1755 FROBISHER LANE
OTTAWA

BUILDING RETROFIT ROADMAP
PREPARED FOR MINTO APARTMENT LIMITED PARTNERSHIP
DECEMBER 21, 2020

IMAGE OF 1755 FROBISHER LANE (MIDDLE) FROM GOOGLE EARTH

BUILDING SCIENCE

Executive Summary

RDH was retained to complete a retrofit study of the Castleview building located at 1755 Frobisher Lane in Ottawa, Ontario, for Minto Apartment Limited Partnership. The 242 suite multi-unit residential building was built in the early 1970s and is 26 storeys with a gross leasable area of 171,000 ft^2.

The increased focus on reducing greenhouse gas (GHG) emissions from existing buildings and the desire by building owners to ensure their buildings can adapt to shifting climate norms are driving mitigation strategies such as building retrofits.

RDH conducted an on-site assessment of the property on October 9, 2020. Castleview is primarily clad with precast wall panels and the original aluminum glazing systems. The suites are primarily heated by hot water baseboard convectors. Both heating and domestic hot water are served by natural gas boilers located in the mechanical penthouse.

We analyzed two years of weather-normalized utility data and found that Castleview typically has an annual energy use intensity (EUI) of 435 kWh/m^2, 80% of which was contributed by natural gas. Of the annual natural gas consumption, approximately 70% was due to enclosure and infiltration related heat loss. Our steady state analysis of enclosure heat loss for an ASHRAE Design Day condition found that 56% of heat was lost through the glazing systems, with 36% due to the balcony doors alone. Exterior walls accounted for 12% of heat loss.

This report outlines the ***Retrofit Roadmap*** for Castleview, summarising the process of our assessment and option analysis for your consideration. The Retrofit Roadmap outlines three options – light, medium, and deep energy retrofit.

→ The light retrofit recommends targeted repairs of the enclosure and windows, and general re-commissioning of the HVAC system.

→ The medium retrofit includes targeted enclosure repairs, replacement of the windows, and the addition of in-suite ventilation.

→ The deep retrofit includes overcladding the precast walls and slab edges, replacing the stucco walls and windows, adding in-suite ventilation, and improving the central heating plant efficiency.

The ***Retrofit Roadmap*** includes two matrices summarizing the proposed enclosure, mechanical, and electrical retrofit options. While the options and energy conservation measures presented are not exhaustive, each step up includes increasing improvements to building enclosure thermal performance and upgrades to the mechanical system.

Results of the ***Retrofit Roadmap*** include estimated energy and GHG savings, as well as relative reduction of heat loss for an ASHRAE Design Day. GHG savings for the options ranged from approximately 0% to 80%.

Potential benefits and drawbacks are provided for each of the retrofit paths considered. The capital cost, construction impact, and maintenance frequency are summarized for each retrofit path on a relative scale of low, medium, and high.

Once you select a retrofit path, the next steps include choosing the specific elements of the rehabilitation program, designing and tendering the repair package, conducting the on-site repairs, verifying operational performance, and implementing ongoing maintenance.

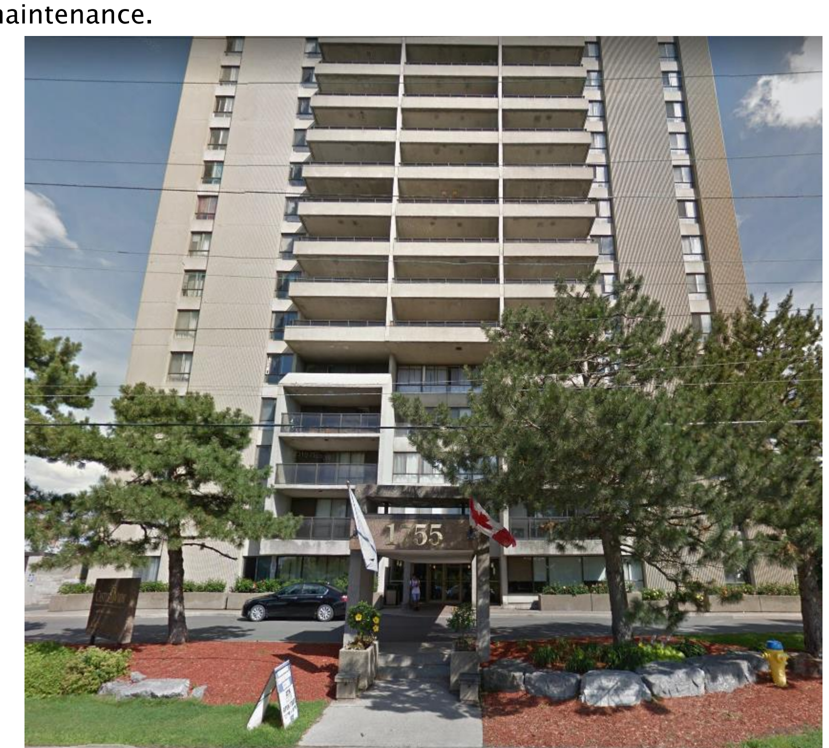

IMAGE OF 1755 FROBISHER LANE FROM GOOGLE MAPS

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PROJECT OVERVIEW

PROJECT DESCRIPTION

The following summarizes the features and characteristics of this multi-family residential building owned by Minto Apartment Limited Partnership:

