on.

294. Other aspects raise issues specific to petroleum, for example aquifer protection and induced seismicity. For these, capability will need to be acquired or built. Taking on new capability is not unusual and is unlikely to be problematic. There are existing examples where a council with particular expertise, such as Waikato Regional Council with regard to dams, undertaking services requiring particular expertise on behalf of other councils.

295. The councils in the region have indicated a desire where appropriate to have common standards for the issue of resource consents. There are a number of mechanisms by which this might be achieved. One option is the adoption of shared services. An alternative is to have common standards and assessment frameworks and use a shared pool of specialist advice whilst using each council's own staff for less specialist matters.

296. MBIE and councils are also working to ensure that the experience gained through managing petroleum in Taranaki is taken into account in developing capability.

Growth strategies and plans

297. While not required under legislation (except in Auckland), councils are increasingly using growth strategies and plans to co-ordinate land use, infrastructure and financial needs when it becomes apparent that a coordinated strategy to provide guidance on particular areas of development would be useful. Recent examples of where such plans have been used in the region include:
   - Hawke's Bay Regional Council Strategic Plan
   - Heretaunga Plains Urban Development Strategy
   - Hawke's Bay Land and Water Management Strategy.

298. In the case that exploration identifies potential for significant petroleum development (such as Scenarios 4 or 5), one option for councils to consider is a 'petroleum management strategy'. This could provide a convenient mechanism for iwi and hapū, local and central government, permit holders, landowners and users and the broader community to discuss petroleum development in the region and agree some key parameters. Such a strategy could be consulted using the special consultative procedure under the Local Government Act 2002.

299. Such strategies are not statutory documents, but they can be implemented through:

- regional policy statements, which can direct city and district council activities to ensure consistency and integration across a region
- resource management provisions
- other planning decisions, including central government spending.

300. A strategy can have a number of potential benefits:

- It can provide a better forum in practice than standard RMA planning tools for constructive engagement at a formative stage on a topic like petroleum given the range of economic, social and environmental issues raised. It does not have to be prepared according to a statutory time frame, which allows it to take the time needed.

- It is a suitable vehicle for harmonising approaches across the regional councils that make up the wider East Coast region.

301. The impact of a strategy may be enhanced to some extent by the engagement of permit holders. This could, for example, lead to agreement by permit holders to share some aspects of infrastructure – for example pipelines.

302. A petroleum management strategy might cover a number of key choices:

- identification of areas from which petroleum development might be prohibited

- mechanisms for identifying sensitive areas, mechanisms and standards for the protection for each class of sensitive area, where existing arrangements are considered potentially inadequate

- arrangements for sharing common infrastructure amongst developers (to avoid duplication and reduce impact)

- high-level policies for development contributions ie the arrangements for payment by permit holders towards development of infrastructure and facilities by territorial authorities, and the recovery of other costs incurred

- coordination, resource sharing and arrangements for common standards between operators

- indication of which areas will be developed first. Later areas might also be covered, but some revision might be required as development progresses and additional information becomes available

- high-level policy regarding acceptable environmental impact and required mitigation/compensation

- associated infrastructure development, including roading and power

- options for addressing any social implications of development (including impact on housing, schooling and health issues).

303. Any strategy would be additional to, and inform councils' planning and consenting functions through, the mechanisms indicated in paragraph 299. Other alternatives to a petroleum management strategy can be envisaged, the key point being to satisfactorily consider the issues illustrated in paragraph 302, recognising that ultimately rules in RMA plans and councils' development contribution policies shape final decisions. The preferred mechanism is most appropriately agreed when the results of exploration and likely development paths are clearer – which may not be for some time.

304. If a Study Region-wide petroleum management strategy were to be developed, consideration would need to be given as to what matters are best considered at the Study Region level, and what matters would be left to regions and districts.

305. It is also possible to envisage a petroleum management strategy being supported by a range of associated elements or subsidiary plans.

