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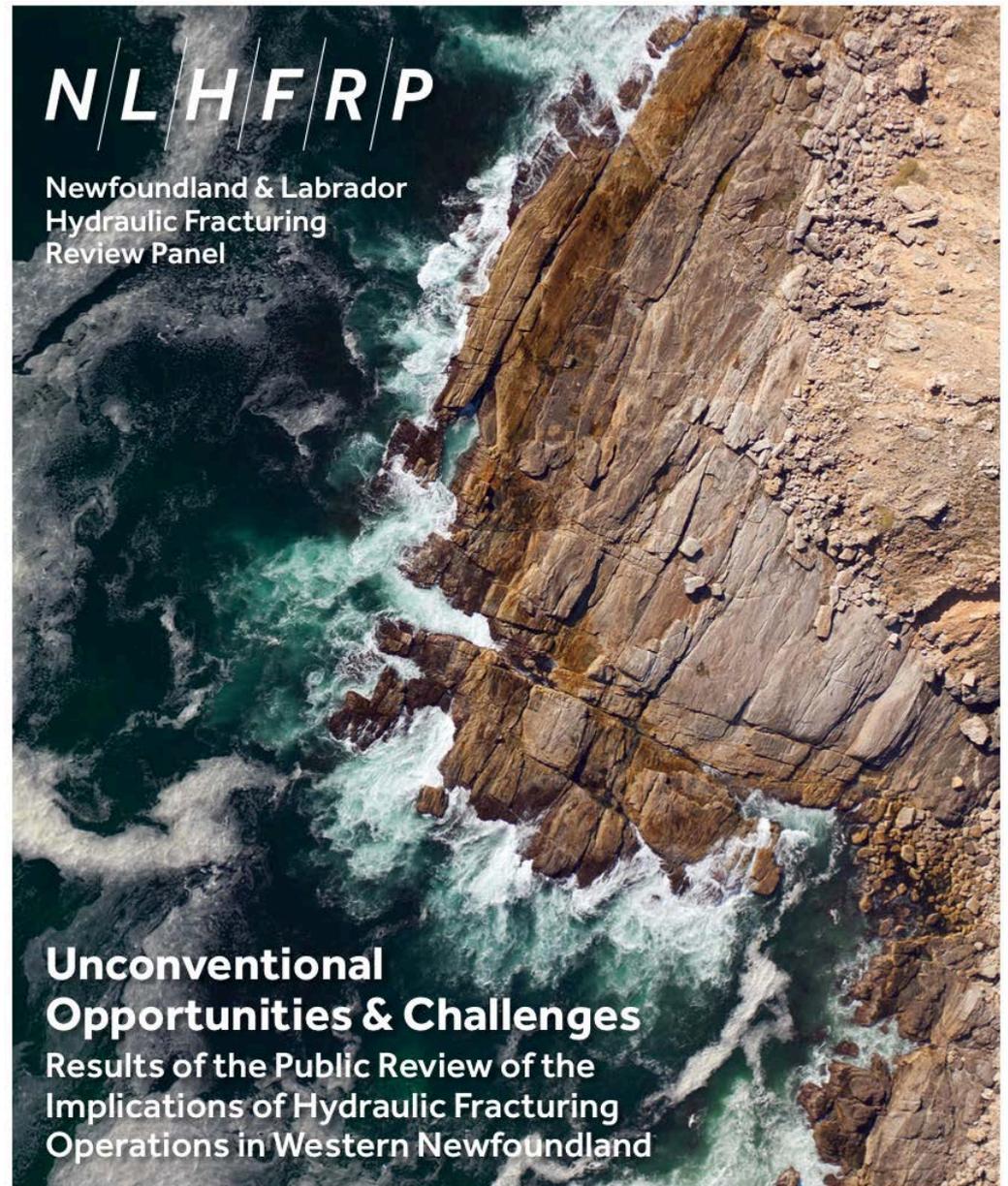
Ray Gosine (Chair)

Maurice Dusseault

Graham Gagnon

Kevin Keough

Wade Locke



Final Report

Dr. Ray Gosine  
(Chair)

Dr. Maurice Dusseault  
Dr. Graham Gagnon

Dr. Kevin Keough  
Dr. Wade Locke

In November 2013, the Minister of Natural Resources announced that no applications for onshore and onshore-to-offshore petroleum exploration using hydraulic fracturing would be accepted until government could undertake a balanced review of regulations, rules and guidelines in other jurisdictions; complete the technical work necessary to fully assess the geological impact in Western Newfoundland; and following this process, undertake public consultations to ensure that residents can comment and are fully informed before any decisions relating to hydraulic fracturing are made.

NLDNR. (2014). *NLHFRP Terms of Reference*. Retrieved from [www.nr.gov.nl.ca/nr/energy/pdf/hydraulic\\_fracturing\\_panel\\_terms\\_of\\_reference.pdf](http://www.nr.gov.nl.ca/nr/energy/pdf/hydraulic_fracturing_panel_terms_of_reference.pdf)