Building Name	Castleview
Vintage	Early 1970s
Location	1755 Frobisher Lane, Ottawa, ON
Building Use	Residential
Building Size	26 storeys, 242 suites
Floor Area	171,000 ft2

IMAGE OF 1755 FROBISHER LANE FROM GOOGLE EARTH

PROJECT LIMITATIONS

The analysis presented in this report is based on documents received, a site visit conducted on October 9, 2020, and other resources such as Google Maps as existing drawings were not available. RDH does not endorse specific products even if they are mentioned by name. The results and analysis are a high-level assessment and are not an indication or guarantee of actual energy savings. Detailed design and analysis would be required to more accurately assess energy and greenhouse gas savings for each option.

SCOPE AND METHODOLOGY

As all levels of government target more stringent carbon emission reduction goals, there is an increased focus on reducing emissions related to operating existing buildings. Deep energy retrofits are fast becoming a key strategy to reach Canada's carbon emission goals.

The work undertaken by RDH Building Science (RDH) explores the possible scopes, costs, and energy savings associated with whole building retrofits of an occupied building. This document outlines a ***Retrofit Roadmap*** for the Castleview building: we build off existing site conditions to provide appropriate retrofit strategies with the intent to achieve increasing levels of energy efficiency. Retrofit options are categorized as light, medium and deep.

Our ***Retrofit Roadmap*** process started with an on-site assessment to understand the building enclosure and mechanical and electrical systems; the site work was completed on October 9, 2020. We then completed a preliminary energy assessment to summarize energy consumption and carbon emissions using two years of weather normalized utility data.

Strategic opportunities to improve energy performance of different building systems, as part of potential retrofit work, are presented as bundles of energy conservation measures. The energy assessments for the measures proposed in this study are completed as simplified energy models, instead of hourly energy models, to provide high-level understanding of each option. The assessment results include Class D costing, a discussion of benefits and challenges, and estimated energy and GHG/carbon reductions for each retrofit bundle. The ***Retrofit Roadmap*** provides a useful tool to demonstrate where the Castleview building is and where it can go in terms of energy performance.

The table below summarizes the definition of light, medium, and deep retrofit paths according to the Tower Renewal Partnership's 2020 report *Advancing Building Retrofits*. The focus of each retrofit path is summarized as follows:

→ **Light Retrofit** – Repairs and like-for-like replacements

→ **Medium Retrofit** – Capital repairs and energy retrofit enhancements

→ **Deep Retrofit** – Comprehensive building upgrade

	LIGHT RETROFIT	MEDIUM RETROFIT	DEEP RETROFIT
ENVELOPE	Envelope maintenance and repair	Envelope maintenance and repair, new windows	Envelope overcladding, high performance windows, and elimination of thermal bridges at balconies to substantially reduce heat loads
MECHANICAL	Like-for-like replacements	HVAC system upgrades, in-suite ventilation , potential for cooling	Resized and upgraded HVAC system, in-suite ventilation, potential for cooling
WATER	Water conservation fixtures	Water conservation fixtures	Water conservation fixtures
LIGHTING	LED lighting in common areas	LED lighting in common areas	LED lighting in common areas
BENEFITS	Short-term payback on utility costs	Significant improvements to resident comfort	Significant improvements to resident health, comfort, and climate resilience
ESTIMATED GHG REDUCTIONS	Up to 20%	~35%	>75%

CLIMATE CHANGE, RESILIENCY & RETROFITS

WHY RETROFITS?

Climate change is projected to have a significant impact on society and the built environment. Shifting climate norms result in changing weather patterns. The underlying cause of this change has been identified as anthropogenic greenhouse gas emissions (GHGs).

To achieve a sustainable future, both climate change *Adaptation* and *Mitigation* are required.

→ **Adaptation** is ensuring our buildings will be able to withstand changing and ever stronger environmental loads.

→ **Mitigation** is minimizing the severity of these future environmental loads by reducing GHG emissions or increasing GHG sinks.

As all levels of government target more stringent carbon emission reduction goals, there is an increased focus on reducing emissions related to operating existing buildings. Deep energy retrofits are fast becoming a key strategy to reach carbon emission goals in Canada.

RETROFIT FUNDING

There is a growing amount of funding available for retrofits in Canada. The following list (which is not exhaustive) includes some currently available retrofit funding:

→ In October 2020 the Canadian Federal government announced an *infrastructure plan* including $2 Billion dollars in funding for large-scale business retrofits

→ NRCan has recently opened the *Green Infrastructure Phase II - Energy Efficient Buildings Program* with $20 million dollars in funding available to accelerate the deployment of high efficiency homes and buildings in Canada

BUILDING CODE UPDATES

Currently, energy performance is not mandated as a part of existing building codes. The *Pan-Canadian Framework on Clean Growth and Climate Change* has stated that federal, provincial and territorial governments will work to develop a model code for existing buildings by 2022.

