Assessing Health Consequences as a Component of a *CEAA* Screening Level Environmental Assessment: the case of the Port Hope Area Initiative

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Abstract

This paper outlines the comprehensive approach to the assessment of potential health effects that was conducted for the environmental assessment (EA) of the Port Granby Project, under the Port Hope Area Initiative (PHAI). The human health and safety considerations study is among the most comprehensive conducted for the purpose of EA under the *Canadian Environmental Assessment Act* (CEAA). The methods and results for radiological and conventional health assessment are presented, including a discussion of the significance of the health effects. The results clearly indicated that feelings of general well-being and of environmental quality and how they then relate to health are important factors in any health and safety study undertaken for EA purposes.

Introduction

In this paper the broad, inclusive approach to the assessment of human health and safety considerations that was applied as part of a *Canadian Environmental Assessment Act* (CEAA) screening-level Environmental Assessment (EA) of the Port Hope Area Initiative (PHAI) projects is described. The PHAI is a community-based program directed at the development and implementation of a safe, long-term management solution for historic low-level radioactive waste (LLRW) and marginally contaminated soil (MCS) that has existed in the Port Hope area (Figure 1) for some seven decades. It represents an agreement between the federal government and the Municipalities of Port Hope and Clarington for the management of the wastes within the respective communities in above-ground facilities designed to last for several hundred years. The PHAI includes two distinct and separate undertakings, namely *The Port Granby Long-Term Low-Level Radioactive Waste Management Project* (The Port Granby Project) and *The Port Hope Long-Term Low-Level Radioactive Waste Management Project* (The Port Hope Project).

The Port Granby Project, which is the focus of this paper, comprises the management of the LLRW and MCS that are currently located at the existing Port Granby waste management facility (WMF). These wastes will be moved to a long-term low-level radioactive waste management facility (LTWMF).

Historical Context

LLRW and MCS present within the easterly portion of the Municipality of Clarington are the result of the recovery of radium from ores mined in the Northwest Territories and uranium concentrates from Canada and other countries that were shipped to Port Hope for processing. For

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the duration of the 1930s, process residues were placed at various locations throughout the Port Hope community, including the municipal landfill and other vacant land sites within the town.

The focus of ore processing shifted in the early 1940s from radium to uranium and by 1948 wastes were being placed at a site near Welcome in the former Township of Hope. The Welcome facility was closed in 1955 and a new waste receiving site was established on the Lake Ontario shoreline near the hamlet of Port Granby in Clarington.

In 1980 the Port Granby WMF was placed under decommissioning orders by the Atomic Energy Control Board (AECB). An agreement between a citizens' committee of the affected community, the municipality and the federal government was reached. The Legal Agreement (Anon. 2000) was signed by the affected municipality and the Minister of Natural Resources, and guides the PHAI.

Scope and objectives of the human health and safety effects assessment

The overall objective of the health and safety assessment was to (1) evaluate the potential project stressors that could affect human health or safety; (2) describe the project-related stressors under existing or pre-project conditions; (3) predict the changes to project-related stressors that could result from the project activities (e.g., construction, increased commuter traffic); and (4) evaluate health effects of changes to project-related stressors. Additionally, a program to monitor health effects was recommended as a method to confirm the effectiveness of proposed effects mitigation and implement adaptive management strategies throughout the life of the Port Granby Project.

Approach and Methodology

To identify and describe the potential project effects, hypothetical human receptors were selected as endpoints of the health effects assessment. The effects assessment model used a "source-pathway-receptor" risk assessment approach and considered a comprehensive suite of environmental stressors and pathways related to the project. This study is noteworthy as it considered both traditional and non-traditional stressors and pathways consistent with Health Canada's holistic definition of health, as "a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity" (Health Canada 1999).

An assessment of the health effects was completed for the following sub-components:

- The radiological health of members of the public;
- The radiological health of workers;
- The conventional health of members of the public; and
- Occupational health and safety.

The health and safety considerations of these four sub-components were incorporated into the assessment as they were judged to be affected by one or more of the following project-related stressors:

- Radiological contaminants, including radionuclides identified as the Contaminants of Potential Concern (COPC) for the Port Granby Project[i], including exposure through all pathways (immersion, absorption, ingestion, and inhalation of air, soil, water and food);
- Air quality, through inhalation exposure to particulate matter and selected criteria air contaminants associated with vehicle exhaust;
- Exposure to conventional (non-radioactive) contaminants, including metals identified as the COPC for the Port Granby Project[ii], through external contact, inhalation and ingestion of air, water, food and soil;

- Noise, from exposure construction and transportation activities;
- Traffic accidents;
- Availability of existing health services, representing access to emergency and routine health care; and
- General well-being, as reflected in demographics, social support networks, personal health practices, income and social status, education, healthy child development and public attitudes.