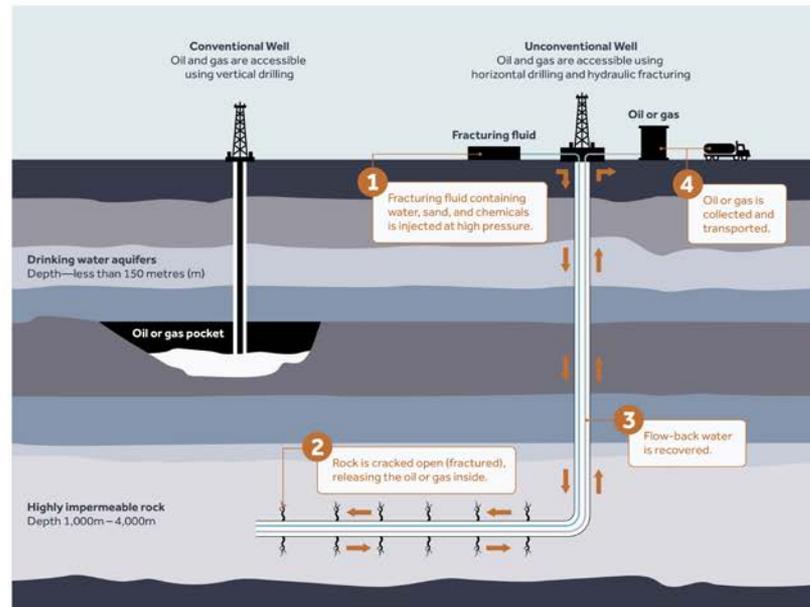
Based on the Terms of Reference for the Panel ...

- The Panel's mandate was to **conduct a public review and advise the Minister of Natural Resources** on the socio-economic and environmental implications of the hydraulic fracturing process with respect to possible exploration and development of the petroleum resources of Western Newfoundland.
- The Panel's primary task was to make a recommendation on **whether or not hydraulic fracturing should be undertaken in Western Newfoundland.**

NLDNR. (2014). *NLHFRP Terms of Reference*. Retrieved from [www.nr.gov.nl.ca/nr/energy/pdf/hydraulic\\_fracturing\\_panel\\_terms\\_of\\_reference.pdf](http://www.nr.gov.nl.ca/nr/energy/pdf/hydraulic_fracturing_panel_terms_of_reference.pdf)

**Figure 3**

Illustration of conventional and unconventional oil and gas operations, (adapted from Rodgers, 2015).



- exploration activities, such as seismic and magnetic surveys, and the drilling of exploratory wells;
- development of infrastructure, including access roads, pipeline rights-of-way, and drill pads;

- construction of transportation and storage facilities, such as pipelines and storage tanks at ports;
- drilling and construction of production wells;
- well completion and stimulation using hydraulic fracturing technology, including the supply of make-up water and disposal of wastewater following fracturing;
- production activities, including disposal of water that is produced with the oil and gas;
- re-stimulation of wells;
- well decommissioning and abandonment; and
- site restoration.

