Maternal And Infant Health And The Physical Environment Of First Nations And Inuit Communities:

A Summary Review

PREPARED FOR

Prairie Women's Health Centre of Excellence (PWHCE)

and the

British Columbia Centre of Excellence for Women's Health (BCCEWH)

APRIL, 2009

R. STOUT, T. DIONNE STOUT & R. HARP

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British Columbia Centre of Excellence for Women's Health

PRAIRIE WOMEN'S HEALTH CENTRE OF EXCELLENCE
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Imagine for a moment, if you will, the emotions we now feel; shock, panic, grief, as we discover that the food – which for generations nourished us and keeps us whole physically and spiritually – is now poisoning us. You go to the supermarket for food. We go out on the land to hunt, fish, trap, and gather. The environment is our supermarket.

As we put our babies to our breasts, we feed them a noxious chemical cocktail that foreshadows neurological disorders, cancers, kidney failure, reproductive dysfunction. That Inuit mothers – far from areas where POPs are manufactured and used – have to think twice before breast feeding their infants is surely a wake-up call to the world.

- Sheila Watt Cloutier

Part 1
INTRODUCTION

First Nations and Inuit women and infants face challenging health issues in their communities where there are environmental risks. Literature examining these contexts and the processes through which health is affected is relatively limited. The objective of this review is to examine and consolidate the available literature on environmental threats to First Nations and Inuit maternal health in order to identify priorities for future research.

"There are circumstances and conditions that are unparalleled to the North…persistent organic pollutants in country foods…are all factors that complicate the delivery of maternity care programs and services."[1]

Methodology

A review of the published literature was carried out on environmental health and effects on maternal First Nations and Inuit health to assess the current body of knowledge. Information on published studies, in the 30-year period from 1978 to 2008, was obtained from primary literature through an extensive search using MEDLINE, Science Direct, JSTOR and ProQuest databases using the search terms Aboriginal, First Nations, Native American, Inuit, maternal, infant, mercury, health, contamination, environment, Canada, toxic, mining, etc.

As well, a search of national political Aboriginal organizations and NGOs, government departments, national maternal/infant health organizations, and health research institutes websites was conducted to find projects and research related to the physical environmental conditions and Aboriginal health, with particular consideration of maternal and infant health (see Appendix).

The information is compiled in an electronic database for easy reference and analysis.

Parameters and Limits

In researching information on agency websites, there were insufficient data uploaded on to sites, thus limiting knowledge on the extent of work on the subjects. Telephone

[1] Exploring Models for Quality Maternity Care in First Nations and Inuit Communities: A Preliminary Needs Assessment. Final Report of Inuit Women's Needs Assessment. National Aboriginal Health Organization (NAHO). 2006.

interviews and in person meetings would augment the findings. However, the use of databases did provide a variety and number of scientific studies.

Given the time limitations assigned to this paper, we could not generate an exhaustive listing of all available research. This is therefore a sampling of research documents drawn over a period of 12 weeks from the databases mentioned above, which represent the most widely and commonly used sources of this type of information by the science / environment / health community. The result was a total of 73 peer reviewed articles.

PART 2
FINDINGS & ANALYSIS

A considerable number of documents, 73 in all, was found on environmental impacts on First Nations and Inuit peoples' health. In particular, environmental contaminants, traditional food supply and human health effects have been a priority for some time. Closely related is the topic of climate change, which will only increase as a research area of concern over time. Resource development (mining, oil and gas, hydro-electric development), waste disposal (solid and nuclear waste), mould in housing, drinking water quality have also been occasional foci of study.

Maternal and infant health is a crucial part of the health of First Nations and Inuit communities. Women and infants face serious health issues related to environmental contamination. Traditional food security and accessibility is an issue for all Aboriginal peoples for cultural and nutritional benefits.

In reviewing the literature, consideration was given to where emphasis has taken place both in terms of group of people (First Nations vs. Inuit), geographical focus, environmental condition and the inclusion of maternal and/or infant health impacts.

Research Timeline

We begin this overview of the state of knowledge of environmental impacts on Aboriginal maternal and infant health with an examination of its chronology. Over the thirty year period beginning in 1978 and concluding in 2008, a total of 73 studies in this subject area were conducted. That is, an average of fewer than three studies per year. Although environmental research specific to Aboriginal maternal and infant health concerns started to appear more regularly by the 1990s, it was still only at the level of one or two studies a year. It was not until 1997 that scientists pursued knowledge of this sort with any frequency.

The greatest amount of research took place from 2000 through 2008, when there were a total of 45 studies, just over double the amount undertaken in the 90s when 21 studies were performed.

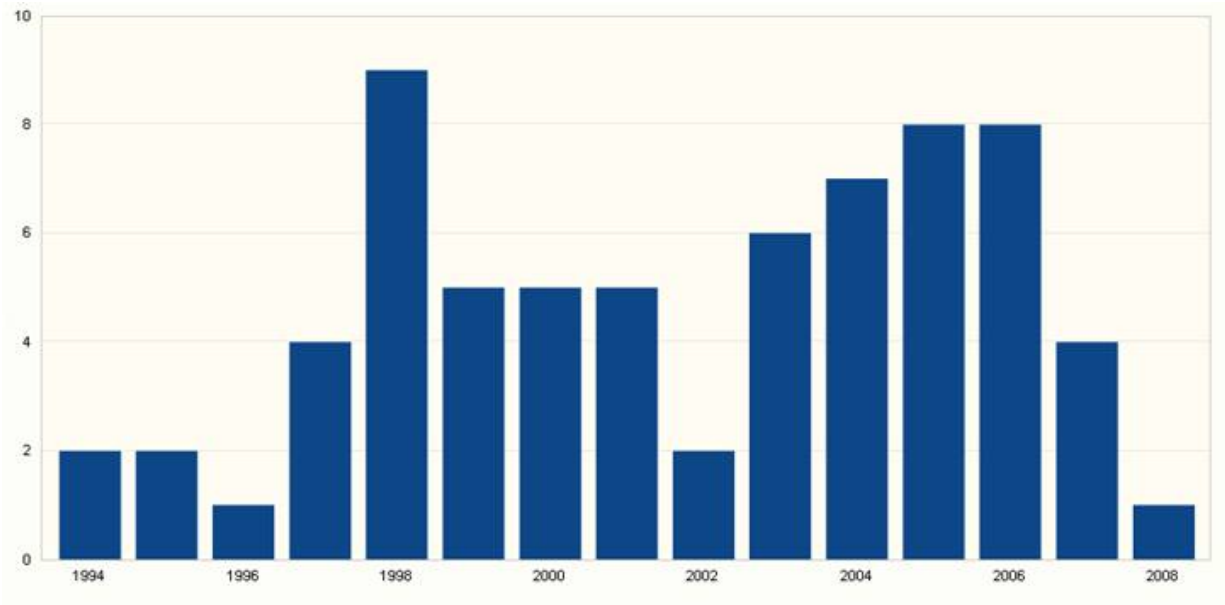

Table 1.1 Timeline, Aboriginal Maternal & Infant Environmental Research, 1994-2008