In concert with consideration of conventional and radiological contaminants in various biophysical media, less traditional pathways including exposure to physical stressors such as traffic, noise or workplace accidents and the pathways through which people's feelings of health and well-being may be influenced by the project were evaluated.

The multidisciplinary EA approach that was undertaken provided the input parameters required for the human health and safety assessment. To achieve the goal of characterizing pre-project conditions, the current levels of exposure to the identified stressors were estimated for people living, working, and participating in recreational activities in the vicinity of the Municipality of Clarington. Input parameters were derived from data gathered to characterize the existing environmental components. Similarly, the predicted post-project changes in the input parameters were compiled from the effects assessment studies conducted for the other components.

Hypothetical receptors were used to represent the people who live and work in the vicinity and who might be exposed to stressors on health as a result of the Port Granby Project (Figure 2). All assumptions regarding receptors and their lifestyles were based on plausible hypothetical scenarios. Several special case scenarios were also considered for estimating upper bounds on lifestyle scenarios and exposure risks associated with certain project works and activities.

Three categories of hypothetical receptors were considered as described below:

- **Area Residents** representing people living and working in the vicinity of the project, but not directly affected by the existing Port Granby WMF or proposed LTWMF on a day-to-day basis;
- **Adjacent Residents** representing people living or working immediately adjacent to the existing Port Granby WMF or proposed LTWMF and who have the potential to be affected by the project in unique ways because of their location and/or lifestyles; and
- **Workers** representing individuals participating in the various project works and activities.

For both the area and adjacent resident locations, three residents were considered, namely:

- A 70-kg adult male – an adult male was chosen rather than a female because men typically have higher food intake rates than women; consequently men would experience a higher level of exposure to stressors;
- A 10-year old child - children have a higher dose coefficient and therefore typically receive a higher exposure than adults; and
- A one-year old infant – a one-year old infant was chosen over a nursing infant since, unlike a nursing infant, a one-year old might be expected to ingest soil or food grown on contaminated soil, resulting in a higher level of exposure to stressors.

A screening analysis was conducted and used to identify the conditions under which workers could be most exposed to stressors as a result of the Port Granby Project. Based on the screening rationale used, a number of worker scenarios were identified and considered in the assessment of the effects of the project.

The health assessment followed a results-oriented process to screen out scenarios where no exceedence of established, health-based criteria or guidelines were known or predicted. As such, it

was determined that the construction and development phase of the Port Granby Project had the greatest potential to result in health effects. In order to evaluate whether the project works and activities would result in a measurable change to radiological health of members of the public and workers, annual incremental radiation doses were calculated for residents and workers predicted to experience the greatest exposure as a result of their location and lifestyles or occupational duties, respectively. The potential toxicological effects of the project on health involved screening the concentrations of non-radiological contaminants in the biophysical media to determine discrete locations for members of the public where the incremental concentration of a contaminant was determined to be measurable in any one biophysical medium, and resulted in a total concentration that was equal to or greater than a conservative, arbitrarily selected 60% of an appropriate health-based criterion or guideline, thereby triggering the requirement for a quantitative health risk assessment. Evaluation of the health effects to workers from exposure to non-radiological contaminants associated with the project considered both acute and chronic occupational exposure scenarios. Physical risks (e.g., falls, noise) to workers were also evaluated.

Results

For illustrative purposes, the results for the health and safety considerations assessment of an adult adjacent resident and a monitoring technician engaged with waste excavation at the existing WMF are presented.

Radiological health of members of the public

Various incremental doses were predicted for members of the public living near the proposed facility. For the purpose of this assessment, a measurable change was defined as an incremental dose of 0.1 mSv/a. The criterion of measurable radiation dose was established based on 10% of the Canadian Nuclear Safety Commission (CNSC) dose limit of 1.0 mSv/a as measurable changes in soil, surface water and air quality may result in a magnitude of 0.1 mSv/a change in radiation dose. This dose also corresponds to approximately 5% of background radiation levels.