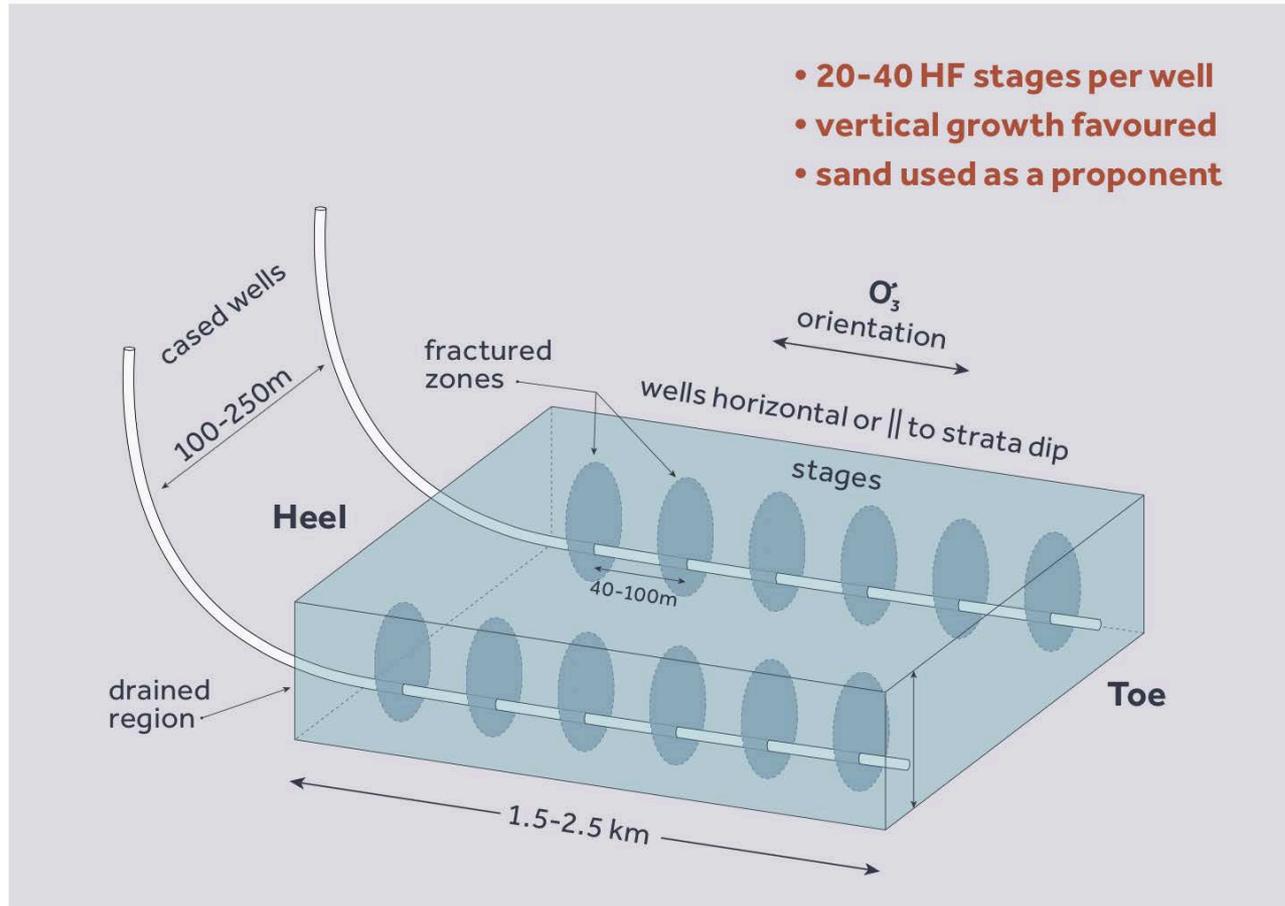


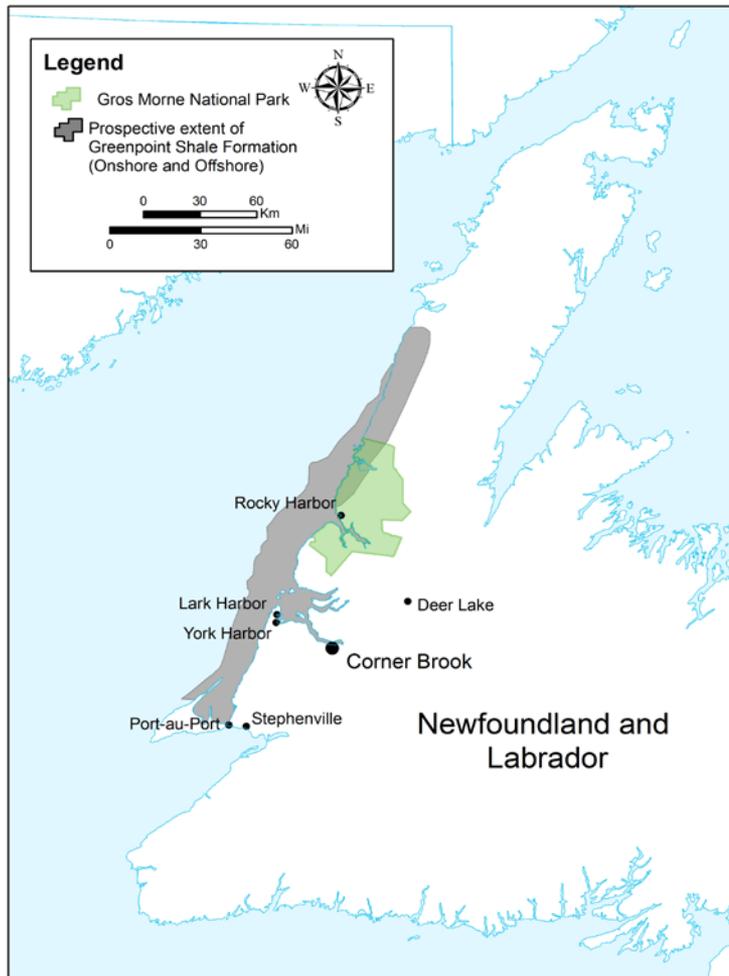
Figure 13. Horizontal well illustrating stages of hydraulic fracturing (Dusseault, 2016).

- The work of the Panel concentrated on the issues most relevant to the health and well-being of the people of, and environment within, Western Newfoundland.
- Through the review process, the Panel considered over 800 documents, including over 600 written submissions.
- The Panel was further informed through the public consultation sessions, face-to-face meetings, and teleconference meetings with a number of individuals and groups.
- The Panel's assessment took into account the work of experts who were commissioned to provide reports on specific topic areas outlined in the Terms of Reference.

The Panel reviewed a substantial body of information gathered during the review process including:

- all documents provided to the Panel by Government upon the appointment of the Panel;
- all documents provided to the Panel by Government at the request of the Panel;
- all documents sourced by individual members of the Panel;
- expert reports on specific topics that were commissioned by the Panel or prepared by individual members of the Panel; and
- over 600 documents that were received in response to a request by the Panel for submissions from the general public and stakeholder groups.

- **Dr. J. Bend**, Distinguished University Emeritus Professor, Schulich School of Medicine and Dentistry, Western University
- **Dr. E. Burden**, P. Geo., Professor of Earth Science (geology of Western Newfoundland), Memorial University
- **Dr. D. Butler-Jones**, M.D., former Chief Public Health Officer of Canada
- **Dr. D. Eaton**, Professor and NSERC Chair in Microseismic Dynamic Systems, Univ. Calgary
- **Dr. B. Goldstein**, M.D., Professor Emeritus, Environmental and Occupational Health, Univ. Pittsburgh
- **Dr. T. Husain**, Professor of Environmental Engineering, Memorial University
- **Dr. F. Khan**, Professor and Vale Chair in Safety and Risk Engineering, Memorial University
- **Dr. E. Krebes**, P. Geo., Professor of Geophysics (seismology), Univ. Calgary
- **Prof. W. Lahey**, Professor of Law (environmental regulation and health law), Schulich School of Law, Dalhousie University
- **Mr. M. LeBreton**, EcoTec Consultants (economic input-output analysis)
- **Dr. R. Martinez-Espiñeira**, Professor of Economics (econometrics), Memorial University
- **Dr. D. May**, Professor of Economics (income and health), Memorial University
- **Dr. K. May**, MayMetrics Analysis Inc. (income and health)
- **Mr. B. Rodgers**, Rodgers Oil and Gas Consulting (economic feasibility and fiscal analysis)
- **Dr. K. Storey**, Keith Storey Consulting and Honourary Research Professor of Geography, Memorial University (social and economic consequences of resource development)

