Construction Cost Review

NUNAVUT HOUSING CORPORATION

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TABLE OF CONTENTS

1.0 Executive Summary

The objective of this study is to conduct a review of the construction cost drivers affecting delivery of public housing by Nunavut Housing Corporation (NHC) through an examination of different construction methodologies, their respective costs and impacts on economic leakage, including a look at construction training for Inuit labour, and considerations for improved construction cost control.

Analysis of NHC's construction allocation methodology and assessment of the Nunavut Down payment Assistance Program (NDAP) are performed as part of this study, with the objective of evaluating their contribution to addressing the current and future housing demand in the territory.

Construction Methodologies, Cost Drivers and Economic Leakage

The NHC single storey fiveplex design used in the tendering of NHC public housing projects is based on traditional stick-built wood frame construction, includes building envelope composition and details that are well developed and designed to provide high levels of insulation and airtightness, and incorporates good building practices for the environment. The design includes a ventilation system designed for this level of airtightness of building with energy recovery features. The contract documents include testing of airtightness of the building envelope to assure that the required airtightness is achieved. The design includes insulation type which is essentially noncombustible, a good practice not mandated by the building code but that can be viewed as a desirable feature to reduce the combustible load in the building envelope given the critical importance of housing in Nunavut. The NHC fiveplex design incorporates good building envelope practice and has evolved over the years based on experience to date.

Our review includes the consideration of what elements of the NHC fiveplex might be considered for offsite prefabrication and what effects this would have on design, on the estimated cost of construction, on schedule, on economic leakage of the project and on the potential for Inuit participation in onsite construction activities.

The alternatives considered in this evaluation include the use of Structural Insulated Panels (SIPs) to replace components on the building envelope, and the potential use of modular prefabrication in the delivery of a single storey NHC fiveplex.

The NHC fiveplex design, by grouping five units together, provides energy efficiencies by reducing the exterior building envelope in comparison with five separate individual housing units. In addition, it is more efficient to have a central mechanical and electrical room and an insulated chase beneath the elevated floor serving five units in comparison with five individual units. Furthermore, the construction of fiveplexes allows for savings due to scale in comparison with five individual units being constructed.

The analysis that has been done studies those parts of an NHC fiveplex that could be considered to be replaced by Structural Insulated Panels and Modular Construction. In both cases, the uniqueness of the central mechanical and electrical room of the fiveplex, the connected service chase below the floor level and appendages such as exterior stairs are considered as needing to be constructed using traditional stick-built construction. Traditional stick-built construction as is now used on NHC fiveplexes has very limited offsite construction (engineered wood trusses, engineered wood beams, millwork). Construction incorporating the use of SIP options reduces the amount of framing and insulating to be done onsite, thus reducing the amount of onsite labour for these components only. In the case of modular prefabrication of housing units offsite, there is a much more significant reduction in onsite labour.

Traditional stick-built construction of NHC fiveplexes results in the least economic leakage, followed by part-SIP and then modular methodologies.

The costs that have been estimated for each of these delivery methodologies are based on NHC tender results for traditional stick-built construction and adjustment of these costs for those parts of construction that would be modified by the use of SIPs or Modular Construction. All of these delivery methods will be affected by variations in the cost of building materials and there is no evidence that the variations in material costs that occurs, and that has occurred more dramatically recently, will affect the comparison or conclusions.

The analysis for the three construction methodologies has resulted in estimated costs that are very similar, but with economic leakages and estimated onsite labour hours that are quite different.

For NHC fiveplexes, there are more risks and challenges associated with construction methodologies that include the use of SIPs or other insulated panels compared with the current methodology of traditional stick-built.

These risks and challenges include aspects such as:

Need to develop designs and tender documents specifically for projects with use of Structural Insulated Panels or Modular Construction

- In the case of Structural Insulated Panels, the need to review in detail code compliance, incorporation and details for building envelope; the need to determine which if any of floor, wall and roof panels will be accepted and how these will be integrated into the overall design; the need to be satisfied that the end product will be as durable as the current traditional stick-built NHC fiveplex.

Reduced number of companies that can provide Structural Insulated Panels and Modular Construction

- This can affect tender prices, the number of bidders and poses risks should the SIP manufacturer or Modular provider have difficulties delivering to the sealift on time.

With Structural Insulated panels and Modular Construction, tendering must start much earlier in order to allow time for design, coordination of design and review of shop drawings in order to meet sealift cutoff dates.

With Structural Insulated Panels and Modular Construction, design coordination is much more critical and oversights or desired Owner changes have more serious effects onsite and are more difficult to deal with than in traditional stick-built construction.

Additional field reviews by the Consultants and SIP manufacturer are recommended compared with traditional stick-built delivery.

Reduced pool of contractors and construction workers experienced with Structural Insulated Panels and Modular Construction.

- The use of SIPs are not part of the experience and expertise of the majority of General Contractors experienced in residential construction. This is even more so the case with Modular Construction which requires a higher degree of organization, oversight, health and safety expertise and logistics expertise than would typically be present in most residential contractors capable of building traditional stick-built residential construction.

While it is recommended that NHC continue to be open and investigate solutions besides traditional stick-built for public housing delivery, we would recommend that Structural Insulated Panel use may be more appropriate should NHC consider in the future smaller housing types (such as single family dwellings) for which SIPs have a longer track record and constitute the majority of buildings using SIPs.

Modular construction is better suited to the construction of large multi-storey buildings with flat roofs in locations where the required hoisting equipment is present or the project is large enough to distribute the costs of such equipment.

Construction Allocation Methodology and Homeownership

We have estimated that in order for NHC to provide enough public housing so that by 2035 the housing need in Nunavut is met, the number of housing units (with 2-bedroom units as the basis on average) would need to be increased from its current levels of construction (100 to 120 units per year) to approximately 280 units per year.

This would among other things be expected to require additional funding, additional NHC staffing, and potentially additional contractors and subcontractors participating in bidding and construction.

In regards to programs such as NDAP which are designed to encourage private homeownership, we are of the opinion that the interest in such down payment assistance will not be significantly increased by changes to the details of this program. This is due to the negative aspects of private homeownership for personal use that exist in Nunavut that include high utility costs, relatively stagnant home resale prices, and high maintenance costs, among others.

Construction Training and Workforce

In regards to construction training and opportunities for increased Inuit participation in construction, this report discusses some of the present challenges that exist and includes recommendations that may be beneficial to increasing Inuit participation and the number of Inuit construction workers available in the territory. The report also addresses limitations regarding the potential increase in the number of Inuit construction workers, given: the available labour pool, the fact that construction work in Nunavut is typically seasonal (less desirable than full-time work), and that construction work is physically taxing and involves long hours. These aspects of construction work make it less appealing than other work alternatives, both in Nunavut and other parts of Canada.

Should there be a review in NNI Policy provisions, one aspect that could be considered is:

- Modifications that might encourage or allow a greater number of contractors available to provide services on public housing projects that in turn would support the delivery of additional needed housing (assuming other constraints such as funding and NHC staffing levels are eliminated).

2.0 Overview

2.1 Purpose

The objective of this study is to conduct a review of the construction cost drivers affecting delivery of public housing by Nunavut Housing Corporation (NHC) through an examination of different construction methodologies, their respective costs and impacts on economic leakage, including a look at construction training for Inuit labour; and considerations for improved construction cost control.

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Key Subjects Addressed in the Study
Cost Drivers for NHC Housing Construction
Construction Methodologies – Stick-Built, Part-Modular and Part-SIP
Construction Methodologies – Costs and Effect on Economic Leakage
Construction Methodologies – Inuit Labour Participation and Training
Construction Allocation Methodology and Home Ownership

2.2 Approach

The approach used in the execution of this mandate is represented through four phases of activity:

PHASE 1 – PROJECT INITIATION

Project Kick-off and Planning – September 2020

PHASE 2 – PROJECT DISCOVERY

Investigation, Documentation Review and Preliminary Analysis – September to November, 2020

- Engagement and Interaction with NHC – Directorate and District Levels (by video conference)
- Review of Documentation and Materials Provided by NHC
- Review and Analysis of Other Data and Housing Research
- Preparation of Stakeholder Engagement Strategy and Materials

PHASE 3 – STAKEHOLDER ENGAGEMENT, ANALYSIS AND REPORT DEVELOPMENT

- Synthesis and Analysis Based on Discovery and NHC Engagement to Date – December 2020
- NHC Feedback and Approval of Stakeholder Engagement Approach and Questionnaire Topics
  - Outreach to Prospective Participants and Scheduling of Interviews
- Engagement Sessions with Stakeholders (by video conference) – January and February 2021
  - Group 1: NHC

    - Group 2: Design Community
    - Group 3: General Contractors
    - Group 4: Subcontractors
    - Group 5: Sealift Providers
    - Group 6: Modular Component Providers
    - Group 7: Structural Insulate Panel (SIP) Providers
    - Group 8: Other Jurisdictions
    - Group 9: Groups Involved in Construction Trades Training
- Synthesis and Analysis Following Stakeholder Engagement
- Writing, Assembly and Submission of Draft Report – March 2021
    - NHC Review of Draft Report

PHASE 4 – REPORT FINALIZATION

- Revisions and Edits Based on Client Feedback
- Issuance of Final Report – June 2021
    - Wrap-up Session with NHC

3.0 Background

The distinct territory of Nunavut is comprised of the three administrative regions of Kivalliq, Kitikmeot, and Qikiqtaaluk, which in turn represent 25 communities.

Nunavut Region Map. ontheworldmap.com/canada/province/nunavut/nunavut-region-map.html

According to the latest data released by Statistics Canada in 2020, the population of Nunavut was estimated to be 39,353 as of July 1, 2020, representing an increase of 1% since the last update 3 months prior on April 1, 2020.[1] With a rapidly growing population contributing to housing demand across the territory, vacancy rates near zero for both market rental units and public housing units according to CMHC data,[2] and the high costs of construction and land availability constraints posing continued limitations on new housing construction, the NHC is increasingly challenged with expanding its portfolio of available housing to support public housing.

[1] https://gov.nu.ca/sites/default/files/nunavut_and_canada_population_estimates_statsupdate_second_quarter_2020.pdf

[2] CMHC Northern Housing Report 2020

3.1 Nunavut Housing Corporation

The NHC's mandate as a public agency of the Government of Nunavut (GN) is "to create, coordinate and administer housing programs […to] provide fair access to a range of affordable housing options to families and individuals in Nunavut."[3]

ORGANIZATION

The NHC's core business services are organized into the following distinct lines of program delivery: Public Housing, Staff Housing, and Homeownership. A corporate team of 100 housing professionals are structured around five offices and further supported by a network of 25 Local Housing Organizations (LHOs), who provide the day-to-day services associated with program delivery to Nunavummiut in the communities. The 3 District Offices set regional priorities and are responsible for ensuring the construction program is successful within its regions, among other supports provided to the LHOs. The District Offices are also responsible for the delivery of various homeownership programs. The Directorate & Corporate Headquarters are comprised of the Executive Committee, the Corporate Policy & Communications group and Corporate Headquarters, providing support to the District Offices among other responsibilities.[4]

PUBLIC HOUSING PROGRAM

The LHOs are responsible for the complete care of the Public Housing portfolio at the community level. This includes unit allocations, rental assessments and collections, and maintenance and repairs. In addition to regular maintenance and repairs on the Public Housing units, NHC is engaged in modernization and retrofits on an ongoing basis to upgrade the public housing stock. These take the form of expansions, energy efficiency upgrades, and major renovations.[5]

New Public Housing construction is a critically important component of the Public Housing program in which new public housing units are built across Nunavut each year.[6]

RESPONSIBILITIES OF THE COMMUNITY

The 25 communities in the territory (24 hamlets and the City of Iqaluit) are responsible for local land development. The NHC uses what existing land is available for their planned builds. Housing costs for more remote areas with undeveloped land would therefore need to include the costs by hamlets for land surveying, road infrastructure and utilities. Only three of the 25 communities, Iqaluit, Resolute Bay and Rankin Inlet, are equipped with a piped distribution system for utility services (called a utilidor). The remaining 22 communities rely on truck service for utilities. This characteristic represents an important cost driver of housing construction, which is discussed in Section 4.0.

3.1.1 Current State of Housing in Nunavut

Data provided to CMHC indicates that total social and affordable housing stock in Nunavut in 2019 was 5,568 units.[7] According to NHC's 2019-2020 Annual Report, there were a total of 5,668 units as of March

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[3] http://www.nunavuthousing.ca/about
[4] http://www.nunavuthousing.ca/about
[5] http://www.nunavuthousing.ca/publichousing
[6] http://www.nunavuthousing.ca/publichousing
[7] https://www.cmhc-schl.gc.ca/en/data-and-research/data-tables/rental-market?guide=Social%20and%20Affordable%20Rental%20Structure%20Survey%20Tables.

31, 2020.[8] [9] This indicates that 100 new housing units were added to the total stock of public housing during this time. Of the public housing units, 95% is owned by NHC and the remainder is leased. In addition to public housing NHC provides over 1,575 staff housing units (of which approx. 30% is owned and 70% leased) and holds mortgages for 146 homeowners[10].

NHC currently serves 21,537 public housing tenants through its public housing units. According to the 2010 Nunavut Housing Needs Survey, public housing accounts for 51% of Nunavut's housing stock and 97% of public housing tenants are Inuit. Due to the absence of private affordable rental housing and given the high costs of independent homeownership, public housing units are home to over half of Nunavummiut. The majority of tenants are in the 18 to 60-year age group, with a sizable number below the age of 18[11].

Table 1: Tenant Age Distribution

6% Over 60 Years	12% 45-60 Years
40% 18-45 Years	42% Below 18 Years

Nunavut has experienced rapid growth in its population, and it is expected to continue to see the same in the coming years, as 82% of the tenants are below the age of 46. Based on the 2009 Nunavut Housing Needs Survey, the territory needed to build 90 units annually just to keep up with population growth[12]. This number will continue to increase due to a likely increase in Nunavut's birth rate among Nunavut's productive age group.

Large gaps exist in Nunavut's "housing continuum," and they are not easily bridged. A housing continuum can be described as a line with two extremes: at one end, homelessness; and at the other end, an owner-occupied home. Between these two points, various types of housing are supported either through the housing market (rentals and purchases) or by government (emergency shelters and social housing). Nunavut's housing continuum skews heavily toward non-market housing provided or supported by government at a significant cost. Market housing is rare; there is some in Iqaluit, Rankin Inlet and Cambridge Bay but in most other communities it does not exist. NHC's public units represent 60 percent of all homes. Many of the remaining units are occupied by government employees who benefit from subsidized rent.

3.1.2 Construction Allocation Methodology

The Corporation continues to address the dire need for housing in Nunavut. Graph 1 shows each community's housing demand. Housing demand is measured using each community's public housing need as a percentage of its existing public housing stock. Funding for these projects is provided by the Government of Nunavut through the capital budget as well as the federal government through the National Housing Strategy. Allocation of housing projects was based on each community's need as a

[8] NHC 2019-2020 Annual Report; available at http://www.nunavuthousing.ca/publications#.
[9] https://nhcweb.s3.amazonaws.com/publications/annualreport_2019-20_0.pdf; page 8.
[10] Nunavut Housing Corporation Business Plan 2019-20
[11] Nunavut Housing Corporation Annual Report 2018-2019
[12] Nunavut Housing Corporation Annual Report 2018-2019

percentage of stock. It is expected that, over time, continued use of relative need as a construction allocation methodology, will narrow the needs gap across all communities.

NHC's construction allocation methodology is discussed in detail in Section 7.0.

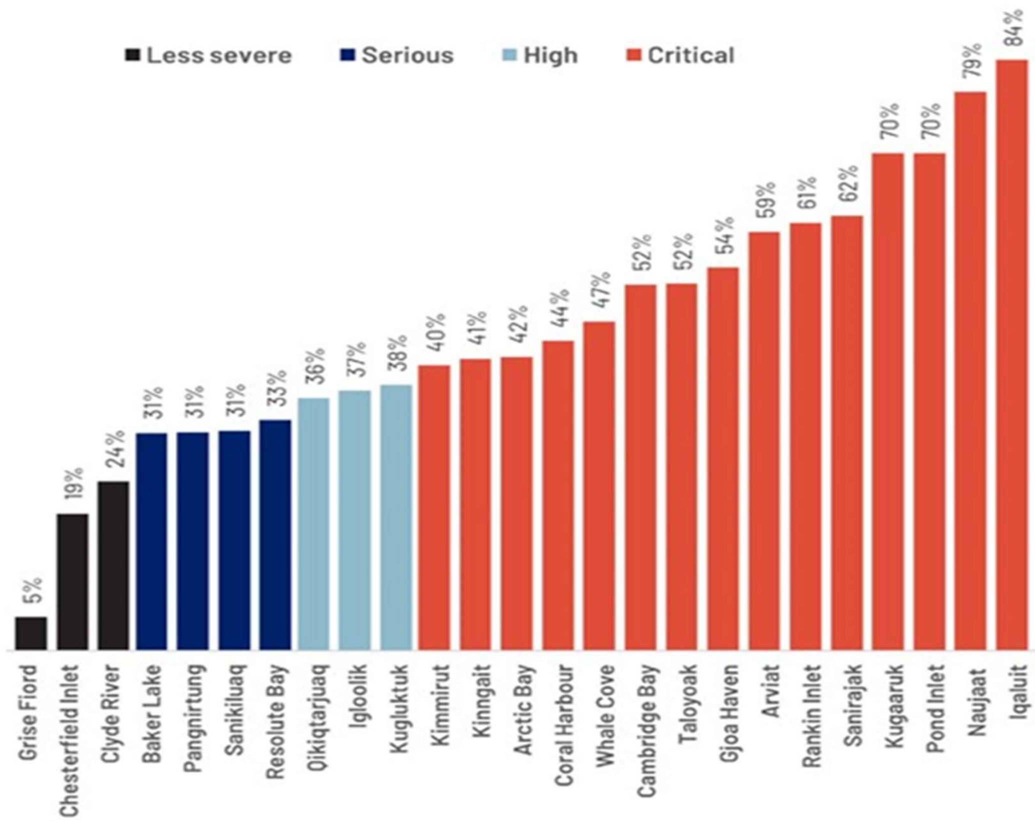
3.1.3 NHC Capital Investment

The NHC runs the Public Housing Program alongside 25 Local Housing Organizations (LHO), each representing a Nunavut community[13]. LHOs assign housing for their communities based on management agreements with NHC, informed by local knowledge and values. Their responsibilities include rental assessments, collections, maintenance, modernization, and improvements.

Since year 2016 NHC has entered into a funding agreement with CMHC for $84.1 million for new public housing construction, housing for seniors, victims of family violence and social housing renovation and retrofit programs. All related work has been completed by the end of 2019-20 resulting in construction of 185 public housing units in 15 communities and renovation and retrofits to public housing, seniors' accommodation, and homeless shelters. In year 2018 NHC entered into the Northern Funding Agreement with CMHC for $24.0 million to be used for new public housing construction. Funding from this agreement will contribute to construction of 60 new public housing units in four communities, with work expected to be completed in 2020-21.

[13] Nunavut Housing Corporation Annual Report 2019-2020

Graph 1: Housing Need as a Percentage of Existing Stock (Source: Nunavut Housing Corporation Annual Report 2019-2020)



During the year the Corporation spent $45.0 million (2018-19 – $48.3 million) to complete 85 public housing units in 10 communities[13] of Arctic Bay, Arviat, Cambridge Bay, Gjoa Haven, Igloolik, Kugluktuk, Naujaat, Qikiqtarjuaq, Rankin Inlet, and Taloyoak[13]. These projects were funded from the Government of Nunavut's capital budget and CMHC's Investment in Affordable Housing and Social Infrastructure Fund programs. The Modernization and Improvement Program ensures the health, safety, and suitability of these units. In 2019-20, $13.5 million (2018-19 – $17.1 million) was spent on modernization and improvements. Funding for the program came from the following sources: Government of Nunavut - $8.5 million; Canada Mortgage and Housing Corporation - $5.0 million[13].

In addition to that NHC has started construction of 80 public housing units in six communities. These projects were funded from the Government of Nunavut's capital budget and CMHC's Investment in Affordable Housing program.

3.1.4 NHC Operating Data

Public housing rental revenue amounts to only 8% of the cost of providing public housing. The bulk of the funds needed to run a viable public housing program, i.e. the remaining 92% of the revenue, comes from transfers from Government of Nunavut (GN) and the CMHC. CMHC revenues are in respect of capital contributions as well as operating revenues through the Social Housing Agreement. GN contributions have increased by 9% in four years and in 2019-20 constituted 78% of the Corporation's revenues. The GN's contribution will continue to grow as more and more housing units are added to the stock[14].

Public housing rent assessments are geared to a tenant's income, meaning the more income a tenant makes, the more rent they are likely to pay. The public housing rent scale assesses income of the two primary tenants in each unit based on the following annual income brackets:

Table 2: Rent Scale Based on Income Brackets (Source: Nunavut Housing Corporation Annual Report 2019-2020)

Below $27,041	Up to $60 a month
$27,041 to $40,000	20% of annual income
$40,001 to $80,000	25% of annual income
$80,000 and above	30% of annual income

With 73% of public housing tenants earning less than $27,041 per year, the Local Housing Organizations' ability to generate revenues from rent is severely limited.

One of the main challenges of operating public housing in Nunavut is the extremely high operating costs. Annual operating costs are approximately four times that of operating costs for public housing units in southern Canadian cities[15]. Water & Sewer costs are the largest single operating expense component for public housing. They are greater than the cost of LHO administration & maintenance combined. The annual average administration and maintenance cost is $8,600 per unit while water & sewer costs are $9,300 per unit per year.

Table 3: Operating Cost Breakdown

Operating Expense Items	Op. Ex./Year ($)
Water & Sewage	9,300
Power	5,400
Fuel	3,100
Garbage	900
Taxes	700
Total - Utilities+Taxes	**19,400**
LHO Admin	2,300
LHO Maintenance	6,300
	8,600
Total including Admin. + Maintenance	**$ 28,000**

3.1.5 NHC's New Builds, Repair and Maintenance

In addition to regular maintenance and minor repairs on the Public Housing units (work of which is performed by in-house staff at the LHO level), NHC is engaged in modernization and retrofits on an

[14] Nunavut Housing Corporation Annual Report 2019-2020
[15] Based on Colliers' experience in working with other public housing providers in southern Canadian cities, where it is observed to be between $5,500 to $7,500 per unit per year. This includes insurance, taxes (sometimes exempt), repair & maintenance, utilities and property management costs.

ongoing basis to upgrade the public housing stock. These take the form of expansions, energy efficiency upgrades, and major renovations.[16]

When major repairs are needed on housing units that are deteriorated enough in which the work cannot be completed without vacating the units, NHC will move existing tenants out and into swing space in the form of other housing units.[17] The waitlist for new housing does not include those tenants whose housing is slated to undergo repairs, but focuses on those who need new housing.

Major repairs, including mould remediation work, are typically tendered out.

3.1.6 NHC Programs

In addition to providing social housing through its rental housing units, NHC also assists Nunavummiut to become homeowners. The NHC offers two types of homeownership programs, Home Purchase Assistance Programs, and Home Renovation and Repair Programs.

ACTIVE HOME PURCHASE PROGRAMS

Active home purchase programs currently offered are:

Nunavut Down payment Assistance Program (NDAP) – In this program Nunavummiut are offered down-payment assistance in the form of a forgivable 2nd mortgage over a 10-year period to subsidize the cost of purchasing an existing home or constructing a new home. There is no forgiveness in the first 5 years. The NDAP contribution is based on 7.5% of the total costs, to a maximum of $30,000. The client's portion of the down payment must be a minimum of 2.5 per cent of the total costs. One-year Nunavut residency is required to be eligible for this program[18].

Interim Financing Program (IFP) – This program offers assistance to Nunavut homeowners to complete repairs, renovations, or additions to existing homes. HRP assistance is a forgivable loan up to maximum of $50,000. An additional $15,000 is available for energy efficiency related items.

Tenant to Owner Program (TOP) – Tenants in NHC Public Housing Program units who are in good standing with the LHO are provided assistance to become homeowners by purchasing a suitable public housing unit that the NHC has approved for sale in consultation with the LHO. The applicant(s) income must fall below NHC's Adjusted Income Eligibility Threshold, but at the same time have sufficient income to pay for all ongoing, mortgage/loan and operating costs of the unit. The applicant's ability to pay will be assessed using current Home Ownership guidelines[19].

Seniors and Persons with Disabilities Home Options Program (SPDHOP) - SPDHOP assists seniors and persons with disabilities who can no longer afford homeownership by allowing them to access public housing upon the sale or transfer of their home.

ACTIVE HOME RENOVATION AND REPAIR

Active home renovation and repair purchase programs currently offered are:

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[16] http://www.nunavuthousing.ca/publichousing
[17] Based on discussion with NHC in Discovery Meeting held on September 24, 2020 (minutes are in Appendix 4).
[18] All program descriptions except TOP based on information provided in NHC's 2019-20 Capital Budget Binder – Standing Committee 2018 and Nunavut Housing Corporation Annual Report 2019-2020.
[19] Based on Cabinet Approved Tenant to Owner Program document dated October 2015.

Home Renovation Program (HRP) - HRP offers assistance to Nunavut homeowners to complete repairs, renovations, or additions to existing homes. HRP assistance is a forgivable loan up to maximum of $50,000. An additional $15,000 is available for energy efficiency related items.

Emergency Repair Program (ERP) - ERP offers assistance for emergency repairs that are required for the continued safe occupancy of a home. The maximum contribution available is $15,000.

Senior Citizens Home Repair Program (SCHRP) - supports senior homeowners with repairs and home adaptations. The maximum contribution available is $15,000 plus eligible freight costs.

Heating Oil Tank Replacement Program (HOTRP) - The Heating Oil Tank Replacement Program (HOTRP) was initially approved by Cabinet in 2010. This program provides assistance to homeowners to replace their heating oil tanks and associated components as well as installation, in the form of a grant of a maximum of $7,500 per unit. This was initially a five-year initiative with a goal of replacing one hundred oil tanks per year for a total of 500 oil tanks across Nunavut. In 2015 the program was revised to ensure that the grant provided meaningful assistance resulting in the increase from $5,000 to $7,500 per unit. The increase effectively reduced the number of targeted replacements from 100 tanks to 66. This Program is in high demand and is expected to continue indefinitely.

Seniors and Persons with Disabilities Preventative Maintenance Program (SPDPMP) - provides support to senior citizens and persons with disabilities who own their own home. The SPDPMP ensures the most vulnerable homeowners are given support in completing preventative maintenance that improves safety, reduce total maintenance costs, and ultimately allow the homeowner to remain in their own home rather than rely on public housing or other social programs. The grant level of this program is set at a maximum amount of $3,000 to cover the cost of materials, freight, and labour.

HOMEOWNERSHIP PROGRAM SPENDING

In 2019-20, $5.0 million (2018-19 – $4.4 million) was spent on Homeownership Programs. Funding for these programs came entirely from the Government of Nunavut's capital budget[20]. Table 4 provides an overview of the distribution of Home Ownership Program Spending across Nunavut.

Table 4: Home Ownership Program Spending

Program	Qikiqtaaluk	Kitikmeot	Kivalliq	Total Nunavut
SCHRP	$ 70,401	$ 35,629	$ 63,295	$ 169,32
ERP	286,989	216,132	576,103	1,079,224
NDAP	986,393	76,125	$95,175	1,157,693
HRP	995,140	507,595	711,031	2,213,766
SPDPMP	3,786	10,975	7,628	22,389
HOTRP	154,919	48,880	196,016	399,815
Total	**$ 2,497,628**	**$ $895,336**	**$ 1,649,582**	**$ 5,042,212**

The Nunavut Down payment Assistance Program, the Home Repair Program and the Emergency Repair programs are by far the most active, accounting for 88% of expenditures and 71% of approved

[20] Nunavut Housing Corporation Annual Report 2019-2020

applications. The Corporation approved 32% (295 applications) out of a pool of 896 applications. In all, 30 applications were declined within the fiscal year while an additional 571 were waitlisted[21].

3.1.7 Project Delivery Model and Methodology

The NHC employs a Supply-Ship-Erect (SSE) model of delivery on all current housing construction tenders, using Combined Labour and Material contracts.

LESSONS LEARNED

In the past on the provision of housing the NHC has used separate Material and Labour tenders, most notably as part of the federally funded $200 million multi-year Nunavut Housing Trust (NHT) initiated in 2006 for the delivery of housing and significantly over budget by the end of 2009 by approximately $60 million[22]. The decision to employ a delivery strategy that issued separate material and labour tenders was made despite the absence of a standardized labour contract having been developed with approved terms and conditions consistently applied and entered into with all contracted suppliers.[23] This had the effect of leaving the NHC vulnerable to all of the associated risks and costs of acting as a general contractor responsible for the supply and re-supply of material throughout the supply chain with little legal recourse in the event of inevitable claims and damages.

POTENTIAL COST SAVINGS OF CONTRACTING METHODS

The perceived advantage of separate Material Supply and Labour contracts might be the potential to save on overhead and profits that would be charged by a General Contractor responsible for both Supply of Material and Labour. Another perceived advantage might be that a government body may have more purchasing power and obtain better pricing than a smaller, private entity might. The potential for cost savings through large bulk purchases was one of the rationales for the NHT, but the relative scale of construction in Nunavut was too small to result in any appreciable savings.

As procurement of construction materials is very specialized, it requires a lot of effort and expertise and maintenance of ongoing relationships in order to be done effectively. General Contractors have this experience and these relationships and are less likely to make mistakes in a procurement of what is needed for a construction project. In addition, when the General Contractor is responsible for both Supply of Materials and Labour, when a mistake is made the cost of that mistake is not borne by the Owner.

It is not recommended by our team that there are any advantages to the use of Separate Material and Labour contracts in residential housing construction.

[21] Nunavut Housing Corporation Annual Report 2019-2020
[22] Nunavut Housing Corporation Lessons Learned Report on the Nunavut Housing Trust, May 2012.
[23] Nunavut Housing Corporation Briefing Note on NHT Deloitte & Touche Review Reports, Sept. 19, 2011.

4.0 Cost Drivers and Construction Methodology

4.1 Cost Drivers for NHC New Builds

There are many factors that contribute to the costs of new construction in Nunavut and including NHC New Builds. Many of these are common to construction in the south of Canada and some are more specific to Nunavut and NHC New Builds.

The list of factors that can affect the amounts bid on all construction projects is extensive and is for Nunavut even more extensive. They include such factors as follows:

- Higher costs of living in Nunavut compared to other locations in Canada;
- Higher costs of foundations compared with foundations for southern housing projects;
- Higher costs due to more severe environment requiring more attention to building envelope details and higher levels of insulation;
- The choice of some building materials that are being used in Nunavut for increased durability reasons but not typical in southern Canadian locations;
- Good Building Practice for Nunavut necessitating different designs than would be suitable in southern Canada;
- Cost and availability of materials;
- Cost and availability of labour;
- Transportation and accommodation for labour;
- Productivity of labour;
- Cost of transportation to the Nunavut community in question of building materials and manufactured items that will be incorporated into construction;
- Limited number of opportunities for transportation of building materials and manufactured items and needed construction equipment to communities;
- Cost and availability of construction equipment needed for the type of construction being undertaken;
- Costs related to more handling and double-handling of materials compared to the south where often materials are delivered just-in-time for installation;
- Costs due to reduced productivity due to weather conditions;
- Costs due to shortened construction season requiring more overtime work;
- Costs due to effects on productivity due to prolonged weeks of overtime work;
- Costs for additional protection of building materials from weather;
- Costs due to higher costs for consumables such as power and fuel needed during construction;

- Costs due to certain equipment needing to be on site for longer than would be the case in southern communities, where equipment can be rented for the duration needed or if owned by a contractor be able to be moved between nearby job sites;
- Costs being higher for General Contractors and Subcontractrors based in Nunavut for office overhead costs and general costs of being in business;
- Costs of due to weather or season needing to shut down construction for a period and then re-opening site and re-mobilizing;
- Costs due to additional snow and ice removal and temporary heating costs;
- Costs due to breakdown of equipment requiring longer to be made functional again;
- Potential for higher tender prices due to a lesser number of firms interested and able to bid compliantly and competitively;
    - Policies and contract document provisions that are intended to promote the construction industry in Nunavut and employment and ownership opportunities for Nunavummiut provide competitive advantages for locally owned firms. These policies and contract document provisions may have the effect of limiting the number of firms submitting bids and in turn affect the value of submitted bids. However, these competitive advantages for firms that qualify for tender price adjustments due to these policies have encouraged and fostered the construction industry in Nunavut and encouraged Inuit ownership and employment in construction.
- When durations are short between contract awards and sealift dates that must be met, this can contribute to bidders needing to include additional materials due to less time for take-offs.

4.2 Review of Approaches Used to Date

4.2.1 Estimating

Based on our discussions with NHC, due to the repeated use of a stick-built single storey fiveplex, it has not been necessary for the NHC to create for each New Build project detailed estimates. Past tender prices provide a good database that is used by NHC to prepare budget estimates. NHC makes adjustments for expected inflation and potential changes in material costs, when preparing budget estimates for new planned builds.

Other factors may be taken into account by NHC in their assessment of the expected costs of New Builds such as: varying sealift rates to different communities, other costs such as air transportation to various communities, varying costs for civil work dependent on available lots and their topography.

We have reviewed the prescribed overall cost breakdown being used for payments to Contractors for stick-built projects with fiveplexes. This breakdown seems fair and reasonable and the distribution of cost items excluding the very Nunavut-specific and unique project-specific items (sealift, labour for piling, labour for civil and labour for insulation) are quite comparable with cost distributions obtained from surveys of stick-built residential construction in the south as would be expected.

4.2.2 Project Management, Procurement and Risk Management

We have reviewed NHC's project management of the new builds as described by NHC in meetings during the Project Discovery phase and as reflected in the process of contract administration outlined in tender documents for recent NHC new builds. The approach of NHC to project management is systematic and this is reflected as follows:

- NHC with their Consultants produce detailed specifications and drawings for the New Housing Builds.
- NHC procures housing in a systematic and well-structured way using GN Procurement. The initial tender documents and all Addenda issued are publicly available. The tenders require that information be submitted at the time of tender allowing NHC to ensure that bids are compliant. The tender process is formal and public using the GN's Tendering website[24]. Tender submissions are evaluated with respect to Inuit labour content and tender bid adjustments (for the purpose of selecting the successful bidder) using NNI Policy provisions. It is outside of our mandate to review or comment on the specific application of these policies and procedures.
- In 2020, 11 public housing fiveplexes were awarded through 5 contracts.[25]
- As is good practice, General Contractors are advised not to proceed with any work until a signed contract is executed with NHC.
- The tender documents reviewed for a recent NHC new build utilizing stick-built construction is very detailed in sections dealing with General Conditions, Division 0, Division 1, the technical specifications and the drawings provided in the tender package. The Addenda we reviewed on projects were well written and detailed. The tender documents we reviewed were in many ways more detailed and explicit than would be seen on many residential housing projects in the southern areas of Canada.[26]
- The tender and contract documents for stick-built 5plex construction are detailed in regard to the requirements related to Progress Billing, required testing and inspections, and technical requirements for the Work.
- The tender and contract documents for stick-built 5plex construction spell out how changes to work are to be priced in detail and unit prices for items subject to variation are included.

Contractors and subcontractors interviewed as part of Stakeholder Engagement who have delivered projects for NHC expressed the opinion that in general the contracts are fair and that mechanisms for evaluation of the value of changes to work are fair. As well the general sentiment is that there are no risks currently being borne by contractors in the contracts that should instead be borne by NHC.

4.2.3 Schedule Management

Based on interviews with Contractors, Subcontractors and Consultants working on NHC stick-built new builds, the following were comments made in relation to project schedule (refer to Section 8 for detailed summaries from engagement sessions):

- Design Consultants have standard designs developed for components of the 5 plexes (1 BR housing unit, 2 BR housing unit, 3 BR housing unit, Utility Chase connecting housing

[24] https://www.nunavuttenders.ca/
[25] https://www.nunavuttenders.ca/
[26] Various NHC RFP/RFT Documentation (Tender documents, bid forms, evaluations and award recommendations).

units with the centralized mechanical room, centralized mechanical room, foundation plans) that are used to produce the tender documents for 5plexes once the composition of the 5plex housing units is determined by NHC in conjunction with the LHO.

- In the fall of the year preceding the tender, NHC finalizes lot selections and composition of the 5plexes, which then enables the Consultants to put together tender documents for the NHC proposed new build.
- Given that the topography for the site still requires additional survey information, the tender documents are issued with assumed first floor elevations and there are potential changes that may occur due to the finalization of the elevation that the first floor needs to be to avoid excavation and disturbing permafrost. These are dealt with through unit prices in the contracts. Depending on the final elevation of the first floor on the high eave side of the 5plex, an exterior door may be changed to an exterior window once the Contractor is on site, in consultation with NHC.
- The final design of the bracing between piles may also be affected by the final elevation determined once onsite for the 5plex.
- Typically, tenders are issued for stick-built NHC new builds in the months of February or March and are awarded before the end of April. The time between award and sealift is rushed and with materials or products that require shop drawing submissions it can lead to challenges in getting materials ordered and delivered to sealift on time.
- Typically piling is done before the sealift arrives and does not delay construction. Materials for the standardized foundation design is in stock in the distributed communities as well as equipment needed for foundation work. The piling contractor typically uses the material their company has stockpiled in communities and then replaces it with material shipped by sealift.
- Contractors try to avoid scheduling the work to minimize costs due to temporary heat or snow/ice removal or productivity diminished by weather and temperature conditions.
- 5plexes are typically framed and house-wrapped with weather-resistant barrier in the first year of the contract. In some cases they are also insulated and other parts of the building envelope installed, and possibly roofing and siding. The level of advancement of the housing in the first year is somewhat variable and dependent on a few factors including weather.
- In the spring following a winter shutdown, the balance of the construction is done and consists of work including: any remaining work on the exterior of the housing complex, the plumbing, HVAC and electrical rough-in and finish work, Building Automation System work, completion of work in the chase under the housing, interior partitions and finishes and millwork, final grading, testing and commissioning, etc. It was noted that at the end of the NHC new builds there are challenges often since many NHC contracts can have the same final required completion date and the same subcontractors can be on many projects.
- It was noted that given the complexities of scheduling work for projects in distributed communities in Nunavut, there is variability in what work is able to be achieved in the year of the Contract Award and how much needs to be done in the year after Contract Award.