ADAPTATION

The projected climate for Ottawa over the next few decades is summarized in the Figure on the right. Extreme weather can manifest as intensified wind speeds and severe precipitation downbursts leading to flood risks and ice storms. Existing buildings must be able to effectively manage current and future environmental loads.

SOURCE: CLIMATE PROJECTIONS FOR THE NATIONAL CAPITAL REGION (2020)

HEATING, COOLING & THERMAL COMFORT

Buildings require active heating and cooling systems. Passive systems should be considered to supplement active systems for energy savings and resiliency to maintain comfort and liveability in the event of power loss.

DURABILITY

Increased extreme storm events require water control strategies that can handle higher levels of precipitation and wind loads. Using durable materials, assemblies and systems extends the period between significant repairs and renewals and reduces lifecycle maintenance costs.

AIR QUALITY

Providing fresh air promotes resident well-being. Adding air filtration within ventilation systems should be considered to manage contaminants from interior or exterior sources.

WATER USE

Buildings should incorporate water reduction strategies such as low flow fixtures, rainwater harvesting, and water efficient landscaping.

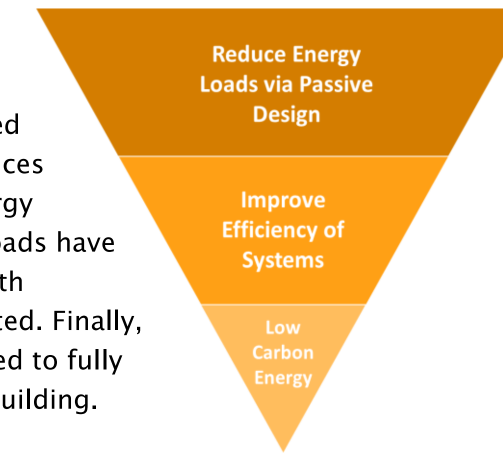
FLOODING

Buildings that may be exposed to flooding should have resilient ground-level and below-grade enclosure assemblies and details.

MITIGATION

The *Global Status Report 2017 by the United Nations Environment Programme* found that the building industry is responsible for over 28% of global GHGs due to operations and 11% due to construction and material extraction. Buildings that produce less GHGs during operation are critical for a sustainable future.

Tiered mitigation shown in the figure on the right builds off the strategy of reducing loads passively with improved building enclosure. This strategy reduces energy consumption by reducing energy needs to meet building loads. Once loads have been reduced, mechanical systems with improved efficiency can be implemented. Finally, renewable energy systems may be used to fully offset energy and carbon usage in a building.



Windows are typically the weakest link in the building enclosure and may account for significant heat loss, cold surfaces, and drafts. Upgrading windows can deliver energy savings and provide more comfortable living spaces.

Exterior insulation added during a cladding renewal project further reduces heating demand and improves the durability of the building enclosure. Adding a continuous air barrier can significantly reduce air leakage which can improve indoor air quality, building durability, and occupant comfort. With increased airtightness, it is important to ensure adequate ventilation will be provided. Ventilation can be delivered efficiently through Heat Recovery Ventilators (HRVs).

Other retrofit opportunities to reduce energy consumption and greenhouse gas emissions include upgrading HVAC systems with higher efficiency equipment, replacing lighting with LED technology, switching to low flow water fixtures, fine tuning controls, etc.

BASELINE RESULTS FOR CASTLEVIEW

OVERVIEW

The building at 1755 Frobisher Lane, known as Castleview, is 26-storeys with 242 units and a gross leasable area of 171,000 sq. ft. The building was built in the early 1970s and has not undergone any major retrofits to the building enclosure. The building is primarily clad with precast wall panels and single pane aluminum glazing systems. The primary roof system is a conventional exposed roof assembly. Each suite has access to a private cantilevered concrete balcony, shown in the figure below.

IMAGE OF SUITE WINDOW AND BALCONY FROM RDH SITE VISIT

The building suites are primarily heated by baseboard convectors served by five hot water boilers located in the mechanical penthouse. The common areas are served by an air handling unit (AHU) with hot water heating coils. The building does not have cooling except a small ductless air conditioner serving the elevator penthouse. Domestic hot water (DHW) is provided by three natural-gas fired boilers and eight storage tanks. A Building Property Condition Assessment report completed in 2018 by Pinchin noted that one of the heating boilers also serves the DHW.

