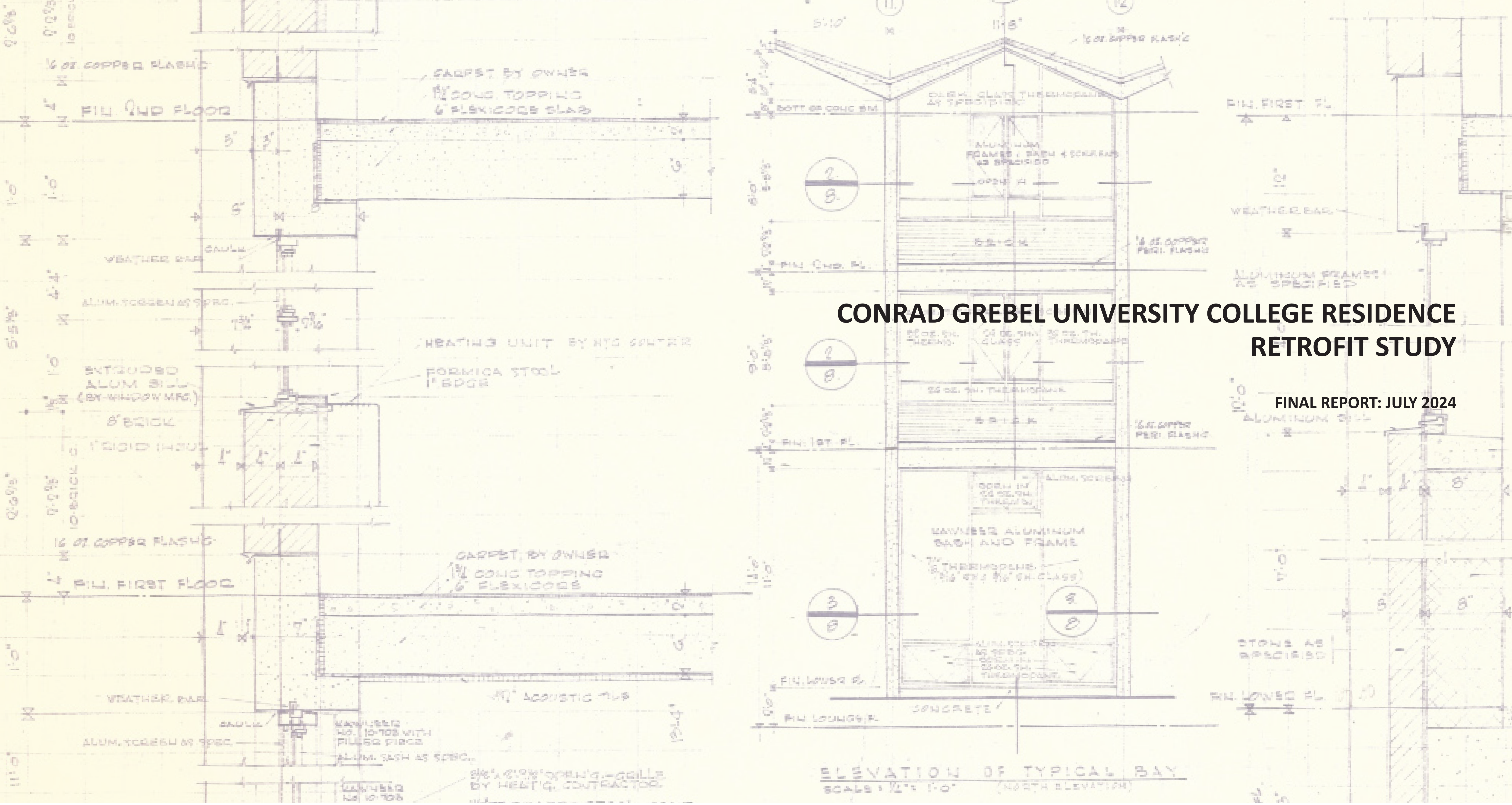


CONRAD GREBEL UNIVERSITY COLLEGE RESIDENCE RETROFIT STUDY

FINAL REPORT: JULY 2024

Conrad Grebel University College

Baird Sampson Neuert architects

WALTERFEDY

Project No: 2023-0757-10

PREPARED BY:

Baird Sampson Neuert Architects

- Architectural Services

in collaboration with

WalterFedy

- Engineering Services
- Energy and Carbon Solutions

PREPARED FOR:

Conrad Grebel University College

Mimi Browne, CHRP

Director of Operations

140 Westmount Rd N

Waterloo, ON N2L 3G6

519-885-0220

Table of Contents

1.0 EXECUTIVE SUMMARY

Baird Sampson Neuert architects and WalterFedy Engineering were engaged by Conrad Grebel University College (CGUC) to investigate the feasibility and potential impact and benefits of a series of retrofit measures to reduce greenhouse gas (GHG) emissions and improve student comfort and inclusivity within the residence wing of CGUC.

CGUC's key objectives for the project included providing gender-neutral washroom facilities within the residence, improving indoor environmental quality and occupant comfort for students by providing cooling and improving heating and ventilation systems, and reducing GHG emissions through energy conservation measures and building system upgrades to help move GCUC towards its commitment of a 35% GHG emissions reduction, below 2019 levels, by 2030. CGUC has indicated an approximate project budget availability of $3M - $3.5M for initial work to achieve these objectives.

Through consultation with CGUC, the scope of the study identified a range of interventions and a recommended sequence of implementation that will focus on the primary project goals of realizing immediate reductions in GHG emissions, as well as making noticeable and visible impact on improving student comfort and inclusivity within the residence area. Retrofit measures have been prioritized in a series of staged interventions as follows:

1. Baseline / existing conditions

2. Electrify the domestic hot water system for the residence using air source heat pump hot water tanks to replace existing gas fired hot water tanks.

3. Renovate existing washrooms spaces to create functional gender neutral washrooms on each floor, and undertake refurbishment of sanitary drainage piping to mitigate / eliminate existing drainage (blockage) issues in sanitary piping.

4. Install a high efficiency air source heat pump system to provide cooling to residence rooms, and replace the existing the gas fired hot water radiant heating system.

5. Replace existing non thermally broken double and single glazed windows in the residence spaces, including stairwells, with high performance modern window systems.

The above scope of work has been evaluated through a calibrated energy modelling process for greenhouse gas emissions reduction potential relative to the operational carbon emission of the full CGUC complex and against a 2019 baseline for measured energy use and GHG emissions, in line with the *Shift:Neutral* commitment. Each measure has also been costed at a Class D level (concept level order of magnitude costs) to benchmark the work relative to current funding availability and potential future funding opportunities.

Implementing all measures above would realize a potential total GHG reduction of 16.7% and have a total estimated construction cost of $5.513M using a Q1 2024 cost basis (future market escalation excluded).

Stage 2 and 3 scope (DHW electrification and gender neutral washroom upgrades) are recommended to be implemented first, as these will provide the most immediate impact to student comfort, inclusivity and functionality of student spaces, realize a significant GHG reduction potential of 7.9%, and can be achieved within a construction budget of +/- $1M, fitting within immediate budget availability.

Stage 4 (air source heat pumps) will increase GHG reduction potential to 16.5%, but is the highest cost measure, estimated at approximately $3.5M construction cost and thus would require additional funding to proceed.

Stage 5 (window replacement) will provide a noticeable improvement to occupant thermal comfort and indoor environmental quality by mitigating current issues of condensation and drafty windows. This measure provides a nominal GHG reduction of approximately 1% - 1.4%, and has an estimated cost of $1.2 M.

While stage 2, 3, and 5 scopes (DHW, washrooms, and windows) could all potentially be achieved within the available project budget, stage 4 work (heat pumps) has been prioritized over stage 5 (window replacement) due to the significant impact on GHG reduction this measure provides. If CGUC anticipates a potential funding pathway to achieving the heat pump upgrades, this should be prioritized. Alternatively, CGUC may consider including window replacement as part of early stage works, within the current available funding, as this intervention will provide measurable and meaningful improvements to occupant comfort, and indoor environmental quality, in addition to nominal GHG reductions.

2.0

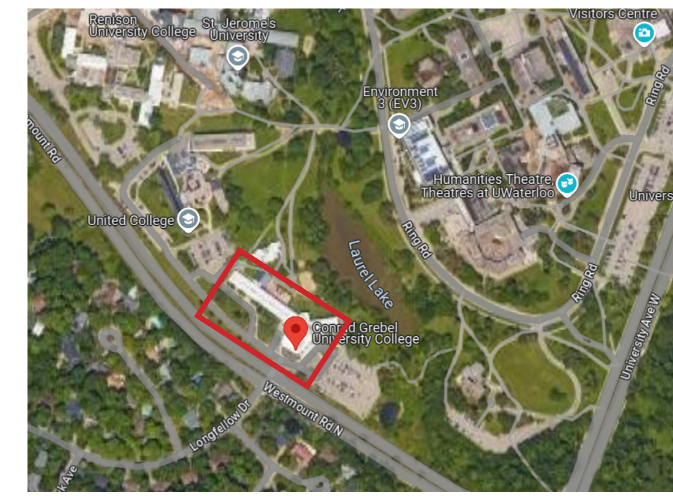
PROJECT SUMMARY

2.1 Background and Existing Conditions

Conrad Grebel University College (GCUC) student residence was built as a free-standing building in 1963-64. Multiple additions and renovations have occurred over the years to create the 4-storey complex that exists today. The residence wing occupies the third and fourth levels at the north end of the complex. The original main entrance to the residence, as well as the heritage stone chapel sits at the third level of the building which is accessible from grade due to the rise in elevation from south to north and from east to west across the site. The residence wing is organized as a linear double loaded corridor on level 3 and 4. Level 3 accommodates 33 residence rooms, 3 communal washrooms, 2 universal washrooms, and a common room, as well as the main entry and foyer to the chapel. The fourth level has 39 residence rooms, 3 communal washrooms and 1 universal washroom. Level 2 of the residence wing contains the main dining hall and kitchen as well as various student and support spaces and provides walk out access to a terrace that overlooks the main campus to the east. Level 1 contains service spaces and is largely below grade at the residence areas. The scope of work area for this study is focused on level 3 and 4 of the residence wing and the chapel, with work extending to service spaces in level 1 as required to support the proposed upgrades.

Essential building components and systems, including windows, heating, and ventilation systems, as well as existing washroom facilities are beginning to reach the end of their useful life expectancy and functionality. Existing heating systems are fossil fuel based and there is no active cooling in the residence area. Residence floors lack effective fresh air ventilation, contributing to poor indoor air quality and increased energy loss in heating season when windows are opened by occupants to provide fresh air to under ventilated residence rooms. Existing windows which are thermally inefficient and drafty are a source of energy loss and increased greenhouse gas emissions from heating systems, and also present user comfort and indoor environmental quality concerns such as condensation which leads to mildew growth, or freezing in winter (it was noted by CGUC staff that curtains have been known to freeze to window frames during cold months).

Existing communal washrooms on each residence floor are currently being used as all gender washrooms,



100m Site location outlined in red along Westmount Rd N.

20m Primary areas of retrofit study are outlined in red.

however the stalls and showers lack appropriate privacy partitions. Washroom finishes are dated, plumbing fixtures are older higher-flow models, and the washrooms lack effective exhaust ventilation, particularly in shower areas, leading to moisture management issues. The existing sanitary drainage lines within the residence wing in general are also prone to frequent backups.

2.2 CGUC Project Objectives

CGUC (the Owner) approached Baird Sampson Neuert (BSN) and Walterfedy (the Consultant Team) to investigate solutions which would improve functional aspects of the residence area, improve infrastructure to support CGUCs inclusive student housing environment, improve indoor environmental quality and occupant comfort for students, and help to move CGUC towards its target of a 35% GHG emissions reduction, below 2019 levels, by 2030, in alignment with the University of Waterloo *Shift:Neutral* climate action plan.

2.3 Focus of Retrofit Study

Initially, four key focus areas within the residence wing were identified by CGUC as the basis of this study. This included: providing gender neutral washrooms; replacing existing windows; upgrading exterior walls (insulate), and providing cooling in residence rooms.

Upon initiation of the project study work with BSN and WalterFedy, targeted retrofit scope items were refined and expanded, in consultation with CGUC, to the following list:

1. Renovate and renew residence washrooms to create a gender neutral solution.
2. Replace windows with high performance models.
3. Provide cooling in residence rooms and upgrade or replace exisiting heating system to reduce GHG emissions.
4. Provide cooling in the chapel.
5. Electrify the domestic hot water system to reduce GHG emissions.
6. Upgrade or repair existing sanitary drainage lines which are prone to blockage.
7. Upgrade to exterior walls (insulating / over-cladding).
8. Lighting Upgrade (LED).