Regional Land Transport Strategies and Programmes

306. While land transport issues are likely to be second order in the context of petroleum development, significant petroleum development would have implications for the land transport system.

307. Regional Land Transport Strategies (**RTLS**s) are high-level plans providing a strategic link between transport activities at a national level and those at a local level. Regional councils, through regional transport committees, can use these to set out the transport goals for their region. They are prepared at least every six years and have a 30 year horizon. This is the same order of timeframe as petroleum development would unfold across the region in Scenarios 4 and 5.

308. Regional Land Transport Plans are prepared every three years to set out a region's land transport activities. They list the activities regions want included in the National Land Transport Programme. They have to be consistent with the RLTS and form the basis for the allocation of funding.

309. Affected communities, Māori of the region, and public in the region must be consulted in the preparation of Regional Land Transport Programmes

How the tools might be used in practice in the East Coast

310. This sub-section section illustrates how the tools available might be used in practice to manage petroleum development under the different scenarios. It is emphasised that it is illustrative. Until there is a clearer idea of the potential for petroleum development, and agreement as to the issues to be addressed, it is premature to prescribe the exact process by which issued may be discussed and responses agreed.

Scenarios 1 & 2

311. Resource consents for exploration wells are issued under current Regional Plans and District Plans (or future revisions that have no greater specific provision for petroleum).

312. Abandonment of further prospectivity means that no more planning or consenting actions are required. There are no significant choices to be made regarding petroleum mining.

Scenario 3

313. Scenario 3 assumes that development is confined to one district and region. While it is plausible that development eventually extends over a boundary, it is not appropriate to take an approach covering the entire East Coast.

- Positive results from exploration wells lead to applications for consents for initial production wells. The initial applications are made under the current Regional and District Plan.
- The next revision of the RPS recognises petroleum development as a significant resource management issue for the region. Objectives and policies are established.
- The District Plan is revised accordingly. Considerable attention is given to zoning as it applies to petroleum development activities.
- The bulk of consenting decisions are made under this new regime.

Scenario 4 & 5

314. Scenarios 4 and 5 assume the initial development will fall within one district but this might be crossed in time. Two (Scenario 4) or up to five (Scenario 5) other areas of development begin with some lag, bringing in additional districts and regions.

- Positive results from exploration wells lead to applications for consents for production wells. The initial applications are made under the current Regional and District Plans.
- At an early stage in the development process, all the local authorities decide to develop a petroleum management strategy with input from central government and iwi. The preparation of the strategy involves a high degree of consultation and is adopted through the special consultative procedure under the Local Government Act 2002. Appropriate governance arrangements would need to be agreed. It is likely that the strategy would take around a year to develop, consult and adopt. It takes a Study Region-wide approach to some matters, but leaves a number of decisions to individual councils
- The RPSs are revised in line with the strategy and include petroleum as a matter of resource management significance. Further consultation takes place as part of this process.

- Regional and District Plans are amended with revised zoning and consenting requirements that reflect the strategy and RPSs. Again, further consultation takes place as part of these processes.

- New arrangements are in place as rigs arrive for production wells. Consenting decisions for these wells are made under the new regime.

- RPSs, Regional and District Plans are revised from time to time in light of experience.

315. In the event of the large-scale transformation envisaged in Scenario 5, it is likely that there would also be a number of other planning actions required, for example to deal with a range of social and infrastructure issues. The need for these might be identified as part of the scoping of the petroleum management strategy, or during its development.

316. More generally, there would be a period of perhaps a decade before production would ramp up, which would give a period of several years to identify issues and choices, determine the best mechanisms to deal with them and put any solutions in place.

Dealing with sensitive areas

317. The planning tools and mechanisms discussed are intended to allow trade-offs between different resource uses and a proposal's benefits and costs. The RMA takes into account sensitive areas. These areas include (but are not limited to) areas of significance to Māori, outstanding natural landscapes, areas of high amenity value with respect to recreation and tourism, areas of conservation importance, and areas important to the region's water resources.