Database / Keyword Analysis

In order to systematically assess the state of knowledge concerning environmental impacts on Aboriginal maternal and infant health, this paper utilizes a database approach, consisting of strictly relevant, peer-reviewed scientific research available on the web. The recurrence of certain terms – extracted verbatim or in some limited cases inferred from the abstracts of each research paper – has led to the generation of a series of keywords. Based on their level of frequency via search queries, these keywords in turn enable one to form broader conclusions about the predominance of certain themes and topics within the body of existing research. The outcome of this quantitative exercise is complemented by a collective synthesis of the individual insights and results of each research project, making for a complete and integrated picture of the state of knowledge in this area.

Of course, many of the research papers under discussion here will often have more than one keyword turn up in a search of their abstracts, while some will have only one appear. Admittedly, the keywords can also feature degrees of unavoidable overlap. However, the goal here is not to convey some exacting statistical portrait of the research, but more simply to identify general trends, to be enriched by an integrated overview of their collective contribution to the general state of knowledge in environmental Aboriginal maternal and infant health.

Research Target Groups

In the matter of groups targeted by the existing research – *i.e.*, expectant/new mothers and infants – 45% of the research was associated with the keyword *maternal/maternity*, with *women* and *mother(s)* coming in at 36% and 10%, respectively.

KEYWORDS	# of studies	% of total
maternal/maternity	33	45%
women	26	36%
mother(s)	10	14%
infant(s)/infancy	31	42%
child/children	17	23%
pre-/peri-/neo-/post-natal	15	21%
pregnancy	12	16%
fetus/fetal	11	15%
newborn(s)	11	15%
birth	10	14%
postpartum	3	4%

Meanwhile, the keyword cluster of *infant(s)/infancy* came up 42% of the time. That result is well ahead of *child/children* at 23% and the variations of *-natal* at 21%. Generally speaking then, it may be said that, based on the above results, current environmental Aboriginal research is more or less evenly divided between maternal and infant concerns (even where that research may overlap).

Aboriginal Identity & Geographic Focus

Where studies have chosen to focus specifically on a population, *Inuit* have clearly been the dominant subject (58%) of research among Aboriginal peoples in this field, followed well behind by *First Nations* (19%) and *Métis* (12%). Perhaps it should come as no

surprise then that *north/northern* also emerges as the single most researched part of the country at 41% with the related *arctic* coming in at 28%, not to mention *subarctic.*

Factor in too that two of the three First Nations that came up are northern-based (the *Cree* of James Bay and the *Dene),* and it becomes quite clear that, at this point in time, the north is the preeminent region for scientific inquiry into environmental Aboriginal maternal/infant health.

KEYWORDS	# of studies	% of total
Inuit	42	58%
First Nations	14	19%
Métis	9	12%
north/northern	30	41%
arctic	28	38%
coastal	10	14%
remote	8	11%
subarctic	4	5%
Nunavik (QC)	14	19%
NWT	12	16%
Nunavut	4	5%
Baffin Island (NU)	3	4%
James Bay (Cree)	3	4%
Ft. Albany FN (Cree)	2	3%
Cree	4	5%
Dene	7	10%
Mohawk	10	14%
Akwesasne	9	12%
Kahnawake	1	1%

Completing this picture of Canada's northern research prevalence, we see the significant recurrence of specific locations like *Nunavik* (19%) in northern Quebec and NWT (16%).

Standing out as an exception to this northern trend is the portion of research (14%) devoted to the southern-based *Mohawk* people of *Akwesasne* (12%) and *Kahnawake* (1%) concerning the environmental effects of living near the St. Lawrence River Seaway. It is obviously the case that the Mohawk are not alone among southern First Nations in facing environmental threats, representing a gap in attention that clearly needs to be addressed.

Sources / Nature of Environmental Threat

With a myriad of chemicals and compounds to deal with, many of them jointly present in a given situation, any list of environmental threats is bound to have some overlap. That said, *contaminant(s)/contamination* would seem to be the nature of the most common threats to communities under study at 62%, with polychlorinated biphenyls or *PCBs* the most specifically researched item at 51%.

KEYWORDS	# of studies	% of total
contaminant(s)/contamination	45	62%
PCBs	37	51%
mercury	25	34%
organochlorine(s)	21	29%
lead	13	18%
DDE	13	18%
metal/s	12	16%
HCB	11	15%
methylmercury	10	14%
POPs	9	12%
DDT	8	11%
waste	7	10%
mirex	7	10%
radionuclides/radioactivity	6	8%
cadmium	6	8%
selenium	6	8%
PCDDs / PCDFs	5	7%
lead	13	18%

Heavy metals showed up quite frequently in studies – from *mercury* (34%) to *lead* (18%) to *cadmium* (8%) – and were often cited together, sometimes alongside the all-purpose keyword itself, namely, *metals* (16%). Similarly, the keyword *organochlorine(s),* which came in at a strong 29%, has its own potential share of overlap with keywords like *DDT* (11%) and *mirex* (10%).

Environmental Effects

In terms of consequences for humans, some terms recurred more often than others, with various forms of the keyword *toxic* (*e.g.*, neurotoxicity, toxicant) topping the list at 30% along with *body burden* at 15%. The potential for environmental links to *diabetes* came up in a small number of cases at 4%.

KEYWORDS	# of studies	% of total
toxic	22	30%
body burden(s)	11	15%
bioaccumulation	6	8%
diabetes	3	4%

Environmental Threat Pathways

Clearly, in the field of research under examination, the main preoccupation of scientists with regard to pathways was *food* (41%), along with related variations of *diet*- (36%). Include the keywords *traditional food* (27%) and *country food* (8%) and that focus only deepens. Given that the geographic focus has been mainly northern, it makes sense that *marine* (21%), *seafood* (8%) and *fish* (32%) came up time and time again in the keyword search. That said, *mammal(s)* did figure into the picture (even if some of them are marine-based) at 14%.

