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Amphibious Housing: An Innovative Approach to Seasonal Flood Mitigation for Vulnerable First Nations Communities

Zachary Ropel-Morski^a, Elizabeth English^a, Scott Turner^{a*}

^a*University of Waterloo School of Architecture, 7 Melville St S, Cambridge, ON, N1S 2H4, Canada*

Abstract

This paper documents an initiative that proposes to implement a pilot program of amphibious housing retrofits for the flood-prone First Nations reserve of Lake St. Martin—an initiative that could also be applied to its neighbouring reserves of Little Saskatchewan and Pinaymootang in central Manitoba, Canada. The objective of the project is to construct and study three inexpensive and culturally sensitive amphibious house prototypes in these highly flood-vulnerable communities. These prototypes would comprise amphibious retrofits to existing prefabricated homes that already belong to this First Nations community. The houses would be moved from their current location in a nearby de-commissioned military base to sites on the reserves that are at high risk of flooding, and then equipped with an amphibious foundation. Community members would be involved in the construction process from the very beginning as a means of gaining first-hand experience in implementing an amphibious retrofit. Using this knowledge, as well as data gathered from tests of the prototypes during flood season, this initiative hopes to catalyze a series of self-initiated amphibious retrofits by residents of these indigenous populations, who could not only outfit their own communities with this technology, but spread word to other Canadian indigenous populations at high risk of flooding about this unobtrusive, inexpensive and well-proven flood mitigation strategy.

Keywords: amphibious housing; amphibious retrofit; seasonal flood-mitigation; indigenous housing; low-income housing

1. Introduction

Lake St. Martin, Manitoba, is home to the Lake Saint Martin First Nations reserve. It is part of a greater community of First Nations reserves represented by the Interlake Reserves Tribal Council, whose members include the nearby Little Saskatchewan and Pinaymootang reserves, as well as the Dauphin River, Kinonjeoshtegon, Lake Manitoba and Peguis reserves. The Lake Saint Martin reserve is a tight-knit community of just over 2,000 people with a deep connection to the land that they inhabit. This connection stems from traditions that are intrinsically linked to the relationship between the land and nearby water.

*Zachary Ropel-Morski. zachropelmorski@gmail.com

Elizabeth English. english@ecenglish.ca

Scott Turner. s6turner@uwaterloo.ca

While seasonal flooding is a natural occurrence in this region, its severity and irregularity have increased in recent years as a result of government-implemented water control infrastructures. This has not only interfered with important cultural practices, but represents a serious danger for the community. After an extreme flood in 2011, the majority of the population of the Lake Saint Martin reserve was forced to evacuate their houses. They have lived in stressful conditions away from their homes, their community scattered, since this event. The Lake Saint Martin community deserves and requires a flood mitigation strategy that is sensitive to their unique cultural needs as well as easy and inexpensive to implement. It should not have to rely on a provincial government whose future projects could continue to follow a pattern of neglect and/or the implementation of water management policies that are disastrous for the Lake Saint Martin community.

2. Context

Lake Saint Martin is located 255 kilometres North of Winnipeg, Manitoba. The lake is approximately 345 km² with 260km of low and swampy shoreline. It is connected to the much larger Lake Manitoba by the Fairford River, and possesses a single outflow in the form of the Dauphin River (Fig. 1). It is made up of two shallow basins, the larger of which receives inflow from the Fairford River, and the smaller of which sits next to the outflow of the Dauphin River. The Dauphin River is significantly smaller than the Fairford River, and thus has limits on how much water can flow through it. This outflow is reduced significantly in the winter months, as the river is prone to frazil ice—gatherings of small chunks of ice distributed throughout the water that further obstruct the flow of water. Lake Saint Martin has a relatively low population on its banks, with the only major settlements nearby being the Lake Saint Martin and Little Saskatchewan First Nations reserves. The sparse population may be a factor in the government's lack of documentation of flood patterns affecting this area.

Lake Manitoba is the third largest lake in Manitoba after Lake Winnipeg and Lake Winnipegosis, with an area of about 4624 km². Historically, due to Lake Manitoba's size and major inflow to Lake Saint Martin, via the Fairford River, the water levels of Lake Saint Martin and Lake Manitoba have been fairly reciprocal when unregulated. This relationship has been drastically changed with the implementation of several pieces of infrastructure.