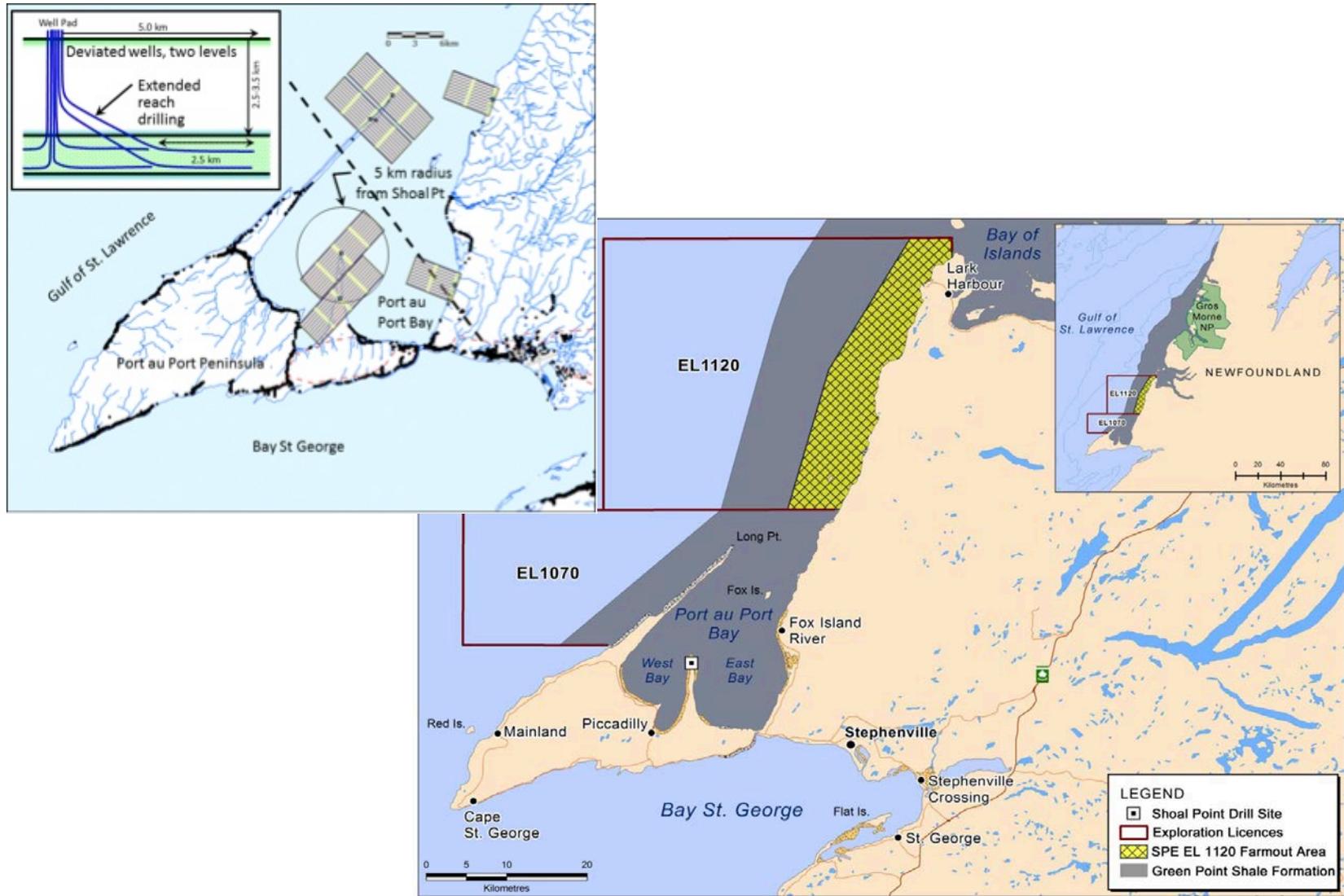


- The Green Point shale formation is of current interest for commercial development by Shoal Point Energy.
- An extensive discussion of the Green Point shale is found in a report entitled “The Green Point Shale of Western Newfoundland (Hinchey, et al., 2014)

Hinchey, A., Knight, I., Kilfoil, G., Hynes, K., Middleton, D., & Hicks, L. (2014). *The Green Point Shale of Western Newfoundland*. Retrieved from [www.nr.gov.nl.ca/nr/energy/pdf/green\\_point\\_shale\\_west\\_nl.pdf](http://www.nr.gov.nl.ca/nr/energy/pdf/green_point_shale_west_nl.pdf)

To illustrate the scale, costs, and benefits of an unconventional oil and gas development project, the Panel developed a full-scale scenario for an unconventional oil and gas development project in Western Newfoundland based on:

- information provided by the Department of Natural Resources at the request of the Panel;
- knowledge in the public domain regarding exploration licence (EL) 1070 held by Shoal Point Energy,
- information submitted to the Panel by Shoal Point Energy;
- publicly available information about oil production from the Bakken formation in North Dakota, Montana, and Saskatchewan; and
- information from the Newfoundland and Labrador Community Accounts.



The main features of the illustrative development scenario include:

- 480 production wells, each including a 2 km long horizontal well section drilled under Port au Port Bay, from 30-40 onshore well pads;
- capacity to drill 80 wells per year for a total of six years to drill and complete the 480 wells;
- hydraulic fracturing of each well would require 4 million gallons of water and 5,000 tons of sand, with 50% flowback of water;
- each well would produce for 20 years; and
- 480 production wells would drain approximately 282 km<sup>2</sup>, corresponding to a best estimate recovery of approximately 150 million barrels of oil along with 75 billion standard cubic feet of gas and 115 million barrels of produced water.

For the base case project (i.e., 150 million barrels recoverable, \$85 US per barrel) and depending on the wastewater handling option:

- the net present value (NPV) for the project using a 10% discount rate is \$1,112 - \$2,261 million, including \$111 - \$226 million to Nalcor Energy as a 10% equity partner;
- provincial government revenue from corporate income tax, royalties, and profit sharing over the 26-year life of the project is \$2,175 - \$3,532 million, or \$84 - \$136 million per year;
- federal government revenue from corporate income tax is \$631 - \$996 million, or \$24 - \$38 million per year; and
- \$273,000 - \$973,000 per year locally from revenue sharing.

