A QUALITATIVE CASE STUDY OF RELATIONSHIPS BETWEEN PUBLIC HEALTH AND MUNICIPAL DRINKING WATER AND WASTEWATER IN CORAL HARBOUR, NUNAVUT

by

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ABSTRACT

Wide health gaps exist between Canada's Inuit population and their non-Indigenous counterparts in nearly all categories. Two basic public health protection principles in any community worldwide are access to safe drinking water and sanitary wastewater management. The purpose of this research was to explore the relationships between public health and municipal water and wastewater systems in Coral Harbour, Nunavut. Using a qualitative case study approach, I conducted 37 interviews with residents and key informants and thematically analyzed the data. Findings suggest that crowded households experiencing domestic water shortages may result in negative health consequences. As well, pre and early settlement water customs are influencing current public health risks thereby requiring special consideration by municipal planners. Given these findings, recommendations include increasing domestic water access, strengthening source water monitoring programs, and establishing intergovernmental public health policies that co-benefit water resource management agendas as well as other priority issues in Nunavut.

LIST OF ABBREVIATIONS USED

PHAC	Public Health Agency of Canada
WHO	World Health Organization
CCME	Canadian Council of Ministers of the Environment
H. pylori	*Helicobacter pylori*
MRSA	Methicillin-resistant *Staphylococcus aureus*
CFU	Colony Forming Units

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CHAPTER 1 INTRODUCTION

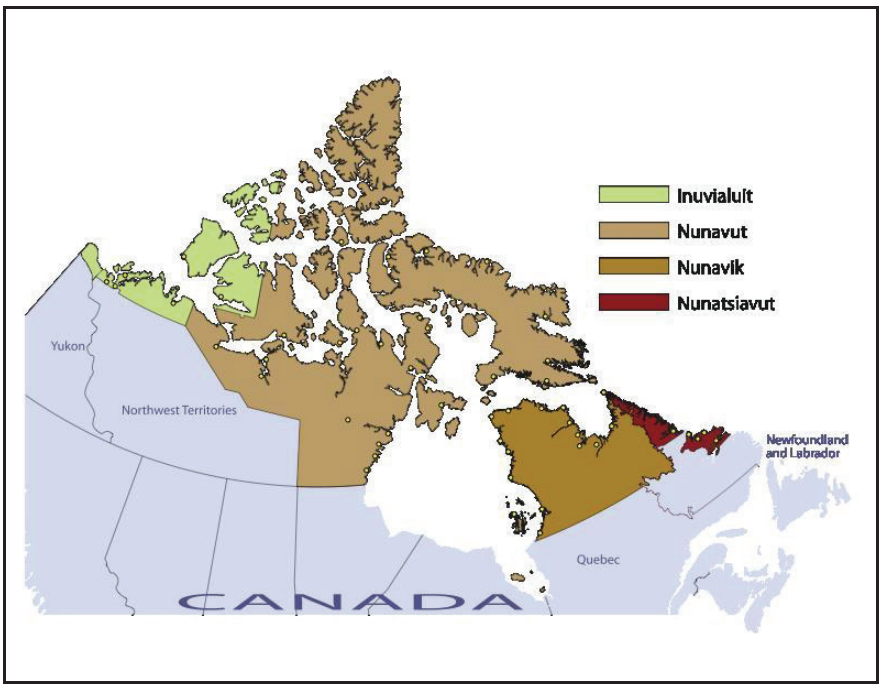
1.1 INTRODUCTION

1.1.1 Problem Statement

Inuit (population 50,000) are one of three distinct Indigenous[1] groups in Canada, along with First Nations (700,000) and Métis (390,000). Traditionally, Inuit were hunters and gatherers and while elements of that lifestyle remain, the majority of Inuit live in rural and remote communities within the four northern Inuit regions in Canada (Figure 1.1: Locator Map of Inuit Regions in Canada). Inuit populations face a number of health disparities relative to Canada's non-Indigenous population (Bjerregaard & Young, 2008). These disparities are a result of several interrelated health determinants including social processes, physical environments, and individual behaviours (Adelson, 2005; Gracey & King, 2009). Many of the specific illnesses facing Inuit are associated with high person-to-person transmission rates due to inadequate water access, sanitation and housing; conditions more common in developing or middle-income nations rather than in communities in an affluent country like Canada (Bjerregaaard & Young, 2008). In addition to these water-related health disparities, a host of new factors including climate change, growing local populations, and impending federal compliance policies have increased the urgency for research that seeks to address the challenges of providing safe drinking water and wastewater treatment services that are appropriate for the physical environment and relevant to the social environment in remote Nunavut communities (Furgal & Seguin, 2006; Inuit Tapiriit Kanatami & Johnson, 2008; Warren et al., 2005).

[1] Within this thesis, the understanding of Indigenous peoples employed is those who self-identify as the original inhabitants of a region or territory and maintain strong links to the surrounding natural environment and their distinct social, economic or political systems and language, culture and beliefs (United Nations, 2013). There are three distinct, politically recognized groups of Indigenous peoples in Canada; First Nations, Inuit, and Métis; they are identified in Canada's constitution as Aboriginal peoples.

Figure 1.1 Locator Map of Inuit Regions in Canada (Inuit Tapiriit Kanatami, 2012)



1.1.2 Research Purpose and Objectives

In response to the issues introduced above, this thesis aims to increase the general understanding of the relationships between Indigenous health and the built environment. In particular, I am asking the following research question:

Within Nunavut's remote Inuit hamlets, what are the relationships between: a) public health practices, behaviours, and decision-making; and b) municipal water and wastewater systems and management?

Four sub-objectives are addressed within this question:

Research Objective #1*:* Investigate the usage habits, opinions, and social patterns of Coral Harbour residents relating to water and wastewater systems and services;

***Research Objective #2**:* Identify potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community;

***Research Objective #3**:* Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region; and

***Research Objective #4**:* Based on new knowledge related to objectives 1-3, recommend some practical applications useful in shaping Nunavut's water, wastewater and public health strategies.

This introductory thesis chapter has begun with an overview of the research problem followed by the purpose and objectives. Next I will discuss background literature to ground the study within existing academic research and theory. From there, I will situate the thesis within the context of Nunavut's territorial water research agenda and introduce the case study community of Coral Harbour. Finally, I will outline the remaining chapters.

1.2 Literature Review

The research is situated in a theoretical framework of Indigenous health and water resource management literature. I begin with a broad review of each of these two fields and narrow towards information most directly related to my research topic.

1.2.1 Indigenous Health

Among the nearly 400 million Indigenous people worldwide, there are many distinct groups and unique cultures (United Nations, 2008). However, one startling commonality among this population is a disparate state of health in comparison to the non-Indigenous populations of their respective home countries. Indigenous groups face inequalities in key population health indicators such as life expectancy at birth and infant mortality rates and also bear disproportionate burdens of both communicable infectious and chronic lifestyle diseases (Gracey & King, 2009).

Health institutions and researchers have recognized that human health patterns are influenced by a number of interconnected determinants which can be categorized as physical environments, social processes, economic conditions, health care services, and individual characteristics and behaviours (Gracey & King, 2009; Public Health Agency of Canada [PHAC], 2011; World Health Organization [WHO], 2012). Underlying these proximal and intermediate determinants and health inequities are the distal determinants of health such as the lasting impacts of colonization, racism and determinism (King et al., 2009; Reading & Wien, 2009). Although specific historical contexts and circumstances of colonization vary worldwide, a common theme permeates: outsiders have displaced the original Indigenous inhabitants from their traditional lands and autonomous ways of life while imposing themselves as the dominant society (Gracey & King, 2009). The harsh legacy of colonization is that many marginalized Indigenous groups live in cycles of poverty and dependence on their colonizers (Richmond & Ross, 2009). Even within developed nations such as Canada, inequitable social, economic and political conditions originating from colonization have left Indigenous groups facing stark health disparities, vulnerabilities, and disease burdens similar to populations in developing nations (Adelson, 2005; Ford et al., 2010).

1.2.1.1 Inuit Health in Northern Canada

Traditionally, Inuit of northern Canada practiced a migratory hunter and gatherer lifestyle (Bjerregaard & Young, 2008). Using localized skills and knowledge honed for survival in arctic conditions, Inuit relied entirely on the surrounding natural environment as their source of sustenance and shelter (Bates, 2007; Bjerregaard & Young, 2008). These close connections to the landscape and wildlife of the region were integral components of the Inuit societal centering, cultural identity, health, and wellness (Bjerregaard & Young, 2008; King et al., 2009). Although Inuit lifestyles still contain many elements of tradition, they began shifting toward established settlements following European contact in the 20th century due to commodity trading opportunities, missionary or government offered health and education services, and also forced relocation (Tester & Kulchyski, 1994). In the 1950s, as federal ruling interests in the region increased, and at the expense of Inuit autonomy, this shift ultimately led to permanent

communities and mixed economies of traditional subsistence and wage-based activities (Young, 2008).

This rapid societal transition to a completely foreign way of life has greatly influenced the health of Inuit populations (Richmond, 2009; Bjerregaard & Young, 2008). Although the pre-contact era was not disease or hazard free, Inuit were conditioned to cope with the familiar health challenges of their natural environment such as recognizable parasitic diseases, cyclical food shortages and accidental injury (Adelson, 2005; Bjerregaard & Young, 2008). Initial European contact exposed Inuit populations to a completely new series of deadly infectious diseases for the first time such as small pox, whooping cough, and influenza (Bjerregaard & Young, 2008). This was followed by a secondary wave of communicable disease within early permanent settlements, namely tuberculosis, which was highly transmissible due to inadequate housing and sanitation (Bjerregaard & Young, 2008).

Theoretically, when a society undergoes a lifestyle transition such as the Inuit have, the health of the population follows a parallel pattern known as the epidemiological transition (Frank & Mustard, 1994). During this transition, the traditional health risks and communicable diseases associated with subsistence practices and substandard living conditions, such as those described above, are minimized as the wage-based economy stabilizes and access to basic shelter, water, sanitation, and nutrition within settlements improves (Forget & Lebel, 2001; Frank & Mustard, 1994). Following this phase of the transition, the society experiences increases in what are referred to as modern health risks, such as chronic and non-communicable diseases (Forget & Lebel, 2001; Frank & Mustard, 1994). However, due to the forced and rapid pace in which the social change is occurring in northern Canada, the health patterns of Inuit have deviated somewhat from this trend and populations are currently bearing a dual disease burden (Bjerregaard & Young, 2008). For example, incidence of modern health risks such as respiratory and cardiovascular diseases, diabetes, certain cancers, and self-inflicted injury and suicide are rising in Inuit populations (Bjerregaard et al., 2004; Tait, 2008). Yet, traditional subsistence health risks such as accidents and drowning, food insecurity, and zoonotic infections contracted through consumption of wild game also remain high (Bjerregaard et al., 2004). Furthermore, while there have been improvements in settlement housing and sanitation from the early

settlement era, communicable infection rates related to housing conditions, water supply, and hygiene are still significantly higher than the Canadian average (Bjerregaard et al., 2004; Egeland et al., 2011; Young & Mollins, 1996).

The underlying impacts of colonization and the broad socioeconomic and environmental determinants which have shaped Indigenous health worldwide are evident within the context of Inuit health in northern Canada. While there have been improvements in baseline population indicators within Inuit populations, a failure to develop public health strategies and interventions that account for the interconnectedness of the broad determinants, are culturally relevant to residents, and practical within the remote artic region has slowed further progress (Giles et al., 2010; Hankivsky & Christoffersen, 2008; Richmond & Ross, 2009). As a result, wide health gaps still exist between Canada's Inuit and their non-Indigenous counterparts in virtually all categories (Bjerregaard et al., 2004; Bjerregaard & Young, 2008). In the next section of this review, I will focus specifically on the relationship between public health and water and wastewater treatment systems. The impacts of colonization and the unique social and physical health determinants in Inuit regions will continue to weave throughout the section.

1.2.2 Water, Wastewater and Public Health

Access to drinking water of safe quality and ample quantity as well as adequate wastewater sanitation are fundamental public health principles and internationally recognized human rights (WHO, 2013). Yet, among the diverse regions of the world, there is a wide variety of water and wastewater treatment and distribution systems. Similarly, the regulatory guidelines and levels of societal acceptance, which define local water and sanitation standards, also vary considerably (WHO, 2010). For example, in developing nations, procuring domestic water and disposing of wastewater is often a daily responsibility of individual families, and may be their most important and time consuming activity each day (WHO, 2013). What is more, within many communities in the developing world, even these arduous practices do not guarantee reliable access to 20 litres of domestic water per capita per day, the absolute minimum recommended for public health protection (Howard & Bartram, 2003). Living in conditions dictated by water insecurity hinders the ability of people to freely participate in educational, occupational and recreational

undertakings thereby perpetuating cycles of poverty for the most vulnerable and marginalized populations in the world (Montgomery & Elimelech, 2007). Furthermore, such conditions cultivate the spread of enteric, skin, eye and other transmissible diseases resulting in millions of preventable deaths per year (Ashbolt, 2004; Prüss et al., 2002).

By contrast, most residents of developed nations are accustomed to the convenience of having safe water piped conveniently into their homes, using upwards of 300 litres of domestic water per capita per day, and draining wastewater immediately out of sight (Environment Canada, 2001a). For them, this amenity is the product of reliable wells and buried septic systems or large subterranean utilities and central treatment plants which are built, operated, and regulated by cooperating levels of government (European Commission Environment, 2012; Health Canada, 2012; United States Environment Protection Agency, 2012). While the health gains from improved water and sanitation services are extremely significant, they do not eliminate all risks (Hrudey & Hrudey, 2007). For example, underestimated risk factors, operational failure or mismanagement of advanced drinking water treatment and distribution systems in developed nations has resulted in serious infectious disease outbreaks (Hrudey et al., 2006; Schuster et al., 2005) including a high-profile case in 2000 in which municipal drinking water in Walkerton, Ontario became contaminated with *Escherichia coli* 0157:H7, *Campylobacter jejuni* and other speculated pathogens killing seven people and causing an estimated 2,300 to become seriously ill (Hrudey et al., 2003). Ineffective or failed wastewater treatment also poses health risks through direct human exposure to harmful effluent and cross contamination of drinking water and food sources (Environment Canada, 2001b; Kivaisi, 2001). Additionally, drinking water sources containing unsafe levels of heavy metals or organic pollutants that have not been properly pretreated are harmful to human health over an extended period of consumption (Day & Dallas, 2011).

Despite Canada's status as a developed nation, it has been widely reported that Indigenous populations in Canada have been underserved regarding water and sanitation services (Canadian Broadcast Corporation, 2011a, 2011b; Health Canada, 2013). Non-existent or ineffective monitoring practices and treatment systems (Bjerregaard, et al., 2008; Rosenberg et al., 1997), unmaintained infrastructure (Bjerregaard et al., 2008), water operator and health worker

shortages (Bjerregaard et al., 2008; PHAC, 2008) and crowded housing conditions (Laracombe et al., 2011; PHAC, 2008; Pollock et al., 2012) are factors that have contributed to the multitude of water and sanitation related issues and disease outbreaks in Canadian Indigenous communities. Despite these reports and evidence of water-related diseases, which in type and severity are more characteristic of those in developing or middle-income nations, Canada has so far demonstrated an inability or unwillingness to improve conditions, which is a task that would entail addressing both the contemporary realities and the underlying social inequities stemming from colonization in Indigenous communities (Adelson, 2005; Reading & Wien, 2009; Waldram et al., 2006).

1.2.2.1 Water, Wastewater and Public Health in Nunavut

When designing appropriate water and wastewater systems, there is no 'one-size-fits-all' strategy; solutions must be localized (Davies & Mazumder, 2003). To begin, planners and decision makers must account for the physical environment including the type (surface and ground) and quality of available source water, terrain, topography, and climate characteristics of the region (Day & Dallas, 2011). They must also consider the people who will rely on the water and wastewater systems to meet their needs and protect their health (WHO, 2010). The size of the user population, their setting (rural or urban), their water-related habits and usage patterns, and the nature of their human-environment interactions should all be reflected in the water and wastewater systems (Davies & Mazumder, 2003; WHO, 2010). For example, the presence of industrial, mining, agricultural or traditional food harvesting activities within the watershed will individually and cumulatively impact the quality of the water source, quantity of water used, wastewater effluent toxicity, potential exposure pathways, and ultimately, the types of health risks faced by the community (Davies & Mazumder, 2003). Relatedly, the economic and human resource capacity of the population needs to be sufficient to meet the construction, maintenance, and operational requirements of the systems and services being considered (Kot et al., 2011; Smith et al., 2006). By gaining an understanding of current and projected demographic, social, cultural, and economic factors in tandem with the characterization of the physical environment, planners and decision makers have access to a comprehensive knowledge base, which can then be used to design water and wastewater solutions that are appropriate at the community level.

Providing water and wastewater treatment services in Nunavut communities and other Arctic regions poses unique socioeconomic and physical challenges. From the social perspective, their remote locations and small populations (typically 200 – 2000 people) eliminates many economies of scale making the investments necessary for large municipal projects such as water and wastewater infrastructure difficult (Marino et al., 2009; Smith et al., 2006). Additionally, any significant investments in water projects places a strain on limited financial resources and likely comes at the expense of other core community priorities such as education, health, or recreation facilities and services (Lam & Livingston, 2011; Marino et al., 2009). Some of the major physical variables to be considered include the extreme temperatures in the region, which are consistently below minus 30° Celsius during winter months, as well as the permafrost that extends deep into the ground year round yet has a top layer that undergoes seasonal thaw-freeze cycles potentially causing buried infrastructure to become unstable (Environment Canada, 2012; Smith, 1996a). Therefore, due to their cost, impracticality, and susceptibility to malfunction in low temperatures, northern communities do not have the underground piped water and wastewater distribution systems linked to central treatment stations, or individual on-site ground water wells and buried septic systems which are used in much of North America (Smith, 1996a).

Instead, most Nunavut communities rely on truck-haul water and wastewater systems. Buildings are typically constructed with separate drinking water and wastewater holding tanks, and are serviced by tanker trucks (See Figures 1.2: Household Water Tank and 1.3: Tanker Truck Delivering Water). In most communities this service is provided daily or multiple times per week. The communities source drinking water from designated lakes or rivers and disinfect it by chlorination prior to household delivery. Filtration and other forms of additional treatment are also utilized in some communities (Smith, 1996a). In addition to municipal water delivery, many residents also choose to independently collect untreated drinking water, or ice for melting, from local lakes and rivers. This custom was routine during the pre-settlement era and remains common both while travelling during extended hunting and fishing trips as well as while at home (Harper et al., 2011; Marino et al., 2009; Martin et al., 2007).

Figure 1.2 Potable Water Storage Tank inside House, Approximate Capacity of 1200 litres (photo credit: author)

Figure 1.3 Tanker Truck Delivering Potable Water to House (photo credit: author)

Municipal wastewater, after it is collected from individual buildings, is removed to designated open-air stabilization ponds (lagoons) and wetlands typically located on the periphery of the community. Trucks discharge the wastewater into the ponds where it freezes throughout the winter. During the warmer spring and summer temperatures, the wastewater melts and is discharged into the wetland and eventual outflow area at the ocean coast (See Figures 1.4: Aerial Photograph of Typical Nunavut Wastewater Treatment Area and 1.5: Tanker Truck Discharging Wastewater). This is known as passive wastewater treatment because, in contrast to mechanical

or chemical systems, all treatment processes (e.g. sedimentation, filtration and microbial decomposition) occur naturally within the stabilization ponds and wetlands (Smith, 1996a). These systems require minimal operation, maintenance, and energy inputs making them advantageous for remote Arctic communities where trained personnel is often unavailable and energy costs are very expensive (Marino et al., 2009; Smith, 1996a).

Figure 1.4 Aerial Photograph of a Typical Nunavut Wastewater Treatment Area consisting of a Stabilization Pond (Lagoon) and a Treatment Wetland (A solid waste dumping area is also situated to the left of the lagoon) (photo credit: W. Krkosek, Dalhousie University)

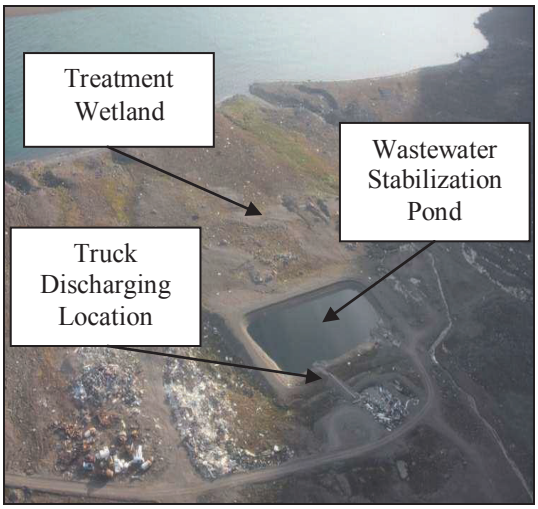


Figure 1.5 Tanker Truck Discharging Wastewater into a Stabilization Pond (photo credit: W. Krkosek, Dalhousie University)

During the Inuit pre-settlement era, that is prior to the 1950s, waste management issues were likely negligible (Bjerregaard et al., 2008). People travelled in small groups as nomadic hunters and gatherers and waste was scattered or buried (Bjerregaard et al., 2008). Current truck-haul water and wastewater systems are substantial improvements over early settlement-era systems. During the early-settlement era in the 1950s and 1960s, individual-haul water and wastewater systems were used in most of the Canadian Arctic. These "barrel and honey bucket" systems entailed individual residents retrieving their own water, or ice blocks, for domestic use from nearby lakes or rivers and storing it within a large barrel in their home. The "honey bucket" was a household pail used to collect wastewater and remove it to a community dumping area or disperse it on the ground outside the home. Trucked water delivery to household barrels and indoor plumbing began in the 1970s or 1980s in most communities but there was no municipal wastewater treatment of any kind. Two studies investigated the complex interrelationships between water use, wastewater treatment, and health outcomes in the region during this era using municipal water delivery data and available records from local health clinics (Michael, 1984; Robinson & Heinke, 1990). These studies found 30 litres per capita per day to be the minimum amount of domestic water required for public health protection in the region at that time, while 65 litres per capita per day was determined as the quantity necessary to reduce excessive incidence of gastrointestinal and skin diseases (Michael, 1984; Robinson & Heinke, 1990). For instance, as domestic water usage rates decreased below 65 litres per capita per day, the gastrointestinal illness incidence rate increased from 5 cases per 100 people to 24 cases per 100, and the skin disease incidence rate increased from 5cases to 27 cases per 100 people (Michael, 1984; Robinson & Heinke). Based on this information and similar research in cold climates, an increased quantity of 100 litres per capita per day was recommended as a standard design value to be used during implementation of truck-haul systems in Arctic communities (Smith, 1996b).

Improved water and wastewater management practices are partially responsible for some of the fundamental Inuit health gains since the early-settlement era such as increased life expectancy and decreased infant mortality rate (Bjerregaard et al., 2008). With that said, Inuit populations still bear a disproportionate burden of many communicable diseases by which person-to-person transmission is associated with domestic water supply shortages, crowded housing, and inadequate hygiene (Bjerregaard & Young, 2008). Examples includes tuberculosis rates 18 to 20

times the Canadian average (PHAC, 2008), and endemic methicillin-resistant *Staphylococcus aureus* infections in some communities (Daloo et al., 2008). A lesser known condition, *Helicobacter pylori* (*H. Pylori*) infection, has also been investigated in Inuit communities (Goodman et al., 2008). *H. Pylori* bacterium is found in the human gastrointestinal tract and, while most people are asymptomatic, infection is more prevalent in developing countries and Indigenous populations' worldwide (Goodman & Cockburn, 2001; Goodman et al., 2008). *H. Pylori* infection has been linked with chronic enteric issues as well as stomach ulcers and cancer (Goodman et al., 2008). Much of the epidemiology of *H. Pylori* is not fully understood (Goodman & Cockburn, 2001), however, inadequate water supplies, poor hygiene and sanitation, and overcrowded housing have been identified as risk factors for interpersonal spread (McKeown et al., 1999).

The traditional subsistence diet of Inuit populations also increases their risk of exposure to environmental contaminants such as industrial chemical by-products and heavy metals (Berner & Furgal, 2005; Suk et al., 2004). Much of the diet consists of locally harvested fish, and land and marine mammals from higher tropic levels, meaning that low levels of contaminants have the potential to bioaccumulate in the food chain creating a health threat to human consumers (Donaldson et al., 2010; Suk et al., 2004). Although, there is a considerable body of literature in relation to Inuit exposure to non-local point source contaminants carried to the Arctic by atmospheric or oceanic transport, to date, there is a dearth of research on human exposure pathways and health risks related to the Inuit diet and local point sources. This is partially due to the small human population sizes and limited anthropogenic pollutions sources such as large scale industry or agriculture (Suk et al., 2004). As human populations and economic development activity in the region increase, however, local point sources of pollution will require further consideration. These include passive wastewater treatment systems, which are potentially open to species of wildlife that are included in the traditional Inuit diet.

Research from a variety of disciplines has begun to assess the associated health risks, vulnerability, and adaptive capacity of Inuit communities in response to climate change (Brubaker et al., 2011; Ford et al., 2007; Ford et al., 2010; Furgal & Seguin, 2006). Among that research, Harper and colleagues (2011) and Martin and colleagues (2007) have reported

specifically on the health risks associated with the Inuit practice of collecting untreated water from surface sources. The primary health outcome noted was increased gastroenteritis, attributed to common waterborne agents such as *Giardia*, *Campylobacter*, and pathogenic *Escherichia coli*, during warmer temperatures (Harper et al., 2011; Martin et al., 2007). Improved water source monitoring and record keeping were among the public health interventions recommended (Harper et al., 2011; Martin et al., 2007). It has also been suggested that entire municipal water and wastewater treatment systems may be vulnerable to climate change-related extreme weather events, rising temperatures, and coastal erosion (Warren et al., 2005). Damage to infrastructure or flooded treatment areas could result in lengthy delays to in-home water service or compromise water quality resulting in waterborne disease outbreaks (Berner & Furgal, 2005; Warren et al., 2005). In remote Arctic communities where health services are minimal and even minor water system breakdowns can last weeks, due to the need to fly-in parts or expertise to complete repairs, waterborne diseases outbreaks would pose significant challenges (Berner & Furgal, 2005; Ford et al., 2010; Marino et al., 2009; Warren et al., 2005).

Historically, Inuit maintained a state of health in balance with their native arctic surroundings (Adelson, 2005; Bjerregaard & Young, 2008). In doing so, they demonstrated unrivalled environmental stewardship, coping skills and ability to adapt in the moment (Bates, 2007). However, 21st century water and health challenges have both local and global elements. As such, they may require an additional skill set that includes longer-term perspective and preparation. These are important considerations for the region's communities and decision makers.

1.2.2.2 Nunavut Wastewater Treatment Program

In 2009, The Canadian Council of Ministers of the Environment (CCME) released the Canada-wide Strategy for the Management of Municipal Wastewater Effluent. The strategy is aimed at creating a consistent regulatory framework regarding the operation of the 3500 municipal wastewater facilities in Canada and has informed new Environment Canada Wastewater Systems Effluent Regulations (CCME, 2009; Environment Canada, 2010). The Government of Nunavut, which is responsible for meeting those regulations and implementing the strategy within all Nunavut communities, has raised concerns about their appropriateness and feasibility for the

territory. Given the operational differences and technical challenges associated with wastewater management in northern Canada, it is possible that many treatment systems will require extensive assessment, upgraded infrastructure, and increased operator expertise and training in order to comply with the new regulations. These types of changes will require considerable financial investment and long-term planning by municipal and territorial governments (Lam & Livingston, 2011).

The national Inuit advocacy organization, Inuit Tapiritt Kanatami, has also responded to the CCME strategy by stating that in order for a Canada-wide regulatory framework to have relevance to Inuit regions, it must include solutions that are appropriate for the wastewater management challenges in northern communities. These solutions must be based on both applied science (engineering) research, which accounts for the technical constraints of an arctic climate, and social science research, which incorporates the water-related "habits, attitudes and social patterns of the residents" (ITK & Johnson, 2008, p. 5).