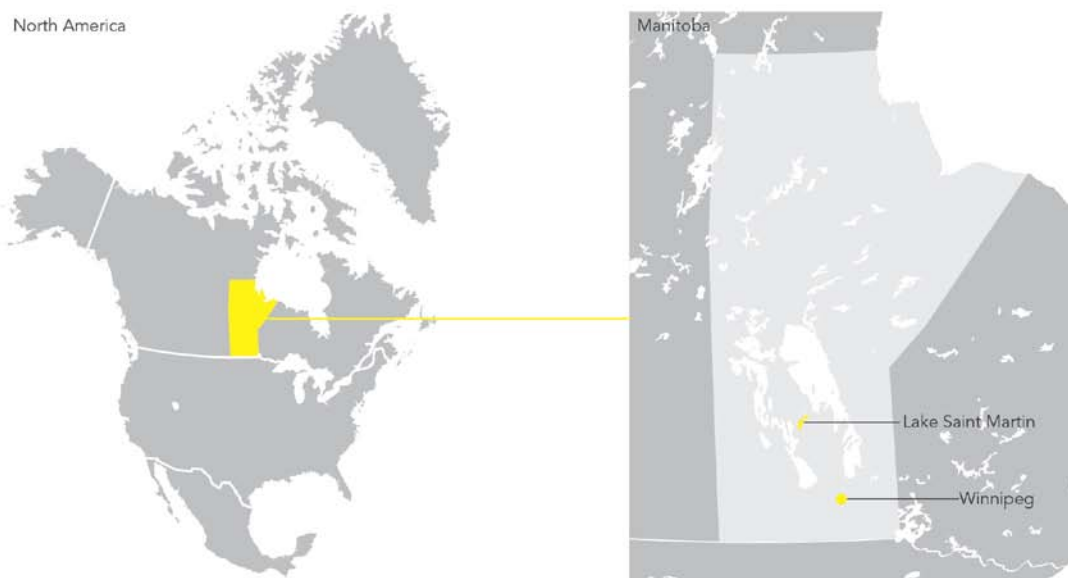


Fig. 1. Map showing Manitoba's watersheds and the relationship between Lake Saint Martin and other waterbodies (Government of Manitoba)