SITE ASSESSMENT

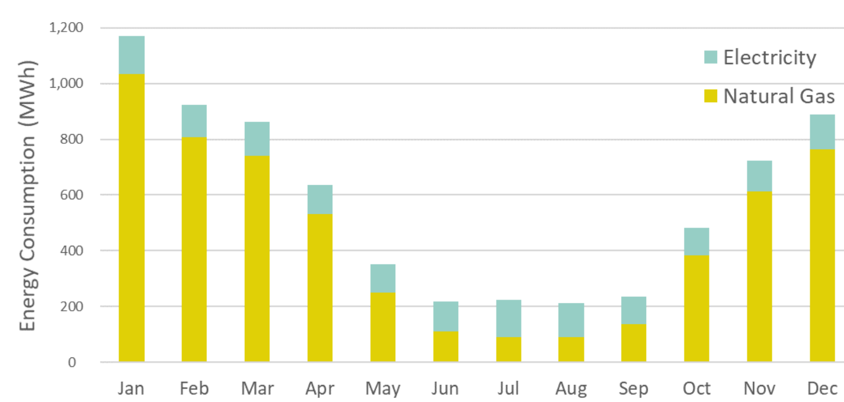
RDH conducted a site visit on October 9, 2020. The site visit included a visual review of the interior conditions of three sample suites to assess the in-service conditions. RDH reviewed the operable and fixed windows, and the balcony doors in each suite. We also accessed the balconies to review concrete slab and brick cladding conditions. We made four exploratory wall cuts in the suites to confirm the presence and type of interior wall insulation.

We conducted a visual review of the building exterior from grade and from balconies of suites accessed. RDH performed exterior sealant test cuts at grade and used a borescope (small camera “snake”) inserted into the sealant test cuts to check for insulation. We accessed the main roof for visual inspection and made one test cut into the roof system to confirm the presence and type of roof insulation.

ENERGY ANALYSIS

UTILITY BILL DATA

Minto provided us with two years of weather normalized utility data for both electricity and natural gas. We note that this utility data also includes consumption by the Site B building, which houses a pool. The Site B building is outside the scope of this study. The bar graph below shows the monthly utility breakdown for Castleview.

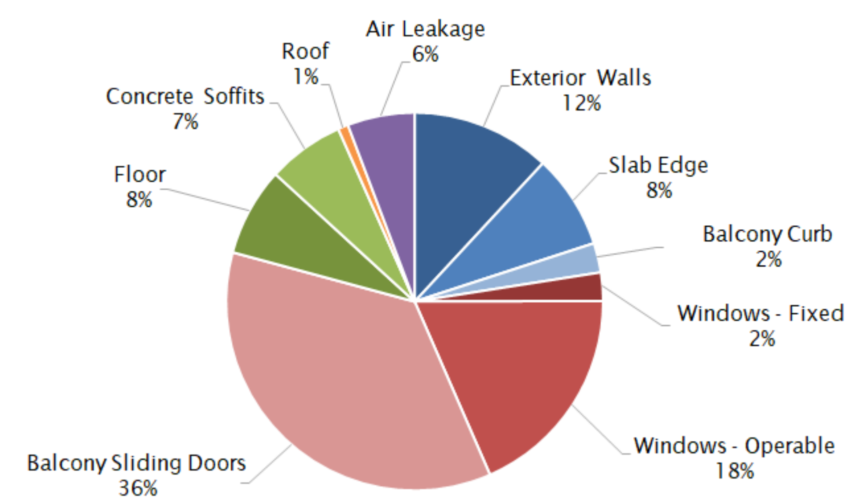


MONTHLY GAS AND ELECTRICITY USE BASED ON UTILITY BILL DATA

Based on the utility data provided and a simplified energy analysis, the Castleview property uses approximately 7,000 MWh of energy annually (energy use intensity EUI of 435 kWh/m^2 annual), of which 80% is natural gas. Of the annual natural gas consumption, 70% is due to enclosure- and infiltration-related heat loss.