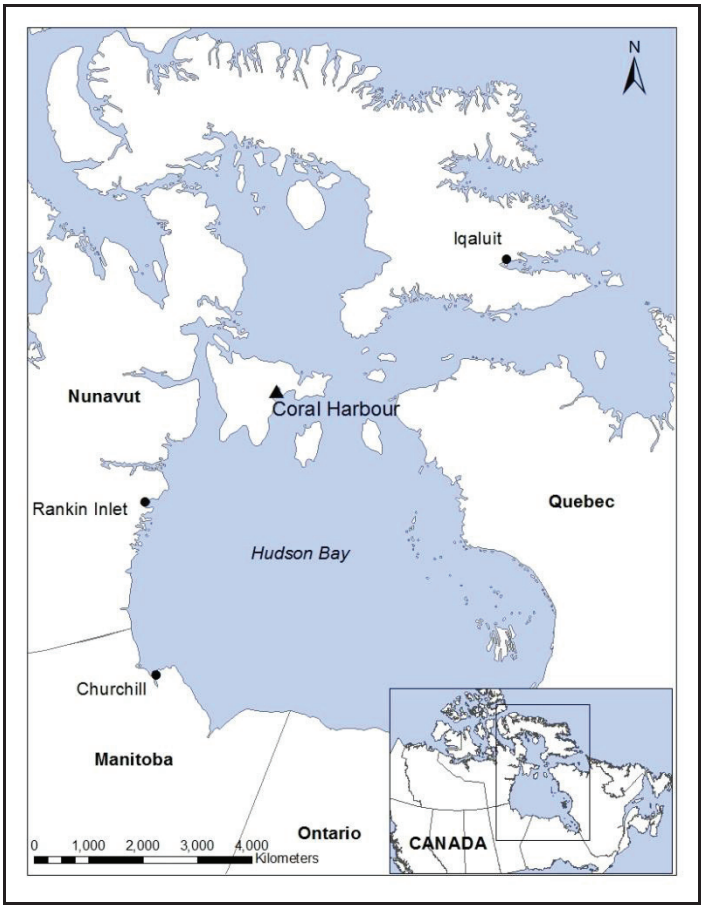
In recognition of these regional concerns, the territories and northern regions of impacted provinces were granted a five-year window to conduct the research necessary to gain a comprehensive understanding of systems currently being used and to develop appropriate solutions before being required to comply with the national strategy (CCME, 2009). In preparation to meet these impending regulations, the Government of Nunavut formed a partnership with researchers at Dalhousie University and established the Nunavut Wastewater Treatment Program. The research which this thesis is based upon is a component of that program of research.

1.3 Case Context: Coral Harbour, Nunavut, Canada

The community of Coral Harbour, Nunavut hosted this case study. Coral Harbour (latitude 64.137° N, longitude 83.167° W) is located in Nunavut's Kivalliq region on Southampton Island in Hudson Bay (See Figure 1.6: Locator Map of Coral Harbour, Nunavut). It is a remote community with no road access, but is accessible by air year-round as well as by sea during the short open-water summer season. Inuit have lived in this region for millennia as migratory

hunter-gathers. European-Inuit contact began in the 1800s and there are a few reports of Hudson's Bay Company traders relocating Inuit to what is present-day Coral Harbour in the 1920s (Damas, 2002). The community of Coral Harbour formed in the 1950s and 1960s as Inuit from the surrounding areas migrated or were relocated to the settlement as the Government of Canada increased their presence in the central Arctic by setting up schools and clinics (Damas, 2002). Coral Harbor is an established hamlet with a mayor and elected council. The hamlet employs staff members who are responsible for day-to-day operations and administration of municipal services and programs.

Figure 1.6 Locator Map of Case Study Site, Coral Harbour, Nunavut, Canada (latitude 64.137° N, longitude 83.167° W)



Coral Harbour's current population is approximately 850, of which 95 percent are Inuit (Statistics Canada, 2012; Statistics Canada, 2007). The population of Nunavut's remote

communities, including Coral Harbour, are young and growing, unlike many other rural and remote regions in Canada (Statistics Canada, 2012). Coral Harbour has a median age of 21.8 years and the population has increased 8.5 percent between 2006 and 2011 (Statistics Canada, 2012). These figures are congruent with Nunavut's overall median age of 24.1 years and population increase of 8.3 percent, but differ significantly from Canada's median age of 40.6 years and population increase of 5.9 percent over the same time period (Statistics Canada, 2012).

Despite this young and growing population, formal education attainment levels are low; 54 percent of residents aged 25-64 have not completed high school or equivalent training (Statistics Canada, 2007). Employment opportunities in the community are also limited to a few small private building and construction companies, two small general stores, ground support for northern airlines who service the region, and various government agencies. Fifty-two percent of residents rely on social assistance payments (Nunavut Bureau of Statistics, 2012). Despite these challenges, many social and cultural elements of the traditional Inuit lifestyle remain strong in the community. For instance, 80 percent of the population report speaking the Indigenous language of Inuktitut at home, with English being spoken as a second language according to a Statistics Canada survey (2007). Many residents are also skilled artists, craftspeople, storytellers, navigators, marine craft operators, mechanics, fishers, and hunters. Indeed, travelling outside the community by boat, snowmobile, or all-terrain vehicle to seasonal campsites for fishing and hunting are important activities, both recreationally and as means of acquiring food. However, without a strong wage-based economy, the community does not generate a tax base, which is typically necessary to support municipally provided services. Therefore, like all municipalities in Nunavut aside from the capital of Iqaluit, the Hamlet of Coral Harbour relies entirely on funding subsidies from territorial and federal levels of government in order to provide residents with essential services such as water and wastewater treatment.

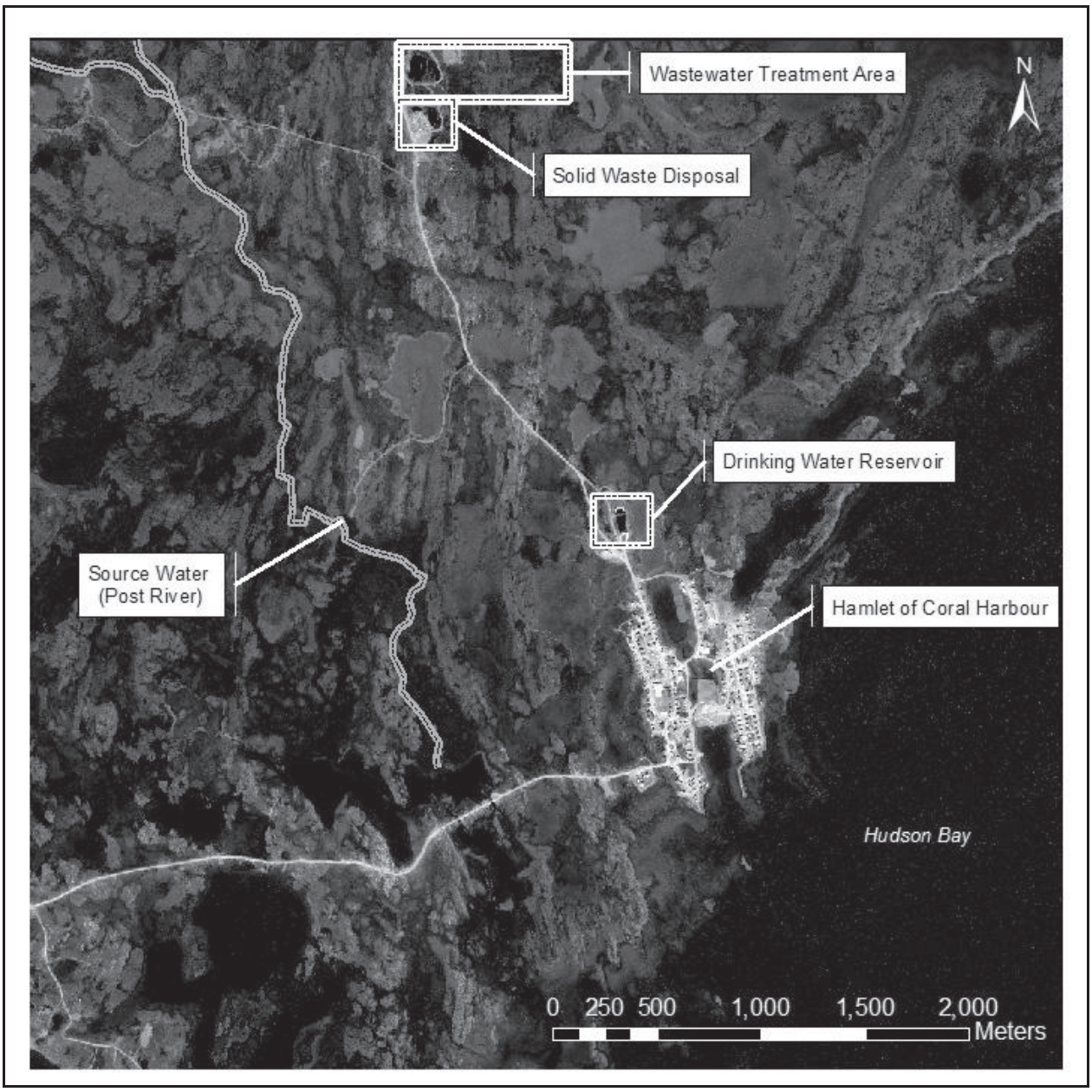
Funding assistance is also used to support public housing in the community. Of the 205 private dwellings in Coral Harbour, approximately two-thirds are public housing units (Statistics Canada, 2012). Unit types consist of single houses, semi-detached houses and row houses. Common in all of Nunavut, the units range in age and state of repair (Statistics Canada, 2010). Also common across the territory, large families and multiple generations or extended families

often reside together in one home. The average number of persons per household in Coral Harbour and Nunavut is 4.0, which is substantially greater than the Canadian average of 2.5 (Statistics Canada, 2012). In fact, the day-to-day reality of the number of people residing in a home may be even far greater. The territory of Nunavut is facing severe overcrowding issues as the population continues to outgrow the housing supply due to high birth rates (Statistics Canada, 2010). "Hidden homelessness" is a descriptor used to explain the housing circumstances in Nunavut wherein relatives and friends who do not have a permanent home reside temporarily in others' residences (Minich et al., 2011; Statistics Canada, 2010).

Coral Harbour uses truck-haul water delivery and wastewater removal systems as described above. Usually, one or two of each type of truck are in operation each day. Typically, single houses in Coral Harbour are fitted with a 1200 litre domestic water holding tank and 2400 litre wastewater holding tank, although older homes may have smaller tanks. Semi-detached and row houses have similar size tanks as single houses, however, unlike single houses, these dwellings are often constructed with shared-access tanks, which are located in an insulated area underneath the building, making it difficult to visually monitor the level of remaining water. This design creates a scenario wherein one household may be withdrawing large quantities of domestic water from the shared tank to the detriment of the other attached households.

The community sources drinking water from the Post River. From there, it is pumped approximately one kilometre into a large holding reservoir surrounded by chain link fence. The water receives chlorination treatment at the reservoir prior to trucked delivery to homes. Many residents also retrieve untreated drinking water, or ice for melting, directly from the Post River and other rivers near the community for consumption in their home. Wastewater, once collected from houses, is deposited into a passive treatment system consisting of a holding pond and large natural wetland with an eventual outflow to the sea. The wastewater treatment area is located approximately two kilometres from the community perimeter, drinking water source, and reservoir (See Figure 1.7: Coral Harbour and Features of the Water and Wastewater Systems). A chain link fence was constructed around the holding pond approximately ten years ago to prevent human and wildlife entry. The wetland remains unfenced although signage is posted in attempt to deter human traffic.

Figure 1.7 Coral Harbour and Features of the Water and Wastewater Systems



The community is served by a health clinic staffed by a team of three or four permanent and rotational nurses, a community health representative, and administrative employees. The nurses are typically non-Indigenous from southern Canada while the rest of the staff members are local Inuit residents. There are no permanent physicians in the community. Rather, general practitioners, dentists, optometrists, and other specialists make scheduled visits to the community throughout the year. Scheduled and emergency patient transfers via air to full service hospitals

in major centres such as Iqaluit (over 500 kilometres) or Winnipeg (over 1000 kilometres), at considerable financial cost to the government health system, are standard practices. Regional environmental health officers also conduct site visits to Coral Harbour and liaise with health clinic staff as well as wildlife conservation officers and the Hunters and Trappers Organization[2]. Additionally, a local group of volunteer residents and representatives from various organizations in the community have begun working on a wellness plan as part of the Nunavut Community Wellness Project and Government of Nunavut public health strategy (Coral Harbour Community Wellness Working Group, 2011; Government of Nunavut Department of Health and Social Services, 2008).

1.4 Organization of Thesis

This thesis has been prepared using a 'two manuscripts' format and is organized into five chapters. Chapter One has provided the research impetus and objectives, a review of background literature used to inform the research, and the case study context. Chapter Two is a detailed description of the methodological approach to data collection and data analysis used during the entire research process. Chapters Three and Four have been prepared as independent manuscripts intended for scholarly publication. They each highlight results and include discussion relevant to the research objectives and background literature. Specifically, Chapter Three explores the relationship between water, wastewater, and Inuit health at the household and family levels. Chapter Four offers a broader assessment of Nunavut's unique water and wastewater systems from the perspective of the community as well as insight from key informants. In following the 'two manuscript' thesis format, these two chapters have been written as comprehensive papers. As a result, both Chapter 3 and Chapter 4 necessarily include restatements of portions of background literature, methodological information, and their own reference list. Chapter Five concludes the thesis with a synthesis of results and discussion of the study's limitations, implications, and recommendations for both practical improvements and future research and policy.

[2] Nunavut Hunter and Trappers Organizations are based in each community in the territory and manage wildlife harvesting among their Inuit members.

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CHAPTER 2 METHODS

2.1 CHAPTER INTRODUCTION

The purpose of this research was to explore associations between water and health in the community of Coral Harbour, Nunavut. Through a qualitative investigation of the relationship between residents and their potable water and wastewater systems, I attempted to gain insight into the impacts that water resources and services have on public health in the community. This research addresses four specific objectives:

(1) Investigate the usage habits, opinions and social patterns of Coral Harbour residents relating to water and wastewater systems and services;
(2) Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community;
(3) Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region; and
(4) Based on new knowledge related to objectives 1-3, recommend some practical applications useful in shaping Nunavut's water, wastewater and public health strategies.

This chapter begins with an overview of the study design, followed by a description of the procedural ethics, research participant recruitment process, data collection methods, data analysis, and finally, my positionality statement. Rationale for decisions made during the various stages of the research process is included in each section. Additionally, efforts to demonstrate the credibility and trustworthiness of the research are also provided throughout the chapter (Baxter & Eyles, 1997). Limitations of the research are discussed in the concluding thesis chapter.

2.2 Study Design

2.2.1 Qualitative Case Study

Qualitative research aims to interpret phenomena and individual human experiences within a natural setting (Denzin & Lincoln, 2005; Hay, 2005). Emphasis is on gaining a holistic understanding of the issue being studied. In order to do so, the general focus is on exploring rich, setting-specific information in effort to elucidate patterns and themes that build toward a localized theory, which fits the data (Creswell, 2007; Richards, 2005). This is in contrast to quantitative inquiries designed to test a predefined theoretical hypothesis and produce widely generalizable results. Within qualitative research, questions are often open-ended, methods are flexible, and analysis is iterative. Such an approach was best suited for the exploratory research topic of this study and would render results of most benefit to the host community of Coral Harbour, Nunavut, while also making valuable contributions to the academic disciplines of Indigenous health, Inuit health, environmental health, and health geography.

A case study approach was utilized within my qualitative inquiry. Issues relating to water and health in the community were explored through the collection and interpretation of data obtained from several information sources including perspectives of residents, insights from key informants, review of government documents related to public health and water operations, and field observations. Presented in detail, this account represents a case description of water-health connections in Coral Harbour, as well as research constructs possibly transferable to similar contexts such as other remote Inuit communities in the Arctic (Baxter & Eyles, 1997; Creswell, 2007; Yin, 2009).

2.2.2 Community Involvement

Establishing a mutually beneficial research relationship with the community was of utmost importance to me, and therefore, deserves introduction in this opening section. Coral Harbour was suggested as a potential case location for this study through their involvement in the Nunavut Wastewater Treatment Program. As introduced in Chapter 1, the Nunavut Wastewater

Treatment Program is a large Government of Nunavut and Dalhousie University research partnership. As a result, a preliminary visit was made to Coral Harbour to meet with interested community members and officials about their need for the type of research I was proposing, as well as the level of involvement they were seeking, should the project interest them (Caine et al., 2009; Inuit Tapiriit Kanatami & Nunavut Research Institute, 2006; Tri-Council, 2010). Near the conclusion of this preliminary visit, I presented specific water-health issues that were identified by the members of the community that I spoke with to the municipal Hamlet council, along with a preliminary research plan. Permission was subsequently granted, via an official letter to conduct this project within Coral Harbour (Appendix A). Details of the preliminary visit and research relationship with the community are provided in Section 2.4.3.

2.2.2.1 Community Research Liaison

With guidance from the Hamlet of Coral Harbour municipal staff, Lorna Ell, a local Community Research Liaison from Coral Harbour was hired to assist with the project. Lorna became an integral member of the research team, working with me during core stages of the research including participant recruitment, data collection, interview transcript return, and presenting preliminary findings to the broader community for validation. Lorna also provided Inuktitut – English translation services and advised on the appropriateness of proposed research techniques within the local context. Her contributions to the research will be described in detail throughout this chapter.

2.3 Procedural Ethics

This research was approved by the Dalhousie University Social Sciences and Humanities Research Ethics Board (Appendix B). Measures of protecting participant anonymity and safeguarding data are described below in section 2.5.3.4. Additionally, no participants were subject to risk or harm as a result of participating in the research.

The Nunavut Research Institute is the organization responsible for research licensing within the Territory of Nunavut. I was informed by the Nunavut Research Institute that the larger Nunavut

Wastewater Treatment Program, which was initiated by the Government of Nunavut, was registered with them during its inception. As my research is a subcomponent of that project, I was not issued an individual permit (Appendix C). It should be clarified that the official title of the Nunavut Wastewater Treatment Program within Government of Nunavut and Nunavut Research Institute records is the 'Northern Municipal Wastewater Effluent Discharge Quality Objectives in the Context of Canadian Council of Ministers of the Environment and Environment Canada Wastewater Systems Effluent Regulations'.

2.4 Recruitment and Description of Research Participants

Two categories of participants were recruited to contribute to this research: residents of Coral Harbour and key health and water informants from the community and region (e.g. Territorial Government). In this section, I detail the informed consent process that was used during recruitment and provide a table demographically describing the two participant categories.

2.4.1 Recruitment of Key Informant Participants

Purposive sampling, defined as a procedure to select a participant sample based on specific characteristics, was used to recruit key informants (Bradshaw and Stratford, 2005). The inclusion criterion was that the individuals must be currently, or had previously worked, in an occupation or role that provided them with specialized insight into water or health issues in Coral Harbour. During the preliminary visit to the community, the following groups were identified as potential sources from which to recruit key informants: municipal water operators, local health centre staff, regional public health representatives, and local environmental organizations.

A total of nine key informants were recruited to participate. Initial contact was made with five out of these nine individuals during preliminary project planning. Therefore, they were familiar with the research topic when formally contacted to participate in the study via telephone, email or fax (Appendix D). I contacted the remaining four key informant participants and explained the research topic using the same recruitment tool (Appendix D). No form of honoraria was provided to key informant participants.

Data provided by key informants were based on their occupational responsibilities and mandates of their affiliated organizations. With the exception of municipal water operators, two or more participants from each group were recruited due to their varying responsibilities within their organization. I deemed I had reached data saturation within the key informant category of participants when at least one information-rich case from each of the above-mentioned groups had been recruited and the participants confirmed that there were no other representatives from their affiliated organization who could provide any further new information (Sandelowski, 1995). One member of the Hamlet staff with knowledge of municipal water operations declined to participate in a formal interview. However, they were willing to provide public information and clarify any uncertainties pertaining to water operations and procedures in the community.

2.4.2 Recruitment of Resident Participants

Resident participants were recruited using a combination of purposive sampling, defined as a strategy of selecting participants that vary along chosen characteristics, and opportunistic sampling, defined as inclusion of research participants based on unexpected and interesting leads discovered during early research phases of work (Bradshaw & Stratford, 2005). Participants selected during purposive sampling were chosen based on 'age', 'gender', and 'number of people who are residing in the household'. These characteristics were chosen because, while developing the research question, I had asserted that differences in social conditions contribute to health status, and these inclusion criteria created diversity and variability within the study population (Bradshaw and Stratford, 2005). During the initial stages of recruiting, 'location of house' was added to the purposive sampling criteria. This was done for two reasons. First, I observed that a dwelling's physical location within the community may be an indicator of the dwelling's water tank age, condition, and vulnerability to extreme weather events. Second, by plotting the dwellings of recruited participants on a map, under recruited areas of the community became apparent. From that point forward, recruiting efforts were directed accordingly. In doing so, I also guarded against any potential bias of the Community Research Liaison to recruit among nearby relatives and neighbours, however unintentional, thereby increasing the overall robustness of my strategy (Baxter and Eyles, 1997).

The Community Research Liaison and I worked together during the recruitment process. Recruitment instruments used included posters displayed in public areas (Appendix E), local radio messages, and word-of-mouth contact (Appendix F). Of the 28 resident participants who were recruited, five actively contacted me to directly express their interest in participating in the study. The remaining 23 participants agreed to participate when asked by the Community Research Liaison and I. A research honorarium of $50.00 was paid to each resident participant at the conclusion of their interview. This dollar amount was suggested by the Nunavut Research Institute as being appropriate in this community context. The participants were not informed of the honoraria during recruitment. It is possible that the residents became aware of the honorarium through word-of-mouth communication within the small community and that this may have acted as an incentive to participate. This was a potential bias among participants that I had no control over. Two residents who initially expressed interest in the topic, and were invited to participate, ultimately declined because they were too busy.

Section 2.5.1 below describes how data was collected over three rounds, each separated by a period of analysis. This staggered research design provided an opportunity for me to familiarize myself with the early data, as additional stages of collection were still in progress. Therefore, during the third round, once it became evident that the new data being collected was largely redundant, I concluded the resident participant data set to be complete (Baxter & Eyles, 1997). This is known as thematic saturation (Morse, 2000).

2.4.3 Informed Consent Process

All participants were provided with an information sheet detailing the study and the voluntary nature of their potential participation (Appendix G). In place of Inuktitut versions of the information sheet and informed consent form, the Community Research Liaison was present to translate the document into Inuktitut as necessary. As detailed in section 2.4.4, thirty-three participants chose to have the consent process and interviewed conducted in English while four chose to do so in Inuktitut. Written informed consent was obtained from all participants.

2.4.4 Description of Research Participants

Thirty-seven total participants were recruited to participate; nine key informants and twenty-eight residents. Participant demographics and characteristics are presented in Tables 2.1 and 2.2. These tables are presented to illustrate the inclusion criterion discussed above within the selected research population and to provide contextualization for participant quotes included in the Findings sections of Chapters 3 and 4.

Table 2.1 Key Informant Participant Characteristics

Participant Code	Organization	Local or Regional	Gender	Age Group	Interview Language
P-KI-1	Local Health Services (LHS)	Local	Female	50-59	English
P-KI-2	Local Health Services (LHS)	Local	Female	40-49	English
P-KI-3	Local Health Services (LHS)	Local	Female	50-59	English
P-KI-4	Local Health Services (LHS)	Local	Female	60+	English
P-KI-5	Public Health (PH)	Regional	Female	40-49	English
P-KI-6	Public Health (PH)	Regional	Male	30-39	English
P-KI-7	Municipal Water (MW)	Local	Male	60+	Inuktitut
P-KI-8	Environment (E)	Local	Male	30-39	English
P-KI-9	Environment (E)	Local	Male	50-59	English
TOTALS N=9	**LHS = 4 PH = 2 MW = 1 E = 2**	**Local = 7 Regional = 2**	**Female = 5 Male = 4**	**30-39 = 2 40-49 = 2 50-59 = 3 60+ = 2**	**Inuktitut = 1 English = 8**

Table 2.2 Resident Participant Characteristics

Participant Code	Gender	Age Group	Ethnicity	Interview Language Chosen	Number of People in Household [a, b]	Location of Home in Community [c]
P-1	F	18-29	Inuit	English	7-8	Newest
P-2	F	30-39	Inuit	English	9+	Middle
P-3	F	30-39	Inuit	English	1-2	Middle
P-4	F	30-39	Inuit	English	5-6	Middle
P-5	M	18-29	Inuit	English	1-2	Newest
P-6	F	30-39	Inuit	English	5-6	Newest
P-7	F	40-49	Inuit	English	1-2	Middle
P-8	M	18-29	Inuit	English	1-2	Oldest
P-9	M	60+	Inuit	Inuktitut	1-2	Middle

Participant Code	Gender	Age Group	Ethnicity	Interview Language Chosen	Number of People in Household [a, b]	Location of Home in Community [c]
P-10	M	30-39	Inuit	English	3-4	Newest
P-11	F	40-49	Inuit	English	7-8	Middle
P-12	M	30-39	Inuit	English	5-6	Middle
P-13	M	30-39	Inuit	English	5-6	Newest
P-14	M	40-49	Inuit	English	1-2	Middle
P-15	F	18-29	Inuit	English	5-6	Newest
P-16	F	40-49	Inuit	English	5-6	Middle
P-17	F	40-49	Inuit	English	1-2	Newest
P-18	F	50-59	Inuit	English	3-4	Middle
P-19	M	18-29	Inuit	English	9+	Oldest
P-20	F	40-49	Inuit	English	3-4	Middle
P-21	M	40-49	Inuit	English	1-2	Middle
P-22	F	18-29	Inuit	English	5-6	Newest
P-23	F	18-29	Inuit	English	3-4	Middle
P-24	M	31-39	Inuit	English	3-4	Newest
P-25	F	18-29	Inuit	English	5-6	Middle
P-26	F	41-49	Inuit	English	7-8	Newest
P-27	M	60+	Inuit	Inuktitut	1-2	Oldest
P-28	M	41-49	Inuit	Inuktitut	1-2	Oldest
TOTALS N=28	**Females = 16 (57%) Males = 12 (43%)**	**18-29 = 8 (29%) 30-39 = 8 (29%) 40-49 = 9 (31%) 50-59 = 1 (4%) 60+ = 2 (7%)**	**Inuit = 28 (100%)**	**English = 25 (89%) Inuktitut = 3 (11%)**	**1-2 persons = 10 (36%) 3-4 persons = 5 (18%) 5-6 persons = 8 (29%) 7-8 persons = 3 (11%) 9+ persons = 2 (7%)**	**Newest = 10 (36%) Middle = 14 (50%) Oldest = 4 (14%)**

[a] Categories have been created for the 'Number of people residing in home' characteristic to protect participant anonymity. [b] Some resident participants reported that the number of people residing in their home varied from day-to-day. The maximum number of people residing in their home with some regularity, defined as a few times per month, has been recorded in this table. [c] The majority of dwellings in Coral Harbour were originally built through public housing initiatives. During these initiatives, several houses of similar design were built in concentrated areas of the community. In reference to three significant periods of housing expansion, Coral Harbour residents colloquially use the categories of 'newest', 'middle', and 'oldest' to signify general areas of the community.

2.5 Research Phases

This section begins with a timeline to convey the iterative and non-linear nature of the research project. Detailed descriptions of each phase, specifically, preparation for fieldwork, data collection, and analysis of data then follow.

2.5.1 Research Phases Timeline

The research phases of qualitative studies are usually not distinct from one another; data collection, analysis, and interpretation happen concurrently over the duration of the project (Creswell, 2007). Accordingly, an iterative design was used during this research. As early data were collected and analyzed, that information was cycled back into the research design, reshaping and directing subsequent phases. Table 2.3 is a timeline of the project, and illustrates the iterative and ongoing nature of the research phases.