318. For most, if not all, sensitive areas there are already protection arrangements in place. It is premature to specify additional measures or arrangements than may be needed regarding petroleum development. Any potential conflict won't be known until mining locations have been identified. However, there are some things that can be said about likely conflict and statutory protection.

Areas of significance to Māori

319. Areas of significance to Māori are addressed at two levels. The Petroleum Programme establishes protocols for input from iwi into permitting and requires the Minister to take into account requests to exclude an area of land.

320. Areas of significance to Māori may be identified in the district plan and activities restricted accordingly. Even if there is no provision in the plan, the RMA requires councils to recognise and provide for these sites in their decisions. District councils are aware that there are many sites that have not been registered. The impact of any development on sites will be considered when making decisions on resource consents and any conditions.

321. Iwi have noted concern that they may not be land owners and that non-notified consents may mean that consultation may not happen in regard to wāhi tapu and other significantly important sites. This could be considered further if commercial discoveries are made.

Landscapes and areas with a high amenity value

322. The landscapes of many parts of Hawke's Bay are an attraction to residents and drive parts of the economy through tourism.

323. These areas are identified in the district plans. There is potential for the district plans to preclude petroleum development in these areas if it is considered to be inappropriate.

Areas of conservation importance

324. The location of public conservation areas in relation to the Study Region is shown in Figure 15.

325. As noted at paragraph 9 above, there are no areas of Schedule 4-listed land within the Study Region (Huramua Nature Reserve, an area of 0.3 ha north west of Wairoa is within the greater boundary but has been excluded).

326. The major non-Schedule-4-listed conservation areas of the region managed by the Department of Conservation – the Ruahine and Kaweka Forest Parks – are outside the Study Region. There are a number of smaller non-Schedule-4-listed public conservation areas within the Study Region.