Cover from the *Shift:Neutral* report. The identified 35% GHG reduction goal guided this retrofit study. Courtesy of the University of Waterloo.

Using existing building drawings and documentation provided by CGUC, and onsite investigation carried out in early 2024, baseline existing conditions were evaluated and established. Proposed design solutions for each of the above retrofit scopes were developed by the Consultant Team and assessed for design (technical and functional), constructability, cost, and energy/GHG reduction benefits. These options are outlined in the following section of the report.

Energy modelling of the baseline condition, as well as potential impacts from proposed retrofits was prepared by WalterFedy's Energy and Carbon Solutions team. The baseline energy model utilizes utility data provided by the Owner, and input on existing system efficiency (mechanical systems, building envelope performance values) based on investigation by the Consulting Team to establish a calibrated assessment of existing energy use. Proposed retrofit measures were then integrated into the model and their potential impact on energy use and GHG emissions evaluated.

The projected GHG reductions for each measure were initially modelled independently (i.e. as if no other measures are implemented) in order to allow for independent evaluation and comparison of the impact and costs of each measure at a high level. As measures are combined, there are interactive effects between certain measures that will change the modelled GHG and energy impacts. For example, GHG savings from low flow water fixtures and GHG savings from electrification of the domestic hot water supply will not be cumulative once both measures are implemented. GHG reduction percentages are relative to the GHG emissions of the entire facility using a 2019 baseline year as requested by CGUC and to align with CGUC's goal of reducing GHG emissions by 35% by 2030 and aligned with the University of Waterloo's *Shift:Neutral* GHG reduction framework.

Ingersoll Cost Consultants were engaged to analyze the potential scope of work for each measure and provide budgetary cost estimates. Budgetary costs are based on concept level scope of work descriptions and supporting diagrams, and drawings. Costs are considered "Class D", and should be taken as a rough order of magnitude estimate, with an estimating range of between of +/- 20% to 30%. Costs are reflective of Q1 2024, with no contingency carried for assumed future cost escalation as the timeline for implementation was not known when preparing this report. Appropriate construction escalation contingency should be carried in any budgeting for future implementation phases if the work. Historical trends in construction cost escalation are recorded and reported quarterly trough StatCan's Building Construction Price Index. Itemized costs for each scope measure and option are included in the appendices to this report.

3.0 INVESTIGATED MEASURES PACKAGES

A high level description of the proposed retrofit solutions developed by the Consultant Team for each scope item, as well as estimated construction cost and energy/GHG impact is summarized below, and expanded in detail in following sections of the report and attached appendices.

1. Washroom Update (Gender Neutral)

Four options for reconfiguration of the three existing communal washrooms on each floor were explored:

Option 1: Refresh washrooms with new fixtures and finishes, including privacy partitions for gender neutral functionality as well as adding shower exhaust. General layout to remain unchanged.

- 2.7% CO^2 reduction. $785K

Option 2: Reconfigure washrooms in current locations to provide three small gender neutral “en-suite” type units within each washroom bay location.

- This option was not carried forward as the dimensions of the resulting configurations were overly constrained.

Option 3: Combine two of the three communal washroom bays into one larger gender neutral washroom and refresh the third existing communal washroom bay as per Option 1.

- 2.7% CO^2 reduction. $723K

Option 4: Combine all three communal washroom bays into one larger gender neutral washroom on each floor.

- 2.7% CO^2 reduction. $642K

2. High Performance Window Upgrade

Options for double glazed and triple glazed high performance aluminum windows were investigated. Infilling the triangular peaks at the top of the level 4 windows was also studied. Depending on the selected supplier, the difference in costs between double and triple glazed high performance window options was marginal (approximately 5-10%), and the difference in GHG reduction is also minimal. Similarly, the option to infill the peaks at level 4 did not result in any measurable improvement in energy performance or cost at the level of detail of this study. However, triple glazed windows may offer other advantages including improved thermal comfort within the residence rooms, greater reduction of condensation risk, and greater acoustic performance.

The use of fiberglass windows which typically offer advantages in performance and cost was investigated however due to the building classification under the Ontario Building Code, and the spacing of windows on each façade the use of combustible fiberglass window frames is prohibited.

Option 1. Full glazing

- 1A. Triple glazed: 0.9% CO^2 reduction. $1.146M
- 1B. Double glazed: 0.9% CO^2 reduction. $1.091M

Option 2. Infilled peaks at level 4

- 2A. Triple glazed with infilled peaks: 1.1% CO^2 reduction. $1.144M
- 1B. Double glazed with infilled peaks: 0.9% CO^2 reduction. $1.097M

3. Residence Heating and Cooling

The approach recommended to provide cooling most efficiently to the residence rooms, while also reducing GHG emissions from space heating, is to decommission the existing hot water radiator system and install a high efficiency air source heat pump with variable refrigerant flow (VRF) system, utilizing roof top outdoor units with VRF terminal units in each residence room. Due to the current issues with poor ventilation in the residence rooms, it was also recommended that small through-wall energy recovery ventilator (ERV) units be installed as part of the mechanical upgrade scope of work. These ERV units would improve fresh air supply and reduce incidental energy loss from opening windows in the active heating (or cooling) season. Changing the heating system to an all-electric VRF approach would also require an electrical service upgrade, replacing the existing 500kVA pole mounted transformer with a new 750kVA pad mounted transformer and upgrading associated distribution within the building to suit the new loads. Two locations for the indoor VRF units within the residence rooms were investigated, including floor-mounted units that would be positioned below the windows, where the existing radiators are currently, or ceiling-mounted units that would be mounted above the corridor entrance door in a drywall bulkhead. The reduction in CO2 emissions resulting from decarbonization of the heating source are partially offset by the addition of electrical load for cooling in the summer, which is not currently provided.

An alternative to the VRF system that still achieves GHG reductions would be to electrify the source of heat for the existing hot water radiant system. This could include replacing the existing boilers with an air source heat pump connected to the existing radiant heating piping and radiators. While this approach may have a lower capital cost, it would not be able to provide cooling as per the original objective to improve occupant comfort. The approach would also require a careful planning of the HVAC controls to ensure that new and aged equipment were integrated in their operation (local thermostatic radiator valves). CGUC also inquired about retaining the existing hot water radiant system as a backup heat source to a new heat pump and VRF system in the case of a major power outage. While this approach is possible it would require an increased level of operations and maintenance to keep both systems functioning. The existing hot water system which would serve as backup to the primary heat pump system, would need to undergo regular inspection and maintenance to ensure equipment is maintained in good working function. This will include regular operation of the circulating pump to keep water moving in the existing piping system and maintenance of chemical treatment in the piping system to ensure longevity and reliability of the system. This option could be explored in future phases of the work.

Option 1. Floor-mounted VRF at window.

- 6.8% CO^2 reduction. $3.219M*

Option 2. Ceiling-hung VRF over doorways.

- 6.8% CO^2 reduction. 3.262M*

*Costs include $478K for electrical service upgrade

4. Chapel Cooling and Ventilation

Multiple options to add cooling in the chapel were investigated. As the chapel is frequently used for musical performances and religious services, a critical requirement of any change or addition to the mechanical system serving the chapel is mitigation of acoustical impacts from mechanical system noise or transfer between spaces. Options investigated included: 1) Installation of a packaged air handling unit outside the chapel. This option was deemed non-viable due to the size of the required equipment and resulting impact on outdoor open space and heritage value of the existing stone chapel. 2) Installation of a ducted VRF system located in the ceiling of the basement space below the chapel. This option was also deemed non-viable due to acoustical impacts on the chapel. 3) Replacement of the existing perimeter hot water radiators with two-pipe fan coil units. Heating would remain from the existing hot water system and a split chiller added to provide cooling. A small condensing unit would be located on the exterior of the building below the existing exit balcony and could be screened to mitigate architectural / heritage impact. A ducted ERV was also proposed to be located in the basement ceiling and ducted to perimeter floor grilles to provide fresh air in the space. As this solution would add an electrical load for cooling (but not otherwise modify the existing heat system) it results in a moderate overall increase in CO^2 emissions.

Split chiller and ERV for chapel cooling and ventilation:

- 1.4% CO^2 increase. $422K

5. Domestic Hot Water Electrification

This measure investigates replacement of existing gas-fired domestic hot water (DHW) tanks with high-efficiency air source heat pump hot water tanks to significantly reduce GHG emissions. The heat pump hot water tanks would extract heat from the mechanical room to heat the DHW. A small electric boiler or VRF unit is proposed to be located in the mechanical room to prevent overcooling and ensure a stable source of heat.

The existing conditions include a natural gas boiler paired with storage tanks sized to serve the residence DHW requirements. There is a separate DHW system for the kitchen (installed in 2020/2021). The proposed electrification focuses on the residence water heating system since this equipment is at the end of its expected service life. Further analysis of this approach is provided in the body of the report.

Given CGUC's desire to maximize the carbon reductions achieved with the installation of electrified domestic water heating equipment, there may be a benefit to installing an interconnection between the two domestic water heating systems (residence and kitchen). Conceptually, this would allow the electrified system to operate as the primary heaters, running most of the time. The natural gas heaters for the kitchen can provide top-up heat for high-temperature uses (dishwashing, janitor sinks, etc.). Additionally, the natural gas water heaters can function as a partial backup system to the residence water heating needs. Future analysis would determine the preferred location for this interconnection and any required valving or controls needed for achieving the desired outcome.

Air Source Heat Pump DHW tanks:

- 7.9% CO^2 reduction. $101K

6. Sanitary Plumbing Refurbishment

The Owner identified ongoing maintenance issues related to sanitary drainage systems, including pipe backups. Given that the majority of sanitary piping is located within enclosed spaces, such as wall risers and below slab, an approach of pipe refurbishment rather than replacement is proposed. Existing sanitary drainage piping within the residence wing and through the existing dining hall space is proposed to be cleaned and re-lined with an epoxy coating (Nuflow system - www.nuflow.com) to reduce friction and improve drainage and prevent leakage at joints and fittings. Where coinciding work to renovate and reconfigure washrooms is occurring, the existing piping and traps will be replaced locally.

Sanitary piping epoxy lining:

- No impact on CO2 emissions. $64K

7. Envelope Upgrade (Wall Insulation)

The existing exterior walls consist of a double-wythe solid brick masonry infill between beams and columns of an exposed concrete structural frame which is expressed on the building facades. Multiple options to add insulation to the existing wall assembly were explored, taking into consideration cost, performance impact, and impact on the building's distinctive visual aesthetic and midcentury modern heritage character.

Options investigated include replacing the double-wythe solid masonry infill with a steel stud assembly with outboard mineral wool insulation, and either brick veneer or a fibre cement panel cladding. For both options, the concrete frame would remain exposed and uninsulated. The study also investigated the feasibility of over-insulating the entire building façade, including the exposed structural frame, and extending insulation onto the underside of the exposed concrete soffit overhangs at level 4. This would be achieved with either a fibre cement panel rain screen wall with mineral wool insulation positioned outboard of the existing structure and masonry wall, or an Exterior Insulated Façade System (EIFS) consisting of a stucco finish on mineral wool insulation. Lastly, a less intrusive approach of applying a spray-applied polyurethane foam insulation on the interior side of the existing masonry would not have any impact on the building appearance from the exterior, and could be sequenced with work to replace the existing radiators which would necessitate a new interior finish to the walls below the window units and provide opportunity for the spray foam to be applied simultaneous to that work.

Option 1. Replace brick masonry infill with brick veneer over insulated steel stud wall:
- 0.5% CO_2 reduction. $507K

Option 2. Replace brick masonry infill with fibre cement panel over insulated steel stud wall:
- 0.5% CO_2 reduction. $553K

Option 3. Fibre cement panel full wall overclad and outboard insulation:
- 1.1% CO_2 reduction. $745K

Option 4. EIFS full wall overclad and insulation:
- 1.1 % CO_2 reduction. $609K

Option 5. Spray applied foamed insulation on interior side of existing brick masonry infill walls:
- 0.5 % CO_2 reduction. $263K

8. Lighting Upgrade

Replacement of the existing incandescent and fluorescent light fixtures within the residence wing with LED fixtures was also briefly investigated. While this measure would reduce electricity consumption for lighting, it also results in a decrease in heat from lighting sources which in turn increases the heating demand on the mechanical system by a marginal amount. With the addition of cooling in the residence however, the replacement of light fixtures with LED fixtures would also mitigate added load on cooling systems in summer months. An upgrade to LED lighting would also reduce lamp replacement frequency, could provide improved lighting conditions (luminance, colour rendering, etc.) and could also be coupled with improvements in lighting controls, such as occupancy and daylight sensors, to optimize performance.