Table 2.3 Research Project Timeline

Dates	**Tasks**
September 2010 – January 2011	- Literature review - Establishment of community contacts - Drafted research proposal
February 2011	- Preliminary community visit
March 2011 – May 2011	- Revised research proposal to reflect input from community visit - Literature review - Ethics board approval - Fieldwork preparation
June 2012	- Fieldwork round 1 of 5: *- Data collection (9 interviews, field observation)*
July 2011 – August 2011	- Interview transcription - Data coding - Data analysis - Literature review - Refinement of data collection instruments and coding structure - Fieldwork preparation
September 2011	- Fieldwork round 2 of 5: *- Data collection (18 interviews, field observation)* *- Research update presentation to Hamlet staff and counselors*
October 2011 – February 2012	- Interview transcription - Data coding - Data analysis - Literature review - Refinement of data collection instruments and coding structure - Fieldwork preparation

Dates	Tasks
March 2012	- Field work round 3 of 5: *- Data collection (10 interviews, field observation)* *- Return of round 1 and 2 interview transcripts* *- Community validation of preliminary results via radio*
April 2012 – June 2012	- Interview transcription - Data coding - Data analysis - Literature review - Refinement of data collection instruments and coding structure - Fieldwork preparation - Preliminary results presented to Nunavut Wastewater Treatment Program advisory committee
July 2012	- Fieldwork round 4 of 5: *- Return of round 3 interview transcripts* *- Past participant validation of results including return of 'quotes in context' to participants for consent to use in thesis*
August 2012 – February 2013	- Thesis writing and revision
March 2013	- Fieldwork round 5 of 5: *- Return of completed research to community via plain language report* *- Note: A secondary purpose of this trip was to initiate a new project with the community on behalf of Dalhousie University. That project is distinct from my thesis research*
April 2013 – August 2013	- Thesis writing and revision - Thesis defense - Submission of manuscripts from thesis to academic journals

2.5.2 Research Preparation

Prior to formally beginning the data collection and analysis processes of the research, several preparation steps were necessary. These included defining the contribution of my research within the overall goals of the Nunavut Wastewater Treatment Program, establishing a research relationship with the host community, and situating the research theoretically by reviewing relevant literature. These steps are described below.

2.5.2.1 Defining the Research within the Nunavut Wastewater Treatment Program

This research was conducted as part of the Nunavut Wastewater Treatment Program. Within this program, a multi-disciplinary team of researchers worked with several communities throughout Nunavut to investigate municipal water and wastewater treatment systems and associated

environmental health risks. Collectively, the overarching goal of the Nunavut Wastewater Treatment Program was to characterize the adequacy of the current systems and create new knowledge that will be useful in shaping future municipal water and wastewater management standards appropriate for the region. As a graduate student member of this team, I had the opportunity to define a thesis project that contributed to that objective, yet had stand-alone significance in my research interest areas and those of the community.

I began the task of defining my project by reviewing the Nunavut Wastewater Treatment Program background documents and meeting with other members of the team. In doing so, I learned about the engineering challenges of municipal water and wastewater management in northern Canada. However, my curiosity was drawn to the underlying human element of the story. I wondered, "What are the connections between the unique physical and social geographies of the region, the water and wastewater systems being used, and the human health of the people that live there?" This broad question served as the foundation of the research design.

As the lone social science student on the multi-disciplinary team, the Nunavut Wastewater Treatment Program leaders believed that research like this, which focused on people and public health, may also serve as a community engagement tool. Therefore, during community updates I often presented my research in conjunction with the students who were working on the engineering aspects of the parent project in an effort to bridge the technical water and wastewater research themes of the Nunavut Wastewater Treatment Program to a local context and related public health or environmental implications.

2.5.2.2 Preliminary Community Visit and Meetings

During the summer of 2010, lead members of the Nunavut Wastewater Treatment Program team visited several of the communities who were to become involved in various components of the project, including Coral Harbour. Through this initiative, Coral Harbour was suggested as a potential case study location for my research. As advised by Chapter 9 of the Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (2010) and Inuit research organizations (Inuit Tapiriit Kanatami & Nunavut Research Institute, 2006), I visited the

community to discuss the need and interest for this research with municipal officials and residents instead of launching the project on my own volition.

During this week-long visit in February 2011, I arranged individual meetings with senior municipal staff, a municipal councillor, health centre employees, and a representative from the local Hunters and Trappers' Organization. During these meetings, I inquired about potential environmental and human health risk issues associated with potable water and wastewater management in the community. I also had several informal conversations with residents of the community to hear their perspectives of interconnected water and health issues. During all exchanges, I was open and forthright regarding my affiliation as a student member of the Dalhousie University and Government of Nunavut research partnership, explaining that the potential project would contribute to the Nunavut Wastewater Treatment Program objectives, as well as contribute towards my graduate degree. However, I expressed my desire to develop a project that also had some form of practical value to the community. At the end of the week, I was invited to present a summary of what I learned during my visit and a proposed research plan at an official Council meeting. Upon returning from Coral Harbour, I was informed of the Council's decision to support the project and an official letter was provided (Appendix A).

During the preliminary visit, I explained to the various parties I met with that I was interested in having the community involved in the research process as a contributing member. Having become familiar with the use of community-based participatory research approaches when investigating Indigenous health issues (Castleden et al., 2008; Fletcher, 2002; Israel et al., 1998), I suggested the possibility of a community advisory group. Such an advisory group would provide input on the design and direction of the research. The primary contacts determined that they were interested in, and supportive of the research, however, they would not be able to commit the time and resources necessary to participate at the level of an advisory committee. Their preferred level of involvement was to receive periodic updates on research progress and to be contacted for assistance as necessary. In lieu, administrative staff from the municipal Hamlet office suggested hiring a Community Research Liaison; they then assisted with the hiring process. As mentioned in Section 2.2.2.1, the Community Research Liaison became an indispensable member of the research team.

2.5.2.3 Ongoing Literature Review

Existing peer reviewed and grey literature was reviewed prior to data collection in order to develop an initial conceptual framework for the study. The review was conducted within literature from the fields of Indigenous health, Inuit health, environmental health and health geography; with emphasis on Arctic public health and water issues. The review of relevant literature remained ongoing for the duration of the data collection and analysis. New information and supporting evidence was incorporated as necessary.

2.5.3 Data Collection Methods

Primary data collection consisted of semi-structured interviews and field visit observations. Data collected using these methods was complemented with secondary data acquired through the review of public municipal and territorial government documents and websites pertinent to water and wastewater operations and public health.

2.5.3.1 Semi-Structured Interviews

Semi-structured interviews were used to gather in-depth accounts of participants' opinions and experiences (Kvale, 1996). This method allowed participants to fully explain the complexities of their interactions with water sources in and around the community, and how those interactions may be directly and indirectly affecting their health (Kvale, 1996).

2.5.3.1.1 Development of Interview Protocols

Two interview guides were developed, one for key informant participants and another for resident participants (Appendices H and I). Both interview guides were developed using information from Nunavut Wastewater Treatment Program background documents, the preliminary community consultation, and the literature review. Categories of questions directed at key informants included: roles and responsibilities of their position, insights into interconnected water and health issues, opinion of the community's perspective on these issues, and plans of their organization in response to changing social and physical environments.

Resident participant question categories included: opinions of water quality and safety, water usage patterns, water issues and concerns, water and health connections, and considerations of social and physical changes in their community. Several open-ended questions were included in each category, giving participants multiple opportunities to speak at length on topics they deemed most important, as well as raise additional points that were not anticipated during research design (Creswell, 2007; Denzin & Lincoln, 2005). Additional follow-up and probing questions were asked to both groups of participants as necessary.

The first round of interviews, which amounted to 8 of the total 37, and were a combination of 3 key informant and 5 resident interviews, also served as pilot interviews. Following this round of field work, and after consultation with the Community Research Liaison and my supervisory committee, the interview guides were slightly revised. Certain areas of questioning were too abstract. In an effort to increase the quality of my interview protocol, a matrix technique, which matched individual interview questions to the specific research objectives being addressed, was used to sharpen the focus of the interview guide (Appendix J). During this phase of reflection and instrument revision, I also decided that going forward I would ask demographic questions about age and number of people within the household only after a rapport had been established and an opportunity presented itself, as I perceived that they may be sensitive questions for some participants. For example, during one of the interviews following this decision, I waited until the participant relayed an experience about how long they had lived in their current home before asking their age and how many people currently resided there. For interviews where no appropriate opportunity arose to ask these questions, I relied on the Community Research Liaison to provide an estimate of this information.

Thirty-six of the thirty-seven interviews were conducted face-to-face in Coral Harbour. The exception was a key informant interview conducted via telephone due to scheduling conflicts. Resident interviews took place in participants' homes, the kitchen of the house that I rented during fieldwork, or the workplace of key informants. Interviews ranged from 25 to 90 minutes in length.

The Community Research Liaison was present during 22 resident interviews and 1 key informant interview: 23 of the total 37 interviews. As a known person from the community, her attendance contributed to a more comfortable interview atmosphere. She provided complete translation during Inuktitut interviews. Relatedly, during English interviews she restated questions or added an Inuktitut word or phrase as necessary if it appeared that the participant was not clear on what was being asked.

2.5.3.1.2 Participatory Mapping Element

Large paper maps (approximately 1 metre x 1 metre) of Coral Harbour and the surrounding areas, based on satellite images, were used as elicitation tools during the interviews. Participants marked the maps with pens and Post-it® notes indicating the physical features and locations that were relevant to their responses, such as the wastewater treatment area, a nearby river, or an all-terrain vehicle trail (Steinberg & Steinberg, 2006). Similar to having the Community Research Liaison assisting with an interview, centering the interview on a local map, aided in creating a more comfortable atmosphere (Castleden et al., 2008). It also created a more equal participant-researcher relationship (Castleden et al., 2008). To explain, as an outside researcher and visitor to the community, I was unfamiliar with many areas and landmarks around the community; therefore, if a participant's response to a question pertained to a specific place in the community, the participant had to teach me about the basic background or historical information of the place using the map as a reference. During these exchanges, the map became their instrument; re-centering power away from the researcher, and to the participant (Beyer et al., 2010).

2.5.3.1.3 Recording Data

All interviews were recorded using either a digital audio recorder or hand-written notes, dependent on participant consent. Creating an exact reproduction of interviews with hand-written notes was challenging. In an effort to increase the reliability of these types of records, I dictated the hand-written notes into a digital audio recorder immediately following the interview whenever possible. By replaying the interview in this manner, I was often able to recall additional parts of the interview that were not fully captured in my hand-written notes.

I transcribed all digitally recorded interviews. Participants were given the option of reviewing their transcribed interview for accuracy (Baxter & Eyles, 1997). A cover letter outlining the return protocol was attached to each transcript (Appendix K). The Community Research Liaison assisted with the return of these documents. Of the 37, 19 participants indicated, at the time they gave informed consent to participate, that they wished to review their transcripts for accuracy. All 19 were given the opportunity to do so.

2.5.3.2 Field Observation Journal

I also kept a field observation journal, which included written entries and photographs, during data collection. The purpose was to gain a more complete understanding of connections between people, water resources, and public health in Coral Harbour and reflection of my data collection (Kearns, 2005). Following an interview, I often added a description of the setting where the research took place, along with notes of subtle details that may have not been picked up during the recording process such as participants' body language or tone of voice during certain questions. These observations, combined with the interview narrative, produced a more robust data record (Richards, 2005). Visual observations and notes collected during site visits to the health centre, wastewater treatment area, and drinking water source were also recorded. Over repeated visits, I also expanded the field journal to include more general reflections on daily life in the remote arctic community. For instance, I created entries contrasting the differences between my summer and winter research visits and my experiences attending community events as my relationships with community members evolved over time. I also made record of my reaction to waking up in the morning to find the water storage tank of my rented house dry, and having my departure flight delayed for several days due to inclement weather. These observations and personal experiences of the social and physical environments were used to triangulate methods and corroborate data collected from key informants and residents (Bradshaw and Stratford, 2005).

During extended research visits to the community, I summarized these field notes into weekly reports and sent them to my supervisor as my representative account of the phenomenon being investigated. In response, her feedback, suggesting alternate angles to view the data were

received while I was still in the field. This debriefing process offered the perspective of a more experienced researcher with less attachment to the study location or individual participants, thereby strengthening the credibility of my account (Baxter & Eyles, 1997).

2.5.3.3 Secondary Supplemental Data

Primary data from interviews and field observation were supplemented with secondary data obtained through the review of selected public print and online documents from the Coral Harbour municipal government and Nunavut territorial government. The documents included community water usage figures, municipal land planning proposals, public housing association water tank sizes, and water-and-food borne disease investigation protocols. They were provided, by request, from the respective departments responsible for these operations. Follow-up was conducted with representatives from theses departments, as needed, to verify information and clarify questions.

2.5.3.4 Confidentiality and Anonymity of Data

Data from the digital audio recorder was immediately transferred to the hard drive of my password protected personal computer. Following the transfer, files were permanently and irreversibly removed from the recorder. To assure that interview data were not directly traceable to a participant, codes were assigned to each participant file. The participant-code key was not stored in the same location as transcribed or audio data files. Only my supervisor and I had access to the participant-code key and interview data files. Data from field observation and secondary sources was general in nature, and not attributed to any individual from the community.

Electronic copies of all data remained stored on my password protected personal computer. Printed back-up copies of all interview data were kept in a secure and locked cabinet in the School for Resource and Environmental Studies office at Dalhousie University. As per the university's policy on Research Integrity, these will be kept on file for five years, after which they will be destroyed. The Community Research Liaison was required to sign a confidentiality agreement (Appendix L).

Anonymity was not possible for this study as I interviewed participants face-to-face or by telephone. Names of participants are not included in this thesis, published academic literature, or any dissemination reports. Rather, codes are used to associate data with corresponding participants.

2.5.4 Data Analysis and Interpretation

Analyzing and interpreting qualitative data is a process of reducing a large volume of data that have been collected into a meaningful representation of the phenomena being studied (Creswell, 2007). Since few standardized analysis approaches exist when undertaking a qualitative inquiry, it is important to present a comprehensive audit trail of the analytic processes and techniques that were used (Miles & Huberman, 1994; Richards, 2005). Doing so, with thorough detail, increases the reliability of the proposed final conclusions and allows readers to decide if elements of the research are transferable to other contexts (Baxter & Eyes, 1997; Denzin & Lincoln, 2005). Accordingly, this section presents a detailed description of the qualitative content analysis process following during this research. NVivo9™, a qualitative data management software program, was used as an organizational aid during this stage of the research.

2.5.4.1 Data Coding

While fully immersed in the data during the detailed task of interview transcription, I made preliminary notes about interesting, reoccurring, or strikingly disparate participant responses as suggested by Dunn (2005). I also noted points that appeared congruent with sections of the conceptual framework, which had been created during the literature review. These notes were used to create an initial coding structure, which would be used to reorganize data into common categories in preparation for more advanced analysis (Dunn, 2005). To test the suitability of these codes, I coded three randomly chosen transcripts. Simultaneously, my supervisor coded the same three transcripts without my suggested codes as a guide. Our individual outcomes were then compared and discussed, establishing some inter-rater reliability in the analysis process (Baxter & Eyles, 1997).

Building on this preliminary work, the coding structure was updated and codes were established in a more detailed and systematic way. This revised structure still consisted of codes induced directly from the collected research data, along with theory-driven codes, which were derived from the literature review (Fereday & Muir-Cochrane, 2006). Based on techniques used by Richards (2005), this collection of codes was then split into two types to improve their usability. The first type, topic codes, also referred to as manifest codes, simply applied a descriptive label to pieces of text according to the subject (Richards, 2005). Example topic codes used included 'potable water delivery' or 'health centre visit'. The second type were analytic codes, also called latent codes, which are more interpretive of the meaning of the text, and used to advance emergent ideas from the data that were worth exploring in the context of the overall research objectives and existing literature (Richards, 2005). Examples include 'perspective of consuming untreated water' and 'communication between water operators and health service providers'. As the entire data set was being coded, I regularly circled back into the data to compare how a specific code had been previously used in earlier coding. Through this process, known as constant comparative analysis, codes were refined, combined, added, or eliminated to improve the clarity of their definitions and their connections between one another (Boeije, 2002; Lewis-Beck et al., 2004).

2.5.4.2 Thematic Analysis & Interpretation

Coding restructured the data from individual interviews and documents into a new format making it possible to examine it, not only by original source, but also by specific categories. These categories were grouped together in an effort to construct patterns and themes that offered an integrated explanation of the connections between water resources, systems and public health in Coral Harbour. As different group combinations were explored, I wrote memos documenting details of these preliminary themes (Richards, 2007). The primary technique used to examine the strength of these emergent themes, and the links between them, was qualitative cross-tabulation (Miles & Huberman, 1994; Richards, 2007). This process involved creating matrices wherein the rows and columns contained specified attribute or code variables that informed the theme. Once populated, each cell in the matrix contained text results that corresponded to the chosen variables. For example, 'age' and 'perspective of consuming untreated water' may have been

examined. This query tool can also be used to search for direct overlap between two or more codes, wherein the same segment of data relates to all of the searched categories (Bazeley, 2007). For example, the codes ‘health centre visit’ and ‘communication between water operators and health service providers’ may have been queried to find text that was coded by both.

Once several exhaustive themes were established, the interpretation stage consisted of returning to the ongoing literature review in order to situate these findings and determine their relevance and potential contribution. As interpretive writing began for the purpose of this thesis, participant quotes were purposefully chosen for inclusion in this thesis to personify the emergent themes and include the participants’ own words in the research.

2.5.4.3 Validating Interpretations

Participants as well as all residents of Coral Harbour, given that the case study was the community writ large, were invited to provide feedback on my research interpretations. This was done using two methods. The first method was through a community-wide public forum, while the second method was having past participants individually evaluate their quotes in the context of the findings. The goal of this research stage was not to persuade the entire community or participant group into complete agreement with all aspects of the findings, but rather to assure that my interpretations were, in fact, plausible explanations of the water–health connections existent in the community (Baxter & Eyles, 1997).

2.5.4.3.1 Community Validation Session

My original design idea for the validation session was a focus group in which community members would be invited to discuss the preliminary research themes. However, the Community Research Liaison suggested an alternate format that she believed would be more engaging. She explained that the community-run radio station has a large listener audience and would be a good medium, as it would allow us to share information about the study and encourage people to call by telephone to provide feedback. The callers’ comments would also be broadcast over the radio stimulating further discussion.

Deciding upon this format, the Community Research Liaison and I structured the show design to include brief summaries of all the main findings in plain language, with generous time allotted in between each finding category to allow members of the community to call in and share their opinion. No participant names or identifiers were included in the session script to assure anonymity. Additionally, the Community Research Liaison and I also prearranged a strategy for how we would handle negative personal comments from callers that were being directed at specific water or health service providers in the community, should they occur. Fortunately, no such situation arose. Prior to the session, I visited the Senior Administration Officer at the municipal Hamlet office to explain and gain approval to use the method. A trained radio station operator was also hired to provide technical support.

The session lasted one and a half hours. All of the discussion topics were read in English by me, with an Inuktitut version following directly after by the Community Research Liaison. Those who phoned in with comments, spoke in the language of their choice; primarily Inuktitut. The Community Research Liaison translated Inuktitut callers' comments into English and recorded them with hand-written notes. The entire session was also recorded with a digital audio recorder. Twenty-four people called in to provide comments on the research. An accurate count of total listeners was not available but the radio operator made a conservative estimate of 150, which is approximately 17% of the total number of residents in Coral Harbour. At the beginning of the session, we advertised that all commenters would be eligible to receive one of five randomly drawn $20.00 prizes. These commenters were not asked to provide informed participation consent as this was not data collection. Rather, the objective of this stage of the project was to subject the research to the broader community for critical comment (Baxter & Eyles, 1997). Immediately following the radio show, the Community Research Liaison and I reviewed the hand-written record to assess its completeness and clarity. The audio record was consulted as needed to fill in portions of the written record that were unclear to create a full transcript of the session. The constructive feedback received through this validation exercises (Appendix M) was integrated into the final writing of this thesis.

2.5.4.3.2 Member Checking

I attempted to contact all participants to evaluate the validity of my interpretations (Baxter & Eyles, 1997). They each received a personalized summary report of the findings written in plain language, which included quotes from their interviews that I had selected for potential inclusion in this thesis. These reports contained a covering letter explaining that their anonymity as a participant would remain protected and that they could decline use of their quotes (Appendix N). Twenty-seven of the twenty-eight resident participant reports were hand delivered by either the Community Research Liaison or I directly to participants. The remaining resident participant could not be reached. Of the nine key informant participant reports, three were hand delivered, four were delivered by mail, and two of the participants could not be reached. To summarize, thirty-four of thirty-seven participants' had the opportunity to comment on the findings. Two participants discussed the research reports with me out of interest; all agreed to have their quotes included in this thesis.

In addition to the participants and community of Coral Harbour, preliminary interpretations were also shared with an advisory committee in May 2012 through the project's affiliation with the Nunavut Wastewater Treatment Program. This committee consisted of territorial government staff and invited academics. These meetings provided a useful setting to have the research considered from a policy-making view point. While I am not aware of any direct outcomes in terms of policy resulting from this meeting yet, the advisory committee will have an additional opportunity to review this thesis and consider its recommendations in full.

2.6 Positionality Statement

Historically, research with Indigenous communities, including Inuit, has usually been initiated from outside the community by non-Indigenous researchers and local perspectives have been underappreciated or only included for token value (Battiste & Henderson, 2000: Smith, 1999). However, research by outside institutions that involves local people in all stages of the process and is relevant to local interests and needs is becoming increasingly supported by Inuit communities (Gearheard & Shirley, 2007; Inuit Tapiriit Kanatami & Nunavut Research Institute,

2006). As an outside researcher, in particular a white researcher from southern Canada, I felt it was important to be informed about these issues and follow guiding resources on how to appropriately engage in research relationships with Inuit communities including, for example, making a preliminary visit to the community and working with a Community Research Liaison (Inuit Tapiriit Kanatami & Nunavut Research Liaison, 2006).

On a more personal level, two critical points stand out when I consider my position as a researcher relative to the study participants. The first was the challenge of working closely with the community as a researcher, while simultaneously being a student who was still in the process of gaining foundational knowledge and research skills. To explain further, prior to this research I had lived in remote Nunavut communities, and experiences from that period of my life informed my research interests in environmental issues and health disparities in the region. Having the opportunity to work on meaningful research that addressed these issues was very fulfilling. However, doing so with what I perceived to be incomplete knowledge and training, was also unsettling and caused me to question the actual benefit of the research to the community.

The second point of my positionality statement stems from an experience at a research conference. At this conference, I attended a session in which a graduate student delivered a presentation about a qualitative study with an Inuit community. The research, not unlike my own, had involved establishing a relationship with the community and interviewing residents. It appeared to be a solid project and was well presented, though not extraordinary or overly memorable. However, a comment from the audience did resonate with me throughout the rest of my own program of study. The presenter was a white southern Canadian; again, not unlike me. During the presentation, she had said, “it is important to be culturally sensitive when working with Inuit communities”. I had not even noticed, as this is common language in the related academic literature and an expression I had probably used in my own research proposal. However, the commenter from the audience asked her what she meant by that expression. The question was not asked with a challenging tone, but it unsettled the presenter and she stumbled through a response that included more academic language such as “appreciating traditional knowledge”, and “accepting different ways of knowing”. The commenter thanked her for her response and then offered an alternate definition. He began by explaining that he was a medical

doctor and researcher with over 30 years of experience working and living in Inuit communities in Greenland. And to him, 'being culturally sensitive' simply meant treating research participants and everyone in the Inuit communities he visited as equals to himself; nothing more and nothing less. By no means do I ignore historical wrongdoings, some of which has caused harm to Inuit communities and contributed to current societal inequity, nor do I dismiss the guiding resources that have been written to help students like me who are interested in working with Inuit communities. However, I carried this simplified definition of 'cultural sensitivity' with me for the duration of my research interactions and time spent in Nunavut.

2.7 Chapter Summary

This chapter has described the methods used through all phases of this research and the rationale for decisions made throughout the process. Chapters 3 and 4 present the findings of my research and discuss their relevance in relation to the literature highlighted in Chapter 1. These chapters have been prepared as manuscripts suitable for submission to academic journals.

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CHAPTER 3 UNDERSTANDING MUNICIPAL WATER AND HEALTH RELATIONSHIPS IN NUNAVUT HOUSEHOLDS: A COMMUNITY CASE STUDY IN CORAL HARBOUR, NUNAVUT, CANADA[3]

3.1 Statement of Student Contribution

K. Daley was responsible for all data collection and analysis, which this manuscript is based upon, as well as writing all sections. H. Castleden actively supervised all stages of research, writing development and contributed to revisions of earlier drafts. R. Jamieson and C. Furgal offered feedback throughout the research process and editorial revisions on this manuscript. L. Ell assisted with data collection and analysis as a Community Research Liaison and reviewed the latter versions of the manuscript.

3.2 Abstract

In northern Canada, the lifestyle of Inuit, while still rooted in tradition, has transitioned from nomadic origins to one of permanent settlements. The provision and safe management of potable water is critical to the functioning and public health of any permanent settlement; Nunavut or elsewhere. In Nunavut however, underground piped water delivery, as found in southern Canada, is simply not suitable for the environmental and economic conditions. Instead, trucked potable water delivery and wastewater removal systems are used. Our exploratory research aims to understand the relationship between water services and health in Nunavut communities. Using a qualitative case study design, we conducted 37 interviews with residents and key informants within Coral Harbour to investigate water usage practices and perspectives of the water system's functionality. These data were analyzed to understand potential environmental health risks and how they may affect families in this remote northern community. We found that 15 of 28 households interviewed face water shortages at least one time per month. Furthermore, delays in regular service have limited their ability to adhere to public health and sanitation guidelines. Individuals most resilient to water shortages are those capable of retrieving their own drinking

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water directly from untreated sources. Residents with extended family and neighbours, whom they can rely on during shortages, are also less vulnerable to municipal water delays. As climate change and demographic trends continue to shape water-health relationships in Nunavut communities, our findings emphasize the need for public health initiatives that encompass both the physical and socio-cultural landscapes of the region.

3.3 Introduction

Among the 370 million Indigenous[4] people around the world, there exists a rich variety of distinct cultures and communities (United Nations, 2008). At the same time, these groups share many commonalties related to the state of their public health. Namely, the health of Indigenous populations is significantly poorer than that of non-Indigenous populations (Gracey & King, 2009). The root causes of this health inequity can often be attributed to processes of colonization and its lasting effects of poverty and discrimination (Reading & Wien, 2009). Over time, what has transpired has been a series of public health challenges, including many associated with inadequate housing, drinking water supplies and sanitary disposal of wastewater within rural and remote Indigenous communities (Gracey & King, 2009; Waldram et al., 2006). Within any given region however, diversity among Indigenous communities exists. Therefore, when attempting to reverse these trends and plan public health interventions, it is important to use an approach that considers the local context. Using a qualitative case study, the purpose of this paper is to investigate the relationship between drinking water, wastewater and health within Coral Harbour; a remote Inuit community located in Canada's Arctic territory of Nunavut.

3.3.1 Inuit Health in Northern Canada

The lifestyle of Canada's Inuit, while still rooted in tradition, has changed significantly in the latter half of the 20th century and into the 21st century. Following European contact, there has

[4] Within this paper, the understanding of Indigenous peoples employed is those who self-identify as the original inhabitants of a region or territory and maintain strong links to the surrounding natural environment and their distinct social, economic or political systems and language, culture and beliefs (United Nations, 2013). There are three distinct, politically recognized groups of Indigenous peoples in Canada; First Nations, Inuit, and Métis; they are identified in Canada's constitution as Aboriginal peoples.

been a transition from a migratory lifestyle, with all sustenance being provided directly from the land and sea, towards permanent settlements centered on wage-based economies and government services (Richmond, 2009; Young, 2008). This transition has influenced the types of health risks facing the population, although not entirely as expected (Richmond, 2009; Bjerregaard & Young, 2008). In theory, as populations have historically transitioned in this manner, the prominent health risks facing the population have generally followed a related pattern known as the epidemiological transition (Frank & Mustard, 1994). Traditional health risks, affiliated with subsistence practices and communicable diseases, have been largely supplanted by what are referred to as modern health risks, which are more closely associated with chronic and non-communicable diseases (Forget & Lebel, 2001). However, as Inuit blend aspects of traditional and contemporary lifestyles, they bear a dual disease burden characterized by aspects of both traditional and modern health risks (Bjerregaard & Young, 2008). For example, cancer, diabetes, and cardiovascular disease – modern health risks – are on the rise in Inuit populations (Bjerregaard et al., 2004). At the same time, traditional health risks such as tuberculosis, unintentional injuries, and food insecurity also remain prevalent (Bjerregaard et al., 2004; Egeland et al., 2011).