- Since provincial government revenues are in the order of \$6.8 billion annually, the annual fiscal impact of the illustrative project (i.e. \$84 - \$136 million) would be in the order of 1.2 - 2.0% of revenues;
- While not an insignificant source of revenue, the annual contribution would be far less than the revenues normally attributed to offshore oil and gas activities, including royalties;
- The provincial revenues would be more in line with revenues from lotteries, vehicle and driver licence fees, tobacco tax, and insurance company tax; and
- The annual provincial revenues, while perhaps very important to Western Newfoundland under certain revenue-sharing models, cannot be considered a “game changer” with respect to the fiscal position of Newfoundland and Labrador.

**Figure 32**

Direct, indirect and induced employment: Deep well disposal option.

CAPITAL EXPENDITURES: DIRECT, INDIRECT AND INDUCED EMPLOYMENT IN PERSON YEARS (PY) AND ANNUALLY FOR 6 YEARS: DEEP WELL DISPOSAL OPTION	DIRECT		INDIRECT		INDUCED		TOTAL	
	PY	Annual	PY	Annual	PY	Annual	PY	Annual
<b>Stephenville – Port au Port</b>	1320	220	434	72	119	20	1873	312
<b>Newfoundland and Labrador</b>	3573	595	2278	380	761	127	6612	1102
OPERATING EXPENDITURES: DIRECT, INDIRECT AND INDUCED EMPLOYMENT IN PERSON YEARS (PY) AND ANNUALLY FOR 26 YEARS: DEEP WELL DISPOSAL OPTION	DIRECT		INDIRECT		INDUCED		TOTAL	
	PY	Annual	PY	Annual	PY	Annual	PY	Annual
<b>Stephenville – Port au Port</b>	649	25	264	10	65	3	978	38
<b>Newfoundland and Labrador</b>	811	31	808	31	238	9	1858	72

**Figure 33**

Direct, indirect and induced employment: Off-site treatment option.

CAPITAL EXPENDITURES: DIRECT, INDIRECT AND INDUCED EMPLOYMENT IN PERSON YEARS (PY) AND ANNUALLY FOR 6 YEARS: OFF-SITE TREATMENT OPTION	DIRECT		INDIRECT		INDUCED		TOTAL	
	PY	Annual	PY	Annual	PY	Annual	PY	Annual
<b>Stephenville – Port au Port</b>	1307	218	430	72	118	20	1855	310
<b>Newfoundland and Labrador</b>	3542	590	2250	375	752	125	6544	1090
OPERATING EXPENDITURES: DIRECT, INDIRECT AND INDUCED EMPLOYMENT IN PERSON YEARS (PY) AND ANNUALLY FOR 26 YEARS: OFF-SITE TREATMENT OPTION	DIRECT		INDIRECT		INDUCED		TOTAL	
	PY	Annual	PY	Annual	PY	Annual	PY	Annual
<b>Stephenville – Port au Port</b>	502	19	267	10	56	2	825	31
<b>Newfoundland and Labrador</b>	627	24	729	28	203	8	1557	60

**Figure 34**  
Direct, indirect and induced gross domestic product (GDP): Deep well disposal option.

CAPITAL EXPENDITURES: DIRECT, INDIRECT AND INDUCED GROSS DOMESTIC PRODUCT (GDP), TOTAL AND AVERAGE ANNUAL FOR 6 YEARS: DEEP WELL DISPOSAL OPTION	DIRECT (\$ MILLION)		INDIRECT (\$ MILLION)		INDUCED (\$ MILLION)		COMBINED GDP (\$ MILLION)	
	Total	Annual	Total	Annual	Total	Annual	Total	Annual
<b>Stephenville – Port au Port</b>	\$216.2	\$36.0	\$29.6	\$4.9	\$21.5	\$3.6	\$267.4	\$44.6
<b>Newfoundland and Labrador</b>	\$402.6	\$67.1	\$188.2	\$31.4	\$104.4	\$17.4	\$695.2	\$115.8
<b>Rest of Canada</b>			\$1,597.6	\$266.3	\$538.1	\$89.7	\$2,135.7	\$356.0
OPERATING EXPENDITURES: DIRECT, INDIRECT AND INDUCED GROSS DOMESTIC PRODUCT (GDP), TOTAL AND AVERAGE ANNUAL FOR 26 YEARS: DEEP WELL DISPOSAL OPTION	DIRECT (\$ MILLION)		INDIRECT (\$ MILLION)		INDUCED (\$ MILLION)		COMBINED GDP (\$ MILLION)	
	Total	Annual	Total	Annual	Total	Annual	Total	Annual
<b>Stephenville – Port au Port</b>	\$520.2	\$20.0	\$25.1	\$1.0	\$11.2	\$0.4	\$556.6	\$21.4
<b>Newfoundland and Labrador</b>	\$534.8	\$20.6	\$78.7	\$3.0	\$30.2	\$1.2	\$643.7	\$24.8
<b>Rest of Canada</b>			\$138.1	\$5.3	\$64.1	\$2.5	\$202.2	\$7.8
TOTAL DIRECT, INDIRECT AND INDUCED GROSS DOMESTIC PRODUCT (GDP): DEEP WELL DISPOSAL OPTION	DIRECT (\$ MILLION)		INDIRECT (\$ MILLION)		INDUCED (\$ MILLION)		COMBINED GDP (\$ MILLION)	
	Total		Total		Total		Total	
<b>Stephenville – Port au Port</b>	\$736.4		\$54.7		\$32.7		\$823.8	
<b>Newfoundland and Labrador</b>	\$937.4		\$266.9		\$134.6		\$1,338.9	
<b>Rest of Canada</b>			\$1,735.7		\$602.2		\$2,337.9	

The primary environmental issues include:

- potential negative impacts on climate change over time from natural gas leakage;
- possible stress on the capacity of local water supplies;
- a poor understanding of the local geology and the potential risks associated with the contamination of local drinking water supplies;
- possible contamination of surface water and groundwater sources from surface spills;
- potential land disturbance and impacts on groundwater and surface water flow as a result of the construction; and
- possible earthquakes that may be induced during hydraulic fracturing operations.