KEYWORDS	# of studies	% of total
food	30	41%
diet/dietary/diets	26	36%
fish	23	32%
Traditional food	20	27%
marine	15	21%
milk	12	16%
mammal(s)	10	14%
food chain	9	12%
water	8	11%
fat	7	10%
breastfeeding	7	10%
meat	7	10%
country food	6	8%
seafood	6	8%
air	6	8%
seal	4	5%
caribou	3	4%
beluga	3	4%

All of these pathways can of course be encapsulated under the umbrella term *food chain* (12%), with infants falling in a sense at the end of that chain via the act of *breastfeeding* (10 %) and its *milk* (16 %).

Other pathways under examination included *water* (which could of course also incorporate *marine*) and *air*, which came up in 11% and 8% of the scientific research, respectively.

Sources of Research

Another potential measure of the state of scientific knowledge arguably derives from the variety of professionals who produce the research. Here, a more broadly based pool of scientists studying a subject ultimately leads to more robust science, *i.e.*, the more minds and eyes the better. After all, such thinking is what partly lies behind the whole concept of peer review. Seen in that light, a search for recurring names of researchers revealed that a significant proportion of the scientific literature concerning environmental threats to Aboriginal maternal/infant health has come from a common set of sources.

Co-Researcher	# of studies	% of total
Éric Dewailly	24	33%
Pierre Ayotte	19	26%
Gina Muckle	13	18%
Suzanne Bruneau	8	11%
Hing Man Chan	6	8%
H. V. Kuhnlein	6	8%
Edward F. Fitzgerald	5	7%
Syni-An Hwang	5	7%
Sandra W. Jacobson & Joseph L. Jacobson	5	7%
Brian Bush	4	5%
K. Cook	3	4%

Possibly worthy of note is the fact that the three most prevalent names (Dewailly, Ayotte & Muckle) have actually worked on 13 studies together as a formal research team, for 18% of the total. It would be of additional interest to look into how many of these researchers are of Aboriginal descent and/or maintain close ties to Aboriginal communities, including place of residence.

Collective Synthesis: Research Clusters

The following clusters of studies illustrate the current overall state of knowledge on environmental threats to First Nations and Inuit women and infants.

Study after study noted how Inuit consumption of relatively large amounts of seafood and marine mammals exposed them to various contaminants. Accordingly, much if not most of the research centered around the assessment and/or evaluation of the suspected links between the traditional northern diet and adverse health effects among Inuit infants and mothers. Among the various findings that make up the general pool of knowledge in this area:

- Dallaire et al. (2004) indicated that two decades of research has found neurological and immunological effects in the developing fetus and in infants exposed to either background or slightly elevated levels of persistent organic pollutants (POPs) such as PCBs

- Van Oostram et al. (2004) stated that among some circumpolar arctic populations, levels of PCBs are in the range where subtle effects on learning and the immune system have been reported

- Dallaire et al. (2004) found a possible association between prenatal exposure to organochlorines (OCs) and acute infections (e.g., upper and lower respiratory tract infections, otitis media) among a cohort of 199 Inuit infants (0-1) in Nunavik, QC

- Dallaire et al. (2004) saw a lack of association when postnatal exposure was considered

- Dallaire et al. (2006) found the incidence rates of acute otitis media (AOM) and lower respiratory tract infections (LRTIs) were positively associated with prenatal exposure to PCBs among a cohort of 343 preschool (age 0-5) Inuit children, and concluded this exposure could be responsible for a significant portion of LRTIs among these children

- However, Dallaire et al. (2006) found “no association” between prenatal PCB exposure and the incidence rate of either upper respiratory tract infections (URTIs) or hospitalization

- Dewailly et al. (2000) concluded that prenatal exposure to organochlorines like DDE, HCB and dieldrin could be a risk factor for acute otitis media among Inuit infants (0-1) from Nunavik

- Ayotte et al. (1994) stated that breastfeeding “strongly influences” a child’s body burden of dioxin-like compounds until age 20 (but not after)

- As part of research about in utero organochlorine exposure among Inuit women from Kativik, QC, Dewailly et al.(1993) revealed negative associations between male height at birth and the concentration of HCB, mirex, PCBs and PCDDs/PCDFs (TEQs) in milk fat

- By contrast, Dewailly et al. (1993) observed positive associations between female birth height and PCBs/PCDDs/PCDFs (TEQs) concentration

- Adeeko et al. (2003) looked at consequences of force-feeding pregnant rats the mixture of 28 POPs found in the Inuit diet at various doses, finding no significant effects on pregnancy outcome but noting dramatic changes in the "gene expression profiles" of both maternal and fetal livers, decreasing both the numbers of genes expressed and the relative intensity of expression, which may have functional implications

- Van Oostdam et al. (2005) showed links between prenatal exposure to OCs and deficits in immune function, increases in childhood respiratory infections, and increases birth weight among infants in Nunavik

- Van Oostdam et al. (2005) showed that the developing foetus is likely to be more sensitive to the effects of OCs and metals than adults, and is the age group of greatest risk in the Arctic

- Van Oostdam et al. (1999) indicated that the developing foetus and breast-fed infant are likely to be more sensitive to the effects of OCs and metals than individual adults and are the age groups at greatest risk in the Arctic

- Exposures tend to be higher in the eastern than the western Canadian Arctic (Van Oostdam et al.: 2005)

- For the Inuit, the OCs of primary concern at this time from the point of view of exposure are chlordane, toxaphene, and PCBs (Van Oostdam et al.: 1999)

- For Dene/Métis, exposure to OCs is, in general, below a level of concern (Van Oostdam et al.: 1999)

- Consumers of traditional foods are exposed to an approximately seven-fold higher radiation dose than non-consumers of traditional foods due predominantly to the bioaccumulation of natural radionuclides in the food chain (Van Oostdam et al.: 1999)

- Muckle et al. (2001) found traditional food intake during pregnancy was unrelated to PCB body burden, which it claimed is more a function of lifetime consumption

- Muckle et al. (2001) corroborated previous findings relating marine mammal and fish consumption to increased mercury and selenium body burden

- Walker et al. (2006) recommended ongoing monitoring of populations at risk and traditional food species, as well as continued international efforts to reduce anthropogenic sources of mercury