The maximum credible predicted incremental doses to adult adjacent residents during the construction and development phase were 4-5% of the annual radiation doses received by adjacent residents under existing conditions. Incremental doses were predicted to be 0.060 and 0.066 mSv/a to southwest and northeast adult adjacent residents, respectively. The difference in the doses between the southwest and northeast adjacent resident were due to the prevailing wind direction. Incremental doses were below those considered to be measurable (0.1 mSv/a).

To ensure the dose estimates were conservative, annual doses were also predicted for upper bound dietary intakes. These intake rates represented more extreme dietary intakes that were likely realistic for only a small portion of the population. As for predicted radiation doses to residents assumed to exhibit median dietary habits, incremental doses were below those considered to be measurable (0.1 mSv/a).

In all cases, the majority of the predicted incremental dose resulted from radon exposure, and remained below the project clean-up criterion and the CNSC public dose limit of 1 mSv/a above background. The estimated total annual doses from all existing natural sources[iii] in combination with the Port Granby Project (i.e., total dose) for adults were lower than the national average of about 2 mSv/a. Radon causes the majority of the annual dose received by members of the public regardless of where they live in Canada (Grasty and LaMarre 2004).

Radiological health of workers

The predicted doses to workers were considerably less than the applicable CNSC dose limits. The maximum dose during LTWMF construction and development was predicted to be 7 mSv/a for a monitoring technician working in the waste excavation area of the existing Port Granby WMF. This predicted dose is within 15% of the CNSC dose limit of 50 mSv for any single year.

Conventional health and well-being of members of the public

Air Quality

Concentrations of PM_{10} and $PM_{2.5}$ resulting from non-project related traffic, off-site haul route traffic and on-site (i.e., at the existing WMF and proposed LTWMF) activities were predicted (SENES 2005). Measurable changes in particulate matter concentrations were predicted to result from the project at all receptor locations; however, none of the resident locations were considered likely to be exposed to an exceedence of the Ambient Air Quality Criteria (AAQC) for PM_{10} (MOE 2001) and $PM_{2.5}$ (CCME 2000). Similarly, while a number of measurable changes in CO, NO_2 and SO_2 were predicted (SENES 2005), there were no exceedences of the established AAQC for any of the parameters at any resident location.

Non-radiological COPC

Based on a screening of all COPC in the environmental media, only a single project work and activity was identified as resulting in a measurable change in exposure for residents who swim in Lake Ontario within the area of the treated effluent plume attributed to the project (Table 1).

Table 1: Screening Conventional COPC for Exposure Pathways Applicable to Members of the Public

Biophysical Environment Component		Port Granby Project Works and Activities Phase			
		Construction and Development Phase	Maintenance and Monitoring Phase		
			Early	Mid	Late
Atmosphere		No exceedences	No measurable change		
Surficial Soils		No measurable changes	No measurable changes		
Surface Water		**Arsenic Uranium**	**Uranium**	No measurable changes	
Groundwater and Geology		No measurable changes	No measurable changes		
Country Foods[a]	Fish	No measurable changes	No measurable changes		
	Produce[b]	Within normal ranges	No measurable changes		
	Rabbit	No measurable changes	No measurable changes		
	Waterfowl	No measurable changes	No measurable changes		

Notes:
[a] Estimated (i.e. modelled) based on concentrations of COPC predicted for the Atmospheric, Soil, Aquatic, and Groundwater and Geology Environments.
[b] Includes leafy and root vegetables, fruits and grains grown locally.

In Ontario, methods for the application of risk assessment are laid out under Reg. 153/04 of the *Environmental Protection Act* (MOE 2004). The target non-cancer risk levels that are allowable in the use of risk assessment are set at 0.2 of the allowable reference dose (RfD) per exposure medium. For cancer risk, the use of target risk levels of 1×10^{-6} per exposure medium are allowed. These target levels are not absolute, and the selection of other target risk levels is allowable subject to a multimedia assessment. For the purpose of this assessment, a change to human health was considered to warrant further attention if the incremental risk attributed to the Port Granby Project was greater than 10 % of the existing risk estimated for residents. It should be noted that all risks were based on median intake rates.

A human health risk assessment of this potential exposure found that cancer risks due to arsenic exposure were estimated to exceed the target risk level for residents who swim in the plume for both existing conditions and the project increment; however, the incremental risk was a small fraction of the existing conditions (2.8%) and was not considered to represent a measurable change in human health risk over existing conditions (Table 2). Non-cancer health risks associated with project-related exposure to arsenic and uranium were below the target hazard quotient (Table2, Table 3).