Health researchers and social scientists as well as public health organizations have recognized that the epidemiological transition, and human health in general, is driven by a number of health determinants broadly categorized as physical environments, social processes, economic conditions, health services, and individual behaviours and characteristics (Gracey & King, 2009; Public Health Agenc of Canada [PHAC], 2011; World Health Organization, 2012). In Canada, the national Inuit organization, Inuit Tapiriit Kanatami, state that Inuits' own view of their health is aligned with this holistic approach: "Inuit have long known that, to be healthy, we need healthy environments, education and employment opportunities, adequate safe housing and social supports as well as access to health care systems" (as cited in Tait, 2008, p. 9). However, a failure to formulate solutions that are culturally relevant and account for the dynamics and interconnectedness of the underlying determinants has prevented many proven health interventions from being successfully implemented in Inuit regions (Giles et al., 2010; Hankivsky & Christoffersen, 2008; Richmond & Ross, 2009). Consequently, while there have been improvements in fundamental health outcomes such as overall life expectancy and infant

mortality rates, substantial disparities still exist between Inuit and the general non-Indigenous population by virtually all measures (Bjerregaard et al., 2004; Young & Bjerregaard, 2008). Included in these disparities are numerous transmissible diseases and bacterium infections such as tuberculosis, *Helicobacter pylori*[5] *(H. pylori)* infection, and methicillin-resistant *Staphylococcus aureus*[6] (MRSA) infection. The human-to-human transmission of all these infections are associated with overcrowded housing, in-home water supply shortages, and inadequate sanitation and hygiene (Daloo et al., 2008; Hennessy, 2008; McKeown et al., 1999; PHAC, 2008).

3.3.2 Water Systems and Services in Nunavut

During the pre-permanent settlement period, Inuit retrieved drinking water, or ice for melting, directly from the source. As they moved across the landscape, waste was typically consumed by sled dogs or dispensed at safe distances from drinking water sources and shelters. During the early settlement-era, beginning in the 1950s, variations of individual-haul systems, locally referred to as "barrel and honey bucket systems", became common in many permanent settlements in the region and remained in use into the 1980s (Michael, 1984). During this period, residents individually retrieved their own water from nearby lakes or rivers and typically stored it within a large barrel. Household wastewater was usually collected in a large pail – "the honey bucket" – and removed from the home (Michael, 1984). Currently, the source water used in Nunavut's municipal water systems is retrieved in much the same as typical southern Canadian systems; that is, source water is usually drawn from lakes or rivers and piped to a central holding reservoir where it undergoes chlorination for microbial control before delivery to residents for domestic use. However, from this point on, municipal water systems and services in most parts of Nunavut are fundamentally different than those typically used in southern Canada. Aside from chlorination, water does not typically receive any additional chemical or physical filtrations, which are methods of removing harmful naturally occurring contaminants from source waters,

[5] *Helicobacter pylori* is a bacterium present in the human gastrointestinal tract. Although most people are asymptomatic, infection is more prevalent in developing countries and some Indigenous populations (Goodman & Cockburn, 2001; Goodman et al., 2008). *Helicobacter pylori* infection has been linked with chronic enteric illness, stomach ulcers and cancer (Goodman et al., 2008).

[6] Methicillin-resistant *Staphylococcus aureus* is a bacterium causing infections in humans that are difficult to treat with standard types of antibiotics. Common infection areas include nostrils and other parts of the skin (Daloo et al., 2008).

and are commonly used in much of southern Canada. Furthermore, extensive underground piped water systems, which are found in most urban areas of southern Canada, are simply not suitable for the environmental and economic conditions in Nunavut (Smith, 1996a). Likewise, permafrost which extends hundreds of metres into the ground also negates the possibility of individual water wells and buried septic systems, which are common options in many of southern Canada's rural settings (Smith, 1996a). Instead, a "trucked water system" is employed in much of northern Canada. Tanker trucks deliver potable (suitable for drinking) water to storage tanks inside dwellings (See Figures 3.1 and 3.2).

Figure 3.1 Tanker truck delivering potable water to house (photo credit: first author)

Figure 3.2 Potable water storage tank inside house, approximate capacity of 1200 litres (photo credit: first author)

Household wastewater is stored in a separate tank and pumped out using specialized trucks. When operating optimally, both water delivery and wastewater pump-out services are provided daily or at least three days per week to each home. Northern municipal wastewater management and treatment systems also differ significantly from those in southern Canada. Large mechanical systems are uncommon as the high infrastructure costs and operational requirements exceed the capacity of most remote communities (Inuit Tapiriit Kanatami & Johnson, 2008; Yates et al., 2012). Rather, wastewater is removed to designated stabilization ponds and wetlands (wastewater treatment areas), which are typically located near solid waste disposal areas outside the community to prevent hydrologic connections with municipal drinking water sources.

Access to adequate quantities of domestic water has a protective effect on human health, as well as the potential to improve poor health situations (Howard & Bartram, 2003). Despite this, international standards for domestic water supply minimum are often overlooked or unspecified (Howard & Bartram, 2003). One available review of literature on water quantity, service level and health by the World Health Organization, comprised primarily of research from developing countries, recognized 20 litres of water per capita per day as the basic minimum necessary for public health protection (Howard & Bartram, 2003). During the transition period from individual-haul to trucked water systems in Canada's northern settlements, a comparable 30

litres of water per capital per day was found to be the minimum amount required for public health protection in the region, while 65 litres per capital per day was determined as the amount of water necessary to reduce excessive incidence of gastrointestinal and skin disease (Robinson & Heinke, 1990). Based on this information, by the 1990s an augmented 100 litres per capita per day was recommended as a standard design value for trucked water supply systems in Arctic communities and is still used today (Smith, 1996b). The current trucked water system is an improvement over complete reliance on individual haul systems. These modifications to municipal water services in the Arctic, in conjunction with general improvements to housing conditions, have decreased the incidence of waterborne disease and transmission of communicable infectious diseases (Bjerregaard et al., 2008). However, rates of tuberculosis and *H. pylori* infection, conditions known to be highly transmissible in unsanitary or water scarce conditions, remain significantly higher in most Inuit communities than the Canadian average (McKeown et al., 1999; PHAC, 2008).

At the same time, changing physical environments, largely due to non-source point anthropogenic climate change, along with a growing population in the region, have also renewed concern regarding the relationships between human health and environment in the Arctic (Furgal & Seguin, 2006). In response to these pressures, health geographers, and other researchers have begun to assess the associated health risks, resilience and adaptive capacity of Inuit communities (Ford et al., 2007; Furgal & Seguin, 2006). Earlier findings have identified potable water sources and access as avenues by which climate change may increase human health risks. For example, Arctic warming may increase the risk of exposure to waterborne pathogens for those who consume untreated water (Harper et al., 2011, Martin et al., 2007), and increased variability in precipitation and storm surges may potentially damage the municipal water infrastructure and open environment wastewater systems used in most Inuit communities, resulting in inadequate treatment or lengthy delays to in-home water services (Berner & Furgal, 2005; Warren et al., 2005).

Recent federal strategies have been developed that will lead to implementation of more stringent municipal wastewater management regulations, with an aim to improve environmental and human health (Canadian Council of Ministers of the Environment, 2009]. However, territorial

governments responsible for funding and implementing the strategy have raised concerns about its suitability given technical challenges associated with water and wastewater management in northern Canada and differences in water usage patterns of the population (Lam & Livingston, 2011). There is a dearth of published research available to inform solutions that are both operationally appropriate to northern physical environments and relevant to the social conditions of rural and remote communities (Bolton et al., 2011; Inuit Tapiriit Kanatami & Johnson, 2008; Kot et al., 2011). Given this, we conducted an exploratory investigation into the current water-health relationship in a remote Inuit community in Nunavut. The main research goal was to conceptualize the specific pathways by which potable water and wastewater systems and services impact health at the household and family levels, with consideration given to the underlying social and environmental determinants shaping health in the region.

3.4 Case Context: Coral Harbour, Nunavut, Canada

Coral Harbour (latitude 64.137° N, longitude 83.167° W) is a remote community located in Nunavut's Kivalliq Region on Southhampton Island, north of Hudson Bay (See Figure 3.3). Inuit have inhabited this region for millennia, traditionally maintaining a hunting and gathering-based subsistence lifestyle. In the 1950s and 1960s the Government of Canada increased their presence on the Island, building a small school and clinic. During this time, nomadic Inuit began to settle permanently in the central community of Coral Harbour and access the education and health care services being offered (Damas, 2002).

Figure 3.3 Locator map of case study site Coral Harbour, Nunavut, Canada

The current population of Coral Harbour is approximately 850, with 95 percent of the residents identifying themselves as Inuit (Statistics Canada, 2012). Unlike many other non-Indigenous rural and remote areas of Canada, Nunavut's population is growing (Statistics Canada, 2009). Coral Harbour's population grew 8.5 percent since 2006, comparable to Nunavut's overall population increase of 8.3 percent and larger than Canada's overall growth of 5.9 percent during the same period (Statistics Canada, 2012). Demographically, Coral Harbour is a young community, with a median age of 21.8 years. Again, this is comparable to Nunavut's median age of 24.1 but in noteworthy contrast to Canada's median age of 40.6 years of age (Statistics Canada, 2012).

In Coral Harbour, large families are common as are multiple generations or extended families residing together. Of the 205 private dwellings in the community, the reported average number of persons per household is 4.0, significantly larger than the Canadian average of 2.5 (Statistics Canada, 2012). In reality, the number of people residing in many homes in Coral Harbour may be larger still; the Territory of Nunavut faces serious overcrowding issues. "Hidden

homelessness" is a term increasingly used to describe the scenario unfolding in Nunavut wherein those who do not have a home live temporarily in others' dwelling (Minich et al., 2011; Statistics Canada, 2010). Because economic opportunities in the community are limited there is no tax base, therefore, the municipality relies on funding assistance from territorial and federal levels of government. As a result, publicly-funded housing comprises approximately two-thirds of the homes in Coral Harbour and they vary in their state of repair; similar to the situation throughout Nunavut and other Indigenous communities in Canada (Statistics Canada, 2010). Dwellings in Coral Harbour consist of single houses, semi-detached houses and row houses. Generally, single houses are fitted with a 1200 litre potable water holding tank, although dependent on the age of the building the tank size may vary. Semi-detached houses and row houses have similar size water tanks. However, unlike single houses, these buildings often include shared-access tanks, which are located in an insulated area underneath them, making it difficult to visually monitor the level of remaining water.

A small health centre in the community is staffed by a team of permanent and rotational nurses – typically from southern Canada, along with local community health representatives and administrative staff including interpreters. There are no permanent physicians. Family doctors, some specialists (eg. dentists and optometrists), and public health officers make scheduled visits to the community a few times per year. Consultation with, and patient transfer via air to, full service hospitals in major centres such as Iqaluit (over 500 kilometres) or Winnipeg (over 1000 kilometres) is the norm despite the considerable cost and distance (for a discussion on the social and physical distance issues associated with rural health see for example Castleden et al., 2010). Despite these challenges, Coral Harbour is a proud, supportive Inuit community and strong ties to tradition remain. Nearly 80 percent of the population speak Inuktitut at home (Statistics Canada, 2007), with English as a second language. Travelling on the land to seasonal campsites or cabins for fishing and hunting remains integral to the lifestyle of residents.

3.5 Methods

The findings described in this paper are based on one arm of a larger municipal water and wastewater services research project underway at Dalhousie University in partnership with the

Government of Nunavut. All research activities were approved by the Dalhousie University Social Sciences and Humanities Research Ethics Board and registered with the Nunavut Research Institute licensing body (a coordinating body for the research licensing process under the Nunavut Scientists Act).

Coral Harbour was identified as a site to conduct this study through their involvement in the larger project. Prior to beginning data collection, we visited Coral Harbour to gauge interest in the topic, need for the research and level of community involvement desired in the project. This preliminary visit included meetings with senior municipal staff and elected officials as well as health centre staff and water system operators as well as casually discussed with local residents. Input gathered from this informal community engagement was presented to the Municipal Hamlet Council in the same week and permission was subsequently granted to conduct the study in the community.

During the course of the research, the Hamlet office was updated on our progress and given opportunities to provide input on our research direction and approach. This occurred both during data collection visits to the community and in between visits via telephone and email communication. The Hamlet also provided administrative support and contextual background information about municipal water and wastewater operations when requested. With the aid of the Hamlet administration, a Community Research Liaison (fifth author) was hired to assist with the research. The Community Research Liaison assisted in participant recruitment, data collection, and analysis stages of the project (See Table 3.1 for a chronological timeline of the study's in-community research stages).

Table 3.1 Timeline of In-Community Research Stages

Date	**Research Stage**	**Length of Stay in Community**
February 2011	Preliminary Consultation	1 Week
June 2011	Data Collection Round 1	3 Weeks
September 2011	Data Collection Round 2	3 Weeks
March 2012	Data Collection Round 3, Preliminary Analysis Feedback	2 Weeks
July 2012	Return of Results, Participant Review of Quotes in Context	2 Weeks

3.5.1 Participant Recruitment, Data Collection, and Data Analysis

A total of 37 interviews were conducted; 28 with residents and 9 with key informants. Key informants were purposefully recruited based on their ability to provide insight on water and health systems, services and issues within Coral Harbour and the Territory of Nunavut. They included water system operators, health care providers, public health representatives and environmental organizations' staff members. Some key informants were based in Coral Harbour and others were located across the territory.

The 28 resident participants were recruited using a combination of purposive and opportunistic sampling. The purposively recruited participants were selected based on age, gender and family size characteristics to provide diversity within the sample (Marshall, 1996). Opportunistic sampling allowed for flexibility and inclusion of additional participants on the basis of interesting leads uncovered during early stages of the research (Bradshaw & Stratford, 2005). The Community Research Liaison led the general participant recruitment process using posters, radio messages and word-of-mouth contact. Participants were given the option to review their interview transcripts for accuracy, as well as an opportunity to review how their quotes would be used in context prior to publication (Baxter & Eyles, 1997).

Interviews with residents pertained to water usage patterns, opinions of water and wastewater treatment and delivery in the community, and water-related health issues. Key informant interviews were related to their occupation or role, and the understanding that position provided them regarding water and health related issues in the community. A number of open-ended and semi-structured questions were included in the interview guide giving the participant opportunity to discuss water and health issues that they deemed important but were not anticipated during the research design (Creswell, 2007; Denzin & Lincoln, 2005; Kvale, 1996). Large maps of the community were displayed during interviews and participants were invited to mark them with pens and notes to indicate physical features and locations that were meaningful to their responses (Steinberg & Steinberg, 2006). During interviews, participants spoke in the language of their choice; either Inuktitut or English. Of the 37 interviews, 33 were conducted in English and 4 in Inuktitut. The Community Research Liaison provided full translation during Inuktitut interviews. Interview data were supplemented with secondary data from the first author's field observation

notes collected during community visits as well as public municipal and territorial government documents relating to water usage figures, land planning and municipal water infrastructure.

Data were analyzed using qualitative content analysis (Miles & Huberman, 1994; Richards, 2005) and constant comparative methods (Boeije, 2002). A code book was created consisting of a combination of theory-driven and data-driven codes (Fereday & Muir-Cochrane, 2006). The theory-driven codes were derived from existing literature on Indigenous and Inuit health, environmental health, and health geography. Data-driven codes were inducted directly from the preliminary community consultations with the community and first round of interviews. Data were coded using NVivo 9™ and continually refined, grouped and categorized into emergent themes relevant to understanding the water-health relationship among participants. On the advice of the Community Research Liaison, a community radio call-in show was used to report and refine our preliminary analysis with Coral Harbour residents and informants who lived in the community (Inuit Tapiriit Kanatami & Nunavut Research Institute, 2006). This forum allowed us to gain feedback from the broader community on the plausibility of analysis (Baxter & Eyles, 1997). Final interpretations were provided to the municipal Hamlet office. Participant quotes, used in the next section, were returned to participants in context for member checking and final permission for usage in this publication (Baxter & Eyles, 1997).

3.6 Findings

Through the interviews with residents of Coral Harbour and key informants, we identified three key themes associated with the role that water has in shaping health and well-being within the household and at the community level: (1) family structures and water usage patterns; (2) vulnerability and adaptation to water delays; and (3) water shortages as a limitation to adherence of health and sanitation advice from public health officials. We expand on these themes in the remainder of this section. A supplementary table containing participating residents' basic demographics, responses related to the number of people within their home, and frequency of water shortages has been included to provide rich contextualization for their included quotes (see Table 3.2).

Table 3.2 Resident Participant Characteristics

	Participant Code	Gender	Age	Number of People Per Household[a]	Reported "Out of Water" Response[b]
1.	P-001	F	18-30	7-8	Often
2.	P-002	F	31-40	9+	Often
3.	P-003	F	31-40	1-2	Rarely
4.	P-004	F	31-40	5-6	Rarely
5.	P-005	M	18-30	1-2	Rarely
6.	P-006	F	31-40	5-6	Often
7.	P-007	F	41-49	1-2	Rarely
8.	P-008	M	18-30	1-2	Rarely
9.	P-009	M	60+	1-2	Rarely
10.	P-010	M	31-40	3-4	Sometimes
11.	P-011	F	41-49	7-8	Sometimes
12.	P-012	M	31-40	5-6	Rarely
13.	P-013	M	31-40	5-6	Sometimes
14.	P-014	M	41-49	1-2	Rarely
15.	P-015	F	18-30	5-6	Sometimes
16.	P-016	F	41-49	5-6	Sometimes
17.	P-017	F	41-49	1-2	Sometimes
18.	P-018	F	50-59	3-4	Rarely
19.	P-019	M	18-30	9+	Often
20.	P-020	F	41-49	3-4	Rarely
21.	P-021	M	41-49	1-2	Rarely
22.	P-022	F	18-30	5-6	Sometimes
23.	P-023	F	18-30	3-4	Sometimes
24.	P-024	M	31-40	3-4	Rarely
25.	P-025	F	18-30	5-6	Often
26.	P-026	F	41-49	7-8	Sometimes
27.	P-027	M	60+	1-2	Sometimes
28.	P-028	M	41-49	1-2	Rarely

[a]Some resident participants reported that the number of people residing in their home varied day-to-day. The maximum number of people residing in their home with some regularity (defined as three or more times per month) has been recorded in this table.
[b]Where participants responded with "often", it meant at least 1 time per week, where participants responded with "sometimes", it meant at least one time per two-four weeks, and where participants responded with "rarely", it meant one time per three months or less.

3.6.1 Family Structures and Water Usage Patterns

According to municipal water usage data we were able to estimate that, on average, each resident uses about 110 l/c/d. This figure is slightly above the aforementioned 100 litres per capita per

day design standard but only one third of the Canadian average (Environment Canada, 2012). Uses for water in the household were consistent among participants and included expected consumption and hygiene activities: drinking, food preparation, bathing, housecleaning, and laundry. However, the amount of water required or desired, by each household in order to complete their day-to-day household tasks varied significantly between participants. Asked about the delivery schedule, which theoretically is daily or every other day given optimal conditions, one participant commented, *"It's pretty good. I think it's about right. It's enough for me, seeing as I'm the only person living in this apartment, I don't need a lot of water" (P-005)*. Another participant stressed the water delivery needs for her family of four, *"It's got to be daily…we'll have no water if it's not delivered on a daily basis (P-023)."* Echoing this response, another participant living in a household of nine described their frequent water shortages:

> *"My [adult sibling] showers every day and that makes my kids complain…if everyone showers or bathes it takes about half of the tank. I have to bathe my three youngest together. I don't like it but those are our limits…the water truck comes almost every day but I always run out of water…It wasn't always like this; not until my family grew. It's probably even more difficult if a family has more babies I bet" (P-002).*

Participants also reported that households with young children often require more water than they receive:

> *"I've been waiting for water since this morning [interview was conducted at approximately 4pm]. And I called the Hamlet twice, still I was waiting. I live in a [row house unit with a shared water tank] and all of us got babies. So maybe twice a week, three times a week, we run out of water…when it's almost gone…I always save a little bit of water for my little one in a container. That's about it. You can't use the toilet" (P-006).*

Contrasting the perspective of large families with young children, a participant who lived alone with her husband explained their reduced water needs, *"...I ask for [water delivery only] every second day" (P-007).* However, the same participant empathized with larger families in

overcrowded conditions, *"It's difficult for them…because sometimes they go on the radio asking to get water delivery…when they can't find the foreman" (P-007).*

Older residents (40+ years) of the community reported that they did not require the same quantity of water and frequency of wastewater removal as the *"younger generation" (Key Health Informant).*

> *"People want to be a lot cleaner nowadays. Children want to [bathe or shower] more and more…not like when we were growing up. It was different. There were hardly any water trucks, no sewage truck. I even had to take the honey bucket out…that's what we used to have, honey buckets. That's the way it was until they started getting the truck. I'm sure it was the same down South [in southern Canada] too; they had their little outhouses and we had our honey buckets" (P-014).*

These older participants, upon recollecting about the more laborious water services in the community during the 1950s and 1960s, had an alternate perspective than younger residents. In short, most were satisfied with current water and wastewater services.

3.6.2 Vulnerability and Adaptation to Water Delays

Many participants reported that municipal water delivery and wastewater removal was prone to inconsistency and delays, further straining access to water in their households. The causes of these water delays were reported as weather (particularly winter blizzards), mechanical problems with the water reservoir pumps or delivery/collection trucks, municipal holidays, and water and wastewater operator retention challenges. Two participants illustrate the impact of intermittent water service on their households:

> *"When a blizzard comes there is lots of snow...where the sewage tanks are…the sewage truck can't get there. They got to get a loader first, get it all out of there and then we can finally get water…three or four days [was the longest water delay caused by this*

situation]…[it was] terrible, frustrating. You need to shower, do dishes, but you can't...[the kids] find it tough too. Everybody uses water" (P-013).

"Sometimes they don't come as often to pump [my sewage tank] out, so my toilet doesn't flush when it's too full. The [sewage holding tank] is underneath the house and in the wintertime it gets awful because it freezes" (P-009).

Participants identified three adaptation techniques to cope with municipal water delivery delays: 1) retrieving their own untreated water, or ice, from local rivers and lakes, 2) relying on neighbours and extended family to borrow water, and 3) altering their daily activities based on water availability. For example, by independently retrieving water, one participant conveyed her high tolerance and ability to deal with delays, *"If winter, [a water delay] is no problem; pick up ice. Summer; we go to one of the rivers and pick up our water ourselves. So it's no problem (P-004).*

Relatedly, many participants conveyed their preference for independently retrieving untreated water as per traditional practices, regardless of a delay situation, which alleviated their dependence on municipal services: *"I get my own water. It's better that way" (P-027).* However, participants did not report equal ability to independently collect untreated water from rivers and lakes during delays: *"it depends on if you have a vehicle or snowmobile"(P-019).*

Relying on extended family and friends was also a common adaptation response. Examples of those responses include: *"My neighbours usually come by to get water, maybe every month…You don't even have to call, you can just walk in…We don't 'borrow' the water and we don't 'return' the water" (P-016)*; *"I go to my neighbours' and use my 4 litre milk carton to get some water" (P-017)*; *"In the wintertime, people pick up some ice and drop it off to me when I'm out. I like getting ice" (P-009)*; and *"When we are low on water, there are some friends and family just around the corner" (P-005).*

Consistently re-arranging their day-to-day activities around water delivery times was a third adaptation technique: *"You always have to think ahead to the next day [when using water]" (P-*

002). Despite noting their frustration, some participants accepted that periodically not having water at your home was part of everyday life:

> *"Six live in this house…well, [it] could be more at times when [relatives] sleep over. When there is more, we run out of water …every two or three days…Most of the time it's not fun…but it's okay…when you are used to not having water" (P-019).*

A key health informant acknowledged the overcrowding issues in Nunavut communities and how this interrelates with water provision matters, *"…A two-bedroom house that has ten people living in it; I don't think that's uncommon at all. However, the Hamlet still has a responsibility to provide these people with water. Just because there are more of them living in one house doesn't mean they should not have access to water."* Another key health informant captured aspects of the above-mentioned adaptation techniques as well as the vulnerability of certain subsections of the population to water delays:

> *"We have other means of getting water during the summer and winter too; melting ice or melting snow…we make do. But for instance, if there are people that don't have so much, like an Elder or somebody who doesn't have a husband and family around them, that for sure creates more problems because they wouldn't be able to get water supplied as much as somebody else…if they are alone in the house".*

Some participants commended the Hamlet on their level of communication when dealing with water delays. In particular, their proactive messaging via community radio: *"They will be a bit behind…[and therefore advise residents to] conserver water (P-014)*. Participants also noted, with appreciation, that the Hamlet employed workers to retrieve truckloads of ice blocks from untreated sources and deposited them in central locations throughout the community for individual household pick-up, to be melted indoors, and used for drinking purposes.

3.6.3 Water Shortages Limit Adherence to Health and Sanitation Advice from Public Health Officials

Water delays and shortages exceeded the notion of inconvenience for some participants, and began limiting their ability to adhere to hygiene related public health practices and routines. For example, one participant discussed the challenges and resulting distress of not being able to follow advice related to her child's skin irritation diagnosis when faced with water shortages:

> *"[The Health Centre said]…it's important to keep everything clean. You know, wash clothes and blankets and sheets often and stuff like that…it's stressful. I end up questioning myself…it starts in the morning and lasts the whole day, trying to keep the house clean and all that, but there are limits. I can't if there is low water…There are no showers and no laundry. You have to spare water for the next day. I am never caught up" (P-002).*

From their perspective, key health informants described Coral Harbour as a community with *"…A lot of trauma [and] a lot of chronic diseases."* They reported specifically on *H. pylori* and MRSA as two communicable infections noticeably present in Coral Harbour, which can be passed from person-to-person in overcrowded or unhygienic housing conditions due to inadequate water usage. Specifically referring to MRSA, one key informant affirmed:

> *"Poor hygiene…does contribute to the disease process… Part of stopping, or prevention of, MRSA is excellent hygiene, so clothes washing, house cleaning, bathing, having your towels clean, all of that. So with that not happening, MRSA is rampant in Nunavut…it's really bad in Coral Harbour."*

Another key health informant provided an additional anecdote regarding the health implications of lengthy water delays in a typical remote Nunavut community:

> *"Hygiene, especially for people with more than four people in the house, would be a growing concern…With tuberculosis or if it's flu season and you have to use the toilet*

so many times a day, and you have a household [with water shortages] it could be a…disaster."

Participants offered diverse perspectives on the themes of family water usage pattern variations, coping with water and wastewater service delays, and the unfortunate reality of coping with health issues without adequate household water supply. Inherent in all responses was the recognition of interconnected determinants shaping the water-health relationship in their individual households and community.

3.7 Discussion

Our study revealed that some households in this remote Inuit community are not receiving adequate quantities of municipally delivered water. As a result, their health and well-being may be negatively affected if they are not capable of supplementing their domestic water supply by other means. In our findings about family structures and water usage patterns, one respondent expressed her hope that water and health providers in her community were aware of how much water, a basic resource, is needed to care for a family. From interview data and in-situ observations, we discovered that the size of a water tank in a public housing unit is standardized to a 4-person dwelling, but age and number of people living there are not. This reality is not being taken into account as effectively as it could be. Grasping the true nature of the housing situation in the region (Minich et al., 2011; Tait, 2008) is pivotal to understanding the interconnectedness of determinants shaping health (Hankivsky & Christoffersen, 2008; Richmond & Ross, 2009).

An important precursor to effective public health interventions is isolating the nature and components of a community's vulnerability (Smit & Wandel, 2006). In relation to water and health stresses in Coral Harbour, *frequent* water supply shortages within households due to intermittent service, not *duration*, were the primary concern. The physical environment and economic realities in Nunavut limit the current options available for municipal water delivery and infrastructure (for a discussion on the burden of regulatory compliance in rural communities

see Kot et al., 2011). However, if the situation is viewed more broadly, the role of other proximal and intermediate health determinants such as adequate housing, health care systems and individual behavior, should be considered in the search for solutions to improve the situation for those most vulnerable to water stresses (Reading & Wien, 2009; Tait, 2008).

Our findings indicate residents of Coral Harbour cope with limitations of municipal water and wastewater systems by retrieving their own water or ice from untreated sources, relying on neighbours and extended family, and reconciling their daily activities with municipal water delivery schedules. Of these strategies, retrieving water independently or relying on social connections were preferred. Participants possessing the knowledge, physical ability and economic means (vehicle, fuel, tools) to access water from an untreated, yet trusted, location felt they were water secure. Friends and family who collectively looked after one another offered similar affirmation. The third strategy did not offer water security and can be understood in one of two ways. On the one hand, this strategy could be seen as a traditional Inuit method of conservation - use only what is absolutely needed. On the other hand, it diminishes the protective effect of ample domestic water quantities in relationship to public health (Bjerregaard & Young, 2008; Hennessy, et al., 2008; Howard & Bartram, 2003) and could be viewed as reverting to the low water usage rates reported in research that took place in the region's settlements during the transition from "individual-haul" (barrel and honey bucket) water and wastewater systems, to municipal services.