- Mercury contamination of fish and game, blood mercury levels in excess of 200 ppb among Inuit and First, and mild symptoms of methyl mercury intoxication among FNs together constitute a "human health hazard" (Charlebois:1978)

- Hansen (1998) confirmed that the greatest source of exposure to POPs and mercury is via food of marine origin and that Greenlanders and Inuit in Canada are among the most highly exposed populations in the Arctic

Research results sometimes generated differences according to, or along, sex-related lines:

- Among the 9 Cree communities of James Bay in northern Quebec, Dumont et al. (1998) found that significantly higher levels of mercury were independently associated with male sex, increasing age and trapper status, along with a correlation between the mercury level of the head of the household and that of the spouse

- Constanze et al. (2005) revealed a continuous decline from 1994 to 2003 in the proportion of male births within the Aamjiwnaang First Nation (near Sarnia ON), a sex ratio decline associated in part with a number of environmental and occupational chemical exposures from nearby petrochemical, polymer, and chemical industrial plants in the Great Lakes/St. Clair River 'Area of Concern'

Some studies revealed findings that ruled out certain links or associations:

- Drawing on a cohort of 454 newborns in Nunavik, Lucas et al. (2004) found no evidence of negative effects caused by their mothers' consumption of environmentally-contaminated seafood on the newborns' gestational age or birth weight

- Ayotte et al. (1995) found, among 499 Inuit adults, that total PCBs and dioxin-like compound concentrations were strongly correlated, had increased with age, and were greater in men than in women

Inuit have been the subject of many comparative studies, not just with Southern non-Aboriginal populations, but with the other Aboriginal groups as well. These comparisons serve to generate baselines:

- Butler Walker et al. (2006) presented “the first human tissue monitoring program covering the entire Northwest Territories and Nunavut for multiple contaminants and establishe[d] a baseline upon which future comparisons can be made”

- The geometric mean (GM) of maternal total mercury concentrations was found to be 2.6 times higher among Inuit than that of the Dene/Metis group and significantly higher than all other groups (Butler Walker et al.:2006)

- Butler Walker et al. (2006) found that 3% of Inuit women participants fell within Health Canada’s “level of concern” range for methylmercury exposure

- Butler Walker et al. (2006) found GM maternal lead was significantly higher in Dene/Metis and Inuit participants compared with the non-Aboriginal group

- AMAP found Inuit mothers from Greenland and Canada had significantly higher levels of oxychlordane, transnonachlor and mirex than Inuit mothers from Norway, Sweden, Iceland and Russia over the period 1994-97, differences that may represent regional dietary preferences or different contaminant deposition patterns across the Arctic (Van Oostdam et al.:2004)

- Butler Walker et al. (2003) established a baseline for exposure to organochlorine and metal contaminants for NWT and Nunavut mothers and newborns: 523 women from May 1994 through June 1999 generated average Inuit maternal PCB levels 3.3 times those of Dene/Metis, and 3.4 times non-Aboriginal levels, while average Inuit umbilical cord blood PCB levels were 3.3–4 fold higher than those of other ethnic groups

- Wheatley and Pardis (1996) found the overall highest levels of methylmercury exposure in Canada were tested among NWT Inuit, where the mean score of women aged 15-45 years was well into the "risk" range defined by WHO for fetal exposure. [see Kravariotis Douglas (2007) which also draws on same tests]

- Chan et al. (1995) revealed that Inuit adults and children in Qikiqtarjuaq on Baffin Island who consumed traditional foods had daily mercury intake levels much higher than the Canadian average. The average weekly intake for all age groups exceeded guidelines of the Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives and Contaminants

- In the period 1989-90, Dewailly et al. (1994) took breast milk samples from 109 Inuit women from northern Quebec whose high intake of seafood is thought to have explained the incidence of PCBs 3.5 times higher than in samples from 96 non-Aboriginal women

- Nunavik neonates were one of two cohorts Dallaire et al. (2008) assessed for the potential impact of transplacental exposure to PCBs and HCB (via seafood) on thyroid hormone (TH) concentrations, observing that OC levels were not associated with a reduction in THs, possibly because essential nutrients derived

from seafood such as iodine may have prevented the negative effects of OCs on the thyroid economy during fetal development

- In examining the OC body burdens of people from the Fort Albany First Nation home to an abandoned Mid-Canada Radar Line station, Tsuji et al. (2005) found greater levels of PCBs among Fort Albany women as compared to Dene/Metis in western NWT and Inuit in central NWT; all three groups consumed low to no amounts of marine mammals

- Looking at the same community as Tsuji et al. (2005) and Tsuji et al. (2006) found elevated levels of PCBs and DDE not just among Fort Albany residents but also people from neighboring Kashechewan First Nation, who had no radar base

- However, Tsuji et al. (2006) seems to slightly contradict the earlier Tsuji et al. (2005) in reporting PCB and DDE levels in First Nation women "comparable [in] magnitude" (as opposed to greater) to those reported for Inuit women living in west/central NWT. Tsuji et al. (2006) indicated that the radar base ("Site 050") appears to have also influenced the organochlorine body burden of people in Fort Albany through higher levels of DDT from contaminated soil surrounding the base's buildings

Some comparisons occurred within Inuit themselves:

- Muckle et al. (1998) found the Inuit of Nunavik and the NWT exhibited the highest exposure levels to PCBs and mercury amongst all groups studied, with a portion featuring concentrations beyond the critical threshold for the appearance of neurological consequences

- Muckle et al. (1998) found variations in exposure levels resulted from the different nutritional practices of each sub-group

Simply documenting the scale and scope of contamination was also a stream of study:

- Chan et al. (1997) employed a statistical model to determine that over 50% of residents in one Arctic community had dietary exposure levels exceeding the tolerable daily intake for mercury, toxaphene and chlordane; in some cases, people had 6 times the provisional tolerable weekly intake of mercury, and over 20 times the tolerable daily intake of chlordane and toxaphene.

- Martin (2007) raised the question of whether climate change has affected the quality of raw water in brooks, lakes, rivers and potentially put Inuit in Nunavik at increased risk of gastroenteric diseases, a link yet to be established by research

- Dewailly et al. (1989) noted with surprise that blubber from arctic ringed seals contained PCDD and PCDF, even though the closest known sources were several thousands of kilometers away

- Lagueux et al. (1999) noted that most research focuses on larger doses of exposure to PCBs and PCDFs at the pre- and peri-natal stage at the expense of chronic, lower-dose exposures

Not all food sources (namely, animals) are the same when it comes to posing and thus determining risks. Nor have all animals necessarily been researched when it comes to every kind of contaminant.