- It was noted that contractors and subcontractors typically work in rotations of 6 weeks on site, 10 hrs per day and 7 days a week, followed by a two week break from working on site.
- It was stated that the vast majority of material is brought to the community by sealift in the year of Contract Award.

Contractors and subcontractors who have participated in NHC new builds did offer several suggestions for the NHC that in their opinion could possibly improve stick-built housing project delivery which include:

- Tendering as early as possible in the year and awarding as soon as possible so that more time is available between contract award and sealift dates. This would allow for more time for shop drawing submissions and reviews. It would also allow more time for supply of items that have longer lead times to meet the Sealift departure.
- Spreading out some of the closing dates would make closing tenders less rushed. Spreading out some of the tender periods would be helpful in the bidding process for Contractors and subcontractors.
- Currently many projects can have the same completion dates which is challenging due to subcontractor trade availability.
- Mechanical subtrade indicated that including low voltage wiring for Building Automation System (BAS) with the Mechanical subtrade instead of with Electrical subtrade would facilitate construction and would allow for one trade to be involved in rectifying and troubleshooting issues with equipment operation that may involve the BAS.

Current durations of tender periods for stick-built were not indicated by interview participants as being especially problematic.

4.3 Different Construction Methodologies

4.3.1 Summary of Approach to Assessing Costs and Distribution of Costs for Different Delivery Methodologies

APPROACH TO ASSESSING COSTS AND DISTRIBUTION OF COSTS FOR DELIVERY USING:

- All Stick-Built
- Combination of Structural Insulated Panels for Floor, Wall, and Roof Panels for the portions of the 5plex with Stick-Built construction on the balance of the 5plex including the Central Mechanical Room and the connected chase under the elevated floor of the 5plex.
- Combination of Modular Construction of the individual housing units in the 5plex and traditional stick-built construction on the balance of the 5plex including the Central Mechanical Room and the connected chase under the elevated floor of the 5plex.

Prescriptive construction requirements can be followed by builders and inspected by code officials without involvement of design professionals. In Canada this would apply to Part 9 structures which are limited to certain restrictions on occupancy, size and number of storeys.

Most wood framed residential construction involves metal plate connected trusses and structural sheathing products such as plywood and OSB panels.

Combination of stick-framing and plant built components can be called component building.

There is a continuum from all traditional stick-built with no engineered and manufactured elements, to what would be current stick-built practice (utilizing manufactured roof trusses, engineered lumber flooring components and manufactured sheathing), through projects that can also utilize factory built uninsulated framed wall and floor panels, to projects involving factory built framed and insulated wall, floor and roof panels, to projects utilizing full factory construction of finished modules that are then interconnected on site.

Modular Housing is different from Manufactured Housing (also called mobile homes).

Manufactured Housing is also constructed using wood-framed methods but is completely factory assembled and delivered to site using an integral chassis for road travel and foundation support.

BASIS OF APPROACH AND NHC CONTEXT

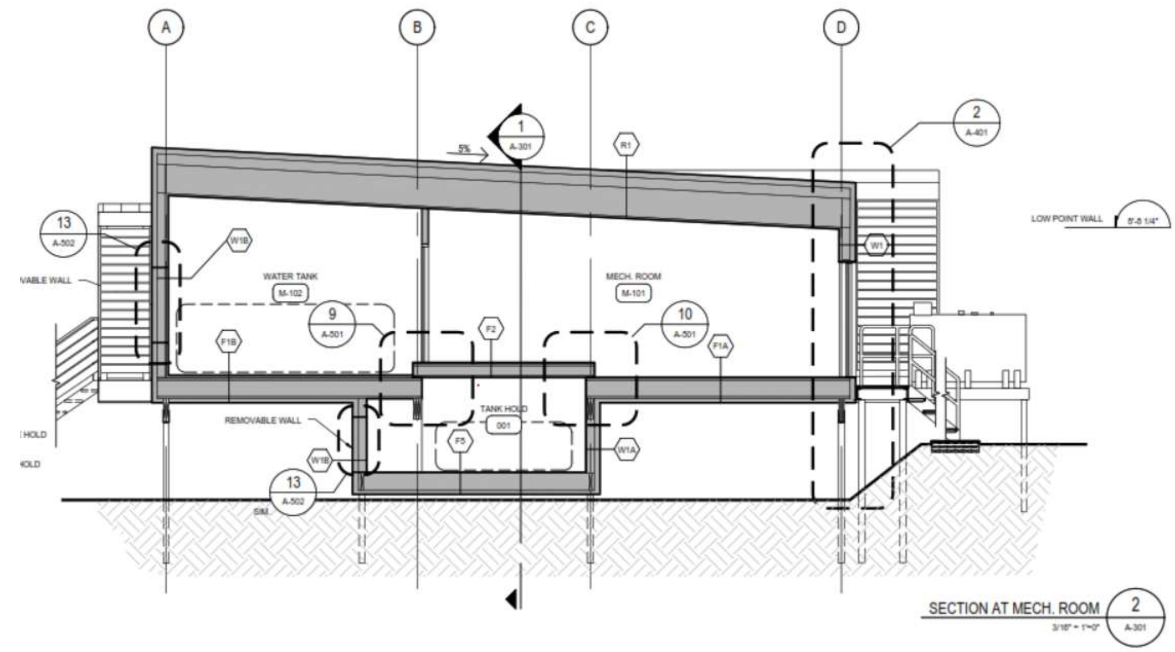
NHC has in the past delivered single storey housing units using a combination of Structural Insulated Floor, Wall and Roof Panels with Stick-built for the balance of construction. These were built in 2009 with design and supply of the structural insulated panels under direct contract with NHC and with NHC contracting separately for all labour including the installation of the SIPs. NHC has reported that there were problems associated with the contracts arranged in this way (as discussed in Section 3.1.7), but not with the performance of the houses themselves.

To date, NHC has not delivered any housing projects in which modular units were prefabricated in the south, shipped by barge to Nunavut and then assembled on site in Nunavut.

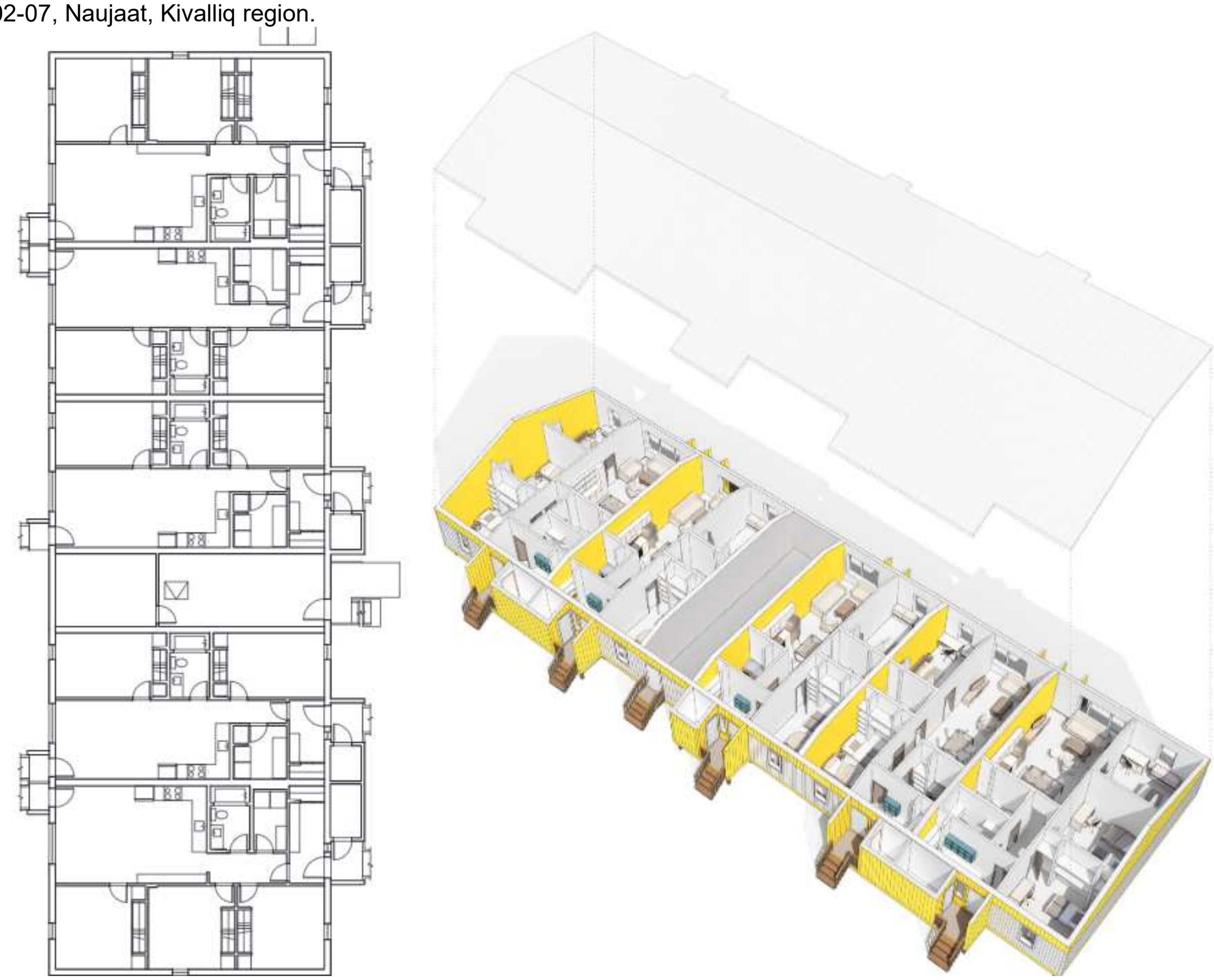
Most of the housing provided by NHC in Nunavut has been stick-built. Different designs have been used including 2plexes, 4plexes and 5plexes. In most cases, these have been single storey but in a few cases two storey with separate units on the second storey. NHC has settled on single storey construction for a number of reasons and in recent years has mostly tendered projects that involved the construction of one, two or three 5plex units.

3D model image of 2019-20 5plex. Nunavut Housing Corporation Annual Report 2018-2019.

The 5plex units are supported above the ground on a foundation consisting of piles and interconnecting wood members. The 5plexes in addition to the 5 units (each being a combination of 2BR or 3 BR units) have a centrally located mechanical room and a crawlspace for services. The 5plexes have sloped roofs and each unit has a stair to grade and a small porch with a cold storage enclosure. The centrally located mechanical room has an exterior fuel tank supported on an elevated platform along with a stair to grade.



Mechanical room section from building section plan. NHC Public Housing 5plex Issued for Tender drawing set, 2020-02-07, Naujaat, Kivalliq region.



Floor plan and 3D model image of 2019-20 5plex. Nunavut Housing Corporation Annual Report 2018-2019.

The 5 plexes are serviced with electricity. In 22 of Nunavut's 25 communities, there is not a utilidor connecting municipal services to the housing complexes. Water is delivered by truck and stored in a potable water tank. Wastewater is collected in a tank and removed periodically by truck.

The NHC has developed a design of a 5plex unit, with accompanying specifications and drawings that incorporate good practices for design and construction in the Arctic and have incorporated NHC's lessons learned both from constructing typically over 100 housing units per annum and also in consultation with the LHOs that manage, maintain and operate the units once turned over to them. The 5plex units are all constructed on site, using materials provided (with the exception of granular materials) that are shipped to the communities by Sealift. Most communities have only one or two sealift arrivals per year which originate in ports in Quebec, near Montreal. There is one other means of delivering to communities by barge and that is barges that originate from Churchill Falls and do service some communities. Workers and some lighter smaller materials can be delivered by air. Equipment required for construction can be delivered by barge.

The sealift has restrictions on what can be transported and where it will be stored on the barges. Sea cans are designed to be stacked on top of each other and secured together. Generally, materials that are not in Sea cans or are not vehicles, heavy equipment or boats are stored in the hold below deck. Sea cans and vehicles, heavy equipment or boats are stored on deck. Often vehicles, boats etc. are transported on top of Sea cans and secured to the Sea cans. Sealift companies have many restrictions and factors to consider when loading the barges so that they are stable in transit and can be efficiently unloaded. Since none of the Nunavut communities have deep harbours with material handling equipment, the Sealift barges must supply in addition smaller rafts or barges which are then used to transport (with locomotion by tug) from the Sealift barge in deeper water to the shallow water at the community shore (beach). This must be done at high tide with the rafts or barges returning to the Sealift barge for reloading and then awaiting the next high tide for the next shipments to shore. Iqaluit is currently in the midst of expanding its port to avail better handling capabilities.

Sealift barges unloading cargo from vessels in Iqaluit in 2013.[27]

[27] [Photo by Peter Varga] https://nunatsiaq.com/stories/article/65674a_plan_for_an_iqaluit_dock/

Sealift has restrictions on dimensions, packaging and weights of freight on the Sealift.

Communities have received both 20 ft and 40 ft Sea cans as part of sealifts. In order to unload Sea cans and move them and other materials to the job site in the community, special equipment is necessary. This equipment either has to reside in the community or be brought in. Equipment that is brought in from outside the community for a project will have to remain in the community (unless it can be transported by air) until the next arrival of the Sealift, which is the only maritime means of transporting between communities and between Nunavut and the south.

The equipment that is needed (aside from power tools) will include:

a) Equipment for piling
b) Excavators
c) Bulldozers
d) Grading Equipment
e) Rock drills (in cases)
f) Forklifts
g) Telehandlers
h) All-terrain crane (for modular option only)

Some of this equipment may reside in the community and be able to be rented to the Contractor provided by the community. Where equipment needs to be brought to the site for the project, the costs of providing this equipment will need to include the costs of transportation in and out and the extended period it will need to be on site. Unlike construction sites in the urban south where equipment is brought on site and removed immediately after its use, this is not the case in remote communities.

Sealift vessel approaching Iqaluit in 2005.[28]

[28] [File photo] https://nunatsiaq.com/stories/article/190310_nunavut_draws_up_plans_for_multi-million_dollar_port_pitch/

The construction workers on these projects come from a combination of:

- The south
- Other communities in Nunavut
- The community of the project

Each of these groups will have costs for transportation and accommodation.

For the purpose of this study, the baseline will be the cost of stickbuilt NHC current design for 5plex construction. This study will try to rationally estimate the cost distribution for the 5plex construction between various contributors to cost.

To do this a representative schedule is developed for each of the construction methodologies being estimated and for the specifics of this methodology as it would be implemented in remote Nunavut communities.

Consideration will be taken of the differences that will be applicable for modular construction of a portion of the 5plexes and also for the use of prefabricated structural insulated panels:

a) Which portions of the NHC 5plex are suitable for use of Structural Insulated Panels or Modular components
b) Transport to Sealift
c) Sealift and marshalling costs
d) Equipment needed on site that would be different from stick-built for either Part SIP or Part Modular options
e) Transportation and Accommodation in Nunavut for workers from south and other Nunavut locations
f) Differences in costs of equipment onsite due to differences in schedule (General Conditions)
g) Considerations that the NHC design for the Arctic conditions is different in many ways for more typical modular housing and that structural insulated panels will need to have the R-values required for use in Nunavut housing and be of panel sizes that can be erected without cranes.
h) Insurance and Bonding

The current NHC design for the 5plex requires some design modifications to be able to use structural insulated panels for part of the construction or to use modular construction for part of the construction.

All of the building materials originate in the south with the exception of granulars.

The labour component is divided between workers from the south, the local community, and other communities in the south.

The NNI Policy regulations on projects by NHC allow for bid adjustments based on Inuit economic participation in the project, which has the objective of promoting success of Inuit-owned Contractors (employing Inuit-owned subcontractors and suppliers of materials, equipment and services) in public tenders for NHC housing projects. In addition, there are mandated minimum percentages of Inuit construction labour employed on a project (with penalties if not achieved) along with Inuit training requirements.

Successful bids for NHC have all been tendered by Inuit-owned organizations on the NTI Registry. It is not known to our team how many tenders have been received for recent NHC projects. It is not known how much profit is embedded in tenders submitted to NHC or how much profit is earned by successful contractors (and their subcontractors, suppliers, etc.) on NHC projects.

For the purpose of this study it will assumed that 12% combined Overhead and Profit are representative of that embedded in tenders both for the General Contractor and the Subcontractors.

It must be assumed for the purpose of this study that the supply and installation of either modular components or structural insulated panels will be as a subcontractor to an NTI-registered General Contractor.

4.3.2 Cost Comparison Between Different Methodologies - Assumptions

We have taken as a representative project for stick-built a total cost of $9 million for a project involving three 5plexes. Each 5plex has been considered to consist of two 3BR and three 2BR units plus a central mechanical room and utility chase and being built in accordance with current drawings and specifications. In lieu of using detailed cost estimates of the current 5plex which are not available, we have used the representative tender price of $9 million for the stick-built three-5plex project and then subdivided the costs into materials and labour using the payment schedule breakdown included in NHC tender documents and which have been stated by NHC to be fairly representative of the cost breakdowns on the 5plex projects. We have compared the NHC payment breakdown with the survey studies of cost breakdowns of thousands of residential housing projects, and they generally agree with the exception of the differing costs for foundations, civil and especially insulation that would apply to NHC housing projects.

LABOUR

For the purpose of the analysis required, we have worked out representative overall hourly labour rates for two categories of labour (non-Mechanical, Electrical, Plumbing) and one for Mechanical, Electrical and Plumbing. We have factored into these rates all the applicable costs including direct labour costs, fringe benefit costs, government mandated costs such as CPP, EI, Workmen's compensation, overtime costs distributed over all hours, estimated travel and accommodation costs, and included Subcontractor O/H&P and General Contractor O/H&P costs. This enables two things to be done:

- Firstly, for both Nunavut and non-Nunavut workers we can assess the percentage of economic leakage attributable to the cost of each labour hour onsite on a project. The percentage of economic leakage is different for a Nunavut-based construction worker and a non-Nunavut based construction worker. This is as expected. This analysis is included in the overall Comparison of Construction Methodologies and Economic Leakage workbook provided with this report in Appendix 2.
- Secondly, we can estimate the number of labour hours for each of the payment categories in the NHC payment structure that adds up to the total labour estimated for the representative stick-built project. This is also included in the main worksheet of the same workbook.

The other assumption that must be made in the analysis is what fraction of the labour of each type of labour payment category is done by Nunavut-based labour and what fraction is done by non-Nunavut labour. These fractions were informed by discussions we had in our stakeholder engagement sessions, but the selection of the fraction was by use. Different projects will invariably have different divisions between Nunavut and non-Nunavut labour on various aspects of the project. This is not a prescribed or static fraction. We did our best to select what we considered based on our engagement discussions to be representative. The overall division on the project between Nunavut and non-Nunavut labour for the stick-built option did compare with typically mandated percentages for Inuit labour, so we are comfortable that the fractions we have used are on the whole representative of a traditional stick-built project to date.

We have maintained the same assumptions for the division of labour between Nunavut and non-Nunavut labour onsite for the analysis of Part SIP and Part Modular options.

COMPOSITION

From reviewing the details of the NHC 5plex designs, our analysis has assumed that Structural Insulated Panels could be used to replace exterior walls, roofs and panels but not party or partition walls. Siding, metal roofing, and water-resistive barrier will be stick-built. The SIP panels would replace only the framing, insulation and sheathing, and air/vapour barrier components. The review of a project with SIP panels is a project that is part Stick-built and part SIP. The estimate of the cost of the part-SIP-part stick-built project is done by making adjustments to both the material costs and the labour cost components to reflect this construction methodology.

Similarly, we have assumed from review of the NHC 5plex design that the portions of the 5plexes which are most suitable to be replaced with modular are the individual housing units themselves. These 2- and 3BR units could be divided into two modules, though there would be changes required such as adjusting the layouts to move the door openings entirely into one unit and not straddling the break where two modules would meet. Due to the specialized nature of the central mechanical room and the connecting chase, we have assumed for the purpose of this analysis that the central mechanical room and connecting chase will be stick-built.

INPUTS FOR PART-SIP

We interviewed a well-established, large SIP panel manufacturer and provided them with a detailed request for budget estimate to which they responded. We utilized the input from the SIP manufacturer along with our analysis of adjustments for deductions of the material and labour costs for components that would no longer be required stick-built due to being replaced by SIPs. This enabled us to calculate an estimated tender price and the labour hours (Nunavut-based and non-Nunavut-based for the part SIP-part stickbuilt option. The worksheet also calculates the total direct economic leakage for this Option and its components. This along with the Exhibit tables below are discussed in more detail in Section 5.2.

INPUTS FOR PART-MODULAR

The analysis for the part Modular-part stick built option followed the same method and provided an estimated tender price and again estimated onsite labour hours for both Nunavut and non-Nunavut construction workers. The worksheet also calculates the total direct economic leakage for this Option and its components.

OTHER COST CONSIDERATIONS VARYING FROM STICKBUILT

Both the part-SIP part-stickbuilt and the part-Modular part-stick built options will require additional costs related to design, project management and project supervision by the Contractor and additional costs for temporary heating. We have included estimates for these in our analysis.

The part Modular-part stickbuilt option also requires additional costs for the provision onsite of an all-terrain crane for hoisting the modules and some equipment for transporting the modules to the site within the community. We have assumed that this additional equipment will be rented near the sealift embarkation point in Quebec, that it needs to be sealifted to the community and then returned to the Montreal area on a subsequent sealift, which could be as much as 13 weeks after the initial Sealift. We have assumed 4 months of rental for this equipment with the Modular Option. We have also included for the cost of a two-man crew for the crane working for five weeks total onsite related to the modular installations.

Construction schedules are found in Exhibits 4.3.2a thru 4.3.2c to illustrate how the three options vary in schedule and the different tasks involved.

Exhibit 5.1 Summary of **Stick-Built** Costs Including Direct Economic Leakage		
Description of Item	**Value ($)**	**Hours**
Estimate of Total Tender Price materials including all O/H and P	4,050,000.00	
Equipment Costs for Foundation and Gravel Pad	225,000.00	
Total Labour including all mark-ups, fringe benefits, workers compensation, EI, CPP, all site and office overheads for subs and GC on direct site labour costs	4,725,000.00	
Total Estimated Tender Price	9,000,000.00	
Total Direct Economic Leakage	**5,405,193.37**	
Economic Leakage Materials	3,280,293.37	
Hours Nunavut Labour		8,119
Economic Leakage Nunavut Labour	128,250.00	
Hours Non-Nunavut Labour		21,521
Economic Leakage Non-Nunavut Labour	1,996,650.00	
% Total Direct Economic Leakage		**60%**
Economic Leakage per $1million construction tender value	600,577.04	
Economic Leakage per Fiveplex (Stickbuilt)	1,801,731.12	

Exhibit 4.3.2a – Assumed Construction Schedule (Stickbuilt)

Assumed Construction Schedule - Stickbuilt

ID	i	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			Stickbuilt Project Tender Start	0 days	Tue 1/4/22	Tue 1/4/22	
2			Tender Period	20 days	Tue 1/4/22	Mon 1/31/22	1
3			Tender Review & Award	30 days	Tue 2/1/22	Mon 3/14/22	2
4			Contract signed	5 days	Tue 3/15/22	Mon 3/21/22	3
5			Contractor award to Subcontractors and Suppliers	5 days	Tue 3/22/22	Mon 3/28/22	4
6			Material and Equipment lists finalized	10 days	Tue 3/29/22	Mon 4/11/22	5
7			Geotech investigation	5 days	Tue 3/29/22	Mon 4/4/22	5
8			Site Survey and determination of First Floor elevation to avoid excavation	5 days	Tue 3/29/22	Mon 4/4/22	5
9			Foundation Design & Shop Drawing Review	15 days	Tue 4/5/22	Mon 4/25/22	7
10			Piling, Civil Works and Bracing between piles	40 days	Tue 4/5/22	Mon 5/30/22	7
11			Material supply made ready in southern locations ready for marshalling	45 days	Tue 4/12/22	Mon 6/13/22	6
12			Trucking of supplies to Valleyfield or Ste-Catherine	5 days	Tue 6/14/22	Mon 6/20/22	11
13			Marshalling and Sealift Loading	7 days	Tue 6/21/22	Wed 6/29/22	12
14			Sealift	10 days	Thu 6/30/22	Wed 7/13/22	13
15			Sealift unloading onto beach	2 days	Thu 7/14/22	Fri 7/15/22	14
16			Mobilization on site	5 days	Mon 7/18/22	Fri 7/22/22	15
17			Chase construction	15 days	Mon 7/25/22	Fri 8/12/22	16
18			Framing up to u/s finish floor framing	15 days	Mon 8/15/22	Fri 9/2/22	17
19			Wall Framing/Sheathing /Exterior located Air Barrier including Roof Framing from Finish Floor up w housewrap and membrane on sheathing	30 days	Mon 9/5/22	Fri 10/14/22	18
20			Install Exterior Windows and Doors and tie into air barrier	15 days	Mon 9/5/22	Fri 9/23/22	18
21			First Air Blower Door Test	1 day	Mon 9/26/22	Mon 9/26/22	20
22			Insulation exterior to sheathing	10 days	Tue 9/27/22	Mon 10/10/22	21
23			Siding and Metal Roofing	20 days	Tue 10/11/22	Mon 11/7/22	22
24			Shut down site and make secure	5 days	Tue 11/8/22	Mon 11/14/22	23
25							
26			Remobilize on site	5 days	Thu 4/13/23	Wed 4/19/23	
27			Electrical Rough in	30 days	Thu 4/20/23	Wed 5/31/23	26
28			Mechanical Rough-in	30 days	Thu 4/20/23	Wed 5/31/23	26
29			Interior Insulation	20 days	Thu 4/20/23	Wed 5/17/23	26
30			Dywall & Ceilings	25 days	Thu 5/18/23	Wed 6/21/23	29
31			Painting	10 days	Thu 6/22/23	Wed 7/5/23	30
32			Receptacles, lights	10 days	Thu 7/6/23	Wed 7/19/23	31
33			Flooring, Baseboard, Trim, Millwork, Fixture installation, Hang interior doors Grilles and Louvres, Appliance install	15 days	Thu 7/20/23	Wed 8/9/23	32
34			Blower Door Test	3 days	Thu 8/10/23	Mon 8/14/23	33
35			Final Commissioning/Training	15 days	Tue 8/15/23	Mon 9/4/23	34
36			Final Deficiencies	20 days	Tue 8/15/23	Mon 9/11/23	34
37			Occupancy Permit/ Turnover to NHC	2 days	Tue 9/12/23	Wed 9/13/23	36

Exhibit 5.2 Summary of **SIP (Walls, Roof, Floors)** Costs Including Direct Economic Leakage		
Description of Item	**Value ($)**	**Hours**
Estimate of Total Tender Price materials including all O/H and P	4,485,000.00	
Equipment Costs for Foundation and Gravel Pad	225,000.00	
Total Labour including all mark-ups, fringe benefits, workers compensation, EI, CPP, all site and office overheads for subs and GC on direct site labour costs	3,924,000.00	
Estimated change in fixed General Conditions for onsite equipment due to reduced duration onsite compared to stick-built - overall duration similar (~1 month shorter)	(10,000.00)	
Allowance for additional temporary heating 6 months including dry heater + generator + power panel + fuel + labour to attend	179,325.00	
Estimated Increase in project management/coordination by GC compared to stick-built (assume additional 1/2-time assistant project manager for 7 months from project award to sealift)	55,770.40	
Allowance for additional design	31,500.00	
Allowance for additional factory inspection by NHC consultant	5,000.00	
Adjustment to bonding and insurance	(4,176.18)	
Total Estimated Tender Price	8,891,419.22	
Total Direct Economic Leakage	**5,394,764.77**	
Economic Leakage Materials	3,619,100.77	
Hours Nunavut Labour		6,581
Economic Leakage Nunavut Labour	104,220.00	
Hours Non-Nunavut Labour		17,931
Economic Leakage Non-Nunavut Labour	1,671,444.00	
% Total Direct Economic Leakage		**64%**
Economic Leakage per $1million construction tender value	641,546.53	
Economic Leakage per Fiveplex (part-SIP)	1,798,254.92	

Exhibit 4.3.2b – Assumed Construction Schedule (Part-SIP)

Assumed Construction Schedule - SIP

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			Prequalification of SIP Providers	30 days	Mon 7/26/21	Fri 9/3/21	2SF
2			Tender Period	20 days	Mon 9/6/21	Fri 10/1/21	
3			Tender Review & Award	30 days	Mon 10/4/21	Fri 11/12/21	2
4			Contract signed	5 days	Mon 11/15/21	Fri 11/19/21	3
5			Contractor award to Subcontractors and Suppliers	5 days	Mon 11/22/21	Fri 11/26/21	4
6			Geotech investigation	5 days	Mon 11/29/21	Fri 12/3/21	5
7			Site Survey and determination of First Floor elevation to avoid excavation	5 days	Mon 11/29/21	Fri 12/3/21	5
8			Foundation Design & Shop Drawing Review	25 days	Mon 12/6/21	Fri 1/7/22	6
9			Piling, Civil Works and Bracing between piles	40 days	Mon 12/6/21	Fri 1/28/22	6

Cont'd, Exhibit 4.3.2b – Assumed Construction Schedule (Part-SIP)

10	Shop drawings and details for all items requiring wall penetrations in SIPS	30 days	Mon 11/29/21	Fri 1/7/22	5
11	Finalization of rough openings required in SIPS based on	10 days	Mon 1/10/22	Fri 1/21/22	7,10
12	SIP Panel Design and Approval of Shop Drawings	20 days	Mon 1/24/22	Fri 2/18/22	11
13	SIP Panel manufacture, crating	40 days	Mon 2/21/22	Fri 4/15/22	12
14	Material supply made ready in southern locations ready for marshalling	45 days	Mon 5/2/22	Mon 7/4/22	15SF,13
15	Trucking of Materials and SIPS to Valleyfield or Ste-Catherine	5 days	Mon 7/4/22	Mon 7/11/22	16SF
16	Marshalling and Sealift Loading	5 days	Mon 7/11/22	Mon 7/18/22	18SF
17	Mobilization on site	5 days	Mon 7/25/22	Fri 7/29/22	18FF
18	Sealift	10 days	Mon 7/18/22	Fri 7/29/22	
19	Sealift unloading onto beach	2 days	Mon 8/1/22	Tue 8/2/22	18
20	Install SIP floor support beams and SIP floor panels	15 days	Wed 8/3/22	Tue 8/23/22	19
21	Chase construction	15 days	Wed 8/24/22	Tue 9/13/22	20
22	Frame Central Mech Room and Connection to Chase	15 days	Wed 8/24/22	Tue 9/13/22	20
23	Install Exterior SIP Walls	10 days	Wed 8/24/22	Tue 9/6/22	20
24	Construct Party Walls and Interior Partitions	15 days	Wed 8/24/22	Tue 9/13/22	20
25	Housewrap SIP wall and Floor Panels	10 days	Fri 9/2/22	Thu 9/15/22	23SS+7 days
26	Install Roof Support Beams	5 days	Wed 9/14/22	Tue 9/20/22	24
27	Install Roof SIPS	15 days	Wed 9/21/22	Tue 10/11/22	26
28	Install Exterior Windows and Doors and tie into air barrier	15 days	Wed 9/7/22	Tue 9/27/22	23
29	First Air Blower Door Test	1 day	Wed 9/28/22	Wed 9/28/22	28
30	Install Weather Resistive Barrier on tp of SIP Roof panels and tie into remainder of Housewrap	15 days	Fri 10/7/22	Thu 10/27/22	29SS+7 days
31	Electrical Rough in	30 days	Fri 10/28/22	Thu 12/8/22	30
32	Mechanical Rough-in	30 days	Fri 10/28/22	Thu 12/8/22	30
33	Siding	15 days	Thu 9/29/22	Wed 10/19/22	29
34	Metal Roofing	15 days	Fri 10/28/22	Thu 11/17/22	29,30
35	Install Dry Heat System	2 days	Thu 10/20/22	Fri 10/21/22	33
36	Shut down site and make secure	5 days	Thu 10/20/22	Wed 10/26/22	33
37	Demobilize except maintain interior heat	120 days	Thu 10/27/22	Wed 4/12/23	36
38	Remobilize on site	5 days	Thu 4/13/23	Wed 4/19/23	37
39	Dywall & Ceilings	30 days	Thu 4/20/23	Wed 5/31/23	38
40	Stop using dry heat system	0 days	Thu 6/1/23	Thu 6/1/23	39
41	Finish HVAC	30 days	Thu 4/20/23	Wed 5/31/23	38
42	Finish Plumbing	30 days	Thu 4/20/23	Wed 5/31/23	38
43	Painting	15 days	Thu 6/1/23	Wed 6/21/23	39
44	Receptacles, lights	15 days	Thu 6/22/23	Wed 7/12/23	43
45	Flooring, Baseboard, Trim, Millwork, Fixture installation, Hang interior doors Grilles and Louvres, Appliance install	15 days	Thu 7/13/23	Wed 8/2/23	44
46	Blower Door Test	3 days	Thu 8/3/23	Mon 8/7/23	45
47	Final Commissioning/Training	15 days	Tue 8/8/23	Mon 8/28/23	46
48	Final Deficiencies	20 days	Tue 8/8/23	Mon 9/4/23	46
49	Occupancy Permit/ Turnover to NHC	2 days	Tue 9/5/23	Wed 9/6/23	48

Exhibit 5.3 Summary of **Part Modular (All but Mechanical Room, Chase & Appendages)** Costs Including Direct Economic Leakage		
Description of Item	**Value ($)**	**Hours**
Estimate of Total Tender Price materials including all O/H and P	6,331,000.00	
Equipment Costs for Foundation and Gravel Pad	225,000.00	
Total Labour including all mark-ups, fringe benefits, workers compensation, EI, CPP, all site and office overheads for subs and GC on direct site labour costs	1,975,705.56	
Additional for 100T rough terrain crane for 4 months plus sealift, plus all inclusive labour costs for crane operator and assistant	168,400.00	
Allowance for construction of 3/4-acre level area for laydown of modular units including cribbing required	20,000.00	
Allowance for temporary removal of overhead hydro lines needed for modular movement from beach to site	10,000.00	
Allowance for additional temporary heating 4 months including dry heater + generator + power panel + fuel + labour to attend	141,975.00	
Estimated Increase in project management/coordination by GC compared to stick-built (assume additional 6 person-months for assistant superintendent plus 1/2-time assistant project manager for 10 months from project award to sealift)	285,465.69	
Allowance for additional design	31,500.00	
Allowance for additional factory inspection by NHC consultant	5,000.00	
Adjustment to bonding and insurance	7,761.85	
Total Estimated Tender Price	9,201,808.10	
Total Direct Economic Leakage	**7,616,050.29**	
Economic Leakage Materials	6,556,855.87	
Hours Nunavut Labour		3,335
Economic Leakage Nunavut Labour	53,148.92	
Hours Non-Nunavut Labour		8,861
Economic Leakage Non-Nunavut Labour	837,645.51	
% Total Direct Economic Leakage		**83%**
Economic Leakage per $1million construction tender value	827,668.89	
Economic Leakage per Fiveplex (part Modular)	2,538,683.43	

Exhibit 4.3.2c – Assumed Construction Schedule (Part-Modular)

Assumed Construction Schedule - Modular

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			Prequalification of Modular Providers	30 days	Mon 7/26/21	Fri 9/3/21	2SF
2			Tender Start	0 days	Mon 9/6/21	Mon 9/6/21	
3			Tender Period	20 days	Mon 9/6/21	Fri 10/1/21	2
4			Tender Review & Award	30 days	Mon 10/4/21	Fri 11/12/21	3
5			Contract signed	5 days	Mon 11/15/21	Fri 11/19/21	4
6			Contractor award to Subcontractors and Suppliers	5 days	Mon 11/22/21	Fri 11/26/21	5

Cont'd, Exhibit 4.3.2c – Assumed Construction Schedule (Part-Modular)

7		Geotech investigation	5 days	Mon 11/29/21	Fri 12/3/21	6
8		Site Survey and determination of First Floor elevation to avoid excavation and whether door or window on high eave side	5 days	Mon 11/29/21	Fri 12/3/21	6
9		Foundation Design & Shop Drawing Review	25 days	Mon 12/6/21	Fri 1/7/22	7
10		Modular Design including shop drawing approvals	10 wks	Mon 11/29/21	Fri 2/4/22	6
11		Piling, Civil Works and Bracing between piles	40 days	Mon 12/6/21	Fri 1/28/22	7
12		Modular Manufacture	80 days	Mon 2/7/22	Fri 5/27/22	10
13		Material supply made ready in southern locations ready for marshalling	45 days	Mon 5/30/22	Fri 7/29/22	14SF,12
14		Trucking of Materials and Modules to Valleyfield or Ste-Catherine	5 days	Mon 7/4/22	Mon 7/11/22	16SF
15		Rental of All Terrain Crane and other equipment required for Modular to go by Sealift	10 days	Mon 6/27/22	Fri 7/8/22	16SF
16		Marshalling and Sealift Loading	5 days	Mon 7/11/22	Mon 7/18/22	18SF
17		Mobilization on site	5 days	Mon 7/25/22	Fri 7/29/22	18FF
18		Sealift	10 days	Mon 7/18/22	Fri 7/29/22	
19		Sealift unloading onto beach and Contractor moving modules to area close to beach to crib up modules	3 days	Mon 8/1/22	Wed 8/3/22	18
20		Organize Building Materials on site	3 days	Thu 8/4/22	Mon 8/8/22	19
21		Move modules to staging area if not able to stay where unloaded from the sealift	5 days	Thu 8/4/22	Wed 8/10/22	19
22		Install Module floor support beams for all Fiveplexes	15 days	Tue 8/9/22	Mon 8/29/22	19,20
23		Move modules to site & Hoist and set Module for 1st Fiveplex	5 days	Tue 8/16/22	Mon 8/22/22	22SS+5 days
24		Move modules to site & for Hoist and set Module for 2nd Fiveplex	5 days	Tue 8/23/22	Mon 8/29/22	23
25		Move modules to site & Hoist and set Module for 3rd Fiveplex	5 days	Tue 8/30/22	Mon 9/5/22	24
26		All Terrain crane no longer needed on site	0 days	Mon 9/5/22	Mon 9/5/22	25
27		Framing, sheathing insulation, siding , air barrier/vapour barrier etc for Mech Room and Chase for 1st of 5 plexes	15 days	Tue 8/23/22	Mon 9/12/22	23
28		Framing, sheathing insulation, siding , air barrier/vapour barrier etc for Mech Room and Chase for 3rd of 5 plexes	15 days	Tue 8/30/22	Mon 9/19/22	24
29		Framing, sheathing insulation, siding , air barrier/vapour barrier etc for Mech Room and Chase for 3rd of 5 plexes	15 days	Tue 9/6/22	Mon 9/26/22	25
30		Install dry heat system in 1st 5 plex	3 days	Tue 8/23/22	Thu 8/25/22	23
31		Architectural Finishing of 1st 5 plex	20 days	Fri 8/26/22	Thu 9/22/22	30
32		Install dry heat system in 2nd 5 plex	3 days	Tue 8/30/22	Thu 9/1/22	24
33		Architectural Finishing of 2nd 5 plex	20 days	Fri 9/2/22	Thu 9/29/22	32
34		Install dry heat system in 3rd 5 plex	3 days	Tue 9/6/22	Thu 9/8/22	25
35		Architectural Finishing of 3rd 5 plex	20 days	Fri 9/9/22	Thu 10/6/22	34
36		Rough in Elec 1st 5 plex	5 days	Tue 8/23/22	Mon 8/29/22	23
37		Rough in Elec 2nd 5 plex	5 days	Tue 8/30/22	Mon 9/5/22	24
38		Rough in Elec 3rd 5 plex	5 days	Tue 9/6/22	Mon 9/12/22	25
39		Rough in Mech 1st 5 plex	15 days	Fri 10/7/22	Thu 10/27/22	31FS+10 days
40		Rough in Mech 2nd 5 plex	15 days	Fri 10/14/22	Thu 11/3/22	33FS+10 days
41		Rough in Mech 3rd 5 plex	15 days	Fri 10/21/22	Thu 11/10/22	35FS+10 days

Cont'd, Exhibit 4.3.2c – Assumed Construction Schedule (Part-Modular)

42		Blower Door test for 1st 5 plex	0 days	Thu 10/27/22	Thu 10/27/22	27,31,39,36
43		Blower Door test for 2nd 5 plex	0 days	Thu 11/3/22	Thu 11/3/22	28,33,40,37
44		Blower Door test for 3rd 5 plex	0 days	Thu 11/10/22	Thu 11/10/22	29,35,41,38
45		M&E finishing 1st 5 plex	5 days	Fri 10/28/22	Thu 11/3/22	42
46		M&E finishing 2nd 5 plex	5 days	Fri 11/4/22	Thu 11/10/22	43
47		M&E finishing 3rd 5 plex	5 days	Fri 11/11/22	Thu 11/17/22	44
48		1st 5 plex- Start-up and Commisssion all systems	10 days	Fri 11/4/22	Thu 11/17/22	45
49		2nd 5 plex- Start-up and Commisssion all systems	10 days	Fri 11/11/22	Thu 11/24/22	46
50		3rd 5 plex- Start-up and Commisssion all systems	10 days	Fri 11/18/22	Thu 12/1/22	47
51		Remove Dry Heat Systems	0 days	Thu 12/1/22	Thu 12/1/22	50,48,49
52		Final Blower Door Tests	3 days	Fri 12/2/22	Tue 12/6/22	51
53		Final Commissioning/Training	10 days	Wed 12/7/22	Tue 12/20/22	52
54		Final Deficiencies	10 days	Fri 12/2/22	Thu 12/15/22	51
55		Occupancy Permit/ Turnover to NHC	2 days	Fri 12/16/22	Mon 12/19/22	54

4.4 Design Considerations

4.4.1 General Design Requirements for NHC Housing

The housing projects that the NHC delivers must satisfy the following:

- Meet the architectural program requirements that have been determined to be required for individual housing units be they one bedroom, two bedroom or three bedroom. The 5plexes that are tendered by NHC have various combinations of one, two- and three-bedroom units as determined in consultation with the LHOs.
- Be suitable for the unique and varying environmental conditions of Nunavut. This means they must be designed to be:
  - From a geotechnical perspective for the specific site
  - For the site with respect to the site-specific loading for snow, rain, wind and seismic
- Be constructed in Nunavut taking consideration of shorter construction seasons
- Be maintained by NHC with some stockpiles and without the requirement of materials or equipment or services that are not readily available
- Have the desired energy efficiency
- Have a building envelope design for which the functioning, integrity and continuity of essential sub-components such as air barrier, vapour barrier, interior and exterior insulation, sheathing, water-resistive barriers, windows and doors, etc. have been fully taken into account and detailed to the degree that it is assured that the building envelope needed for energy efficiency and durability of the housing can be realized during construction.
- Operate so that the buildings maintain the desired energy efficiency and indoor conditions
- Take account of Best Practices for Design in Nunavut
- Take account of lessons learned from previous housing construction projects and input from those using, operating and maintaining the housing projects constructed to date

- Through attention to detail in the drawings and specifications, reduce the likelihood of change orders which can be more impactful in Nunavut than in the south due to shorter construction seasons and the time and cost of transporting additional materials or equipment to the job site.