The changing social-cultural environment is also influencing the water-health relationship. Our findings suggest that water usage patterns differ by age: the younger generation (and fastest growing demographic in Canada) is using more water. If this trend continues, and the community continues to rely on individually retrieved untreated water as a strategy to overcome municipal water delays, younger residents who have lived in the permanent settlement their entire lives may be without the learned experience necessary to selectively retrieve their untreated water from sources perceived as having low risk – experience older residents acquired through a traditional lifestyle on the land, ice and sea. Moreover, this younger generation of Inuit has been exposed to a greater breadth of public health messaging regarding the protective effect of ample domestic water quantities and also has more familiarity with the less restrictive piped water

systems used by most other Canadians. As today's youth increases its political prowess, they may (rightly so) be less likely to accept water limitations, and the associated health risks, as facts of daily life in Nunavut.

The changing physical environment is also impacting the water-health relationship. Warming trends in the region may increase the risk of waterborne pathogens in untreated water; particularly in sources that are located in the populated areas of the settlements or near open environment wastewater treatment areas (Harper et al., 2011; Martin et al., 2007). As such, changes may be required in municipal water resource management strategies to limit exposure risk from wastewater treatment systems (Yates et al., 2012). Changing environments notwithstanding, any number of biological or chemical contaminants could theoretically be naturally present within the untreated water sources. Despite their perceived pristineness, a potential public health risk exists since these sources are never monitored. Therefore, a fundamental question arises to whether this adaptation strategy, having communities relying on untreated and unmonitored water supplies, is acceptable from a Canadian public health perspective.

3.8 Implications

In addition to health disparities between Inuit and non-Indigenous populations in Canada (Young & Bjerregaard, 2008), our exploratory case study reveals that further inequities also exist within subgroups of the population. The consequences of water shortages and service delays are more severe for participants in overcrowded housing, families with young children, and individuals with existing health issues such as communicable infections. For these vulnerable subsections of the Inuit population, water shortages and delays may surpass mere inconvenience and actually create significant health risks as their ability to adhere to hygiene and sanitation advice from public health professionals is restricted. Essentially, housing inadequacies and resulting water security issues are perpetuating traditional health risks related to infectious disease transmission (Bjerregaard et al., 2008; McKeown et al., 1999) and as a result, susceptible populations require additional, and novel, public health interventions (Lebel, 2003). The 100 litres per capita per person water supply design standards that current municipal delivery rates are based on was

informed by research that assumed homogeneity within Inuit communities and households (Robinson & Heinke, 1990; Smith, 1996a). It is now evident that this is no longer, and perhaps never was, the case. Therefore, it is time to revisit this design standard. Water supply design standards based on volume of household water tanks, actual number of occupants per household and realistically achievable municipal water delivery schedules may be more appropriate and accurate for today's North. Furthermore, such revised water supply figures, in complement with current "person per room" indicators used in overcrowded housing research (eg. Tait, 2008; Larcombe et al., 2011) may strengthen approaches to addressing the health consequences of housing issues in the region. More practical public health interventions include increased municipal delivery service, and incremental installation of larger water storage tanks and water systems which reuse shower water for toilet flushing in public housing units and building codes. Similar to Martin et al. (2007), we also suggest monitoring untreated water sources that are being used as drinking water and that consideration be given to the installation of outdoor faucets at the water reservoir, which provide treated water, and are accessible to residents for self-filling containers during delays in trucked service. Finally, systematic communication procedures between health centres and municipal water operators wherein health officials prompt additional water delivery to certain households based on their medical situation may be effective.

3.9 Conclusion

This research offers a portrayal of the interconnected relationship between water and public health in a remote Arctic community. As Inuit continue to balance elements of both traditional and contemporary lifestyles, this study has uncovered a complex scenario: in a natural environment abound with fresh water sources, some families are without adequate water supply at home. Daily water delivery per person in Coral Harbour is one-third the Canadian average. However, this is an estimate based on gross municipal delivery figures. Our data revealed that, while these relatively low domestic water quantities are adequate for some families, those living in overcrowded households are accessing water at volumes more typically seen in developing countries such as India, Bangladesh and some East African nations (Howard & Bartram, 2003). Although people are adapting by retrieving untreated water independently or sharing between

households, as was customary, – for some subsections of the population – water shortages are limiting their ability to follow Canadian public health standards.

While our findings are specific to Coral Harbour, there is some transferability to other communities given the commonalities in environmental and social conditions in northern Canada and other arctic regions. The research approach and recommendations offered here in our investigation of water and health in an Inuit community may also be valuable in strengthening future action on the heath, water security and housing burdens shared by Indigenous populations worldwide.

3.10 References

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CHAPTER 4 WATER AND WASTEWATER MANAGEMENT PRACTICES IN ARCTIC COMMUNITIES: PERSPECTIVES FROM CORAL HARBOUR, NUNAVUT, CANADA[7]

4.1 Statement of Student Contribution

K. Daley was responsible for all data collection and analysis, which this manuscript is based upon, as well as writing all sections. H. Castleden actively supervised all stages of research, writing development and contributed to revisions of earlier drafts. R. Jamieson and C. Furgal offered feedback throughout the research process and editorial revisions on this manuscript. L. Ell assisted with data collection and analysis as a Community Research Liaison and reviewed the latter versions of the manuscript.

4.2 Abstract

The provision of safe drinking water and wastewater sanitation are universally recognized as crucial to ensuring public health protection. Water and wastewater management practices are regionally tailored to suit specific locations and reduce health risks for the populations they aim to serve. They are designed for the physical environment, but also appropriate for the human environment – the sociocultural and economic circumstances of the community. In the Arctic territory of Nunavut, Canada the water-health challenges facing Inuit communities relate to an arctic climate, geographic remoteness, and tradition-based lifestyles. The purpose of our research was to gain understanding of how residents of the Inuit community of Coral Harbour, Nunavut (latitude 64.137° N, longitude 83.167° W) perceive the functionality of their water and wastewater systems and to explore related areas of potential health risk. Taking a qualitative case study approach, we conducted 37 interviews with residents and key health, water and environment informants. In our findings, we observed how the population's rapid transition from a migratory hunting and gathering lifestyle to permanent settlements with municipally provided utilities is influencing present-day water usage patterns, public health concerns, and the level of

[7] This manuscript has been prepared for submission to Polar Geography Journal.

priority decision-makers place on water and wastewater management. In our discussion we compare and contrast this scenario to water related health risks in others areas of Canada and worldwide, highlighting the lessons that can be applied across regional scales but also emphasizing place-specific circumstances that are unique to the Arctic and therefore deserve additional consideration when developing municipal water resource management and public health strategies in Nunavut as well as geographically and culturally similar settings.

4.3 Introduction

Access to safe drinking water and wastewater sanitation are internationally recognized as basic public health principles and necessary for sustaining human life (World Health Organization [WHO], 2013). However, water and wastewater treatment management practices vary worldwide; consequently the measures of acceptable water and wastewater standards also vary considerably (WHO, 2010). For example, in developing nations without centralized water infrastructure, acquiring water for domestic use and disposing of wastewater is often a daily manual task for individual families. If clean water is scarce, hauling water by pail from a distant source may constitute their most important and time-consuming activity of each day, and even then, these arduous tasks do not guarantee minimum levels of public health protection for many people (Howard & Bartram, 2003; WHO, 2013). When settlements are lacking safe domestic water and sanitation practices, this creates unhygienic living conditions wherein enteric, skin, eye and other transmissible diseases can spread rapidly between people and become difficult to inhibit (Ashbolt, 2004). This results in millions of preventable deaths per year among vulnerable populations (Montgomery & Elimelech, 2007; Prüss et al., 2002).

In stark contrast, most citizens of developed nations are accustomed to having treated water conveniently flow from household faucets and having wastewater drain immediately out of sight. These amenities can be provided in a decentralized manner, as is usually the case in rural areas where wells and on-site buried septic systems (small scale sewage treatment) are used. Or, in a centralized manner, as seen in larger towns and cities, where more sophisticated underground utilities and treatment plants serve whole communities. Community-scale systems and services are typically built, operated, and regulated by cooperating levels of government and other

stakeholders (European Commission Environment, 2012; Health Canada, 2012; Jalba et al., 2010; United States Environmental Protection Agency, 2012). While positive health effects from improved water and sanitation services are significant, they do not guarantee the elimination of all water-related health risks (Hrudey & Hrudey, 2007). For example, operational failure or mismanagement of more sophisticated drinking water treatment systems can also result in serious waterborne disease outbreaks in developed countries when the risk factors are not properly assessed and managed (Hrudey et al., 2006; Schuster et al., 2005). Such was the case in Walkerton, Ontario, Canada in 2000 when the municipal drinking water supply became contaminated with *E. coli* O157:H7 killing seven people and causing thousands more to become severely ill (Hrudey et al., 2003). Furthermore, water sources found to have high levels of heavy metals or organic pollutants, which have not been properly monitored and pretreated, can prove toxic over an extended period of consumption (Day & Dallas, 2011). Likewise, ineffective or failed wastewater treatment also poses health risks through human exposure to harmful effluent via unintentional direct contact, cross contamination of drinking water sources, or bioaccumulation in the food chain (Environment Canada, 2001; Kivaisi, 2001).

Although Canada is a developed nation, the relative substandard state of water and sanitation services in many Canadian Indigenous[8] communities has been widely reported, and in some cases, is comparable to conditions in developing countries (Canadian Broadcasting Corporation, 2011a, 2011b; Health Canada, 2013). Lacking or aging infrastructure, improper monitoring and treatment, shortages of skilled operators and health professionals (Bjerregaard et al., 2008), and inadequate housing conditions (Laracobe et al., 2011) are all interrelated factors which have contributed to the increased number and severity of water and sanitation related issues in Canadian Aboriginal communities. Underlying these factors are colonially[9] rooted social inequities which perpetuate the resulting health disparities (Adelson, 2005; Reading & Wien, 2009; Waldram et al., 2006).

[8] Within this paper, the understanding of Indigenous peoples employed is those who self-identify as the original inhabitants of a region or territory and maintain strong links to the surrounding natural environment and their distinct social, economic or political systems and language, culture and beliefs (United Nations, 2013). There are three distinct, politically recognized groups of Indigenous peoples in Canada; First Nations, Inuit, and Métis; they are identified in Canada's constitution as Aboriginal peoples.

[9] Colonialism in Canada is the displacement or appropriation of Indigenous peoples lands and rights by settlers of primarily European descent as well as the lasting, conscious or subconscious, racist and marginalizing attitudes and actions directed at Indigenous people (Adelson, 2005).

4.4 OBJECTIVE

Within the isolated Inuit communities of Nunavut (all but one of which are located north of the 60th parallel), the specific water and wastewater factors that require consideration include the arctic climate, permafrost, geographic remoteness, tradition-based lifestyle, and socioeconomic challenges facing the young territory[10] (Lam & Livingston, 2011). In a continued effort to improve the health and well-being of Nunavut residents, the Government of Nunavut has launched a five-year research program aimed at developing wastewater management practices tailored for the territory. The primary objectives of that research program are centered on physical science research, as the results will be directly used to prepare for forthcoming changes to quantifiably defined wastewater effluent treatment targets that all Canadian municipalities must meet (Canadian Council of Ministers of the Environment, 2010). The Canadian Inuit advocacy organization, Inuit Tapiriit Kanatami, have emphasized that wastewater management solutions must also account for the economic realities of the remote communities as well as the social patterns and practical needs of the systems' end users as the scale of these factors between Nunavut and the rest of Canada are substantial (Inuit Tapiriit Kanatami & Johnson, 2008).
In response, this paper draws on perspectives from residents as well as key informants from a remote Inuit community with the specific objective documenting and problematizing the human dimension of the water and wastewater challenges in Arctic Canada – the connections between the physical and social geographies, the water and wastewater systems, and the health of the people.

4.5 BACKGROUND

4.5.1 Evaluating Water and Wastewater Management Strategies

In communities where advanced water and wastewater systems are possible, planners and decision-makers use several criteria to select practices suitable for the location. Obviously, the

[10] In 1999, Nunavut officially separated from the Northwest Territories through the establishment of a modern land claim for Inuit creating a new Canadian territory. Under the terms of the agreement, jurisdiction over some territorial matters and policy was transferred to the newly formed Nunavut government (Government of Canada, 1993).

physical environment of the location is very important. For example, the types (surface and ground) and quality of source water available, terrain, topography, and climate are all physical characteristics taken into account early in the planning process (Day & Dallas, 2011). Equally important in planning decisions are the sociocultural and economic environments: the circumstances and needs of the people who will rely on the water and wastewater systems (World Health Organization, 2010). To begin with, the size of the user population and their water-related habits, attitudes, and state of health and well-being should be considered (Sullivan, 2002; Parkes et al., 2010). At the broader community scale, the presence of industrial, mining, or agricultural activity in the region will also individually and cumulatively impact the water source quality, water usage quantities, and wastewater effluent toxicity, which, in turn, may increase human health risks (Davies and Mazumder, 2003). Also, the economic and human resource capacity of the population needs to be sufficient to meet construction, maintenance and operational requirements of the infrastructure and services being considered (Kot et al., 2011; Smith et al., 2006). An understanding of the current and projected sociocultural, demographic and economic conditions in tandem with the characterization of the physical environment produces a comprehensive knowledge base for system possibilities and user needs (Waltner-Toews et al., 2003). Governments and stakeholders can then use this to inform water and wastewater decisions that provide their communities' with the best possible public health protection (Parkes et al., 2010; Montgomery & Elimelech, 2007; Sullivan, 2002).

4.5.2 Water and Wastewater Management Practices in Nunavut, Canada

The Arctic territory of Nunavut is one of the most sparsely populated regions in the world (See Figure 4.1 Locator Map of Nunavut). The 32,000 inhabitants reside in 27 remote settlements (1 city, 24 hamlets, and 2 outpost camps). The communities are spaced over a land mass that is more than two million square kilometres and there is no road access between communities, or from any one community to any other province or territory (Young, 2008). The Inuit are the first permanent inhabitants of the region, and comprise approximately 84% of the current population (Statistics Canada, 2007).

Figure 4.1 Map of Canada with the territory of Nunavut highlighted

Operating water and wastewater systems in Nunavut communities and similar Arctic regions presents unique physical, sociocultural and economic challenges. For one, the region regularly experiences temperatures below minus 30° Celsius during winter months and permafrost extends into the ground year round (Environment Canada, 2012; Smith, 1996a). Secondly, the financial investments necessary to support large water utility infrastructure projects are not feasible at this time. This is because the remote communities of approximately 100 to 2000 people are geographically isolated from one another eliminating many economies of scale. Moreover, economic ventures and opportunities are limited meaning there is no resident tax base to support such projects and, therefore, the municipality is reliant on transfers from other levels of government in order to provide essential services (Lam & Livingston, 2011; Marino et al., 2009). The typical systems for water and wastewater management used in most North American communities, largely relying on buried conveyance systems, are largely impractical for conditions in Nunavut due to their cost and susceptibility to malfunction in low temperatures (Smith, 1996a). Instead, most Nunavut communities use truck-haul distribution systems[11]. Every building is constructed with two storage tanks; one for drinking water and one for wastewater. Municipal tanker trucks provide drinking water delivery and wastewater removal daily or

[11] Exceptions to these the truck-haul drinking water systems include Iqaluit, Rankin Inlet, and Resolute Bay which use full or partial utilidor systems; these are above-ground, insulted pipes connecting buildings to central water treatment stations

multiple times per week[12] (See Figures 4.2 Tanker Truck Delivering Potable Water and 4.3 Household Potable Water Storage Tank). The truck-haul system standard currently used is designed to provide approximately 100 litres of water per person per day to each resident (Smith, 1996b). The raw source water is drawn from lakes or rivers near the communities and disinfected using chlorine before being trucked to individual dwellings (Smith, 1996a). In addition to trucked delivery, many Inuit residents also choose to collect their own untreated drinking water, or ice for melting, directly from local lakes and rivers, as was customary during the pre-settlement era[13] (Harper et al., 2011; Marino, et al., 2009; Martin et al., 2007).

Figure 4.2 Tanker truck delivering potable water to house (photo credit: first author)

[12] Except when delivery vehicles break-down, operators are unavailable due to illness or travel away from the community, and when weather conditions prevent delivery.
[13] The pre-settlement era is everything pre-1950s, at which time Inuit were relocated or encouraged to move to settlements (See footnote 2 on colonialism).

Figure 4.3 Potable water storage tank inside house, approximate capacity of 1200 litres (photo credit: first author)

Household wastewater is collected and trucked to a designated discharge and treatment area consisting of natural, or engineered, stabilization ponds (lagoons) and wetlands[14] on the community perimeter (See Figures 4.4 Typical Nunavut Wastewater Treatment Area and 4.5 Wastewater Tanker Truck) (Smith, 1996a). Wastewater is emptied from the trucks to the stabilization pond where it is held frozen through the winter months before being discharged from the pond to the wetland during the spring or summer before eventually flowing to the ocean (Smith, 1996a). Within these stabilization ponds and wetlands, all treatment processes (e.g. sedimentation, filtration, and microbial decomposition) occur naturally (Smith, 1996a). Known as passive wastewater treatment, these systems require minimal operation compared to more technically complex mechanical or chemical systems making them advantageous for remote Arctic communities where trained personnel may be limited and energy costs are high (Marino et al., 2009; Smith, 1996a). Among these systems, there are some differences in how each municipality manages their system. Some are manually decanted using pumps or siphons, while others discharge in an uncontrolled manner through permeable gravel berms. The later situation would presumably pose the greater health risk (Smith, 1996a).

[14] Exceptions to these wastewater treatment systems include Iqaluit, Rankin Inlet, Resolute Bay, and Pangnirtung which use some additional screening, filtering, or biological treatment to remove debris, coarse material, or additional solids.

Figure 4.4 Aerial photograph of a typical Nunavut wastewater treatment area consisting of a stabilization pond (lagoon) and a treatment wetland. (A solid waste dump area is situated to the left of the lagoon) (photo credit: W. Krkosek, Dalhousie University)

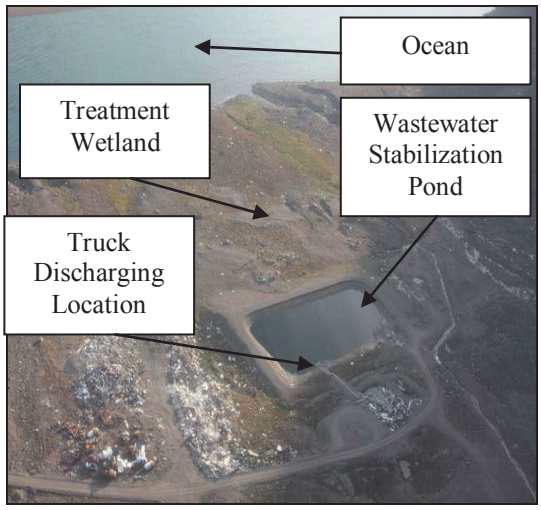


Figure 4.5 Tanker truck discharging wastewater into a stabilization pond (lagoon) (photo credit: W. Krkosek, Dalhousie University)

Pre-settlement, Inuit were nomadic hunter and gatherers who travelled in small family groups. The waste they created was minimal compared to a permanent community and was usually scattered or buried (Bjerregaard et al., 2008). Beginning in the 1950s, when the federal government's interest in establishing permanent settlements in the region was increasing, and

lasting into the 1980s (or later in some instances), early communities relied on various individual-haul systems. Referred to locally as the "the barrel and honey bucket", residents collected their own water, or ice blocks, and stored it within a large barrel. Household wastewater was collected in a simple pail – "the honey bucket" – which was then removed to either a designated community dumping spot or emptied on the ground outside the home. Upgraded water and wastewater management practices, together with relative[15] improvements in other living conditions, have resulted in some fundamental health gains within Inuit populations in Arctic communities such as increased overall life expectancy and decreased infant mortality rates (Bjerregaard et al., 2004; Young & Bjerregaard, 2008). Despite this, wide gaps remain between Inuit and non-Indigenous Canadians in most health categories (Bjerregaard et al., 2004; Bjerregaard & Young, 2008). Among these are several transmissible diseases by which spread is associated with inadequate levels of sanitation and hygiene, and domestic water supply shortages (Bjerregaard et al., 2004). Examples include tuberculosis (PHAC, 2008), *methicillin-resistant Staphylococcus aureus* infection (Daloo et al., 2008), and *Helicobacter pylori* (*H. pylori*) infection (Goodman et al., 2008). Similar water-health relationships have also been investigated in Native communities in rural Alaska, which have geographical and sociocultural similarities to Inuit communities in Canada's Arctic (Hennessy et al., 2008). Inuit populations are also at higher risk of environmental contaminants due to their traditional diet which includes significant proportions of locally caught fish, as well as land and marine mammals (Berner & Furgal, 2005; Donaldson et al., 2010; Suk et al., 2004).

Additionally, within the context of climate change research, it has been suggested that the basic water and wastewater systems in remote Arctic communities are vulnerable to extreme weather events, rising temperatures, coastal erosion, and flooding (Berner & Furgal, 2005;Warren et al., 2005). For example, damaged infrastructure or flooded treatment areas could compromise water quality and public health protection resulting in waterborne disease outbreaks (Berner & Furgal, 2005; Warren et al., 2005). The fate and transport characteristics of many pathogenic microorganisms may change with rising temperatures as well (Berner & Furgal, 2005). Referring to the health impacts of such an occurrence and the strain that would be imparted on the limited

[15] Despite improvements in the improved condition of new housing structures being built in Nunavut compared to the early-settlement era, housing remains as an important issue in the territory. Housing shortages, crowded housing, and aging public housing units in disrepair are all problems (Minich et al., 2011).

capacity of remote arctic communities, Warren and colleagues (2005) indicate that, "the magnitude of the health crisis is dependent upon resources that are available to respond to the emergency and the time frame in which resources are made available" (p. 488). Currently the territory does not have a rigorous drinking water quality monitoring and reporting protocol (Hrudey et al., 2006). In most Nunavut communities, medical services consist of only a small clinic and even minor water system repairs can take weeks due to the need to fly-in parts or expertise. Therefore, despite any reports or evidence of recent large-scale waterborne disease outbreaks in Nunavut, such an occurrence would pose a significant threat (Berner & Furgal, 2005; Ford et al., 2010; Marino et al., 2009; Warren et al., 2005).

4.6 Case Context: Coral Harbour, Nunavut, Canada (latitude 64.137° N, longitude 83.167° W)

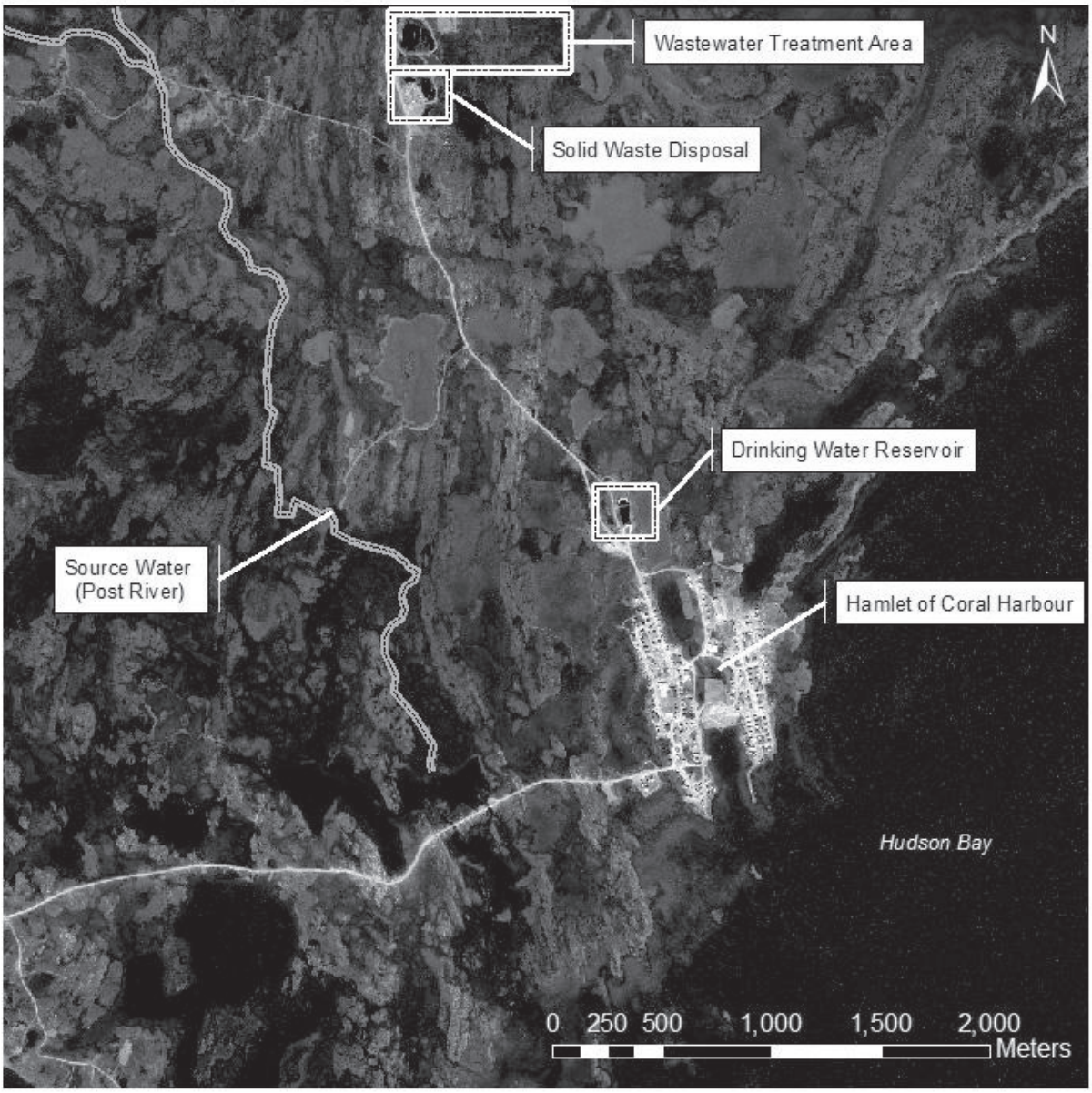
Coral Harbour, Nunavut is a remote community located on Southampton Island, north of Hudson Bay (See Figure 4.6 Locator Map of Coral Harbour). The community has a population of 850 residents representing an 8.5 percent increase since 2006, due primarily to high birth rates (Statistics Canada, 2012). Ninety-five percent of Coral Harbour residents are Inuit and the community remains closely connected to traditional hunting and gathering practices, which are reflected in their mixed economy of wage employment and subsistence activities (Statistics Canada, 2007).

Figure 4.6 Locator map of case study site Coral Harbour, Nunavut, Canada

Coral Harbour uses truck-haul water delivery and wastewater removal systems as described above. The municipality sources drinking water from a river approximately one kilometre from the community. The river water is pumped into a large holding reservoir which is located on the edge of the community. The reservoir is uncovered but surrounded by a chain link fence. At the reservoir, the water is chlorinated and then trucked to storage tanks in individual homes. Many residents also independently retrieve raw drinking water, or ice for melting, from the same source river. The municipal wastewater discharge and treatment area consists of a stabilization pond (lagoon) and wetland. It is located approximately two kilometres from the community, drinking water source, and reservoir (See Figure 4.7 Coral Harbour's Water and Wastewater System Features). The lagoon was constructed in 2003 and prior to that time wastewater was discharged directly into the natural wetland (Nunami Jacques Whitford Ltd., 2007). Effluent from the lagoon ideally flows in an east-to-west direction through the approximate two

kilometers of wetland before reaching the ultimate receiving waters, which is the Arctic Ocean. A chain link fence surrounds the lagoon to limit human and wildlife traffic while the wetland remains open. The current municipal wastewater management licensing criteria is set at a maximum of 10,000 colony forming units (CFU) of viable bacteria per 100 millilitres of sampled water from the treatment wetland (Nunavut Water Board, 2013). Despite any reported wastewater related disease outbreaks, this treatment target may appear lax in contrast to allowable CFU maximum regulations in other regions that use wetlands for municipal wastewater treatment (United States Environmental Protection Agency, 1999).

Figure 4.7 Reference Image of Coral Harbour's Water and Wastewater System Features



The community is serviced by a small health clinic; there is no resident doctor. Rather, the clinic is operated by three or four nurses and support staff. General practitioners visit the clinic approximately once per month. Regional public health officers conduct site visits to the community biannually and as needed for investigations of individual diseases cases and

outbreaks. In between visits, they liaise regularly with the health clinic and local environment and hunter sand trappers organizations on community public health matters.