Table 2: Estimated Cancer Risks due to Arsenic Exposures Applicable to Residents Who Swim in the Port Granby Project Effluent Plume

Receptor	Estimated Risk Levels from Arsenic Exposures				
	Existing Conditions (2004) Risk[a]	Port Granby Project Increment Risk[b]	Project Increment as Percentage of Existing Risks (%)	Total Risk (LTWMF Construction & Development)	Target Risk
Cancer Risks[c]					
Typical Swimmer					
Adult	**7.0×10^{-5}[d]**	**1.1×10^{-6}**	2	**7.1×10^{-5}**	1.0×10^{-6}
Avid Swimmer					
Adult	**7.0×10^{-5}**	**2.0×10^{-6}**	3	**7.2×10^{-5}**	1.0×10^{-6}
Non-Cancer Risks[e]					
Typical Swimmer					
Adult	**2.2**[d]	0.034	2	**2.2**	0.20
Avid Swimmer					
Adult	**2.2**	0.061	3	**2.3**	0.20

Notes:
[a] Represents maximum credible risks associated with existing conditions for five year exposure duration.
[b] Represents maximum credible risks associated with project works and activities.
[c] Incremental Lifetime Cancer Risk (ILCR) based on ingestion, inhalation, absorption and immersion pathways.
[d] Bolded values represent an exceedence of the target risk level.
[e] Hazard Quotient (HQ) based on ingestion, inhalation, absorption and immersion pathways. Includes health risks such as digestive upset, skin rash, head aches and respiratory difficulties.

Table 3: Estimated Non-Cancer Risks due to Uranium Exposures Applicable to Residents that Swim in the Port Granby Project Effluent Plume

Receptor	Estimated Risk Levels from Uranium Exposures[a]				
	Existing Conditions (2004) Risk[b]	Port Granby Project Increment Risk[c]	Project Increment as Percentage of Existing Risks(%)	Total Risk (LTWMF Construction & Development)	Target Risk
Typical Swimmer					
Adult	0.048	0.0031	6	0.051	0.20
Avid Swimmer					
Adult	0.048	0.0088	18[d]	0.057	0.20

Notes:
[a] Hazard Quotient (HQ) based on ingestion, inhalation, absorption, and immersion pathways. Includes health risks such as kidney toxicity and possible superficial inflammation of the skin (erythema).
[b] Represents maximum credible risks associated with existing conditions for a five-year exposure duration.
[c] Represents maximum credible risks associated project works and activities.
[d] Shaded boxes indicate that the predicted incremental risk attributable to the project was greater than 10 % of the estimated risks for existing conditions.

The basic assumptions used to determine the human health risk assessment model input concentrations were as follows:

- Residents were assumed to be exposed for a five-year duration. Maximum predicted concentrations for the LTWMF construction and development phase were assumed to occur for all five years of exposure; and
- Appropriate bioavailability factors were applied to input concentrations in order to more realistically evaluate measurable health risks that may occur as a result of the project.

Noise

For the purposes of this assessment, an incremental noise level of ≥6 dBA was considered to represent a likely measurable change that could affect residents' health and well-being. Under worst case scenario conditions, adjacent residents were predicted to experience up to a 6 dBA increase in noise as a result of construction-related activities. A similar increase was predicted for residents living adjacent to the proposed primary transportation route as a result of project-related traffic. As these predicted incremental noise levels were between 6 to 12 dBA depending on the specific location of the resident, the increase in noise was considered to be noticeable to the average member of the public. These noise levels do not, however, exceed the sound level at which hearing impairment has been indicated to occur (70 dBA over a 23 hour period) (WHO 1999).

Traffic

Traffic levels were predicted based on the maximum number of trucks and commuter vehicles anticipated to operate as a result of the project (Gartner Lee 2005). It should be noted that the Port Granby area is rural in nature, and does not have a large population or high traffic volumes. The population of Port Granby has remained stable since 1993 and was not predicted to increase significantly in the near future (MMM 2004). Therefore, existing traffic levels were assumed to be representative of non-project related traffic levels during the construction and development phase. The project was predicted to contribute an additional 330 vehicles to the daily traffic volume, increasing traffic by 76% to 147% along recommended transportation routes assuming that all trucks and staff vehicles travel the recommended haul route.