In environments such as Nunavut, the end product of housing is less forgiving of design oversights and construction errors and poor workmanship, than would be the case in less severe environments.

This has implications regarding how tender documents are structured related to the balance of prescriptive versus performance-based requirements in the tender documents for housing projects.

Currently, the tender documents for projects with NHC 5plex stick-built housing units are, as expected, mostly prescriptive. There are some parts of the tender requirements that are performance-based such as engineered wood products (engineered wood beams, engineered floor and roof joists) and piling that need to be designed by suppliers or subcontractors, respectively, to the General Contractor for the stipulated load. These specific items are also typically designed by suppliers/subcontractors on projects in the south.

The tender documents developed by NHC and their Consultants for stick-built projects such as NHC fiveplexes are very detailed and well suited to achieving success on stick-built projects. The fact that the vast majority of the detailed design is by NHC's Consultants keeps control of the design with NHC and limits the need for coordination with and detailed review by NHC's Consultant of design by the Contractror Team.

4.4.2 General Design Considerations for Building Envelope

Conventional or prescriptive construction practice is based on experience as much as technical analysis and theory.

Cold-weather condensation in building envelopes is primarily due to outward air leakage. Generally, condensation due to air leakage outstrips diffusion of water vapour. Use air barriers to stop airflow and vapour control (vapour diffusion retarders or barriers) to limit vapour movement by diffusion.

Sheathing on the outside of the studspace provides a surface where water vapour in air can condense depending on the temperature of the sheathing relative to the temperature at which water vapour will condense out of the air.

Construction moisture is all excess wetness in the building fabric before the service life starts. This could be from rain or snow during construction, hygroscopic moisture in apparently dry materials, and can cause increased risk of mould and surface condensation and durability issues. Hygroscopic moisture, surface and interstitial condensation are vapour related. Hygroscopic moisture is the moisture content in a material in equilibrium with the relative humidity on pore air. Hygroscopic moisture reflects an equilibrium state. Too high or too low an RH value can cause problems: too low a value in timber can cause cracking, whereas too high a value can foster mould.

A wood framed exterior wall must be as airtight as possible. An envelope assembly can have multiple air barriers. In cold climates breaches in vapour barriers lead to air exfiltration from within buildings, which cause moisture laden air to move from inside the building toward the exterior. If this moisture laden air reaches a surface that is sufficiently cold, moisture will condense inside the assembly (wall, roof, floor). Openings in the air barrier(s) are unavoidable but extreme care must be taken to minimize them. Air-tightness tests during construction is one means of helping to assure this. Any moisture that is deposited in the building envelope assembly must be able to dry to the outside, which requires that any materials that restrict vapour movement outside the intended vapur barrier allow for this moisture diffusion toward the outside.

According to the BC Housing Research Centre, R22+ Effective Walls in Residential Construction:[29]

- For walls with split insulation (some insulation inside exterior sheathing and some insulation outside exterior sheathing) such as the NHC fiveplex wall assembly:
  - 2 x 6 wall (GB, poly, 2 x 6 studs with batt insulation, plywood sheathing, vapour permeable sheathing membrane, rigid mineral wool, strapping, cladding)
  - Need to consider vapour permeability of sheathing membrane and exterior insulation to avoid risk of creating condensation in the assembly or reducing the ability to dry any incidental wetting that occurs
  - Air barrier can be at exterior sheathing membrane or interior sealed sheathing or airtight poly
  - Insulation in stud space can be mineral wool, fiberglass, blown-in cellulose or fiberglass or spray foam
  - Exterior insulation can be semi-rigid mineral wool, rigid mineral wool, semi-rigid fiberglass, EPS, XPS, polyisocuranate (polyiso) and closed cell polyurethane foam: each have differing permeabilities which are vitally important to the drying capacity of the wall assembly.

P 29 chart shows that with 2 x 4 stud wall (with R-12 batts), 5.5 inch of exterior insulation is needed (of R=4/inch) to get effective R over 32 (R=333.4) and that with 1.5 inch (R=4/inch) end up with R effective = 17.4.

The same chart shows that with 2 x 6 stud wall (R-19 batts), 4 inch of exterior insulation is needed (of R=4/inch) to get effective R over 32 (R= 32.4).

Insulation placed on the exterior of the stud wall increases the temperature of moisture sensitive wood sheathing and reduces condensation risk and durability problems.

Unless the majority of the insulation is placed on the outside of the sheathing, a vapour barrier should be installed on the inside of the stud wall.

Foam plastic insulation is relatively impermeable and will not allow for moisture to dry outwards and two vapour barriers can inadvertently trap moisture in the assembly leading to fungal decay and decay.

If vapour impermeable insulation such as foam is used, the ratio of insulation outboard to inboard can be considered to maintain sheathing at a safe level and avoid condensation.

In general, a vapour permeable exterior insulation combined with an interior vapour barrier typically provides a lower risk wall than one with an impermeable exterior insulation.

[29] BC Housing Illustrated Guide - R22+ Effective Walls in Residential Construction in B.C., available at https://www.bchousing.org/research-centre/library/residential-design-construction/ig-R22-effective-walls-residential-construction?sortType=sortByDate

COMMENTARY ON R-VALUE FOR NHC FIVEPLEX EXTERIOR WALL DESIGN

Nominal RSI value takes into account the thermal resistance of the insulation layer only, which is typically batt insulation placed between the studs. Effective RSI value, on the other hand, takes into account the cumulative value of thermal resistance for all materials within the assembly.

Using the CWC effective R calculator (The Canadian Wood Council's Thermal Wall Design Calculator), Version 5 Wall ID 309 is similar to the NHC wall but has a 2-inch exterior semi-rigid stone wall instead of 1.5 inch. It has 2 x 6 studs at 16 inch on centre, plywood/housewrap/semi-rigid stone wool on outside of studs and poly and drywall on inside of studs, with R-19 batts in stud space.

The simulated durability analysis using WUFI type analysis indicates that even for Edmonton (the coldest of the Canadian locations simulated), the wall is very durable with good drying potential to the outside, with risk of interstitial condensation reduced by raising the temperature of the exterior sheathing (plywood). The dew point in the heating season will fall outside the inner surface of the stud cavity. It does state that for colder climates the thickness of the insulative sheathing must be increased to maintain dew point condensation outside of the inner surface of the stud cavity and insulative sheathing.

The effective R-value of the entire assembly is 23.31.

The Centre of Cavity R-value is R=28.91. Note that this compares with the R-32 stated in NHC documents.

If advanced framing were to be used, the effective R-value with Advanced Framing (as per NBC 9.3.6.2.4.1(1)) would calculate to be 24.05.

Reduction in wood use framing stud members (19.2" or 24" o/c) with no additional engineering required.

ANALYTICAL METHODS OF EVALUATING THE POTENTIAL FOR MOISTURE ACCUMULATION IN BUILDING ENVELOPE ASSEMBLIES

Vapour retarders help prevent RH in materials reaching levels where mould can germinate and deterioration due to moisture can occur. Air barriers help prevent moisture laden interior air from exfiltrating from the inside of the building and depositing moisture inside the building envelope assembly.

Interstitial condensation is vapour deposited in building assemblies. Temperature gradients can force construction moisture, hydroscopic moisture and absorbed water or drained water to evaporate and condensate elsewhere in an assembly. The driving forces are diffusion and more importantly air ingress.

There are many transient heat, air and moisture models that exist today and which are used for checking for interstitial condensation in building assemblies; hence the potential for deterioration of building materials and potential for mould growth.

The Institute for Research in Construction (IRC) of the National Research Council of Canada (NRC) has developed such computer models in the past but currently do not offer or support them.

Two such models that exist are:

- Delphin: https://bauklimatik-dresden.de/index.php?aLa=en
    - Hygrothermal analyses can be applied to building envelope assemblies which solve the coupled transient heat and mass transfer taking the hygroscopicity of the materials into account. Moisture transfer by vapour diffusion and convection is considered. Hourly

representative weather data can be used for a location over a few years for moisture design calculation. The analysis also uses prescribed values for indoor air temperature and humidity. Such analyses can be used to assess the risk for mould growth. Mould growth precedes rot for wood.

- WUFI: https://web.ornl.gov/sci/buildings/tools/wufi/
    - Additionally, building consultants in North America have come to use WUFI.

It is not known whether the availability of hourly temperature records for Nunavut communities exists for use of such models, or if studies have been done to date using these models for any Nunavut communities analyzing various building envelope assemblies. This has been done in other northern communities.

1-D hygrothermal computer modelling analyses are targeted to engineers, architects, building scientists, contractors, and other professionals. Such programs can be used for case studies allowing users to study where several parameters are changed one at a time to gauge the sensitivity of the wall response, or what-if scenarios. Such 1D models are intended to evaluate the potential for moisture build-up in a wall over time for a wall of a given composition. They assume moisture movement through vapour diffusion and not explicitly through air leakage.

Situations involving air leakage, water leaks and gravity, however, are best handled using the 2-D hygroscopic computer models and require more expertise of a researcher to set up the ‘virtual wall’ representation.

Should NHC decide to consider construction using building envelope and structural designs other than the prescriptive design which is laid out in NHC tender documents for traditional stick-built construction conforming to NBCC Part 9, it is recommended that detailed requirements be developed including:

- Clear definition of R-values required (and explicitly how they are to be computed) for the overall building envelope assembly. The NHC fiveplex designs show all the elements in the wall assembly and indicate an R-value of R=32. This is the R-value midway between studs and is not an overall wall assembly R-value taking into account framing.
- Clear definition of the building envelope details required to be provided for review by NHC and their Consultants.
- Clear definition of building envelope assessment regarding the potential for moisture deposition within the building envelope and potential for either material deterioration and mould development within the building envelope assembly. This should include at minimum an analysis of the steady state temperature gradient through the proposed assembly for chosen exterior and interior conditions deemed representative for the location in question and for the coldest month in the winter. It may also be deemed appropriate that hygroscopic modelling be done.
- Clear definition of whether the proposed design is to be done using NBCC Part 3 or Part 9. The current stick-built design is in accordance with NBCC Part 9.

For proposed designs using structural insulated panels or other proprietary insulated panel systems, the proponent should provide for the project in question the required documentation and engineering design that demonstrates to NHC, its Consultants and the OCBO that the proposed solution meets the requirements of the NBCC.

Note that even for Insulspan, the one SIP manufacturer that has had a Canadian Construction Materials Centre (CCMC) Evaluation Report performed for Canadian use of its structural insulated panels[30], this evaluation report is restricted to single family homes (as indicated on page 9 of the report).

4.4.3 Design Related Considerations for Construction Using Other Types of Construction Methodology than Full Stick-Built

When types of construction methodology or delivery different from the current stick-built are being assessed, it needs to be considered how this will impact:

- Design and required reviews of design by the Contractor Team
- Coordination of design between NHC Consultant Team and Contractor produced design
- Reviews to assure quality of end product
- Division of design responsibility

For example, if there is a desire to allow the use of prefabricated building components on a project (such as Structural Insulated Components, Prefabricated Walls using studs and sheathing only or housing units prefabricated in Modules), then the use of these prefabricated components can affect the overall design, design details, and the materials incorporated within the design.

Prefabricated components may be acceptable to the NHC or suitable only for certain parts of the overall housing projects, and prefabricated components only of a certain design and composition.

In addition, the prefabricated components that may be accepted for use in future NHC projects will need to be accepted by both NHC and the NHC Consultant Team, for those aspects for which they are responsible for the overall design.

4.4.4 Design Related Considerations for Possible Use of Prefabricated Framed Uninsulated Panels

The design related considerations to allow the incorporation of more prefabricated elements than currently incorporated in the NHC stick-built 5plex design could include:

PREFABRICATED FRAMED (NOT INSULATED) PANELS

- The use of structural, prefabricated floor, wall, or roof panels incorporating framing, engineered wood products, and sheathing but not insulation.
- This does not require a change to the stickbuilt design or the materials used in the current stick-built construction of these framing elements.
- The shop drawings of the panels would need to be reviewed from a structural perspective and to ensure that there are no anticipated problems with the building envelope construction on site. It is believed that these wall designs would need to be designed by or reviewed by an engineer who is a member or licensee of NAPEG. The structural design of these prefabricated wall components would be designed by an engineer working for the fabrication plant. The structural engineer for such a fabricator would need to become licensed with NAPEG, if not already a member. The

[30] https://www.insulspan.com/wp-content/uploads/2019/03/13016-R_e-Insulspan-SIP-System-1.pdf

manufacturer of these panels would need to be certified to the requirements of CSA A277-16, Procedure for Certification of prefabricated buildings, modules and panels.

4.4.5 Design Related Considerations for Possible Use of Structural Insulated Panels (SIP)

The design related considerations to allow the incorporation of more prefabricated elements than currently incorporated in the NHC stick-built 5plex design would include code compliance, building envelope performance and structural performance.

STRUCTURAL INSULATED PANELS

- The use of structural, prefabricated wall, floor or roof panels incorporating insulation and air barrier and vapour barrier. Structural insulated panels are composed of two skins that are adhesively bonded to a core of foam insulation. The structural insulated panels that are most typically used in residential construction are engineered products but involve some deviations from the NHC stick-built design namely:
  - Typically, the use of OSB (Oriented Strand Board) panels and not plywood
  - Typically, the use of EPS (Expanded polystyrene insulation)

The NHC stick-built design avoids OSB on the exterior envelope and uses plywood instead.

The NHC stick-built design utilizes stone wool insulation whereas SIPs use either expanded polystyrene or polyurethane (also called polyisocuranate) insulation. Batt form stone wool insulation has R-values of 3.5/inch whereas expanded polystyrene board has R-values of 3.8 to 4.4 and is higher for graphite EPS (such as Neopor). SIPs particularly when using foam cores incorporating graphite can achieve higher overall R-values in the same space. Stone wool insulation is relatively non-combustible. EPS is combustible. However, whether using exterior wood framed construction with stone wool insulation or exterior Structural Insulated Panels, what is required to meet Building Code in both cases is the provision of drywall on the inside.

Most SIPs (more than 95%) use OSB and not plywood. We have not been able to find a SIP provider serving the Canadian market that manufactures SIPs that have plywood skins. OSB is perceived by many to be more susceptible to swelling of the edges of the panels from moisture than plywood panels. This has caused some avoidance in the past for the adoption of SIPs.

Nevertheless, SIPs of the typical composition of OSB skins and EPS cores have been used in many locations including the north of Canada and in Nunavut by NHC in the past. With the use of SIPs in northern locations such as Nunavut, the only problems we have been able to find reference to are instances of failures of roof SIP panels in Alaska due to problems associated with sealing joints in roof panels, which was caused by moisture being deposited by air exfiltration and trapped in the roof panels. This has led to additional measures being recommended for joints in roof panels and manufacturers of SIPs insisting that vapour permeable materials only be applied on the top surface of the roof panel exterior skin. This can be challenging when the desire is that the product applied on this surface be the best product to prevent entry from water from outside.

Structural Insulated Panels are not as explicitly dealt with in the NBCC as is stick-built construction. Some but not all SIP providers have had Structural Evaluation reports done for their products. Some SIP providers rely on Structural Evaluation reports that have been done by industry organizations such as SIPA (Structural Insulated Panel Association). SIPs have been used in many jurisdictions in Canada, but they will require the approval of the Chief Building Official for a project. The design of the structural insulated panels would be stamped by a Professional Engineer registered in Canada for the SIP manufacturer. This engineer may be required to be licensed with NAPEG. The division of responsibility for design will need to be identified (as with other pre-fabricated components) and NHC's Consultant Team will need to review SIP component designs both from a structural and building envelope detail and integrity perspective.

ADVANTAGES AND DISADVANTAGES OF SIP

Structural insulated panels have some distinct advantages and some disadvantages over the same functions being provided by stick-built construction.

- Advantages: Speed of construction, simplification of construction, less potential variability in the quality of construction of the building envelope, and the ability to achieve higher whole wall R values by reducing thermal bridging.
- Disadvantages: More attention to coordination during design is needed since modifications to SIPs on site are difficult and panel erection is sequential and can be held up by damaged SIPs, improperly fabricated SIPs or changes desired to the exterior wall design.

RECOMMENDATIONS

- We recommend that if SIPs are considered to be allowed as prefabricated structural components, then the preparation of prototypical design drawings and specifications needs to be done and issues related to any concerns (from NHC or their Consultants) regarding materials or building envelope design or details with SIPs needs to be identified and resolved in advance.
- We recommend that if SIPs are being permitted for NHC projects, then the dimensions of the NHC 5plexes need to be reviewed to coordinate them with the standard dimensions of SIPs.
- We recommend that discussions be held with the Chief Building Official as well to identify what submissions will be required to support a Building Permit application for a design that incorporates Structural Insulated Panels. Bear in mind that some projects use SIPs as cladding only (nail-based SIPs). The use of SIPs in lieu of stick-built framed construction would have them

used as full structural members, which is the purpose for which they were originally developed and for which they are designed.

SIPs can be designed with recesses cut for electrical boxes through the interior skin and a portion of the foam core and vertical and horizontal chaseways in the foam. These can then be used for wiring on site by using fishtapes to fish wires through the core. It is simpler if the electrical installations are inboard of the inner skin of the SIPs. Note that due to the structural use of the SIPs, any modifications to the SIPs must be approved by the SIP manufacturer's engineer and what would be permitted as a field modification is very limited.

Note that with the use of SIPs in NHC housing projects there will still be portions constructed with traditional stick-built construction such as:

- mechanical chase and attached central mechanical room
- interior partition walls
- party walls (unless it is decided that SIP party walls can be covered with noise-reducing drywall to achieve the desired acoustic separation between units)
- exterior platforms and enclosures

- We also recommend that if NHC decides to permit the use of SIPs in future projects that the prequalification of SIP suppliers and possibly of the General Contractors that would be installing the SIPs be undertaken. The manufacturer of the panels would need to be certified to the requirements of CSA A277-16 Procedure for Certification of prefabricated buildings, modules and panels.

When SIPs were used in 2009 by NHC on 143 homes, they were manufactured by KOTT Group who are no longer involved in SIP manufacturing. One of the key project team members representing KOTT at the time now operates a consulting company specializing in arctic projects. In a discussion that our team had with this individual as part of the stakeholder engagement, it was identified to us that a key component of the success of construction using SIPs is training and supervision of SIP erection crews, since the success of SIP projects hinges on the SIP panel joints, which must be done correctly. This individual did not have any recollection of particular problems with SIP panels being damaged in transit.

Compared to full Stick-Built construction, construction involving SIP components requires a higher level of the following from the General Contractor:

- Project Management
- Ability to coordinate the design
- Additional site supervision staff for SIP related components

The use of SIP panels when compared with stick-built will result in an increase in the percentage of total contract price for materials due to the additional prefabricated component, the SIPs. This will likely require a different cash-flow schedule from NHC to the Contractor than with stick-built in the form of higher initial payments, with payments for SIPs possibly being required before the shipment of SIPs by Sealift.

CHALLENGES WITH INNOVATIVE BUILDING PRODUCTS (INCLUDING SIPS)

New methods of construction face challenges with respect to building codes. Canada has a National Building Code (NBC) that releases new versions every 5 years. Each province either chooses if and when to adopt the updated versions with their own province-specific amendments, or to release their own building code entirely. While Canada has a National Building Code, adoption and enforcement are the responsibility of the provincial/territorial jurisdictions.

The building code is made up of multiple parts. Houses and certain other small buildings (less than 3 storeys high and 600 m^2) are considered Part 9 Buildings. Part 9 drives the majority of the code requirements for such buildings, with references to other parts where the scope of Part 9 is exceeded. NHC fiveplexes are designed in accordance with Part 9 of the NBCC. Part 9 is very prescriptive and is intended to be able to be applied by contractors.

Larger buildings are considered Part 3 Buildings and Parts 1 through 8 apply. Part 3 is the largest and most complicated part of the building code. It is intended to be used by engineers and architects.

STRUCTURAL INSULATED PANELS

Innovations in building construction include structural insulated panels (for vertical loading, in-plane and tranverse loading – load bearing walls), structural insulated panels (for transverse and diaphragm loading – roof and floor panels), and insulated panels for transverse loading only (non-load bearing cladding).

Structural insulated panels can have a variety of compositions:

SIP PANEL TYPE	EXAMPLE MANUFACTURER	SKINS	FOAM	R-VALUE (FOAM ONLY)
OSB faced	Insulspan, Innova Panels	7/16“ OSB	EPS	R= 4 /inch
	Insulspan, Innova Panels	7/16” OSB	Neopor	R= 4.8 /inch
Plywood faced	Innova Panels	Plywood	EPS or Neopor with Innova	R= 4 /inch for EPS R= 4.8/inch for Neopor
MgO board faced	Innova Panels (Miami, FL), MgO Systems (Calgary, AB)	½ inch MgO board	EPS, Neopor	R= 4 /inch for EPS R= 4.8/inch for Neopor
No facing but combination of 2 exterior layers of steel bonded to EPS – Mfg notes that that in certain designs, structural sheathing is not required to be added	Greenstone Building Products (Brandon, MB)		EPS	R= 4/inch for EPS

Structural insulated panels are composed of an insulated foam core between two rigid board sheathing materials. The foam core is generally one of the following: expanded polystyrene (EPS), extruded polystyrene (XPS), and polyurethane foam (PUR). With EPS and XPS foam, the assembly is pressure laminated together. With PUR, the liquid foam is injected and cured under high pressure.

The most common sheathing boards are oriented strand board (OSB). Other sheathing materials include sheet metal, plywood, fiber-cement siding, and magnesium-oxide board.

Structural Insulated Panels, as a load-bearing construction material, are structurally efficient, energy efficient and easy to use in construction. They have high strength-to-weight ratio and can resist axial, transverse and racking loads. Therefore, they can be used as structural materials for roof, wall and floor panels. Some building structures can be made of SIPs without including additional framing or insulating materials.

Due to the limited application and research on SIPs, their body of knowledge is still lacking. The structural performance of SIPs as has been reported varies from manufacturer to manufacturer as each uses different SIP construction and connection details. In applying SIPs as structural materials, apart from addressing conventional structural issues, there is another major concern related to long-term performance, mainly caused by creep. Both facial and core materials experience high creep behaviour, and it has been found that the creep of SIPs is predominantly caused by the core material (foam).

Sheathing Type Chart for Structural Insulated Panels

SHEATHING TYPE	BENEFITS	DRAWBACKS
Oriented Strand Board (OSB)	Load bearing; readily available; tested; large panel size up to 8' x 24'	Subject to mould and a reduction in structural capacity if exposed to moisture; not fire resistant; must be treated for termites; difficult substrate for most common joint tapes. Tests have been done to demonstrate that if SIP panels are saturated once before installation, but then dried so that OSB reaches equilibrium moisture content, then there is no decease in structural capacity. SIP panels must be prevented from OSB skins accumulating moisture.
Plywood	Lateral strength	Availability; price; limited panel size; subject to mould and reduced structural capacity if exposed to moisture for a prolonged period of time; not fire resistant; must be treated for termites.
Magnesium Board	Resistant to mold, termites, and fire	Availability; testing; limited panel size.

Joint design is imperative for structural and long-term durable performance. One particular weakness of SIPs is air penetration from the interior at joints or penetrations. In cold climates, if warm humid interior air reaches the interior face of the outer sheathing layer it can condense, causing rot and deterioration. Frequently this outer layer is OSB, which is particularly susceptible to moisture damage.

Proper joint design should be given special attention, and if properly executed in the field, will eliminate the air infiltration problems. The primary joint design generally includes seals within the thickness of the panel, typically spray foam or gaskets. There should be an overflow seeping of the spray foam at the joints to indicate a full depth joint seal as shown in the figures below. An additional secondary seal air seal of tape or gasket should be provided at the interior face of the panel, especially in cold climates.


Two of the most widely used panel joint connections are the surface spline and the block spline. The surface spline joint connection consists of strips of OSB or plywood inserted in slots in the foam just inside each skin of the SIP. The block spline is a thin and narrow SIP assembly that is inserted into recesses in the foam along the panel edges. The surface spline connection and the block spline connection result in a continuous foam core across the panels, eliminating air infiltration at the joints. If structurally required, panel joints can be reinforced with one or more 2x lumber studs or Laminated Veneer Lumber (LVL) along the edges of the two panels to be connected. One disadvantage of this type of connection is that a thermal bridge is created at the joint. Another joint connection, mechanical Cam locks, creates a tighter joint between panels, but makes up only a small percentage of the market. Cam locks can only be set in PUR because the locks require a higher tensile strength than provided by other foams and the foam needs to expand and set around the lock's flanges. In any type of connection, the seam along the sheathing must be covered with a continuous line of foam sealant and/or panel tape.

Chart of Typical SIP Whole Wall R-values (excl. effect of any embedded structural members at joints)

THICKNESS	EPS	XPS	PUR
Density in Panel (lb/ft^3)	0.90	1.5	2.3-2.5
4-1/2"	13.1	17.7	22.7
6-1/2"	19.9	27.2	35.1
8-1/4"	26.0	35.5	46.0
10-1/4"	32.9	45.0	N/A
12-1/4"	39.8	54.6	N/A

Note: The R-value for a type of EPS called Neopor that is graphite enhanced EPS is typically 1.2x the R-value per inch of standard EPS (R=4.8/inch instead of R=4/inch).

Since the majority of SIP construction is used in combustible construction where the SIP walls are load bearing, NFPA 285 compliance does not apply. At this time, there appear to be no NFPA 285 tests that have been performed for SIP wall construction. SIP assemblies are typically protected from fire with drywall on the inside, unless the facing material is fire resistant such as cement board or MgO board. In addition, there is treatment of foam core to address required flame spread ratings.

With SIPs it is important that:

- Details are provided for a continuous inner line of redundant air seal at all joints and penetrations using sealant, foams, tapes, and gaskets.
- Exterior wall and roof water resistance barriers (WRB) are provided for. Note that the WRB should be vapor permeable and must make all joints water and airtight.
- Properly designed HVAC systems are required to address the air tightness and energy efficiency inherent with SIP designed buildings.
- The project design team should review any field cutting of SIPs.
- Foam sealing of SIP panel joints shall be reviewed for continuous full deep sealing. Usually proper foam sealant installation can be observed by foam seeping at the joints, which will need to be cleaned off the panel exterior surface.
- The inner redundant air seal is commonly accomplished with gaskets placed over the bearing points, spray foam, and with tapes at exposed joints. Careful selection of tapes and primers suitable for the panel type for long-term adhesion to the panels is important. Note that OSB is particularly problematic for most common construction tapes. Proprietary tapes for use at OSB joints are to be used.
- Innovative construction technologies are not “typical practice“. The availability of experienced installers should be taken into account when considering both initial installation and maintenance in the future.

Other considerations for use of SIPs and other innovative building products:

- *Field Mock-up is highly recommended.* A mock-up representative of the design assembly should be required. This could be completed as a small chosen area of the construction prior to full construction production. It could also be done in advance at the manufacturer’s plant, so that there is an opportunity to ensure that construction details and installation will be successful.
- *Field Observation is highly recommended.* Field observation is recommended for the installation of the innovative products and their components, for quality assurance of fabrication and installation.
- *Shop Drawing Coordination is essential.* Installation shop drawings must be required showing all adjacent construction and related work, including flashings, gaskets, sealants, structural components in the products, attachments, and indication of sequencing of the work.

Innovative systems require expertise on the part of the building designer, the manufacturer, the fabricator, and the installer. The Architect and Engineer of record may consider engaging an outside consultant, if such expertise is not available within the project team.

Although the total time for manufacturing and assembling of innovative building products is often iless than that of a framed structure, more time is required in planning. Openings in the panels, non-orthogonal designs, electrical, and all coordination must be determined prior to the manufacturing of the products. Window and door opening dimensions must be known in advance.

The contractor and the installers should be experienced with the innovative building product. It is recommended that they be trained to help prevent poor installation of the products by a crew unfamiliar with the product. The Architect and Engineer of record along with the manufacturer should observe the construction of the product for compliance with the approved project submittals.

Since the foam cores act as a vapor barrier, the weather resistant barrier must be vapour permeable in order to allow the panels with foam cores to dry outward. A continuous air space, between the drainage plane and the exterior cladding, and vented openings at the top and bottom of the walls to allow for convective air flow is recommended to ensure adequate drying. This also applies to panels used as roof structure. Air should be able to flow under the roofing material between the eave and the ridge. In addition, all panel joints, openings around windows and doors, and other chases should be properly sealed and/or flashed to prevent moisture infiltration.

Particular attention to details that ensure that interior air infiltration never reaches the outer sheathing layer is imperative, or that ensure the outer sheathing is kept at a temperature where condensation will not occur.

In 2019, SIPA produced a Final Draft Structural Insulated Panel Engineering Design Guide intended when implemented to be used by design professionals and to supplement SIP manufacturers' literature. This document considers SIPs composed of wood facing materials and foam cores. The core is considered to be either EPS or polyurethane (PU). Splines that are considered include block splines, surface splines and reinforcing splines. The design approaches considered include Allowable Stress Design and Limit States Design. Consideration is given to resistances to loading of differing durations (short, normal and permanent) due to the importance of creep with SIPs which is not a factor for conventional stick-framed housing. In addition, SIPs due to the presence of foam cores when subjected to out-of-plane loading experience calculable deflection due to both flexure but additional deflection due to shear. This is different than for traditional stick-built timber. This needs to be taken into account especially for roof and wall SIPs.

The SIPA Engineering Design Guide has design parameters such as bending and shear modules which are a factor of short, normal or permanent loading and differentiates between EPS and PU.

According to the commentary of this SIPA document, most SIP manufacturers' published structural values are suitable only for use with the average divided by three (ADT) design method allowed by the US International Building Code (IBC) and US International Residential Code (IRC). Designers must understand the underlying context of the design information provided in SIP manufacturers' designs. In the ADT design method, the allowable strength is computed as the average of ultimate loads divided by a factor of safety of three; this allowable strength is compared with Allowable Strength Design load combinations.

Canadian codes do not use Allowable Strength Design provisions and Allowable Strength Design load combinations.

Canadian codes do not have very much explicit discussion regarding Structural Insulated Panels. US based codes such as the International Residential Code (IRC) do have clauses pertaining to SIPs. This requires that structural designers from the SIP manufacturers and those reviewing design on behalf of owners such as NHC, have a high degree of familiarity with the details and codes, standards and manufacturer test results that are appropriate for use in assuring compliance with the intent of Canadian building codes.

As previously mentioned, one manufacturer of SIPs has had evaluation reports done to demonstrate compliance with Canadian codes. NRC's Evaluation Report CCMC 13016-R Insulspan SIP system[31] confirms that the Insulspan SIP System complies with the NBC 2010 when used as exterior loadbearing wall, and roof panels when used in accordance with the conditions and limitations of the evaluation report. These conditions include that loadbearing walls have lumber studs as structural ribs at 1.2m o.c; for roof panels there are either lumber or I-joists installed as structural ribs at 1.2m o.c. Panel thicknesses are 115mm, 165mm, 210mm, and 260mm and 310mm for roofs. Spans for various loadings are included in Section 3 of the evaluation report based on manufacturer's tests.

One of the conditions of this report is that Insulspan panel product as a structural insulating framing system is limited to single family housing within the scope of Part 9. When used as part of wall and roof panels, the installation must conform to the signed and sealed load tables for "Insulspan Structural Insulated Panels" dated January 20, 2010 for walls and roofs. The CCMC Evaluation report also cautions that Insulspan SIP system wall panels consisting of two layers of OSB and EPS foam core must have interior painted drywall with a composite vapour permeance of 15ng/(Pa s m^2) installed on the warm side of the assembly; cladding design must prevent the OSB from being subjected to wet conditions.

The report states that the sheathing membrane must be properly installed and shed water to the exterior and that there must be 10mm air space for drainage outside the sheathing membrane. The report warns that unlike conventional roof structures (roof trusses or roof rafters), the failure of roof coverings could lead to rapid accumulation of moisture in the top skin accompanied by a change in performance of the panels and likely permanent sagging of the roof panels. The report states that the design of roof cladding for use with SIP roof panels must provide a reduced risk of water penetration compared to conventional roof trusses. The second line of defence could include 15lb to 30lb asphalt-impregnated membranes or modified bituminous membrane. The CCMC Evaluation includes limitations on spans for roof panels in OSB weak and strong direction when OSB splines instead of structural ribs are used.

Currently Insulspan warns against covering the top of roof panel exterior sheathing with a material that is vapour impermeable.

PAST PROBLEMS WITH ROOF SIP PANELS WITH OSB FACES

A number of SIP projects in Juneau, Alaska have experienced premature deterioration of SIP roof panels. These occurred on projects a number of times and in the latter cases even when the causes of the original failures were known (attributed to workmanship and air exfiltrating through interior roof joints and moisture accumulating in the roof panels). Reports have been published regarding SIP roof panel failures on multiple projects in Juneau, Alaska. These reports describe evidence that interior air infiltration through the joints in the SIP roof panels indicated premature deterioration of the top of the OSB skin of the roof panel joints. The general conclusion reported was that the moisture damage was due to evidence of the lack of proper joint panel sealing. Note that despite failures of roof SIP panels in Juneau and local knowledge of this concern, there have been subsequent projects in Juneau with SIP roof panels that encountered the same problems.

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[31] https://www.insulspan.com/wp-content/uploads/2019/03/13016-R_e-Insulspan-SIP-System-1.pdf

NHC should be aware of these past problems and the guidance on the matter given in documentation by SIPA and the Insulspan CCMC Evaluation Report, if considering the use of SIP panels as roof panels.