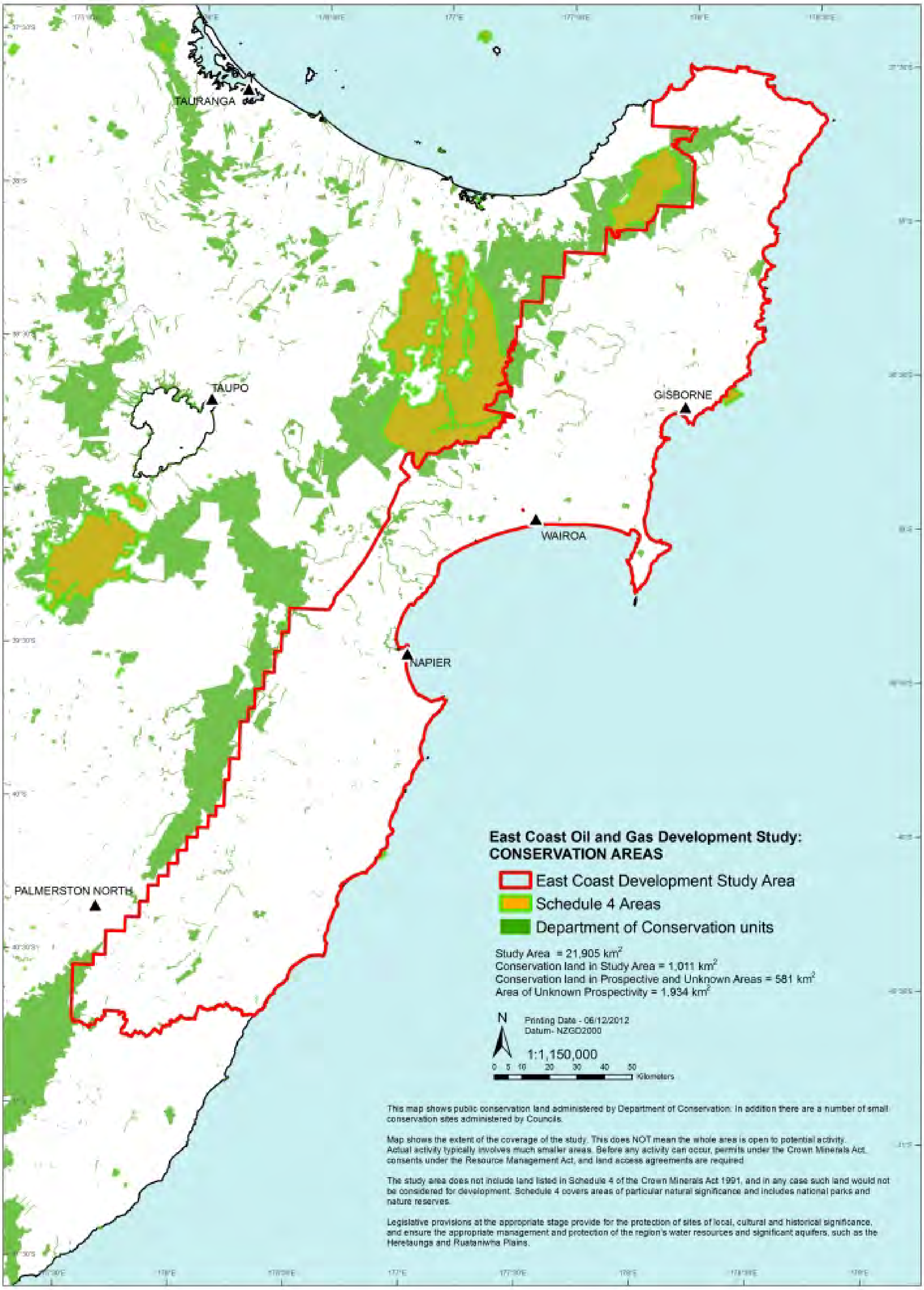
327. The total public conservation land in the Study Region overlapping the prospective resource (or where the presence of the prospective resource is not known) is 581km^2 which is less than 4% of the Study Region.

328. In addition, there are a number of small conservation areas administered by councils. Because these were not available in geographic information systems (GIS) form from all the councils, they have not been included in Figure 15, but they are identified in District Plans.

329. In most cases with the smaller conservation areas, there is potential for drilling to take place under conservation land horizontally from an adjacent location without conservation impact, if this is considered acceptable.

330. Access to Crown-owned conservation land for petroleum exploration and mining requires the permission of the Minister of Conservation.

Figure 15: Public conservation areas



Areas of importance to the region's water resources

331. The importance of properly managing the region's water resources is recognised through existing plans prepared under the RMA, and additional documents such as the Hawke's Bay Land and Water Management Strategy. Councils are concerned that the integrity of water resources should not be compromised by petroleum development and have a range of planning tools to provide for their protection.

332. To understand the extent to which areas with potential for petroleum development overlap the regions aquifers, this study commissioned a report by GNS Science: *The Extent and Depth of Known East Coast Aquifers*[36].

333. A summary of the findings is set out in Figure 16.

334. Figure 16 shows only recognised aquifers. In addition, most river valleys will have ground water sources. An indication of this is provided in the map of well locations set out in Figure 10 of GNS Science's report.

335. There is a degree of uncertainty about the bottom extent of most aquifers (most bores extend into but not through the aquifer) and a hi gh degree of uncertainty about the depth of the oil bearing formations[37]. Nevertheless, in most cases the resulting uncertainty is small in relation to the estimated vertical separation.

336. Figure 16 shows that a number of major aquifers are in the prospective area. These include the Waipoa Valley (Poverty Bay Flats), the Heretaunga Plains, the Poukawa Basin and Otane (Papanui Stream Valley). The major aquifers of the Ruataniwha Plains and Tararua are mostly outside the prospective area.