4.7 Research Approach and Methods

Several communities are participating in various components of the larger Nunavut municipal water management research program. For this particular research, the Government of Nunavut suggested Coral Harbour as a possible case study because the community's previous involvement as a field site for engineering aspects of the larger research project, geographic and population similarities to several other communities in the territory, and previous participation in other public health initiatives (Coral Harbour Wellness Working Group, 2011). The lead author made a preliminary visit to Coral Harbour in March 2011 to discuss the community's interest in expanding their involvement within the larger research program beyond being only a field site for the technical engineering aspects. Specifically, the research team was interested in broadening the foci to include drinking water, and more importantly, we were interested in working closely with the community to add a human dimension to the project – perspectives of the water systems' users. At the conclusion of this one-week visit, a summary of the community's interest and a research plan were presented to the Hamlet of Coral Harbour's elected municipal council and senior administrative employees in request to conduct the study in Coral Harbour. Given the substantial interest from residents and community organizations, permission was granted. The municipal office also advised on the hiring of a Community Research Liaison[16], who assisted with participant recruitment, interviews, validation of results, return of participant transcripts, and gaining consent to include participant quotes in dissemination material. During all of these research activities, she provided translation as needed between English and Inuktitut.

4.7.1 Participant Recruitment and Description

A total of 37 participants were recruited: 9 key informants and 28 general residents (see Table 4.1: Summary of Key Informant and Resident Characteristics). Key informants with expertise in

[16] The fifth author.

water operations, health services, or environmental and wildlife issues were purposefully recruited based on their ability to provide insight into the research objectives (Bradshaw & Stratford, 2005). General residents were recruited through a combination of purposeful and opportunistic sampling (Bradshaw & Stratford, 2005). The purposive sampling criteria included gender and age to gain a diversity of perspectives and variability within the community (Patton, 1990). Opportunistic sampling was also used to recruit additional participants based on potentially important leads that were uncovered during early rounds of data collection (Bradshaw & Stratford, 2005). Word-of-mouth contact, posters, and local radio messages were used as recruiting tools. Ethical approval to conduct this research was obtained from Dalhousie University's Research Ethics Board and informed consent was obtained from all research participants[17].

Table 4.1 Participant Characteristics

Category	Total	Gender	Age Range	Ethnicity
Key Informants	N = 9	Female = 5 Male = 4	Not Applicable	Inuit = 3 Non-Inuit = 6
Residents	N = 28	Female = 16 Male = 12	18-29 = 8 30-39 = 8 40-49 = 9 50-59 = 1 60+ = 2	Inuit = 28

4.7.2 Data Collection, Analysis, and Interpretation

Primary data were collected using semi-structured interviews (Kvale, 1996) over the course of four field visits to Coral Harbour between June 2011 and July 2012. Each visit lasted two to three weeks. During interviews, residents were asked to discuss their opinions regarding community water and wastewater management practices and related health risk perceptions. Interview questions directed at key informants were similar in nature, however, they were also asked to elaborate on water-health issues facing the entire Arctic region based on insight from their role within their respective organizations. Large paper maps of the community and

[17] Typically any university-based research in Nunavut requires a license from the Nunavut Research Institute. In this case, with the Government of Nunavut as a partner and funder, a license was not required but the project was registered with the Nunavut Research Institute.

surrounding area were displayed during all interviews. As participants were responding to questions, the maps were used to reference locations and physical features that they identified as important aspects of the community's water landscape (Steinberg & Steinberg, 2006). Interviews were recorded using either a digital audio recorder or hand written notes, depending on participant consent. The lead author transcribed all interviews and they were returned to participants to verify accuracy (Baxter & Eyles, 1997).

Interview data were supplemented with secondary field observation data obtained during site visits to the wastewater discharge and treatment areas, drinking water source and reservoir, and the local health clinic. Additionally, municipal and territorial government employees provided relevant information for a document review. Documents reviewed included municipal water usage figures, community land planning proposals, and communicable water and food borne disease investigation protocols.

Data were examined using a process of qualitative content analysis. To begin, all data were coded using categories that were induced directly from the data themselves, or categories which had been defined during a literature review of pre-existing water resource management and Indigenous health research (Fereday & Muir-Cochrane, 2006; Richards, 2005). The coded data were then further examined for patterns and themes. The qualitative data management software program NVivo9™ was used during the analysis process. Each participant received a summary of the research findings, which included representative quotes from their interview. At this time, they were encouraged to provide critical feedback as well as informed consent for anonymous inclusion of their quotes in research output materials (Baxter & Eyles, 1997). Our interpretations were also shared with the community at large to evaluate their validity (Baxter & Eyles, 1997) by way of a local radio event, a very popular communication medium in Coral Harbour. Each of the major thematic findings was explained and listeners phoned in to ask questions and discuss the plausibility of our interpretations. Preliminary results were also critiqued by an advisory committee consisting of territorial government staff, as well as invited third-party academics, who were unaffiliated with the research. Feedback received during these stages was incorporated into the findings, which are presented below.

4.8 Findings

Our findings establish the community users' perspectives of the functionality and associated risks of Coral Harbour's water and wastewater systems. They elucidate how traditional practices and early-settlement municipal services have influenced current usage habits and public health concerns related to water and wastewater management. Key informants' perspectives project the long-term water resource management and public health planning that is necessary in order to respond to these community needs and prepare for the unique challenges across the region. Participant quotes are used throughout the findings and the gender and age range are provided to give context to quotes.

4.8.1 Past Practices

Overall, participants had a high level of awareness regarding drinking water and wastewater treatment systems and management practices, as exemplified by one participant's comparison of Coral Harbour to other Indigenous communities in Canada: *"I know we are better off than some" (female, 40s)*. This keen awareness may be a reflection of the fact that in-home water and wastewater services are relatively recent amenities in the region. For instance, one participant described his experiences prior to moving into the settlement in the 1950s: "*We weren't living in the settlement at Coral Harbour so we would get [ice to melt for drinking water] ourselves by dog team in the winter and water from the river in the summertime; that was the way of travelling and getting water" (male, 60+)*. Regarding wastewater practices, another participant noted, "*Before there were buildings, there were tents that we lived in. We were really careful with our waste back then. We had to go very far away to dump waste. We used to dig holes and bury it, or [alternatively] the [sled] dogs would eat [all of the waste] back then" (male, 60+)*.

As more families moved into the settlement of Coral Harbour in the late 1950s and early 1960s, government services increased and more dwellings were constructed through public housing initiatives. Our data reflect a chronological narrative of water that parallels this period of community history. One resident begins the account: *"The water and sewage system is fairly new. In the 1960s and 1970s we lived in [housing that did not have plumbing] and everyone went*

to get water for themselves. There was just a large community container" (male, 50s). Another participant explains that this community water container was filled *"from the lake in the summer and [from the same lake after] using an auger though the ice in the winter. There was no Javex (chlorine-based, or any other type of disinfectant) used." (male, 50s).* Transitioning the conversation to wastewater services, the same participant explains, "*Sewage and garbage pick-up [services] had started [at this time]. We had honey buckets (pail toilets lined with disposable plastic bags) and we would put the bag outside with the garbage into barrels. A truck would come and pick them up*." This truck deposited both solid waste and wastewater into a dump site beyond the perimeter of the settlement. There were no municipal wastewater treatment systems of any kind.

Beginning in the 1980s *"there was a water truck and water storage tanks [inside most homes], but no pipes in the house. Running water was afterwards. It was a lot of work [retrieving water from the storage tank for daily usage] and taking the honey bucket out" (female, 40s)*. The community's drinking water reservoir was also built during this decade. However, prior to construction of the reservoir, a former water truck driver stated that, *"the trucks went right to the river and drew water from there. They [added] chlorine [into the filled truck]" (male, 50s).* During the 1980s the community also transitioned from the original settlement dump site to the current separated solid waste and wastewater treatment areas as recalled by a participant: *"[The community used the old dump site] until someone figured out it was too close to the sea and so I guess they stopped and moved [waste deposits to the current sites]" (male, 50s).*

Reflecting on the positive progression of water and wastewater services in Coral Harbour, a younger participant noted: *"I think there were even houses without pipes in the 90s. I'm glad that no one has to live like that anymore" (female, 20s).* Similarly, a key informant summarized the scale of the settlement's transition:

> *"As the community grew, they had to accommodate then just as we do now. When you walk around town, you can see the old areas and the newer areas [based on] the difference between houses. Every time a new area was built, [water and wastewater services] evolved. It took us time to keep up regarding water and sewage systems. My*

fellow Canadians in the South had these types of things for a while but it takes time. That's how it evolved to what we have now."

4.8.2 Perspectives of Current Risks

The two most prominent concerns amongst residents regarding current water and wastewater management practices in the community were: 1) perceived health risks related to the proximity, and potential hydrological connectivity, of the wastewater discharge and treatment area to nearby lakes, residential or recreational areas, the drinking water reservoir, and the treatment wetland's sea outflow point; and 2) the accessibility of the drinking water reservoir and the wastewater treatment area to wildlife. These are community concerns because local caribou, geese, eggs, fish, sea mammals and other wildlife are regular parts of most residents' diet, thereby creating, *"a potential vector or mechanism for disease" (key informant).* Residents agreed that the chain link fencing constructed around the wastewater stabilization pond (lagoon) and drinking water reservoir has been effective, but the treatment wetland is still open and residents believe that there are remaining wildlife access issues: "*It's kept the caribou out but I know the geese go in there over the fence, and I know there are ducks in the lakes near the [wastewater treatment area], and other smaller birds that lay eggs, like sand pipers and eider ducks, around there too" (male, 40s)*. While explaining indirect human health risks via the consumption of wildlife that may have come in contact with wastewater contaminants, a key informant alluded to interconnected socioeconomic factors in the community that contribute to this potential route of exposure and the fact that some residents are likely not aware, or do not fully understand, that the wetland areas is receiving wastewater effluent that is only partially treated: *"If [residents] have the means to go to the bird sanctuaries or further away, where there are more geese, they go. But there are lots of people in town that don't have snowmobiles and quads (all-terrain vehicles) and they will be shooting geese close to town and collecting eggs within walking distance."*

In addition to traditional hunting and gathering practices, an affinity for non-chlorinated drinking water, or melted ice, retrieved directly from rivers still persists among many participants. In fact, not only is it perceived to have a better taste, but many residents trust the quality and safety of water that their families have personally collected from known sources more than municipally supplied chlorinated water, as one participant explains: *"To actually know there is nothing added*

to it feels safer" (female, 20s). Another participant elaborates, explaining that traditionally, the critical feature of trusted water is not that it is chlorinated but that it comes from a fast flowing source: *"[Municipal water] has a weird taste sometimes; mostly in the summer time. We get water from the river and that is better. It's really good. It's flowing. It's not in the same spot. The water reservoir is just sitting there. It should be moving and flowing" (male, 60+).*

Several participants attributed increased enteric illness during the spring season to water and wastewater management practices. As large volumes of snow accumulate in the wastewater treatment area over the long winter, and then, when temperatures rise in the spring residents were concerned about the possibility of the melt water carrying contaminants as it flows into nearby bodies of water and other community areas. One participant shared his view of this situation: *"For some reason every spring, say May or June, everybody in town gets the stomach aches, diarrhea, vomiting, and stuff like that. It seems to happen every year. I think it's the water" (male, 30s).* Although no cases of enteric illness with a link to wastewater management practices have been confirmed at the local health centre, a key health informant also contemplated this issue: *"I wonder about the diarrhea and vomiting going around in the community in the spring. Is it something from the food or water?"*

The prevalence of *Helicobacter Pylori* infections has also garnered the attention of both health providers and residents in the community, in part due to the high level of uncertainty associated with the epidemiology of the bacterium (Goodman & Cockburn, 2001; Goodman et al., 2008): *"[the bacterium] just sort of stays, and for whatever reason, it just multiplies to an out of control state [in the community's Inuit population] and they experience a lot of abdominal pain"* (*key informant*); *"It has gotten worse…a lot of people are getting that H. Pylori. So I've been wondering is it from our water, or from our caribou, or from something else? What's causing it?" (female, 30s).* In response to both common and emerging waterborne disease and contaminant issues in Coral Harbour and across the territory, key health informants have resources and strategies which are meant to be applicable Canada-wide but have proven considerably more difficult to apply in Nunavut. Findings related to these challenges as well as potential water-health opportunities for the regions are documented in the next section.

4.8.3 Addressing Challenges and Recognizing Opportunities

Key health informants made particular reference to current drinking water and public health protection policies and pointed out the challenges of applying them to conditions in Nunavut:

> *"The Canadian Drinking Water Quality Guidelines [Health Canada, 2012] are [available as a resource] but Nunavut is struggling with that. Typically, [Nunavut communities including Coral Harbour] are not filtering the water, just chlorinating it. The water sources are really good from what I can gather; they typically have good bacteriological results. But, there is no general chemistry or metal scan done on the water sources. Also, a lot of concern comes from the fact that they are handling the water a lot. They are putting it in trucks and then trucking it to individual homes."*

Another key health informant explains the issues related to incomplete water quality records in Nunavut: *[As remote fly-in communities], it's very difficult for Hamlets to send their water to an accredited laboratory because of flight schedules and frequency of cancellations, however, the Hamlets have a legal obligation to get their water tested."* In addition to these geographic challenges, the social environment in remote Inuit communities also indirectly has an impact on water safety:

> *"Sometimes water samples don't come in. Compliance issues like this lead me to believe that this is not a [top] priority [for Nunavut municipalities]. They are struggling with so many things. That is not to excuse it either…but there are a lot of other things that form priorities in the communities and rightfully so; there is a lot of hunger, a lot of homelessness. There are other kinds of social problems going on the communities so I think that Hamlets are placing their focus on those issues [above water and wastewater management]" (key informant).*

At the same time, key health informants were not confident about the preparedness of the local health resources to deal with potential water-related public health issues, such as a large outbreak of waterborne disease in the community:

"I think it would overwhelm us pretty quickly. The majority of health centres or outpost stations do not have a resident doctor. The nurses are your first point of contact and your caregivers. When you have a small centre [such as Coral Harbour], obviously it doesn't take much to overwhelm the nursing staff. And the tertiary care centres in Iqaluit, Rankin Inlet, or Winnipeg (where patients would be transferred to by air) would get overwhelmed as well. So they have the expectation that the [patients] get maintained here, so you would have to get relief nurses [flown] in. We have a hard enough time getting staff as it is. I don't believe the territory is prepared for anything like that."

All key informants described how these challenges stemming from Nunavut's remote geography and minimally staffed government departments have groomed them to be resourceful, collaborative, and novel in their work approach. Health, municipal water, environmental conservation, and Hunter & Trapper Organizations[18] often cooperate, both formally and informally, through the sharing of expertise, information, labour, and equipment. Another key health informant emphasized how these virtues of resourcefulness and spirit of collaboration exemplify the type of attitude needed as Nunavut aims to develop sustainable 'made-in-the-North' strategies to overcome their unique water, wastewater, and public health challenges:

"This is a new Territory. We have an opportunity. Let's use it for the benefit of the population. This is not the South, but that doesn't mean that the public health standards should change. [The residents of Nunavut] are people of Canada. They deserve the same standards and quality as the rest of Canada. Public health shouldn't be sacrificed – but how we get there may be different than how we do it down South."

In the findings we see evidence of the enduring influence that sociocultural values and behaviours from periods past have on contemporary water usage patterns and human-environment interactions, and in turn, the implications for municipal water resource management and public health. We now discuss these findings relative to water related health risks in others areas of Canada and worldwide, highlighting the lessons that can be applied across regional

[18] Nunavut Hunter and Trappers Organizations are based in each community in the territory and manage wildlife harvesting among their Inuit members.

scales but also emphasizing place-specific circumstances that are unique to the Arctic and therefore deserve additional consideration when developing municipal water resource management and public health strategies in Nunavut as well as geographically and culturally similar settings.

4.9 Discussion

The water and wastewater management practices in Nunavut present dual scenarios of waterborne disease risk. In one scenario, risks are reflective of those typical to conditions in developing nations wherein populations have only basic, if any, community-level water and wastewater systems and public health protection yet rely heavily on their immediate environment and surroundings for subsistence (Ashbolt, 2004; Kiviasi, 2001). For example, the practice of consuming untreated drinking water, which dates back to pre-settlement Inuit lifestyles, may increase the duration and frequency of exposure to local environmental contaminants within contemporary permanent communities (Harper et al., 2011; Martin et al., 2007; Suk et al., 2004). Despite Nunavut being a territory of Canada, the most accurate scale for weighing these benefits and risks may be found through an understanding of similar water resource management practices in developing nations.

Furthermore, the water-related practices dating back to pre-settlement Inuit lifestyles have significant cultural value and have an important role within local economies. By no means is our intention to dissuade these customary activities or downplay their benefit, however, such activities also inherently present different public health risks associated with current municipal water and wastewater management practices.

The second scenario of waterborne disease risk sees Nunavut facing similar challenges to those of municipalities in southern Canada or other developed nations. In our findings, key informants discussed incomplete monitoring and record-keeping, and shortages of qualified operators. Additionally, there are challenges with maintaining residual chlorine levels through the many steps of northern water distributions systems (treatment plant to truck, truck to household tank, household tank to tap) before the water reaches household taps, which is essential to protecting

public health. These are all factors that have contributed to waterborne disease outbreaks in non-Arctic Canadian communities using more advanced water and wastewater systems in affluent nations (Hrudey et al., 2003; 2006; Kot et al., 2011; Schuster et al., 2005). Often, water and wastewater system design decisions are heavily based on best practices that have proven suitable in past locations with similar physical environment characteristics (Day & Dallas, 2011), however, this second risk scenario also reinforces the need to tailor technical best practices to also account for place-specific social, cultural and economic variables such as the public health trends, living conditions and water use related behaviours of the local population (Waltner-Toews et al., 2003; Montgomery & Elimelech, 2007; Sullivan, 2002).

The feasibility of passive wastewater treatment systems to lower pollutant concentrations in an arctic climate has been demonstrated from a purely physical science perspective (Yates et al., 2012), but in-depth research has not yet been conducted on the exposure pathways and human health risks associated with treating wastewater in natural ponds and wetlands – which are potentially open to wildlife – in Inuit communities with traditional diet practices. Although potential exposure pathways and community concerns have been highlighted in our findings, it is difficult to demonstrate a direct causal relationship between select illnesses and environment or living conditions in a research context (Agency for Toxic Substance and Disease Registry, 2005). With that said, the addition of qualitative data about the water and wastewater systems users' behaviours to technical knowledge of water and wastewater operations does allow potential exposure pathway assumptions to be refined (Agency for Toxic Substance and Disease Registry, 2005). When applied in our study, this approach created a more accurate understanding of human-environment interactions. This type of information can be used to begin assessing situations where residents may be potentially exposed to hazards, the degree of health risks involved, and where public health interventions could be targeted. A full human health risk assessment of the exposure pathways identified would need to involve an extended period of further research and evaluation. This fact notwithstanding, given our current understanding of the situation, short-term precautionary measures could be implemented in order to decrease the likelihood of preventable risks. For example, to overcome some of the challenges surrounding drinking water testing and protection in the region, we recommend participatory water and community-based environmental monitoring programs which have proven effective in other rural

areas of Canada as well as developing nations (Conrad & Daoust, 2008). Additionally, increased signage and wildlife barriers in wastewater treatment areas should be erected, and regular reviews of health data pertinent to waterborne disease issues at community levels to identify seasonal patterns – if any exist – should be undertaken.

With respect to longer-term strategies, water management frameworks which are being applied in southern Canada could be adapted for northern communities. Frameworks such as the multi-barrier approach to drinking water safety advocate proactive protection of watersheds to characterize and maintain quality of water sources, which in turn informs the types of treatment and filtration needed at central plants and along distribution systems (Davies & Mazumder, 2003). Examples of adapting those best practices for conditions identified by the community in our findings include watershed monitoring for pathogens associated with animal vectors and multiple testing checkpoints for chlorine residuals along the distribution system, including the reservoir, delivery trucks and a selected households or public buildings.

In our findings, key informants identified the dilemmas Nunavut municipalities face regarding initiating a water and wastewater management protection framework such as the one described and allocation of limited financial and human resources in general amongst community priorities. Despite a common goal among the involved agencies – providing citizens with the best environmental and human health protection possible – it is easy to understand why investment in water and wastewater resource management gets deferred when it is pitted against more immediate socioeconomic and health issues in Nunavut such as food security and housing shortages. Yet the reality remains that the types of water-health issues Nunavut faces require long-term perspective and preparation, especially with a growing population (Statistics Canada, 2007; 2012), climate change, trans-boundary contaminants and the risk of contaminant bioaccumulation in the Inuit diet (Berner & Furgal, 2005; Donaldson et al., 2010). Investment in water resource management should also be viewed as an investment in overall health. Long-term preparations in water resource management will ultimately contribute to the overall well-being of Nunavut communities (Montgomery & Elimelech, 2007; Parkes et al., 2010; Sullivan, 2002). Specific areas of co-benefit may include food security via increased protection of local food sources from environmental contaminant exposure, housing inadequacy issues via improved

public housing maintenance schedules that include water storage tanks and plumbing upgrades, and overall community capacity building via water operator, technician, tradesperson, environmental scientist and health professional oriented education and training programs.

4.10 Conclusion

On the global scale, everyone deserves to benefit equally from the current state of knowledge about safe drinking water, sanitation, and public health (WHO, 2010). However, the world is an array of diverse landscapes and populations so the products of this knowledge – implemented practices, systems, and interventions – will differ, and be unique, from place to place. As threats to water security increase around the world, this will only become more critical (Vörösmarty et al., 2010). This paper has highlighted the need for decision-makers and planners to consider the human dimensions of communities as they develop water and wastewater management strategies and guidelines. Decisions should not be based solely on an engineering design that is compatible with the location's physical environment. Rather, a more comprehensive and collaborative assessment process should be followed that factors in the societal norms, values and behaviours of the people living there and the broader demographic, economic and historical circumstances of the community. Despite differences in perspective and priorities that may exist among the various agencies and decision-makers involved in this process, through high levels of communication and cooperation between all parties, it is possible to foster understanding regarding the long-term planning needed to address current issues while also preparing for challenges on the horizon (Jalba et al., 2010). As such, this research may be most valuable when considered in complement with concurrent environmental engineering research While the findings reported in this case study are specific to Coral Harbour, Nunavut, Canada, the research approach contains a substantial degree of transferability to other rural, remote, Indigenous communities facing similar water-health complexities.

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CHAPTER 5 CONCLUSION

5.1 INTRODUCTION

This concluding chapter summarizes the entire research project and synthesizes the links between the purpose, key findings, and background literature. Additionally, the limitations of the study are discussed, recommendations for action and future research are proposed, and some closing comments end the chapter.

As introduced in Chapter 1 and restated in the manuscript chapters, the remote communities of Nunavut face unique water and wastewater management challenges due to their social, economic and physical environments (Inuit Tapiriit Kanatami and Johnson, 2008; Lam & Livingston, 2011; Smith, 1996). At the same time, Nunavut's Inuit population bears a disproportionate burden of ill-health relative to Canada's non-Indigenous populations (Adelson, 2005; Bjerregaard & Young, 2008), especially when it comes to communicable diseases typically associated with inadequate water access, sanitation and housing conditions. In some instances, the diseases rates Inuit experience are more comparable to developing nations rather than Canada (Bjerregaard et al., 2008: Gracey & King, 2009). The theme of this thesis was to increase understanding of the relationships between Indigenous health and the environment during life in contemporary communities.

The study is a component of larger wastewater management project undertaken by researchers at Dalhousie University and funded by the Government of Nunavut as they prepare to develop strategies appropriate for the territory in response to the *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* (Canadian Council of Ministers of the Environment, 2009). Within the context of that larger project, the specific objectives of this qualitative study was to understand how municipal water and wastewater management practices are influencing public health practices, behaviours, and decision-making at the household and broader community level within Coral Harbour, Nunavut. Four specific subobjectives addressed were:

Research Objective #1: Investigate the usage habits, opinions, and social patterns of Coral Harbour residents relating to water and wastewater systems and services;

Research Objective #2: Identify potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community;

Research Objective #3: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region; and

Research Objective #4: Based on new knowledge related to objectives 1-3, recommend some practical applications useful in shaping Nunavut's water, wastewater and public health strategies

The research was grounded in a theoretical framework of Indigenous health and water resource management literature. Methods of data collection used included semi-structured interviews, site visit observation and government document reviews. Data were thematically analyzed using a qualitative content process that included theory-driven and data-derived coding and, from this, five key findings resulted. In the following section, I will highlight these findings and point to their relationship with relevant literature.

5.2 Key Findings

Finding 1: Some households in Coral Harbour are experiencing domestic water shortages. Family structure and size are predictors of which households may be vulnerable to water shortages.

Daily water use per person in Coral Harbour was estimated at 110 litres. This is approximately one-third the Canadian average (Environment Canada, 2001). Although some households reported this as adequate to maintain a satisfactory state of health and well-being, more than half of the participating households (15 of 28) reported experiencing water shortages at least once per

month over a 12 month period. Families of five people or greater were more likely to report water shortages (according to Statistics Canada (2012) the average household size in Coral Harbour is 4.0 and in Canada is 2.5 residents). In addition, families with infants and children, regardless of the number of people residing in the home, often required more domestic water than they are currently receiving through municipal delivery systems.

It is recognized that Nunavut is facing housing shortages resulting in crowded living conditions and dwellings in various states of disrepair (Minich et al., 2011; Tait, 2008). As well, the population of both Coral Harbour and the entire territory of Nunavut is growing and the younger demographic is increasing at the fastest rate (Statistics Canada, 2012). Based on these trends in relation to this finding, occurrences of domestic water shortages are likely to increase under current conditions and practices.

Finding 2: Abilities to adapt to water shortages are not equal across all Coral Harbour households. As a result, some segments of the community are more vulnerable to hygiene and sanitation related health risks than others.

Current municipal water delivery and wastewater removal services are prone to inconsistency and delays due to winter blizzards, mechanical problems with equipment or trucks, reduced service during municipal holidays, and operator retention challenges. Typical delays could last 12 - 48 hours and occur several times per month. During these periods of intermittent service, residents of Coral Harbour may be receiving significantly less than the average 110 litres of water per person per day. In fact, some households may be functioning during these periods with water quantities in the range of 20 - 50 litres of water per person per day or less; these rates are comparable to those in water insecure developing nations (Howard & Bartram, 2003), or Arctic Canada's early settlement period of the 1950s and 1960s when individual-haul water systems were the only option (Michael, 1984; Robinson & Heinke, 1990). Although startling, this finding is not altogether surprising given the political state of affairs surrounding safe drinking water and Indigenous peoples in Canada and globally (Health Canada, 2013; Montgomery & Elimelech, 2007).

The three adaptation techniques Inuit in Coral Harbour used to cope with municipal service delays include: 1) individually retrieving untreated surface water; 2) relying on neighbours and extended family to share available water; and 3) altering daily activities to suit water availability. Worth noting, the ability to use these techniques is not equal across all households. For example, the factors limiting residents' use of the first two techniques include lacking the material means to collect untreated water (e.g. all-terrain vehicle and fuel to operate it) and fewer social connections to rely on for shared water (e.g. less extended family members).

The third technique, altering daily activities to suit water availability, is the default choice when domestic water quantities cannot be supplemented using one of the other two options. However, this technique is fundamentally flawed as it does not offer long-term water security. For participants faced with only this option, the globally recognized protective health effects of domestic water in ample quantity are minimized and their ability to adhere to hygiene and sanitation related public health practices is seriously restricted (Howard & Bartram, 2003; World Health Organization, 2013). For instance, unhygienic housing conditions - due to water scarcity - fosters the human-to-human transmission of several infectious diseases known to be prevalent in Nunavut such as *Helicobacter pylori* infection (Goodman et al., 2008), *methicillin-resistant Staphylococcus aureus* infections (Daloo et al., 2008), and tuberculosis (Bjerregaard et al., 2008; Public Health Agency of Canada, 2008). Even the best efforts by families to inhibit the spread of these diseases through preventive hygiene and sanitation measures within their homes will be largely ineffectual without adequate and consistent domestic water access. At a broader scale, living in conditions where water availability dictates the timing of daily tasks and reduces the ability to engage in educational, occupational, and recreational opportunities diminishes overall well-being (Montgomery & Elimelech, 2007).

Finding 3: Pre- and early settlement water-related practices influence current behaviour and public health risks in Coral Harbour.

It is recognized that Inuit communities likely have a higher susceptibility to environment contaminants exposure due to their diet which includes significant amounts of local wildlife, fish, sea mammals, birds, and raw surface water (Berner & Furgal, 2005; Suk et al., 2004; Bjerregaard & Young, 2008). Given this, gaining a comprehensive understanding of the social

and physical environments in Nunavut through community inclusive research practices was critical in working towards improved water and wastewater management.