When it comes to Structural Insulated Panels that have facings other than OSB and plywood which have design information contained in Wood Design Codes and Standards, there is even less information available from any sources other than the manufacturers and distributors of these panels.

SIPS WITH MAGNESIUM OXIDE (MGO) FACING BOARDS

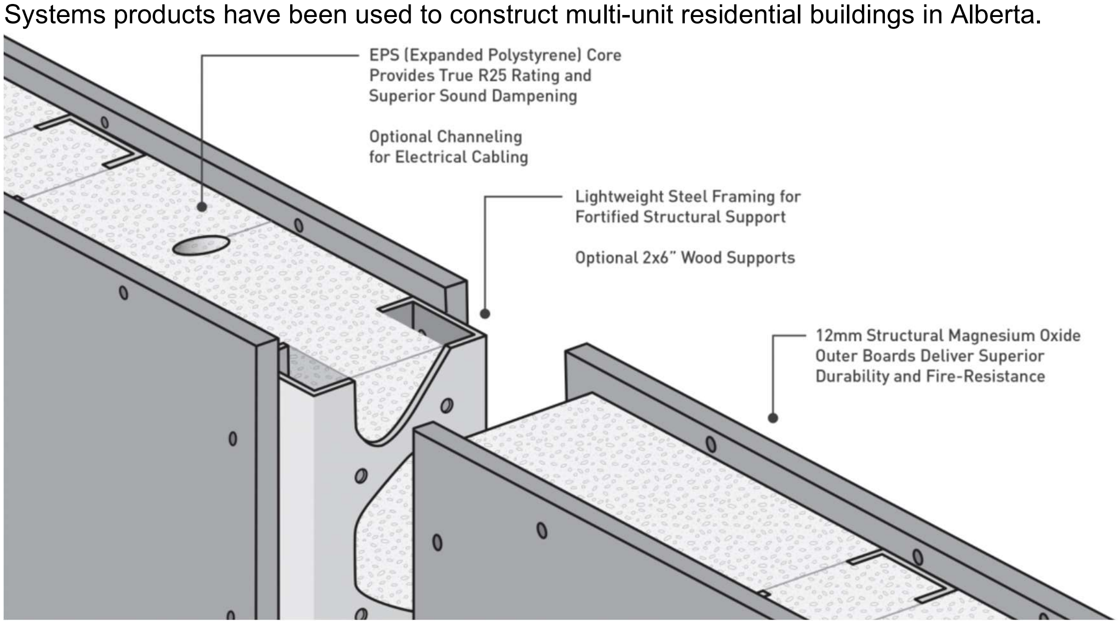
There are SIPs that feature combinations of MgO (magnesium oxide board) facing with OSB facing foam cores (EPS, Neopor) or with both faces being MgO board. The advantages of MgO board over OSB are very high resistance to fire and less susceptibility to deterioration due to moisture.

MgO Systems and Innova Panels are two companies that provide SIPs with MgO facing. Innova Panels manufactures in Florida. MgO Systems of Calgary, Alberta provides SIPs with both panels being magnesium oxide board.

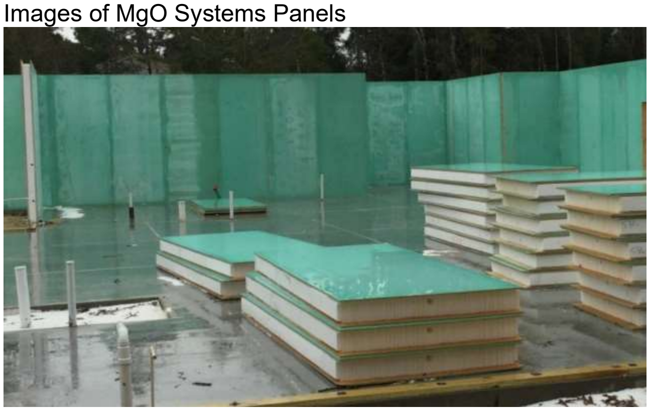
SIPs constructed with MgO board would have better resistance to deterioration due to moisture. Given foam cores, structural evaluation would need to consider for floor and roof panels, the effect of deflections out of plane due to flexure and also shear. In addition, the effect of load duration needs to be considered when evaluating structural capacity and deflection.

In Europe, there have been examples of premature deterioration of MgO board used in construction attributed to poor quality control of manufacturing of MgO board coming from some suppliers in China. MgO Systems of Calgary, Alberta have stated that their products which use imported MgO board are subject to stringent quality control and that their products have not experienced the problems reported in Europe.

The C3 Engineered Wall System by MgO Systems is a proprietary method of construction, using manufactured panels that are joined together in the field. Each structural panel is comprised of ½" thick Cast Cement Composite (C3) sheets, adhered under pressure to cores of EPS, and strengthened with internal supports. These panels are typically 6½" thick for exterior walls and 4' wide by 8', 9', or 10' tall as single units. The internal supports can include fiberglass framing to reduce thermal bridging. MgO Systems products have been used to construct multi-unit residential buildings in Alberta.



Images of MgO Systems Panels



INSULATED PANELS WITHOUT FACING MATERIALS (ICE PANELS)

There are other innovative products such as ICE panels, including from Greenstone Building Products in Brandon, Manitoba consisting of EPS cores with embedded galvanized steel channels that are thermally separated between the inside and outside faces. These panels have structural properties, and the manufacturer states that there are situations where exterior sheathing is not required. This would need to be evaluated on a case-by-case basis. Exterior walls must resist vertical loading, combined vertical loading and flexure due to lateral loads or for providing resistance to in plane shear forces. Roof and floor panels must resist out of plane flexure and also may need to provide diaphragm action.

The website for ICE panels offers access to some design information. The use of ICE panels as part of NHC fiveplexes would need to be evaluated from a partial substitution of framing and insulation for NHC standard fiveplex buildings. A fully detailed design would need to be done by a structural engineer familiar with the ICE system and reviewed by a structural engineer working for NHC to determine if the panels could be potentially integrated to replace components of the fiveplex. In addition, additional sheathing required for structural adequacy would need to be determined. Since these panels include foam, consideration should be given to what is known about structural capacity and deflections as affected by load duration.

It is beyond the scope of this report to evaluate the feasibility and structural adequacy of of ICE panels for incorporation into NHC fiveplexes.

ICE panels are a new innovative building product. Currently, ICE panels are not permitted under Part 9 of the building code.

ICE panels can and have been used in Part 9 buildings but are not designed prescriptively. Prescriptive design looks at each component of the build to ensure it meets a minimum acceptable standard established by the jurisdiction. Performance design looks at the building as a whole, and requires structural analysis, design and energy-use modelling to predict usage against an acceptable baseline.

ICE panels can be evaluated for performance based designs found in Part 3 of the building code which are typically complex, large-scale, commercial buildings reviewed by an architect.

As most authorities having jurisdiction (AHJ) use the prescriptive method for today's residential builds, this presents challenges for the adoption of innovative products in residential Part 9 construction.

Greenstone Building Products advertises that:

- ICE Panels have been evaluated to meet the intent of the National Building Code of Canada
- They can be designed to cost effectively meet the requirements of the National Energy Code
- The design of the ICE panel follows the criteria for Part 3 buildings of the National Building Code of Canada
- Each ICE panel is designed and sealed by a structural engineer
- ICE panels are tested to international testing standards and inspected by QAI Laboratories - an international accredited laboratory.

Greenstone Building Products claims that ICE panels are a nationally and internationally approved building technology to meet current and future building codes. NHC, their Consultants and the OCBO (being the AHJ) would need to review available documentation and Code Evaluation reports to assess the potential applicability of these panels for use in NHC fiveplex designs.

OTHER POSSIBILITIES

There may be other designs utilizing nail-based SIPs as insulated cladding panels supported by an uninsulated wood structural framing sized solely for structural considerations (and not the accommodation of a certain thickness of batt insulation), that may be worth consideration even though they will likely involve less onsite labour and more economic leakage compared with the current design, though less than with the use of Structural Insulated Panels as replacement for the structural system.

In addition, it may be worth considering alternative approaches such as the R.E.M.O.T.E wall system advocated by the Cold Climate Housing Research Centre in Alaska.

If in the future NHC is considering constructing single family dwellings, consideration should be given to the Integrated Truss Home developed by the Cold Climate Housing Research Centre and constructed in remote locations in Alaska using a combination of a trained superintendent and foreman, along with a crew of eight local community members.

4.4.6 Design Related Considerations for Possible Use of Modules to Replace Housing Units (1BR, 2BR, 3BR)

The design related considerations to allow the incorporation of more prefabricated elements than currently incorporated in the NHC stick-built 5plex design could include modular provision of the housing unit portions of the NHC 5plexes.

MODULES

Modules could be designed and constructed to closely replicate the design of the 1 BR, 2 BR and 3 BR units that are part of the NHC 5Plex. Some changes would be required to layouts and there would be some changes to dimensions that would make the units more suitable to modular construction. The design of the modules could be stamped by a Professional Engineer registered in Canada for the Modular manufacturer. This engineer may be required to be licensed with NAPEG. The division of responsibility for design will need to be identified (as with other pre-fabricated components) and NHC's Consultant Team will need to review Modular component designs both from a structural and building envelope detail and integrity perspective.

ADVANTAGES AND DISADVANTAGES OF MODULES

Modular construction has some distinct advantages and some disadvantages over the same functions being provided by stick-built construction.

- Advantages: speed of construction, simplification of construction, less potential variability in the quality of construction.
- Disadvantages: more attention to coordination during design is required, since modules come to the site completed except for the work that needs to be done at the joints between modules or that can only be done after the modules are joined together; modules need to be designed and reinforced for hoisting and protected during transit from the factory to the site.

RECOMMENDATIONS

- We recommend that if construction using modular components is considered to be allowed as prefabricated components, then the preparation of prototypical design drawings and specifications needs to be done and issues related to any concerns (from NHC or their Consultants) regarding modular construction be identified and resolved in advance.
- We recommend that if construction by modules is being permitted for NHC projects that the dimensions of the NHC 5plexes be reviewed to coordinate them with standard dimensions of modules, and that restrictions on modular size due to trucking and hoisting limitations on site be factored into design.
- We recommend that discussions be held with the Chief Building Official as well to identify what submissions will be required to support a Building Permit application for a design that incorporates Modules.

Note that with the use of Modules in NHC housing projects there will still be portions expected to be constructed with traditional stick-built construction such as:

- mechanical chase and attached central mechanical room
- exterior platforms and enclosures

- We also recommend that if NHC decides to permit the use of Modules in future projects that the prequalification of Modular suppliers and the General Contractors that would be installing them be undertaken. The manufacturer of the panels would need to be certified to the requirements of CSA A277-16 Procedure for Certification of prefabricated buildings, modules and panels.

Compared to Stick-Built construction and construction involving SIPs, Modular Construction requires a higher level of the following from the General Contractor:

- Project Management
- Ability to coordinate the design
- Scheduling
- Ability to manage a more intensive schedule with a higher number of peak workers on site during construction
- Ability to staff and obtain sufficient labour and subcontractor staff onsite for an intense, continuous period of construction

- More sophisticated Health and Safety expertise particularly related to review of hoisting plans and operations
- More on-site supervision staff

The use of Modules will result in a large increase in the percentage of total contract price for materials compared with other stick-built or part-SIP due to the value of the prefabricated Modules. This will likely require a different cash-flow schedule from NHC to the Contractor than used in Stick-built or Part SIP-Part Stickbuilt, in the form of much higher initial payments, with payments for modules likely being required before the shipment of modules by Sealift.

4.5 Stick-Built, Modular and SIP

4.5.1 Key Themes for Stick-Built

Stick-built construction has the advantage of being the norm for residential construction by NHC and in all of Canada, and thus it is what General Contractors, Subcontractors and suppliers are used to for residential construction.

Stick-built construction is flexible and more able to accommodate changes on site than delivery methods that utilize more off-site prefabrication such as delivery using prefabricated panels (uninsulated framed floor, wall or roof panels or Structural Insulated Panels) or fully factory-prefabricated housing modules.

Construction by traditional stick-built does not require that specialized hoisting equipment such as all-terrain cranes be brought on site.

Traditional stick-built is suitable for all Nunavut communities regardless of the number of Sealift sailings.

Traditional stick-built construction is well suited to all residential construction as it is the norm.

Traditional stick-built construction will require the most onsite labour which should result in the highest potential for overall hours of local construction employment.

4.5.2 Key Themes for SIP

Combining traditional stick-built construction with Structural Insulated Panels is not the norm for residential construction by NHC nor in Canada. The majority of General Contractors and Subcontractors generally have little or no experience with Structural Insulated Panels. The subcontractors that install SIPs are framers. They can view SIPs as threats to their trade since it reduces the overall labour for framing, as will any prefabricated panels.

Subcontractors that work on numerous projects with SIP panels are reported to become enthused with the product and its efficiency. There is a learning curve with any approach in construction that is new to those involved. This makes it unlikely that a General Contractor would opt to utilize SIPs as part of a bid unless:

- the tender documents are developed with SIPs in consideration
- there is enough time to get proper quotations from qualified SIPs
- the schedule for the project is structured such that there is sufficient time before the Sealift dates for design and manufacture of SIPs

Construction with SIPs is less able to accommodate changes onsite than traditional stick-built and thus requires more pre-planning as well as more time and effort to coordinate the SIP panels with the balance of the design.

Construction using SIPs does not require that specialized hoisting equipment such as all-terrain cranes be brought onsite provided the widths of panels are limited to 4 ft.

SIPs combined with traditional stick-built are suitable for all Nunavut communities regardless of the number of Sealift sailings.

When a construction project utilizes SIPs, a part of the overall end product is performed in the plant manufacturing the SIPs, meaning there is a reduction in overall labour hours required onsite given that work is not expended on site.

The overall percentage of Inuit construction labour on site is expected to remain similar to that of traditional stick-built, but the overall number of hours of construction will decrease. It is important that this distinction is understood. The labour involved in the manufacture of prefabricated components is not construction labour, it is labour for manufacturing.

4.5.3 Key Themes for Modular

Modular construction is not the norm for residential construction by NHC nor in Canada. The majority of General Contractors and Subcontractors generally have little or no experience with Modular Construction. Residential Modular Construction in the south is mostly on single family homes where a modular housing provider is a subcontractor to a General Contractor or the Modular provider acts as the General Contractor. On large-scale multi-storey modular residential construction in urban areas, the modular provider is usually as subcontractor to a General Contractor. For projects in remote areas where residential housing for work camps is provided, the modular provider is often the General Contractor.

This makes it unlikely that a General Contractor would opt to utilize modular components as part of a bid unless:

- the bidder is a provider of modular housing
- the tender documents are developed with Modular Housing in consideration
- there is enough time in the tender period to get proper quotations from qualified modular suppliers
- the schedule for the project is structured such that there is sufficient time before the Sealift dates for the design and manufacture of Modular components

Construction with Modular components is less able to accommodate changes onsite than traditional stick-built and thus requires more pre-planning as well as more time and effort to coordinate the modules with the balance of the design.

Construction using Modules does require specialized hoisting equipment such as all-terrain cranes.

The design of the modules must be designed for:

  - hoisting on and off trucks
  - travel from manufacturing plant to Sealift departure port in Quebec

  - hoisting off onto Sealift boats, then hoisting from Sealift boats to barges, then unloading on the beach in the Nunavut community
  - transport from the beach to the building site, then hoisting onto the foundation, and finally securing the modules to the foundation and to each other.

Modular Construction is only feasible for Nunavut communities in which:

- There is enough time between a Sealift arrival and a subsequent Sealift departure that specialized equipment such as large all-terrain cranes can be brought up to the community by Sealift, used for the erection of modules and then returned to their point of rental on a subsequent Sealift departure date from the community.
  - For a three fiveplex NHC housing project, we estimate that the time required for the crane to be on site is four weeks. Given that there can be equipment breakdowns we would advise that for a project with three fiveplexes, there must be six weeks minimum between sealifts in the same year. Since the time between sealifts for communities with multiple sealifts can be larger, for certain communities the period of rental required for a Modular build can be as much as 4 months.
  - The above obviously does not apply if there is an suitable crane available to the Contractor. Based on the current NHC design with each housing unit comprised of two modules we calculate that a 100T crane is likely required.
- There is space very close to the beach to accommodate the safe storage above HWL of all the modules. This would need to be an area of about 1 acre of fairly level ground for storing the modules. This is because the time for the Sealift to be in the community is very limited and the site will not be able to accommodate the modules and still allow construction to proceed.

When as with modular construction a large part of the overall end product is performed in the plant manufacturing the SIPs, there will be significantly less overall labour hours required onsite given the significant pre-work done on the modules that is not expended onsite.

The overall percentage of Inuit construction labour on site is expected to remain similar to that of traditional stick-built, but the overall number of hours of construction will decrease significantly. It is important that this distinction is understood. The labour involved in the manufacture of prefabricated components is not construction labour, it is labour for manufacturing.

4.6 Single Family, Multiplex Dwellings, and Tiny Homes

MULTIPLEX VS. SINGLE FAMILY DWELLINGS

Given the high costs of energy in Nunavut, it is good practice to build multi-dwelling housing to reduce the extent of exterior wall building envelope and hence enhance the energy efficiency of the housing. In addition, the construction of multiplex units compared with single family dwellings is more cost effective and more efficient to operate and maintain by NHC.

Single family dwellings require more land to build on and higher costs to extend roads and services to, be it only electrical in communities with other services trucked or in communities with utilidors.

TINY HOMES

Tiny Homes are very small homes designed to accommodate in cramped quarters one person or at most two people. They have adherents in mostly southern locations where year-round living can involve considerable time outdoors. Our team is unable to comment on the suitability of Tiny Homes for housing for the Nunavut context. We have investigated a number of providers of them but have not found any with similar construction as that provided by NHC in terms of building envelope and insulation levels. As single dwellings, Tiny Homes will have the same disadvantages compared with multi-plex dwellings, even if a Tiny Home design were developed that had a design appropriate for the environment of Nunavut. The high cost elements of residential construction in Nunavut still apply to Tiny Homes. The cost of water and sewage tanks, bathrooms, kitchens, etc. are still applicable. Simply reducing the square footage of the livable footprint will not proportionately lower the overall cost. In fact, the cost per sq ft. will be higher for Tiny Homes than for regular sized units.

Tiny Homes can be built either as mobile homes or meeting the requirements of the NBCC and CSA A277-16 for the certification of prefabricated buildings, modules and panels. Different jurisdictions have differing requirements for Tiny Homes.

We have also investigated container homes and have yet to find any that can accommodate the insulation levels required by the NHC in their new builds. The main limitation with container homes is that they generally have insulation installed on the interior of the sea can and their internal dimensions are very limited to start. It may be possible to construct a container home with insulation on the exterior of the sea can and with a properly designed and functional building envelope. This would require a design evaluation that is outside the scope of the current study.

5.0 Analysis of Economic Leakage Related to Different Construction Methodologies

5.1 Methodology

Economic Leakage analysis is an important and worthwhile tool for territorial governments in Canada, and a number of such studies have been completed in the recent past. Economic leakage means that funds are flowing out of a given territory either to elsewhere in Canada or outside the country altogether. Such leakage flows carry the implication that, if they could be prevented by increasing procurements of local supplies and labour, more jobs and wealth could be created and retained inside the territory. Accordingly, leakage should be identified, and the question raised "could our local economy provide the same competitively?" Naturally, the question of raising the proportion of total incomes that are derived within the territorial economy is a vital one for territorial governments, as they have issues of remoteness, lack of scale, transportation costs, insufficient infrastructure, etc., not faced by large urban areas elsewhere in Canada, that create barriers to higher prosperity.

We can briefly summarize two different approaches to assessing the economic leakage of the Nunavut housing construction sector. The two overall methods are "Top Down" and "Bottom-Up".

TOP-DOWN ANALYSIS

Top-down analysis, as its name implies, uses macroeconomic statistics to calculate what is retained inside the territorial economy and what "leaks", according to business and census surveys. To illustrate, a top-down approach would be to use the Statistics Canada Input-Output (I/O) tables. Statistics Canada keeps extensive quantitative data on the inputs and outputs of numerous industries. As well, and very importantly, the Statistics Canada data calculates the input-output "multipliers", or coefficients that relate value of outputs to inputs, and particularly, the value of "leakages" whereby the output is dependent on imported materials, parts, equipment, or labour. Hence, very often the GDP "multiplier" is less than 1: $1,000,000 of total economic activity only produces (say) $850,000 of direct Canadian GDP output, the remaining $150,000 having gone outside the country. Only a few sectors show coefficients greater than 1. Most "leak" in one way or another.

A study by a major international accounting and consulting firm for the Canadian Association of Defence and Security Industries (CADSI), using the top-down Statistics Canada Input-Output tables, calculated that a billion-dollar procurement in defence generated about $790 million in direct Canadian GDP. The rest leaked.

Unfortunately, the level of leakage in Canada's northern territories is high, i.e., a lot of inputs to economic activity have to be imported from outside the territories. The Bureau of Statistics of the North-West Territories (NWT) did a detailed top-down analysis of NWT I/O multipliers. These showed leakages for every sector of the NWT economy. For example, Agriculture and Forestry showed a multiplier of 0.63: 37% of the value of output in these sectors had leaked out of the NWT. Supporting activity sectors did a little better: only 25% leaked. These were, significantly, about the best sectoral results for the NWT from the standpoint of lessening leakage.

In the case of construction in the NWT specifically, the multiplier was 0.42; that is to say that 58% of the value of output in NWT construction was lost to leakage. That is not optimum. As well, it gets worse: the NWT numbers suggest that the labour income multiplier of NWT construction was only 0.24. In sum, out of any $1 million spent on construction in the NWT, $580,000 went to the south or elsewhere, and only $240,000 of the remaining direct-spent $420,000 went to supporting labour income (jobs).

It should be emphasized that this is not quite the end of the economic story, however. There are positive indirect and induced effects from such local economy spending, which are not captured in the direct spend impact, as the income flows that are retained in the local economy get spent. These can be expressed through a “spending multiplier”, typically in the range of 1.2-2.0 as the various incomes that are retained in the Territories (and Canada) get spent and reverberate within the general economy. Thus, the eventual economic impact of the hypothetical defence procurement given from CADSI above would be actually larger and more positive. Nevertheless, the I/O coefficients are a good guide to leakage.

This top-down approach is often very credible, considering Statistics Canada’s renowned reputation for statistical integrity, and numerical skill. However, we would suggest that this approach is not optimum for this Nunavut Housing assignment, largely because a truly representative set of Nunavut territorial Input/ Output Tables have not yet been fully developed: Moreover the Statistics Canada tables are primarily oriented towards specific industries and not regions.

Accordingly, we would suggest that separate location-specific and industry-specific calculations are required to research territorial leakages. We call this a “bottom-up” approach.

BOTTOM-UP ANALYSIS

In a “bottom-up” analysis, the local economy sector under consideration, such as Nunavut housing, is disaggregated into key individual projects, and a separate economic leakage assessment is made for each. That is what has been done here.

The hypothetical three Nunavut housing construction scenarios were (see Section 4, above, for more detailed descriptions):

- Traditional “Stick Built” construction

Essentially this is a form of custom construction using conventional materials brought up from the south (i.e., Ontario and Quebec), and assembled by labour at the construction site, in the local community. Normally a standardized design and ground layout is used.

- Use of Structural Insulated Panels (SIP)

SIP Panels can substitute for walls, roof and floors, and would be manufactured/assembled in the “south” and taken by sealift to the construction site in Nunavut and installed.

- Use of Prefabricated “Modular” sub-assemblies

Individual building modules are constructed in the “south” and would be taken by sealift to the construction site in Nunavut and assembled.

Each of these methodologies carry different implications for local content before completion, and therefore how much of the total funding commitment would be lost or retained in Nunavut.

In sum, these three construction scenarios were analyzed to allow cost comparisons on a consistent basis. As well, we used the consistent scenario represented by building three (3) fiveplexes for the comparisons. (I.e., a total of 15 housing units). The fiveplex design is a common one used by NHC in the territory for public housing.

It should be noted that the analysis of separate cost components required detailed evaluation and incorporated and benefited from the information obtained in the stakeholder engagements. Our analysis has been based on the following:

- available literature
- available reference material applicable to construction estimating
- the creation of and response to requests for budget estimates (in particular related to SIP and modular technologies)
- stakeholder engagements including with sealift providers (related to marine transport shipping costs)

5.2 Conclusions Related to Direct Economic Leakage for Different Construction Methodologies

The results of our analysis can be found in Exhibits 5.1, 5.2, and 5.3.

STICK-BUILT CONSTRUCTION METHODOLOGY

Exhibit 5.1	Summary of **Stick-Built** Costs Including Direct Economic Leakage	
Description of Item	**Value ($)**	**Hours**
Estimate of Total Tender Price materials including all O/H and P	4,050,000.00	
Equipment Costs for Foundation and Gravel Pad	225,000.00	
Total Labour including all mark-ups, fringe benefits, workers compensation, EI, CPP, all site and office overheads for subs and GC on direct site labour costs	4,725,000.00	
Total Estimated Tender Price	9,000,000.00	
Total Direct Economic Leakage	**5,405,193.37**	
Economic Leakage Materials	3,280,293.37	
Hours Nunavut Labour		8,119
Economic Leakage Nunavut Labour	128,250.00	
Hours Non-Nunavut Labour		21,521
Economic Leakage Non-Nunavut Labour	1,996,650.00	
% Total Direct Economic Leakage		**60%**
Economic Leakage per $1million construction tender value	600,577.04	
Economic Leakage per Fiveplex (Stickbuilt)	1,801,731.12	

The total cost of building 3 five-plexes using the usual and conventional stick-built methodology works out, on this analysis, to be $9.0 million. Of this sum, $5.405 million leaks out. This is a leakage rate of 60%.

The main leakage factors are:

Materials**,** which represent costs of $4.05 million, and of which $3.28 million leaks. A particularly noteworthy loss is the 10% of total bid for materials (approx. $0.9 million) that goes to sealift and transportation insurance and brokerage, as almost all necessary materials have to be brought to Nunavut from the “south”.

Non-Nunavut labour**,** which takes 21,521 hours, and thereby leaks $1.997 million.

Leakage from Nunavut labour**,** which accounts for 8,119 hours, but even here, certain factors, such as pension and other benefits, nevertheless lead to leakage of $0.13 million. It is also noteworthy, and may perhaps seem a bit surprising, that the Nunavut share of the labour hours is less than that of the imported workers. Finally, these numbers are broadly harmonious with the NWT results described above.

SIP (WALLS, ROOF, AND FLOORS) CONSTRUCTION METHODOLOGY

Exhibit 5.2 Summary of **SIP (Walls, Roof, Floors)** Costs Including Direct Economic Leakage		
Description of Item	**Value ($)**	**Hours**
Estimate of Total Tender Price materials including all O/H and P	4,485,000.00	
Equipment Costs for Foundation and Gravel Pad	225,000.00	
Total Labour including all mark-ups, fringe benefits, workers compensation, EI, CPP, all site and office overheads for subs and GC on direct site labour costs	3,924,000.00	
Estimated change in fixed General Conditions for onsite equipment due to reduced duration onsite compared to stick-built - overall duration similar (~1 month shorter)	(10,000.00)	
Allowance for additional temporary heating 6 months including dry heater + generator + power panel + fuel + labour to attend	179,325.00	
Estimated Increase in project management/coordination by GC compared to stick-built (assume additional 1/2-time assistant project manager for 7 months from project award to sealift)	55,770.40	
Allowance for additional design	31,500.00	
Allowance for additional factory inspection by NHC consultant	5,000.00	
Adjustment to bonding and insurance	(4,176.18)	
Total Estimated Tender Price	8,891,419.22	
Total Direct Economic Leakage	**5,394,764.77**	
Economic Leakage Materials	3,619,100.77	
Hours Nunavut Labour		6,581
Economic Leakage Nunavut Labour	104,220.00	
Hours Non-Nunavut Labour		17,931
Economic Leakage Non-Nunavut Labour	1,671,444.00	
% Total Direct Economic Leakage		**64%**
Economic Leakage per $1million construction tender value	641,546.53	
Economic Leakage per Fiveplex (part-SIP)	1,798,254.92	

The total cost of building 3 five-plexes using the SIP methodology works out, on this analysis, to be slightly cheaper than Stick-Built at $8.891 million. Of this sum, $5.395 million leaks out – virtually exactly the same as for the Stick-Built method. This is a leakage rate of 64%. Accordingly, while the total cost is less, the savings come mostly from reduced labour demand on-site during construction. This is logical, because the point of using SIP structures for the floors, roof and walls is to reduce the need for assembly time at the buildings when they are put up.

The main leakage factors are:

Materials, which represent costs of $4.485 million, and of which $3.62 million leaks. If anything, costs going to sealift, and transportation insurance and brokerage, actually increase as compared to Stick-Built, owing to costs relating to more elaborate packaging, and dedicated transport from the SIP manufacturer to the supplying sealift station.

Non-Nunavut labour, which takes 17,931 hours, and thereby leaks $1.67 million.

Leakage from Nunavut labour, which accounts for 6,581 hours, but even here, certain factors, such as pension and other benefits, nevertheless lead to leakage of $0.1 million.

Accordingly, although there is a savings in total costs, this savings is disproportionately from Nunavut-supplied factors, and the total sum retained within the Nunavut economy is much the same as for Stick-Built.

PRE-FABRICATED MODULAR CONSTRUCTION METHODOLOGY

Exhibit 5.3 Summary of **Part Modular (All but Mechanical Room, Chase & Appendages)** Costs Including Direct Economic Leakage

Description of Item	Value ($)	Hours
Estimate of Total Tender Price materials including all O/H and P	6,331,000.00	
Equipment Costs for Foundation and Gravel Pad	225,000.00	
Total Labour including all mark-ups, fringe benefits, workers compensation, EI, CPP, all site and office overheads for subs and GC on direct site labour costs	1,975,705.56	
Additional for 100T rough terrain crane for 4 months plus sealift, plus all inclusive labour costs for crane operator and assistant	168,400.00	
Allowance for construction of 3/4-acre level area for laydown of modular units including cribbing required	20,000.00	
Allowance for temporary removal of overhead hydro lines needed for modular movement from beach to site	10,000.00	
Allowance for additional temporary heating 4 months including dry heater + generator + power panel + fuel + labour to attend	141,975.00	
Estimated Increase in project management/coordination by GC compared to stick-built (assume additional 6 person-months for assistant superintendent plus 1/2-time assistant project manager for 10 months from project award to sealift)	285,465.69	
Allowance for additional design	31,500.00	
Allowance for additional factory inspection by NHC consultant	5,000.00	
Adjustment to bonding and insurance	7,761.85	
Total Estimated Tender Price	9,201,808.10	
Total Direct Economic Leakage	**7,616,050.29**	
Economic Leakage Materials	6,556,855.87	
Hours Nunavut Labour		3,335
Economic Leakage Nunavut Labour	53,148.92	
Hours Non-Nunavut Labour		8,861
Economic Leakage Non-Nunavut Labour	837,645.51	
% Total Direct Economic Leakage		**83%**
Economic Leakage per $1million construction tender value	827,668.89	
Economic Leakage per Fiveplex (part Modular)	2,538,683.43	

The total cost of building 3 five-plexes using Modular components works out, on this analysis, to be more expensive than Stick-Built or use of SIP parts at $9.2 million. Of this sum, $7.62 million leaks out. This is a leakage rate of 83%. Accordingly, while the total cost is higher, the leakage rate actually goes up significantly.

The main leakage factors are:

Materials**,** which represent costs of $6.33 million, and of which $6.56 million leaks. Costs going to sealift and transportation insurance and brokerage substantially increase, owing to costs relating to packaging and dedicated transport for movement to originating sealift supplying station.

Non-Nunavut labour**,** which takes 8,861 hours, and thereby leaks $0.84 million.

Leakage from Nunavut labour**,** which accounts for 3,335 hours, but even here again, certain factors, such as pension and other benefits, nevertheless lead to leakage of $0.05 million.

Accordingly, although there is a savings in labour costs, this savings is disproportionately from Nunavut-supplied factors, and the total sum retained within the Nunavut economy is less than for Stick-Built or SIP methods.

5.2.1 Additional Effects of Direct Economic Leakage for Different Construction Methodologies

Looking for more positive factors to reduce leakage in the Nunavut building construction sector faces some considerable barriers.

ECONOMIC BARRIERS: LACK OF SCALE ECONOMIES

In the course of this research, the project team endeavoured to determine if there was potential for NHC to capitalize on economies of scale, i.e., if through standardization or other means the output of housing could be ramped up more efficiently with greater throughput. Unfortunately, our research did not show opportunities to gain efficiency significantly through economies of scale (larger construction throughput). Our team compared the costs of building one (1) five-plex as contrasted with building three. This showed no differences in unit costs.

To a considerable extent, there has already been an important degree of standardization in NHC's construction: the standardized design and ground layout of the five-plex concept; the use of a below-floor "utilidor" allowing common access across all the units of the five-plex to water, sewer, and electricity connections in communities with this system and service tank provisions for those without, etc.; standardized measurements and panel sizes; and others.

MATERIALS

With the exception of sand and gravel, no residential building materials are available within the territory of Nunavut. The bulk of materials must be brought in from the south. It means costs are disproportionately high before construction can even begin.

The alternative is air freight, and this is employed throughout Nunavut for higher-value-add goods, such as fresh produce, consumer goods such as electronics, and other valuables. However, except for emergencies, such as necessary repairs, building materials cannot be justified for air freight.

All three construction methodologies are limited by these factors. Accordingly, it will be difficult to offset the Materials leakages in Nunavut (but see discussion of SIP and/or prefab Modular below).

USE OF NON-NUNAVUT (TRANSIENT) LABOUR

Could the Nunavut component of the labour requirements be increased? Already a considerable proportion of the total labour requirements is fulfilled by local labour, even if still not a majority of the labour hours. If it could be increased, there would be a corresponding reduction in leakage and an increase in retained incomes within the Territory.

Unfortunately, there are some barriers to increasing the participation of local construction labour.

- First, competition from better-paying jobs, such as mining, in the Territory. Moreover, these continue year-round, and are not just seasonal.
- Second, the construction season is quite short. A transient worker from the south may be able to get more work outside the Nunavut construction season upon their return to the south, but the opportunity for year-round work in construction is not similarly available for local workers.
- Third, whereas general trade and labouring jobs can be filled by Inuit Labour (and currently often are), more specialized work requirements may be outside of training and education available in Nunavut.
- Fourth, specialized training and education for construction goes hand in hand with apprenticeship opportunities, which are more likely to be offered by employers when there is continuous construction such as is the case in southern locations. Training opportunities are more available the higher the volume of construction.

5.3 Challenges and Opportunities for Increases in Local Participation in Construction Through Possible Local Prefabrication

The question could be asked whether it would be feasible for there to be manufacturing facilities in Nunavut (logically Iqaluit) to construct some common standardized parts such as engineered wood products (roof trusses, engineered joists, engineered wood beams or even prefabricated panels such as Structural Insulated Panels).

There are many factors that work against the economic feasibility of prefabricating engineered components in Nunavut for use in residential construction in Nunavut. The factors that work against prefabrication of components in Nunavut include the following:

- The size of the population and the size of the market in Nunavut
- All of the materials that are included in the finished products plus the waste created in the production that needs to be sealifted from the south
- The costs of sealift from one community such as Iqaluit to other communities are a considerable fraction of the cost of sealift from the south to Nunavut
- There is not one larger community in Nunavut that is connected by sealift with all other communities directly and able to access these communities as early in the year as scheduled sealifts from embarkation ports in Quebec
- This would require storage of large amounts of raw materials at a plant located in Nunavut compared with southern located manufacturing facilities that benefit from integrated supply networks and JIT (Just-in-time) delivery of inputs to manufacturing
- Prefabrication requires indoor manufacturing facilities which will have higher construction and operating costs than similar facilities in the south.
- Prefabrication plants need to be able to produce year-round and ship product out immediately after fabrication. Engineered wood products and SIPs require that the inputs to fabrication be stored properly as do the fabricated outputs. This includes control of moisture content among other things. Engineered wood products cannot be stored outside without considerable efforts at protection over the winter months. Orders for prefabricated components from within Nunavut would be seasonal and it would be unlikely that a plant in Nunavut could operate year-round.
- Prefabrication plants require specialized equipment such as CNC machining equipment and presses and certifications to standards such as CSA A277-16 and others. This involves costs in obtaining and maintaining certifications that in the south are distributed over a much larger plant output than would be realized in Nunavut. This is especially the case for engineered wood I-beams, LVLs and Structural Insulated Panels.
- Prefabrication plants have markets for the waste created in the prefabrication process that do not exist in Nunavut
- Many of the materials used in prefabrication plants such as Oriented Strand Board that will be used in fabrication of I-beams and Structural Insulated Panels are not suitable for being shipped to Nunavut, due to the sizes involved and the protection required to ship these inputs to factories that fabricate it in large sizes that prefabrication plants typically receive.

OTHER JURISDICTIONS

Our team's research did uncover a SIP fabrication facility in Alaska, which has some of the same economic challenges as Canada's territories; however, Alaska has a population of close to 800,000 (as opposed to Nunavut's 39,000) and this means that much more direct manufacturing can be justified, because the market is that much larger. Also, the SIP facility in Alaska has direct road access to markets and relatively good access to manufacturers of Oriented Strand Board. This SIP facility, rather than use EPS or Polyurethane board, imports the raw materials (which occupy a fraction of the shipping volume of the foam core that is created) and creates the polyurethane core using the OSB skins as formwork. This is a sophisticated process and a plant with a large enough market to sustain it.

CONCLUSION

There is little opportunity to reduce economic leakage and provide increased employment in Nunavut by shifting the abovementioned type of prefabrication to locations in Nunavut.

5.4 Summary of How Different Construction Technologies and Contracting Methods Can Affect Economic Leakage/Economic Development Potential Within Communities

Different construction methodologies can affect the degree of leakage in the Nunavut construction sector, but the problem of economic cost/effectiveness remains. And problems of Inuit content remain with all three approaches assessed herein.

A perspective that should not be overlooked is that the procurements for Nunavut housing that are made in the "south" (principally Ontario and Quebec) represent important markets for those provinces. The leakage from the Nunavut construction value is not helpful to the Nunavut economy, but it does assist the Ontario and Quebec economies.