LED Lighting upgrade:
- 0.5 % CO_2 reduction. $235K

Package 1: Gender Neutral Washrooms

EXISTING CONDITIONS AND RETROFIT OBJECTIVES:

- Retrofit objective: Renovate existing washrooms on student residence floors to create gender neutral washrooms, improving existing conditions of access, privacy and safety, ventilation and accessibility.
- Each residence floor has three existing multi-stall washrooms, as well as one recently built universal washroom and shower.
- Existing washrooms are used a gender neutral but lack privacy, and proper ventilation.
- Existing sanitary pipes prone to clogs (see package 6 for pipe refurbishment)

PROPOSED RETROFIT SUMMARY:

- Several options were studied for refurbishment and reconfiguration of the existing multi-stall washrooms, as well as two options for reorganization of the washroom locations within each floor plan. The investigation resulted in 3 feasible options to renovate the existing washrooms at CGUC into gender neutral washrooms that prioritize inclusivity and privacy. Low flow fixtures are proposed in all options which reduce facility GHGs by 3% and water consumption by 17%. Each option includes new wall and floor finishes, new lighting, improved exhaust ventilation, full privacy partitions, and meet current OBC barrier free requirements.

  - Option 1: "Refresh" existing multi-stall washrooms. Scope includes new finishes, new plumbing fixtures and new privacy partitions with mechanical ventilation.

  - Option 2A, and 2B: Reconfigure each single bay multi-stall washroom to create small private washrooms (ensuite type). This option was deemed non viable due to code restrictions and dimensional constraints and was not considered further.

  - Option 3: Consolidated washrooms to create one double-bay multi-stall gender neutral washroom plus one refreshed single bay gender neutral washroom (option 1 scope) . Scope involves switching an adjacent residence room with a washroom, and knocking down the non-load bearing wall in between to create a double wide room (two structural bays) to be fit out as a gender neutral washroom. The existing universal washroom / shower room would remain.

  - Option 4: Consolidated washrooms to create one triple-bay gender neutral washroom on each floor. Scope involves switching two adjacent residence rooms with the two other washrooms on each floor and creating a single a triple-bay muilt-stall gender neutral washroom to serve all studets on each floor. The existing universal washroom / shower room would remain.

ENERGY AND COST SUMMARY

Energy Conservation Measure (ECM)	ECM Option	GHG Reduction		Cost
		tCO2e/yr	%/yr - full site	$
Low-flow Fixtures in Washrooms ("P1")	1 - Refresh	12	2.7	784,878
	3 - Double Bay			723,486
	4 - Triple Bay			642,462

EXISTING CONDITIONS AND CHALLENGES

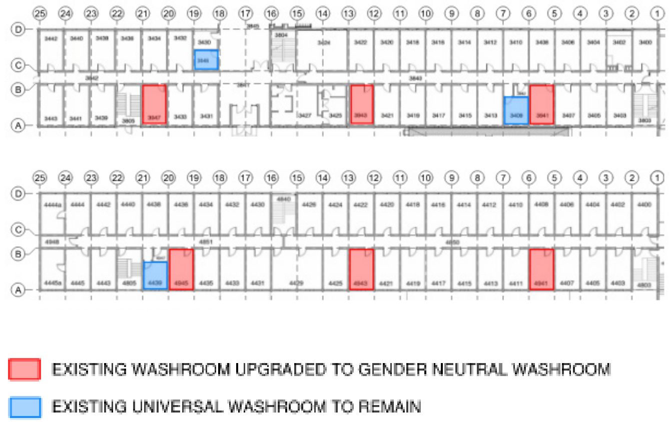
Shower stall doors / curtains are not secure and provide limited privacy

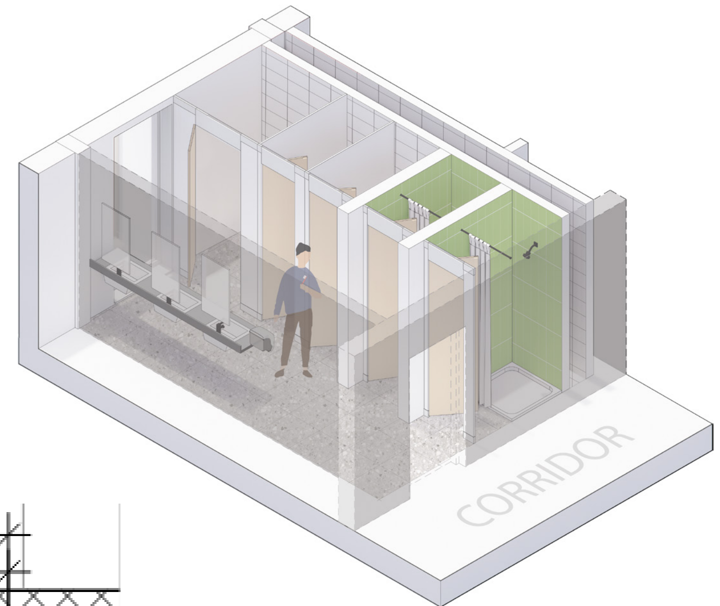
Waterclose stalls doors do not provide privacy required for a gender neutral washroom

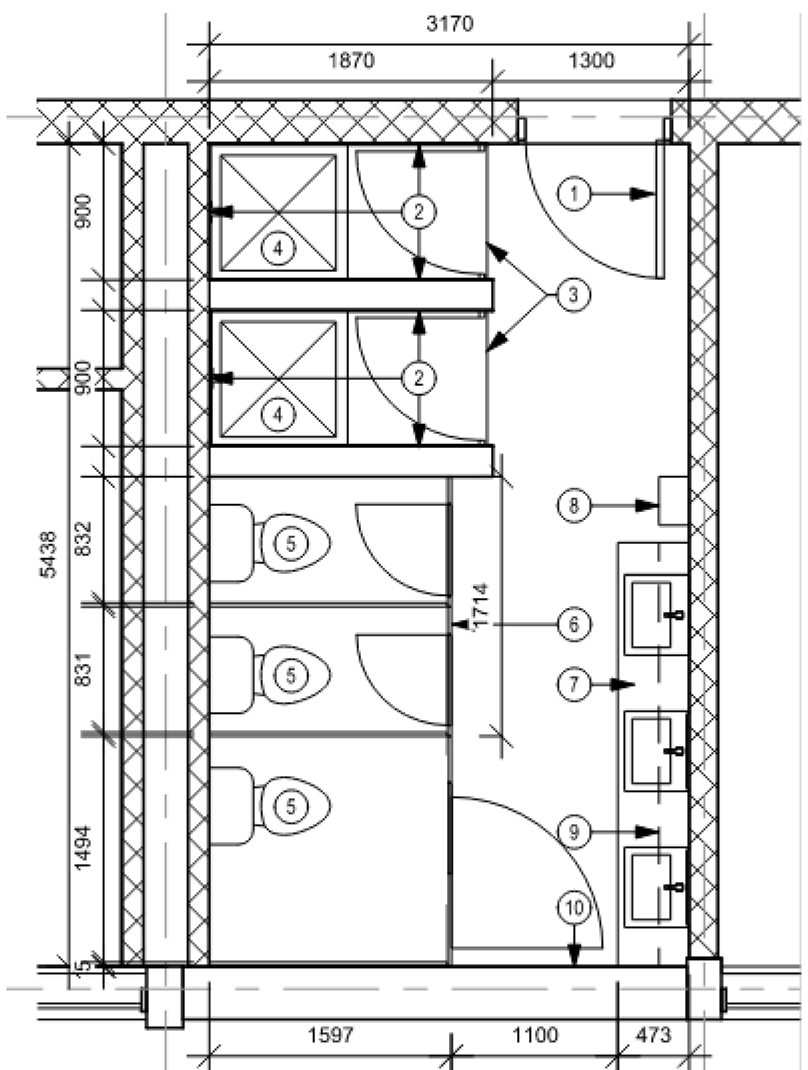
Existings step up into showers is awkward and non accessible

Lack of ventilation in showers

FULL PRIVACY PARTITIONS (ALL OPTIONS)