The project-related incremental increase in traffic was utilized to predict the number of traffic accidents that may occur as a result of the project. The predicted accidents were based on the rate of accidents per kilometre that typically occur in the province of Ontario. The potential for 0.7 collisions per year as a result of the project was predicted based on typical accident statistics per kilometre in the province (Ontario Ministry of Transportation 2003).

Availability of Existing Health Services

There were two hospitals identified in the area that provide emergency care in addition to other services. No measurable change in the demographics associated with the project was expected to occur. Therefore, no change in the availability of existing health services was anticipated from project demands.

General Well-Being

Health can be influenced by a number of interrelated factors, including income and social status, education, employment and working conditions, physical environment, biology, genetic endowment, social support networks, personal health practice and coping skills, healthy child development, health service, culture and gender. Several indicators of overall community health were characterized for this study including demographics, social support networks, personal health practices and coping skills, income and social status, and education.

While no measurable changes were predicted to occur at a community health level (Gartner Lee 2005), all of the works and activities associated with the construction and development phase were considered likely to result in a measurable change in some members of the public's overall well-being by affecting their feelings of health, their satisfaction with the community and their feelings of safety and security. Such changes in individual people's feelings were considered to have the potential to increase stress and reduce quality of life.

Public attitude research (Haussmann Consulting and Gartner Lee 2004) indicated the majority of residents did not anticipate a change in their feelings of health and sense of well-being as a result of the various project works and activities (58-72%). However, 11% to 17% of survey respondents indicated that their feelings of health and sense of well-being would either decrease somewhat or a great deal as a result of the various project works and activities associated with facility development, excavation activities or transportation activities. The number of respondents that indicated their feelings of health and well-being would either increase somewhat or a great deal as a result of the project works and activities ranged from 7% to 12%. Eight percent of individuals were predicted to experience a reduction in their feelings of personal security as a result of completion of the construction and development phase, while the same number (8%) anticipated feeling an increased sense of personal security. The majority of residents (75%) expected to experience no change in their feelings of personal security, and 8% were undecided at the time of the survey. There were no significant differences in attitudes reported by respondents among sub-groups.

In terms of feelings of health and sense of well being associated with facility development activities, respondents who lived closer to the proposed facility were more likely to state that feelings of health and sense of well-being would change adversely. Similarly, women, as well as respondents who lived closer to the proposed facility, were more likely to state that feelings of health and sense of well-being would change adversely, as a result of transportation activities associated with the project.

Conventional occupational health and safety

Non-radiological Contaminants and Air Quality

Evaluation of the health effects to workers from exposure to non-radiological COPC (i.e., conventional contaminants) during the LTWMF construction and development phase considered both acute and chronic work-related exposure scenarios. The maximum concentrations of airborne particulate matter attributable to the project were predicted to remain below the National Institute for Occupational Health and Safety (NIOSH) criteria established for both TSP and $PM_{2.5}$[iv].

The predicted maximum contaminated dust exposures developed for workers (SENES 2005) within the excavation area, on-site haul route, and placement areas were well within the established time weighted average (TWA) (8 hr) criteria (NIOSH 2002); therefore, it was predicted that no measurable change to worker health would result from acute exposure conditions. For the purposes of determining likely chronic changes to worker health based on work-related exposure to non-radiological COPC, an assessment for chronic exposure scenarios associated with specific job duties and maximum credible exposure durations was conducted.

Risks were estimated for each plausible exposure pathway (i.e., incidental ingestion of wastes, incidental ingestion of particulate matter and drainage water, inhalation of particulate matter, and dermal absorption of wastes and drainage water). Target risk estimates for workers in this assessment were defined as a hazard quotient (i.e., non-cancer risks) of 1.0 or an ILCR of 1×10^{-5}. With the exception of arsenic exposure for workers, the hazard quotients and ILCR values were below target risk levels defined for workers for all COPC (Table 4). The predicted risks to the workers from arsenic exposure were determined likely to be adverse and required consideration of mitigation measures.

Table 4: Estimated Risks for a Flagman/Monitoring Technician at the Excavation Area of the WMF

Contaminant	Exposure Pathway			
	Ingestion (LLRW)	Inhalation (PM_{10})	Dermal Contact (LLRW)	Total Risk[a]
Cancer Risks				
Arsenic (As)	8.7×10^{-5}	1.1×10^{-5}	2.0×10^{-8}	1.1×10^{-4}
Non-cancer Risks				
Arsenic (As)	3.5	0.5	0.00081	4.2

Notes:
The flagman/monitoring technician was considered to be an adult male working at the excavation area of the existing WMF for 285 consecutive days over the five years that excavation will be carried out.
[a] Accounts for additional exposure pathways not included in this table.