The primary public health issues, many of which follow from the environmental issues, include:

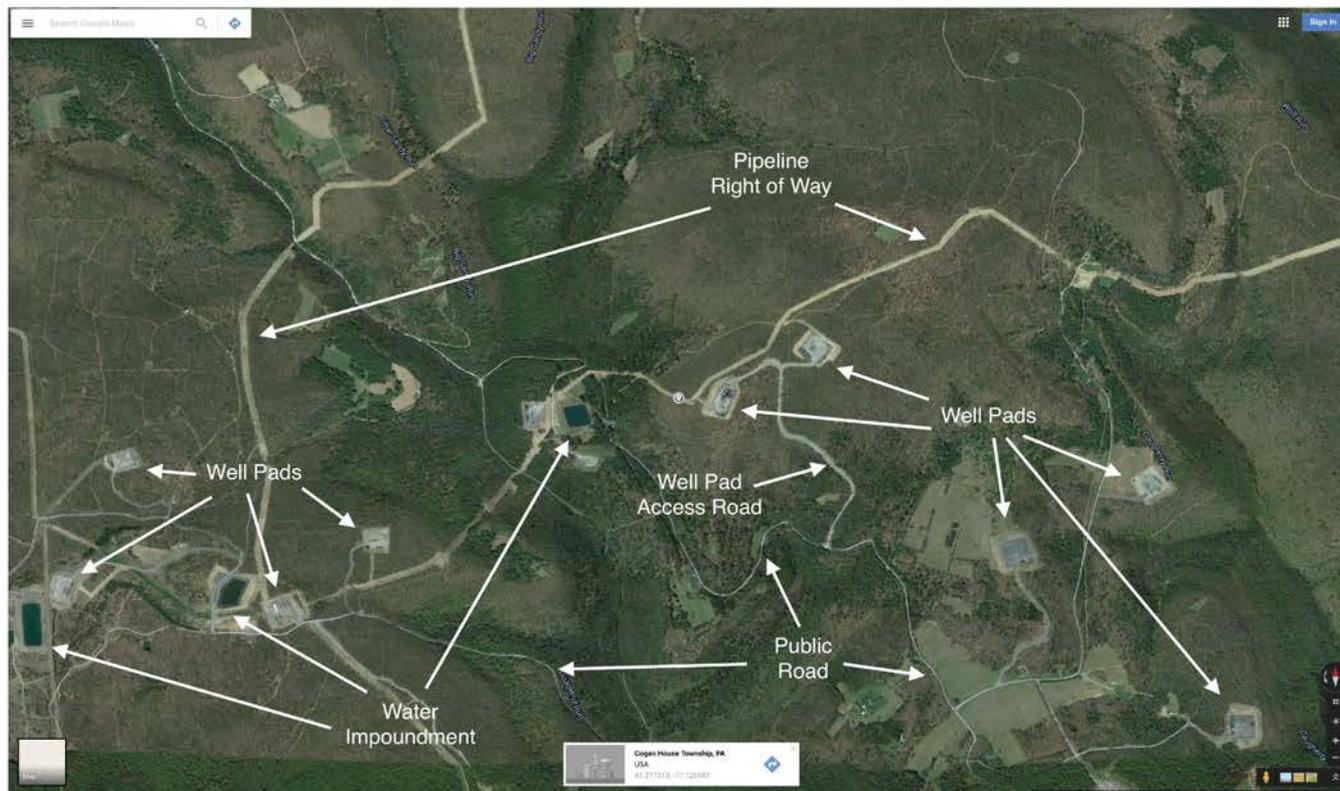
- potential exposure to airborne toxicants arising from spills of fracturing fluids, wastewater, and petroleum products; leaks from wells; and emissions from large numbers of diesel trucks and equipment used during the development of wells;
- possible degradation in drinking water quality due to surface spills and migration of gas and chemicals;
- potential exposure to wastewater or other hazardous fluids as a result of accidents; and
- increased anxiety about potential health risks from the immediate and cumulative effects of industrial development, including effects from an increase in truck traffic, an increase in the likelihood of accidents, and an increase in noise.

The primary socio-economic issues include:

- possible increased stress on the healthcare and social services systems as a result of boomtown effects;
- potential negative impacts on other economic sectors, such as the fishery, tourism, and agriculture;
- possible negative effects on recreational uses of land and water;
- inadequate fire and emergency services in the region of development;
- potential major changes to the way of life in the vicinity of development as a result of the intensity of industrial activity, particularly during well construction;
- potential negative effects on Qalipu Mi'kmaq culture in the vicinity of development due to impact on the environment; and
- lack of confidence that Government can provide effective regulatory oversight of unconventional oil and gas development.

**Figure 8**

Google Maps view of hydraulic fracturing sites in Lycoming County, Pennsylvania.



### Figure 9

Google Maps view of drilling operation at a site in Lycoming County, Pennsylvania.



**Figure 10**  
Wellhead ready  
for hydraulic  
fracturing.



**Figure 12**

Pumping trucks and other equipment on well pad.



**Figure 15**

A producing well pad containing 10 gas wells near Williamsport, Pennsylvania.