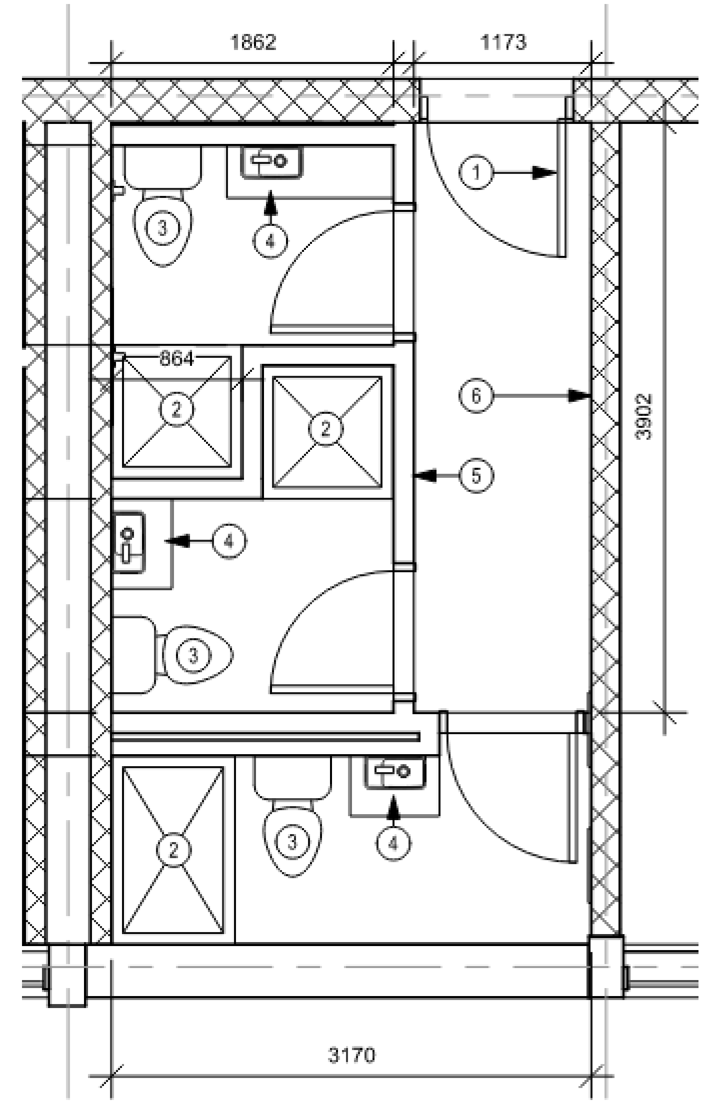


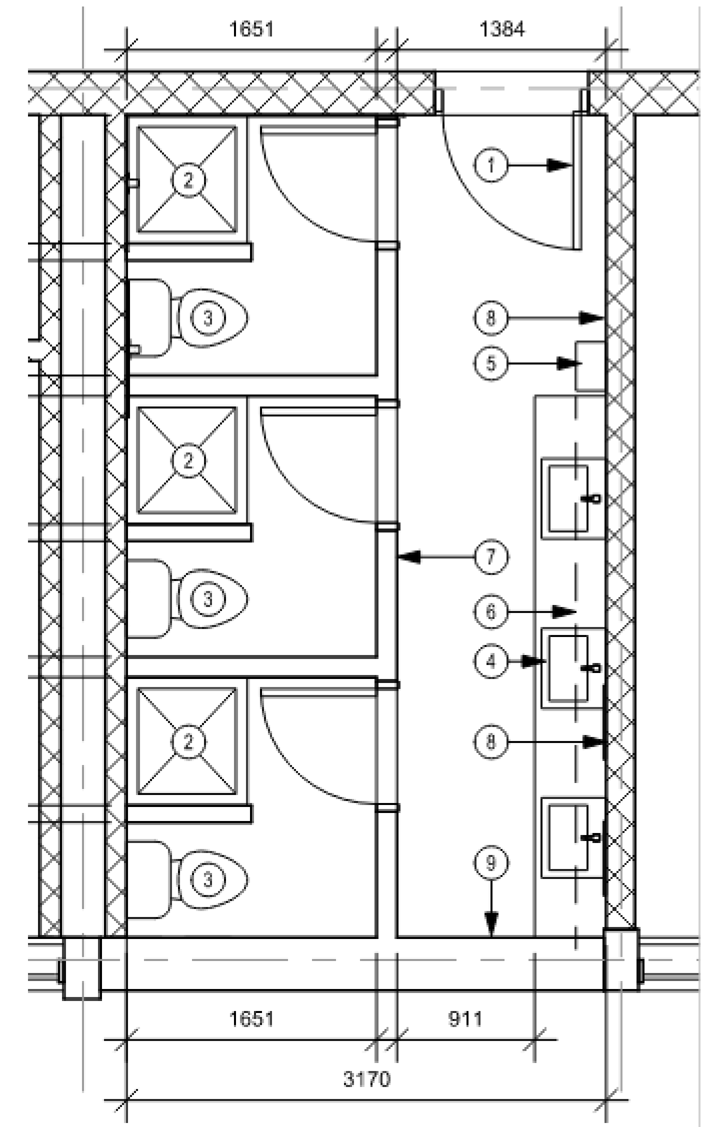




New full privacy partitions, new finishes and new fixtures

OPTION 1: REFRESH EXISTING MULTI-STALL WASHROOMS





OPTION 2A: ENSUITE

OPTION 2B: ENSUITEVARIATION

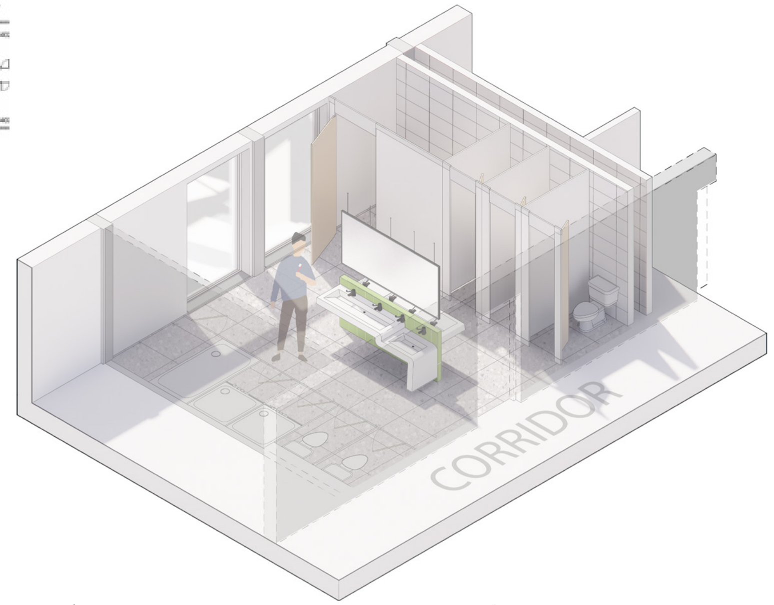
Option 2A and 2B investigated reconfiguraiton of the existing washroom spaces to create private multi fixture washroom stalls (ensuite type). These options were deemed non viable due to building code restrictions related to distance between barrier free washroom facilities, as well as due to lacking accessibility and inclusivity due to the small dimensions available for the washroom spaces.

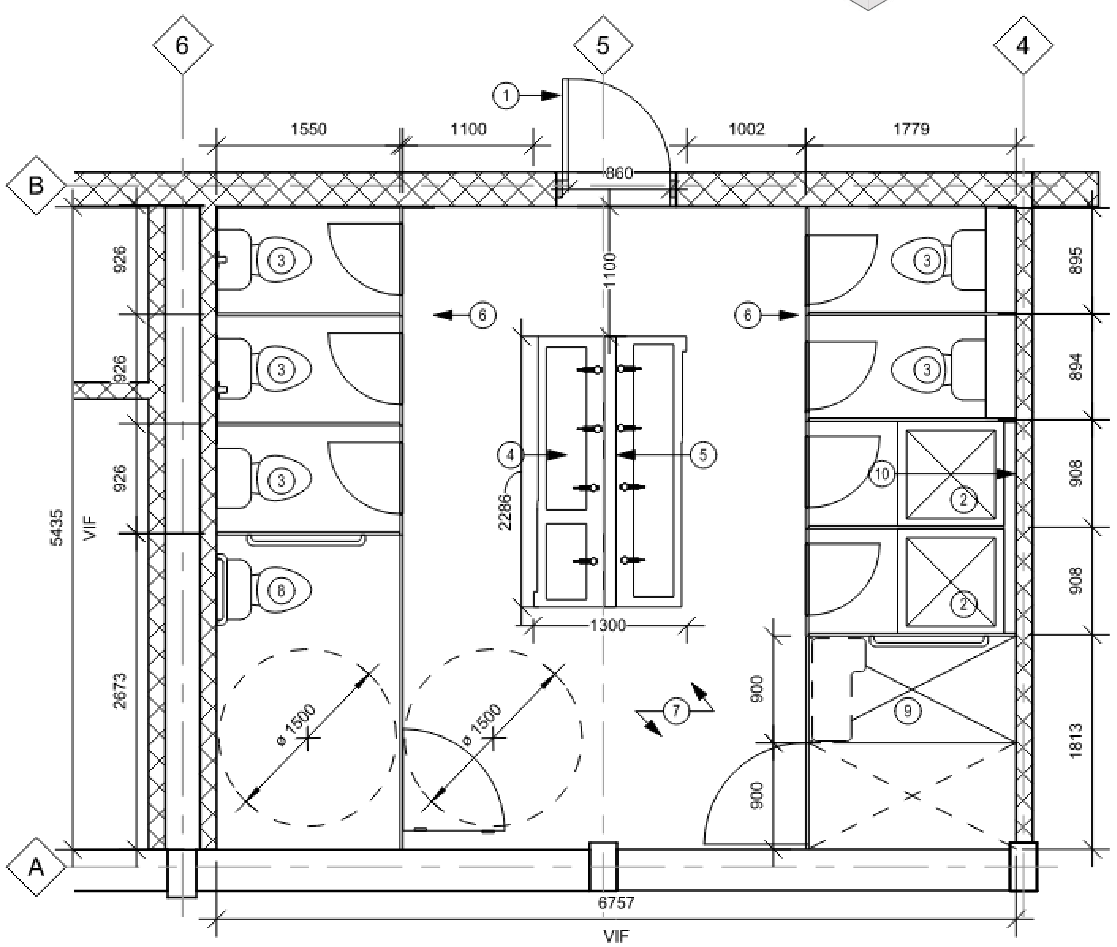
OPTION 2A, 2B: RECONFIGURE EXISTING WASHROOMS

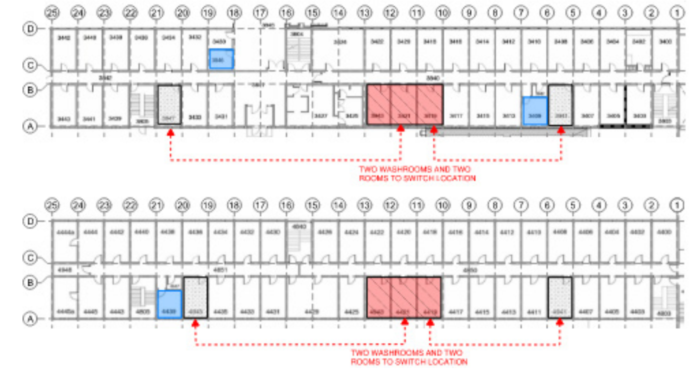
EXISTING WASHROOM UPGRADED TO GENDER NEUTRAL WASHROOM

EXISTING UNIVERSAL WASHROOM TO REMAIN

KEY PLAN



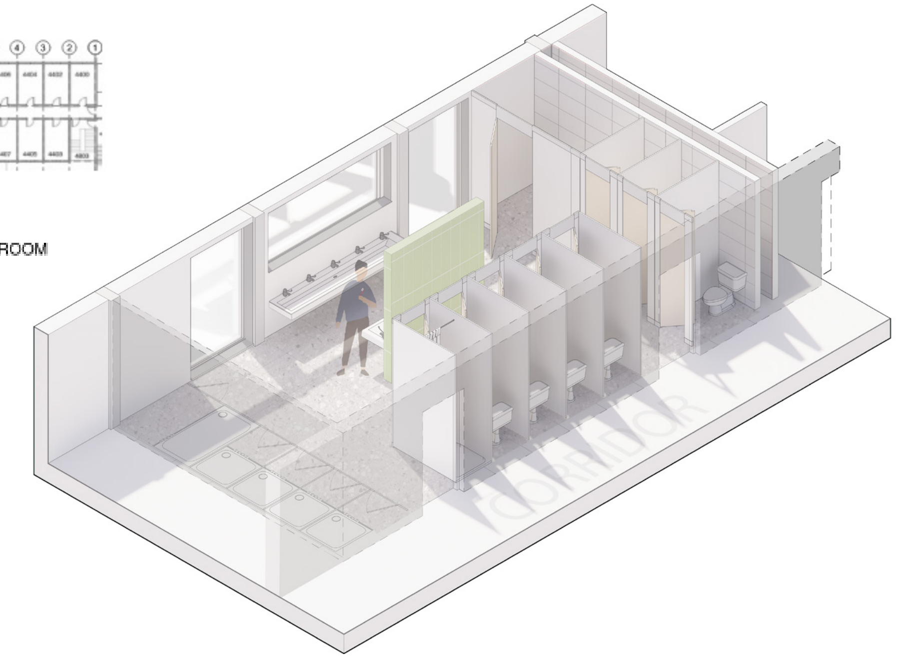


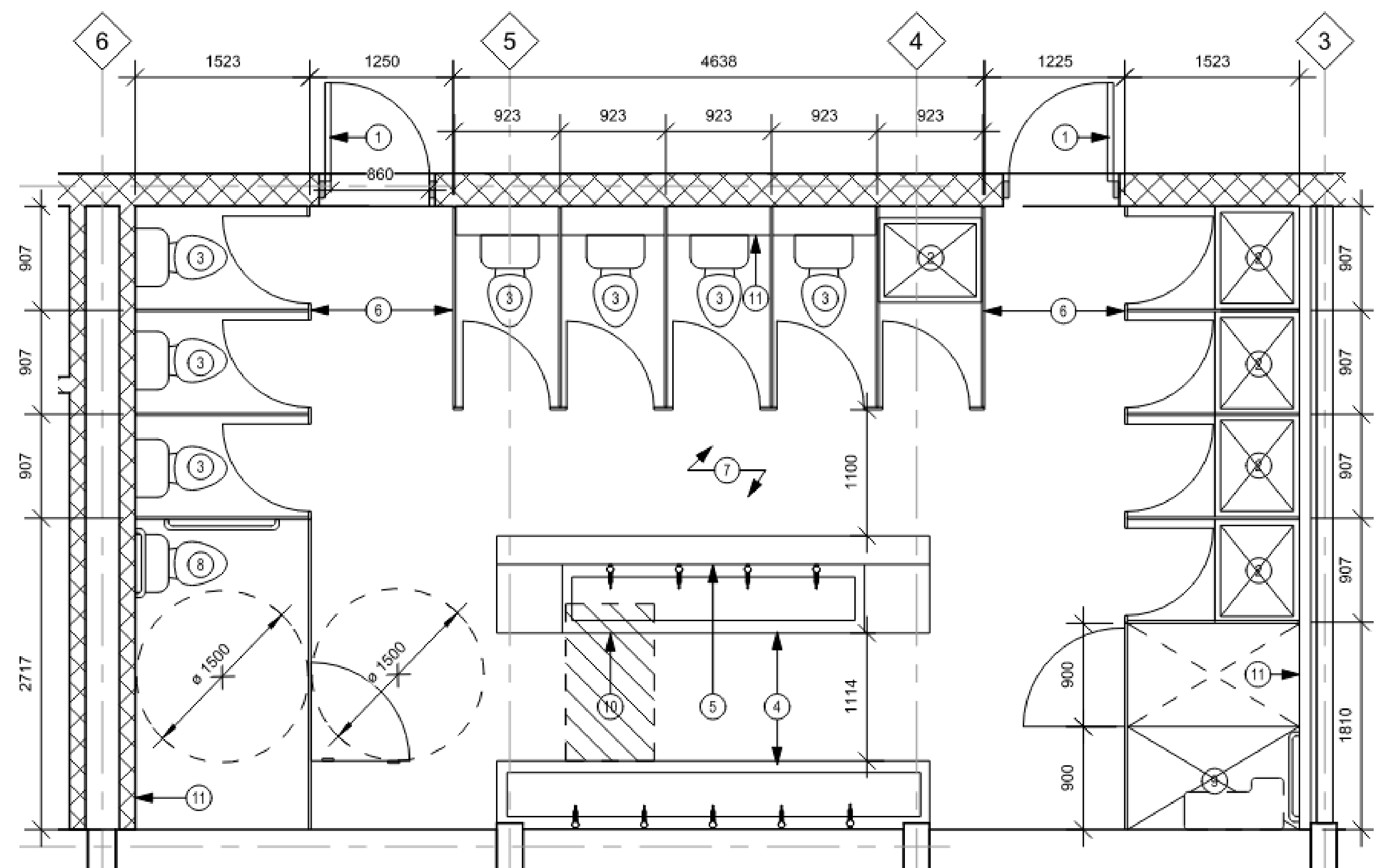


EXISTING WASHROOM UPGRADED TO GENDER NEUTRAL WASHROOM

EXISTING UNIVERSAL WASHROOM TO REMAIN

KEY PLAN





<u>OPTION 3: CONOLIDATED WASHROOMS</u>
ONE DOUBLE BAY, ONE SINGLE BAY

<u>OPTION 4: CONSOLIDATED WASHROOMS</u>
ONE TRIPLE BAY

Package 2: Windows

EXISTING CONDITIONS AND RETROFIT OBJECTIVES:

- Retrofit objective: Replace existing windows on level 3 and 4 of the residence wing to improve energy performance and occupant comfort.
- Existing windows in residence suites are typically double glazed units in non thermally broken aluminum frames. Calculated U value 1.6 W/m^{2}K.
- Existing stairwells are single glazed in non thermally broken aluminum frames. Calcluated U value 5.2 W/m^{2}K.