- Cameron and Weis (1993) assessed the country food diet of 16 families in Sanikiluaq, NWT, to find that, of all species consumed, the fat of ringed seals and beluga had the highest concentration of DDE and total PCBs. Moreover, contaminant concentrations in local seal fat were about two times higher than Western Arctic sites, but lower than those reported from various European sites

- Dewailly et al. (1989) noted that DDT and PCB~ are the only organochlorines that have been monitored on a systematic basis in arctic marine mammals.

As for what to make of this traditional diet/contaminants correlation in everyday practice, many researchers argued that the benefits of traditional food must be weighed against the risks, as seen in the following findings and advice:

- After conducting contaminant exposure assessments in 28 indigenous communities in Canada, Chan and Receveur (2000) found mercury exposure to be "greatest among communities with high use of marine mammals as food," yet speculated whether the decreased use of traditional food "could result in … [an] increased risk of diabetes and cardiovascular disease"

- Hansen (2000) wrote of the very difficult balancing act between the risks and benefits of country foods, as their nutritional benefits are substantial, especially compared to southern/market foods, not to mention their social, cultural, spiritual and economic benefits

- Ayotte et al. (1995) stated that dietary benefits from the sea-food based diet of 499 Nunavik Inuit still outweighed the hypothetical health risks

- Hansen (2000) recommended that consumption of traditional food continue, and noted the need for dietary advice to Arctic peoples so they can make informed choices

- Van Oostdam et al. (2005) felt, whatever the decision about country food consumption, it should involve the community and take into consideration the many aspects of socio-cultural stability, and strive for a solution that will be the most protective and least detrimental to the community

- Chan et al. (1997) counselled that assessment of health risks from the relatively high contaminant exposure must also consider the nutritional, economical, cultural, and social importance of traditional Arctic foods, and noted the absence of a "comprehensive risk management scheme" in its community of focus

- Wheatley and Paradis (1996) noted: "the need to balance the theoretical basis of the risk assessment, for different population groups and for different exposure patterns, against the potential real impact on health caused by restrictive advice on consumption of traditional foods, especially fish"

- Based on a dietary survey of 1012 Aboriginal individuals in 16 western NWT communities, Berti et al. (1998) concluded that the low health risks associated with the consumption of irradiated caribou were outweighed by the physical, social and cultural benefits derived from hunting and eating caribou

- Mos et al. (2004), conducted a survey of the coastal Sencoten (Saanich) First Nation in BC, and documented the high social and economic importance of traditional foods in their diet (encompassing at least 25 marine species), providing "an important first step in risk assessment"

- Furgal et al. (2005) indicated that, in general, the approach taken to communicating the risks of environmental contaminants in the food chain to northern Aboriginal communities has been "poor, "ad hoc" and unfocused, leading to "increased fear and confusion in [those] communities, changes in [their] dietary behaviour and traditional lifestyles… and associated impacts on their society, economy, and health," revealing the need for better "planning and evaluation… and possibly changes to the scale at which communication work is done in northern communities"

The state of knowledge sometimes improves through the discovery of new diagnostic/assessment tools, or the refinement of existing ones:

- Plusquellec et al. (2007) found that concentrations of lead (due to prenatal exposure) in cord blood samples from 169 eleven-month-old Inuit infants in northern Quebec were "significantly related" to several aspects of behavioral function, evidence of the "considerable potential" of infant behavioral assessment in helping to detect low-to-moderate associations between neurotoxicants and certain behaviors

- Muckle et al. (2001) conducted a study on infant development in Nunavik and observed that "relatively low correlations" between organochlorine and

methylmercury concentrations may make it easier to identify the specific developmental deficits attributable to each toxicant

- Muckle et al. (2001) also revealed “weak correlations” between contaminants and nutrients, which could aid in documenting the “possible protective effects afforded by either n3-PUFA or selenium against neurotoxic contaminants”

- Saint-Amour et al. (2006) meanwhile found selenium and omega-3 polyunsaturated fatty acids did *not* help protect against methylmercury and PCB toxicity as once thought, when they used a measurement of pattern-reversal visual evoked potentials (VEPs)

- Ayotte et al. (2003) found that PCB concentration in any of the “biologic media” – i.e., maternal/cord plasma and breast milk – served as a good indicator of prenatal exposure to PCBs among Inuit in Nunavik

- Lagueux et al. (1999) confirmed that “CYP1A1 enzyme induction” and “DNA adducts in placental tissue” are useful biomarkers of early effects from environmental exposure to organochlorines

- Bharadwaj et al. (2006) documented the beginnings of a 1995 pilot project assessing the long term effects of fetal exposure to methylmercury in Grassy Narrows and Whitedog First Nations, based on newer and more “subtle neuropsychological development tests” given to fetally-exposed children now in secondary school

- Based on 47 Aboriginal newborns from St. Lawrence River regions, data from Fitzgerald et al. (2004) supported “a negative association” between tumor necrosis factor-alpha secretion by cord blood mononuclear cells and prenatal organochlorine exposure, a relationship which, if causal, “would suggest a role for this important proinflammatory cytokine in mediating organochlorine-induced immunotoxicity in infants” who were developmentally exposed

- The transfer of radionuclides from uranium mining operations to northern Saskatchewan Aboriginal peoples via the lichen-caribou-human food chain was the subject of study conducted by Thomas and Gates (1999), which reported that lichen concentration ratios (i.e., the plant's ability to take up a contaminant) proved “useful in predicting caribou meat concentrations” of radionuclides by relating caribou tissues to lichens or rumen (stomach) contents

- After administering the caffeine breath test (CBT) to 103 Akwesasne Mohawk adults exposed to PCBs through fish consumption, Fitzgerald et al. (2005) produced results in support of the notion that activity of the enzyme cytochrome P-450 1A2 (or CYP1A2) may be a marker of an early biological effect of PCB exposure, which could make the CBT a potentially “useful tool to monitor such effects”

Some research found a downward trend in the presence of contaminants (although no study implied the trends were necessarily permanent):

- Dallaire et al. (2003) reported “strongly significant decreasing trends” for PCBs, DDE, DDT and HCB with “no significant trends” detected for chlordanes among infants in three Nunavik communities

- Dallaire et al. (2003) also found a “significant reduction” of lead and mercury concentrations, but saw no clear linear or exponential trend

- The decreases in contaminants seen in Dallaire et al. (2003) could be due to a decrease in food contamination, changes in dietary habits, or, most likely, a combination of both.