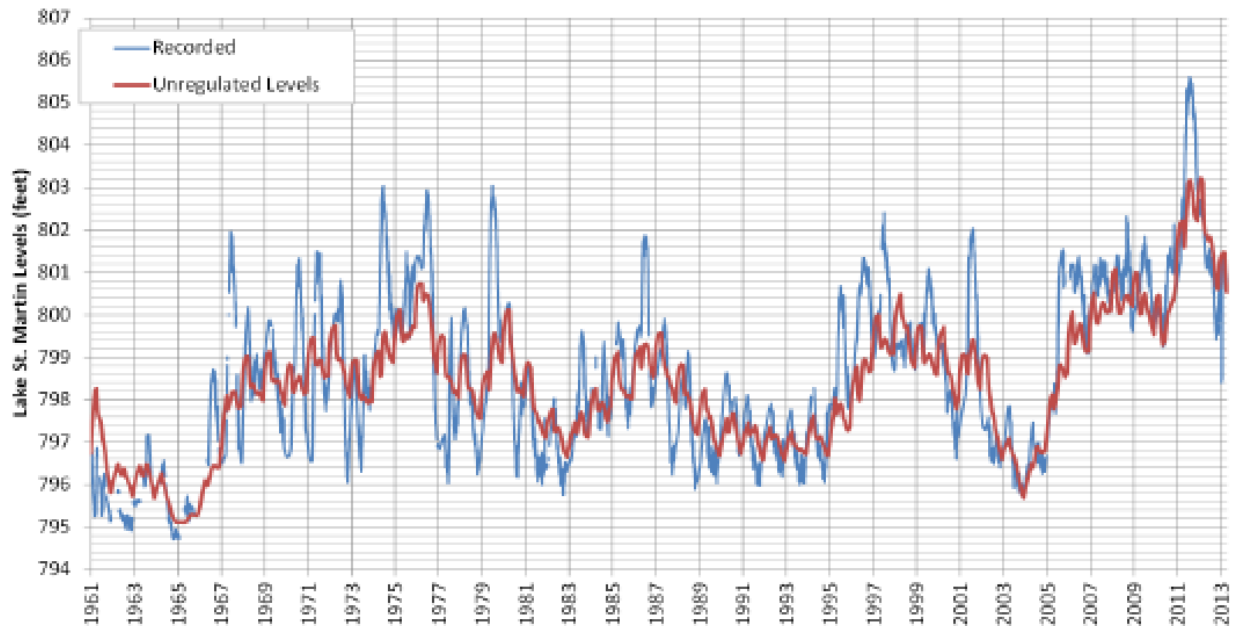


Fig. 2. Water levels in Lake Saint Martin since the implementation of water control infrastructures (Government of Manitoba)

In order to protect the inhabitants of the shores of Lake Manitoba from unwanted floods or drought, the provincial government of Manitoba has implemented several major water control infrastructures. Two of these infrastructures are the Portage Diversion, a channel that diverts water from the neighbouring Assiniboine River to Lake Manitoba, and the Fairford River Water Control Structure, a concrete stop log system that can restrict or increase outflows from Lake Manitoba to the Fairford River as needed. While these pieces of infrastructure have certainly made water levels a lesser problem along the shores of Lake Manitoba, they have also interfered with the natural relationship of high and low water between Lake Manitoba and Lake Saint Martin, much to the detriment of the Lake Saint Martin, Pinaymootang and Little Saskatchewan communities.

The Fairford River Water Control Structure was constructed in 1961, without any consultation with the First Nations leaders, along the banks of Lake Saint Martin. While it has certainly served its purpose of protecting the populations on the banks of Lake Manitoba from flooding and drought, it has also created significantly worse flood and drought conditions on Lake Saint Martin (Fig. 2). The structure, by allowing the government to reduce Lake Manitoba's outflows to the Fairford River during times of low water, and increase outflows during times of flooding, has effectively severed the reciprocal link between the water levels of Lake Manitoba and Lake Saint Martin, and instead created an inverse relationship. When outflows are obstructed to better serve the population of Lake Manitoba during times of low water level, water levels on Lake Saint Martin drop even more significantly than they would under usual drought conditions. When outflows are increased to prevent flooding on Lake Manitoba, Lake Saint Martin experiences even more severe floods than they would under usual flood conditions. These negative impacts on Lake Saint Martin have been worsened further by the construction of the Portage Diversion in 1970. The Portage Diversion was constructed with the intention of increasing flows to Lake Manitoba from the Assiniboine River, effectively lowering the river's water level and increasing the water level of Lake Manitoba to a reasonable level. In conjunction with the Fairford River Water Control Structure, the flood levels in Lake Saint Martin have been increased significantly, putting these relatively independent First Nations communities at great risk of flooding. In constructing these major water control infrastructures without consulting the communities of the Lake Saint Martin and Little Saskatchewan reserves, the provincial government has effectively deprioritized the concerns of

these First Nations communities, who have a history of being marginalized by all levels of government in Canada, with limited input in decisions regarding their own safety.

In 2011, Lake Manitoba and the Assiniboine River experienced extreme and unprecedented levels of flooding that left many homes along the southern banks of the lake either damaged or destroyed. This flooding, while extreme on Lake Manitoba, was even worse on Lake Saint Martin. Through the use of the Fairford River Water Control Structure, these unusually high levels of water were diverted through the narrow Fairford River and into Lake Saint Martin, where flooding was so severe and dangerous to residents that a government evacuation was forced for the Lake Saint Martin and Little Saskatchewan reserves, as well as many isolated rural communities on its banks. The majority of the Lake Saint Martin reserve was destroyed, and left unlivable in the flood, with water levels remaining high enough to make inhabitation nearly impossible. Other communities were also heavily damaged, but with reduced severity. As a result, the government began to formulate plans for the Lake Saint Martin emergency channel, which was put into action in November of 2011. While the channel did significantly reduce water levels in Lake Saint Martin, helping to overcome the artificially high flooding from the other water control infrastructures, such an intervention would not have been necessary if the needs of these communities had been addressed prior to the flood (Government of Manitoba, 2013).