PROPOSED RETROFIT SUMMARY:

- Options for double glazed and triple glazed window replacement were explored. Triple glazed offers a marginal energy and carbon reduction for the complex, but also offers added benefits in terms of thermal comfort and mitigation of interior side condensation. Options for infilling the top “peak” portion of the level 4 windows with a solid insulated wall were also investigated. The use of high performance aluminum frames is propsoed. Fibreglass frames were investigated but are not permitted by the Ontario Building Code in a non sprinklered building due to combustibility concerns. The following 4 options are presented for window replacement:
-
    - 1A) Replace all windows with high performance triple glazed aluminum windows. U value 0.98 W/m^{2}K.
    - 1B) Replace all windows with high performance double glazed aluminum windows. U value 1.2 W/m^{2}K.
    - 2A) Replace all windows with high performance triple glazed aluminum windows and infill upper peaks at level 4 with solid infill wall. U value 1.36 W/m^{2}K (windows), 0.22 W/m^{2}K (walls)
    - 2B) Replace all windows with high performance double glazed aluminum windows and infill upper peaks at level 4 with solid infill wall. U value 1.2 W/m^{2}K (windows), 0.22 W/m^{2}K (walls)

Energy Conservation Measure (ECM)	ECM Option	GHG Reduction		Cost
		tCO2e/yr	%/yr - full site	$
Windows ("P2")	1A - Full replacement w/ triple glazing	2	0.9	1,145,995
	1B - Full replacement w/ double glazing	2	0.9	1,090,683
	2A - Infill peaks with triple glazing	5	1.1	1,143,613
	2B - Infill peaks with double glazing	4	0.9	1,096,738

OPTION 1A: TRIPLE GLAZED
OPTION 1B: DOUBLE GLAZED

OPTION 2A: TRIPLE GLAZED WITH PEAK INFILL
OPTION 2B: DOUBLE GLAZED WITH PEAK INFILL

HIGH PERFORMANCE ALUMINUM WINDOW SYSTEMS

Package 3: Residence Heating and Cooling

EXISTING CONDITIONS AND RETROFIT OBJECTIVES:

- Improve comfort and reduce energy and GHG emissions associated with heating and cooling in the residence rooms
- Existing conditions provide heating through hot water radiators connected to the gas fired boiler system
- No existing cooling system in residence wing
- No existing mechanical fresh air ventilation

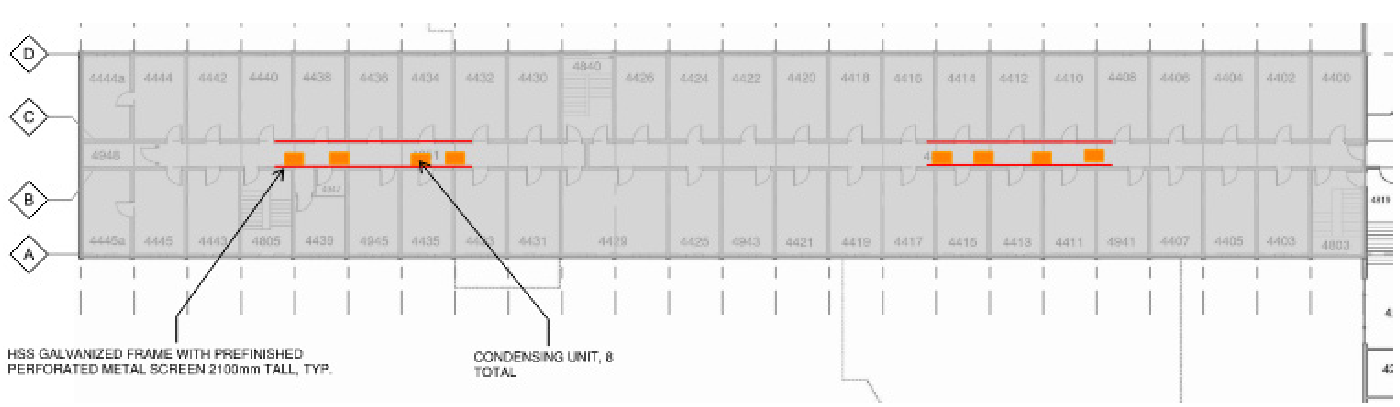
PROPOSED RETROFIT SUMMARY:

- High efficiency air source heat pump system with indoor VRF units
- 8 rooftop condensing units on roof of residence wing with architectural screening
- Individual VRF units within each residence room. Two options for VRF location are proposed for further consideration: (1) Wall mounted unit located underneath residence windows (2) ceiling mounted unit concealed in gypsum bulkhead
- Through-wall ductless Energy Recovery Ventilator (ERV) proposed for each suite to improve indoor air quality
- Base building electrical service upgrade is required to address new electrical loads from added cooling and conversion of heating fuel source (gas to electric)

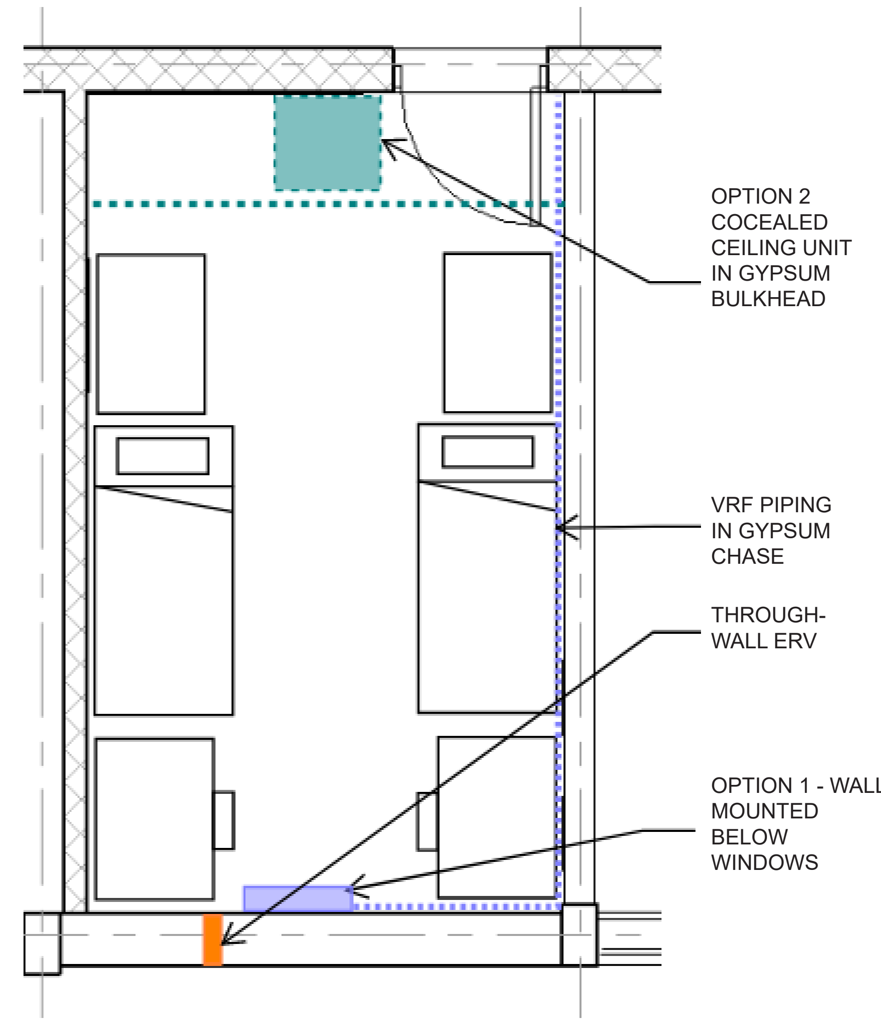
ENERGY AND COST SUMMARY

Energy Conservation Measure (ECM)	ECM Option	GHG Reduction		Cost
		tCO2e/yr	%/yr - full site	$
Heat Pumps ("P3")	1 - Wall unit*	30	6.8	3,217,157
	2 - Ceiling unit*			3,261,297
ERVs ("P3")	n/a	-8	-1.8	Included

*Cost above include $478,164 electrical upgrade cost



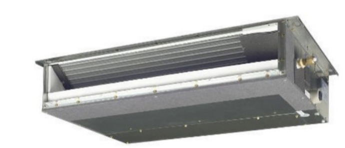
ROOFTOP PLAN



TYPICAL RESIDENCE PLAN

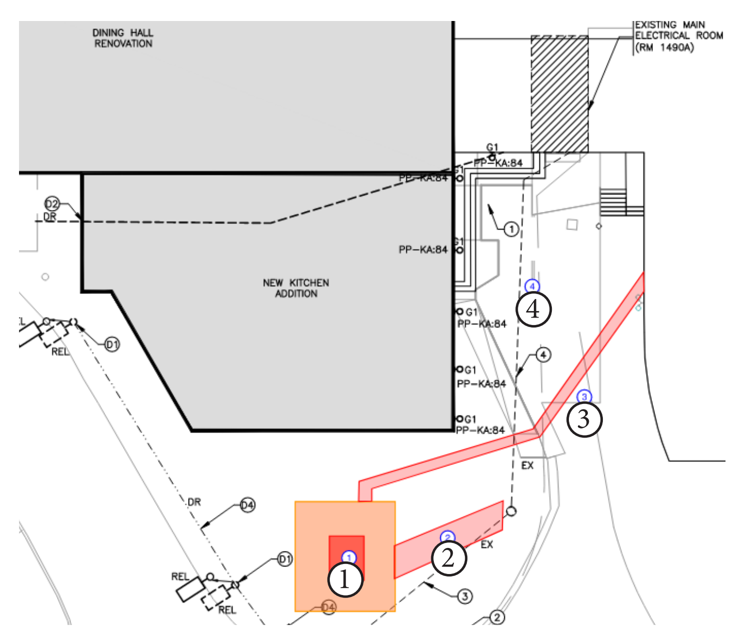
ROOFTOP CONDENSING UNIT

THROUGH-WALL ERV



CEILING VRF UNIT

WALL VRF UNIT



ELECTRICAL UPGRADE SITE PLAN

1. NEW ENOVA PADMOUNTED TRANSFORMER (RED) AND EASEMENT (ORANGE)
2. NEW UNDERGROUND PRIMARY DUCTBANK FROM EXISTING POLE
3. NEW UNDERGROUND SECONDARY FROM TRANSFORMER TO NEW SERVICE ENTRANCE SWITCH IN BASEMENT. CAREFUL EXCAVATION REQUIRED DUE TO EXISTING SERVICES IN LANEWAY.
4. EXISTING SECONDARY TO BE REMOVED AND CONDUITS CAPPED.