- A retrospective analysis of Grassy Narrows and Whitedog First Nations shows a decreasing methylmercury trend in both communities according to Wheately et al. (1997)

- Among the 9 Cree communities of James Bay in northern Quebec, Dumont et al. (1998) found that the proportion of the population with mercury levels greater than 15 mg/kg declined from 14.2% in 1988 to 2.7% in 1993/94, but cautioned that the decrease may not be permanent, and does not necessarily imply the issue is definitively resolved

- Dallaire et al. (2002) showed results that prenatal exposure to persistent OCs (including PCBs, chlordanes, DDT/DDE and HCB) declined significantly between 1993 and 2000 among newborns from the Lower North Shore of the St. Lawrence River, in all age and ethnic groups, Aboriginal newborns included

- From 1992 to 1995, Fitzgerald et al. (2004) drew blood from 111 pregnant Mohawk women from Akwesasne, a reserve near three hazardous waste sites, and found a geometric mean concentration of total PCBs “similar to that in other studies of women with no unusual exposures to PCBs,” results the author(s) link to “a significant decline in local fish consumption from an annual mean of 31.3 meals a year or more prior to pregnancy to an annualized mean of 11.7 meals during pregnancy,” reportedly the result of advisories against consumption of local fish by pregnant/nursing women

- Chan et al. (1999) found that, contrary to the perception of its Mohawk residents, Kahnawake’s “fish were not particularly contaminated,” with levels of cadmium, lead, arsenic, PCBs and other chlorinated pesticides “at least 10 times lower than the guideline levels,” and although some predatory fish had higher-than-prescribed levels of mercury, average daily intakes of mercury were still below guideline levels

Looking at the state of First Nations maternal/infant health in relation to potential environmental threats, studies undertaken mostly focus on the Akwesasne Mohawk population:

- Conducted among 138 Akwesasne Mohawk Nation girls 10-16.9 years of age, Denham et al. (2005) investigated the relationship between the timing of girls' first menstrual period or menarche and their levels of exposure to DDE, HCB, PCBs, mirex, lead and mercury via substantial industrial development on the nearby St Lawrence River

- Denham et al. (2005) conducted an analysis of multichemical exposure and suggested that the odds of reaching menarche may be sensitive to relatively low levels of lead and a specific group of potentially estrogenic PCB congeners, although it urged caution in interpreting these results

- Denham et al. (2005) stated that additional investigation was warranted into whether low toxicant levels might affect reproduction and disorders of the reproductive system

- Bharadwaj (2006) offered a longitudinal overview of the "two most extensively sampled communities" in Canada, Grassy Narrows and Whitedog First Nations that were exposed to 'point source' mercury pollution in the 1970s

- Among 97 Mohawk women in Akwesasne, a reserve in the vicinity of three hazardous waste sites, Fitzgeral et al. (2004) found a reduction of PCB concentrations in their breast milk that paralleled a corresponding decrease in local fish consumption, possibly the result of advisories directing pregnant and nursing Mohawk women not to eat the fish

- Codru et al. (2007) found that "elevated serum PCBs, DDE, and HCB were positively associated with diabetes" in a cross-sectional study of 352 Mohawk adults, whereas mirex was observed to have "a negative association" with diabetes

- Newman et al. (2006) found a "significant negative relationship between PCB levels and two separate measures of long term memory" in Mohawk adolescents in Akwesasne and "a negative relationship with a measure of comprehension and knowledge"; although not large, the relationships provided "evidence of subtle negative effects of PCB exposure"

- Fitzgerald et al. (2001) found that a reduction in breast milk DDE concentrations among 97 Akwesasne Mohawk women from 1986 to 1990 paralleled a corresponding decrease in local fish consumption, which may be the result of advisories against the practice issued over the previous decade

- However, Fitzgerald et al. (2001) did find elevations in mirex concentrations in the 97 Akwesasne women's breast milk, "consistent with the fact that it is a

common contaminant in the region and throughout the Lake Ontario-St. Lawrence River Basin"

- Hwang et al. (2001) found that PCB congener patterns in the breast milk of 97 Akwesasne Mohawk women who ate the most local fish more closely resembled patterns in fish caught at or close to a nearby waste site than women in the same community who ate less fish, an outcome which "demonstrates how PCBs may be 'fingerprinted' as they migrate offsite from industrial sources and ultimately result in human exposure"

- With evidence for "significant excess in incidence and prevalence of hypothyroidism" among Mohawk women 30 years of age and older due to PCB exposure, Sukdolová et al. (2000) provided an on-going study investigating long-term exposure to PCBs and acquired hypothyroidism "in order to identify the critical exposure routes and to develop and apply toxic equivalents for thyroid disease for the various PCB congeners."

Mercury and methylmercury have been long-standing areas of research, as seen in the following studies:

- Bharadwaj et al. (2006) indicated that Health Canada has collected data on Inuit and First Nations' methylmercury levels for 25 years and now has now completed a national review

- Hoover et al. (1997) used "dose-response analyses" combined with "a probabilistic exposure assessment" to conclude that methylmercury ingestion via fish caught from natural lakes and a reservoir Aboriginal people in BC "does not pose a significant risk" if eaten in reasonable quantities

- Macdonald et al. (2000) reinforced the concern that of all the metals, mercury "provokes the greatest concern," and appears to be increasing in the Arctic due to global human activities, but "are not evenly distributed nor are the pathways by which they enter and move within the Arctic well understood"

Other studies approached these issues through the more qualitative lens of attitudes:

- Hine et al. (1997), conducted a survey of four northern communities about a proposed underground nuclear waste repository in the Canadian Shield, found the strongest opposition among Aboriginal respondents, who were less trusting, had less faith in science and technology, and perceived the proposal's costs to be higher than their non-Aboriginal respondents.