ENCLOSURE STEADY STATE HEAT LOSS

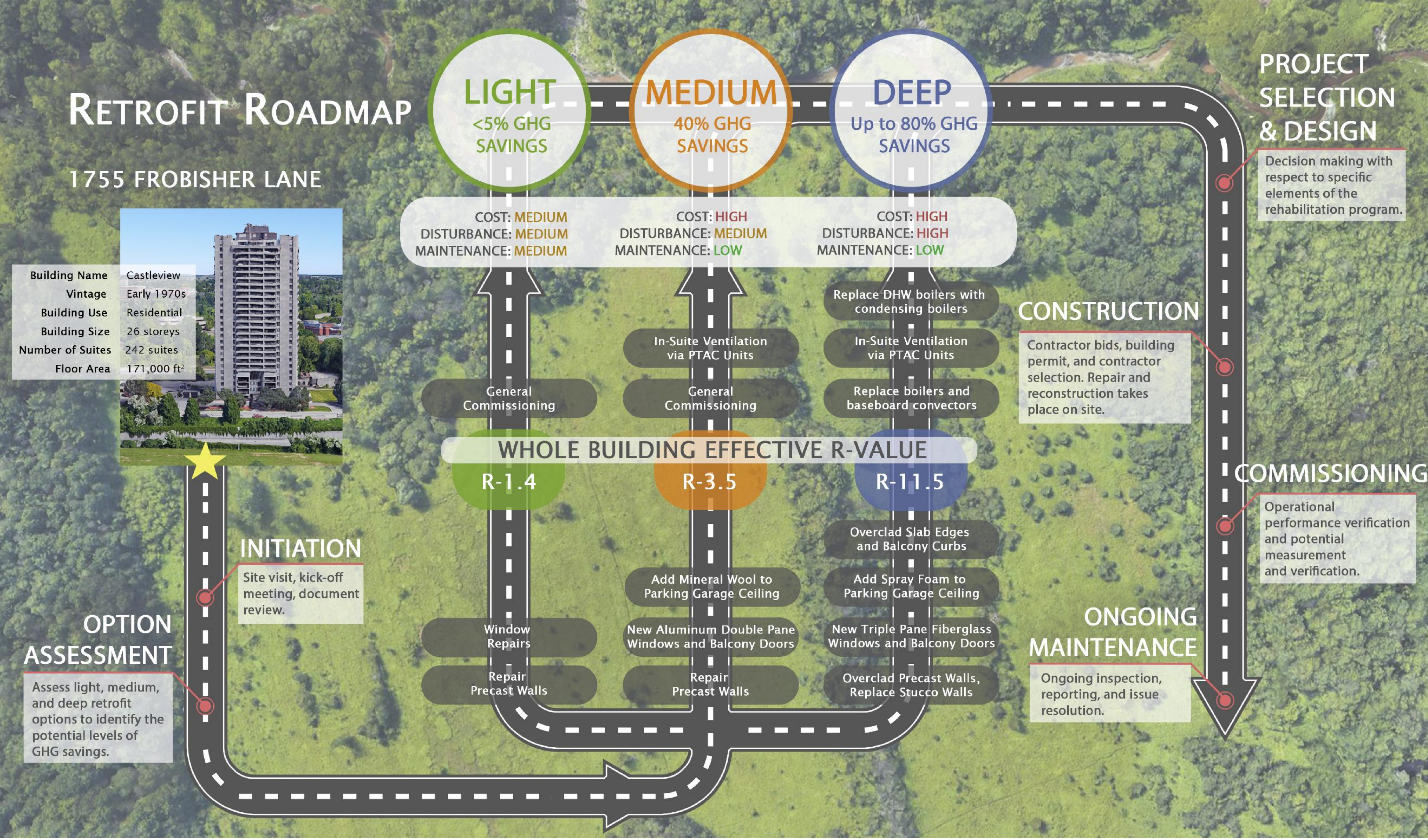
The pie chart below shows the breakdown of enclosure and infiltration from steady state analysis of heat loss for an ASHRAE Design Day condition. We estimated the thermal performance of the enclosure systems based on existing documentation and our on-site observations. Nearly 60% of the heat loss in the building is through the glazing components, with the balcony sliding doors contributing over 30% to building heat loss.



COMPONENTS OF STEADY STATE HEAT LOSS THROUGH THE EXISTING BUILDING ENCLOSURE (ASHRAE DESIGN DAY CONDITIONS)

RETROFIT ROADMAP

Based on the results of the analysis of the existing building, we bundled different retrofit measures to create light, medium, and deep retrofit paths. The ***Retrofit Roadmap*** can be found on the following page which summarizes the process and results.


RETROFIT ROADMAP
1755 FROBISHER LANE
Building Name Castleview
Vintage Early 1970s
Building Use Residential
Building Size 26 storeys
Number of Suites 242 suites
Floor Area 171,000 ft²
LIGHT
<5% GHG SAVINGS
MEDIUM
40% GHG SAVINGS
DEEP
Up to 80% GHG SAVINGS
COST: MEDIUM
DISTURBANCE: MEDIUM
MAINTENANCE: MEDIUM
COST: HIGH
DISTURBANCE: MEDIUM
MAINTENANCE: LOW
COST: HIGH
DISTURBANCE: HIGH
MAINTENANCE: LOW
Replace DHW boilers with condensing boilers
In-Suite Ventilation via PTAC Units
In-Suite Ventilation via PTAC Units
General Commissioning
General Commissioning
Replace boilers and baseboard convectors
WHOLE BUILDING EFFECTIVE R-VALUE
R-1.4
R-3.5
R-11.5
Overclad Slab Edges and Balcony Curbs
Add Mineral Wool to Parking Garage Ceiling
Add Spray Foam to Parking Garage Ceiling
Window Repairs
New Aluminum Double Pane Windows and Balcony Doors
New Triple Pane Fiberglass Windows and Balcony Doors
Repair Precast Walls
Repair Precast Walls
Overclad Precast Walls, Replace Stucco Walls
INITIATION
Site visit, kick-off meeting, document review.
OPTION ASSESSMENT
Assess light, medium, and deep retrofit options to identify the potential levels of GHG savings.
PROJECT SELECTION & DESIGN
Decision making with respect to specific elements of the rehabilitation program.
CONSTRUCTION
Contractor bids, building permit, and contractor selection. Repair and reconstruction takes place on site.
COMMISSIONING
Operational performance verification and potential measurement and verification.
ONGOING MAINTENANCE
Ongoing inspection, reporting, and issue resolution.