Despite this new infrastructure, the communities of Lake Saint Martin have remained evacuated since the flood, due to the severity of damage in the community. The government has been housing residents in various hotels across Winnipeg, with much resistance over paying for living expenses while separating the First Nations people from the land that is so important to their traditional way of life (Forbes, 2013). This evacuation has had significant stress on the close-knit community, whose members have been separated from one another for four years now. The mental health of the community has been greatly impacted since the flood as well, with multiple youth suicides and other untimely deaths of both young people and the elderly. The First Nations leaders attribute this to the stress of the evacuation, and the need to return home (Paul, 2014).

The first plan the government hatched for temporary relocation was launched in February, 2012, when the government opened temporary housing for residents of the Interlake Tribal Reserve in a decommissioned military base near Gypsumville, about 15km West of the Lake Saint Martin reserve. The base was outfitted with 65 fully furnished modular homes, a project that cost the government \$14,000,000. The initiative, however, was not particularly successful. Few Lake Saint Martin residents moved to the homes after Lake Saint Martin chief Adrian Sinclair publicly opposed the project. Sinclair and the other members of the band council expressed fears that if the community was to be inhabited, it may prevent any work being done to reestablish a community on their land (Goomansingh & Logan, 2013). In February 2015, the community launched a series of protests at having been evacuated for four years, urging the government to take some action and responsibility (CBC News, 2015). Soon after, negotiations between the provincial government and Interlake Reserves Tribal Council began to relocate the Lake Saint Martin community to a site close to their previous home, but at a higher elevation. Construction of this new community began in June of 2015, a \$35,000,000 project, but there is still unrest among many residents of Lake Saint Martin (Fig. 3). Despite the site's higher elevation, the community continues to be fearful of flooding and that the events of 2011 will repeat themselves (CBC News, 2015).

The people of Lake Saint Martin have been wronged by a provincial government of whom they are now even more distrustful. In the construction of this new community, they need to be assured that they will be able to live on the land they hold so dear without having to suffer such a lengthy evacuation ever again. The indigenous people of the Lake Saint Martin reserve require a flood mitigation strategy that is sensitive to their cultural needs, and that they can put into place independently of the provincial government.



Fig. 3. (a) A protest through the streets of Manitoba (CBC); (b) Chief Adrian Sinclair signs document for relocation (CBC)

3. Proposal

Amphibious housing is a proactive flood mitigation strategy that can be deployed using low-cost materials and building techniques that are easily replicable without skilled labour. It provides a safe and healthy living environment after flood events, enabling people to return their communities under circumstances that would usually result in lengthy evacuation or unsafe living conditions. During a flood event, an amphibious house rises with the water levels, floating safely on top of the water, with lateral movement restricted by vertical guidance posts. When the flood water recedes, the house lowers directly to its original position on the ground.

In contrast to the top-down flood control measures that the Canadian and Manitoban governments typically adopt, the buoyant foundation system is an adaptive and effective means of flood mitigation in areas where rising flood waters are not accompanied by high flow speeds. Amphibious foundation systems maintain a home's relationship to the ground level by supporting the house at a slightly raised elevation under normal circumstances. Successful amphibious foundation systems can be found in Maasbommel, Netherlands, and at Old River Landing, Louisiana, where they provide flood protection that is more reliable, more convenient and less expensive than what can be achieved by other retrofit strategies such as permanent static elevation.

The buoyant foundation system is a retrofit strategy that basically works like having a floating dock installed under the house, except that it is on dry land most of the time. A structural subframe attaches to the underside of the existing house, under which flotation elements, or "buoyancy blocks" are secured (Fig. 4). These blocks are typically made of Expanded Polystyrene (EPS), but can be modified to utilize other buoyant materials based on local circumstances. To provide resistance to the lateral forces of wind and flowing water, steel vertical guidance posts are located near the outer corners of the house, and connect to extensions of the subframe. Sewer and gas lines are equipped with self-sealing breakaway connections, while typical water and electricity lines are replaced with long, coiled "umbilical" lines. When flooding occurs, the buoyancy blocks lift the house, with the structural subframe transferring the forces between house, blocks and posts. The vertical guidance posts keep the house from going anywhere except straight up and down, always above the surface of the water (English, 2009). The do-it-yourself nature of this system speaks to why this is an appropriate strategy for the Lake Saint Martin community, whose residents seek independence from a provincial government that is at best indifferent to their needs.