337. In some locations permit holders are likely to choose to not drill where there are major aquifers. Where aquifers are associated with intensive agriculture, land access and infrastructure may be too costly.

338. Elsewhere, it is possible that permit holders may seek to drill where there is ground water. Petroleum development can and does coexist with the existence of aquifers in many locations around the world, including in Taranaki. The PCE notes in her report that wells are almost always drilled through aquifers to reach the oil and gas formation. The risks associated with this and management responses are set out in section 6 above.

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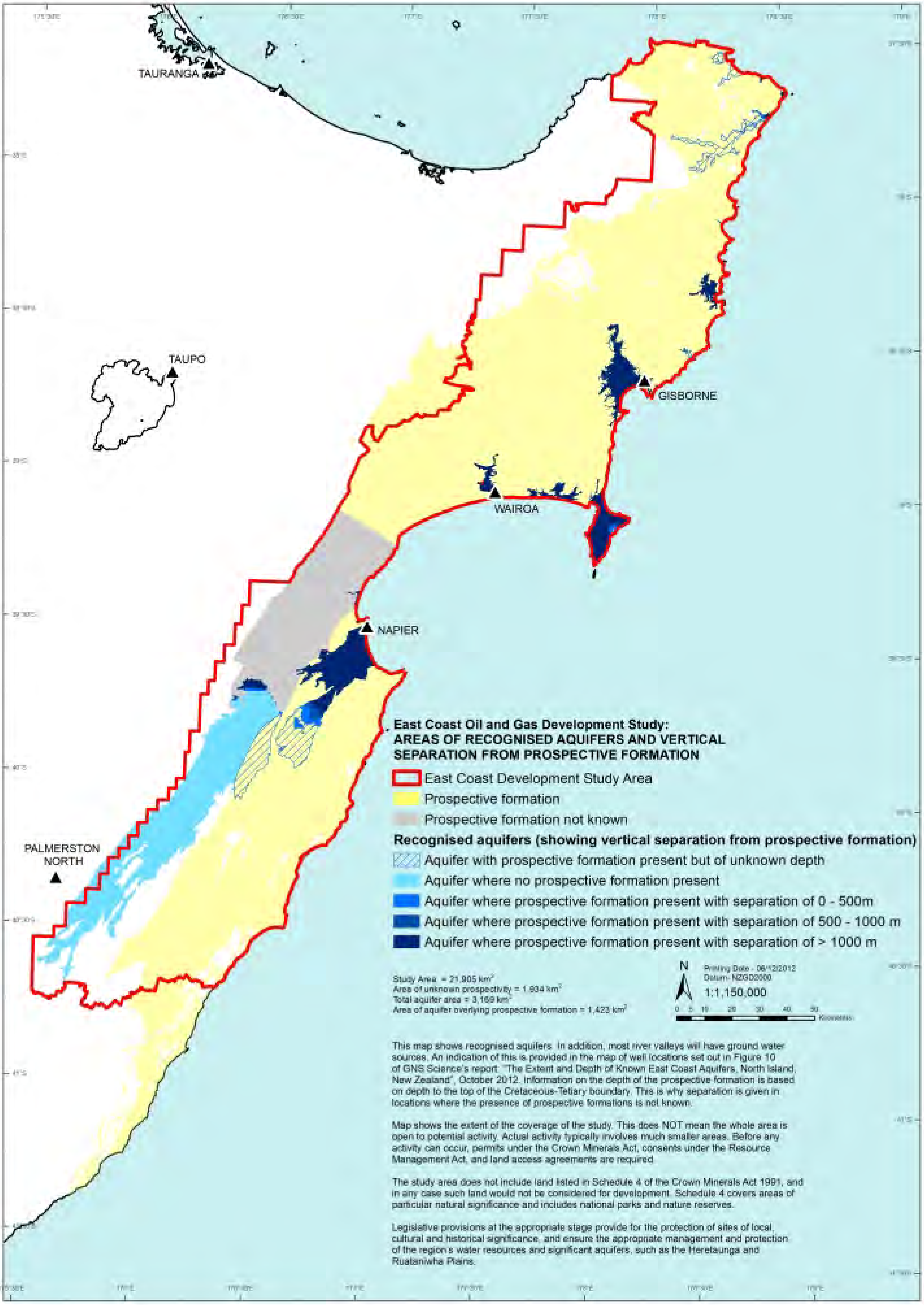
36 Available at www.med.govt.nz/sectors-industries/natural-resources/oil-and-gas/petroleum-expert-reports/east-coast-oil-and-gas-development-study