Building Enclosure Retrofit Matrix

		EXISTING BUILDING		LIGHT RETROFIT		MEDIUM RETROFIT						DEEP RETROFIT	
WHOLE BUILDING R-VALUE		Existing building effective R-value	R-1.4 [1]	No change from existing	R-1.4	Using **Option 1** Windows	R-3.5	Using **Option 2** Windows	R-3.7	Using **Option 3** Windows	R-4.0	Existing building effective R-value	R-11.5
PRIMARY ROOFS		Conventional roof assembly (exposed membrane) with 2" rigid polyisocyanurate insulation	R-11.4	Roof replacement to match existing	R-11.4	Roof replacement to match existing					R-11.4	Roof replacement to match existing	R-11.4
MECHANICAL PENTHOUSE WALLS		Corrugated metal cladding with 1" thick exterior rigid EPS insulation	R-5.0	No change from existing	R-5.0	No change from existing					R-5.0	Replace metal cladding with 4" thick exterior insulation and rainscreen cladding	R-15
PRIMARY ABOVE-GRADE WALLS	PRECAST	Pre-cast panels with 2" thick exterior rigid EPS insulation and uninsulated steel stud wall	R-10.7	Targeted repairs to precast and exposed concrete & exterior sealant replacement to match existing	R-10.7	Targeted repairs to precast and exposed concrete & exterior sealant replacement to match existing					R-10.7	Overclad pre-cast with 4" thick exterior insulation and rainscreen cladding (i.e., metal cladding or EIFS)	R-25
	STUCCO	Non-drained stucco over uninsulated steel stud wall	R-2.9	No change from existing	R-2.9	No change from existing					R-2.9	Replace non-drained stucco with 4" thick exterior insulation EIFS system	R-18
SLAB EDGE		Uninsulated pre-cast panels outboard of concrete slab edge	R-0.5	No change from existing	R-0.5	No change from existing					R-0.5	Overclad pre-cast with 4" thick exterior insulation and rainscreen cladding	R-15
BALCONY SLAB EDGE		Uninsulated concrete balcony slab	R-1.2	No change from existing	R-1.2	No change from existing					R-1.2	Exterior insulated concrete curb under balcony door	R-1.8
PRIMARY EXTERIOR GLAZING SYSTEMS	FIXED WINDOW	Aluminum framed windows with clear double glazed IGUs, no low-e coating, and no argon gas fill	R-1.0	Targeted IGU replacement to match existing	R-1.0	**ENCL Option 1** New aluminum framed, thermally broken windows and balcony sliders with clear **double glazed** IGUs [2]	R-2.5	**ENCL Option 2** New aluminum framed, thermally broken windows and balcony sliders with clear **double glazed View Glass** IGUs [2]	R-3.0	**ENCL Option 3** New aluminum framed, thermally broken windows and balcony sliders with clear **triple glazed** IGUs [2]	R-4.0	New **fiberglass** framed punched windows with clear **triple glazed** IGUs [2]	R-7.2
	OPERABLE WINDOW	Aluminum framed single pane windows with horizontal sliders	R-0.5	Localized gasket and weatherstripping replacement	R-0.5								
	BALCONY SLIDERS	Aluminum framed single pane balcony sliding glass doors	R-0.5	Localized gasket and weatherstripping replacement	R-0.5								
PARKING GARAGE SOFFIT		Uninsulated concrete deck	R-0.5	No change from existing	R-0.5	2" semi-rigid mineral wool insulation installed to underside of concrete deck					R-8	2" closed-cell spray foam insulation installed to underside of concrete deck	R-12

(1) All R-values are effective R-values in the unit ft2·F·hr/ BTU. Estimated effective R-values include the anticipated impact of thermal bridging based on experience. Thermal calculations have not been conducted for this study.
(2) Assumes new IGUs include low-e coating, argon gas fill, and warm edge spacers.

MECHANICAL & ELECTRICAL RETROFIT MATRIX

LIGHT RETROFIT

The light retrofit strategies for mechanical and electrical systems focus on retro-commissioning of the existing HVAC system. Retro-commissioning tunes the existing equipment and controls to ensure the system is performing as intended. It is difficult to accurately estimate the potential savings from retro-commissioning an existing system therefore no savings were assumed to be conservative.

MEDIUM RETROFIT

The medium retrofit strategy for mechanical and electrical systems builds off the light path. This path includes in-suite ventilation provided by through-wall packaged terminal air conditioning (PTAC) units with makeup air capabilities. The purpose of this unit is to provide in-suite ventilation but provides the option for in-suite cooling which improves building resiliency and increases occupant comfort. The suites have an existing service cavity in the wall next to the balcony that is now closed off but may have once housed an air conditioning unit. This service cavity is ideally suited for quick installation of a new PTAC unit. The airflow from the central air-handling unit (AHU) can be reduced due to the in-suite ventilation.