A number of studies considered specific contaminants and projected their remaining life-span in the Arctic:

- Macdonald et al. (2000) reported that, despite a 1970s PCB production ban, "the Arctic presently shows little evidence of reduced PCB loadings," anticipating that reduction will ultimately take "decades"

- Macdonald et al. (2000) stated that lead loadings in the Arctic "appear presently to be decreasing due to source controls (*e.g.*, removal of [lead] from gasoline)"

- Macdonald et al. (2000) noted how drastic reductions in the production/use of the organochlorine insecticide HCH rapidly led to reductions in "atmospheric burdens," leaving only the Arctic ocean as its "major reservoir and transport agent," which will not clear itself of HCH for "decades"

- Drawing on a cohort of 314 Cree infants (9 months old) from northern Quebec, Willows and Gray-Donald (2002) observed that those infants found to have anemia or iron-deficiency anemia also had a higher mean geometric blood lead concentration than their non-anemic counterparts

- Willows and Gray-Donald (2002) also found "a significant negative correlation between blood lead and hemoglobin concentrations, and between blood lead and serum ferritin concentrations" among its northern Cree infant cohort

Certain studies attempted to address specific gaps in knowledge, in some cases piloting research questions in their area:

- Tsuji et al. (2005) noted how few data exist with respect to the human body burden of OCs in residents of communities located in close proximity to northern radar line sites, which are direct point sources of contamination

- Denham et al. (2005) claimed to be one of the few studies to examine the effects of common levels of pollutants such as lead and POPs on human sexual maturation, and the first to examine the possible effects of multiple toxicant exposures

- Based on a community-wide pilot inspection of 26 homes of asthmatic children living on the Elsipogtog Reserve (NB), Berghout et al. (2005) concluded that the range of mould damage, though "similar to that seen elsewhere in Canada," tended to "reflect more serious maintenance problems"

- Lawrence and Martin (2001) suggested that substandard housing is a major contributor to poor health among BC First Nations because of bacteria, moulds and dust mites fostered by humid, damp living conditions, a situation which puts, among others, the very young at particular risk for diseases like asthma

Where to go forward from here was also the subject of some studies, including some indications of best practices:

- Hansen (1998) recommended that priority be given to establishing protocols for the control of POPs and heavy metals under the Convention on Long Range Transboundary Air Pollution

- Furgal et al. (2006) reviewed experiences from two projects in Arctic Inuit communities where a multi-stakeholder, participatory framework for assessment best supported the necessary analysis, understanding, and enhancement of community capabilities to respond and adapt to local health impacts of climate change

- Suppiah et al. (2004) outlined a BC First Nations approach to solid waste management meant to provide remote communities with sustainable alternatives to waste dumping and incineration, such as the integration of collection services for multiple communities, education in appropriate disposal options, and waste reduction

- Mailman et al. (2006) reviewed the pros and cons of various strategies to lower methyl mercury concentrations in hydroelectric reservoirs, ranging from better site selection to intensive fishing, the addition of different elements (*e.g.*, selenium, lime, phosphorus) to the burning or removal of trees; but whichever of the many possibilities are chosen, the authors believe the "most promising strategy will be one that is agreeable to all affected people"

- Noël et al. (1998) recalled how community involvement in a mercury information program for James Bay Cree had been "essential to its success," as member-identified needs led to such tools as trilingual (French, English and Cree) brochures and posters, a radio message, and individual and group meetings

Programs and Initiatives

There are a number of research, policy and advocacy programs and initiatives working on contaminants and the environment, nationally and internationally. The table below is a sampling of governmental, non-governmental and research-based organizations in Canada whose focus is to understand, document, and exchange knowledge related to contaminants, the environment and Aboriginal health. Although many of the organizations listed below speak at times to the impacts of environmental threats on the health of First Nations and Inuit women and infants within their work, none have a specific gender-based or child-centered mandate as such.

A list of projects (the Appendix) found when this manuscript was developed, can be downloaded from http://www.pwhce.ca/maternalInfantHealth_Environment.htm or requested from PWHCE or BCCEWH.

PROGRAM	**Northern Contaminants Program – Indian and Northern Affairs Canada (NCP-INAC)** **http://www.ainc-inac.gc.ca/nth/ct/ncp/index-eng.asp**
MANDATE	Addresses human exposure to contaminants in wildlife species that are important to the traditional diets of Northern Aboriginal peoples
FOCUS AREAS	✔ Human health research ✔ Environmental monitoring and research ✔ Education and communication ✔ National/regional coordination and Aboriginal partnerships

PROGRAM	**Northern Contaminated Sites Program – Indian and Northern Affairs (NCSP-INAC)** **http://www.ainc-inac.gc.ca/nth/ct/ncsp/index-eng.asp**
MANDATE	Focuses on the clean up and remediation of a number of contaminated sites in the North
FOCUS AREAS	✔ Ensuring the protection of human health and safety, and the environment by remediating contaminated sites while supporting employment and training of Northerners ✔ Providing northern regional economic development programming ✔ Working with territorial governments to transfer province-like responsibilities for the management of land and resources

PROGRAM	**National First Nations Environmental Contaminants Program – First Nations and Inuit Health Branch/Assembly of First Nations/First Nations University of Canada (NFNECP-FNIHB/AFN/FNUniv)** **http://www.afn.ca/article.asp?id=2396**
MANDATE	Assess the extent of environmental contaminant exposure and the potential for associated risk to the health and well being of First Nations in Canada
FOCUS AREAS	✔ Supports innovative research on environmental and health impacts from contaminants in First Nations communities ✔ National, regional and local components

PROGRAM	**Environmental Health Program - First Nations and Inuit Health Branch (EHP-FNIHB)** **http://www.hc-sc.gc.ca/fniah-spnia/pubs/aborig-autoch/2007_compendium/2_2_environ-milieu-eng.php**
MANDATE	Community-based program to protect and improve First Nations (on-reserve and south of 60) health through the reduction of health risks, injuries or deaths. Strives to create and maintain healthy and safe community environments through the investigation of potential environmental health related outbreaks
FOCUS AREAS	✔ Drinking water and sewage ✔ Food Safety ✔ Facilities health inspections ✔ Housing ✔ Transportation of dangerous goods ✔ West Nile Virus

PROGRAM	**Environmental Research - First Nations and Inuit Health Branch (ER-FNIHB)** **http://www.hc-sc.gc.ca/fniah-spnia/pubs/aborig-autoch/2007_compendium/2_2_environ-milieu-eng.php**
MANDATE	Carries out laboratory and field studies, research, monitoring and surveillance; and predictive modeling efforts, in the context of risks posed by environmental contaminants (chemical, biological and radiological) to the First Nations and Inuit peoples and the balancing of health protection measures including remediation with traditional knowledge and the broader determinants of health
FOCUS AREAS	✔ Provide scientific research into concerns expressed by First Nations and Inuit communities regarding human health and environmental linkages. ✔ Provide laboratory and statistical services with respect to scientific research and monitoring. ✔ Monitor and assess scientific developments in the field of the environment's impact on human health at local, national and international levels. ✔ Improve environmental health risk awareness and community human resources capacity through community research and monitoring projects