**Figure 43**  
Well pads and wind turbines, Lycoming County, Pennsylvania.





SUMMARY	
Total truckloads per well	3,320
Average number of truckloads per day during construction	309
Average number of truck movements per day during construction	590
Average number of truckloads per day during production	127
Average number of truck movements per day during production	254

**Figure 18**

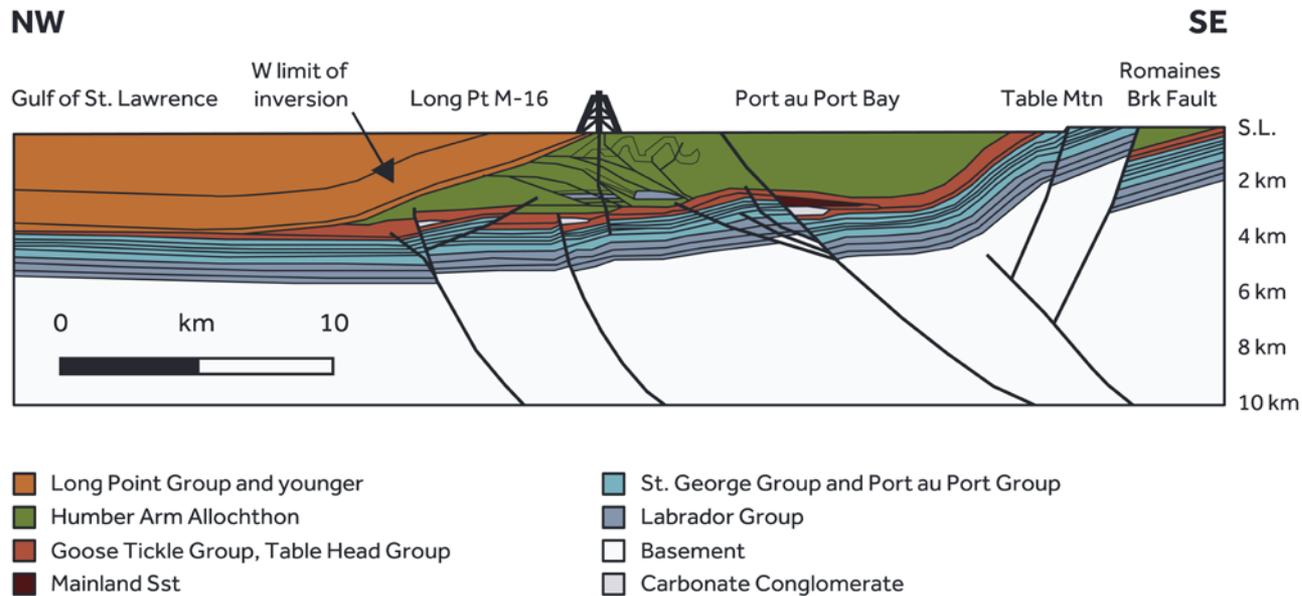
Refolded folds and faults along coastal outcrop of the Green Point shale (Burden, 2016).



*“The style of folding and faulting of the shale observed in outcrops onshore around Port au Port Bay is likely a good indication of the deformation that occurred at depth” (Hinchey, et al., 2014).*

**Figure 19**

Cross section of subsurface geology across Port au Port Bay (Hinchey, et al., 2014).



*“There needs to be some proof that the complex geology we see on the surface disappears at depth, or that the multitude of fault and fracture we see on the surface can be successfully modeled and engineered under appropriate underground pressure and temperature to achieve a safe and sustained hydrocarbon flow” (Burden, 2016).*

*“Because the available seismic data do not provide effective images of the Humber Arm Allochthon or the Green Point shale, a modern seismic program in the region would greatly improve the ability to predict where the Green Point shale occurs at depth, how the composition of the Humber Arm Allochthon varies internally, and how it was affected by regional deformation and faulting. Such higher quality data would also be crucial for designing - and predicting the effects of - an initial hydraulic fracturing program, as well as any future production operations” (Hinchey, et al., 2014).*

*“Evaluating the amount and kind of deformation and fracturing at each proposed site will be an important part of the risk assessment for any hydrocarbon exploration of the Green Point shale. The greater the abundance of interconnected crosscutting fractures, the easier it is for hydrocarbons - or any fluid - to leak out of the formation” (Hinchey, et al., 2014).*

- With respect to “*whether or not hydraulic fracturing should be undertaken in Western Newfoundland*”, a simple yes or no recommendation is not appropriate nor responsible given the unknown and unresolved issues.
- A number of gaps and deficiencies must be addressed before conditions could exist that would allow for hydraulic fracturing operations to proceed reasonably and responsibly.
- At this point, the “pause” in accepting applications involving hydraulic fracturing should remain in effect while some of the supplementary recommendations are implemented.

## Supplementary Recommendations

**The supplementary recommendations represent a cautious, evidenced-based, and staged approach to better-informed decision-making with respect to whether hydraulic fracturing operations should be permitted. Recommendations with decision-gates (indicated by ?) may lead to a decision that development should not proceed. Government should use a transparent, robust decision-making framework that includes a roadmap and time-frame for actions arising from the recommendations, and defines the roles of various stakeholders.**

 These red-stage recommendations, which are related primarily to public policy and processes, must be implemented before lifting the “pause” on accepting applications for hydraulic fracturing.

 If a decision is made to proceed to the yellow stage, these recommendations relate to more site-specific considerations and actions. Applications from proponents may be accepted at this stage.

 If a decision is made to proceed to the green stage, these recommendations describe operational processes and practices that must be implemented before industrial activities commence.