While as a group they are similar in concept, the technical aspects of each specific amphibious design may vary greatly depending on the social context of local culture, the local construction practices, the local availability and cost of materials, and preferred installation techniques. Buoyant foundations act as not only a passive and easy-to-implement alternative to traditional flood mitigation strategies, but also a culturally sensitive solution that minimizes the need for relocation, encouraging continuity in communities' ways of life. In this way, significant cultural

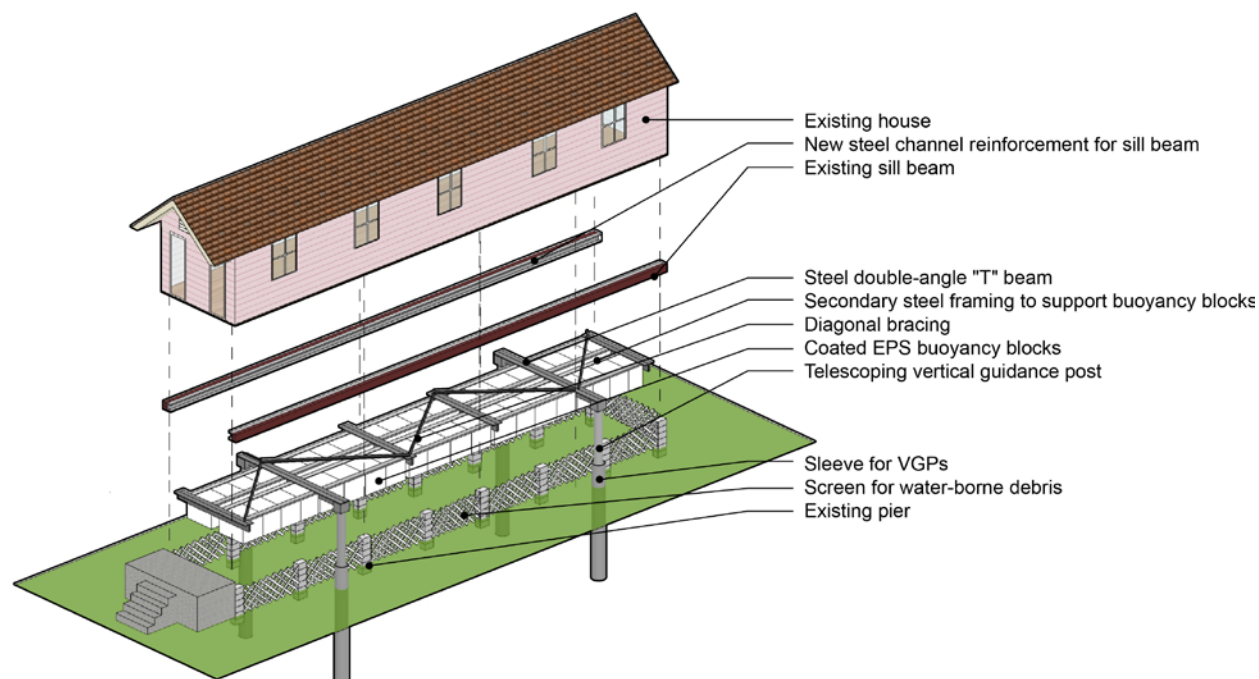


Fig. 4. An exploded axonometric drawing showcasing the different elements of a buoyant foundation designed for a Louisiana “shotgun” house (source: Buoyant Foundation Project)

practices and ties to the land can be preserved, an important step in maintaining cultural traditions. Buoyant foundation retrofits are also environmentally sensitive solutions that attempt to work in concert with a region’s natural flood cycles, rather than obstructing the water or attempting to modify its course, the environmental repercussions of which are clearly demonstrated by the situation in the Lake Saint Martin reserve.