DEEP RETROFIT

The deep retrofit strategy for mechanical and electrical systems builds off the medium path. This path includes replacing the domestic hot water boilers with high efficiency condensing boilers, replacing the baseboard convectors, and two options for improving the central heating plant.

Mechanical Option 2 moves towards electricity as the main source for the central hot water system with air-to-water heat pumps. The existing condensing boiler would be retained and used as a top-up natural gas boiler when the outdoor air temperature is too low. The heat pumps have efficiencies of up to 300%.

			EXISTING	LIGHT	MEDIUM	DEEP
ELECTRICAL	LIGHTING		LED bulbs in all common areas	No change from existing	No change from existing	No change from existing
DOMESTIC HOT WATER	HEATING		One condensing and two atmospheric gas-fired boilers with an average efficiency of ~84%	No change from existing	No change from existing	Replace two existing atmospheric boilers with condensing boilers with 96% efficiency. Keep Lochinvar boiler, as it is already high efficiency (assumed minimum 94%).
DOMESTIC HOT WATER	FIXTURES		Low flow plumbing fixtures	No change from existing	No change from existing	No change from existing
MECHANICAL	VENTILATION		Corridor ventilation 75 cfm/door	Re-Commissioning of HVAC system	Reduce corridor ventilation and install in-suite ventilation units	Reduce corridor ventilation and install in-suite ventilation units
MECHANICAL	HEATING	PLANT	One condensing and four atmospheric gas-fired boilers with an average efficiency of 86%	Re-Commissioning of HVAC system	Re-Commissioning of HVAC system	**MECH Option 1** Replace existing atmospheric boilers with 96% efficient condensing boilers . Keep PK Mach boiler as it is 94% efficient. **MECH Option 2** Replace existing atmospheric boilers with Air-to-Water Heat Pumps. Keep PK Mach boiler as top-up boiler.
MECHANICAL	HEATING	IN-SUITE	In-suite hydronic perimeter heating (baseboard convectors)	Re-Commissioning of HVAC system	Re-Commissioning of HVAC system	Replace baseboard convectors with low-temperature perimeter heating system
MECHANICAL	COOLING		None	No change from existing	In-suite ventilation units can provide cooling (optional)	In-suite ventilation units can provide cooling (optional)

RESULTS OVERVIEW

EXISTING BUILDING

The building enclosure has not been retrofitted since its construction in the early 1970s, with the exception of the roofing systems circa 2000. The high level energy analysis completed using weather-normalized utility bills demonstrated the annual energy use intensity (EUI) of the existing building to be 435 kWh/m^2. Natural gas contributes to 80% of the annual energy consumption. Of this annual natural gas consumption, approximately 70% was due to enclosure and infiltration related heat loss. The steady state analysis of enclosure heat loss for an ASHRAE Design Day condition found that 56% of heat was lost through the glazing systems, with 36% due to the balcony doors alone. The best area to focus on to reduce heat loss, save energy and reduce greenhouse gas emissions is the windows.

RETROFIT RESULTS

There are many options to improve overall thermal building performance, occupant comfort, air tightness, durability, energy consumption, and GHG emissions, as a number of the enclosure systems are nearing the end of their service life.

The energy savings and GHG emission savings are summarized in the table on the next page. The range in values are due to the different options within each retrofit path. The medium retrofit path includes three different window types, and the deep retrofit option includes two different mechanical heating plant upgrades.

LIGHT RETROFIT

The light retrofit option includes targeted base building repairs to the roof and exterior walls to maintain serviceability, which are in accordance with Pinchin's Building Performance Condition Assessment on March 23rd, 2018.

A large portion of the capital cost for this option is the replacement of the existing main roof and penthouse roof assemblies, which are nearing the end of their service life. Renewals of the exterior sealant joints around the existing windows and precast panels is included. Providing access to the exterior walls (i.e., swing stage) will bear another significant portion of the capital cost. Tenant disruption is mitigated as most of the work can be completed from the exterior. The replacement of the roof assemblies can be staggered or phased with the exterior wall repairs if necessary.

There are no HVAC system replacements in this path. The retrofits included retro-commissioning the HVAC system. According to *Natural Resources Canada*, re-commissioning can achieve 16% energy savings, with a typical payback of just over a year.

Based on conversations with the team at Minto, the DHW fixtures in Castleview are low-flow, and the common area lighting has been upgraded to LED, therefore no additional mechanical energy conservation measures were included as part of the light retrofit strategy.

MEDIUM RETROFIT

The medium retrofit option includes all of the light retrofit strategies plus replacement of the existing single pane aluminum windows and balcony sliding doors, which are the leading cause of heat loss in the building. This option includes insulating the soffit of the underground parking garage (below conditioned space), which is currently uninsulated. The replacement of the existing glazing systems will have the most significant trade-off between investing capital cost and improving whole building thermal performance. The enclosure repairs can be staggered or phased to balance cost and disruption.