The main community concerns identified with current municipal water and wastewater management practices in Coral Harbour were: 1) perceived health risks related to potential hydrological connectivity of the wastewater discharge and treatment areas to nearby lakes, residential or recreational areas, the drinking water reservoir, or the treatment wetland's sea outflow point; and 2) the potential for cross contamination of the drinking water reservoir and wastewater treatment area with respect to wildlife.

The influence of pre- and early settlement Inuit practices on current water-related behaviour patterns is evident in these community concerns as they allude to several possible exposure pathways and potential vectors for disease related to traditional subsistence diets and practices. Therefore, the waterborne health risks that must be accounted for in Nunavut are not typical of most other regions in Canada and more reflective of communities in developing nations wherein populations have only basic, if any, community-level water and sanitation systems yet rely on their immediate environment for subsistence (Ashbolt, 2004; Kiviasi, 2001).

Finding 4: Nunavut communities face water-related public health risks similar to those found in other small Canadian municipalities, and local health care services are not prepared to deal with community-wide waterborne disease outbreaks.

In addition to the traditional waterborne disease health risks, Nunavut communities also face challenges similar to those found in small non-Arctic municipalities. For example, the drinking water management practices in Coral Harbour involve multiple stages of handling wherein contaminants could enter the water at various locations, including, for example, from the reservoir to the truck, from the truck to the home storage tank, and during cleaning of the home storage tank. Other risk factors identified include a lack of source water quality monitoring, incomplete post-treatment water data records, and shortages of qualified operators. These are all factors that have contributing to waterborne diseases outbreaks in non-Arctic municipalities (Hrudey et al., 2003; 2006; Kot et al., 2011; Schuster et al., 2005). The minimal health services

in Nunavut's remote communities are currently not prepared to deal with the effects of a large waterborne disease outbreak.

Findings 5: Community water and wastewater management improvements will also indirectly co-benefit health and socioeconomic inequities in Nunavut.

Prioritizing the needs of Nunavut's remote communities can be overwhelming for decision-makers given the current health and socioeconomic inequities in the territory (Dewailly & Furgal, 2012). However, water and wastewater management decisions should not be in made in isolation or only for their short-term impact on minimizing direct water-related health risks. Rather, water resource management decisions should be assessed by their maximum long-term benefit to all interrelated areas which determine the overall well-being of Nunavut communities (Montgomery & Elimelech, 2007; Parkes et al., 2010; Sullivan, 2002). Examples of interrelated agendas that may co-benefit food security through increased local food source protection from environmental contamination (Berner & Furgal, 2005), housing issues via improved water storage tanks and plumbing in public housing units (Minich et al., 2011), and overall community capacity by means of water operators, environmental protection, and health professional education and training programs (Smith, 1996). Although completely defined frameworks do not currently exist to coordinate shared efforts between government departments and other parties invested in these areas of co-benefit, individuals working in these positions already cooperate on many issues and share expertise, information, labour, and equipment. Thus, a community of practice exists and the potential for further and expanded collaboration is possible.

Independently, each of these findings raises important points regarding the water-health relationship in Coral Harbour. Then, considered as a whole within the broader context of interrelated physical, social, and economic environments in Nunavut, we gain a more complete understanding of the complexities involved in the relationship between municipal water and wastewater services and public health behaviours and decision-making.

5.3 Limitations

While this research has produced several significant findings, it is necessary to also assert the limitations associated with the study prior to suggesting practical recommendations and theoretical contributions. The limitations include the transferability of the findings, potential research bias, and data collection challenges.

Transferability

Transferability refers to the fit of findings from qualitative research within contexts outside the study situation (Baxter & Eyles, 1997), in contrast to the quantitative research measure of generalizability, which is the degree to which research findings relating to a defined sample are representative of a broader population (Vogt, 1993). Water resources management and public health are important concerns for many Indigenous communities across Canada and around the world (Gracey & King, 2009; Health Canada, 2013). At the same time, it is important to recognize the diversity between Indigenous groups as well as the differences within regions and even single communities (Adelson, 2005; Bjerregaard et al., 2008). This is especially important when categorizing subsections of a population or community as 'vulnerable' to specific health risks (Ford et al., 2010). This qualitative case study has specifically explored the connections between health and water and wastewater management practices within the Inuit community of Coral Harbour, Nunavut. It presents the lived reality of *some*. It does not represent a universal truth representative of *all* people and conditions in the community, in Nunavut at large, or in all rural and remote Indigenous communities across Canada and the global Arctic. The result of this case study is a localized theory and may not be widely generalizable outside of Coral Harbour and Arctic communities with very similar characteristics. However, the construct of investigating the broad, complex drivers of a local water-health situation through a community perspective in an effort to position the research as part of a unique solution is transferable (Lebel, 2003).

Where comparisons between communities and Indigenous populations have been drawn within this research, they have been based on similar water and wastewater management practices, health conditions, rural and remote geography challenges, or combinations of those criteria. Given this, rich descriptions of these same criteria have been included here in an effort to

provide readers with the detail necessary to make their own judgment of the degree to which the findings are transferable to other settings and research contexts.

Researcher Bias

While complete researcher objectivity is unattainable (Guba & Lincoln, 1994), efforts have been made to limit researcher bias and checkpoints have been inserted throughout the research design to reflect upon it (Baxter & Eyles, 1997). For example, in collaborating with a local Community Research Liaison during data collection and analysis, a research team consisting of both an 'outsider' and 'insider' was formed. This increased legitimacy throughout the process as my 'outsider' research conceptions developed through university training and background literature were often revisited and balanced with more locally appropriate, 'insider' ways of seeking knowledge (Battiste & Henderson, 2000; Castleden & Kurszewski, 2000). Additionally, interpretation of the interview data is dependent on my inherently subjective coding during analysis (Richards, 2005). In effort to reduce researcher bias during this stage, preliminary themes elucidated from this coded data were vetted by several parties (thesis supervisory committee, participants, community at large via radio, an advisory committee consisting of government and academic representatives unaffiliated with the research) for constructive criticism and validation to reduce researcher bias (Baxter & Eyles, 1997).

Limited number of water system operator participants

Of the nine key informants who participated in the study, only one was a full time water system operator. In total, there are approximately three to six full time or part time operators in the community. Attempts were made to recruit more of these operators, however, for a number of reasons they did not participate. For example, two operators expressed interest in participating but we were unable to schedule an interview despite several attempts due to their long and sometimes unpredictable shift work.

Research process challenges

As any graduate student or more senior researcher can attest to, challenges constantly arise during the course of a research project and working through them is an important part of the process. I have grouped the major difficulties that I encountered below into three challenges,

believing they are worth discussing for the benefit of future researchers. I have also included how the study design was adapted accordingly each time, whether that decision was based on the level of data available, guiding literature or in consultation with research partners.

The first challenge incurred was recruiting participants from the general population. As an outside researcher, I was aware of taking the time necessary to make relationships in the community, as opposed to hastily beginning to recruit participants on the initial days of each visit to the community (Inuit Tapiriit Kanatami, & Nunavut Research Institute, 2006). Admittedly, following this approach can prove difficult when community visits are limited by time and finances. During my first data collection to Coral Harbour in June 2011, my initial recruiting efforts included posters, local radio announcements and word-of-mouth advertising. Only three participants from the general population were recruited using these instruments alone. It was at this point in the research process that I began working side-by-side with Community Researcher Liaison, Lorna Ell. From this point forward, participant recruitment improved considerably with 28 total residents from the general population participating in the study by the end of the data collection period in March 2012.

The second challenge related to calculating water usage rates in the community. Initially, I was planning to ask participating households to monitor their water usage rates over a specific period but upon beginning data collection, I quickly determined that this was overly onerous for the participants. Therefore, the '110 litres of domestic water per person per day' figure is based on aggregated monthly municipal delivery totals divided by the total population of Coral Harbour. The suitability of this estimate was field tested by measuring the volume of several household tanks, multiplying that volume figure by the number of fill-ups per week, and dividing the total by the number of residents in the home. The results of these field tests were within a reasonable range of the 110 litres per person per day.

The third data collection challenge involved a section of the semi-structured interview guide that pertained to changing social and physical conditions at the regional and global scale and perceptions of their impacts on water and health. Initial interviews did not elicit rich responses on this topic. This was not entirely unexpected as Inuit philosophies about planning historically

focus on the 'known present' and trusting in their skills and knowledge sets to adapt as required, as opposed to long-term prediction (Bates, 2007). Adjustments to the interview guide did improve data collection during later stages in effort to align the research inquiry with this philosophy. For instance, I began opening this section of the interview with questions like, "how do you and your family prepare for an extended trip out on the land?" and "if an unexpected health issues occurs when you are several hours or days away from the community, how do you deal with it?" I also discussed specific world events with some participants and paid particular attention to the parts of their responses where they related what happened in other parts of the world to their own region. For example, one participant told me that after the well-known 1986 Chernobyl nuclear power plant accident in Ukraine, which released radioactive particles into the atmosphere, residents in the region were very aware of possible impacts on the Arctic region. In a second example, I was in the home of a participant in September 2011 while they were watching news coverage of a plane that crashed in Russia killing 43 people. The conversation then shifted to plane crashes in the Arctic over the last few years and I sensed that issues such as these are a constant consideration in an isolated community like Coral Harbour, where air travel is a necessary component of health care and other routine aspects of life. These lines of interview questioning did improve my understanding of the perceived impact changing global physical and social environments have on local issues. In hindsight, it may have also been beneficial to recruit additional key informants such as a regional climate change adaptation expert who could have potentially discussed impacts on water and wastewater systems in more detail (although literature from this area has been incorporated in the study) and an economic development planner from the territorial government who could have offered more specialized insight into the potential impacts of increasing global interest in natural resource extraction, security, shipping, tourism, and other economic endeavors in the region.

5.4 Recommendations

Based on the findings of this study, seven action-oriented and research-oriented recommendations have been identified. Recommendations for action are meant to directly benefit the community of Coral Harbour and the territory of Nunavut. Three of the four recommendations listed in this category were proposed by study participants. Some of these

recommendations complement and inform existing programs and policy while others represent new initiatives. Recommendations for research are longer term ideas aimed at addressing remaining knowledge gaps and expanding the research agenda of Indigenous health issues related to water and wastewater management.

5.4.1 Recommendations for Action

Recommendation 1: Increase domestic water quantities

The quantity of water provided to homes should be increased. In turn, this also necessitates increased wastewater removal services. This could be accomplished by increasing the frequencies of trucked delivery and incremental installation of larger water storage tanks and grey water reuse systems in future public housing projects. Additionally, as Martin et al. (2007) have suggested, the installation of self-serve faucets at the water reservoir, which provide treated water, and are accessible to residents during delays in trucked service may be a useful option. If implemented, the faucet should be enclosed in a heated area so it is functional during all types weather conditions since many of the municipal trucked water delivery delays occur during winter blizzards. Finally, a communication protocol between the local health centre and municipal water operators wherein health officials prompt additional water delivery to designated households based on their medical needs may prove effective.

Recommendation 2: Develop a comprehensive municipal water and wastewater treatment zone environmental monitoring program and waterborne disease outbreak emergency plan

Based on the potential exposure pathways described by resident participants and key informants who participated in this study, a more comprehensive environmental monitoring program should be crafted for the municipal water and wastewater treatment zones. The program should include comprehensive drinking water testing for various contaminants at multiple points throughout the source-to-tap delivery chain (e.g drinking water safety plan). This would create some new work responsibilities for municipal water operators; therefore, the requisite training should be provided and could be facilitated by regional environmental health officers. Additionally, an increase in the signage and wildlife barriers should be placed in the water reservoir and wastewater discharge and treatment area. Finally, regular reviews of suspected waterborne disease cases

should occur at the community and regional level in an attempt to identify any seasonal or emerging patterns. Water-borne diseases appear to be under-reported Canada-wide; therefore, an improved surveillance system such as this would inform appropriate intervention strategies (Brunkard et al. 2011; Bakker & Cook 2011; Chowdhury 2013). Emergency response plans in the case of a community outbreak should also be developed in collaboration with territorial level health services.

Recommendation 3: Initiate a monitoring program for untreated drinking water sources

Given the considerable reliance and affinity for untreated drinking water in the community, a monitoring program of preferred locations should also be initiated. This would likely not be a responsibility of the Hamlet as their mandate is to provide treated drinking water to resident's homes and public buildings. This fact notwithstanding, people always have a personal choice of what water they prefer to use, therefore, the untreated drinking water monitoring program could be a volunteer initiative. Basic training could be organized through environmental health officers for those community members interested in participating and the costs for necessary equipment would be reasonably minimal. The local hunters and trappers' organization may be a good candidate to coordinate volunteer efforts given their role in the community and ability to incorporate traditional knowledge into what would be a novel program. Such calibrated training currently exists in other geographic regions; for example, the CURA H2O project (www.curah2o.com) in Nova Scotia has online community-based water monitoring training and certification that allows volunteers to achieve a particular standard of skill and a database for storing their data. This project is also underway in low-income countries including Nepal and Gambia with success. Given the comparisons of life in Nunavut with the experiences of those in other parts of Canada, as well as developing countries, a project such CURA H20 may be applicable in the region.

Recommendation 4: Develop frameworks for co-benefit interventions and policies

This research will specifically contribute to the Government of Nunavut's Wastewater Treatment Program. However, as that program concludes and begins to translate the knowledge into policy in 2015-2016, a framework should be developed to explore opportunities for co-benefit on additional water, health, and priority issues in the territory. Targeted cooperative interventions

will produce substantial health gains within communities, while sharing the implementation costs across multiple territorial departments or municipal governments. Additionally, from this research it has become evident that housing inadequacies are contributing to water insecurity, which in turn may be perpetuating infectious disease transmission. These water-related findings could be used to complement crowded housing research (Tait et al., 2008) to push that agenda forward and strengthen approaches to addressing the health consequences of housing issues in the region.

5.4.2 Recommendations for Research

Recommendation 5: Conduct a human health risk assessment of Arctic drinking water and wastewater treatment systems

This exploratory study identified local issues but was not intended to quantify the actual risks between water and wastewater management practices and specific health outcomes. Meanwhile, there has been a recent call for increased risk-based analytical assessments within Inuit health research, which can be used to inform targeted health interventions (Furgal et al., 2010). More specifically, gastrointestinal pathogen research is lacking in many regions including the Arctic (Goldfarb et al., 2013) due to the many challenges of conducting such studies (Bakker & Cook, 2011). Therefore, a follow-up human health risk assessment of Arctic wastewater treatment systems is recommended. In particular, a study that focuses on the potential exposure pathways associated with the traditional Inuit diet.

Recommendation 6: Undertake further drinking water research

As mentioned throughout this thesis, my research was a component of larger Government of Nunavut project initiated in effort to prepare for forthcoming changes to wastewater treatment practices. Early during my research, it became apparent that at current the more pressing issues at the family and household level was constrained drinking water access and perceived quality issues. Informed by this these community concerns, a drinking water research initiative has already been launched by researchers at Dalhousie University. Within the program, samples were collected from several points in the distribution chain (trucks, housing tanks, faucets, etc.) and participants were interviewed about their drinking water habits. Water samples are being

analyzed for chemical (e.g. metals) and microbiological (e.g. bacteria, protozoan) contaminants. Although this study is only beginning and results are not yet known, I recommend continuing this line of research. Additionally, an epidemiological drinking water study similar to the work of Harper et al. (2011) within Inuit communities in Nunatsiavut that incorporates waterborne diseases data from the local health centre and environmental monitoring data from drinking water sources may be valuable.

Recommendation 6: Expand research on contrasting long-term planning philosophies research

Based on the findings and limitations of this study with Coral Harbour, I believe there is opportunity for expanded and more nuanced research on the contrasting philosophies of preparing of change between Inuit and much of the predominant university-led literature (Bates, 2007). Although much of the long-term planning research taking place in the Arctic is currently focused on climate change, study designs that can improve on the limitations stated above would be valuable towards documenting how Inuit communities perceive, and are (or are not) thinking long-term about the potential local impacts of many global phenomenon such as growing populations, increasing oil and food costs, and environmental degradation.

5.5 Concluding Comments

Throughout this study of the human dimensions of water and health relationships, Nunavut was - at times - compared to the rest of Canada while - at other times - also compared to developing nations. These comparisons were not drawn to equate Canada as the gold standard when it comes to water-related health issues, or to reduce developing nations to the lowest common denominator in the same category. In fact, the question could, and should, be raised as to why anyone in the world has to bear water-related health burdens in the 21st century given the available technologies and state of public health knowledge. Instead, the comparison was made to emphasize the disparity. Inuit communities of Nunavut deserve at least the same water and public health services afforded to their fellow Canadians. This is currently not the case and the matter will become only more magnified as global pressures upon the world's finite water resources increase. Through this research we can begin to see that such a state of equity is

attainable with the appropriate attention to the distinct social, economic, climatic, and geographic conditions in the North.

5.6 References

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APPENDIX A Letter of Community Support and Community Consultation Report

HAMLET OF CORAL HARBOUR
P.O. BOX 30 BOUR, NUNAVUT
X0C 0C0
PHONE: 867 - 925 - 8867
FAX: 867 - 925 – 8233
E-MAIL: munch@qiniq.com

March 16, 2011

Kiley Daley
School for Resource and Environmental Studies
Dalhousie University, Nova Scotia
Phone: 902-826-1898
Email: kiley.daley@dal.ca
Mailing Address:
15 Ingram River Lane
Ingramport, NS
B3Z 4A2

Re: Letter of Support

Dear Kiley,

The Hamlet Council of Coral Harbour gives support of your sub-project to undertake community-driven research on the environmental issues noted in your community consultation report.

If you have any questions or concerns, please don't hesitate to contact our office.

Kind Regards,

Leonie Pameolik
Senior Administrative Officer

Hello Leonie,

Thank you once again for your time and assistance during my recent visit (Feb 22 - Mar 1) to Coral Harbour to introduce the Dalhousie University wastewater project and explore the possibility of working with the community on a related environmental health sub-project.

During our last meeting on February 28th, we discussed the possibility of having a letter of support for this project.

As per your suggestion, I have summarized community comments about environmental health issues related to the wastewater project stemming from formal and informal meetings with Hamlet Council, Hamlet employees (water and sewage workers), Hunters and Trappers Organization, Health Centre employees, and community residents. Thank you very much for your offer to bring this information and my request for community support to the next Council meeting on March 10, 2011.

Summary of Community Concerns

-Concern about the closeness of the sewage lagoon/wetland and dump to the fresh water supply.
-Concern about the possibility of runoff from the sewage/lagoon and dump flowing towards the streams and lakes in town instead of flowing towards the ocean.
-Interest in water and wastewater management planning for the future as the population of Coral Harbour grows.
-Concerns about water and wastewater as the climate in Coral Harbour changes.
-Concern about impacts related to wildlife (Ravens around the lagoon and water reservoir, caribou near the lagoon in the past)
-Interest in other areas of town that have been used as dumping sites (lakes behind arena) and possible contamination from old military operations (near the airport).

Request for Letter of Support from Coral Harbour

In addition to my role in the wastewater project as a research assistant, I would like to undertake community-driven research on the environmental issues noted above for my thesis research as a graduate student in the School for Resource and Environmental Studies. If this is of interest to Coral Harbour, I will need a letter confirming your support in order to apply for a license from the Nunavut Research Institute.

My hope is that a sub-project like this which incorporates the habits, attitudes and social patterns of the community can be very useful to Coral Harbour in planning and managing their water resources when combined with the technical part of the wastewater project (testing and sampling of the lagoon runoff).

Proposed Project Timeline

March - June 2011: Develop study Parameters with Coral Harbour Council.
June 2011: Data Collection (Round 1)
July 2011: Preliminary Data Analysis
August 2011: Data Collection (Round 2) and Share Preliminary Findings from Round 1.
September - December 2011: Detailed Data Analysis and Progress Report

January 2012: Data Collection (Round 3) and Share Preliminary Findings from Rounds 1 and 2.
February - May 2012: Detailed Data Analysis and Progress Report
June 2012: Community Presentation of Study Results
August 2012: Submission of Formal Study Report

Please note; the wastewater project has dedicated funds to involve members of the community in our research, maintain regular contact, keep people updated on what we are doing, listen to feedback and share what we have learned during our time in Nunavut.

If you, the Mayor or any Councillors have any questions before a letter of support can be written, I can be contacted by email or phone anytime. My contact information, as well as an address to which a letter of support can be mailed is included below. You may also contact my graduate supervisor, Dr. Heather Castleden, at 902-494-2966 or heather.castleden@dal.ca with any concerns.

Sincerely,
Kiley

Kiley Daley
School for Resource and Environmental Studies
Dalhousie University, Nova Scotia

Phone: 902-826-1898
Email: kiley.daley@dal.ca
Mailing Address:
15 Ingram River Lane
Ingramport, NS
B3Z 4A2

APPENDIX B Letter of Approval from Dalhousie University Social Sciences and Humanities Research Ethics Board

DALHOUSIE UNIVERSITY
Inspiring Minds

Social Sciences and Humanities Research Ethics Board
Letter of Approval

Date: June 1,2011.

To: Kiley Daley, School for Resource and Environmental Studies
Dr. Heather Castleden , School for Resource and Environmental Studies

The Social Sciences Research Ethics Board has examined the following application for research involving human subjects:

Project # 2011-2455

Title: A Community-Based Approach to Understanding Perceptions of Water-Related Environmental Health Risks in Coral Harbour, Nunavut

and found the proposed research involving human subjects to be in accordance with Dalhousie Guidelines and the Tricouncil Policy Statement on *Ethical Conduct in Research Using Human Subjects.* This approval will be in effect for 12 months from the date indicated below and is subject to the following conditions:

1. Prior to the expiry date of this approval an annual report must be submitted and approved.
2. Any significant changes to either the research methodology, or the consent form used, must be submitted for ethics review and approval *prior to their implementation.*
3. You must also notify Research Ethics when the project is completed or terminated, at which time a final report should be completed.
4. Any adverse events involving study participants are reported immediately to the REB

Effective Date: May 31,2011.
Expiry Date: May 31,2012.

signed: [redacted]
Dr. Helene Deacon (Chair SSHREB)

IMPORTANT FUNDING INFORMATION - *Do not ignore*

To ensure that funding for this project is available for use, you must provide the following information and FAX this page to RESEARCH SERVICES at 494-1595

Name of grant /contract holder _____ Dept. _____
Signature of grant / contract holder _____
Funding agency _____
Award Number _____ Dal Account # (if known) _____

Dalhousie Research Services • Research Ethics • 6299 South Street,2nd Floor, Suite 231 • Halifax, NS, Canada • B3H 4H6
Tel: 902-494-1462 • Fax: 902-494-1595 • Email: Catherine.Connors@dal.ca • www.dal.ca/~research

APPENDIX C Nunavut Research Institute Correspondence

Date: Tue, 17 May 2011 18:52:38 +0000 [05/17/11 3:52:38 PM AST]
From: Cote, Mosha <Mosha.Cote@arcticcollege.ca>
To: Kiley Daley <Kiley.Daley@Dal.Ca>
Subject: RE: Sub-component of licensed project

Hello Kiley,

Had this study actually been licensed by NRI, you wouldn't require further authorization as you are a component of the study.

Since the University is partnered with the Government of Nunavut, an NRI license is not required.

Kind Regards,

Mosha Cote
Manager Research Liaison
Nunavut Research Institute
(867)-979 7279-P
(867)-979 7109-F
www.nri.nu.ca
mosha.cote@arcticcollege.ca

-----Original Message-----
From: Kiley Daley [mailto:Kiley.Daley@Dal.Ca]
Sent: Monday, May 16, 2011 7:49 AM
To: Cote, Mosha
Subject: Sub-component of licensed project

Hello Mosha,

My name is Kiley Daley; a graduate student from Dalhousie University. This summer I will be working on the following project which was licensed by the NRI in Summer of 2010:

'Northern Municipal Wastewater Effluent Discharge Quality Objectives in the Context of CCME MWWE Strategy and Environment Canada's Wastewater Systems Effluent'.

This project is a partnership between Dalhousie University and the Government of Nunavut-Community & Government Services Department.

My name is not on the original license. However I will be working under the supervision of the Dalhousie University professors and staff who are named on the license. My research, which is a component of the project, will include interviewing people about their risk perceptions associated with water and wastewater management.

My questions to you are;
Am I covered by the original NRI license?
If not, do I need to send an amendment or apply for a new separate license?

Thanks for considering my questions. If you need more information or would like to discuss anything further please email or give me a convenient time that I can call you this week.

Regards,
Kiley Daley

Dalhousie University
School for Resource & Environmental Studies
Email: kiley.daley@dal.ca
Phone: 902-826-1898

APPENDIX D Key Informant Participant Recruitment Script

Dear [name of potential key informant]

My name is Kiley Daley. I am a graduate student at Dalhousie University located in Nova Scotia. As you will recall, we spoke in [February 2011 or date of last contact] regarding a study titled "A Community-Based Approach to Understanding Perceptions of Water-Related Environmental Health Risks in Coral Harbour, Nunavut". My work is a sub-project of a large wastewater management project partnership between the Government of Nunavut and Dalhousie University.

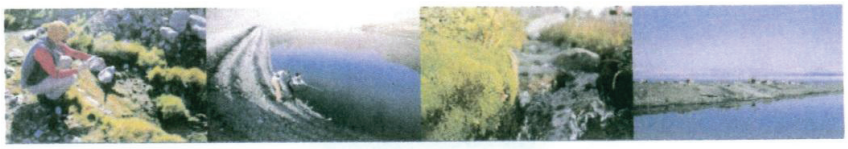
When we last spoke, I was conducting preliminary project planning and learning about issues specific to Coral Harbour. I am now beginning the formal data collection by investigating the issues further and would like to invite you to be part of my research. As a representative from [name of key informants' institution] your insight into the study is very valuable. Your participation would involve taking part in an approximate one hour in-person interview with questions pertaining to your experience and involvement in water resources and related environmental health issues. With your permission, the interview will be audiorecorded. You will have the opportunity to review the transcription for verification.

I will be visiting Coral Harbour in June 2011. I will contact you upon my arrival to give you more information and see if you are interested in participating. If you are interested in participating, please contact me. If you have any questions prior to my visit, please feel free to contact me by telephone at 902-826-1898 or email at kiley.daley@dal.ca.

Thank you for your time.

Kiley Daley

APPENDIX E Resident Participant Recruitment Poster (in English and Inuktitut)



Are You Interested In Being Interviewed About Water And Health?

Dalhousie University is working with Coral Harbour to learn more about water and health in the community and we would like to hear from you.

Lorna Ell (Coral Harbour) and Kiley Daley (Dalhousie University) are the interviewers. There are no right or wrong answers. Everyone's opinion and perspective is important.

Please call 925-8018 if you are interested. We look forward to hearing from you. Thank you.

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APPENDIX F Resident Participant Recruitment Script

Note: This script may be adapted slightly and used a radio announcement with the assistance of a community liaison. It would be announced in Inuktitut and English

Hello,

My name is Kiley Daley. I am a student doing graduate studies at Dalhousie University in Nova Scotia. I am a part of a project partnership between Dalhousie University and the Government of Nunavut. The goal of the partnership is to work with hamlets to proactively plan for upcoming regulations that assure wastewater is managed and sewage lagoons are operated in a safe manner.

My specific research study is titled "A Community-Based Approach to Understanding Perceptions of Water-Related Environmental Health Risks in Coral Harbour, Nunavut". The purpose of this study is to learn about Coral Harbour residents' perceptions, attitudes, habits and social patterns associated with potable water (water that is suitable for drinking) and wastewater (sewage). This information will provide insight on how water-related environmental health risks affect individuals, families and culture in the community. It is important to note that this research is exploratory in nature and not a reactionary response to a current water-resource related emergency in the community.

I visited Coral Harbour back in February 2011 to learn about some community concerns. Now, with the support of the Hamlet, I will be interviewing a broad range of residents in the community in attempt to gain an in-depth understanding of these concerns. As long as you are over the age of 18, I would like to invite you to be part of the research. Your participation would involve taking part in an approximate one hour in-person interview. With your permission, the interview will be audiorecorded. You will have the opportunity to review the transcription for verification. The interview will be held at a time and public location that is convenient for you.

I'll contact you again soon to see if you are interested in participating. If you are interested in getting more information in the meantime, please contact me at [name and phone number of accommodation while in Coral Harbour] or through [name of community liaison].