The 'red-stage' recommendations describe actions, primarily related to public policy and processes, that the Panel feels must be undertaken before the “pause” can be lifted. These recommendations include:

- identify, adopt, and demonstrate best practices in community engagement;
- create and implement an ongoing program of public education about the scale, risks, and benefits of unconventional oil and gas development in Western Newfoundland;
- review and update public policy and regional development plans that describe the role, if any, of unconventional oil and gas development in the province;
- decide whether Government will make the investment required to better understand and mitigate key risks;
- safeguard Gros Morne National Park from development, and initiate the process to establish a buffer zone;

The 'red-stage' recommendations continued:

- undertake the basic scientific studies required to understand the potential impacts and geological-based risks of development, particularly risks related to health, environment, and seismicity;
- complete Health Impact Assessments for potential development regions;
- require that all engineering and geoscience work be undertaken by licenced professionals and companies with permits to practice in Newfoundland and Labrador;
- study potential development sites from a land-use perspective and with consideration to short-term and long-term coastal change;
- participate in national and international research programs related to well integrity; and
- establish an appropriate regulatory framework for unconventional oil and gas development.

If the results of implementing the **red-stage** recommendations lead to a decision that Government will give further consideration to permitting unconventional oil and gas development, the '**yellow-stage**' recommendations should be implemented.

- The **yellow-stage** recommendations relate primarily to more site-specific studies or assessments needed in advance of industrial activity.
- During the **yellow-stage**, the “pause” in accepting applications involving hydraulic fracturing could be removed so that some preparatory work could proceed (e.g., planning for exploration by proponents, and reviewing proposals from proponents by government and the regulator).
- Proponents, however, would need to understand that some of the **yellow-stage** recommendations include decision-gates that could result in a decision by Government not to proceed further. For example, a more comprehensive cost-benefit study by the province, an independent assessment of risk, or new scientific knowledge, could lead to a decision that there is no basis to proceed with development.

The 'yellow-stage' recommendations include:

- model realistic full-scale development scenarios, including a plan for use of excess associated gas and a requirement for substantial local benefits, to better understand the costs and benefits of development;
- collect the baseline environmental, public health, and ecological data and model the effects of development;
- carry out further scientific studies related to understanding how the Green Point shale will respond to hydraulic fracturing operations, including an assessment of the prospect of using deep disposal wells for wastewater;
- review and update the environmental impact assessment process;

The **yellow-stage** recommendations continued:

- complete an independent assessment of the associated environmental and public health risks;
- develop ongoing monitoring programs for collecting relevant environmental and public health data, for interpreting the data, and for publicly reporting on impacts;
- assess the potential impacts on civil infrastructure and services;
- develop an adaptive risk management framework, including an approach for monitoring and managing seismicity risks;
- undertake a review of the existing healthcare, fire and emergency services, and social services systems to identify the necessary improvements;

The **yellow-stage** recommendations continued:

- implement additional elements of the regulatory framework, including mechanisms for meaningful public participation by population and public health experts, and processes for review and continuous improvement of regulations;
- require proponents to implement community engagement plans that demonstrate public confidence has been attained and is maintained throughout a project;
- secure an equity position in future developments; and
- develop a well integrity monitoring program and require an appropriate security deposit from proponents.

The 'green-stage' recommendations reflect the actions that the Panel believes need to be taken if, as a result of implementing the red-stage and yellow-stage recommendations, a decision is made by Government to permit unconventional oil and gas development in Western Newfoundland.

- There are numerous green-stage recommendations, primarily related to operational processes and practices, that the Panel feels will be straightforward to implement, assuming public confidence and support from the various community, industry, and Government stakeholders has been achieved.
- The green-stage recommendations must be implemented before industrial activities commence and remain in place throughout a project.

The 'green-stage' recommendations include:

- require best practices to be followed by industry, including minimizing GHG emissions and installing groundwater monitoring wells;
- provide appropriate resources for health care, social services, fire and emergency services, and community support;
- implement regular testing and reporting on population health, air quality, water resources, and ecological species populations and health in areas where there is development;
- disclose the composition of all hydraulic fracturing fluids in a database that is in the public domain;
- plan development to minimize impacts on local residents;
- use best practices for site development, management, and decommissioning;

The 'green-stage' recommendations include:

- minimize development impacts on lands, including footprints of well pads;
- minimize the risks to aquatic species;
- develop an abandoned well program;
- implement plans for waste and wastewater management, including seismic risk management if deep disposal wells are to be utilized;
- ensure health professionals have immediate access to accurate information about the composition of fluids used or produced at each development site; and
- ensure transparency in the management of risks, and engage independent experts in the oversight of the regulatory process, including the monitoring and evaluation requirements.

- Implementing these staged recommendations constitutes a cautious way forward without pre-judging the impact and potential of unconventional oil and gas development in Western Newfoundland.
- Some of the recommendations give rise to decision points, where further evidence will inform Government decisions about whether to permit development or about any conditions or restrictions on specific activities that may be imposed.

Within the context of Western Newfoundland ....

- if the cost and technological barriers are too high, development will not happen;
- if supportive public policy and regional economic development frameworks and a robust regulatory regime are not implemented, development should not be permitted; and
- if the science of the geological formation continues to be poorly understood, the technical risks associated with development will remain unacceptably high.

The Green Point shale resource, and other oil and gas resources that may be present in Western Newfoundland, represent unconventional opportunities and challenges for industrial development and economic growth in the region. These opportunities and challenges deserve more detailed investigation and consideration than has been given to date.

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- **Mr. E. Foran**, Foran Management Consulting
- **Ms. L. Fusco**, Ph.D. candidate, University of Toronto
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- **Dr. C. Loomis**, former Vice-President (Research) and President, pro tempore, Memorial University
- **Dr. J. McLaughlin**, P.Eng., President Emeritus, University of New Brunswick
- **Dr. A. Meisen**, P.Eng., former President, Memorial University, and President, Canadian Commission for UNESCO
- **Dr. P. Moody-Corbett**, Senior Associate Dean, Northern Ontario School of Medicine
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