Package 4: Chapel Cooling

EXISTING CONDITIONS AND RETROFIT OBJECTIVES:

- Retrofit objective: Add cooling to the chapel. Avoid any acoustical impact from mechanical system noise/
- Existing conditions provide heating through hot water radiators connected to the gas fired boiler system
- No existing cooling in chapel
- No existing mechanical ventilation

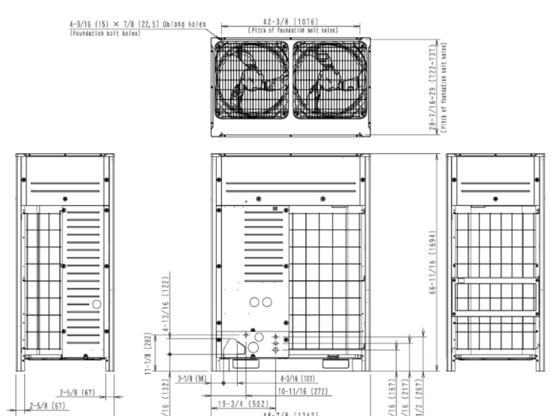
PROPOSED RETROFIT SUMMARY:

- Three options explored, including:
  - 1) Packaged Air Handling Unit. This option was deemed non viable due to equipmet size
  - 2) Ducted VRF in basement ceiling. This option was deemed non viable due to acoustical impact
  - 3) Replace existing perimeter radiators with two pipe fan coil units. Heating provided from existing hot water system. A split chiller system will be added and piped to the fan coil units to provide cooling. The outdoor condensing unit is proposed to be located below the existing exit landing and provided with and architectural screen.
- A ducted energy recovery ventilator (ERV) is proposed to be located in the baement below the chapel space, and ducted to perimeter floor grilles to improve indoor air quality and ventilation in the space.

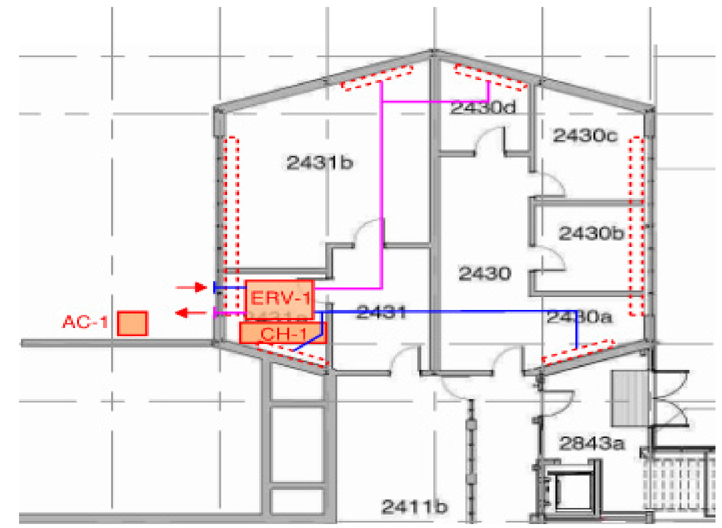
ENERGY AND COST SUMMARY

Energy Conservation Measure (ECM)	ECM Option	GHG Reduction		Cost
		tCO2e/yr	%/yr - full site	$
Chapel Cooling ("P4")	3 - Perimeter fan coils	-6	-1.4	422,266

OPTION 1: AHU
(Deemed non viable due to equipment size on site)

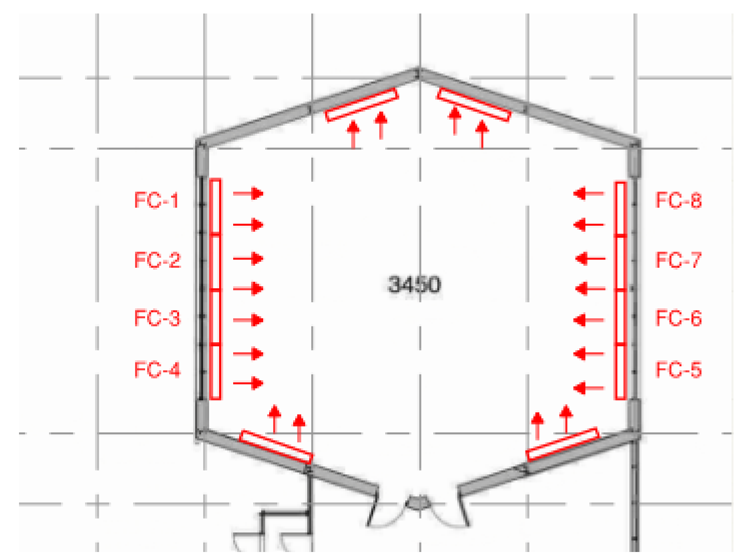


OPTION 2: DUCTED VRF
(Deemed non viable due to acoustical impact)

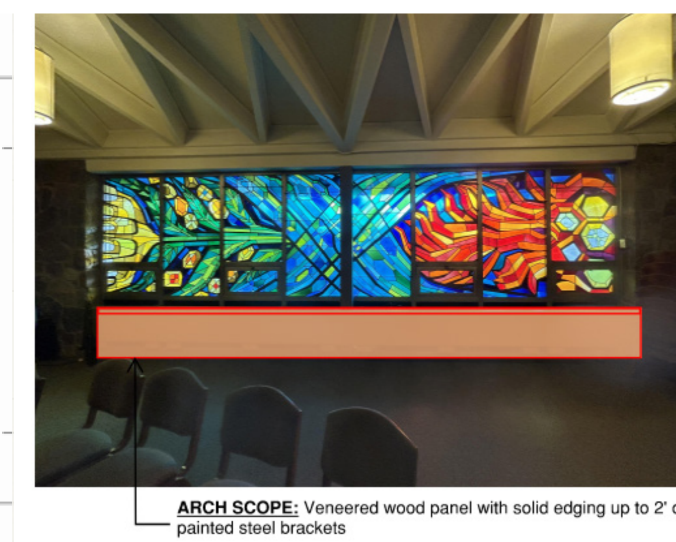


BASEMENT PLAN
SHOWING ERV AND INDOOR CHILLER UNIT

OUTDOOR CONDENSING UNIT



CHAPEL PLAN
SHOWING PERIMETER FAN COIL UNITS AND FLOOR REGISTERS



PERIMETER FAN COIL UNITS BELOW WINDOWS

OPTION 3: FAN COIL UNITS AND SPLIT CHILLER

Package 5: Domestic Hot Water Electrification

EXISTING CONDITIONS AND RETROFIT OBJECTIVES:

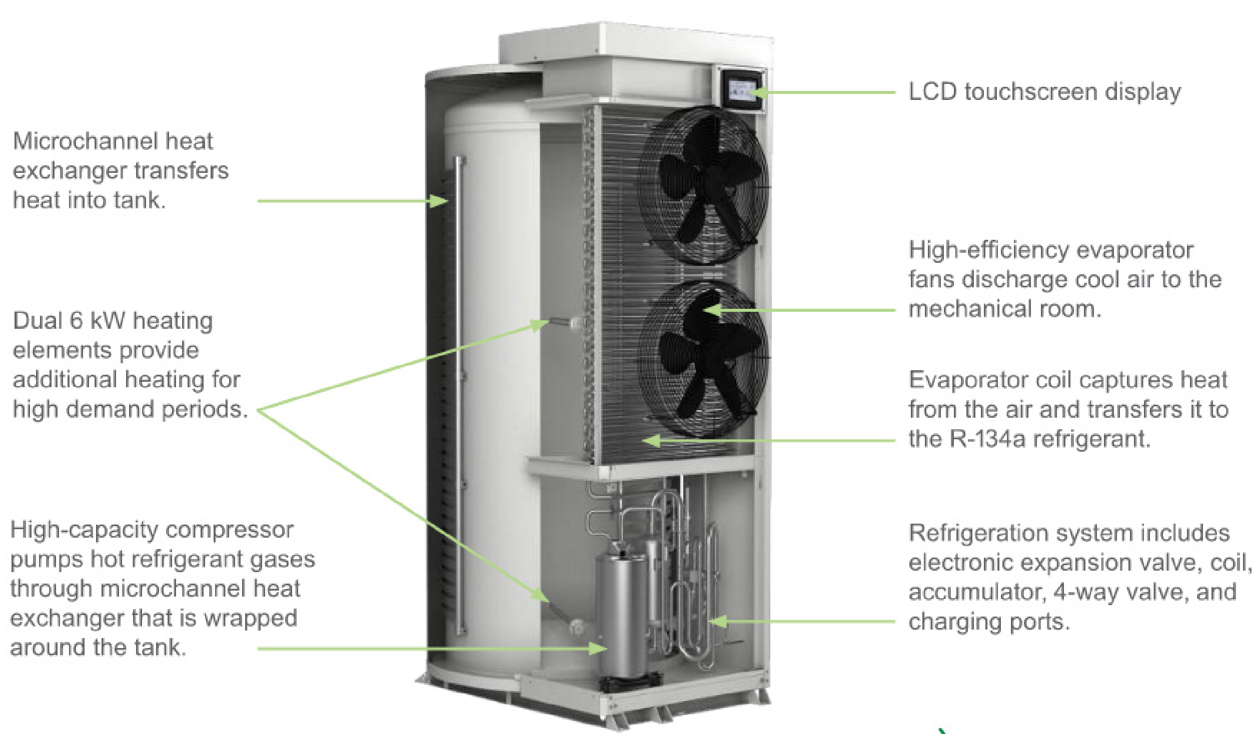
- Retrofit objective: Explore the replacement of existing gas fired domestic hot water tanks serving the residence wing with new air source heat pump hot water tanks to reduce greenhosue gas emissions.

PROPOSED RETROFIT SUMMARY:

- Replace two existing gas fired hot water tanks with commercial heat pump domestic hot wter system.
- Provide a small electric boiler or VRF to ensure stable soruce of heat within the mechanical room to prevent over cooling the room.

ENERGY AND COST SUMMARY

Energy Conservation Measure (ECM)	ECM Option	GHG Reduction		Cost
		tCO2e/yr	%/yr - full site	$
Heat Pump Domestic Hot Water ("P5")	n/a	35	7.9	101,485



COMMERCIAL HEAT PUMP DOMESTIC WATER HEATER

Package 6: Plumbing Sanitary Refurbishment

EXISTING CONDITIONS AND RETROFIT OBJECTIVES:

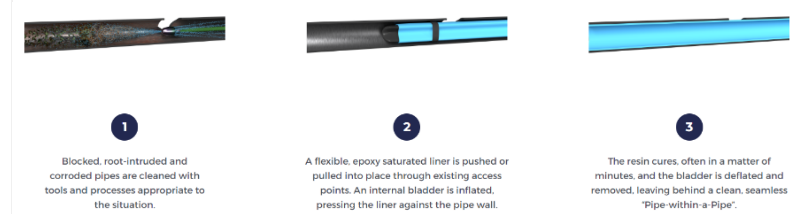
- Retrofit objective: Replace or repair aged existing sanitary piping to address existing issues with pipe clogs and poor drainage