37 The available information that does exist is to the top of cretaceous period strata, which is used as a proxy.

Figure 16: Map of aquifers



339. The extent of the risk in practice is determined by a number of factors, including:

- the extent and location of faults: in most cases this can only be determined with further geological investigation

- the extent of separation between the aquifer and the oil bearing formation: as noted Figure 16 is a guide only, but it shows that in most cases the separation is greater than 1,000 metres, which is well above the minimum required to be confident that any created fractures will not extend between the two layers (It is possible to fracture safely with care with separations of less than 500 metres.)

- the extent to which the oil bearing layer is capped with an impermeable layer. GNS has indicated that there is an effective seal over the prospective formations.

340. The existence of aquifers does not preclude hydraulic fracturing operations but is taken into account in the consenting process.

Appendix 1: Reports Specially Commissioned for this Study

The following reports were specially commissioned for this study and are available on the MBIE website at www.med.govt.nz/sectors-industries/natural-resources/oil-and-gas/petroleum-expert-reports/east-coast-oil-and-gas-development-study.

- *East Coast North Island – Oil Resource Play – Development Scenario Models*, Michael Adams Reservoir Engineering, September - October 2012
- *Geological Input into the Evaluation of a Potential East Coast Resources Play*, K J Bland and R Quinn. GNS Science Consultancy Report 2012/250, September 2012
- *Economic Potential of Oil and Gas Development*, NZIER, November 2012
- *The Extent and Depth of Known East Coast Aquifers* G Zermansksy, C Tschritter, and A Lovett. GNS Science Consultancy Report 2012/273, October 2012

Appendix 2: Terms of Reference

East Coast Oil and Gas Development Study
Terms of Reference

Background

1 The Mayors of Gisborne, Tararua, Central Hawkes Bay, Hastings, Napier and Wairoa, and the Chairs of Horizons and Hawkes Bay Regional Councils (the **East Coast Mayors and Chairs**) and the Ministry of Business, Innovation and Employment (**MBIE**) have expressed an interest in knowing more about the economic potential for the region of possible oil and gas development, as well as the potential footprint.

2 The East Coast Mayors and Chairs and MBIE, with support from the regional Economic Development Agency Business Hawkes Bay, have agreed to carry out a joint study of the possible strategic impact that a variety of different development scenarios may have on the region.

3 The study is intended to put the East Coast Mayors and Chairs and Business Hawkes Bay in a position to be able to issue a realistic report that can inform local debate on proposed exploration drilling activity. In a similar way, an independent report commissioned by the Economic Development Agency Venture Taranaki indicates the value of the oil and gas industry to the Taranaki Region.

Study

4 It is envisaged that the following elements would feed into the report:

(a) an overview of general development potential in the region, including a report on geology and oil and gas prospectivity;

(b) a detailed assessment of one potential development scenario by an existing permit-holder, including field development and construction, infrastructure and labour requirements, and environmental (footprint) impacts. This assessment would be peer reviewed by an independent consultant;

(c) a report on significant aquifers in the region (to ensure their protection);

(d) an economic study of the national impacts of the potential development referred to in paragraph (b) above, and ‘high’ and ‘low’ alternative scenarios;

(e) a study of the local economic impacts of those scenarios;

(f) a high-level assessment of the environmental footprint of those scenarios.