The system developed by the Buoyant Foundation Project is one that lends itself well to the circumstances facing the people of Lake Saint Martin. In the construction of the new Lake Saint Martin community, it would be relatively simple and straightforward to design and fabricate a series of amphibious prototype homes equipped with buoyant foundations to address the particular environmental considerations of Lake Saint Martin. Given that the new community will likely be equipped with modular housing similar to what is in reserves across Manitoba and the rest of Canada, it would be realistic to expect that the community could initiate a series of amphibious retrofits across the entirety of their newly constructed or relocated homes. Re-establishing the Lake Saint Martin community with this method of flood-proofing has numerous advantages, which include assuring residents that their possessions will remain undamaged during the inevitable seasonal floods, enabling shorter evacuation periods, fostering a sense of independence from government assistance, maintaining the cultural attachment to the land, and saving the government the millions of dollars that it would otherwise spend on more environmentally impactful water diversions and on the costs of relocation.

While this paper focuses on the Lake Saint Martin community, their experiences have been similar to other communities in the Interlake Reserves. The second author visited the Pinaymootang Reserve in January 2015 to begin a dialogue about the issues these communities faced resulting from the flood events of 2011 and to introduce the concept of buoyant foundations and their potential to reduce flood damage. The concept of amphibious retrofits for the at-risk Interlake Reserves was well received by the Pinaymootang community, as well as Pinaymootang’s Chief, Garnet Woodhouse, and the three Interlake Reserves Tribal council members with whom she was fortunate to meet during her visit to the Pinaymootang reserve. What follows is a plan for the possible implementation of amphibious prototypes in the Lake Saint Martin reserve, and a strategy for their implementation across other reserves.

4. Implementation

While this initiative has yet to receive adequate funding, the projected timeline for the project would proceed as described below:

Early spring would be spent recording data and documenting the impacts and effects of the regional flood cycle on the Lake St. Martin reserve and surrounding areas. This would give a better understanding of variances in geographical impact and water levels, and inform our design and implementation process. This would also be a good opportunity to document the site and its surrounding areas. Early summer would be dedicated to completing any additional background research, and producing prototype designs for the houses to be retrofitted. These designs would be documented with full construction drawing sets. Efforts would then be focused on finalizing the designs before construction. The Interlake Reserves Tribal Council would be consulted throughout the process to assess the appropriateness of the designs and to identify the best sites for their implementation. Both a structural and a marine engineer would then review the construction drawings. The structural engineer would assess the structural adequacy and integrity of the prototype design, and calculate the technical requirements of the subframe and the vertical guidance posts. The marine engineer would review the design to ensure that the amphibious foundation, which behaves much like a floating dock, has sufficient buoyancy and buoyant stability. Once the Tribal Council and both engineers had approved the drawings, the design phase would be complete.

Late summer would focus on installing the below-ground components of the foundation for the houses that would be moved to the Lake Saint Martin, Little Saskatchewan and/or Dauphin River reserves before the ground freezes in October. The foundation would be set into the ground, and the structural subframe would be assembled without any actual buoyant elements installed yet. If the final designs were to incorporate telescoping vertical guidance posts rather than static posts, the sleeves would be set into the ground. Residents of various reserves under the Interlake Reserves Tribal Council would be involved in the construction process from the very beginning, learning the simple and readily accessible process of retrofitting a house with a buoyant foundation. In learning this first-hand they would be able to replicate the process in the future, and pass the knowledge to other Bands. In autumn, the focus would be on retrofitting any suitable pre-existing Lake Saint Martin houses with buoyant foundations, and moving the new homes to their respective locations (Fig. 5). New foundations would be constructed for the existing homes following the same approach as the other prototypes. The buoyancy blocks would then be applied to the subframe of the house, and the home would be placed on the new amphibious foundation.



Fig 5. (a & b) Prefabricated homes on the Pinaymootang reserve, representative of housing types common to the area that could be retrofitted with buoyant foundations.

With the foundations set, and the retrofit of the existing home complete, the houses would proceed to be attached to their new buoyant foundations, and outfitted with the buoyant elements of the design. Once buoyant elements are fixed, their various utility lines would be set up and the new buoyant homes would be fully functioning. The houses moved from the former military base would be ready for their new occupants to move in at this point.