Physical Risks

Project construction activities were determined likely to result in measurable physical risks, which for the purposes of this assessment, was defined as a single work place injury. Lost time accident frequency rates (LTAFR) and total recordable accident frequency rates (TRAFR)[v] ranging from 2.0 to 3.0 (LTAFR) and 8.0 to 10.0 (TRAFR), respectively, were predicted based on the similarity of the project works and activities with routine tasks or jobs and functions found within the construction industry and the aggregate production industry. It was anticipated that 277,050 person-hours will be worked during the construction and development phase (Golder 2004). Based on the upper values for LTAFR and TRAFR in the construction and aggregate industry, a total of 4.2 lost time accidents and 13.9 recordable accidents were predicted to occur.

In addition to accidents, workers may also be exposed to noise levels that may affect their health. Noise levels within 15 metres of the Port Granby LTWMF and existing WMF were predicted to range from 93-95 dBA. This noise level was considered measurable (6 dBA above background)[vi] and exceeded the level at which physiological effects may occur (90 dBA over a period of 8 hours consistent with the *Ontario Health and Safety Regulations for Industrial Establishments*.

Discussion

Radiological health of members of the public and workers

In general, very few people were estimated to receive measurable radiation doses from exposure to LLRW and MCS under existing conditions. Dose reductions were not predicted to occur as a direct result of the project. However, an overall benefit of the project related to precluding or minimizing the potential for effects associated with exposure to the wastes that might occur if existing land use controls were to fail in the future.

Conventional health of members of the public

Air Quality

Given that all concentrations of PM_{10} and $PM_{2.5}$ were below the established criteria for both parameters and any incremented increases were small, it was determined that unacceptable health risks will not occur as a result of the project. While it was recognized that research is emerging to indicate threshold-based criteria (i.e., LOAEL) may not account for linear dose responses, particularly for $PM_{2.5}$ exposures (Harrison and Yin 2000), the assessment recognized that it is currently not possible to achieve NOAEL in the ambient atmospheric environment, nor is it expected to be possible in the foreseeable future. Similarly, given that all concentrations of CO, NO_2 and SO_2 were below the established AAQC it was determined that unacceptable health risks due to exposure to evaluated criteria air contaminants will not occur as a result of the project.

Non-radiological COPC

Cancer risks due to arsenic exposure were estimated to marginally exceed the target risk level for residents who swim in the Port Granby Project treated effluent plume for both existing conditions and the project increment during the construction and development phase. However, the incremental risk from the project was a small fraction of the existing conditions and only slightly exceeded the target risk level of 1×10^{-6}. Following the methodology for this assessment, as the project-incremental risk did not represent a change of more than 10% of the risk associated with existing conditions, it was determined not likely to represent a measurable change in risk. It is further noted that this special case scenario represented unlikely behaviour as it would require residents to swim at a beach that is not readily accessible due to high bluffs and to remain in the waters proximate to the end of a discharge pipe for an extended period of time. Based on this assessment and the conservative nature of the health risk model, this special case was judged not to represent an adverse effect associated with the project.

The change in human health (non-cancer risk) due to arsenic exposure attributed to the project was below the threshold that would indicate any effect on human health, and was considered to represent a negligible risk. However, the non-cancer risks due to arsenic exposure exceeded the risk guideline for residents who swim in the plume under existing conditions.

A potential measurable change on human health due to increased uranium exposure that could be experienced by residents who regularly swim in the plume of treated effluent in Lake Ontario was predicted to occur for all avid swimmers. However, the health effects that may result from the project were not judged to be adverse as both the project incremental risk and the estimated total risks remained below the target risk estimate of 0.2. Uranium exposures to residents who swim within the treated effluent plume attributed to the project were determined not likely to affect the health of members of the public.

While the incremental cancer and non-cancer risks were considered negligible to low, and were not deemed to be adverse effects of the project, it was acknowledged that some measures to reduce people's concerns over any level of risk may be prudent. Accordingly, strategies to manage potential exposure of members of the public to the treated effluent plume were recommended.

Noise

The project construction and transportation activities will occur only during daytime hours. As a result, any adverse effects associated with noise would be small and similar to noise generated commonly by projects such as road or utility upgrades in a residential area (Cowan 1994). Predicted incremental increases in noise did not result in any exceedence of the noise threshold at which physiological effects can occur.