We did not perform a formal economic impact analysis of the economic impacts of the three construction methodologies assessed here, because, on the numbers and results generated by this analysis, there would be little difference between the three methodologies. Nevertheless, enhancing the construction and housing sectors in Nunavut is a very desirable goal, in light of the benefits of finding export industrial sectors, such as mining, that could provide domestic income to Nunavummiut, and for which better housing for workers is required.

6.0 Training and Construction Workforce

6.1 Current Local Inuit Involvement in Housing Construction

6.1.1 Minimum Inuit Labour Level on Housing Construction Contracts (NNI Policy)

All publicly tendered contracts for NHC housing construction projects are governed by the regulations of the Nunavummi Nangminiqaqtunik Ikajuuti (NNI) Policy, last amended in 2017. The NNI was developed by the GN in close consultation with Nunavut Tunngavik Inc. (NTI) and came into effect in 2000.[32]

Under section 18 of the NNI regulations, the Contract Authority is to establish the mandatory minimum Inuit Labour level requirement for each Procurement Process.[33] In the case of NHC public tenders, the prescribed minimum level of Inuit labour as a percent of total labour by dollar value is 30%.[34]

This mandated minimum % assures Inuit labour participation that otherwise wouldn't be assured on such projects. However, since the mandatory minimum is measured by dollar value and not, say, labour hours, it is more difficult to monitor and ensure that a contractor provides the hours necessary to increase "on-the-job training, apprenticeship, [and] skill development [for Inuit]…through the performance of work on contracts",[35] in alignment with one of the stated objectives of the NNI Policy, so long as the minimum dollar value is achieved. This is consistent with experiences shared by contractors during our stakeholder engagement sessions, who generally reported struggling with the seemingly conflicting pressures of providing on-the-job training while delivering the projects on schedule.

6.2 Availability of Local Inuit Labour for Construction Trades

6.2.1 Labour Force and EI Data

According to Statistics Canada data as shown in Table 5, in 2020 the total number of persons employed in construction in Nunavut was 500. The breakdown of this labour force by community was not readily available, but would be an important statistic to further illustrate the distribution of employment in construction across the territory.

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32 http://nni.gov.nu.ca/Regulations
33 https://nni.gov.nu.ca/sites/nni.gov.nu.ca/files/NNI-Regs-amendment_2_0.pdf, page 18.
34 https://www.nunavuttenders.ca/UploadedDocs/RFT%20110000783%20RANKIN%20INLET.pdf, page 35.
35 https://nni.gov.nu.ca/sites/nni.gov.nu.ca/files/NNI-Regs-amendment_2_0.pdf, page 17.

Table 5: Employment in Nunavut by Industry, Annual averages 2004-2020 (persons in thousands)[36]

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total employed	7.5	7.8	8.7	9.7	10.8	10.7	11.5	11.8	12.1	12.7	12.0	12.2	13.0	13.0	12.9	13.0	12.1
Goods-producing sector	0.7	0.6	0.8	1.2	1.2	1.0	1.5	1.4	1.3	1.4	1.2	1.4	1.6	1.2	1.5	1.6	1.2
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Forestry, fishing, mining, oil and gas	0.0	0.0	0.0	0.2	0.3	0.0	0.3	0.4	0.5	0.4	0.2	0.2	0.3	0.4	0.5	0.5	0.2
Utilities	0.2	0.0	0.2	0.4	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.2	0.3	0.2
Construction	0.3	0.3	0.4	0.4	0.6	0.6	0.7	0.7	0.7	0.7	0.6	0.8	0.8	0.6	0.6	0.7	0.5
Manufacturing	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Services-producing sector	6.8	7.2	7.9	8.5	9.6	9.7	10.0	10.4	10.7	11.2	10.8	10.9	11.5	11.8	11.5	11.4	10.9
Trade	1.1	1.0	1.1	1.0	1.3	1.3	1.6	1.8	1.8	1.6	1.4	1.3	1.4	1.5	1.5	1.8	1.5
Transportation and warehousing	0.4	0.4	0.4	0.5	0.6	0.6	0.6	0.7	0.9	1.0	0.5	0.5	0.8	0.9	0.7	0.9	0.5
Finance, insurance, real estate and leasing	0.4	0.6	0.5	0.5	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6
Professional, scientific and technical services	0.0	0.2	0.3	0.2	0.0	0.0	0.0	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.2	0.2	0.3
Business, building and other support services	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.5	0.3	0.3	0.4	0.3	0.4	0.2	0.2
Educational services	0.9	0.9	0.9	1.1	1.4	1.5	1.3	1.4	1.5	1.6	1.5	1.7	1.8	1.7	1.5	1.5	1.5
Health care and social assistance	0.7	0.7	0.9	1.1	1.2	1.2	1.3	1.1	1.4	1.2	1.3	1.6	1.6	1.5	1.9	1.7	1.7
Information, culture and recreation	0.2	0.0	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.0	0.0	0.2	0.0	0.2	0.2	0.0	0.0
Accommodation and food services	0.4	0.2	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.5	0.4	0.4	0.4	0.4	0.4	0.2	0.2
Other services	0.2	0.3	0.3	0.4	0.3	0.3	0.4	0.4	0.3	0.2	0.3	0.3	0.4	0.3	0.4	0.3	0.3
Public administration	2.2	2.3	2.4	2.7	3.0	3.0	2.9	2.9	2.8	3.4	3.7	3.3	3.4	3.6	3.4	3.6	3.8

Note: 0.0 are estimates with less than 200 employed
Source: Statistics Canada, Labour Statistics Division, custom tabulation NUt12an.ivt

In order to gain an understanding of the potential available pool of labour in Nunavut for construction, Employment Insurance (EI) statistics for Nunavut were assessed.[37] From the three reference tables of data shown below current as of March 15, 2021, in which:

- Statscan Table 4 shows the active EI beneficiaries by age group as a number;
- Statscan Table 5 shows the active EI beneficiaries by age group as a percentage; and
- Statscan Table 9 shows the active EI beneficiaries by gender as a percentage;

Table 4: EI active beneficiaries by province or territory and age group – Number of beneficiaries (Statscan March 15, 2021)

Provinces and territories	Under 25	25 to 34 years	35 to 44 years	45 to 54 years	55 to 64 years	65 and older	Total
Nunavut	190	390	280	230	110	20	1,210

Table 5: EI active beneficiaries by province or territory and age group - Percentage of beneficiaries (Statscan March 15, 2021)

Provinces and territories	Under 25	25 to 34 years	35 to 44 years	45 to 54 years	55 to 64 years	65 and older	Total
Nunavut	15.7%	32.2%	22.8%	18.7%	8.9%	1.6%	0.1%

[36] Statistics Canada, Labour Statistics Division, custom tabulation, April 9, 2021.
[37] https://www.canada.ca/en/employment-social-development/programs/ei/statistics.html#s3

Table 9: EI active beneficiaries by province or territory and gender - Percentage of beneficiaries (Statscan March 15, 2021)

Provinces and territories	Female gender	Male gender	Gender diverse	Total
Nunavut	46.0%	54.0%	0.0%	0.1%

- One can extrapolate that 1,210 persons are EI beneficiaries and therefore available for work in the territory; and
- Approximately half of this number is female, for whom nationwide uptake for construction employment is relatively low compared with males. (In September 2020, Skills Canada Nunavut hosted a well-received workshop out of the Kivalliq campus of the Arctic College to introduce dozens of girls from 15 communities to work in a variety of trades, including carpentry, plumbing, and machine operation.[38] More of these special programs would enable young women in the territory to become exposed to such work opportunities.)

- From Table 5 we know that 500 is the total number of persons employed in construction in 2020 in Nunavut, out of 12,100 (or approximately 4% of the workforce). This is lower than the 6 to 8% average employed in construction in the south as referenced in the following table from Statistics Canada:[39]

USING INFORMATION FROM STATSCAN TABLE 6 - Employment by province and industry, seasonally adjusted January 2021			
PROVINCE	Total employed thousands	Total employed in construction	% in Construction
Nlfd & Labrador	222.1	17.4	7.83430887
PEI	78.4	6.6	8.418367347
NS	462.7	36.6	7.910092933
NB	361.8	22.4	6.191265893
QC	4102.1	282.4	6.884278784
Ontario	7085.5	535.4	7.556276904
Manitoba	631	48.3	7.65451664
Sask	547.4	41.1	7.50822068
Alberta	2181.4	226.5	10.38324012
BC	2599.6	218.9	8.420526235

- The percentage employed in construction in various provinces and territories is reflective of the economy and need for construction and also to some degree reflects the level of interest in construction. 4% of 1,210 is only approximately 48 persons distributed across the territory and including all age groups.

[38] https://www.nunavutnews.com/kivalliq-news/girls-try-their-hands-at-trades-in-rankin-inlet/
[39] https://www150.statcan.gc.ca/n1/daily-quotidien/210409/t006a-eng.htm

- Even if the higher percentage of 8% were used, the number of persons currently not employed in construction in Nunavut that would be expected to be available and interested in working in construction would only increase to 96.

From the above analysis it appears that the approximate number of Nunavummiut currently not employed in construction who might be available and interested in working in construction is in the order of 4% of the current EI beneficiaries, for an approximate pool of 48 to 96 persons across the territory and including all age groups. This represents a very limited pool of additional labour that is available for work in construction (as unskilled labour and in skilled trades), and that could be expected with the right opportunities to become construction workers.

Further investigation of the construction labour market in Nunavut is recommended particularly where additional data may be available at the community level. Any collection of data should consider the cataloguing of skills available in each of the territory's 25 communities.

6.3 Construction Trades Training in Nunavut

6.3.1 Apprenticeship and Certification

The GN Department of Family Services (DFS) is responsible for the certification of trade occupations, skilled trades and apprenticeships in Nunavut while supporting and promoting career development in these areas. The Apprenticeship Unit of DFS supports skilled workers and apprentices on their way to becoming journeypersons either with or without their Interprovincial Standards Red Seal certification. The Apprenticeship Unit also certifies eligible trade occupations. The Unit is governed by the Apprenticeship, Trade and Occupations Certification Act and makes decisions based upon recommendations of the Nunavut Apprenticeship, Trade and Occupations Certification Board.[40]

DFS is presently implementing an update to the Apprenticeship, Trade and Occupations Certification Act that introduces to the Board the power to create a subcredential level (a new type of sub-journeyperson), with plans to introduce a practice-based credential level to allow those with a limited academic background to demonstrate competence.[41]

6.3.2 Sanatuliqsarvik Nunavut Trades Training Centre

The Kivalliq campus of the Nunavut Arctic College is located in Rankin Inlet, and is the site of the Sanatuliqsarvik Nunavut Trades Training Centre.[42] This trade school facility has existed since 2009, and offers formal training programs for skilled trades (carpenter, electrician, plumber, oil heat systems technician, and housing maintainer) at both the pre-apprenticeship and apprenticeship levels,[43] as supported by DFS.

From 2009 until 2019, Sanatuliqsarvik only offered apprenticeship programs, meaning that only those interested in becoming journeypersons with full certification in the traditional skilled trades could enroll in training. Until recently there was no official recognition at the sub-journeyperson level in Nunavut, a major gap in skills development. In 2017, NHC and NNI begin developing a skilled worker trades program with a basis in apprenticeship combined with comprehensive curriculum to provide trainees with a jump start in

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[40] https://www.gov.nu.ca/family-services/information/apprenticeship-trade-and-occupations-certification
[41] Based on discussion with DFS on March 17 and April 14, 2021 (summarized in report section 8.2.2).
[42] https://arcticcollege.ca/locations-1
[43] https://arcticcollege.ca/trades-and-technology

obtaining work experience: 75% of the work of the trades could be achieved by anyone who had completed the first 2 years, or blocks, of the full 5 years of the core trades journey.[44] The Foundation block program was launched in January 2019 and since then its implementation has been complicated by the pandemic.

6.3.3 Challenges to Establishing a Local Construction Workforce

In the course of our analysis and engagement with various stakeholders, our team has identified the following factors that represent challenges to both the existence and the establishment of a local, consistent and available construction workforce in the territory:

LIMITED LABOUR POOL AVAILABILITY

As discussed previously in 6.2.1, available labour market data suggests that there is a limited pool of Inuit labour available in the territory for work in construction, whether as unskilled labour or in the skilled trades. This has translated into, among other things, a heavy reliance on southern skilled workers, which has negative impacts on economic leakage for the territory.

Over the next decade, the Canadian construction industry in general is facing a looming shortage of skilled workers due to an aging workforce. This will impact Nunavut as the number of southern skilled workers available to work in the territory would be expected to drop off noticeably. To further illustrate this point, in the first half of 2019, about 13,000 jobs were unfilled across Ontario's construction sector.[45]

EXISTING TRAINING PROGRAMS DO NOT FULLY REFLECT CURRENT DEMAND

According to DFS, the level of interest in construction trades training is high compared with the pass rate for trade exams. DFS reports receiving on the order of 100 trade entrance exam requests in a given year[46], with an approximate pass rate of only 20%.[47] This speaks to the rigorous nature of the training programs but also highlights the need for enhanced tutoring opportunities, which the introduction of a practice-based credential should help to address.

Despite the recent expansion of training beyond apprenticeship to include foundation blocks, and to include housing maintainers, program offerings are still limited beyond the traditional skilled trades. In order to reflect both the level of interest in the communities and the practical realities of establishing a sustainable construction labour force, an expansion towards alternative programs that enhance capacities in operational maintenance and repairs could help to diversify the interest in the trades that already exists and improve learning outcomes.

According to DFS, small and medium-sized Inuit firms often report difficulty navigating procurement processes as they have not been offered the required training in this respect. When competing with southern firms, even if the Inuit firm has the skills required to perform the work, they will often lose out due to a gap in skills related to bidding and tendering.

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[44] Based on discussion with DFS on March 17 and April 14, 2021 (summarized in report section 8.2.2).
[45] https://news.ontario.ca/en/release/54929/attracting-and-retaining-millennials-key-to-future-of-skilled-trades
[46] This number is high in comparison with the 4% of the Nunavut workforce employed in construction. The high level of enrollment requests suggests a higher level of interest by Nunavummiut in construction than exists nationwide, but further development of new data streams is warranted.
[47] Based on discussion with DFS on March 17 and April 14, 2021 (summarized in report section 8.2.2).

ECONOMIC DEVELOPMENT AT THE COMMUNITY LEVEL

There is limited data available at the community level regarding the inventory of skills and capabilities. Fourteen years ago, GN embarked on a substantial mandate to catalogue the skills available in each community in order to determine the employment opportunities that might be available.[48] The project was discontinued prior to its conclusion, but such an undertaking would be extremely useful today.

Building up and analyzing these types of data streams would go a long way to strengthening each community's overall understanding of its individual economic opportunities related to construction and the skills gaps that if closed would enable higher Inuit participation in construction.

ON-THE-JOB TRAINING IS DIFFICULT TO SUMMON DURING A PROJECT

The onus placed on contracting companies to provide on-the-job training to Inuit workers that are hired under the minimum level of Inuit labour participation mandated by the NNI Policy, while well-intentioned, has not translated into the desired outcomes based on the insights gleaned by our team in the course of this study. Besides not being incentivized to provide training in the form of labour hours (as opposed to dollar value, which is currently the basis for the minimum percentage), a contractor implementing a construction project with a defined delivery schedule is not naturally geared to also juggle the demands of providing on-the-job training.

It may be worth considering construction training in a community as an adjunct to the construction project and not embedded in the project.

The NNI Policy, which originated with the intent that apprenticeships would be formed out of partnerships with contracting companies, has had mixed results over the years. It is widely understood that many general contracting companies have utilized Inuit as unskilled labour by default, which often leaves Inuit without the needed skills development for anything other than unskilled labour opportunities. This further reinforces the effect of reduced voluntary participation by Inuit in these construction opportunities.

Language can be a barrier. It may be helpful that contractors hire Inuit foremen to act as a liaison between southern and Inuit construction workers.

IRREGULAR FREQUENCY OF CONSTRUCTION PROJECTS

Given Nunavut's short construction season and the NHC's planned new builds for public housing that see construction alternating between different communities each year, building ongoing experience in the trades is very difficult. Developing continuity of construction skills in the territory is therefore challenging to sustain without travel either south or between communities where active construction is taking place.

THE NEED FOR TRAVEL OUTSIDE OF COMMUNITIES

Having to travel outside of one's community, or even south outside of the territory, in order to reap either job opportunities or on-the-job training is a discouraging factor for many Inuit who might otherwise find work in construction desirable.

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[48] Based on discussion with DFS on March 17 and April 14, 2021 (summarized in report section 8.2.2).

OVERLAP WITH TRADITIONAL SEASONAL ACTIVITIES

The typical construction season in Nunavut is limited with exterior works taking place primarily over the summer months. This period coincides with important traditional activities for Nunavummiut that are vital to communities, such as hunting and harvesting. In Kivalliq, July is the time for caribou meat harvesting for nipku (jerky) and August is berry season. Camping and boating season runs right into October and can involve a half-day of travel to reach if not more. For Inuit these activities will tend to win out over construction season opportunities occurring at the same time.

SHORTAGE OF TEACHERS AND TRAINING PERSONNEL

As Department of Education works on expanding course offerings in high schools that have a construction trades facility, a longer-term challenge facing communities with these facilities is the availability of teachers across the different communities. The course offerings in high school are locally developed and are therefore dependent on having the personnel available in the hamlet or community who can deliver the education.

6.4 Summary of How Different Construction Methodologies Affect the Potential Local Labour Inputs

Different construction methodologies require differing amounts of site labour. Traditional stickbuilt construction as NHC is currently undertaking requires the most site labour. The use of offsite fabricated components, such as structural insulated panels, reduces the amount of site labour required. To an even greater degree, modular construction reduces the amount of site labour required. Reductions in the total amount of site labour required reduces accordingly the potential for Inuit labour participation.

6.5 Role of Increased Local Construction Trade Availability on Economic Leakage

In general, if there were increased local construction trade availability, this would allow for the use of more local onsite labour which would have the effect of reducing economic leakage. As stated before, the incorporation of SIPs has the effect of reducing the onsite labour required, and even more dramatically, this is the case with full modular construction.

It is comparatively easier to train new construction workers in the fields of framing, insulating, and interior finishes and more difficult to train qualified workers in plumbing, sheet metal, HVAC, fire protection, and electrical trades. Interruptions in continuous employment in the former aspects of construction would be expected to be less detrimental to skills development than in regulated trades such as the latter group (plumbing, sheet metal, HVAC, fire protection and electrical).

6.6 Opportunities and Recommendations

- Make improvements to the current training programs offered in the territory and so that they are more flexible in jump-starting the work experience of trainees, and to make apprenticeships easier to obtain. Introducing subcredentials and other adjustments to the Apprenticeship, Trade and Occupations Certification Act would help.
  - Updating this Act to introduce more supervision, which DFS is presently carrying out, will enable easier accumulation of hours by trainees towards, say, a housing maintainer, obtained through on-the-job training with a general contractor who would supervise on a

particular trade (such as plumbing) without mandating that it be direct apprenticeship hours.

    - It is our understanding that amendments to the NNI Policy are being proposed in which bidders will be required to submit a comprehensive training plan for Inuit labour at the time of tender, which would be assessed as part of the bid evaluation criteria. Following contract award, the successful bidder would then be required to submit a training plan for each Inuit employee.[49] It is expected that this would introduce a point of monitoring as a periodic check-in for support of on-the-job training progress for Inuit but also to ensure that the commitment made by the bidder at the time of tender is honoured.

- Consider providing construction training in a community as an adjunct to the construction project and not necessarily embedded in the actual execution of the project. For example, small unheated structures beneficial to the community might be constructed by trainees for practice in construction framing.
- Generate and build on new data streams at the community level to help identify economic opportunities in construction and to close skills gaps by enabling a more tailored approach to training programs offered to community members.
    - DFS is creating an electronic registry to connect Nunavummiut with trades capabilities to employers seeking workers on construction jobs. The web-based tool, similar in principle to LinkedIn, will allow Inuit to self-identify their skills and volunteer their services to contractors.[50]
    - Consider creating a job pool approach that is led at the community level. This could be managed by the GN who would effectively become the hiring contractor responsible for management of the Inuit workforce and their apprenticeships.
    - Target having at least 1 full-time journeyperson in each of the core trades available in every community, perhaps on an on-call basis.
- Promote the development of skills for Inuit in maintenance and repairs (mould remediation, insulation, HRV maintenance/repair, etc.) to mitigate the negative effects of noncontinuous construction projects on skills development.
- Enhance the promotion of supervisory roles in construction as an attractive option for Inuit.
    - Encourage experienced Inuit construction personnel to liaise/translate with the general contractor to promote stronger interaction on projects between southern and Inuit labour forces.
- Offer training for Inuit firms to navigate procurement processes (bidding and tendering) to better situate them in competition with southern firms. This would be likely to result in greater participation by local firms to compete for work.

[49] Based on discussion with DFS on March 17 and April 14, 2021 (summarized in report section 8.2.2).
[50] Based on discussion with DFS on March 17 and April 14, 2021 (summarized in report section 8.2.2).

7.0 Construction Allocation Methodology and Private Home Ownership

7.1 Construction Allocation Methodology

In order to address housing demand through development of new housing units, NHC has developed a methodology to allocate resources to the various communities across Nunavut based on their severity of need. This is referred to as the Construction Allocation Methodology and it allows NHC to budget, plan land acquisition and address certain site-specific conditions in advance. Public housing builds are prioritized using this needs-based allocation methodology. This would include construction of new units and redevelopment of decommissioned old units that are at their end of life.

NHC's allocation methodology uses the ratio of waitlist numbers and current public housing stock numbers in a community to ascertain the severity of need in that community. Figure 1 illustrates the formula used determine the severity of need as a ratio of the number of applicants (also referred to as the Needs List) in a community to the number of existing housing stock in the community. Using the results of this formula communities are ranked and prioritized for allocation of new housing construction. The higher the severity of need, the higher a community's rank[51]. Figure 1: Formula to Determine Relative Need in Communities

Figure 1: Formula to Determine Relative Need in Communities

$$\frac{\textit{No. of Applicants on Waitlist in a community}}{\textit{Existing stock in a community}} = \textit{Severity of Housing Need in a Community Expressed as a percentage}$$

The needs ranking is adjusted to reflect the number of public housing units already planned or under construction in a community.

For instance, if a community has:

- 500 public housing units.
- A waitlist with 100 applicants; and
- 20 units are under construction (but not completed and in inventory)

The adjusted formula to calculate waitlist as a percentage of stock is:

$$\frac{100-20}{500+20} = 15\%$$

The formula shows how much more public housing is needed to eliminate a community's wait list. In this example, housing stock needs to be increased by 15% to address the backlog for public housing.

This approach makes it possible to compare public housing need between large and small communities and allocate resources in an equitable manner across the territory. NHC has been continually studying

[51] NHC's Planned Builds and Public Housing Construction Allocation and Methodology, February 2020

the outcomes of this approach and making modifications and refinements to the above formula to ensure that limited funds for housing construction benefit Nunavummiut in the fairest and most valuable way. For example, prior to the year 2015-16 the needs list was based on the applicant's arrears status; but since 2015-16, the NHC has used slightly modified needs list numbers that include all applicants regardless of their arrear's status[52]. This allows for an even more accurate representation of need in each community.

Even though allocation of public housing construction is based on the severity of need, it also relies on the availability of land and hamlet infrastructure. NHC typically builds several fiveplex buildings in communities, where possible. This results in lower costs per unit. Also, if developable land is not immediately available construction may be deferred and delivery of new housing will be significantly impacted. In order to manage these risks, NHC has recently adopted a two-year planning cycle. This allows for identifying opportunities and associated risks in advance, and accommodate additional regulatory requirements required under the new Chief Building Officials office. It will also allow hamlets more time to ensure lots are available and developed.

Although the current allocation methodology ensures equitable distribution of resources to all communities based on severity of need, it does not take into account the nature of need. That is if the new housing units developed are going to resolve their challenges related to housing suitability. Nunavut has the highest average household size of 3.6; in comparison the national average is 2.4. 2016 Census data for Nunavut shows that over 30% of the households have 5 or more persons. Currently NHC assumes 1 bed, 2 bed and 3 bed units would accommodate 2, 4 and 6 persons respectively.

NHC's new public housing module is based on a five-plex design that can include, for example, three 2-bedroom units and two 3-bedroom units. NHC has indicated to us that for planning purposes, fiveplexes are assumed to consist of five 2-bedroom units, which would accommodate 20 persons. (Each unit accommodates 4 persons.) Currently NHC determines the type of units to be built based on the information by LHOs in respective communities. NHC is reviewing the possibility of adding a general measure of 'overcrowding' criteria to the allocation formula. Overcrowding data is not dependent on people filling in waitlist applications regularly. It is possible that family sizes of the families have changed since they were allotted units and will require allotment of larger units or additional smaller units to allow some of the family members to move out. LHOs could collect the number of households currently living in overcrowded units (more members in a unit than planned) and present it as a ratio to the number of existing units in the community to capture the severity of overcrowding.

NHC has indicated that they could also collect information on the number of tenants in units that are larger than required (where there may be such cases). The overall ratio of overcrowding to over-accommodation tempered with the number of units that are correctly sized for the tenants would be useful information to help make this metric work better.

Engagement with the NHC at the District Office level with regards to Allocation Methodology and the topics described in this section occurred during the Project Discovery phase. The minutes of the meeting from October 29, 2020 are found in Appendix 5.

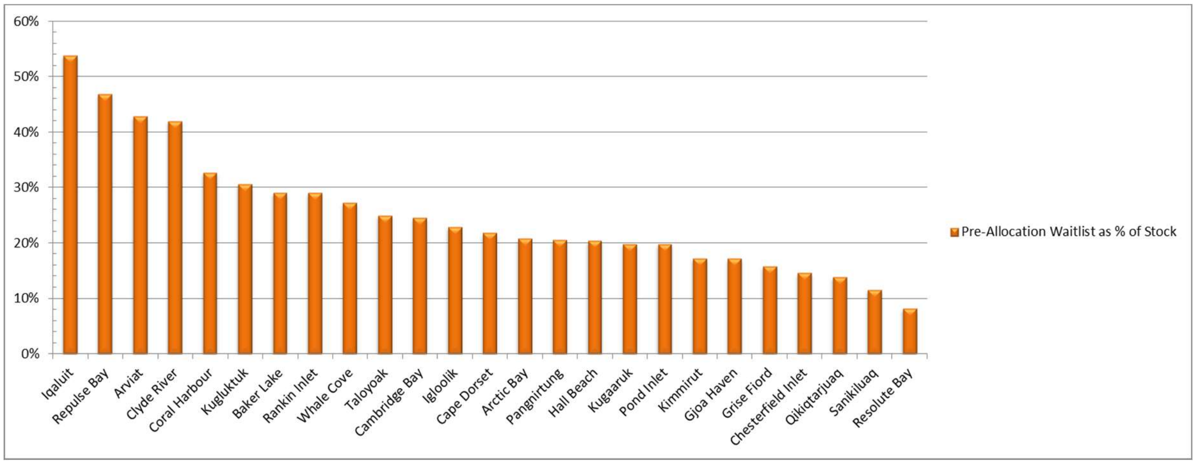
[52] NHC's Allocation Methodology - January 2018 v2

7.2 Construction Allocation Methodology Between Communities

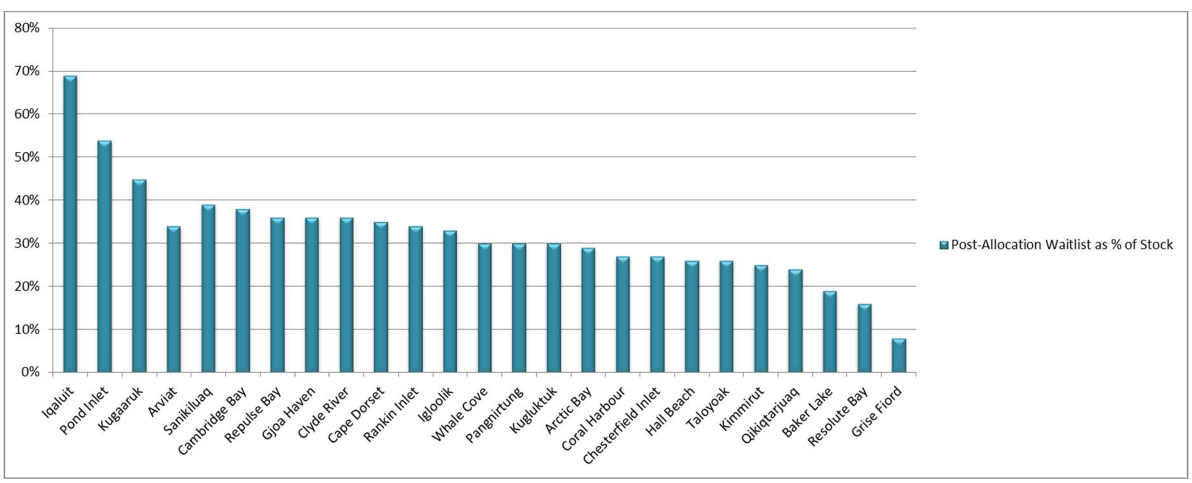
The goal of the allocation methodology is to address Nunavut's housing crisis in a way that is fair to all communities. This means reducing the size of the gap in public housing need between communities and eliminating the imbalance of need by community.

Since the inception of the methodology for the allocation of $100 million federal funding in 2013, the need has become more even across communities. This is demonstrated in the three graphs below. The graphs represent need by community[53].

Graph 2: Waitlist as % of Stock in 2013 - Pre $100M Allocation[53]

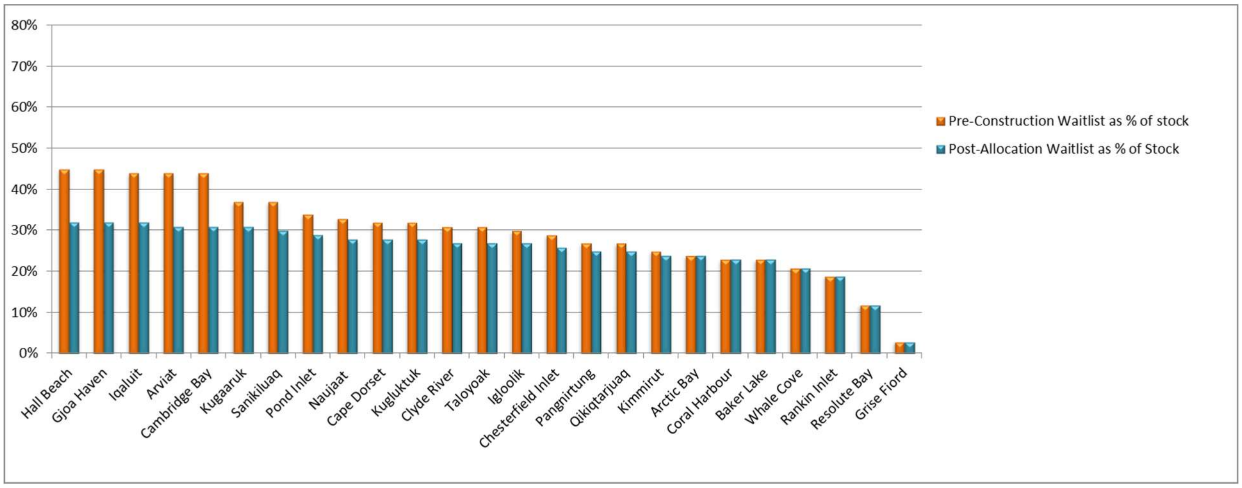


Graph 3: Waitlist as % of Stock in 2015 - After 3 Rounds of Construction Funding[53]



53 NHC's Allocation Methodology - September 2016

Graph 4: Waitlist as % of Stock – Pre and Post-Allocation of 2017/18 and 2018/19[54]



Since 2013, relative difference in need between communities has been reduced. While the actual need as a percentage of stock numbers vary by year, based on new needs lists, each new housing allocation creates greater equity between communities, as demonstrated in the charts above[54].

7.3 Waitlist, Projected Population Growth and NHC New Builds

The current construction allocation methodology relies on waitlisted applications to estimate the severity of need in a community. In order to understand how best the waitlist data captures the housing needs of the community, an independent assessment of housing needs on the basis of demographic data was conducted, and is found in Appendix 3 of this report. This analysis was conducted using external data sources from CMHC, Statistics Canada, Nunavut Bureau of Statistics, among others.

Table 6 shows the population forecasts (based on data from Nunavut Bureau of Statistics) to the year 2035 that has been used for analyzing the housing demand forecasts.

Table 6: Nunavut Bureau of Statistics Population Forecasts for Nunavut, 2019-2035 (in thousands)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Baffin	20,89	21,18	21,47	21,76	22,04	22,30	22,56	22,80	23,05	23,36	23,59	23,83	24,06	24,30	24,55	24,78	25,02
Kivalliq	11,46	11,67	11,88	12,08	12,28	12,49	12,70	12,91	13,12	13,36	13,58	13,80	14,02	14,25	14,47	14,69	14,90
Kitikmeo	7,016	7,091	7,166	7,239	7,312	7,382	7,450	7,515	7,579	7,644	7,712	7,783	7,851	7,919	7,987	8,052	8,112
NU	**39,37**	**39,95**	**40,52**	**41,08**	**41,64**	**42,17**	**42,71**	**43,23**	**43,75**	**44,37**	**44,89**	**45,41**	**45,94**	**46,47**	**47,00**	**47,53**	**48,04**

In 2019, the NHC waitlist for public housing had 2,816 applicants assumed on average to have a household of 3.6 persons, including themselves. This equates to 3.6 x 2,816 = 10,138 persons needing to be housed in new NHC public housing units.

The projected increase in the total population of Nunavut between 2019 and 2035 is expected to be approximately 8,700 persons. Currently, the percentage of Nunavut residents in public housing is approximately 90%. Assuming that the percentage of population increase needing public housing is equal to the current percentage of Nunavut residents needing public housing, the additional number of persons

[54] NHC's Allocation Methodology - September 2016

expected to require public housing between 2019 and 2035 will be 90% of 8,700 persons or 7,830 persons.

Between 2019 and 2035, an estimated total of 17,968 persons (10,138 + 7,830) would need to be provided with NHC public housing in order that the waitlist is reduced to zero. This would require 17,968/20 = 898 fiveplexes or 898 x 5 = 4,490 2-bedroom units. If, in these intervening 16 years, 100 units were built on average per year, the deficit in 2-bedroom units would be 4,490 – 1,600 = 2,890. If the average number of 2-bedroom units built per year over this period were increased to 200, then the estimated deficit in 2035 would be 1,290 in year 2035. To eliminate the deficit in year 2035, 281 2-bedroom units would need to be built on average per year (or, a 180% increase in annual new builds).

The above illustration uses the housing density of NHC planned new builds. NHC new builds, when occupied by the number of persons for which they were designed, represent what NHC considers a solution that adequately houses the number of persons for which it was intended.

As new builds are completed and occupied, it should be possible using community current population numbers to validate the accuracy of waitlist data. If there is a concern that the information obtained in waitlists is not accurate enough to forecast future needed housing builds, estimates could be done on a regional basis using demographic data and population forecasts. Housing demands based on demographic data and population forecasts can be used for the purposes of (in an overall aggregate sense) validating the accuracy of the total numbers overall on regional waitlists.

7.4 Avenues Other than Public Housing Related to the Provision of Increased Housing Supply

Public housing policies generally target residents achieving self-reliance, and promote movement along the housing continuum, toward unsubsidized rental housing or owner-occupied homes[55]. However, this depends on the residents' ability to support themselves. Currently, for most Nunavummiut, housing is unaffordable unless it is subsidized, and Nunavut's current gaps in the housing continuum make self-reliance an extraordinarily difficult goal. This coupled with high cost of building or buying a home and high cost of operating and maintaining a residential property, put housing ownership well beyond most residents' reach.

Income disparities in Nunavut are very large. In 2008, almost half the population – more than 15,000 people – received income support payments for at least part of the year. As per 2016 Census data, average personal income in Nunavut actually exceeded the national average[56], but the median income levels were the lowest in the country, which indicates that a large number of Nunavummiut did not earn the high average income and therefore have little or no choice other than depending on public housing. Other alternatives require higher incomes, or savings for down payments.

Another perspective is to view income against the territory's dependency ratio, which compares the number of income-earners aged 19 to 64 to those under 19, and to those 65 plus. Nunavut's dependency ratio was 79.1, compared to a national ratio of 64.4[57]. This indicates that Nunavummiut who earned

[55] "Let's Build a Home Together" Summary: Framework for the GN Long-Term Comprehensive Housing and Homelessness Strategy Prepared by the NHC.
[56] 2016 Census Profile – Canada, Nunavut
[57] Statistics Canada – Dependency Ratios

incomes supported more dependents than anywhere else in Canada, leaving them with very little remaining for savings or mortgages or unexpected repairs and maintenance.

The Canada Mortgage and Housing Corporation (CMHC) defines an affordable home as one whose costs do not exceed 30% of household income. In such a scenario it cannot be expected that the majority of the residents of Nunavut can afford to buy a home.

Due to the logistics, extreme weather and limited amount of developable land, housing in Iqaluit is among the most expensive to provide in Canada[58]. The minimum income needed to own and maintain a single-family house in Nunavut is approximately $145,000. By this measure, 98 percent of public housing tenants could not afford to own and maintain a house such as an average detached three-bedroom house available in the resale market at $510,000[58]. Its annual carrying cost – mortgage, utilities, and repairs – would put homeownership beyond the reach of most Nunavummiut.

The growing mining explorations in the territory have brought strong job growth. There are other economic sectors that can create jobs and wealth and ensure sustained economic growth, but they will take many years to mature. Even in the presence of economic development that produces steady employment and improves financial security, the high cost and limited availability of housing options compel many Nunavummiut to continue on as public housing tenants[59].

It is expected that the private housing market for those currently reliant on public housing will remain small. Annual transactions in the resale market are under 40 in most years. Also, the housing market in Nunavut is unique in that the house prices do not appreciate as in other places. The combination of extreme climate and overcrowding result in the need for frequent and regular maintenance of existing stock. In social housing, the maximum rent, paid by the few tenants that have high enough incomes, covers the operating costs (refer Table 3: Operating Cost Breakdown) but not the capital costs. Without proper timely maintenance, houses in Nunavut can quickly become uninhabitable. According to Framing Sustainable Options for Housing in Canada's North, northern houses can "fall apart faster than a typical mortgage can be paid off" especially if they are poorly designed, with the result of negative equity in the home[60]. In such a scenario any typical financial benefits associated with home ownership are not valid. With extremely high prices and high operating costs coupled with low and uncertain employment and incomes being the reality for most Nunavummiut, promoting home ownership beyond the current scale will remain challenging.