Until the arrival of the spring floods, various technologies and other strategies would be investigated to monitor the status of the prototypes when the flood occurs. By making presentations, attending conferences and writing reports, information would be disseminated about this project to other First Nations communities that might be interested in implementing this strategy, to the larger national disaster mitigation and climate change communities, both professional and academic, and to interested federal, provincial and local government agencies.

The next regional flooding would be expected to occur during mid spring. During this period data would be recorded to be used for making improvements to the designs for further applications. The early summer months would be spent analyzing the various forms of data that were gathered during the flood, to identify any concerns or issues in the design or construction that may have been revealed. The remainder of the summer months would be spent making any necessary revisions to the prototypes, before signing off on a finalized design for wider distribution. A report on the findings of the initiative would then be prepared, and possibilities for future implementation of the amphibious technologies investigated. Using the construction drawings, and their own first-hand experience in applying buoyant foundations, the community members trained in the construction could begin to apply amphibious retrofits across the various Interlake Reserves Tribal Council communities.

This rough timeline for construction would allow for a relatively straightforward installation and study period, with time to allow for the teaching of the process of retrofit to the community, the gathering of necessary information and findings, and the presentation of such findings in a legible and easy to understand manner.

5. Conclusion

The people of Lake Saint Martin share an intense connection to the land on which they live, and they do not want to leave their homeland. The provincial government of Manitoba put in place the water diversions that have made their previous settlement unlivable and has a track record of making decisions without consulting the community. It is reasonable to expect that they will continue to make culturally insensitive decisions in terms of housing for the people. The Lake Saint Martin community is in dire need of a flood mitigation solution that addresses flood conditions for the region in which they live without ignoring their specific cultural and social needs. This solution must be inexpensive to implement, sensitive and responsive to the community's traditional practices, and able to be applied without the involvement of an unreliable and un-empathetic government.

Buoyant foundations fulfill all of these criteria. With their low cost, easy implementability, and minor impact to the environment and character of a community, buoyant foundation construction is an appropriate and cost-effective method of flood mitigation particularly suited to this community. Should the timeline highlighted be followed, and the method of construction taught, this initiative could very well be the first step in the recovery of a self-sustainable Lake Saint Martin community. With the knowledge gained from this initiative, the Lake Saint Martin community could easily become the first in a chain of flood-resilient First Nations in Canada, communities that strive to retain their individuality in what is, for them, not only a dangerous physical environment, but a hostile political environment.

References

CBC News (2015). "Lake St. Martin relocation plans 1 step closer to becoming a reality." *CBC News*, June 22, 2015. Accessed June 22, 2015. <http://www.cbc.ca/news/canada/manitoba/lake-st-martin-relocation-plans-1-step-closer-to-becoming-a-reality-1.3123327>.

CBC News (2015). "Lake St. Martin flood evacuees protest being out of homes for 4 years." *CBC News*, May 8, 2015. Accessed May 8, 2015. <http://www.cbc.ca/news/canada/manitoba/lake-st-martin-flood-evacuees-protest-being-out-of-homes-for-4-years-1.3066717>.

English, E. (2009). *Amphibious foundations and the Buoyant Foundation Project: Innovative Strategies for Flood-Resilient Housing*, International Conference on Urban Flood Management, UNESCO-IHP and COST Action C22, Paris, France, 25 – 27 November 2009.

Forbes, S. (2013), "Lake St. Martin - still homeless." *Winnipeg Free Press*. Accessed May 6, 2015. <http://www.winnipegfreepress.com/opinion/analysis/lake-st-martin---still-homeless-206231981.html>.

Goomansingh, C., & Logan, N. (2013). "Homes set up for Lake St. Martin flood victims remain empty, set to be moved." *Global News*, April 9, 2013. Accessed August 30, 2013. <http://globalnews.ca/news/467225/homes-set-up-for-lake-st-martin-flood-victims-remain-empty-set-to-be-moved/>.

Government of Manitoba (2013). *2011 Flood: Technical Review of Lake Manitoba, Lake St. Martin and Assiniboine Water Levels*.

Paul, A. (2014). "Deal for a new Lake St. Martin." *Winnipeg Free Press*, July 16, 2014. Accessed July 16, 2014. <http://www.winnipegfreepress.com/special/flood/deal-for-a-new-lake-st-martin-267287121.html>.