General

5 It is intended that the final report will be available by mid November 2012.

Appendix 3: Glossary

bbl	barrel - a unit of volume equal to 0.159 m^3
bbl/d	barrels per day, a measure of production
block offer	a competitive tender method of offering exploration permits over “blocks” of available land
BOE	barrels of Oil Equivalent, a measure of the equivalent amount of oil to provide the same energy as a mixture of oil and gas
bopd	barrels of oil per day, a measure of production
CGE	computable general equilibrium (a type of economic forecasting model)
CMA regime	the Crown Minerals Act 1991 and the associated regulatory regime
CMA	Crown Minerals Act 1991
COC	a change of permit conditions process, used to alter the terms, duration or minerals of a permit
EUR	estimated ultimate recovery, the total amount of petroleum expected to be recovered from a well. Usually measured in BOE
flare	the burning of unwanted gas at the well site
formation	a distinctive and continuous body of rock
fracking	hydraulic fracturing - see paragraphs 49 to 55
fracturing	hydraulic fracturing - see paragraph 49 to 55
GDP	gross domestic product
GNDI	gross national disposable income, a measure of how well-off a nation’s residents are
HSE Act	Health and Safety in Employment Act 1992
MBIE	Ministry of Business, Innovation and Employment
NZES	the New Zealand Energy Strategy
NZP&M	New Zealand Petroleum & Minerals, the branch of MBIE responsible for managing the Crown’s petroleum and minerals resources
PCE	Parliamentary Commissioner for the Environment
petroleum	oil and gas
proppant	particles (often sand) added to hydraulic fracturing fluid to hold fractures open after hydraulic fracturing.
prospective formation	for the purposes of this study, the prospective formations are the Whangai and Waipawa formations shown in Figure 3 on page 22
RMA	Resource Management Act 1991
rohe	traditional tribal area, territory
seismicity	the frequency and distribution of earthquakes

shale	a fine grained rock formed by the consolidation of particles into thin relatively impermeable layers
Study Region	the region shown in Figure 2 on page 16
venting	releasing gas from a well directly into the atmosphere; usually done to prevent a dangerous build-up of pressure

Appendix 4: Summary of East Coast Permits

Permit	Permit holder	Parent
52976	ECEV II Limited	New Zealand Energy Corp. Exploration and production company listed on the TSX Venture Exchange. www.newzealandenergy.com
38348	Eastern Petroleum (NZ) Limited	TAG Oil Ltd. Exploration and production company listed on the Toronto Stock Exchange. www.tagoil.com
50940	Eastern Petroleum (NZ) Limited	TAG Oil Ltd. Exploration and production company listed on the Toronto Stock Exchange. www.tagoil.com
38346	Westech Energy New Zealand	Energy Corporation of America. A privately held exploration, production and transport company. www.energycorporationofamerica.com
53806	Marauder Resources East Coast (NZ) Limited	Marauder Resources East Coast Inc. Exploration and production company listed on the Toronto Stock Exchange. www.maraudernrg.ca
38349	Orient Petroleum (NZ) Limited	TAG Oil Ltd. Exploration and production company listed on the Toronto Stock Exchange. www.tagoil.com
52694	East Coast Energy Ventures Limited	New Zealand Energy Corp. Exploration and production company listed on the TSX Venture Exchange. www.newzealandenergy.com
38342	New Zealand Energy Corp	New Zealand Energy Corp. Exploration and production company listed on the TSX Venture Exchange. www.newzealandenergy.com

It is common for exploration and production companies holding permits to go into partnership with others at some point in the exploration and development cycle. TAG Oil has done this with Apache Corporation (www.apachecorp.com) for phase one of its East Coast operations (although Apache has recently indicated it will not continue its involvement into phase two).