The Nunavut government has developed programs to encourage and support homeownership by offering down-payment assistance and rent-to-own contracts for public housing tenants, and a condo purchase program for government employees in staff housing. It also offers programs that help with the cost of home repairs. Programs such as the Nunavut Down payment Assistance Program (NDAP) and Tenant to Owner Program (TOP), assist Nunavummiut in becoming homeowners. But the funding provided by these programs are inadequate for most potential buyers. As indicated during the Nunavut Housing Corporation's Appearance before the Standing Senate Committee on Aboriginal Peoples - March 23, 2016, 74.7% of the territory's public housing clients earn less than $22,800 a year. Since NDAP funds only 7.5% of the purchase up to a purchase limit of $400,000, (in a resale[61] market where the average

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[58] CMHC 2019 Housing Market Outlook Northern Housing
[59] "Let's Build a Home Together" Summary: Framework for the GN Long-Term Comprehensive Housing and Homelessness Strategy Prepared by the NHC.
[60] Study of Prefabrication for Housing in Nunavut, NHC, 2016
[61] Purchase price of new units would be significantly higher to the order of $750,000 to $1,000,000. This estimate is based on the current cost of construction of new housing units.

price varies from $350,000 to $515,000) it is not clear how the goal of reducing reliance on public housing, through increasing private homeownership, can be achieved at a larger scale. Similar challenges apply to the TOP applicant(s) as their income must fall below NHC's Adjusted Income Eligibility Threshold, and at the same time have sufficient income to pay for all ongoing, mortgage/loan and operating costs of their potential unit.

The case for supporting home ownership is weaker than the case for providing affordable housing since the level of subsidy required for supporting homeownership is substantial and represents a transfer of public funds directly to a homeowner, who is more likely to be on the higher income scale within the territory. Affordable public housing can be targeted to the most vulnerable population that will see the highest benefit in terms of health, education, and other outcomes.

There is strong evidence that affordable housing generates improved outcomes for low-and-moderate-income households such as positive health and education outcomes by lowering household stress, enabling the purchase of nutritious food, and supporting family stability. Children living in inadequate or unaffordable housing are known to perform poorly academically; on the contrary a suitable home improves their likelihood of academic achievement and the completion of post-secondary education[62] paving the way to creating a healthy and educated workforce. It has been established that post-secondary graduates earn nearly $5,000 more annually than those with a high school education – a number that is likely to increase as workers advance in their careers, the result of this increased earning potential is greater contributions to economic growth. Availability of affordable housing is also an important component in attracting employers and job-related investment in communities. In addition to improved human capital outcomes, investment in affordable housing can also help towards eventually reducing government expenditures on high-cost subsidy programs that are currently needed for Nunavummiut.

The two key challenges in providing affordable housing are funding high upfront capital costs and long-term operating costs. In the case of Nunavut these two are significantly higher than anywhere in the country. Given these realities, expecting private sector investment is not practical as investors will also incur the same costs and have a need to generate profits in addition to the financing and operational costs during the lifecycle of the assets, driving the housing costs even higher. There is limited possibility for effective public-private partnerships for social housing initiatives.

An alternative view may shed some light into the potential solution – for example, if a building's lifecycle costs are assessed, it would be evident that approximately 70% of it can be attributed to its operating phase. When NHC assists an existing tenant in becoming an owner it is these costs that NHC transfers to the tenant, or saves, which it can reinvest in the development of additional units or use it to expand the funding allocation to programs like NDAP. Also, as there is a limited quantity of single family dwellings available for purchase in the primary market, NHC could consider selling some of its existing older stock (single family dwellings or duplexes) to tenants through NDAP. NHC could also consider increasing the purchase limit, contribution ratio and cap for NDAP, based on annual housing market data. However, increasing availability of NDAP may increase the number of potential buyers for resale private homes which could result in the increase in resale home housing prices. If NDAP were to be used for new private home construction, the same impact on resale home prices would not be expected.

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[62] Zon, Noah, Melissa Molson, and Matthias Oschinksi. 2014. Building Blocks: The Case for Federal Investment in Social and Affordable Housing in Ontario (Toronto: Mowat Centre).

Between NDAP and CMHC, Nunavut and Canada have one of the most, if not the most, generous support programs for homebuyers in the world. NHC also indirectly subsidizes water and sewage rates, waste collection and other services that typically are collected as part of the municipal service fees or taxes. The private housing market in Nunavut depends on these subsidies. More private market homeownership would have the effect of driving up costs for utility rates which would impact NHC public housing operating costs. There should be a review of the real costs of community operations and viability that includes the subsidy structures present within the territory before any major initiatives are developed to further encourage private homeownership through additional subsidies targeting increased private homeownership.

Private homeownership, if it is to increase, is expected to be the result of economic development in Nunavut. It should not be expected that increased private homeownership will reduce the need for public housing new builds. Private homeownership uses more land and requires more infrastructure development per person than NHC fiveplex construction.

8.0 Stakeholder Engagement

8.1 Related to Construction Cost Drivers and Methodologies

An important component of this study has been consultation with the NHC, the design community, general contractors, key subcontractors, and other companies or organizations that have provided services for the delivery of housing solutions in remote Arctic locations.

8.1.1 Methodology

Over a period of 6 weeks from September through October 2020, Colliers met with the NHC at both the directorate and community levels to participate in discovery sessions on the overall topics covered in this study. In January 2021, two meetings were convened with the NHC for the imparting of additional insights specifically on construction cost drivers and comparative construction methodologies.

Through the month of February 2021, a series of virtual interviews was conducted by Colliers with a variety of firms and individuals. These interviews focused on construction cost drivers and comparative construction methodologies. Their purpose was to seek new information or opinions about the following:

a) Differing construction methodologies and their respective costs and comparative cost advantages/disadvantages
b) Avenues for increasing Nunavut skills and participation related to housing construction in Nunavut
c) Avenues for increasing housing delivery in Nunavut

Stakeholders were selected based on their prior involvement in delivering housing projects in the Arctic in locations with remoteness, access and conditions for construction similar to those of Nunavut communities. A list of firms was presented to the NHC for their input in narrowing down to roughly 20. From there, the NHC issued electronic invitations to each prospective interviewee, requesting their voluntary participation in a 60-90 minute session. A total of 11 respondents replied indicating their willingness to participate. Virtual sessions were then scheduled by Colliers on an individual basis with each stakeholder, with the NHC opting out of direct participation in these interviews to encourage more open discussion.

In consultation with the NHC, questions were developed in advance for each group of stakeholders. These questionnaires, along with a technical slide deck prepared for contextual information that would be presented during the interview, were submitted to participants for review prior to each session and were intended to guide these discussions rather than act as a script. This material can be found in Appendix 4.

To maintain confidentiality of the opinions of respondents, the summary of results from these interviews covered in the ensuing section will be generalized for each group and will not be attributed to specific individuals.

8.1.2 Summary of Results from Interviews Related to Construction Cost Drivers and Comparative Construction Methodologies

NHC (DIRECTORATE LEVEL)

- Experience Related to Cost

- It has not been the NHC's experience that construction efficiencies, as reflected in tender pricing, are evident even when a project with, for instance, 5 units is compared with a project with 20 units (each comprised of multiples of standard NHC fiveplexes), all constructed in one community.
- However, overlapping projects in a community that a general contractor is already mobilized on can provide a bidding advantage for that contractor if upcoming projects being tendered in that community are aligned to start the same year the previous project(s) are being turned over.
- A considerable cost driver is the absence of cranes in most communities with the exception of the larger hub communities.
- The allocation of risk between contractor and NHC is considered appropriate in existing contracts. This has typically been the case except where NHC has in the past taken on material supply responsibility and contracted the labour portion to general contractors, a challenging approach that has not been repeated.
- Change orders during construction have not been a source of significant concern on standard projects to date.
- Standard contract provisions for contractor progress payments are based on percentages complete. The stipulated breakdowns are considered close representations of actual cost breakdowns across projects.
- In standard NHC contracts there is one holdback release at final completion.
- Contractors are entitled to Government of Nunavut (GN) rates for sealift transport.
- Hamlets are transparent with all bidders during the tendering of projects; i.e. there is no known bidding advantage for one contractor over another with respect to pricing.

- Experience Related to Schedule
  - NHC's planned builds have typically followed an 18-month schedule, with contract award in April and expected completion the following October.
  - Prior to COVID-19, the primary causes of delays have been attributed to sealift schedules, flight schedules, availability of trades, and weather.
  - Even when delayed, contractors have rarely extended completion past the December holiday period of that completion year.
  - Prior to the arrival of the first year's sealift, work on civil, piling and site services is usually advanced. Three communities in Nunavut have Utilidors (Iqaluit, Resolute and Rankin).
  - The bulk of materials is typically brought to site in the first year's sealift to minimize the wait time for materials not arriving until August in some communities the second year. Materials not being used until year two would then be stored and protected onsite for the winter (usually in sea containers). There have been few instances of moisture damage.
  - The stage at which housing construction stops during the first year of the build is dictated by weather and on any materials not scheduled to arrive until the following year's sealift.
  - The objective is to be roof tight in the first year of the build. The less units being built at a time by a single crew the more that can often be accomplished (including windows, siding, then boarding up until the next year).

  - Work usually resumes in March/April of year two.
  - The availability of representatives required to perform site inspections or reviews as needed has not presented a major issue to the project schedule to date.
- Experience Related to General Conditions
  - Heavy machinery/equipment that is typically used on a stickbuilt fiveplex are telehandlers or front-end loaders with forks. If cranes are used, they are usually owned by the contractor who would also own a telehandler, which would be the preferred first option due to crane costs.
  - Regarding the availability of this heavy equipment inventory in communities for material handling/transport, there is usually at least a front-end loader in each community. There are only 4 full-sized cranes permanently located across the territory of Nunavut (in hub communities).
  - General contractors will arrange for a telehandler rental if available in larger communities or bring up their own on the sealift.
  - The two primary sealift providers also have some machinery on their vessels, which would be transported by the hamlet or the general contractor to the project site on arrival.
  - General contractors are responsible for making their own storage arrangements.
  - General contractors are responsible for making their own arrangements for security and maintenance during the off-season in between construction periods.
- Experience Related to Structural Insulated Panels (SIP)
  - NHC's experience with SIP in 2009 has been with the construction of 143 single family dwellings of roughly 1,200 square feet each.
- Experience Related to Local Inuit Construction Labour
  - Regarding the NNI Policy, NHC applies a minimum 30% Inuit Labour content requirement on all construction contracts.
  - It is the NHC's experience that Inuit construction labour is usually sourced from the local community where the project is being developed. Local Inuit hired for the project will normally remain on the project.
  - Regarding the approximate distribution of work on housing construction by Inuit Labour, this will vary by community. Inuit Labour participation primarily consists of general labour, but can also involve trades helpers, Red Seal carpenters, electrical, and plumbing.
  - In small hamlets without a plumbing shop, a local worker might be engaged to work with the project's plumbing subcontractor.
  - Finish carpentry and envelope work is almost always performed by non-Nunavut labour brought on by the general contractor.
  - Inuit Labour content requirements and bidders' compliance with the minimum levels are calculated prior to contract award.
  - If funding and NHC project staffing were not constraints, the maximum number of housing units that NHC could deliver in a year would range from 180-215 (compared to 106 units in 2020, in which NHC spent all funding allocated for that year as it does every

year). Without even taking the NNI Policy into account, NHC believes there would still be a significant struggle to source labour, whether local or non-Nunavut, to accommodate such an increase in housing construction.

- Therefore, efforts to increase Inuit participation in construction delivery are not incompatible with the objective of eliminating the backlog in available housing.

The preceding section summarizes feedback received from the NHC over 2 sessions in January 2021 specifically focused on construction cost drivers and comparative construction methodologies. Prior discovery meetings with NHC stakeholders took place in 2020 that would have included discussion on these topics. Minutes of these 2020 meetings are found in Appendix 5.

Questionnaire material for these sessions is found in Appendix 4.

DESIGN COMMUNITY

- Experience Related to Design of NHC Housing Construction Projects (Stickbuilt)
    - Overall design responsibility rests with prime consultant
    - Current designs have some degree of over-design for worst-case scenarios, with the exception of structural engineering which has begun to assign communities into two groups for the dimensioning of joints, to better capture the peculiarities of the different communities.
    - Topographic surveys are not typically available for the designer due to timing of site selection (refer Schedule section below), therefore the LIDAR data is used by both the structural engineer to determine load requirements, and by the architect to make assumptions for positioning of elevations.
    - General contractor required to provide a site survey right away, which the piling contractor uses as an input for a desktop geotechnical assessment of soil conditions for the general contractor. With these two components, the piling contractor is then able to finalize precise detailed and site-specific pile and bracing design.
    - Benchmark is the high point from which the mechanical chase is built. Final level of the first floor is then determined.
    - Three communities in Nunavut have Utilidors but the remainder require truck services for utilities, which involves incorporating a water tank into the design.
    - NHC and other professional site reviews have worked well including electrical inspections. Office of the Chief Building Official (OCBO) visits are more challenging to coordinate as the mandatory list of viewings are 8 in total. If any of these visits results in a deficiency, approval to proceed will not be granted until the deficiency is corrected.
    - Project substantial completion inspection will aim to involve all parties being present at the same time (NHC, prime consultant, general contractor, OCBO)
- Experience Related to Cost and Tendering
    - Regarding whether pricing is higher in Nunavut than in Nunavik for similar work, it was commented that pricing has gone up significantly in recent period in both regions without known notable differences.
    - Degree of competition varies between the years. Some tenders receive 6-7 bids while others can receive as few as 2-3.
    - If OCBO visits pose coordination issues onsite with workflow (i.e. if work cannot continue until deficiency is corrected) there can be a cost implication, as the general contractor is responsible for building permit fee only.
- Experience Related to Schedule
    - Sites for NHC are not typically confirmed until the end of the fall (late November). Prime consultants will complete as much of the design as possible beforehand so that site specific adjustments can be incorporated immediately once the site is confirmed following the decision from the local hamlet/community.

  - Site plan is then developed in which zoning and setbacks are verified by the prime consultant. Variances are applied as required. Fit-on-site is also verified for the model of fiveplex selected by the hamlet/community.
  - This pre-modelling of the fiveplex plans and immediate uptake of site plans is possible for prime consultants familiar with the standard NHC stickbuilt designs but is unlikely to be the case for a new design team or in the event of a major design change.
  - Site survey by the general contractor must be done before snow arrives so that a desktop geotechnical assessment can be performed.
  - Variability in what work is completed in year 1 and year 2, but piles are usually driven in the first year. There have been instances in which piles cannot be driven until the spring or even the fall, due to weather and/or availability of tractors for civil trade, after which the structure is erected (framed and wrapped only, no insulation) and unheated until the following spring. Crews will strive to place the metal roof unless weather does not allow enough time, in which case it is protected until work can resume next spring.
  - Building construction can be delayed for up to several months due to rain.
  - In Nunavik, communities receive 3 sealifts per year so construction can be completed in one year.
  - It is observed that work on construction sites in Nunavut seem protracted when compared with Nunavik.
- Experience Related to Modular Housing Construction Projects
  - In one Nunavik example involving modular, a tender process included 1 fourplex and 1 twoplex, for which the twoplex was awarded competitively as a modular build.
  - Option was given to bidders to bid as stickbuilt or factory-built, requiring proof of demonstration that same performance level could be achieved for factory-built.
  - Modular experience went well although sites were on gravel pads not piles (whereas sites on NHC jobs can be more challenging, with steeper grades, etc.).
  - This enabled modules to be rolled in. A crane was not used, instead modules were set on steel beam frames for transport and lifting.
  - Mechanical room was centralized, similar to NHC's fiveplex designs. This room was built modularized in the Nunavik example.
  - Site required truck service for utilities, so tank was still needed. Height of sewage tank dictated height of the finished floor.
  - Building was raised on concrete blocks with chase underneath on a perfectly level site.
  - Site work was confirmed at the very last minute and was thus challenging to organize.
  - Factory inspections of the modules were performed by the design team.
  - The modules were subject to a fair amount of cracked gypsum and finishing during transport that required field repair.
- Feedback on Possible Use of Modular Components or SIP on NHC Housing Projects
  - SIP is a product that would be introduced into the envelope. Current use of rockwool and outbound rockwool insulation on NHC's projects is based on its ability to breathe. Would

SIP add resistance to humidity migration? Would need to verify degree of permeance to ensure SIP is not classified as a low-permeance material or vapour barrier.

  - OCBO does extensive plan reviews for code conformity (NBC2015 with Nunavut building code now incorporated). Their opinion on SIPs and modular component would be important from a code compliance perspective.
  - Components of the SIP package would be studs, insulation, intermediary panel, and air barrier. Membranes can be factory-laminated. Tyvek can be factory-installed.
  - Engineered components (roof trusses, floor trusses, lumber, etc.) would have contractor responsible for providing engineered stamped shop drawings to prime consultant
  - But the overall design responsibility would still rest with the prime consultant, unless tendered as a design-build.
  - Local labour content would be reduced as insulation and other general tasks may no longer be available for Inuit participation.
- General Observations and Suggestions for NHC Consideration
  - The biggest challenges posed for designers in current approach are (i) the sites are not confirmed early and (ii) topographic surveys are not available before planning. The effect being that civil and pile designs are not 100% at time of tender.
  - Any move to incorporate SIPs would require revisiting of all assembly components (roof, walls, floor) and analysis of its hydrothermal properties plus an R&D process to verify each product, prior to acceptance and implementation.
  - Adequate additional time for design would be required (the stickbuilt approach for confirmation of site in late fall followed by a quick design would not be feasible).
  - If new approaches are implemented, tender period needs to be extended and designs must be 100% complete.
  - It is recommended that a pilot be pursued first for any new approach.
  - Such a pilot could involve one fiveplex in one community, or it could even involve one community in which two fiveplexes are being delivered: one as a stickbuilt and one as a pilot for a new approach (involving SIP or involving modular components).

Questionnaire and presentation materials for these sessions are found in Appendix 4.

GENERAL CONTRACTORS (GC)

- Experience Related to NHC Housing Construction Projects (Stickbuilt): Cost
  - Whether a GC is already mobilized in a community for which a tender is being submitted can offer a bidding advantage to that GC (availability of major equipment, accommodations, established connections).
  - There are not many opportunities for economies of scale for a GC performing multiple projects at one time unless the projects are all in the same community as it is inefficient for some trades to be spread across geographically. The higher the volume of work in one community the more savings available.
  - Cranes are extremely costly to transport to a community via sealift. Unlikely that a crane would be brought over for a smaller project such as two fiveplexes. In instances when a crane is left in a community it is only financially justified if multiple projects are being delivered by that GC to offset the cost of transport and maintenance. Even if the crane is in a community with multiple sealifts in a year, allowing for it to be brought on and potentially removed in the 2nd or 3rd sealift, the cost (in the order of $50,000) of doing so makes this unlikely.
  - General conditions costs vary across communities in Nunavut: the more northerly the community, the higher the costs for logistics, flights and accommodations by a wide margin. This has less to do with weather conditions but is about geographic location/ remoteness.
  - One GC has observed a particularly high volume of design changes (not just civil/piling site conditions) during construction over the recent 1-2 years of involvement on fiveplex projects, with 45-50 change orders on one project alone.
  - COVID-19 has presented many indirect costs to GCs related to quarantining in 2020.
- Experience Related to NHC Housing Construction Projects (Stickbuilt): Schedule
  - GCs will schedule work according to the NHC's project schedule. Usually this allows enough time to enclose the building in the first year and re-start on schedule.
  - Piling is usually completed before sealift arrival in year 1. If delayed due to unsuitable conditions, equipment needed for piling will not be available again until the summertime.
  - Ability to advance work is influenced by what material and equipment GC has onsite.
  - Decision to stop work in year 1 is dictated by weather and by the status of progress: if building is enclosed then there is no weather factor as work can continue indefinitely. One GC regularly has 40 personnel working over the winter.
  - For outdoor work, the colder it is the more productivity becomes an issue. January and February are the worst months. But if the project is behind schedule then the GC will have no choice but to resume.
  - GCs adapt every year as winter start dates vary.
  - If timing will not guarantee that roof completion is possible, one GC will not even begin erecting walls that year.
  - Communities in the High Arctic can pose more challenges for mitigating schedule risk when there is only 1 sealift per year to rely on. If something is missed in that sealift it can

be difficult to reconcile the following year. For example if kitchen cabinets have a long lead time and will not make the first year's sealift, arriving the following year in mid-September, this leaves only 2 weeks to the October project completion. The GC may decide to transfer the risk in the form of higher tender pricing so that the items can be flown in instead.

- Experience Related to NHC Housing Construction Projects (Stickbuilt): Bidding and Tendering
  - Extended time period between tender closing and contract award leaves little time for final negotiations between GCs and suppliers. The risk of price fluctuations is transferred to the GC, who may be forced to transfer them to NHC by building the contingency into their bid price
  - It can be very challenging for GCs when the same M&E subcontractors win the bulk of fiveplexes awarded in the same year, especially if they are in different communities
- Experience Related to NHC Housing Construction Projects (Stickbuilt): General Conditions
  - Material handling is less of an issue for larger GCs who have established a network of local contractors in some communities and/or who may have their own machinery/ equipment available. Also sealift's services/equipment can usually be leveraged
  - Extent of equipment usually available onsite according to the GCs interviewed are excavator, telehandler, elevated platform
  - Availability of hotel accommodations in local communities has been a logistical challenge given intermittent availabilities – often these rooms are reserved in blocks by GN or other parties and will involve 1 week on, 1 week off during which GCs are hard-pressed to find alternate accommodations for workers. Moving in and out is disruptive but necessary if there are no other available options in that community.
  - Rental housing is an option, based on monthly rates regardless of the number of occupants.
- Experience Related to NHC Housing Construction Projects (Stickbuilt): Transport
  - GCs with the resources to do so will crate and containerize all materials (other than structural steel) in-house
  - The same GCs allow for overstock of some items for damage during transport
- Experience Related to NHC Housing Construction Projects (Stickbuilt): Labour
  - Non-Nunavut employees work on a 6-weeks on, 2-weeks off basis (pre-COVID-19)
  - There is no overtime premium, all employees work the same amount of hours as a matter of safety (max. 70 hours/week @ 10 hours/day, 7 days/week)
  - Local employees usually work 5-6 days/week
  - Skilled trades such as plumbers and electricians are not paid a higher base rate in Nunavut than in the south. GCs entice workers not by higher base rate but by ability to work 70 hours a week.
  - Establishing and maintaining flow of productivity among trades is easier to do when there are multiple projects being delivered at the same time by a GC.
- Experience Related to Local Inuit Construction Labour

  - Inuit content is based on hours (not dollar value)
  - Piling contractor who is used on all NHC projects typically represents between 25-35% Inuit content for the GC's submission
  - One GC's experience regarding the approximate breakdown of labour between disciplines based on hours in some communities (varies across projects): Framing/insulation up to 50% Inuit labour; siding/roofing up to 70%; flooring 0% (install considered specialty trade); drywall up to 50%; finishes/painting 10% at most; mechanical electrical & plumbing up to 30% Inuit labour.
  - Availability of Inuit construction labour varies between communities: In Iqaluit, it can be harder for a GC to recruit due to government competition; in Grise Fjord or Resolute Bay it can be difficult to reach minimum levels. GCs will sometimes transport Inuit workers from other communities to the one where project(s) are being delivered.
  - One GC has been able to employ the same local personnel over the years, with a base established in each local community.
  - Increasing quality of work by local workers is evident in communities where this GC has performed more frequent work over the years.
  - Repetitive projects in the same communities would give opportunity for more Inuit participation over the longer term to allow continuity of skills development.
  - On one GC's experience with a modular classroom project, the minimum Inuit Labour content required was 20%; this was easily achieved given the reduced total onsite work
- Experience Related to Modular Construction Projects
  - One GC has built a classroom project in Nunavut using modules, benefits of which were a lot of time saved and very efficient work onsite
  - These benefits were balanced however by the fact that modules are challenging to deliver due to sealift capacity and cost of freight (shipping requires dedicated planning)
  - Also there is a greater requirement for professional inspections to be performed at many milestones compared with stickbuilt
  - In terms of sequence of work, greater onus on civil being completely finished prior to the arrival of the sealift carrying the modules, so that the trailer/truck being used for transport of modules from the beach to the project site can be loaded back onto the same departing sealift
  - Tripod foundation was used in the absence of piles in the classroom project example
  - Another GC was involved in the Aqsarniit Hotel in Iqaluit which was recently built using modular units sealifted from China.
  - This hotel involved 75 units of modules which were shipped to Iqaluit using a private chartered vessel and a series of barges organized by the GC. Dollies lifted the modules from barges and were dragged off to site. Units were unloaded in 5 days, then placed and erected in 8 days. Building was enclosed and heated quickly enough to forestall weather interruption to construction. Project was completed in 1 year (even with COVID-19) with the piles having been placed in the previous year.

  - Almost all material was shipped from the south. A crane was brought to site by the GC for this project. A combination of rental housing units and a commercial hotel was used for staff accommodation.
  - Only the entry to the meeting rooms was stickbuilt.
  - Challenges experienced by the GC on the hotel include: tidal flows, design changes, OCBO plan approval took longer than expected, few opportunities for local labour participation
- Experience Related to Use of SIP on Construction Projects
  - On one GC's experience with SIP for floors/walls/roof on a project in Kugaaruk, there were no cost savings at the end of the day compared with stickbuilt.
  - Roof was pre-insulated with vapour/air barrier pre-installed at the factory. Partition walls were filled with insulation.
  - A crane with a boom truck was brought to Kugaaruk by the GC specifically for erection of this project. Telehandlers did not have enough capacity for larger panels. Crane allows easy access to entire building perimeter.
  - Panels were made as large as possible in this instance for economical reasons. The more panels and attachments there are, the less economical it is for the GC.
  - On this SIP project it was difficult to reach the 30% Inuit Labour content requirement given the extent of framing and finishing work required, expertise that was not available in the local community for that project.
- Feedback on Possible Use of SIP on NHC Housing Projects
  - Use of SIP on floors and walls is no different (same construction) since buildings are on piles, so floors are just walls installed horizontally. Use of SIP on roofs may be more challenging to install without a crane.
  - To incentivize and promote GCs to bid on a SIP project, the volume/scale of work would be important.
- General Observations and Suggestions for NHC Consideration
  - An earlier contract award would go a long way to better planning and coordination by the GC before sealift. Suggest that stick-built contracts be awarded by mid-February. The issue is the extended period between tender closing and award, which is precious time that could be used to verify all quantities, materials etc. prior to the June sealift.
  - When tendering multiple projects, given that all NHC tenders close on the same day, a gap between the October 1st substantial completion date in many communities and a different date in the High Arctic communities (suggest 1-2 months) would be beneficial in relieving pressure on the same M&E subtrades trying to juggle crews between communities to satisfy same delivery milestones across multiple projects, as is often the case even with different GCs.
  - If NHC pursues an alternative approach to stickbuilt, a design review should be done first prior to issuing for tender.
  - If use of SIP is incorporated, the timing of procurement would need to be changed so that tendering and award is done the preceding fall to allow adequate time for design and

manufacturing. The number of contracts awarded at the same time would also need to be revisited and adjusted.

- Consider implementing more design-build projects, as in Sanikiluaq and Arviat in the past.

Questionnaire and presentation materials for these sessions are found in Appendix 4.

SUBCONTRACTORS

PILING

- Experience Related to NHC Housing Construction Projects: Schedule
  - As long as piles are driven prior to sealift arrival, piling contractor does not affect critical path of the project schedule
  - However, earlier tendering is very beneficial to mitigate the risk of early thaw on certain sites that may not be buildable if less permafrost is available. Other sites can have rock that is too fractured to case through and construct a socket.
  - It is possible that the piling contractor may, in consultation with NHC, change the site if it is too wet by the spring (as in the case of Kugaaruk last year, with the piling set to reconvene this year).
  - Piling contractor can otherwise have 90% of the sites done by the summer.
  - If NHC desires more assurance, then piling a year ahead would guarantee completion by sealift arrival. A factor to consider is whether GC tenders would also go out a year earlier (currently, GCs are carrying the piling contractor as a subtrade and have their price built into the tender with a mark-up applied), or if foundation would be contracted directly by NHC.
  - This year NHC issued tenders much sooner (~1.5 months) than in the past which was beneficial.
- Experience Related to NHC Housing Construction Projects: Cost and Tendering
  - Bracing costs vary depending on how high the piles end up being from grade to finished floor but piling contractor hasn't run into much variability even without a bracing design on the drawings (able to pre-design based on LIDAR data).
  - The recent addition by NHC of civil engineering to design teams to bolster the design has required adjustment on the part of the piling contractor to supply more bracing
  - Wages are higher depending on the time of year; for instance, February's wages are 30% higher than those of March.
- Experience Related to NHC Housing Construction Projects: Quality
  - Because a pile's capacity is eroded by vertical and lateral loads, higher grade steel and heavier walls have begun to be implemented by the piling contractor recently to account for variability between communities. Maximum pile size is 5.5" which allows for the maximum capacity.
  - Piling contractor always performs a complete survey of their own prior to work and another after completion (as-built). Currently upgrading survey procedures with a more precise layout process.
  - Piles do not get tested rigorously in Nunavut though there is other careful monitoring that is done (e.g. of air track, cuttings, grout sampling, watching bedrock quality for where sockets will be, etc.)

  - Pile movement over the years has only been evidenced in adfreeze piles. Ground temperature monitoring occurs more closely now than in the past. Adfreeze piles are sunk down 12 metres if needed.
  - As there is currently only one piling contractor operating on NHC projects, should the number of housing builds ever increase, the piling contractor would require a year's adjustment period to bolster its capacity to deliver.
- Experience Related to NHC Housing Construction Projects: General Conditions/Transport
  - Piling contractor ships up an allowance of 150-220 piles (equivalent of 3 fiveplexes worth) ahead of time to the communities as a stockpile.
  - Piling contractor also has at least 1 drill and 1 compressor available in each of the 25 communities. When not in use, these are stored in a sea container filled with all consumables, 1 in each community, along with stockpiled piles and 500 bags of grout depending on the community.
  - Excavation is not required even for the mechanical chase under the units for services. In fact, this chase dictates the height of the building and the piling contractor sets the elevations from this point. There is not typically cross-bracing in the central bay where the chase is, although this is site-specific (e.g. Pond Inlet has cross-bracing).
- Experience Related to Local Inuit Construction Labour
  - Piling contractor is legitimately 100% Inuit-owned and employs many locals.
  - Often the Iqaluit crew (plus any of the 3-4 other crews depending on volume of work) will travel within the territory to the local community and hire local workers on arrival
  - Challenges to increased Inuit participation include local jobs competing with the piling work that snatch up the talent and an already small pool of candidates.
- Feedback on Possible Use of SIP on NHC Housing Projects
  - Avoid over-bracing of buildings
- Experience Related to Modular Construction Projects
  - Previous experience in Cambridge Bay and Rankin Inlet (fiveplexes for a private developer)
  - Some firms from northern Quebec had not considered that cranes would not be available. Only loaders and telehandlers are onsite for pile installs
- Feedback on Possible Use of Modular Components on NHC Housing Projects
  - More horizontal and vertical bracing would be required with the use of modules
  - May need to carry larger, thicker caps and gussets for verticality. If too far off then may have to cut off and do fabricated I-beam
  - Wood-frame modules should not increase piling loads too much as the construction is similar to stickbuilt
  - May only be feasible in communities with multiple sealifts to allow for bringing crane in and removing it in the same sealift year
- General Observations and Suggestions for NHC Consideration

- If modules are pursued as a methodology, it may be worth prioritizing the first sealift communities (those with multiple sealifts), in order to avail a crane for the erection and send the crane off on a departing sealift in the same year.

Questionnaire and presentation materials for this session are found in Appendix 4.

SUBCONTRACTORS

MECHANICAL

- Experience Related to NHC Housing Construction Projects (Stickbuilt): Tendering and Schedule
    - Mechanical strives for all material to be delivered in the 1st sealift even in communities with multiple sailings. This helps mitigate long delays with some equipment if the bulk of it is available immediately.
    - The duration between contract award and the first sealift is very short and always presents a risk for mechanical equipment ordering. This year the shop drawing review period seemed shorter than usual due to radiators and other cabinet heating system components needing 16 weeks lead time instead of the usual 8 weeks (result of COVID-19).
    - This has resulted in the above components not being able to make this year's sealift.
    - Material is paid in full only once sealift arrives in a community, so mechanical will cover all material costs first to pay their suppliers sooner. As such, tendering and awarding earlier does not benefit the mechanical subcontractor in the same way as with GCs given their cashflow is in fact extended if shop drawings and material orders are placed earlier, but the sealift timing doesn't change.
    - Mechanical subcontractor typically mobilizes in year 2 after the winter (GC will take care of rough-ins). By that time, the building is enclosed (walls and roof). Mechanical trade will start in the mechanical room and in the bedroom units. No issues with mechanical being delayed to start.
    - When there are multiple mechanical subcontractors working in a community, this is advantageous. Subtrades are insulated from the competitive bidding challenges that GCs might experience. But costs are lower all around and all parties stand to gain if accommodation and equipment is already available (hoisting, telehandlers, non-trade-specific tools that GCs otherwise provide).
- Experience Related to NHC Housing Construction Projects (Stickbuilt): Coordination/Workflow
    - As mechanical room isn't large, plumbing and insulation work in there requires coordination of space with electrical trade.
    - Portion of mechanical work is approximately 75% in the mechanical room and distribution to the units (for heating system), and 25% within the units themselves.
    - Mechanical has more plumbing than ventilation work, so will try to organize such that multiple areas requiring more ventilation can be addressed in one mobilization. This is dependent on the GC.
    - Regarding efficiencies of scale between doing one fiveplex and multiple fiveplexes, this is dependent on the GC. If GC has enough labour to advance activities quickly, subtrades can follow behind so that by the time mechanical sub picks up in year 2 of construction, there is plenty of available work to do. Wholly dependent on GC leading the charge.
    - Regarding automation and thermostat controls, currently all control wiring is done by electrical trade. This has been problematic for warranty issues related to heating in terms of who is responsible (mechanical who provides the heating system equipment or

electrical who performed the control wiring and is responsible for sequence of operations?), as most of the time the issue is on the control wiring side.

- Sometimes 3rd party inspections for deficiencies have sprung up that were not previously known or planned for through the GC, as in Kugaaruk. This can lead to inefficiencies in workflow.

- Experience Related to NHC Housing Construction Projects (Stickbuilt): General Conditions
  - Mechanical subcontractor will use a combination of sealift and air freight for materials. Equipment such as pipe threaders will typically be shipped in a sea container as it's more economical.
  - One mechanical subcontractor is trying to shift to more use of sea containers in Nunavut than crates, given that they are easier to handle and have flexible uses onsite compared to crates. But crates are still used more than sea containers at present
  - One mechanical subcontractor performs their own material receiving and inventory control in the south prior to delivery to sealift. Crates will be checked at the sealift port. GC will then check for damages on arrival at the community.
  - GC is responsible for offloading all mechanical's materials from sealift to jobsite, no issues to report with exception of this year in which a bath shower that was shipped in crates was damaged and required site repair as it was a long lead item.
  - If damage occurs in transport or there are missing items, mechanical subcontractors who have the resources, such as a warehouse in Iqaluit, can draw from those supplies and have them sent to the community where the project is taking place. Otherwise they are sourced locally if available and if not, sourced from outside the territory.
  - Weather has not been an impediment to starting work. Most fiveplexes will start this year in April. As subtrade, mechanical contractor has not experienced problems (e.g. if the telehandler is frozen, GC is responsible to resolve and is able to do so, etc.).
  - GC handles accommodations/setting up of a site camp, just needs from mechanical sub the number of man days required
- Experience Related to NHC Housing Construction Projects (Stickbuilt): Change Orders
  - It is rare that a required change order cannot be accommodated due to sealift constraints. Usually creative solutions and problem solving will enable a workaround; items can be flown up if unavoidable.
- Experience Related to NHC Housing Construction Projects (Stickbuilt): Labour
  - Non-Nunavut mechanical labour is hired from many places (Alberta, Quebec, Mexico, etc.) although quarantining has been a major issue this year
  - Mechanical trades usually work on a 5-weeks on, 2-weeks off basis, but COVID-19 has required shifting this arrangement to 4-weeks on, 4-weeks off for quarantine (which is not a sustainable approach)
  - COVID-19 has presented significant challenges to hiring workers regardless of wages
- Experience Related to NHC Housing Construction Projects (Stickbuilt): Local Inuit Construction Labour

   - One mechanical subcontractor has been able to increase the amount of local labour participation on their insulation work in Kugaaruk within the past year.
   - This situation varies across communities. Often it is not a challenge to reach the minimum % of Inuit content but other times it is. Sometimes when local labour is available, mechanical trade will see no-shows.
   - In Iqaluit, one mechanical subcontractor has enough volume of work that year-round opportunities for Inuit employment is available in forms such as: shop work, snow removal, airport operations
   - Regarding the availability of instruction and training opportunities for qualified trades in all communities, it is considered that larger communities offer the ability for more continuity of skilled trades development as there are naturally more projects to work on. For Inuit interested in skilled trades, travelling to hub communities may be important.
   - According to feedback from one mechanical subcontractor: Inuit training and skilled application potential is high and what is on offer by the company is interesting, but other priorities and livelihood factors compete for local demands. It is unclear whether interest in plumbing trades specifically is untapped. Given specialization of mechanical work, skills on hand are generally required for job satisfaction. It is not easy to start in a training capacity.
- Experience Related to Modular Construction Projects
   - One mechanical subcontractor was also involved in the Aqsarniit Hotel in Iqaluit built using modular units sealifted from China.
   - The subtrade recalls coordination challenges with connections and types for the imported installations.
- Feedback on Possible Use of SIP or Modular Components on NHC Housing Projects
   - If SIP or modular are being pursued for completion in one season, it may be more challenging from mechanical subcontractor's perspective not to have trades tripping over each other.
   - Could be coordinated to have mechanical room and chase completed first prior to placement of modular/SIP.
   - If modules were sealifted to communities and fixtures were damaged in transit, repairs may take awhile if parts need to be ordered; increased volume of materials and overstock would also be needed
   - If SIP used for exterior walls…Currently the following services are run in exterior walls: water for tank service, sewage pump line, piping penetrations (all in mechanical room area, not along units), possibly thermostat wiring by electrical.
   - Current design does not have any additional room for modular fittings between the floor spaces. Services that can be run in the space now are heating, piping, plumbing (domestic water), sewage piping.
- General Observations and Suggestions for NHC Consideration
   - Consider improvements to division of responsibility for controls in the project specifications between mechanical and electrical.