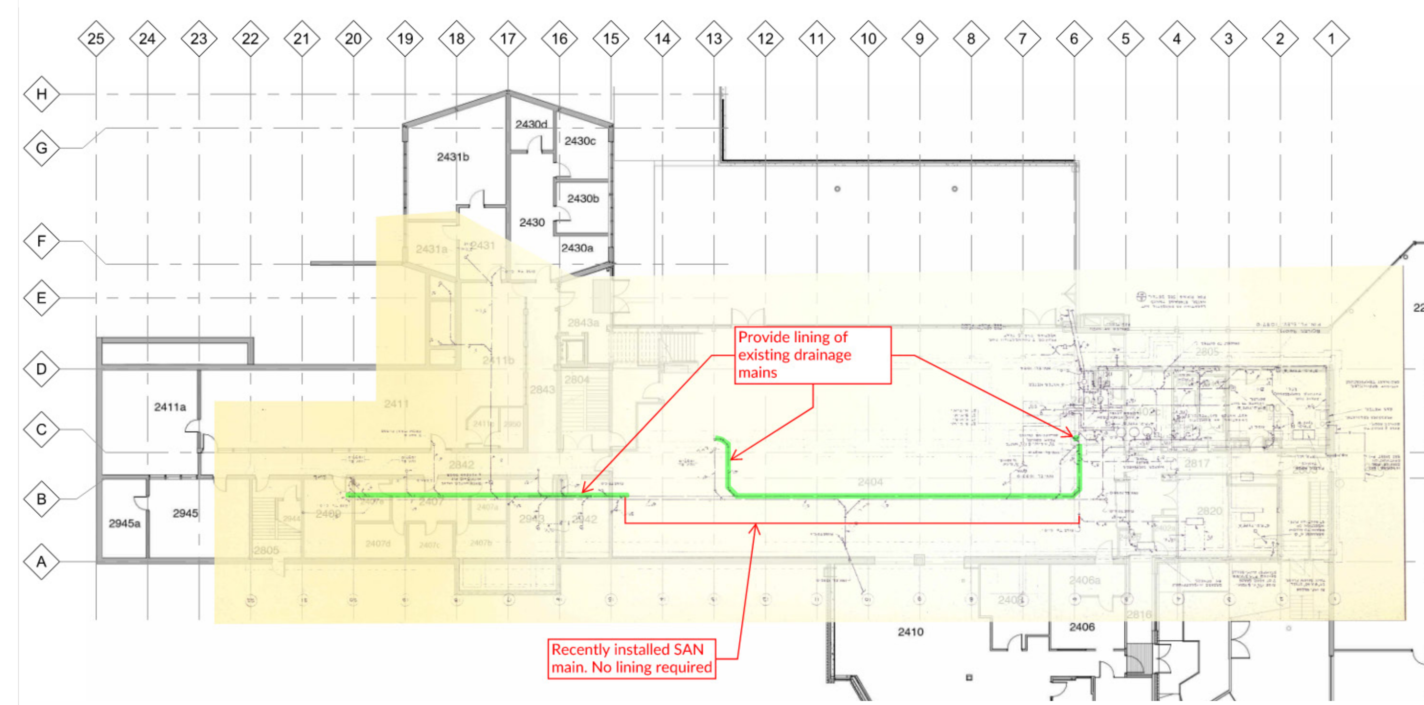
PROPOSED RETROFIT SUMMARY:

- Existing sanitary drainage piping within the residence wing and through the existing dining hall space is proposed to be cleaned and re-lined with an epoxy coating (Nuflow system - www.nuflow.com) to reduce friction and improve drainage. Existing drainage piping and P-traps to be replaced locally where washroom renovations are proposed.

ENERGY AND COST SUMMARY

Energy Conservation Measure (ECM)	ECM Option	GHG Reduction		Cost
		tCO2e/yr	%/yr - full site	$
Plumbing Sanitary Refurbishment	n/a	n/a	n/a	64,063





EXISTING SANITARY PIPING

Package 7: Walls - Insulation and Cladding

EXISTING CONDITIONS AND RETROFIT OBJECTIVES:

- Retrofit objective: Explore options for overcladding and insulating existing exterior walls of the residence wing as a means to reduce energy use and GHG emissions.
- Existing exterior walls are an unisulated double wythe clay brick assembly with a nomimal layer of interior side rigid insulation (25mm) and drywall / plaster board finish on metal studs. Calculated U value: 0.906 W/m²K.

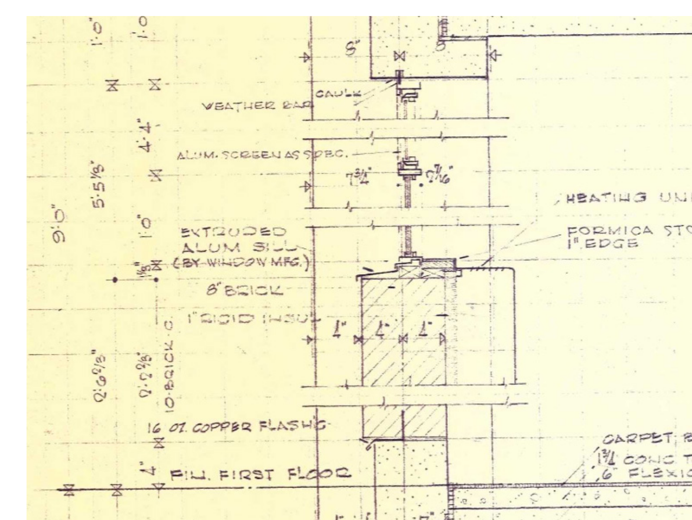
PROPOSED RETROFIT SUMMARY:

- A total of five (5) options were exlpored:
  - 1) Replace existing double wythe brick wall below window openings with steel stud wall assembly, 200mm semi rigid mineral wool insulation and brick veneer cladding. Proposed U value 0.16 W/m²K.
  - 2) Replace existing double wythe brick wall below window openings with steel stud wall assembly, 200mm semi rigid mineral wool insulation and fibre cement panel cladding. Proposed U value 0.16 W/m²K.
  - 3) Overclad existing double wythe brick wall below window openings with 100mm semi rigid mineral wool insualtion fibre cement panel cladding, and overclad exposed concrete structural framing with 50mm semi ridig mineral wool insulation and fibre cement cladding. Proposed U value: 0.266 W/m²K.(wall) 0.281 W/m²K (columns)
  - 4) Overclad existing double wythe brick wall below window openings with 100mm semi rigid mineral wool insualtion fibre cement panel cladding, and overclad exposed concrete structural framing with 50mm semi ridig mineral wool insulation and fibre cement cladding. Proposed U value: 0.266 W/m²K.(wall) 0.281 W/m²K (columns)
  - 5) Add new offset framing with drywall finish and 75mm of spray foam insulation to interior side of existing brick infill walls. Proposed U value: 0.313 W/m²K

ENERGY AND COST SUMMARY

Energy Conservation Measure (ECM)	ECM Option	GHG Reduction		Cost
		tCO2e/yr	%/yr - full site	$
Walls ("P7")	1 - Replacement with brick veneer	2	0.5	507,180
	2 - Replacement with fiber cement pane	2	0.5	552,493
	3 - Overclad with fiber cement panel	5	1.1	744,641
	4 - Overclad with EIFS	5	1.1	609,250
	5 - Interior replacement	2	0.5	263,156

TYPICAL EXISTING FACADE BAY (EAST SIDE)



EXISTING SECTION DETAIL AT WINDOW

OPTION 1: BRICK VENEER INFILL

OPTION 2: FIBER CEMENT PANEL INFILL

OPTION 3: FIBER CEMENT PANEL OVERCLAD

OPTION 4: EIFS OVERCLAD

OPTION 5: INTERIOR INFILL (RETAIN FACADE)

Package 8: Lighting Upgrade

EXISTING CONDITIONS AND RETROFIT OBJECTIVES:

- Retrofit objective: Explore the energy benefits of replacing the existing incandescent/fluorescent lighting fixtures in the residence wing with LED fixtures.

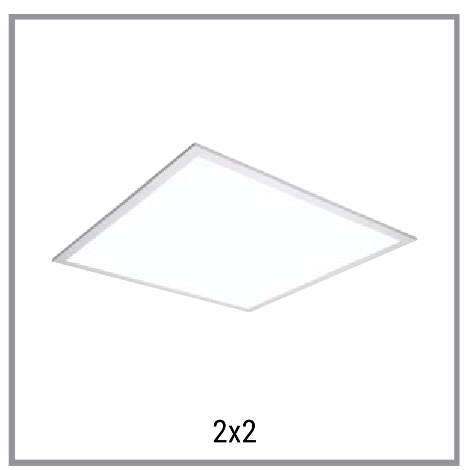
PROPOSED RETROFIT SUMMARY:

- The following fixtures would be included in this retrofit solution: fixtures above washroom vanities (12), 2x2' corridor light fixtures (60), new dorm room pendents (70), and new downlights in the shower rooms (12)
- This measure reduced electricity consumption for lighting, it also increases heating demands for the mechanical system due to a lack of emitted heat.
- LED lighting upgrade would reduce lamp replacement frequency, improve lighting conditions (luminance, colour rendering etc.), and could be coupled with lighting controls to optimize performance.

Proposed shower room fixture

Proposed washroom vanity fixture

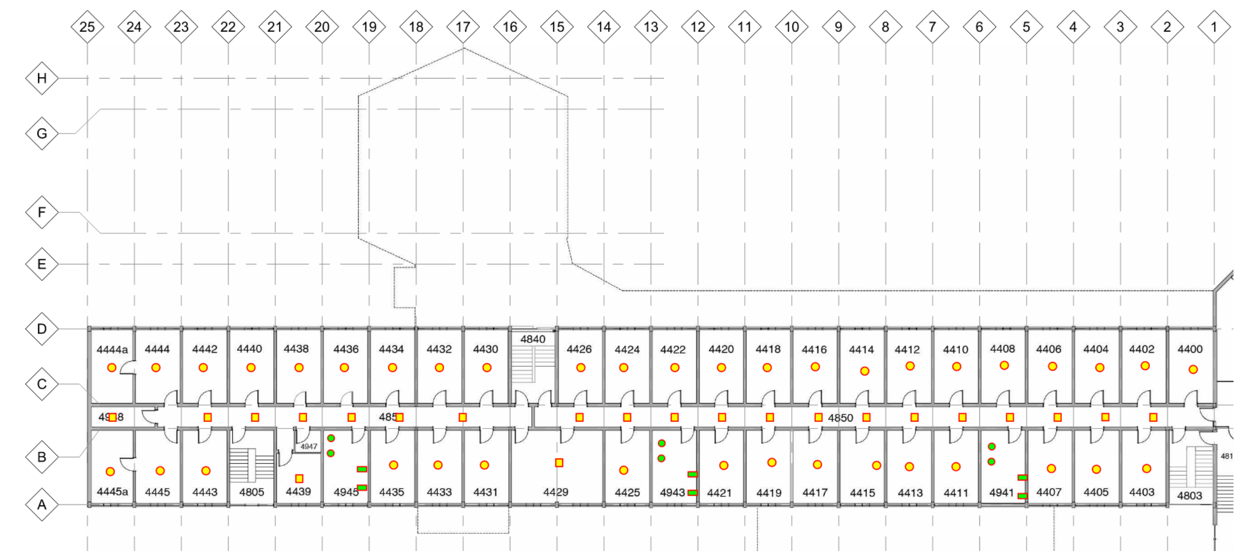
Proposed dorm room pendent



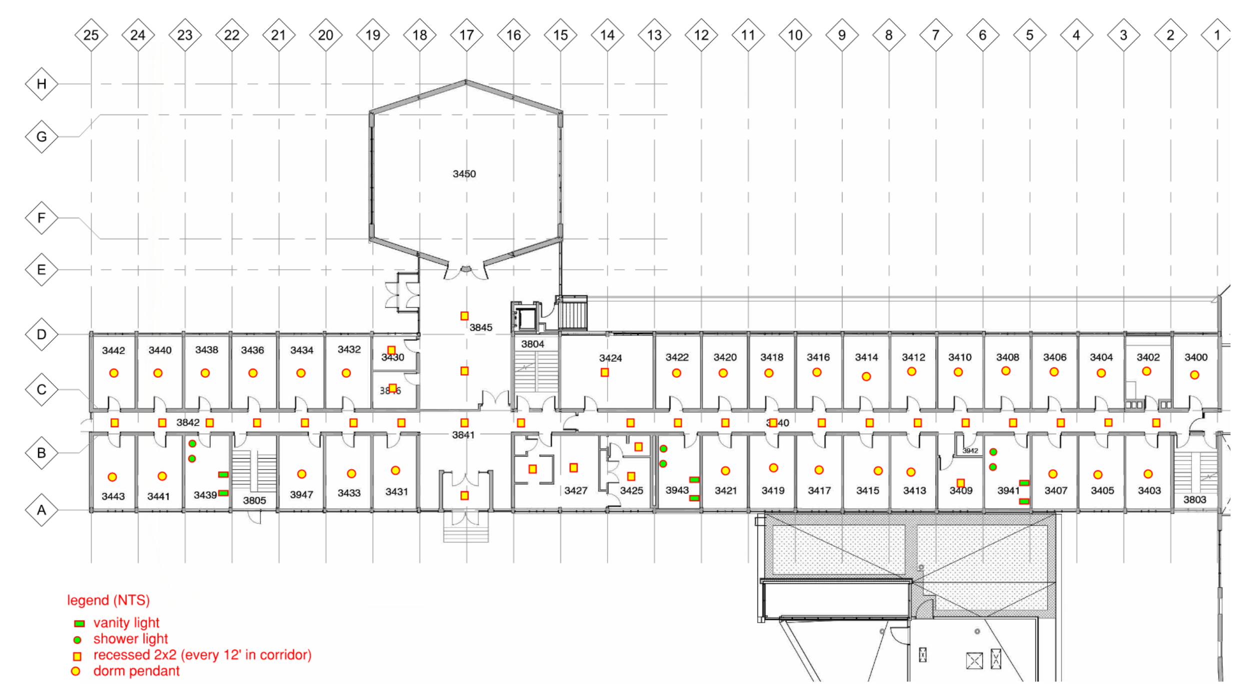
Proposed dorm corridor fixture

ENERGY AND COST SUMMARY

Energy Conservation Measure (ECM)	ECM Option	GHG Reduction		Cost
		tCO2e/yr	%/yr - full site	$
LEDs ("P8")	n/a	2	0.5	234,938



Proposed Level 4 light fixture replacement | NTS



Proposed Level 3 light fixture replacement | NTS

4.0

OPTION SELECTION, SCOPE PRIORITIZATION & IMPLEMENTATION

Proposed design solutions, along with projected GHG impacts and budgetary estimated costs, were presented to GCUG management in spring 2024. Through subsequent discussion and review between CGUC and the Consultant Team, preferred options were identified for each retrofit measure, and a final prioritized list of retrofit stages for potential future staged implementation was identified as follows:

***Stage 1:* Baseline / Existing Condition**

***Stage 2:* Electrify the domestic hot water system for residence using air source heat pump hot water tanks to replace existing gas fired hot water tanks.**

This measure has high value in realizing immediate reductions in GHG emissions for a relatively low capital cost, and the equipment is due for replacement soon. The work is primarily located in the mechanical room, and can be implemented in the near future with minimal disruption to building occupants.