PROGRAM	**Centre for Indigenous Environmental Resources – CIER** **http://www.cier.ca**
MANDATE	Established in 1994 by a group of First Nation Chiefs from across Canada, CIER is a national, First Nation-directed environmental non-profit organization. Supports First Nations in identifying threats to the health of their environment, develop sustainable resource use solutions, and promote restoration and protection.
FOCUS AREAS	✔ Climate change ✔ Sustainable communities ✔ Conserving Biodiversity ✔ Protection of Lands and Water

PROGRAM	**Manitoba Environmental Contaminants Pathfinder – CIER** **http://www.cier.ca/**
MANDATE	To help First Nations write community-led, environmental contaminants research proposals.
FOCUS AREAS	Help First Nations: ✔ Identify environmental contaminant concerns and issues ✔ Identify potential project ideas ✔ Assist with RFNECP proposal submissions for 2008 – 2009 ✔ Assist with RFNECP proposal submissions for 2009 – 2010

PROGRAM	**Manitoba Regional First Nations Environmental Contaminants Program - FNIHB** **http://www.cier.ca/WorkArea/downloadasset.aspx?id=1228**
MANDATE	Funding program to help First Nations develop community-based projects that explore the link between human health and environmental contaminants.
FOCUS AREAS	✔ Exposure: Assessment of First Nations peoples' exposure to environmental Contaminants (assessing concentrations of contaminants in food sources (game, fish, plants) or through human tissue sampling. ✔ Risk Management: Assessment of environmental trends of human exposure to contaminants and identifying risk management strategies (developing eating guidelines for game, fish, or plants or other risk management strategies) ✔ Effects: Research impacts of environmental contaminants on human health and wellbeing (assessing direct health impacts or social, cultural, and economic impacts of known environmental contaminants and results on health).

PROGRAM	**Centre for Indigenous Peoples' Nutrition and Environment – CINE (McGill University)** **http://www.cier.ca/**
MANDATE	An independent, multi-disciplinary research and education resource for Indigenous Peoples, CINE was created to meet demand expressed by Aboriginal Peoples for participatory research and education to address their concerns about the integrity of their traditional food systems.
FOCUS AREAS	✔ **Social sciences:** determination of traditional and market food selection in relation to environment and culture. The various social forces contributing to changing dietary patterns and nutritional health are also examined. ✔ **Laboratory sciences:** determination of nutrient and contaminant content in traditional food systems, wildlife, humans, and ecosystems. ✔ **Data analyses:** determination of extent of food use in relation to nutrient and contaminant levels to address questions of holistic human nutrition and health, and benefit/risk evaluations.

PROGRAM	**Network Environments for Aboriginal Health Research (NEAHRs) – Canadian Institutes of Health Research (CIHR)/ and Institute of Aboriginal People's Health (IAPH)** **http://www.cihr-irsc.gc.ca/e/27071.html**
MANDATE	Established in 2007, NEAHRs Collaboration between seven regional centres (NEARBC/Alberta ACADRE Network/Centre for Aboriginal Health Research/Indigenous Health Research Development Program/Atlantic Aboriginal Health Research Program/Indigenous Peoples' Health Research Centre/Nasivvik Centre for Inuit Health and Changing Environments and 2 national centres; Anisnawbe Kekendazone – CIET and the National Network for Aboriginal Mental Health Research.
FOCUS AREAS	✔ Explore critical Aboriginal health issues ✔ Develop network of centres across Canada responsible for developing the next generation of aboriginal health researchers ✔ Focused research efforts on determinants of health in Aboriginal communities

PART 3
CONCLUSIONS

Preliminary recommendations include conducting further research to be undertaken on the physical environmental risks for maternal and infant health. More research is considered necessary on southern Aboriginal peoples and First Nations communities, with an urgent need to better understand the impacts that environmental contaminants have on First Nations and Inuit women and children. As well as adding to the body of knowledge on environmental threats to First Nations and Inuit communities, further examining these issues will provide valuable information for health and environmental policy decision-makers and program development in Canada and facilitate the direction of resources and actions to the necessary areas of environmental research and work.

The following areas are in need of greater research as to how they specifically act to affect the health of First Nations and Inuit women and their infant children.

Environmental contaminants: Aboriginal people have expressed concern in continuing to eat traditional foods due to the biomagnification in the food chain and offering breast milk to their infants because of the fear of contamination. Studies have investigated prenatal exposure to mercury, polychlorinated biphenyls and organochlorines and levels of toxins in breast milk and umbilical cord blood samples. The research pays most attention to maternal and infant health.

Resource Development, including mining and hydro-electricity: Methyl mercury, lead, arsenic contamination are some of the toxins that are affecting water, marine and terrestrial plants and animals and of course humans in nearby communities.

Waste Disposal, including nuclear waste: National Dialogue on Nuclear Waste Disposal between the five national Aboriginal political organizations and the Nuclear Waste Management Organization (NWMO), monitored by Natural Resources Canada, took place over a period of three years (2003-2005) to develop a long-term management of nuclear waste. Solid waste disposal has also been contested where large urban centres are close to Aboriginal communities. Contamination of drinking water and soil is a great concern for communities.

Climate Change: There has been substantial focus on climate change and its impact on Aboriginal peoples and research is continuing to expand. Most studies and work have centered attention on the North for obvious reasons. The Center for Indigenous Environmental Resources (CIER) is currently conducting work on climate change and communities south of 60.

Household Mould: Canada Mortgage and Housing Corporation, Indian and Northern Affairs Canada and Health Canada have jointly issued a publication on mould in First Nations housing and its prevention and treatment. Research has focused on asthma in children in particular, and recent news has warned about mould's negative impacts on pregnant women and infants.

Drinking water quality: Many Aboriginal communities live with a boil water advisory. One program recently developed was the 2003 Indian and Northern Affairs Canada and Health Canada First Nations Water Management Strategy (FNWMS) which is to reduce drinking water health risk in Aboriginal communities and involves communities to play a part in keeping the water clean.

PART 4
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