- Having mechanical be responsible for automation/controls, not electrical, would reduce the field coordination required during construction and start-up/testing, and allow for a clear point of contact for maintenance during the warranty period.

Questionnaire and presentation materials for these sessions are found in Appendix 4.

SEALIFT PROVIDERS

- General Information/Experience Related to Shipping on Nunavut Construction Projects
  - Building materials are usually shipped in a combination of crates, sea containers, or on their own (bundled as wood, trusses, etc. which are bound with metal strapping and 4”x4” plywood blocking to facilitate forklift handling)
  - Mechanical items typically get crated while rougher items are bundled.
  - 20’ sea containers are the most common, though 10’ containers are becoming more popular in Nunavut.
  - 40’ containers are seen less often as they are more difficult to handle and less stable; they do not have pocket forks as 20’ containers do and therefore require special equipment to offload to site such as a crane which is not common in most communities, so would need to be brought up by the contractor specifically for the work. Also 40’ containers have greater weight restrictions than 20’ containers
  - Both sealift companies can provide crating services, but packaging guidelines are clear so service can be contracted to a third party or performed by the GC. If done by sealift, costs are usually per cubic meter. There is no restriction for crate dimension/size.
  - Maximum cargo weight is 15 tons. Shipping rates are per container per modular or cubic meter or ton of cargo.
  - Sealift only responsible for delivery up to the high-water mark. However, both sealift companies are equipped and will assist with unloading at the community as a service if arranged in advance. If transport support is needed to the project site the cost for the service will depend on how long the sealift’s schedule is impacted
  - Level of coordination on sealift arrival to community is minimal so long as already planned in advance
  - Insurance: Limit if liability included is rate per cargo unit. Vehicle or other heavy machinery is by weight. Both sealift providers can offer supplementary insurance. Mining companies or large contractors usually provide their own coverage.
  - Both sealift companies service every Nunavut community. GN contracts dictate the frequency schedule for each community. Some northernmost communities only see 1 sailing per season
  - Though independent of each other, the sealift schedules between the two providers are in tandem given they are constrained by the same conditions (weather, geography, etc.) and the two companies will typically arrive within a week of one another in a community
  - Servicing at the Port of Churchill, Manitoba is only by NEAS at this time and is not a high volume operation as compared with the Ports of Sainte-Catherine and Bécancour *(previously Valleyfield)*, Quebec
- Experience/Feedback Related to Shipping on NHC Construction Projects (Stickbuilt)
  - Standard construction materials as with traditional stickbuilt design tend not to be bulky, so shipping costs are lower than for other construction types

  - Provided that cargo is properly packaged or crated, both to protect cargo and to promote efficient operations, shipping for this form of construction is the least challenging for sealift providers
  - Sealift companies monitor Nunavut Tenders website and will regularly contact the clients of successful bidders to start the planning process. Often if an unknown company is the winning bidder with a tender price 30% lower than others, for example, a sealift provider will be proactive to forestall potential shipping-related hurdles
- Experience/Feedback Related to Shipping of Modular Components on Construction Projects
  - Modular is becoming more popular in the region. Represents added challenges for every party involved in the logistics chain.
  - One sealift provider transported a dozen 20’ modules to Cambridge Bay in 2019.
  - The Aqsarniit Hotel in Iqaluit had modules of varying sizes, up to 70’ in length, which could be positioned on barge. Stack Modular (China) modules were placed on steel frames. Have seen others on wood frames.
  - Each year, site/base camp developments regularly present cargo involving modular components
  - One sealift provider’s experience is that when modules are more than 30’ long, they can position trailers on barge and roll them off. 20’ long modules can be placed sideways on barge and be carried off by a loader.
  - The above is dependent on how the module can be handled (using forklift, crane, etc.)
  - If a 14’ module is handled with a forklift then the module would need to be factory-fitted with customized fork pockets to allow for 8’ long forks
  - Lifting with a crane can be challenging if the module does not have lifting lugs built in. Sealift provider would need some involvement in the design stage to ensure proper positioning of lugs on the modules. Then, proper rigs that match the location of the lifting lugs would need to be available to avoid collapsing the modules from tension.
  - If no lifting lugs, can (although less preferable) enable a basket lift by placing nylon straps underneath, pre-supplied by the supplier and in the correct position.
  - With modular, sealift will often perform a preliminary stow plan to map out how the shipment will fit onto vessels. If something cannot be stacked on deck, it must be known early on. If a sealift company stands to lose revenue space (say 500 cubic meters that cannot be sold) then a premium could possibly apply but this is reviewed in the stow plan.
  - If a module cannot be stacked, then it will either need to be lashed to a container on deck or lashed below deck. If it is lashed below deck and destined for the first port of delivery, then this poses a big challenge.
  - Lashing lugs are essential to have on modules to secure modules to the vessel. This is another element that should be part of design. If designed properly they can often double as lifting lugs.
  - Ultimate decision of where to stow is made by sealift provider
  - Sealift will not turn cargo away if it “takes up” vessel space that otherwise may have been filled by other cargo. Modules are charged by volume.

- Similarly, the volume of modules to satisfy a large order (e.g. 20,000 sq. ft. or enough for 4 fiveplexes) would not risk being turned away due to other needs of a community. Sealift providers are contractually required to satisfy the needs of the GN and that includes NHC. The main thing is to ensure that reservations are made within the posted cut-off dates to guarantee space for first (and sometimes only) sailings.
- Past the cargo cut-off date there is no guarantee of space for bulky items like modules.
- Just as important as the stow plan are the following details which are needed by the time modules arrive at the wharf or staging area: Whether modules can be lifted (usually need a lifting design), where the lifting logs are located, general arrangement of modular, center of gravity, weight and dimensions. The cargo is then moved to the crane located at the vessel.
- Then, at the port where vessels are loaded, methodology must be determined prior to loading (if no stow plan): loading sequence, how discharged, etc. Modules are usually tagged with an identifier and this can be used at multiple stages to facilitate the build (loading, unloading, and assembly).
- Next, lifting logs are used which the crane hooks to, the crane lifts the cargo and then the cargo is positioned/placed onto the vessel, which it is then secured and lashed to.
- While there is plenty of equipment available at the port of loading, more than likely that same equipment is not available at the destination community. Iqaluit has advantage of contractors that own big loaders. Some municipalities also have loaders but it is not the norm.
- Usually when a sealift provider is aware of a modular build, they will anticipate that the contractor is bringing a crane and/or other equipment to site by sealift. May decide/need to divide between two sealifts (equipment on the 1st and modules on the 2nd). But other means of transporting modules that don't involve a crane have also been observed.
- Once sealift is anchored at destination, barges are moved into the water. Then lateral movement from ship to shore with the crane. Once barge reaches the beach, a loader is used to transfer module from barge to beach.
- Sealift will offload to barge at the high water mark. If sealift has arranged to deliver to jobsite as well, can either use: (i) a flatbed trailer (trailer on barge, module on trailer, barge to shore, ramp and then tractor truck hooked onto hydraulic trailer on which modules are sitting, then use wood block stands so that modules can be lowered onto them, then transported by trailer to site); or (ii) have module dragged over on skis (with a structure under the module that is stable enough to be chained and dragged but that is not too heavy).
- For those communities with a single sailing per season, and a crane has been brought along, it could sit for an entire year – very costly and unlikely that a GC would do so. One sealift provided described a workaround that was devised for the 2019 Cambridge Bay project in which the crane was delivered to the community, while the sealift continued on to other communities and on its way back it stopped in Cambridge Bay to pick up the crane which had completed its job onsite. However, this required both luck and plenty of coordination between the community, crane operator and the GC, and may be difficult to repeat and be impossible in some communities.

  - Insurance: Sealift companies have a maximum liability on modular components that is not a large value (say $2,800) per package or bundle. As such, the Owner would need to take out additional insurance. Sealift companies will often contact the insurer to notify of the custom nature of the cargo.

- Experience/Feedback Related to Shipping of SIP on Construction Projects
  - 2009 NHC project with KOTT Group (SIP manufacturer) – Sealift provider recalls shipping went well without any major challenges. A visit to the manufacturer's plant enabled early preparations for logistics. Panels were closed-crated (approx. 18'x8'x8') and were bulky and lightweight.
  - Closed crates are ideal and safest for SIP, however open crating with poly or other packaging options could be explored to reduce costs. Closed crates must be watertight if panels are water sensitive.
  - Sea containers are not recommended as panels are long and likely to break off inside.
  - For the NHC KOTT project, sealift provider recalls a combination of stowage below and on deck. These crates would have been floating (as the aim is to keep heavier items on bottom).
  - Another SIP project experience involved the panels found to be damaged on arrival at project site.
  - No height limitations by the sealift for vessel loading, but dimensions of panels must account for road transport restrictions. Or, depending on the size of the project and where port of loading and builder are located, if volume of order is large enough arrangements could be explored with a sealift provider to have the vessel make a stop at a port not on the sealift schedule in order to facilitate water access.

- General Observations and Suggestions for NHC Consideration
  - Important to focus on loading/offloading limitations and equipment capacities on a per-community basis when looking at different construction approaches.
  - May be able to gauge trends from prior years' final sailing schedules to determine the likelihood/possibility that a major piece of equipment such as a crane could be retrieved in the same sealift season.
  - Best to strive for early deliveries if implementing new construction methodologies. The earlier the planning discussion can begin the better (between December and March, for example). With modular, the objective is to maximize stowage on the vessel.

Questionnaire and presentation materials for these sessions are found in Appendix 4.

MODULAR COMPONENT PROVIDERS

The following summary is abbreviated as the participant submitted their questionnaire responses to Colliers prior to the engagement session, and the responses were reviewed during the interview. The summary below should be read together with the participant's responses found in Appendix 4.

- Experience Related to Use of Modular Components on Construction Projects
  - Primarily for mining sector in Nunavut (100 modules in 2020); also used modules for airport camps last year in Iqaluit.
  - This manufacturer noted that modules should be ordered 4-5 months in advance of required delivery.
  - Modules entail high shipping costs; this manufacturer estimated $25,000 per module.
  - The maximum height of a module that can be transported by sealift is 12'9", including the steel understructure.
  - Any module that the sealift company needs to hoist with a crane must be solid underfoot, otherwise the module will not be integral by the time it arrives at the project site (likely to be damaged from multiple hoists).
  - A steel frame (2 steel beams with a cross brace) is proposed as a rigid structure in order to protect the modular unit during loading and transport activities. The frame can then be re-used/repurposed as span load for framing of the unit if the design allows.
  - Despite road transport restrictions being 16', the maximum height for the module is 12'.
  - During shipping and transport, the modules do not require crating but poly (plastic wrap) protection is required.
  - While sealift companies prefer not to stack the modules, they can be designed to be stackable/shackled. If so, the entire frame system would need to be designed this way.
  - The current NHC sample fiveplex design spanning 39' with a 2BR unit of 22' length would need to be shipped in two units, as they could be as large as 39' x 11' per unit.
  - If pile foundations are already in place when modules arrive, there could be limited manoeuvering room to move the modules into place around the prepared foundations.
  - A loader would be required onsite to allow for this type of lifting. Carrying capacity required is 22,000 lbs. Would need to confirm that a loader can lift modules 10' high. Modules will be lifted from below, never hoisted from above.
  - There is a possibility that the centralized position of the mechanical chase may need to be rearranged.
  - A variety of R-values can be accommodated.
  - CSA A277 certifies all electrical distribution within the manufacturer's modules. The necessary hook-ups will need to be handled by the electrical trade separate from the manufacturer.
  - The maximum order of modules that this manufacturer can accommodate is 4 fiveplexes per community.
- General Observations and Suggestions for NHC Consideration

- A loader may not be able to lift 10ft high, this should be confirmed
- Before bidding and tendering a modular option, a dedicated design package (not stickbuilt) must be developed for modular to make it fair to all bidders
- How flexible is the NHC regarding room orientation/layout in the standard fiveplexes?

Questionnaire, responses, and presentation materials for this session are found in Appendix 4.

STRUCTURAL INSULATED PANEL PROVIDERS

MANUFACTURER

The Q&A format of this summary is reflective of this engagement session having followed the questionnaire content very closely. The questions below are taken directly from the questionnaire, which is found in Appendix 4.

- Has your company:

  (a) manufactured multi-unit SIP housing

  (b) shipped SIP housing by sea

  (c) shipped to remote locations by boat that do not have docks to receive truck trailers

  (d) shipped to locations where availability of cranes is a challenge

  (e) designed and manufactured SIP units (whether housing or other) for arctic conditions?

  - Yes to all of the above.
- For the design required to produce custom SIP housing units based on owner's requirements, do you typically work with a design team under your umbrella to finalize the design?
  - Building design is not done in-house. Usually the prime consultant or design alliance provides the manufacturer with the design which the manufacturer then takes and produces the drawings for the SIP components.
- How does the division of design responsibility between a general contractor and your firm affect warranties provided?
  - GC must review the SIP drawings which can be engineer stamped by the manufacturer prior to production. So long as this process is followed the warranty is intact.
  - If GC decides to perform any site modifications, warranty could be invalidated
- Would your firm be able to accommodate a different design intended for the arctic? What volume of order would be required to fit an order into your production runs? When would an order need to be placed to allow for design, manufacture and ship to sealift location in Valleyfield/Ste-Catherine, Quebec?
  - Yes, there is not a cookie-cutter design. Some limitations but based on a scan of the fiveplex example provided there should not be an issue. Simple designs are where SIPs can excel as they are easy to manufacture, cut down on time onsite, and allow structure to be erected quickly.
  - No minimum order but client benefits from maximizing an order for reasons of freight costs. Window and door openings are not charged, just the area of the material. Seen in terms of how many truck loads are needed; if 1.5 trucks then better to have 3 truckloads than 2 if only 1 is full.
  - Design takes the longest period of time in the order process (approx. 10 weeks). The first order within that time is the most involved; subsequent orders are quicker (3-4 weeks to manufacture).

- Have you provided SIP walls that are not constructed on foundation walls but on elevated insulated stick-built platforms (e.g. as is the case in Nunavut housing construction), or have you provided SIP floor panels that are installed on support platforms elevated above the ground?
  - These SIPs are structural grade OSB skinned. Jumbo panels 8'x'24' get factory-pressed, then all panels are produced from these "ice cream sandwich" molds. Plywood panels cannot be produced in this size as that size of plywood is not available, which limits their use in SIP.
- What materials and levels of insulation have you provided in SIPs to date?

  e.g. Are the skins always OSB? Have you produced SIPs with plywood skins? What types of insulation and insulation levels does your factory accommodate for SIPS for walls, for roofs and for floors? For OSB skins, are there options related to types of OSB that have increased resistance to deterioration or swelling due to moisture?
  - OSB can swell if wet but if allowed to dry out completely there are not typically any lasting effects (better than a standard 4x8 plywood sheet). Because OSB should not be exposed to elements, cladding of some sort is still needed. Typically these projects are set up on piers so bottoms may be exposed. A "stow" coating can be factory-installed on the underside of panels for sealing rather than field application. This is not applied to roof panels. An ice and water shield is needed from the eave's edge up to the hot part of the roof (though there is no hot part on a SIP roof). Recommend following roofing manufacturer's instructions.
  - Core options favour EPS as it performs better in test data at cold temperatures with R-value of 3.8 per inch even before OSB is factored in. This increases as the temperature increases (data based on testing at 70F/21C). Neopore (GPS) is EPS that is graphite infused (R-value of 4.7 per inch). Borite treated EPS panels help with swelling and acts as an insect repellant (rodents do not go after EPS but rather the OSB).
- For SIPs of different core composition, how do they differ in performance in fires? And protection in terms of interior protection that needs to be added (e.g. drywall)
  - SIP's performance is fairly equivalent to stud frame wall for FRR. Need the drywall to help achieve FRR. SIP's foam contains a chemical that resists fire. If there is fire within the panel it would extinguish itself. Once the heat source is removed the flame will die.
- Are standard accepted details available for penetrations through your SIPs (e.g. vent pipes)?
  - Yes, there is plenty of information available on the website in the Resources tab including technical library with product info bulletins, installation guides and assembly details.
- Do you have standard details for the installation of doors and windows in the SIPs to provide integrity of the building envelope?
  - See previous response.
- Do you regard the foam core as the air barrier that should be tied into the windows and doors? If so where? Or do you rely on/recommend a separate air barrier and vapour barrier be installed on the inside of the SIP panel and that ties into windows and door components?
  - Typically have Tyvek on the exterior before installing windows. The window is taped to the Tyvek and space between window frame and box & headers is sealed. Then the exterior is framed in wood and tied into the framing.
- Does EPS have a feature that prevents it from drying out?

  - Not aware of this notion nor whether it has been tested. Panels sometimes get wet on job sites but by the time they are installed it is not an issue. But suppose there may be limitations if vapour barrier is on the outside.

- In order to provide a roof or floor diaphragm does the interconnection of panels typically have 2’x members embedded in the panel joints?
  - Best to refer to the website for transverse load charts and the different charts for 2’x lumber and double 2’x lumber.
- Are there restrictions on how long SIP panels may be stored before installation (period of sealift, period on site after sealift till installation)?
  - No restrictions so long as protected from weather, panels can be stored indefinitely with no effect on warranty.
- Are long term deflections for sustained loads an issue for floor panels?
  - Not aware of specific restrictions but if there is a 13’ span between beams would not want heavy object such as a piano in the middle.
- Which of your panel types have test reports – evaluation reports recognized by the NBC and for what applications and options do these exist?
  - Only SIP manufacturer that has RCCMC certifications and all of the Canadian certifications.
  - Has access to competitor SIPA testing but pay for their own. Testing numbers are conservative compared to competitors. Has same EPS rating as competitors but differences in calculations due to conservative numbers.
- For roof and floor applications do you recommend that supporting members be separate and underneath the end of your panels? Or embedded within the depth of your panels at joints?
  - For roof applications, dependent on load and span. Typically 2’x with double 2x12 at each joint (4’ o.c.). The 2x12s are attached to one panel, the other panel has foam relief, SIP sealant is applied, the two panels are pushed together then nailed off. This provides continuity between panels so no differential deflection.
  - Similar for floor applications; have tended to see triangulated space frames, though NHC uses piles and saddles. When SIPs used for floor, the panel is placed then tongue & groove OSB is installed over top of the panel. NHC’s design has insulated floor with 2x4 over top for support – this will also work. Ensure no carpet or other flooring surface applied directly on top of the SIP panel.
  - Regarding connection between ends of panels at beam locations, there is always 2’x material on the end; for instance with 2x12 roof panel one long edge would have double 2’x attached and the other would have double 2’x (similar arrangement of fastening on long edge as on short edge).
- For the location in question (Nunavut) and the type of housing to be constructed, do you recommend a) SIP wall panels b) SIP roof panels and/or c) SIP floor panels?
  - Recommend SIPs for all of the fiveplex components (walls, roof and floor).
- Would you recommend using either horizontal or vertical plane to make the joints?

- May be easier to do horizontal as already laying flat on same plane – just slide panel into place. Recommend to get joints tight, use big 3" wide ratchet straps, one on each end of panel, then nail off.

- What changes to the design and temporary measures are needed to accommodate shipment by sea? When you have shipped by sea, were your terms F.O.B. delivery to site or delivery to boat?
    - Typically responsible for delivery up to the port of loading, then transferred to the builder/GC from the port to the destination. Currently preparing a large order for delivery to sealift for a project in Sanikiluaq in May 2021.
- What is the maximum distance that you have transported SIP units by road? What are the approximate costs of transport of SIP units by road? What are the typical sizes of modules that you ship by road?
    - The SIP order for Sanikiluaq is being manufactured in Michigan and transported by truck to Quebec. Frequently does this route for another customer in Quebec.
    - Cost of freight for the Sanikiluaq order is $3,400 per truckload from Michigan to Quebec. Approximately 4000 sq.ft. of roof and 4000 sq.ft. of flooring for a total of 5 trucks = $17,000 in freight total to the port.
- In terms of different options for shipping SIPs by boat to Nunavut, would these include:

  (a) shipping SIPs stacked horizontally inside watertight crates?
    - Yes

  (b) shipping SIPs stacked together and banded and protected with poly?
    - This is typically what's requested.
- What is usually shipped together with the SIP order (along with the panels themselves)?
    - Tyvek, splines, screws, washers, sealants, sealant guns, lifting plates – these are part of the same crate loads with the panels.
    - All adhesives and sealants required to connect the panels together and to adjacent structural members (such as sill plates, ridge beams, purlins) are provided.
- What provision of power tools for installation and field modifications can be provided by your firm?
    - Tools for field modifications to foam at spline joints, caulking guns, adhesives and caulking, 2-part expanded foam plus gun, seam seal tape (that goes inside of joints) and lifting plates (to attach to roof panels using straps to boom into place with telehandler).
- Does your company have the ability and means to support construction in a remote location?
    - Yes. For a first-time order, in-person services for a few days are usually provided at cost. Virtual support is always available and this is often done for first-of activities (e.g. first joint, first adhesive, etc.). Extensive webinars and installation manuals are available through the website library.
- Can your SIPs be installed without use of a crane?
    - Yes, and it is more often done without a crane. The set-up is usually involving a telehandler with forks and an extendable boom.

- In your opinion, how do SIPs compare to stickbuilt homes regarding construction time for floors, walls and roofs? Is this based on your experience in southern locations? Do you have experience in remote locations – how has it varied? How has it varied for first time installers of SIP panels?
    - Floors, walls and then roof in that order for degree of time saved by using SIP instead of stickbuilt construction, but the difference is not significant.
- Have you had issues with any SIP panels installed due to improper or incorrect installations by others? For SIP roof panels? For SIP wall panels? For SIP floor panels?
    - If the manufacturer's installation guides and assembly details, which are simple, are followed, there are typically no issues. Following the manuals may take longer at first but will ensure a quality installation.
    - Where issues have been seen are when carpenters try to rush the installation (e.g. 3 days versus 3 weeks perhaps due to expectations at time of hiring, etc.). The manufacturer's drawings are very detailed so it is difficult to make a mistake; however, the pace at which a carpenter may be accustomed to working (i.e. install as many and as quickly as possible) may leave details like sealing and other critical tasks specific to SIPs vulnerable to being missed.
    - With an experienced crew, this kind of installation is easier to get right than a stickbuilt assembly due to its simplicity.
- Can carpenters be assisted by the general labour provided by the GC or does it need to be a carpenter?
    - As almost all of the work is completed at the factory, the construction required onsite when using SIP is simple, clearly mapped out and repetitive in nature.
    - The application of adhesive is the most important activity. There is no tricky joinery involved. A skilled carpenter is needed for the supporting members and beams. However, the rest of the crew can be unskilled labour.
    - Based on direct experience, a crew of 4-5 can perform the installation of wall panels with one skilled carpenter, as long as a telehandler is available for support. In the example discussed, a crew of 4-5 were able to put up 1,000 sq.ft. of SIP wall panels on the first day (which was also a training day). For scale, the total wall area for the project was 2,000 sq.ft.
- What are the temperatures that must be in effect during installation of SIP panels to do proper work with adhesives and sealants with your SIP panels? For what duration do these temperatures need to be maintained after application?
    - The SIP sealant product must be stored at a warm temperature when not in use. There is otherwise no need for a long curing time to keep joints at certain temperatures.
- How is the manpower required for SIP installation for wall panels, floor panels and roof panels affected by the width of panels?
    - More affected by the volume/quantity. The more panels there are, the more corners and therefore joint work that there is. Joint work represents 90% of the installation.
- What inspections do you require from the owner at your plant of the SIP fabrication before it is shipped?
    - Approval/sign-off on the SIP drawing package.

- If electrical chases or embedded conduits are provided in your panels, are pull strings installed at the factory?
    - Pull strings are not installed. Electrician will usually just use fish tape. There are no embedded conduits supplied with panels, they are voids cut into the foam with a chase.
- Do you provide details for all required interconnection of panels and connection to other parts of the structure?
    - Yes, all of the details for ridge, beam connections, etc. are in the installation manuals and SIP drawings that are sent to site.
- Is there anything that your firm would look for in an RFP to enable you to respond well, for designing and producing SIP components for homes where components are shipped to and completed in remote communities in Nunavut?
    - Not specifically, but the process of designing and producing panels requires a strong architectural package to work from. Modifying the fiveplex drawings from stickbuilt would make the design process easier.
- For a low slope roof such as 5% as applicable to the NHC fiveplexes, are there advantages/ disadvantages for placing roof panels parallel to eaves or perpendicular to the eaves?
    - None to note.

STRUCTURAL INSULATED PANEL PROVIDERS

ARCTIC CLIMATE BUILDING AND SIP SUBJECT MATTER EXPERT (SME) – FORMERLY OF KOTT

- Experience Related to NHC Construction Project Using SIP (2009)
  - NHC issued an RFP for a project involving the use of SIP on 143 homes with detailed requirements.
  - SME recalls the RFP was unique for the SIP industry at the time and KOTT took the approach of focusing on satisfying NHC's requirements, where other SIP manufacturers in pushing their products as-is missed addressing some key concerns and requirements of the specifications.
  - KOTT in effect became a SIP manufacturer to implement the project. Working in KOTT's favour was that at the time, it had the backing of a big organization and demonstrable ability to pull off such a large-scale project.
  - The homes were 3-bedroom attached bungalows with both structural and cladding SIPs.
  - Foundation types were piles (Qikiqtaaluk), screw piles and some space frame/multi-point (Kitikmeot and Kivalliq).
  - KOTT had in-house structural engineering. At the time the OCBO did not exist. The NBC had not yet been amended to include the Nunavut Building Code.
  - Requirements for SIP from the start were for plywood skins instead of OSB, given NHC's concerns about the susceptibility of OSB to swelling and deterioration from moisture.
  - Regarding air leakage control, NHC's requirements were 0.06 air changes/hour for this design (more rigorous than the Passive House standard and higher than NHC's fiveplexes, which makes sense as a 3BR bungalow is a more complex design).
  - To mock-up the design to NHC's requirements, KOTT erected a sample building using plywood skins. This mock-up revealed a significant amount of air leakage as a result of the building not being airtight, which was tied to the use of plywood. This was an important design development.
  - Following this development KOTT worked with NHC to assess whether the air leakage issues could be mitigated by going to OSB skins. KOTT's factory thickened their OSB skins to 19/32 from a standard of 7/16 typically used by SIP manufacturers on panels. Then found a supplier that was willing to strengthen the OSB using a different formulation with more hydrophobic properties (more wax).
  - With this R&D approach, NHC accepted the use of OSB instead of plywood.
  - Blower door tests in the field were required by the contractor to prove compliance with the air leakage requirements. These were performed, the levels were achieved and all of the tests passed.
  - KOTT produced a detailed construction manual and video in anticipation of meeting the challenges of this piloted approach in the region and with the objective of enhancing local participation in construction on the project.
  - NHC contracted out the installation. KOTT supplied a crew of trainers (14 people working in pairs) who travelled between communities providing support for the erection of these buildings by the successful GC.

- In general, the training support was effective as it was a form of on-the-job training. Not all labourers were trained in advance of the SIP arrival to sites in each community. Possibly the effectiveness of this training was helped by the fact that this was an unfamiliar and new technology so contractors were more open to learning.

- Experience/Feedback Related to Use of SIP on Construction Projects in Nunavut
    - SME's current experience with SIP (2021) is as design consultant for a new facility in Sanikiluaq for an environmental research association.
    - This involves a timber-frame building with glulam columns and beams, with structural SIPs used on floor panels. The remainder of SIP use is for cladding (roof and walls).
    - The decision to use a post-and-beam construction was related to factors such as the client's objectives for carbon sequestration, aesthetic, environmental and factors related to the speed of construction.
    - The unique hybrid assembly of the Sanikiluaq example reflects SME's strategy for design in Arctic conditions which are: (a) to make a building airtight; (b) to eliminate the risk of condensation either through air or vapour; and (c) to detail the air leakage control membrane to make it easy to control, test and have its performance confirmed during construction prior to the completion of assembly.
    - Between the columns there are 2x4 walls with structural sheathing on the exterior. These 2x4 walls are on the same plane as the outside of columns. Structural sheathing can be fastened to the outside face of the timber column. There is a continuous OSB (7/16) skin around the building. The air barrier will be applied onto the outside of the skin. Then the SIP panels are applied on top of the air barrier. Lateral load resistance is provided to the building from the interior, not the exterior, using the inner load as shear diaphragm.
    - In the above assembly configuration, the blower door test can be performed on the building before the SIP panels are installed.
    - In the same example, all lateral load restraint is being handled without SIPs. Therefore, engineering for wind, seismic and lateral loading is being taken care of by the structural engineer who is not having to review SIPs for diaphragm analysis.
    - SIP manufacturers typically have in-house structural engineers.
    - Regarding the hybrid use of SIP in Nunavut applications (i.e. not necessarily on emphasizing their structural capability), SME posits that the "promise" of a SIP is to provide structure, thermal control, vapour control, and moisture control (to some extent). But need also to consider services and wiring (electrical, communication, etc.) required to be run to the exterior. The 2x4 walls built with the system used in the above example in Sanikiluaq would offer the flexibility for a service chase without concern about airtightness, and the 2x4 would provide the structure needed.
    - Regarding structural code review and approval, the use of structural SIPs is likely to encounter obstacles in Nunavut without standards to reference. The current National Building Code (amended in 2018 to incorporate Nunavut Building Code) does not specifically address SIPs. There is little at all about structure in the 2018 amendment.
    - If a community or hamlet cannot refer to building code or standards for the use of structural SIPs, the road to acceptance may not be smooth.

- Additionally, the OCBO involves a plans examiner who reviews designs specifically for code compliance and will point to this gap in the building code.
- Regarding SIP panel joints, SME noted that spray foam is not an effective means of sealing joints below certain temperatures. But prefabrication in the north in theory allows for the shell to be completed prior to winter, eliminating the issue of spray foam not performing below certain temperatures.
- However, joints should still be designed to minimize the need for spray foam. This is a function of the variety of SIP manufacturers out there but few in Canada. Most manufacturers rely on spray foam but this ought to be reduced in Arctic locations.
- Caulking is less of a concern, with silicone an effective and suitable product
- The strategy for air leakage control should not rest solely on the SIP, but on membranes used in conjunction with the panel assembly. Membranes have fewer joints. If sealant can be applied in the sequence of construction, and the blower door test performed while the joints are still accessible and can be reinforced should the test fail, then the panels are no longer the primary mode of air barrier.
- Air leakage control membrane can be anywhere in the assembly; if on the exterior then the joints and penetrations are visible. The vapour barrier must be on the interior.
- If the structure is airtight, then controlling vapour diffusion is simple. Air leakage is the likelier culprit.
- Most common foam insulation type used in SIPs is expanded polystyrene (EPS). Usually Type 1 is suitable for northern construction, though Type 2 has more compressive strength and was used on the 2009 NHC project. The compressive strength of foam can be easily engineered, up to a Type 4. Not usually an issue for multi-unit housing unless heavy floor tanks are involved, in which case can use a higher type for the floor panels.
- EPS has a lower carbon emissions factor in the manufacturing process than extruded polystyrene (XPS), and EPS is less costly to ship. Neopore is graphite infused with 20% improvement per unit of thickness in thermal performance.
- When selecting panels, one should look for the highest thermal resistance per unit. The R-values that NHC requires are available in a thinner panel to reduce shipping costs.
- Of the panel types (floor, wall, roof), installation difficulty is highest with roof panels as they require a means of lifting. Floor and wall panels can be erected by hand.
- As with all types of construction projects in Nunavut, telehandler availability is critical for SIP construction.
- Another example involving SIP was on a 3,600 sq.ft. duplex in Iqaluit where the floors and walls were done using SIP but a trussed roof was used to mitigate risk of telehandler not being available. A trussed roof can be erected manually in a short timeframe. In this example, the performance of that sealed space was monitored using sensors (the space was unventilated but had an open vapour).
- Regarding the use of SIPs for dividing/party walls between units in a duplex or multiplex, SME notes that SIPs are not well-suited for acoustics and indeed cannot recall having seen a UL or CSA registered acoustic assembly using SIP. A variety of materials is needed to uncouple the drywall from rigid parts of the assembly.

- General Observations and Suggestions for NHC Consideration
  - Ensure requirement for Nunavut registration of structural engineer is captured in tender documents.
  - Consider a hybrid approach to the use of SIP: for example, send a modularized unit to the project site, employing local labour in setting up the enclosure, use SIP as a cladding system outside of the building which can also involve Inuit participation.
  - Reference 2017 Report prepared for Natural Resources Canada: Panelized Building Systems for Northern Multi-Unit Residential Buildings

Questionnaire and presentation materials for these sessions are found in Appendix 4.

OTHER JURISDICTIONS

COLD CLIMATE HOUSING RESEARCH CENTER (CCHRC)

- General Sharing of Experience: Housing Construction in Alaska
  - CCHRC has tried to simplify designs over the years to facilitate transport and soil condition challenges. It is important that designs respect the desires of the local people.
  - Alaska has deep permafrost that is melting quickly. CCHRC has experimented with urethane mat reinforcement, which can work well if done before August.
  - Barge arrives in August, building begins in October and work often continues through the winter
  - Alaskan regional community housing authorities build their homes with crews that are 95% Indigenous. All of the construction labour is supplied in-house unless specialized. Materials are tendered out.
  - Yukon Delta which is owned by the people has been successful with housing construction, with effective regional workforce training.
  - CCHRC helps local communities with administering contractor exams to enable General Contractor licensing, but English language is a common barrier.
  - Alaska's current housing need is in the neighbourhood of 10,000 homes
- Experience with Use of Different Design and Innovations in Northern Housing Construction
  - REMOTE (Residential Exterior Membrane Outside insulation TEchnique) Wall System[63]: In which the wood components of the building become part of the building space. This was derived from Canadian building science. It is most durable for use in population centres and much simpler than a double wall with insulation types. Any truss manufacturer can provide a REMOTE wall structure; see Atmautluak example below. The downside of this structure is its high cost (approximately 400,000 US$ per home, up from $200K budgeted).
  - Eight-sided prototype homes in Quinhagak (2010)[64]: These homes were very successful for reasons of good design reflecting the community's tastes; they can be built in wintertime; they can be picked up and moved by 2 people; they do not drift; and they are super efficient, using only 800L of fuel a year.
  - Integrated truss system prototype homes in Atmautluak (2013)[65]: Integrated truss is used in areas where ice roads can be used and where there is access to timber (which can be transported in the winter). These homes can be built in 6 weeks in the summer. The Atmautluak examples were 3-bedroom homes that consume 500L of fuel oil a year. They have been modified not to use urethane to reduce costs.

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63 http://cchrc.org/media/REMOTE_Walls.pdf
64 http://cchrc.org/quinhagak-prototype/
65 http://cchrc.org/media/atmautluak_plans.pdf

- AkWarm[66] is an energy modelling software tool developed through the Alaska Housing Corporation for energy rating and R-value requirements of homes, including standard practices for insulation. Homes have a 0.4 rating for air tightness.
- CCHRC uses locally manufactured expanded polystyrene (EPS) on the exterior instead of rockwool (wool insulation is not permitted for use in Alaska). Despite EPS being high carbon-emitting material, this is offset by the combustion needs for heating that is reduced.
- Were rockwool permitted, a stick frame building in Alaska with 4" layered rockwool on the exterior, strapped and covered with steel is considered a perfect simple wall.
- Fourplex prototype in Venetie (2014)[67]: Built as a teacher housing complex using logs as a superstructure with a standoff wall inside and an R-70 envelope, the home consumes 1500L of fuel oil per year (approximately 2,000 US$ in heating cost per year).
- Modular: There have been quite a few modular builds in remote Alaskan communities. A project involving modules was considered near Anchorage that would use triodetic foundations and be skid into place via barges using only local labour.
- SIP: Alaska has local SIP manufacturing capabilities.
- Alaskan inspections are required for anything that is financed. An energy rating is also a requirement in which the home must meet building energy efficiency standards (BES), which is part of AkWarm.

A questionnaire was not used for this outreach session.

[66] https://www.ahfc.us/EFFICIENCY/TOOLS/AKWARM-ENERGY-RATING-SOFTWARE
[67] http://cchrc.org/VENETIE-PROTOTYPE/

8.2 Related to Construction Trades Training

Another important component of this study has been consultation with the GN, and in particular, Department of Family Services (DFS) Career Development Division, whose experience in providing construction trades training in the territory offers unique insight into the challenges associated with enhancing the opportunities available to Inuit who desire employment in construction, and the complex relationship that exists with southern construction companies involved in NHC housing builds and who are subject to minimum local labour content under the NNI Policy.

8.2.1 Methodology

Over a period of 4 weeks from March through April 2021, Colliers met virtually with DFS at the directorate level on two occasions to participate in an engagement and follow-up session regarding this subject. On the recommendation of NHC, a senior economist with Department of Economic Development and Transportation was also consulted via email for employment data information.

8.2.2 Summary of Results from Interviews Related to Construction Trades Training

GROUPS INVOLVED IN CONSTRUCTION TRADES TRAINING

DEPARTMENT OF FAMILY SERVICES, CAREER DEVELOPMENT (GN)

The Q&A format of this summary is reflective of this engagement session having followed the questionnaire content very closely. The questions below are taken directly from the questionnaire, which is found in Appendix 4.

- What has been the history of Nunavummiut engaged in education and training related to construction trades?
  - Department of Family Services (DFS) is responsible for regulation and certification of skilled trades, occupations and apprenticeships (incl. Red Seal exams) in the territory while also promoting career development in the trades, offering publicly available training, wage subsidies, trade school funding and other tutoring and literacy training programs.
  - DFS has historically seen difficulty by Nunavummiut to pass trade exams
  - Only since 2009 has a trade school facility existed in Nunavut (Arctic College in Rankin Inlet) offering formal trades courses for carpenter, electrician, plumber, oil heat systems technician, and housing maintainer; prior to 2009, Nunavummiut seeking training would attend Aurora College in Fort Smith, NT
  - From 2009-2019, Nunavut Arctic College offered only apprenticeship programs, with no trade occupation training programs other than full certification. This had limited capability to develop skills in those who were not interested in becoming journeypersons. As a territory with no official recognition for sub-journeypersons this represented a major gap in trades training.
  - In 2017, NHC and NNI began developing a Skilled Worker Trades program with a basis in apprenticeship combined with comprehensive curriculum to provide trainees with a jump start in obtaining work experience (75% of the work of the trades can be achieved by those who have completed the first 2 blocks of the 5 blocks of the core trades journey).