Thank you.

APPENDIX G Participant Information Sheet and Informed Consent Form

Participant Information and Informed Consent Form
(Page 1 of 4)

Title of the study
A Community-Based Approach to Understanding Perceptions of Water-Related Environmental Health Risks in Coral Harbour, Nunavut

Principal investigator
Kiley Daley, Dalhousie University
Phone: 902-826-1898, Email : kiley.daley@dal.ca

Academic supervisor
Dr. Heather Castleden, Dalhousie University

Introduction
We invite you to take part in a research study being conducted by Kiley Daley who is a graduate student at Dalhousie University, as part of his Master's of Environmental Studies degree. Your participation is this study is voluntary and you may withdraw from the study at any time. The study is described below. This description tells you about the risks, inconvenience, or discomfort which you might experience. Participating in this study might not benefit you, but we might learn things that will benefit others. You should discuss any questions you have about this study with Kiley Daley.

Purpose of the study
The purpose of this study is to learn about Coral Harbour residents' perceptions, attitudes, habits and social patterns associated with potable water (water that is suitable for drinking) and waste water (sewage). This information will provide insight on how water-related environmental health risks affect individuals, families and culture in the community. Additionally, this work will also contribute to a larger project being conducted by the Government of Nunavut and Dalhousie University in which hamlets across Nunavut are proactively preparing to meet new waste water management (sewage lagoon) regulations.

What will happen
You will be asked to participate in one in-person interview with the principal Kiley Daley that will take approximately 1 hour. You will be asked questions about how water is used in the

community and how you perceive it affects health. During the interview, you will have the option of showing the principal investigator areas of the community that are related to your responses. If preferred, these locations can be pointed out on a paper map instead. If you give permission, interviews will be audiorecorded and transcribed. You will have the opportunity to review your transcript of verification. The transcripts of these interviews as well as notes made on the maps will be analyzed by Kiley Daley to find common themes and important differences among the responses. The results will be presented in several different ways. They will be included in academic papers and conferences. They will also be returned to Coral Harbour in the form of a community presentation and a summary report. The interview will take place in Coral Harbour at a time and place that is convenient for you. The transcript of the interview will be delivered to you for review and verification.

Possible risk and discomforts

There is minimal risk to participating in this study. It is important to note that this research is not a reactionary response to a current water-resource related emergency in the community. All recent testing of the community's drinking water has shown it to be of excellent quality. However, Kiley Daley has received the support of the Hamlet to explore risk perceptions related to water and environmental health related issues.

However, in the event that you experience any stress or discomfort from your involvement in this study, we ask that you contact the Health Centre at 867-925-9916 to discuss the situation.

Possible benefits

There are no direct benefits of participation. Although not guaranteed, possible indirect benefits include using information collected to inform future water-related community decisions in areas of public health, land use planning and training for water operators.

Privacy

Within the final results no names will be used. With your permission, direct quotes may be included but no names will be used. You will be given the option to review and approve any direct quotes in text that are chosen for inclusion in final results before they are published.

If a translator is required to assist the principal investigator he/she will be required to sign a confidentiality agreement.

Questions

If you have any questions about this study, please contact Kiley Daley in person when he is in the community or by collect call (902-826-1898) or email (kiley.daley@dal.ca) at any other time.

Problems or concerns

If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director of Dalhousie University's Office of Human Research Ethics Administration, for assistance by collect call at (902-494-1462) or email (catherine.connors@dal.ca).

PARTICIPATION INFORMATION & INFORMED CONSENT SIGNATURE PAGE

Title of the study
A Community-Based Approach to Understanding Perceptions of Water-Related Environmental Health Risks in Coral Harbour, Nunavut

Research Team
Principal Investigator – Kiley Daley (902-826-1898, kiley.daley@dal.ca)
Academic Supervisor – Heather Castleden (902-494-2966, heather.castleden@dal.ca)

To be completed by the research participant:	**Circle Yes or No**	
1. Do you feel you have received sufficient information to participate in this research study?	Yes	No
2. Do you understand that you are about to participate in a research project?	Yes	No
3. Have you had an opportunity to ask questions and discuss this study with a member of the research team?	Yes	No
4. Do you understand the benefits and risks in participating in this study?	Yes	No
5. You are free to refuse to participate or withdraw from this study at any time. You will not have to offer a reason and this will not affect you. All the interview information provided will be discarded at this time. Is this understood?	Yes	No
6. Have the issues of confidentiality and anonymity been explained?	Yes	No
7. Do you give permission for the use of full quotations in the written results? Your name will not be used. You will be given the opportunity to see the quote in text and make a final decision on whether it is used or not.	Yes	No
8. Would you like to review and confirm the accuracy of your interview transcripts?	Yes	No
9. Would you like to receive a copy of the final report?	Yes	No
10. Do you give permission to have the interview audiorecorded?	Yes	No

I agree to take part in this study.

Signature of Research Participant: _____

Printed Name: _____

Signature of Witness: _____

Printed Name: _____

Date: _____

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

Signature of Researcher or Designee: _____

Date: _____

THE INFORMATION SHEET IS ATTACHED TO THIS CONSENT FORM AND A COPY IS GIVEN TO THE RESEARCH PARTICIPANT

APPENDIX H Key Informant Participant Semi-Structured Interview Guide

Preamble

As you will recall, we spoke a number of months ago when I was doing preliminary work in preparation for a study that would explore the relationships between water resources and health in the community. Today, I'm going to be asking you some questions about the institution you work for and the roles and responsibilities of your position in relation to water and health. As [insert key informants role] you have valuable insight to contribute to this topic. I also want to remind you that there is no right or wrong answer to each question. Do you have any questions before we begin?

Ok, I'm going to turn the audio recorder on now…

Roles & Responsibilities of Key Informant

- What is your job title what organization do you work for?
- What are your main responsibilities with that job?
- Can you tell me about a typical day or week at work?
- What type of training is needed for this position?

Follow-up and probing questions:

- *Can you explain to me how the process works? [Referring to participants mention of a process that is routine to their occupation]*

Community Perceptions

- Based on your experience with your organization, do you think the community gives much thought to where their water comes from and how it is managed?
- Based on your experience with your organization, can you tell me if there have ever been issues about how these resources are managed?
- Based on my last visit to Coral Harbour, I've heard that there are other lakes and rivers in the community that people retrieve drinking water from. Are you able to tell me about or point out any of those areas?
- I've also been told that there are lakes and rivers in the community that have been used for dumping waste in the past. Are you able to tell me about or point out any of those areas?

Follow-up and probing questions:

- *Follow-up questions are expected to relate to specific issues that were raised during the PI's preliminary consultation. These issues may include proximity of waste water treatment area to inhabited areas, impacts on wildlife, residents attributing illness to drinking water.*

Water-Health Connections (more 'water-health connections' questions in 'specific' category)

- Are you hearing about any water-related illnesses? Has anyone ever said to you, "I have problems with the water"?

Planning for Change

- What do you think is the most important water issue in Coral Harbour
- During my last visit to Coral Harbour, I was told that the population of the community is growing. With that growing population, the Hamlet is planning where to build new houses and other infrastructure. How do you think water and waste water services need to be considered in that planning?
- Have there ever been problems that caused a delay of several days or more in water delivery or waste water removal from homes (storm, broken machinery, contamination)?
- If so, please describe. If not, how do you think the community would react and adapt?
- Have you noticed any environmental change (changes in the ice, water, land, air) in Coral Harbour over recent years? If so, can you tell me about the change point out some of the areas you are referring to?
- If you noticed environmental change, what kind of consideration do you think need to be given to water and waste water services in the face of that change?
- In relation to last question, have there been changes to the water resources?
- What are your biggest concerns this year? In 5 years? In 100 years?
- How will it affect your responsibilities? What will you have to do differently in your job?

Specifics for individual key informants

- *Can you tell me about 'water-related illnesses' in the community? Does the Health Centre keep track of GI complaints? (Health Centre Employees)*
- *Are a lot of the ailments that people attribute to water warranted?*
- *Are statistics on H.Pylori collected?(Health Centre Employees and Environmental Health Officers)*
- *Is water testing done? At what point in the systems is it done? What kind of water data is available for Nunavut and Coral Harbour?(Hamlet and Environmental Health Officers)*
- *Can you speak to water usage patterns in the community on a household level? For example, is overcrowding or potable water conservation an issue?(Health Centre Employees)*
- *When did water delivery begin in Coral Harbour? When did sewage service start? When did motorized vehicles arrive which allowed for these services? (Hamlet)*

Do you have any other comments that you want to include? They can be related to any of the past questions or general comments.

Thank you for talking with me today. I'm going to write down what we talked about and I see from your consent form that you do/do not want a print out of our talk. I will get that to you by XX date and you can let me know if I got anything wrong. I will be here for a couple more days if you think you forgot anything you wanted to say. I will also be back again in XX month to do some follow up.

APPENDIX I Resident Participant Semi-Structured Interview Guide

Preamble

The goal of this study is to learn about the relationships between water resources and health in the community. There is no right or wrong answer to each question. All opinions are meaningful and valuable. Do you have any questions before we begin?

Ok, I am going to turn the audio recorder on now…

Community Perceptions

- When you think about your health, what comes to mind?
- When you think about water, what comes to mind?
- Where do you get your water from?
- What do you think about water quality here in Coral Harbour? Compared to (other Nunavut communities, other Canadians down south)…
- Do you know where the community treats sewage / wastewater?
- Do you ever wonder about how either of these processes work?
- Do you have any (other) concerns about drinking water here or the sewage?

Water Usage Patterns of Interviewee

- How often is fresh water delivered to your house?
- How often is sewage removed from your holding tank?
- How many people live in your home?
- Based on my last visit to Coral Harbour, I've heard that there are other lakes and rivers in the community that people retrieve drinking water from. Are you able to tell me about or point out any of those areas?
- Why do some people retrieve water from these sources instead of relying only on the Hamlet delivered water? Is the quality of that fresh water as good today as it was in the past?
- I've also been told that there are lakes and rivers in the community that have been used for dumping waste in the past. Are you able to tell me about or point out any of those areas?

Issues & Concerns

- Have there ever been problems that caused a delay of several days or more in water delivery or waste water removal from your home (storm, broken machinery, contamination)?
- If so, how did you react and adapt?
- Earlier we talked about how waste water treatment works in Coral Harbour. I would like to return to that. Can you elaborate on any concerns you have with the process?

Water-Health Connections

- Do you trust the quality of the water that is delivered to your house? Do you boil or filter it? How about collected water?
- Have you ever gotten sick from the water? If yes, did you ever report it to anyone or get treatment? Did it exacerbate an existing health condition?
- If there are delays in delivery of drinking water or removal of wastewater, how does this impact your day-to-day living?
- Do you think that waste water is managed and treated safely in Coral Harbour?
- Have you ever spoken with a health service representative about water issues and the potential impacts on your health?
- Have you ever contacted the Hamlet (or other levels of government) about water issues and the potential impacts on your health?

Follow-up and probing questions:

- *Follow-up questions are expected to relate to specific issues that were raised during the PI's preliminary consultation. These issues may include proximity of waste water treatment area to inhabited areas, impacts on wildlife, residents attributing illness to drinking water.*

<u>Planning for Change</u>

- If there was a long delay in water or waste water services in the community (a week or more), how do you think you and your family would cope?
- During my last visit to Coral Harbour, I was told that the population of the community is growing. With that growing population, the Hamlet is planning where to build new houses and other infrastructure. How do you think water and waste water services need to be considered in that planning?
- Have you noticed any changes to the land, water, or air in Coral Harbour over recent years? If so, can you tell me about the change point out some of the areas you are referring to?
- If you noticed any changes to the land, water, or air, what kind of consideration do you think need to be given to water and waste water services in the face of that change?
- If you could change one thing about the community water resources what would it be?
- I'm trying to learn about how Coral Harbour may plan its water services in the future. How would you plan for something like a long camping trip for example? (*Question added by Kiley and Heather after data collection trip 1).*

Do you have any other comments that you want to include? They can be related to any of the past questions or general comments.

Thank you for talking with me today. I'm going to write down what we talked about and I see from your consent form that you do/do not want a print out of our talk. I will get that to you by XX date and you can let me know if I got anything wrong. Thanks so much – I have a small gift of appreciation for your time (pass honoraria). I will be here for a couple more days if you think you forgot anything you wanted to say. I will also be back again in XX month to do some follow up.

APPENDIX J Research Objectives & Interview Questions Matrix Exercise

Research Objectives & Interview Questions Matrix Exercise (Document 1 of 2)
Key Informant Interview Guide

Student: Kiley Daley
Project Title: A community-based approach to understanding perceptions of water-related environmental health risks in Coral Harbour, Nunavut
Date: August 2011

Interview Questions	**Research Questions/Objectives**					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
What is your job title?	●	●	●			
What organization do you work for?	●	●	●			
Can you tell me about a typical day or week at work?	●	●	●			
What type of training is needed for this position	●	●	●			

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Probe: Can you explain to me how the process works? (referring to participants mention of a process that is routine in their occupation)	●	●	●			
Based on your experience with your organization, do you think the community gives much thought to how the water services operate in the community? That is, how potable water arrives and where wastewater goes?	●	●				●

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Based on your experience with this organization, can you tell me if there have ever been issues with how these services?	●	●				
Probe: Follow-up questions related to specific issues mentioned which may include perception of drinking water quality, proximity of wastewater treatment area to inhabited areas, wildlife in wastewater treatment area, other	●	●	●			●

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Based on my last visit to Coral Harbour, I've heard that there are other lakes and rivers in the community that people retrieve drinking water from. Are you able to tell me about or point out any of those areas?	●	●				
I've also been told that there are lakes and rivers in the community that have been used for dumping waste in the past. Are you able to tell me about or point out any of those areas?	●	●				

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
In your position/job, has anyone ever come to you and said, "I have an issue related to water"?	●		●			
Are you hearing about any water-related illnesses in the community?	●		●			
Can you tell me about 'water related illnesses; in the community?	●		●			
Does your department keep records of possible water-related illness complaints? (Health Centre Employees & Environmental Health Officers)	●		●	●	●	
Probing questions related to specific illness mentioned (ex. H Pylori)	●		●			

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Probing questions related to specific illness mentioned (ex. H Pylori)	●		●			
Are a lot of the ailments that your patients attribute to water warranted? (Health Centre Employees & Environmental Health Officers)	●		●			
Is water testing done in the community? (Hamlet and Environmental Health Officers)	●	●				●
At what points in the system is the testing done? (Hamlet and Environmental Health Officers)	●	●				

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
What types of water testing data or statistics are available for Coral Harbour? (Hamlet and Environmental Health Officers)	●	●		●	●	
Through your day-to-day work, are you able to speak to water usage patterns in the community on a household level? (Health Centre Employees and Hamlet)	●	●				
Probing question related to specifics such factors such as overcrowding, water delivery rates, preferences for raw or chlorinated	●	●				

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
When did water services begin in Coral Harbour? (Hamlet)	●	●		●		
Probing questions that relate such as when did motorized vehicles arrive which allowed for these services? How was waste dealt with before that?	●	●		●		
What do you think is the most important water issue in Coral Harbour today?	●	●				

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
During my last visit to Coral Harbour, I was told that the population of the community is growing. With that growing population, the Hamlet is planning where to build new houses and other infrastructure. How do you think water and waste water services need to be considered in that planning?					●	

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Have there ever been problems that caused a delay of several days or more in water delivery or waste water removal from homes (storm, broken machinery, contamination)? If so, please describe. If not, how do you think the community would react, adapt?	●			●		
Have you noticed any environmental change (changes in the ice, water, land, air) in Coral Harbour over recent years? If so, can you tell me about the change point out some of the areas you are referring to?	●			●		

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Have you noticed any environmental change (changes in the ice, water, land, air) in Coral Harbour over recent years? If so, can you tell me about the change point out some of the areas you are referring to?	●			●		
If you noticed environmental change, what kind of consideration do you think need to be given to water and waste water services in the face of that change?	●			●		
In relation the last line of questioning (changes in the community), how would it affect your responsibilities?	●			●		

Research Objectives & Interview Questions Matrix Exercise (Document 2 of 2)
General Population Interview Guide

Student: Kiley Daley
Project Title: A community-based approach to understanding perceptions of water-related environmental health risks in Coral Harbour, Nunavut
Date: August 2011

Interview Questions	**Research Questions/Objectives**					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
What do you think about the drinking water quality in Coral Harbour?	●	●	●			
Do you ever think about where the drinking water that gets delivered to your house comes from and how the wastewater is handled?	●	●				●
How often does fresh water get delivered to your house?	●	●				

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
How often is sewage removed from your house?	●	●				
How many people live here; do the water and sewage truck comes often enough?	●	●	●		●	
Based on my last visit to Coral Harbour, I've heard that there are other lakes and rivers in the community that water is retrieved from. Is this something that you do? Are you able to tell me about or point out any of those areas?	●	●				
Which water (delivered or raw) do you prefer?						
How often do you collect water?	●	●				

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
What activities do you use each type of water for?	●	●				
Why do you prefer raw water (if they indicate this)?	●	●				
Is the quality of the raw water as good today as it was in the past?	●	●				
I've also been told that there are lakes and rivers in the community that have been used for dumping waste in the past. Are you able to tell me about or point out any of those areas?	●	●				

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Have there ever been problems that caused a delay of several days or more in water delivery or waste water removal from your home (storm, broken machinery, contamination)?	●	●		●		
Is so, how did you react?	●					
Earlier we talked about how waste water/sewage treatment works in Coral Harbour. I would like to return to that specifically for a moment. Can you elaborate on any concerns or thoughts you had on that process?	●	●				

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Do you have any other concerns about drinking water or wastewater systems?	●	●				
Probe questions relating to specific issues raised by participant. May be perception of drinking water quality, proximity of wastewater treatment area to inhabited areas, wildlife in wastewater treatment area, other	●	●				
Do you trust the quality of the water that is delivered to your house?	●	●	●			

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Do you boil or filter/Brita the water? Cleaning the holding tank? What about fresh water?	●	●	●			
Have there ever been boil water advisories or other similar information about the water in the community? Who do they come from (Hamlet, Health Centre)?	●	●	●			
Have you ever gotten sick from water? If so, do you think it was delivered or raw?	●	●	●			
If yes, did you ever report it to anyone or get treatment? Did it exacerbate an existing health condition?	●		●			

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
If there are delays in delivery of drinking water or removal of wastewater, how does this impact your day-to-day living?	●	●	●			
Do you think that waste water is managed and treated safely in Coral Harbour?	●	●	●			●
Have you ever spoken with a health service representative about water issues and the potential impacts on your health?	●		●			

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Have you ever contacted the Hamlet (or other levels of government) about water issues and the potential impacts on your health?	●	●	●			
If there was a long delay in water or waste water services in the community (a week or more), how do you think you and your family would be impacted?	●			●		

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
I'm trying to learn about how Coral Harbour may plan its water services in the future. How would you plan for something like a long camping trip for example? Do you collect water as you need it because it is so plentiful or collect a lot at once? What about waste?	●	●		●	●	

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
During my last visit to Coral Harbour, I was told that the population of the community is growing. With that growing population, the Hamlet is planning where to build new houses and other infrastructure. How do you think water and waste water services need to be considered in that planning?	●				●	

Interview Questions	Research Questions/Objectives					
	Objective 1 (main research question): Investigate the habits, attitudes, and social patterns of Coral Harbour residents relating to water and wastewater systems and services	*Sub objective 1a:* In order to answer the main question we need to understand the pieces of the relationship: Water usage, Hamlet provided potable water and waste water services and those independent of the Hamlet	*Sub objective 1b:* In order to answer the main question we need to understand the pieces of the relationship: Health concerns attributed to water	*Objective 2:* Conceptualize potential environmental health risks related to water and wastewater systems and services, and how they impact individuals and families in the community	*Objective 3*: Explore perceptions of how the water-health relationship will be impacted given changing physical and social conditions in the region	*Objective 4:* Generate new knowledge that will be practical in shaping Nunavut's water, wastewater and public health strategies
Have you noticed any changes to the land, water, or air in Coral Harbour over recent years? If so, can you tell me about the change point out some of the areas you are referring to? If you noticed any changes to the land, water, or air, what kind of consideration do you think need to be given to water and waste water services in the face of that change?	●			●		
If you could change one thing about the community water resources what would it be?	●					

APPENDIX K Interview Transcript Return Letter

Return of Interview Transcript

Title of Study
Perceptions of Water-Related Environmental Health Risks in Coral Harbour, Nunavut

Project Leader
Kiley Daley
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Community Research Assistant
Lorna Ell
Coral Harbour, Nunavut
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In the past, you participated in our study by sharing your opinions related to water and health in the community during an interview. Thank you for your valuable contribution.

At that time, you indicated that you would like a copy of your interview transcript (a written document of what was said during the interview) returned to you. Your transcript is now available.

If you would like to read the document to make sure that we have accurately recorded your opinion, please do so. If you have any feedback or questions please contact either Kiley or Lorna within one week. If you would like assistance reviewing the document and interpreting it into Inuktitut, Lorna will assist with this.

If you agree that this document is accurate, you do not have to contact us. This document is yours to keep.

Thank you. This project will conclude in early 2013 and the community will receive updates through the Hamlet office.

APPENDIX L Community Research Liaison Confidentiality Agreement

Community Research Liaison

Confidentiality Agreement

Title of Study
Perceptions of Water-Related Environmental Health Risks in Coral Harbour, Nunavut

Principal Investigator
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Consent to Provide Liaison and Interpreter Services

I am aware that in the course of my participation as a Community Research Liaison in this study, I may have access to confidential information. Any such information must be kept in confidence and only used in connection with the principal investigator and in connection with the work assigned to me in this study.

_____ _____
Signature of Community Research Liaison Date

_____ _____
Signature of Principal Investigator Date

APPENDIX M Summary of Community Validation Session

Overview	Date: March 12, 2012 The following script was used to guide the community validation of results radio session. The session was delivered in English and Inuktitut. We received approximately 24 callers/commenters. Most of the comments were in Inuktitut. Community Researcher Lorna Ell, translated and transcribed using written notes in real time.
Introduction	This is Kiley Daley and Lorna Ell. We have been working on a project for Dalhousie University that is trying to fully understand the connection between water and health in Coral Harbour. We have conducted many interviews in the community over the past months. We would now like to present some of the main topics and have other people call in and share their opinions. There is no right or wrong answers. Everybody's opinion is important. We will keep track of everybody's name that calls in and put them in a draw for prizes. You can only be entered into the draw once. We will announce the prize winners at the end. We will be on the radio for 1.5 hours. Note: The topics below were used to initiate discussion points about the preliminary findings. However, it is possible that people tuned in to the radio at various times and were not aware of the format we were using. Therefore their comments may correspond directly to a topic or water-health connections in general. We did not limit people or attempt to direct their comments to a specific topic

Topic 1	What do you think about the quality of the drinking water in Coral Harbour and why do you think that? Comments and Feedback: -The water is good. If it was bad, I wouldn't drink it. -The water reservoir is too close to the dumps. Lots of people are sick, bugs in the stomach, no good. I think it's from water and kids would have worms in stomach. Smelling it, it's okay. Too close to dumps. Ravens and any kinds of birds get into reservoir. The reservoir needs a top. Too many people are getting stick and taking too many pills. -Tap water is no good, bad for tea. Nilak (Inuktitut word for ice) is better with tea. Tap is okay for coffee. -Dumps tipping to water reservoir. It's bedrock shouldn't leak down. Bugs, want to know about flying bugs. H. Pylori; where did it come from? I boil water from the tap. Fresh water is good to have, not trying to gross out on tap. -Get fresh water to Brita to put in pot, then boil 5 minutes and then put back. That what she does when she thinks there is something fishy. And plastic water tanks should be cleaned as much as possible. -I use Brita, the waters good. Ravens shitting on reservoir, going into the snow, the snow looks awful. -I want to know what they put in our water in Nunavut? How much fluoride? - Coral Harbour has the 2nd best drinking water in Nunavut. The water reservoir is too close to town and the dumps. Whenever there is something in water everyone gets sick, animals and people. -Cover the reservoir. Wind blows all over but brings pollutants to the ground -Too low, sewage lagoon to lower part, too close to lights. Old oil to air, then pollutant. -Spring/Summer, other side of land, old barrels dripping everywhere. Used to burn old fuel to get rid of it, summer time old flames from the dump are going to pollutants and dropping to water.

Topic 2	During the interviews most people told us they prefer fresh water when they can get it. Where are the best areas to collect it? And do you think the fresh water is as good today as in the past? Comments and Feedback: -Same old original spot to get ice (Lorna's words referring to the spot by the yellow bridge/airport road). -Ice is good, if you have good ice plus Brita they are same (when asked which is better). And it's never changed from then to now -Questions to Kiley about the project and public health related to water. -Now that spring is coming, the lakes are no good for tea or water. In the spring time water is no good anymore, kind of rotten. Sea ice is good in the spring to drink. -Yellow bridge is good for water and the same spot for sea ice. Still water is no good for tea, -Rivers are good for drinking water, good tea with white cups. -26 years checking water all the time, good all the way. -Cover the reservoir. -Underneath have a tube to clean the raven shit, have a tube to clean summer, then do another load of water. -Kirchoffer river, no pollutants, ice from Kugluktuk, snow for water, Kirchoffer ice crystals best. -To get snow from here, think about pollutants first. After a snow fall, there is no metal or minerals. -Me and my family thought the water was getting us sick; thinks it's the water. In Iqaluit, they stopped taking pills. -Granddaughter sick to stomach, thinks it is from water. -Dump and sewage are higher than the water reservoir. In spring time snow flows to water reservoir. -Tap water is no good for drinking tea. -In winter the spot to get ice is the yellow bridge on the airport road. -In summer, Kirchoffer River for water. -River is best for water, way its flowing. -In winter time, ice is the best for drinking,

Topic 3	Do you think that water and sewage are handled in a way that is safe and healthy for you and your family? Comments and Feedback: -Raven shit makes us sick, shitting on the ice in reservoir. -Good water, it's good for tea! Mothers told me not to gross out on water. -Tap water, how can we make it better? What about tanks? How can we clean them? -Is too much boiling not good? How long is best to boil the water? -How does the Brita work?
Topic 4	During the interviews we heard that people with larger families or young children need a lot of water compared to smaller families or adults. Do you have any comments about this? Comments an d Feedback: -Some houses, the toilet (sewage tank) is too small. Smaller tanks, not enough water. More water delivery, every day, daily. Those houses need more water and sewage pump out, daily.
Topic 5	Would you change anything about water services? Comments and Feedback: -We can't change. If there was a utilidor, it would freeze up in the winter. No one would get water. -Blasted reservoir. -Last year, cleaned out water tank and found two types of worms. -Everyday pumpout is good for sewage, and getting water delivery every day. Changes will slow down things including staff. -Old times, ladies would get water and take out toilet. Don't change a thing about the services. -It's good, everything's good. No changes. -Is the reservoir being tested? -Dust getting into the water is a concern too. -The "need" to put an "enclosure" over the water reservoir. -Ravens are in the reservoir as well, sleeping there. -Also, Kirchoffer is good clean water but ravens like the bridge out there too.
Conclusion	Thank you everyone. If you have comments that you would like to make about water and health but did not get a chance to speak or would like to speak in person to the project team. Please contact Kiley or Lorna.

APPENDIX N Research Validation Participant Cover Letter

Return of Interview Quotes

Title of Study
Perceptions of Water-Related Environmental Health Risks in Coral Harbour, Nunavut

Project Leader
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Coral Harbour, Nunavut
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In the past, you participated in our study by sharing your opinions related to water and health in the community during an interview. Thank you for your valuable contribution.

As part of the study, reports are now being written. These documents will become part of the project leader's university graduation requirements. They may also be published in journals related to water, health and Arctic issues. They may also be shared with the Hamlet, territorial government departments and other organizations who are interested in water, health and Arctic issues. As a study participant, you are also entitled to a copy of the final documents once they are complete.

Some of your quotes may be included in these documents as they are excellent examples or descriptions of the water, health and Arctic issues that we are studying. It is important to include your quotes as they represent the voice of the people and community. However, you will not be identified by name and your contribution to the study will remain anonymous.

Your quotes that **may** be used are attached. If you would like to review them, please do so. If you have any feedback or questions please contact either the project leader or community research assistant within one week. If you would like assistance reviewing the document and interpreting it into Inuktitut, the community research assistant will assist with this.

If you do not have any feedback or comments, you do not have to contact us. This document is yours to keep.

Thank you. This project is ongoing with a completion date anticipated for early 2013 and the community will receive updates through the Hamlet.