Traffic

While traffic accidents may occur anywhere along the transportation routes, they were considered most likely to occur at the intersections. The assessment found that the risk of a traffic-related death was extremely low as a result of project-related traffic. While one collision may result in a potential injury over the course of the construction and development phase, this was not considered significant compared with the number of traffic accidents in Durham Region from existing traffic.

General Well-being

It was hypothesized that the greatest potential for changes in satisfaction with the community would occur among residents living closest to the LTWMF (Gartner Lee 2005). The Local Resident and Farmer Survey (Gartner Lee 2004) showed that 11 out of 18 respondents living nearest the LTWMF will likely be less satisfied with their community because of the Port Granby Project. Similarly, the results of this survey suggested that more than half of the nearby residents (10 of 18 respondents) anticipated that they will experience a decrease in their feelings of personal security as a result of the project. As the assessment found that some measurable changes may

occur in people's feelings of health, sense of well-being, feelings of safety and security and feelings of satisfaction with community as a result of the project, a program of continued and consistent protocols for delivering information and receiving input to/from residents was recommended to mitigate any adverse effects.

Conventional occupational health and safety

The assessment found that unacceptable risks to the conventional health and safety of workers would not result from the project. If the use of personal protective equipment was implemented in an effective and consistent manner, it was anticipated that there would be no residual adverse health effects to workers resulting from exposure to conventional contaminants. Although particulate matter was not predicted to have a measurable effect on worker health, it was recognized that there may be isolated meteorological conditions or operating practices that result in visible wind blown dust. If such circumstances arise, additional mitigation measures including increased application of dust suppressants, use of appropriate respiratory protection (e.g., dust mask), covering active areas or brief cessation of operations were recommended to alleviate any potential acute effects to worker health. Follow-up monitoring and auditing was recommended to ensure the proposed mitigation measures were effective in reducing the potential exposure of workers to arsenic. Effects due to physical risks and noise were judged to be potentially adverse to worker health and consideration of mitigation was required to reduce or avoid them.

Conclusion

The assessment found no significant adverse effects on the health and safety of workers and members of the public as a result of the Port Granby Project. A number of mitigation measures were identified to avoid or limit adverse effects.

Utilizing the holistic approach to health assessment revealed effects associated with stress and perception of environmental quality and its relation to health and general well-being, which may not have been realized by the prevalent traditional approach to health and safety considerations studies. The approach undertaken in this health assessment allowed for the recommendation of appropriate strategies to minimize the health effects associated with feelings of general well-being and to design a follow-up monitoring plan that takes into account not only exposures to radiological and non-radiological contaminants but also noise, traffic, access to health services, satisfaction with living in the community, and feelings of personal health and security. This study represents a benchmark achievement for health and safety considerations assessment in Canada. It provides a strategic approach to assessment and may be used in developing a standard methodology for conducting future health assessments.

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[i] Radiological COPC include Radium-226 (and decay products), Thorium-230, Thorium-232 (and decay products), and uranium.

[ii] Non-radiological COPC include antimony, arsenic, barium, boron, cadmium, cobalt, copper, fluoride, lead, mercury, molybdenum, nickel, selenium, silver, uranium (included for its chemical toxicity), vanadium, and zinc.

[iii] Excludes all industrial and medical sources of radiation.