- However, this "Foundation block" program was only launched in January 2019 and since then has been complicated by the pandemic (with work experience interruptions).
- Today DFS is in the process of implementing an update to the Apprenticeship Act that introduces to the apprenticeship and certification board the power to create a subcredential level, and then a practice-based credential level to demonstrate competence in those with a limited academic background.

- What interest has there been in construction trades and apprenticeships in Nunavut?
  - There has been plenty of interest; DFS estimates receiving in the order of 100 trade entrance exam requests in a year with a pass rate of ~20%.
  - Practice-based credentials and tutoring system being introduced by DFS under the new act should help with the low pass rate of what is very rigorous training.
- To your knowledge, is there any information available regarding how many construction workers reside in Nunavut and in which trades they work? (Construction labourers; Framing; Insulating; Plumbing; HVAC; Fire Protection; Electrical; Flooring; Drywall; Structural Steel; Rebar and concrete; Heavy Equipment Operators; Crane Operators)
  - DFS can provide statistics regarding the number of Nunavummiut who have become journeypersons since the founding of Nunavut in 1999.
  - Tracking apprentices only tells part of the story, as there are Inuit who work on trades who never went through the certification process
  - DFS noted that 14 years ago there was a substantial mandate undertaken by GN to catalog the skills available in each community as a way of cataloguing employment opportunities available to each community. This project faltered over the next year.
  - DFS is creating an electronic registry to connect Nunavummiut with trades capabilities to employers seeking workers on construction jobs. The web-based tool, similar in principle to LinkedIn, will allow Inuit to self-identify their skills and volunteer their services to contractors (similar in principle to LinkedIn).
- Where do Inuit who are trained in construction in Nunavut typically end up working?
  a) In residential, commercial and industrial construction in Nunavut for private companies
  b) For government or housing authorities
  c) For mines
  d) In other fields or jurisdictions
  - Difficult to access/pull data identifying employers, but it is believed the vast majority of Inuit construction trades work for housing associations, for GN in supervisory/ management positions, and for local contractors (or are themselves local contractors).
  - Housing trainers and electricians are in high demand by mines
- In your experience, has it been an issue that Nunavut loses trained construction workers to other parts of Canada?
  - It is not generally the case that many Inuit trained construction workers leave the territory. People do not wish to leave their communities.

  - Even travel between communities within Nunavut can be a barrier to those seeking employment, e.g. those who wish to participate in mine projects change their minds if they have to leave their community.

- We have been able to assemble some statistics (not all current) for Nunavut communities which list the percentages of employment/unemployment and percentages of employment in various sectors including construction. However, this data does not include numbers of persons. From what we have been able to gather, we cannot find any statistics that might indicate how many people in various communities might be available and interested in working in construction. Would you have any insight or data regarding this information?
  - Colliers was referred to an economist in Department of Economic Development and Transportation for more data
  - Granularity of this data makes it a challenge for one comprehensive body like Statistics Canada to compile; the use of census records as the most reliable form of data is also limited due to the notion of “occupation” as a definitional matter in Nunavut
  - NHC has information on the proportion of Inuit content on a project based on bids; in absence of hard data, it can be extrapolated that Inuit content is low across the board in construction
  - DFS working on creating new forms and streams of data
  - Other sources suggested to be consulted: Nunavut Statistics Bureau, GN Community Profiles website, CMHC, NILFA, NWConstruction Association, Department of Human Resources
- Are there construction trade related courses available in high schools in Nunavut? Are there mentors in communities available to share knowledge with youth in high school regarding opportunities in construction and what education is required for entry into certain trades?
  - Newly constructed high schools in the territory have been built with a construction trades facility. Department of Education working on expanding course offerings.
  - One issue is that these courses are locally developed rather than territory wide, and therefore dependent on the availability of teachers in communities. Some hamlets have nobody available to train in their high schools due to the scarcity of teachers.
  - Nunavut Early Apprenticeship Training (NEAT) program was launched briefly in 2010 as a preparatory for high school students to transfer to trades school. DFS is currently working with Department of Education to re-launch the NEAT program which requires uptake by high school principals to fully adopt given it is additional curriculum.
- Are there courses readily available regarding safety in construction, such as WHMIS, Working at Heights, Confined Space Entry?
  - These are readily available. Nunavut Arctic College is set up so that safety courses are built into existing programs.
  - However, there is a barrier to attaining much of the operator training and that is Driver’s Licenses, which are difficult for Nunavummiut to obtain and which you cannot drive on roads without. DFS notes that this is being added to programming.

- Given that currently construction in Nunavut involves a large number of southern workers who do not speak Inuktut, is language a barrier for either training or work in the construction field for Inuit working in construction?
  - In a way language does not even have a chance at being a barrier, as many southern companies will not make the attempt to engage Inuit workers in construction
  - Many construction teams that come up from the south immediately set up work camps, thereby limiting or eliminating any interaction or engagement with the local community
  - In terms of language, it can be more challenging if the company is from Québec without even a “bridge” to Inuit who speak English
  - Could consider introducing a bridging or translation role to the program, to allow for better interaction between southern and Inuit forces on a construction project. Perhaps training Inuit supervisors/forepersons who are bilingual and have skills in a trade to spend time in the south, etc. This may help with making supervisory roles in construction more attractive to Inuit (as they are not currently popular).
- In your experience, how do year-round traditional Inuit activities overlap with the typical construction season in Nunavut?
  - Hunting and harvesting are vital activities for communities. In Kivalliq, July is the season to harvest thin caribou meat to turn into nipku (jerky); August is berry season.
  - Even those who have gainful employment are expected to participate in such activities with their families.
  - Summer is camping and boating season which runs right into October. Travel time to/from one’s cabin can take hours.
  - Such activities overlap with and are valued over typical construction season opportunities in Nunavut
  - There is also the matter of southern workers who prefer taking their vacations in July and August and therefore head south.
- Are there any changes to delivery of apprenticeship programs or mandated requirements for training programs currently captured in NHC’s tender documents that may be considered to help promote increased development of Inuit participation in construction?
  - Under the current NNI mandate, bidding contractors are not required to submit their detailed Inuit labour plan for the project until following contract award.
  - To address this, changes are being introduced to bidding regulations so that bidders are to submit a comprehensive Inuit training plan at the time of tender, which would be evaluated by DFS for CGS procurement as part of the bid evaluation criteria.
  - Once the contract is awarded, the successful bidder would be required to submit a training plan/programme for each individual Inuit employee in the bidder’s overall labour force for the project. This would introduce a point of monitoring for each Inuit worker by DFS (and NHC) to periodically check in and touch base with the worker and track progress of training, etc. throughout the project rather than only at the end.
  - DFS also highlighted a pilot that is being carried out by the Nunavut Arctic College in Rankin, in which the College as part of their training program is working with a local team

in Arviat together with the OCBO to build a single family home on the lot of a fire-destroyed building.

  - Such pilots are examples of DFS's vision of providing practical, hands-on experience to students while allowing them to build on their academic skills, for example, when working on furnace and other HVAC systems to apply theories of training being imparted at the same time.

- Is there anything that we haven't discussed related to construction training that you would like to share?
  - NNI Policy originated with the intent that apprenticeships would result from partnerships with southern companies. The reality of the program today is that Inuit are being treated as unskilled labour by southern companies (with some exceptions; there have been limited examples where the NNI regulations translated into the desired training opportunities for Inuit). This leaves Inuit with many skills out of contention for anything other than unskilled labour opportunities with southern contractors.
  - This has the effect of reducing the number of Inuit who voluntarily participate.
  - Small and medium sized Inuit firms often have difficulty navigating procurement processes as they have not been given the required training; therefore when competing with southern firms, even if the Inuit firm has the skills to perform the work, they tend to lose out due to a gap in skills related to bidding and tendering.
  - Because each jurisdiction sets their own standards for Red Seal certification (as it is not a national standard), when Nunavut was established as a territory Alberta's standards were adopted.
  - The Apprenticeship/Certification Act is being updated to expand flexibilities by introducing more supervision. For instance, southern contractors can supervise Inuit labourers associated with a direct trade without direct apprenticeship, while still allowing for the accumulation of hours towards, say, a housing maintainer.
  - The above is intended to address the limiting factor in the creation of a local inventory of labour presented by mismatches between journeypersons with apprentices or when southern companies refuse to apprentice Inuit.
  - Because NNI regulations for minimum local content are measured on the basis of dollar value and not labour hours, contractors are not incentivized to provide hours.
  - Making virtual mentorship opportunities available is also in an idea stage (DFS)

The questionnaire and presentation materials for these sessions are found in Appendix 4.

GROUPS INVOLVED IN CONSTRUCTION TRADES TRAINING

DEPARTMENT OF ECONOMIC DEVELOPMENT AND TRANSPORTATION (GN)

The questions below were emailed on March 30, 2021 to a senior economist referred to Colliers by NHC. In response to these questions, the economist provided the latest employment data by sector for the territory (also found in Appendix 4): Employment data by sector, 2004 to 2020

- Are there statistics regarding total employment in construction in Nunavut, and in particular, in residential construction?
- Are there statistics by community in Nunavut regarding how many people are available for work, and how many people are willing to travel to other communities in Nunavut to work?
- From current Statistics Canada data referenced below, we wonder whether it would be reasonable to assume that the approximate number of people currently not employed in construction that might be available and interested in working in construction would be in the order of 8% of the current EI beneficiaries, given that:
    - Only approx. 1,210 persons are EI beneficiaries (available for work) in Nunavut; half are women for which nationwide uptake for construction work is relatively low;
    - Generally employment in construction is 6 to 8% of population in the south. This reflects level of interest in construction among other things. 8% of 1,210 is only approximately 100 persons distributed across the territory and including all age groups.

REFERENCE TABLES

Table 4: EI active beneficiaries by province or territory and age group – Number of beneficiaries (Statscan March 15, 2021)

Provinces and territories	Under 25	25 to 34 years	35 to 44 years	45 to 54 years	55 to 64 years	65 and older	Total
Nunavut	190	390	280	230	110	20	1,210

Table 5: EI active beneficiaries by province or territory and age group - Percentage of beneficiaries (Statscan March 15, 2021)

Provinces and territories	Under 25	25 to 34 years	35 to 44 years	45 to 54 years	55 to 64 years	65 and older	Total
Nunavut	15.7%	32.2%	22.8%	18.7%	8.9%	1.6%	0.1%

Table 9: EI active beneficiaries by province or territory and gender - Percentage of beneficiaries (Statscan March 15, 2021)

Provinces and territories	Female gender	Male gender	Gender diverse	Total
Nunavut	46.0%	54.0%	0.0%	0.1%

9.0 Conclusions and Recommendations

9.1 Construction Allocation Methodology

The goal of the allocation methodology is to address Nunavut's housing crisis in a way that is fair to all communities. This means reducing the size of the gap in public housing need between communities and eliminating the imbalance of need by community.

Since 2013, relative difference in need between communities has been reduced. While the actual need as a percentage of stock numbers vary by year, based on new needs lists, each new housing allocation creates greater equity between communities, as demonstrated in our assessment.

9.2 Estimated Annual Housing Starts Required to Eliminate Housing Deficit by 2035

We have estimated that in order for NHC to provide enough public housing so that by 2035 the housing need in Nunavut is met, the number of housing units (with 2-bedroom units as the basis on average) would need to be increased from its current levels of construction (100 to 120 units per year) to approximately 280 units per year.

This would among other things be expected to require additional funding, additional NHC staffing, and potentially additional contractors and subcontractors participating in bidding and construction.

9.3 NDAP and Homeownership

In regards to programs such as NDAP which are designed to encourage private homeownership, we are of the opinion that the interest in such down payment assistance will not be significantly increased by changes to the details of this program. This is due to the negative aspects of private homeownership for personal use that exist in Nunavut that include high utility costs, relatively stagnant home resale prices, and high maintenance costs, among others.

Private homeownership, if it is to increase, is expected to be the result of economic development in Nunavut. It should not be expected that increased private homeownership will reduce the need for public housing new builds. Private homeownership uses more land and requires more infrastructure development per person than NHC fiveplex construction.

9.4 Construction Training and Workforce

There are limitations regarding the size of the construction workforce in Nunavut. Currently there are an estimated 500 people employed in construction. Based on the number of people available for work and typical participation rates in construction, we would expect this could increase by 50 to 100 persons.

Opportunities and recommendations for construction training are discussed in section 6.6.

Given the substantial increase in number of housing starts required to eliminate the housing deficit discussed in 9.2 above, coupled with the projected Canadian shortfall in construction workforce, it is expected that Nunavut will have challenges in this regard.

Should there be a review in NNI Policy provisions, one aspect that could be considered is:

- Modifications that might encourage or allow a greater number of contractors available to provide services on public housing projects that in turn would support the delivery of additional needed housing (assuming other constraints such as funding and NHC staffing levels are eliminated).

9.5 Cost Drivers, Construction Methodologies and Economic Leakage

9.5.1 Approach

A representative NHC project involving three fiveplexes has been studied in detail with the objective to assess the differences in estimated costs, schedules, potential complications and risks in executing such a project.

The NHC single storey fiveplex design used in the tendering of NHC public housing projects is based on traditional stick-built wood frame construction, includes building envelope composition and details that are well developed and designed to provide high levels of insulation and airtightness, and incorporates good building practices for the environment. The design includes a ventilation system designed for this level of airtightness of building with energy recovery features. The contract documents include testing of airtightness of the building envelope to assure that the required airtightness is achieved. The design includes insulation type which is essentially noncombustible, a good practice not mandated by the building code but that can be viewed as a desirable feature to reduce the combustible load in the building envelope given the critical importance of housing in Nunavut. The NHC fiveplex design incorporates good building envelope practice and has evolved over the years based on experience to date.

Our review included the consideration of what elements of the NHC fiveplex might be considered for offsite prefabrication and what effects this would have on design, on the estimated cost of construction, on schedule, on economic leakage of the project and on the potential for Inuit participation in onsite construction activities.

The alternatives considered in this evaluation included the use of Structural Insulated Panels (SIPs) to replace components on the building envelope, and the potential use of modular prefabrication in the delivery of a single storey NHC fiveplex.

The NHC fiveplex design, by grouping five units together, provides energy efficiencies by reducing the exterior building envelope in comparison with five separate individual housing units. In addition, it is more efficient to have a central mechanical and electrical room and an insulated chase beneath the elevated floor serving five units in comparison with five individual units. Furthermore, the construction of fiveplexes allows for savings due to scale in comparison with five individual units being constructed.

The analysis that has been done has studied those parts of an NHC fiveplex that could be considered to be replaced by Structural Insulated Panels and Modular Construction. In both cases, the uniqueness of the central mechanical and electrical room of the fiveplex, the connected service chase below the floor level and appendages such as exterior stairs are considered as needing to be constructed using traditional stick-built construction. Traditional stick-built construction as is now used on NHC fiveplexes has very limited offsite construction (engineered wood trusses, engineered wood beams, millwork). Construction incorporating the use of SIP options reduces the amount of framing and insulating to be done onsite, thus reducing the amount of onsite labour for these components only. In the case of modular prefabrication of housing units offsite, there is a much more significant reduction in onsite labour.

9.5.2 Conclusions Regarding Cost

The costs that have been estimated for each of these delivery methodologies have been based on NHC tender results for traditional stick-built construction and adjustment of these costs for those parts of construction that would be modified by the use of SIPs or Modular Construction. All of these delivery methods will be affected by variations in the cost of building materials and there is no evidence that the variations in material costs that occurs, and that has occurred more dramatically recently, will affect the comparison or conclusions.

The detailed analysis did not identify any significant differences in estimated cost between Stick-built, Part SIP-Part Stick-built and Part Modular-Part Stick-built. The analysis indicated that Part SIP-Part Stick-built could result in a slightly lower overall cost and Part Modular-Part Stick-built could result in a slightly higher overall cost, as compared with Stick-built. The analysis for the three construction methodologies has resulted in estimated costs that are very similar, but with economic leakages and estimated onsite labour hours that are quite different.

However, the level of confidence in the estimated costs for either Part SIP-Part Stick-built or Part Modular-Part Stick built is less than the known value of tenders that have been received for traditional stick-built construction. The accuracy of the estimates done for the Part SIP-Part Stick-built and Part Modular-Part Stick-built to compare with traditional stick-built are believed to be in the range of -10%+ 20%.

The reason that the believed accuracy of the estimates is less in the upward direction is that the estimates, including budgetary estimates for the SIP supply and Modular supply, are based on the information contained in the NHC fiveplex drawings and documents and not on designs that have been produced specifically for the tender of designs incorporating either SIPs or Modular components. In addition, there are a limited number of companies capable of manufacturing and supplying either Structural Insulated Panels or Modular construction of housing units for incorporation in the NHC 5plex.

9.5.3 Conclusions Regarding Schedule

Each methodology requires a different overall design, procurement and construction schedule. These schedules are detailed in section 4.3.2. Traditional stick-built requires less time for design and procurement and can be tendered closer to sealift dates than is the case with the use of SIPs or modular construction. Traditional stick-built is more flexible regarding interruptions in construction. With SIP and especially modular construction, it is necessary for reasons of protection of the purchased products (SIPs and modules) that construction is not interrupted (and if so, the enclosures must be completed and interior heating provided in the winter months). As such, the use of SIP or modular construction involves additional constraints related to schedule.

9.5.4 Conclusions Regarding Economic Leakage

Traditional stick-built construction of NHC fiveplexes results in the least economic leakage, followed by part-SIP and then modular methodologies.

The evaluation of estimated direct economic leakage comparing traditional stick-built, Part SIP-part Stick Built and part Modular-part Stick Built may be debated regarding the exact numerical value of economic leakage or available number of labour hours for local workers. However, the conclusion regarding which Option involves more direct economic leakage is undeniable and borne out by common sense. The more prefabrication that is done outside of Nunavut on a project, the more economic leakage will occur and the less required hours there are for construction onsite and hence the less available hours for Nunavut involvement on site.

9.5.5 Conclusions Regarding Risks

For NHC fiveplexes, there are more risks and challenges associated with construction methodologies that include the use of SIPs (or other insulated panels) or modular construction compared with the current methodology of traditional stick-built.

The following should be considered:

Need to develop designs and tender documents specifically for projects with use of Structural Insulated Panels or Modular Construction

- In the case of Structural Insulated Panels, the need to review in detail code compliance, incorporation and details for building envelope; the need to determine which if any of floor, wall and roof panels will be accepted and how these will be integrated into the overall design; the need to be satisfied that the end product will be as durable as the current traditional stick-built NHC fiveplex.

Reduced number of companies that can provide Structural Insulated Panels and Modular Construction

- This can affect tender prices, the number of bidders and poses risks should the SIP manufacturer or Modular provider have difficulties delivering to the sealift on time.
- Tenders that involve either SIPs or Modules will have limited competition for these parts of the tender. This can cause unwanted surprises in tender prices submitted. In addition, unfamiliarity, or evaluation of risks by bidding General Contractors, can result in tendered prices higher than we have estimated.

With Structural Insulated panels and Modular Construction, tendering must start much earlier in order to allow time for design, coordination of design and review of shop drawings in order to meet sealift cutoff dates.

- Stick-built has the advantage that it does not require contract award additional months before Sealift in order that the designs can be done for prefabricated components such as Structural Insulated Panels or Modules. Projects with either SIPs or Modules will likely require advancement of payments before these items arrive in Nunavut, which represents some financial risk.
- As well, should the manufacture of the SIPs or Modules not be completed in time for Sealift, the projects would be delayed automatically for one calendar year.

With Structural Insulated Panels and Modular Construction, design coordination is much more critical and oversights or desired Owner changes have more serious effects onsite and are more difficult to deal with than in traditional stick-built construction.

- NHC has detailed designs and tender documents for traditional stick-built execution. Stick-built execution has the advantages of familiarity and the depth of experience of NHC, NHC's Consultants and Contractors who work for NHC.

- Structural Insulated Panels or Modules need to be coordinated with the balance of the design needing to be executed using stick-built. Stick-built allows for NHC and NHC Consultants to design using exactly the composition of building envelope desired by NHC and the materials that NHC wishes to utilize without any possible compromises such as using OSB instead of plywood in the case of SIPs. Stick-built does not involve potential risks that can arise with the division of responsibility that occurs between NHC Consultants and the Consultants working for manufacturers of either Structural Insulated Panels or of Modules.

Additional field reviews by the Consultants and SIP manufacturer are recommended compared with traditional stick-built delivery.

Reduced pool of contractors and construction workers experienced with Structural Insulated Panels and Modular Construction.

- The use of SIPs are not part of the experience and expertise of the majority of General Contractors experienced in residential construction. This is even more so the case with Modular Construction which requires a higher degree of organization, oversight, health and safety expertise and logistics expertise than would typically be present in most residential contractors capable of building traditional stick-built residential construction.

9.5.6 Conclusions Regarding Construction Methodology

For reasons of cost, schedule, risk, and economic leakage, our conclusion is that there are no solid reasons for NHC to reconsider at this time the method (by General Contractor) and the Construction Technology (Traditional stick-built) that is currently being used for its public housing projects.

While it is recommended that NHC continue to be open and investigate solutions besides traditional stick-built for public housing delivery, we would recommend that Structural Insulated Panel use may be more appropriate should NHC consider in the future smaller housing types, such as single family dwellings, for which SIPs have a longer track record and constitute the majority of buildings using SIPs.

Modular construction is better suited to the construction of large multi-storey buildings with flat roofs in locations where the required hoisting equipment is present or the project is large enough to distribute the costs of such equipment. These are not the features of NHC’s chosen single-storey fiveplex projects.

Appendix 1 REFERENCES

A1.1. Background Information

A1.1.1. FROM NHC

1. DPRA Study of Prefabrication Options for Housing in Nunavut, November 2016
2. RFP 110000004-01-Arviat Design-Build example from 2017-18 (with Modular, SIP and stick-built submissions)
3. RFP 110000004-02-Cambridge Bay Design-Build example from 2017-18 (with Modular, SIP and stick-built submissions)
4. Nunavummi Nangminiqaqtunik Ikajuuti (NNI) Policy, 2016

A1.1.2. FROM OTHER SOURCES

1. Table of References, June 29, 2021
2. PSPC Guide on Government Contracts in the Nunavut Settlement Area, December 2019
3. Nunavut Department of Community and Government Services, How to Guide – Doing Business with the Government of Nunavut, undated

Appendix 2 ASSUMPTIONS, OPTIONS CONSIDERED & COSTING FOR DIFFERENT CONSTRUCTION METHODOLOGIES

A2.1. Assumptions

1. Colliers Summary of Approach to Assessing Cost Drivers (doc#821191-0026(1.0)), December 2020
2. Construction Methodology Comparison and Economic Leakage Workbook (doc#P7201-1642168982-45(1.0)), March 2021
3. Assumed Construction Schedule – Stickbuilt, March 2021
4. Assumed Construction Schedule – SIP, March 2021
5. Assumed Construction Schedule – Modular, March 2021
6. National Association of Home Builders (NAHB), Cost of Constructing a Home, February 2020. https://www.nahbclassic.org/generic.aspx?sectionID=734&genericContentID=271883

Appendix 3 Housing Need Assessment

In order to understand how best the waitlist data captures the housing needs of the communities, the following independent assessment of housing needs on the basis of demographic data was conducted using external data sources from CMHC, Statistics Canada, Nunavut Bureau of Statistics, among others.

As the social housing demand is a function of residents' inability to afford market rents due to low income levels, two sources of information that track this information were used - Statistics Canada's Census Family Low Income After-Tax Measure (CFLIM-AT) and Statistics Canada's/CMHC's Core Housing Need (CHN).

In year 2016, based on tax-filer data and the CFLIM-AT measure (using the "updated methodology")[68] [69] there were approx. 10,330 people or 29% of the population of Nunavut in the low-income category. Using the ratio of 29% of the population in low-income and applying it to the population forecasts from Table 6, Nunavut's total low-income population by year for the period 2019-2035 is forecasted in Table 7.

Table 7: Low-Income Population (using the CFLIM-AT - which has determined that 29% of the total Nunavut population is in low-income in year 2016),

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Baffin	6,060	6,144	6,228	6,312	6,392	6,468	6,543	6,615	6,685	6,776	6,842	6,911	6,980	7,049	7,119	7,188	7,256
Kivalliq	3,325	3,385	3,445	3,504	3,563	3,623	3,683	3,744	3,806	3,875	3,940	4,003	4,068	4,133	4,197	4,261	4,323
Kitikmeot	2,035	2,057	2,078	2,099	2,120	2,141	2,161	2,179	2,198	2,217	2,236	2,257	2,277	2,296	2,316	2,335	2,353
NU Total	**11,419**	**11,586**	**11,752**	**11,915**	**12,076**	**12,232**	**12,386**	**12,539**	**12,689**	**12,868**	**13,018**	**13,171**	**13,325**	**13,479**	**13,633**	**13,784**	**13,932**

According to the Census 2016 data, 31% of all households in Nunavut have "5 or more persons". Table 8 provides the ratio of various household sizes in Nunavut as per 2016 Census data. This information is used in the analysis to estimate future household formation and unit requirements. This is preferable to simply using the average household size number (3.6) for Nunavut overall, as there is a large number of "5 or more persons" households in Nunavut makes the use of averages less than ideal.

Table 8: Breakdown of Nunavut's Private Households by Size, 2016 Census Data

Household Size	% of Households 2016 Census
1 person	19%
2 persons	19%
3 persons	15%
4 persons	16%
5 or more persons	31%
Total Households	**100%**

Applying the ratio of the household sizes to the Low-Income Population data in Table 7 segmentation of low-income population by household size is obtained (refer to Table 9).

[68] Figure 3 is based on the "updated methodology" for Census Family Low Income After-Tax Measure (CFLIM-AT) statistics derived from the T1 Family File. The updated methodology was introduced in April 2018.
[69] See also: https://www150.statcan.gc.ca/n1/pub/75f0002m/75f0002m2018001-eng.htm

Table 9: Low-Income Population Segmented by No. of Persons in Private Households (using the proportions calculated from the 2016 Census, from Figure 5)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1 person	2,158	2,190	2,221	2,252	2,282	2,312	2,341	2,370	2,398	2,432	2,460	2,489	2,518	2,547	2,576	2,605	2,633
2 persons	2,199	2,231	2,263	2,294	2,325	2,355	2,385	2,414	2,443	2,478	2,507	2,536	2,566	2,596	2,625	2,654	2,683
3 persons	1,739	1,765	1,790	1,815	1,839	1,863	1,887	1,910	1,933	1,960	1,983	2,006	2,030	2,053	2,076	2,100	2,122
4 persons	1,798	1,824	1,850	1,876	1,901	1,925	1,950	1,974	1,997	2,026	2,049	2,073	2,097	2,122	2,146	2,170	2,193
5 or more	3,525	3,577	3,628	3,678	3,728	3,776	3,824	3,871	3,917	3,972	4,019	4,066	4,114	4,161	4,209	4,255	4,301
NU Total	**11,419**	**11,586**	**11,752**	**11,915**	**12,076**	**12,232**	**12,386**	**12,539**	**12,689**	**12,868**	**13,018**	**13,171**	**13,325**	**13,479**	**13,633**	**13,784**	**13,932**

For the purposes of calculating the number of units required to address the housing needs of low-income population a target household size needs to be chosen. Table 10 sets this as 2.4 (average Canadian household size) for all households more than 2 persons, instead of 3.6, to determine the number of units required to reduce overcrowding.

Table 10: Applied Household Size by Household Size Category

Household Size	Applied Average Household Size
1 person	1
2 persons	2
3 persons	2.4
4 persons	2.4
5 or more persons	2.4

This calculation estimates the total number of units required in year 2019 to be 6,200 units (refer to Table 11). When compared to the number of units available in 2019, which is 5,568, the unmet need in year 2019 would be 632 units. This is lower than the waitlist recorded in 2019 of 2,816 applicants. As this approach is solely based on affordability it may not be providing the correct insights into the nature and magnitude of need, which is also based on aspects such as suitability and adequacy[70]. And for this reason, it would be imperative to perform the analysis based on the second approach, i.e. Core Housing Need.

Table 11: Unit Requirements by Household Size (using the Applied Household Size, from Figure 6)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1 person	2,158	2,190	2,221	2,252	2,282	2,312	2,341	2,370	2,398	2,432	2,460	2,489	2,518	2,547	2,576	2,605	2,633
2 persons	1,099	1,116	1,131	1,147	1,163	1,178	1,193	1,207	1,222	1,239	1,253	1,268	1,283	1,298	1,313	1,327	1,341
3 persons	725	735	746	756	766	776	786	796	805	817	826	836	846	855	865	875	884
4 persons	749	760	771	781	792	802	812	822	832	844	854	864	874	884	894	904	914
5 or more persons	1,469	1,490	1,512	1,533	1,553	1,573	1,593	1,613	1,632	1,655	1,675	1,694	1,714	1,734	1,754	1,773	1,792
NU Total	**6,200**	**6,291**	**6,381**	**6,469**	**6,557**	**6,641**	**6,725**	**6,808**	**6,890**	**6,987**	**7,068**	**7,152**	**7,235**	**7,318**	**7,402**	**7,484**	**7,565**

[70] https://www.cmhc-schl.gc.ca/en/housing-observer-online/2018-housing-observer/13-point-6-percent-urban-households-were-core-housing-need-2016#:~:text=A%20household%20is%20said%20to,meets%20all%20three%20housing%20standards)

According to Statistics Canada's 2016 Census, 36.5% of Nunavut *households* are in Core Housing Need (CHN). By comparison, other territories and the nation overall are at 15%, and 13%, respectively.[71] Likewise, 47.2% of Nunavut's 2016 population was in core housing need, according to the 2016 Census (16,705 persons in CHN / 35,395 total Nunavut population = 47.2% of total population). Applying the ratio of 47.2% to the population projections from 2019 to 2035, it is estimated that over 18,500 people in the Territory were in core housing need.

Table 12: Total Population in Core Housing Need (47.2% of Total Population)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
18,586	18,857	19,127	19,393	19,654	19,908	20,160	20,408	20,652	20,943	21,188	21,437	21,687	21,938	22,188	22,434	22,676

Applying the ratio of the household sizes (in Table 10) to the estimate of total population in core housing need, provided in Table 12, segmentation of population in core housing need by household size is obtained (refer to Table 13). This shows that the aggregate housing unit requirement in 2019 is approximately 10,091 units.

Table 13: Unit Requirements By Household Size (using the Applied Household Size, from Table 10)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1 person	3,513	3,564	3,615	3,665	3,715	3,763	3,810	3,857	3,903	3,958	4,005	4,052	4,099	4,146	4,193	4,240	4,286
2 person	1,789	1,816	1,842	1,867	1,892	1,917	1,941	1,965	1,988	2,016	2,040	2,064	2,088	2,112	2,136	2,160	2,183
3 person	1,180	1,197	1,214	1,231	1,247	1,263	1,279	1,295	1,311	1,329	1,345	1,361	1,376	1,392	1,408	1,424	1,439
4 person	1,219	1,237	1,254	1,272	1,289	1,306	1,322	1,339	1,355	1,374	1,390	1,406	1,422	1,439	1,455	1,471	1,487
5 or more	2,391	2,426	2,460	2,494	2,528	2,561	2,593	2,625	2,657	2,694	2,725	2,757	2,790	2,822	2,854	2,886	2,917
NU Total	**10,091**	**10,239**	**10,385**	**10,530**	**10,672**	**10,809**	**10,946**	**11,081**	**11,213**	**11,371**	**11,504**	**11,640**	**11,775**	**11,911**	**12,047**	**12,181**	**12,312**

Assuming that the 2019 waitlist number of 2,816 refers to total applicants and that an applicant represents a household (of whatever size) and they can only be on the waitlist once, the 2019 waitlist represents unmet demand of 2,816 housing units. It is to be noted that this 2,816-number is part of the 10,091 units calculated in Table 13. They are Nunavut residents in need of housing because of low-income, or because they do not have adequate or suitable housing. Based on this approach the 2019 housing stock deficit is calculated as the difference of estimated total unit requirements of 10,091 and 5,568 total existing supply, which is 4,523 units (in deficit). This calculated deficit of 4,523 units is congruent with a recent study presented to the Nunavut Legislature (September 2020) identifying that 3,545 households in the territory are still in need of housing.

In addition to the approaches mentioned earlier, an alternative analysis is also tested. The prior analyses were based on research identifying the proportional breakdown of households in Nunavut and a target household size of 2.4 for all existing households over 2 persons, the alternate approach uses the NHC's occupancy assumptions for its current new builds; 1 bed, 2 bed and 3 bed units accommodate 2, 4, and 6 persons respectively. When these assumptions are considered, it could translate into the household size assumptions in Table 14.

[71] Source: https://www.cmhc-schl.gc.ca/en/data-and-research/core-housing-need/core-housing-need-data-by-the-numbers#:~:text=37%25%20of%20Nunavut%20is%20in,the%20government%20or%20their%20employer

Table 14: Applied Household Size by Household Size Category, Considering NHC Current Assumptions

Household Size	Applied Average Household Size
1 person	1.0
2 persons	2.0
3 persons	2.4
4 persons	4.0
5 or more persons	6.0

Applying the household size assumption in Table 14 to the estimate of population in core need, the total number of units required in year 2019 is 8,169. The housing stock deficit based on this estimate calculated as the difference of estimated total unit requirements of 8,169 and 5,568 the total existing supply, is 2,601 units; this is close to (but lower than) the 2019 waitlist of 2,816.

Table 15: Unit Requirements by Household Size

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1 person	3,513	3,564	3,615	3,665	3,715	3,763	3,810	3,857	3,903	3,958	4,005	4,052	4,099	4,146	4,193	4,240	4,286
2 persons	1,789	1,816	1,842	1,867	1,892	1,917	1,941	1,965	1,988	2,016	2,040	2,064	2,088	2,112	2,136	2,160	2,183
3 persons	1,180	1,197	1,214	1,231	1,247	1,263	1,279	1,295	1,311	1,329	1,345	1,361	1,376	1,392	1,408	1,424	1,439
4 persons	731	742	753	763	773	783	793	803	813	824	834	844	853	863	873	883	892
5+persons	956	970	984	998	1,011	1,024	1,037	1,050	1,063	1,078	1,090	1,103	1,116	1,129	1,142	1,154	1,167
NU Total	**8,169**	**8,289**	**8,407**	**8,524**	**8,639**	**8,750**	**8,861**	**8,970**	**9,078**	**9,206**	**9,313**	**9,423**	**9,533**	**9,643**	**9,753**	**9,861**	**9,967**

Table 16 shows the projected increase in number of units at the current rate of approximately 100 units per year.

Table 16: Actual Stock in 2019 + 100 Units

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
5,568	5,668	5,768	5,868	5,968	6,068	6,168	6,268	6,368	6,468	6,568	6,668	6,768	6,868	6,968	7,068	7,168

Table 17 shows the projected increase of unit needs deficit from year 2019 based on CHN Measure and Assumptions in Table 10. It is estimated that NHC will have to supply new units at the rate of approximately 600 units per year to significantly reduce or eliminate the deficit by year 2035.

Table 17: Stock Deficit based on CHN Measure and Assumptions in Table 10

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
4,523	4,571	4,617	4,662	4,704	4,741	4,778	4,813	4,845	4,903	4,936	4,972	5,007	5,043	5,079	5,113	5,144

Table 18 shows the projected increase of unit needs deficit from year 2019 based on CHN Measure and Assumptions in Table 14. It is estimated that NHC will have to supply new units at the rate of approximately 265 units per year to significantly reduce or eliminate the deficit by year 2035.

Table 18: Stock Deficit based on CHN Measure and Assumptions in Table 14

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
2,601	2,621	2,639	2,656	2,671	2,682	2,693	2,702	2,710	2,738	2,745	2,755	2,765	2,775	2,785	2,793	2,799

The above analysis shows that when aspects other than affordability, such as suitability and adequacy are layered over the analysis, results vary significantly. The key outcome of this analysis is that further investigation may be required to determine if the current application and waitlist system is accessible to all residents in need of housing and the units that are being allotted to these residents remain suitable for their needs in the long term.

Appendix 4 STAKEHOLDER ENGAGEMENT INPUTS & OUTPUTS

A4.1. Presentation Materials

1. Colliers Outline of Interview Approach for Stakeholder Engagement (doc#821191-0025(3.0)), Updated February 10, 2021
2. Colliers Technical Presentation (doc#P7201-1642168982-43(1.0)), February 2021

A4.1.1. QUESTIONNAIRES

1. NHC
2. Design Community
3. General Contractors
4. Subcontractors
5. Sealift Providers
6. Modular Component Providers – With Responses
7. Structural Insulated Panel (SIP) Providers
8. Groups Involved in Construction Trades Training

A4.1.2. FOLLOW-UP INFORMATION FROM INTERVIEWS

1. Design Community:

   (i) Nunavut Building Code Act and Regulations

   (ii) Notice of Inspection Checklist

2. Sealift Providers:

   (i) Final 2020 Sailing Schedule, NEAS

   (ii) Assumptions for Modular rates, NEAS

   (iii) Cargo insurance rates

3. Modular Component Providers:

   (i) Budgetary Estimate for (3) NHC Fiveplexes

4. SIP Providers/SME:

   (i) Budgetary Estimates for (3) NHC Fiveplexes from Four Providers

   (ii) Summary Table for SIP and ICE Panel Budgetary Estimates

(iii) Panelized Building Systems for Northern Multi-Unit Residential Buildings, Cold Climate Building Inc., March 2017.

5. Government of Nunavut, Department of Economic Development and Transportation:

(i) Nunavut Employment Data by Industry, Labour Statistics Division, 2020.

Appendix 5 MINUTES OF MEETINGS WITH NHC

1. Colliers Proposed Meeting Plan (doc#821191-0017(1.0)) – October 5, 2020
2. Kickoff Meeting – September 17, 2020
3. Discovery Meeting #2 – September 24, 2020
4. Meeting #3 (Meeting A) – October 21, 2020
5. Meeting #4 (Meeting B) – October 29, 2020

Appendix 6 RFP