Stage 1 (Baseline)

ECM	Carbon Reductions (full site relative to baseline)		Cost ($)
	tCO2e/yr	%/yr - full site	
Baseline	442	n/a	0

Stage 2

ECM	Carbon Reductions (full site relative to baseline)		Cost ($)
	tCO2e/yr	%/yr - full site	
Domestic Hot water air source heat pump	407	7.9	101,485
		total:	$ 101,485

Stage 3

ECM	Carbon Reductions (full site relative to baseline)		Cost ($)
	tCO2e/yr	%/yr - full site	
Domestic Hot water air source heat pump	406	8.1	101,485
Low-flow water fixtures			784,878
		total:	$ 886,363

***Stage 3:* Implement washroom upgrades and undertake refurbishment of sanitary drainage piping.**

Upon review of the washroom configuration options, CGUC indicated preference for Option 3, to combine two existing washroom bays in the "long end" of the residence floor and reconfigure as a larger gender-neutral washroom occupying two structural bays. The third washroom, located in the "short end" of the building on each floor would be refreshed in its current layout to be a functional gender-neutral washroom. This approach will allow the floors to be used flexibly and for varying occupant groups throughout the year. An example of this would be in the summer month when the "short end" of the floor plate is often used for shorter term rentals, and the "long end" for visiting groups or individuals with regular undergraduate student occupants throughout the year. All upgraded washrooms would include new low flow fixtures, new finishes, privacy partitions and functional shower and general room ventilation and exhaust.

Refurbishment of the existing sanitary drainage lines would be planned to occur at the same time as the washroom upgrades. Where the washroom work is taking place on levels 2 and 3, and in the ceiling of level 1, existing piping could be replaced where it is exposed and easily accessible. In other areas where existing piping is concealed in shafts, walls or below slab, the internal epoxy coating system would provide improved drainage, reduced blockages, and improved pipe seals.

Undertaking washroom upgrades and refurbishing the sanitary systems must be strategically planned to minimize disruption to building occupants and down-time of the washrooms and plumbing systems.

Refurbishment of the sanitary piping would impact piping all the way to the building outflow point, and would therefore entail a brief period (1 day) where all plumbing systems would need to be shut off. This work could be done over a term break (winter break for example) when the building would be largely unoccupied.

Washroom renovations would result in temporary loss of access to at least one of the three existing washrooms on each floor at a given time. Work sequencing for the washrooms could be as follows:

1. Renovate the single bay washroom in the short end, with residents temporarily using one of the other two single bay washrooms in the main corridor while work is taking place.
2. Renovate/expand one of the single bay washrooms in the main corridor into a double bay washroom. The renovated washroom in the short end, plus the other single bay washroom in the main corridor would remain in operation. One residence room would be lost during this time period.
3. Once the double bay washroom is operational, the remaining unrenovated single bay washroom would be renovated back into a residence room.

Renovation of the washrooms in the proposed double bay configuration would require one residence room currently adjacent to a washroom to be converted into part of the enlarged double bay washroom. Similarly, this proposed reconfiguration would result in one of the existing washrooms being converted into a residence room. The changing use and layout of the spaces within three structural bays on each floor (from washroom to residence room or vice versa) would also require reconfiguration of the exterior windows in these areas. As such, in order to complete the work as designed, replacement of the windows and infill wall assembly in three structural bays

Stage 4

ECM	Carbon Reductions (full site relative to baseline)		Cost ($)
	tCO2e/yr	%/yr - full site	
Domestic Hot water air source heat pump	369	16.5	101,485
Low-flow water fixtures			784,878
Air source VRF with residence room ERV			3,217,157
Wall Option 5: Spray applied foamed insulation on interior side of existing brick masonry infill walls			263,156
		total:	$ 4,366,676

Stage 5

ECM	Carbon Reductions (full site relative to baseline)		Cost ($)
	tCO2e/yr	%/yr - full site	
Domestic Hot water air source heat pump	368	16.7	101,485
Low-flow water fixtures			784,878
Air source VRF with residence room ERV			3,217,157
Wall Option 5: Spray applied foamed insulation on interior side of existing brick masonry infill walls			263,156
Windows Option 1A: Full replacement high performance triple glaze windows			1,145,995
		total:	$ 5,512,671

on each floor would be required as part of implementing the washroom retrofit scope.

***Stage 4:* Install residence cooling and heating upgrades (ASHP and VRF), and wall insulation (inboard side)**

Conversion of the residence heating system to electric air source VRF offers significant improvements in operational efficiency and occupant comfort. The proposed system will also provide cooling, and is proposed to be coupled with the addition of single room through-wall energy recovery ventilator units to improve indoor air quality within the residence area.

Of the options investigated for placement of the VRF terminal units, locating these as floor-mounted units below the windows has a slight cost advantage, mainly because of the ability to avoid adding condensate pumps since condensate can be run easily out through the exterior wall which is typical practice with split unit cooling systems.

The existing hot water radiant heaters positioned below the windows are integrated into the wall finish in this area. Removal of these units to install the new VRF units would therefore also require a new interior finish (drywall or similar) on the interior side of the brick wall below the windows. There would be a logical economy in combining the installation of the VRF system with application of the proposed 75mm of closed cell polyurethane foam insulation onto the back of the brick prior to constructing the new drywall finish, as proposed in the exterior wall upgrade option 5 above. Prior to undertaking this work, design work in the future stages of project implementation should include a hygrothermal analysis of the existing brick masonry to confirm that the addition of spray foam on the interior side will not cause any detrimental impacts or premature deterioration of the brick due to impact on masonry drying and temperature / freeze-thaw cycles. While the existing brick appears in good condition and it is anticipated that the addition of spray foam will not create any technical concerns, this type of analysis is typical and common as part of good building science practice.

It is anticipated that installation of the new heat pump and VRF system should be scheduled to occur outside of the heating season, between mid-April or early May to late September or mid-October. Lead times for mechanical equipment will need to be planned for and factored into work scheduling. The contractor could also pre-fabricate standardized pipe runs or components to minimize time required inside of each residence room. Piping connections from the roof top outdoor units would need to be distributed to each interior VRF terminal unit. This piping would be organized to run along the roof and down several new small shafts that would be positioned within select residence rooms. Piping that will need to run from the corridor ceiling level within each residence room to the VRF terminal unit at the outer wall would either be left exposed and jacketed or could be concealed in a pre-fabricated metal bulkhead enclosure to minimize the need for messy drywall work within the residence room, and above desks and beds.

***Stage 5:* Replace existing windows with high performance models**

The last stage of work would be the replacement of the existing non thermally broken windows with high performance thermally broken units, with triple or double glazing. As noted above, the estimated cost premium for triple glazing is minimal, while the increase to triple glazing offers improvements in occupant comfort and indoor environmental quality. That said, pricing for both double and triple glazed higher performance thermally broken window systems could be carried through to a supply tender to defer decision making on window type until actual costs are presented from industry / trades.

Installation of the new windows will be disruptive to students living in each room while work is being done to remove the existing window, prepare the opening, install the new window and complete perimeter connections and seals, as well as interior finishes such as a new interior window stool (interior sill) etc. Conducting this work while rooms are occupied is possible, however it may present challenges such as disruption to students study work etc, construction safety issues and the need for contractors to delineate a work zone near the window that students would not enter, as well as possible issues around property safety, theft, harassment etc. that would need to be planned for in order to avoid problematic scenarios that could impact the work, or more importantly student safety and comfort.

An alternative to conducting the work within occupied rooms, would be to deploy a “hotelling” approach. In this approach, there would be 2-4 rooms taken out of operation on each floor at one time, located immediately above and below each other or in immediately adjacent structural bays of the elevation. These rooms could be unoccupied for several days while work is taking place to install the new windows and associated secondary work. Work would then move over to the next set of rooms and the students occupying them would temporarily “hotel” in the first set of rooms. As work moves on to the third set of rooms, students that are in the “hotel” rooms would move back to their original / permanent rooms, and another set of students would be displaced into the “hotel” rooms for a week or so while work takes place in their rooms etc. This approach would require well planned sequencing by the contractor / construction manager, and a “just in time” commitment for material delivery from the suppliers, or capacity for on site or off site material storage by the contractor to ensure that the materials are sequenced and available on site in small batches and at the timing required to maintain flow from one set of rooms to the next.

A qualitative evaluation of contractors bidding this work would be required and ultimately the contractors would need to propose the most functional approach to sequencing the work, that meets certain parameters set by CGUC, such as setting out a maximum number of rooms that can be available at any one time on a floor, prescribing any time limitations for noisy work etc.

Other Considerations:

While stage 2, 3, and 5 scopes (DHW, washrooms, and windows) could all potentially be achieved within the available project budget, stage 4 work (heat pumps) has been prioritized over stage 5 (window replacement) due to the large impact on GHG reduction this measure provides. If CGUC anticipates a potential funding pathway to achieving the heat pump upgrades, this should be prioritized. Alternatively, CGUC may consider including window replacement as part of early stage works, within the current available funding, as this intervention will provide measurable and meaningful improvements to occupant comfort, and indoor environmental quality, in addition to nominal GHG reductions.

It was decided by CGUG that the remaining retrofit measures investigated, including adding cooling in the chapel, and replacing lighting with LED fixtures would not be prioritized at this time. These scopes of work are not critically tied on any of the other measures listed above, and could be revisited in the future.

5.0 CONCLUSION

Through a process of investigation and iterative options development, the Consultant Team (BSN and WalterFedy), working with the Owner (CGUC), have identified a series of staged retrofit measures, listed below, to incrementally upgrade and renew critical aspects of the residence wing of Conrad Grebel University College.

- Electrify the domestic hot water system for the residence using air source heat pump hot water tanks to replace existing gas fired hot water tanks.
- Renovate existing washrooms spaces to create functional gender-neutral washrooms on each floor, and undertake refurbishment of sanitary drainage piping to mitigate / eliminate existing drainage (blockage) issues in sanitary piping.
- Install a high efficiency air source heat pump system to provide cooling to residence rooms and replace the existing gas-fired hot water radiant heating system.

Replace existing non-thermally broken double and single glazed windows in the residence spaces, including stairwells, with higher performance modern window systems.

These measures can be undertaken within a single construction project, or through a staged set of interventions undertaken sequentially as funds become available. CGUC has identified a total project budget of approximately $3 - $3.5M available for the work at this time (including construction and all soft costs). The total cost of the work above is estimated to cost $5.5M + for construction costs (not including market escalation). The proposed measures present a GHG reduction potential of 16.7%, with the most impactful reductions coming from electrification of the domestic hot water system, and the implementation of an electric heat pump system for residence heating plus cooling, as these measures propose a switch from fossil fuel technology to all-electric systems. The recommended sequence of interventions has been prioritized in consultation with GCUC to focus first on the highest value work that will realize immediate GHG reductions, as well as achieve measurable and visible improvement to the functionality, inclusivity, and comfort of student living spaces.