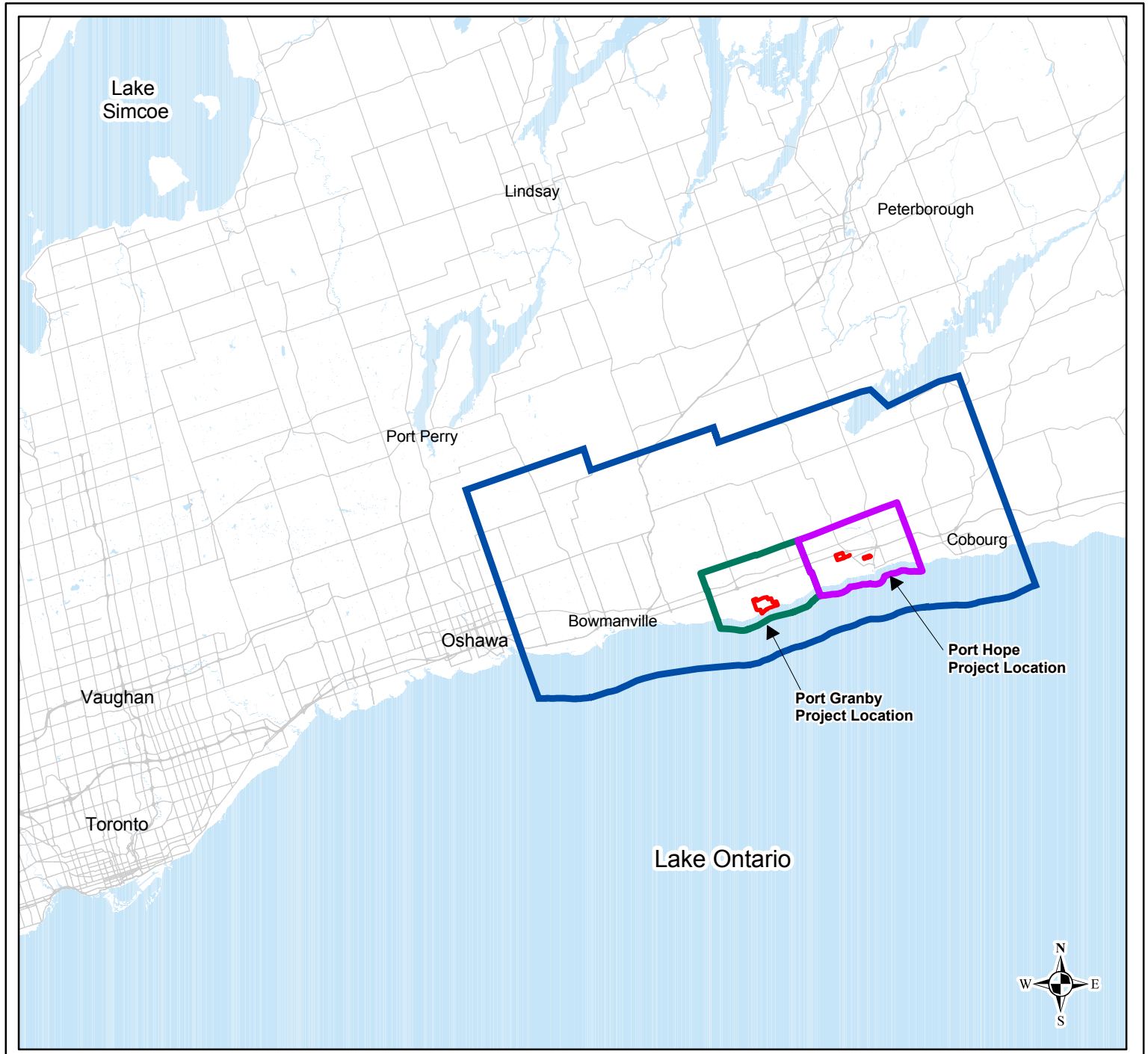
[iv] NIOSH criteria for $PM_{2.5}$ were conservatively applied to the predicted concentrations of PM_{10}.

[v] LTAFRs and TRAFRs include medical treatment and restricted work cases.

[vi] Typically changes in noise levels between 1 and 3 dBA were not considered perceptible above background. Changes of 5 dBA or more were considered typically perceptible and may invoke a response by humans (while 4 dBA was considered perceptible it typically does not invoke adverse response).

Figure 1

Port Hope Area Initiative Location Information



Legend

- Roads
- Site Study Area
- Port Granby Local Study Area
- Port Hope Local Study Area
- Regional Study Area

0 10 20 30

Kilometres

1:650,000

REFERENCE

NRVIS Base data supplied by MNR(1998)
Data reprojected to UTM NAD83
Produced by Golder Associates under Licence with the Ontario Ministry of Natural Resources

Date: February 2005

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Figure 2

Public Receptors for Human Health Environmental Effects Assessment

Legend

- City/Town/Village
- Area Receptor
- Adjacent Receptor
- Transportation Adjacent Receptor
- Municipal Boundary
- Roads
- Railway
- Local Study Area (Port Granby Project)
- Site Study Area (Port Granby Project)

0 1 2 3

Kilometres

1:50,000

REFERENCE

NRVIS Base data supplied by MNR(1998)
Source: Golder 2004 [1811]
Data reprojected to UTM NAD83
Produced by Golder Associates under Licence with the Ontario Ministry of Natural Resources

Date: February 2005

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