Installing in-suite ventilation with a PTAC unit, with the option to add cooling, will require suite entry and resident disruptions. Installing the in-suite unit in the existing service penetration could reduce the disruptions. It is assumed that there is electrical service to that location of the wall, which is likely if the space was previously used for an air conditioning unit. Electrical capacity for the PTAC would need to be confirmed.

This path demonstrates approximately 30% energy savings and 40% GHG emission savings. The GHG savings is larger is due to greater reductions in natural gas consumption which is high in greenhouse gases. Cooling is optional with the PTAC units therefore the associated energy consumption for cooling in not included in our analysis.

The largest capital cost for the medium mechanical strategies is improved ventilation strategy – with the majority of this additional cost being the in-suite PTAC units. Part of this retrofit includes installing a variable frequency drive (VFD) on the central AHU to reduce the flow. Alternatively, the central unit could be fully replaced with a smaller unit. Doing so would increase the capital cost for this option by approximately $100,000.

RESULTS OVERVIEW

DEEP RETROFIT

The deep retrofit option includes all of the medium retrofit elements plus a comprehensive building enclosure upgrade that adds an exterior insulated rainscreen overcladding and significantly reduces thermal bridging at slab edges and balcony curbs.

The deep retrofit option will have the largest associated capital cost and construction impact; however, it will significantly improve overall building performance and the lifespan of the building. The overcladding would require exterior swing stage or scaffolding access around the entire building; however, the exterior work could be staggered or phased with the interior mechanical work. Replacing mechanical equipment in the penthouse would likely require a crane or helicopter for removal and replacement. Electrical service upgrades may also be required with the installation of air-source heat pumps, as the majority of HVAC would be served electrically.

Installing in-suite ventilation with a PTAC unit with the option for cooling and replacing the perimeter heating system will require suite entry and tenant disruptions. This work can be completed while the suite is occupied with tenant coordination and estimate the tenant disruption to be one to two days per suite.

The deep retrofit strategy demonstrates 50-60% energy savings, and 60-80% savings in GHG emissions. The increased GHG savings is due large savings in natural gas consumption which is GHG intensive. While cooling is optional with the PTAC units, we have not included the associated energy consumption for cooling in our analysis.

The largest capital cost for the deep mechanical and electrical strategies is the replacement of the central plant and perimeter baseboard convectors with low-temperature heating.

	EXISTING	LIGHT	MEDIUM	DEEP
% ENERGY SAVINGS	0%	0%	~30%	50-60%
% GHG EMISSION SAVINGS	0%	0%	~40%	60-80%
WHOLE BUILDING THERMAL PERFORMANCE	R-1.4	R-1.4	R-3.5 to R-4.0	R-11.5 (1)
RELATIVE CAPITAL COST	Low	Medium	High	High
RELATIVE CONSTRUCTION IMPACT	Low	Medium	Medium	High
RELATIVE MAINTENANCE FREQUENCY	High	Medium	Low	Low
AESTHETIC	1970's vintage building	Same overall existing appearance with some areas of visible cladding repairs	Flexibility with new window design could improve aesthetic with some areas of visible cladding repairs	Flexibily with new façade design (windows and walls) that will stand-out

(1) Deep retrofit whole building R-value with fiberglass triple glazed IGUs. Substituting double glazed View Glass IGUs decreases to R-7.5, substituting aluminum framed triple glazed IGUs decreases to R-8.8.

Class D Costing

The Class D costing is summarized in the table below. A detailed breakdown of these costs is included in the Appendix.

	ENCLOSURE COST		MECHANICAL COST		TOTAL (1)
LIGHT	$1,590,000		$50,000		**$1,640,000**
MEDIUM	**ENCL Option 1** New aluminum framed, thermally broken windows and balcony sliders with clear double glazed IGUs	$7,100,000	$740,000		**$7,840,000**
	ENCL Option 2 New aluminum framed, thermally broken windows and balcony sliders with clear double glazed View Glass IGUs	$10,210,000			**$10,950,000**
	ENCL Option 3 New aluminum framed, thermally broken windows and balcony sliders with clear triple glazed IGUs	$7,580,000			**$8,320,000**
DEEP	$14,420,000 (2)		**MECH Option 1** Replace existing atmospheric boilers with condensing boilers with 96% efficiency	$3,550,000	**$18,450,000**
			MECH Option 2 Replace existing atmospheric boilers with Air-to-Water Heat Pumps. Keep existing condensing gas boiler for top-up	$4,250,000 (3)	**$19,150,000**

(1) The allowance for Engineering, Design, Administration and Field Review Allowance not included in the total. The fee would be approximately $50,000 for light, $100,000 for medium, and $150,000 for deep.

(2) The enclosure cost for the deep retrofit option includes the use of EIFS overcladding. Exterior mineral wool insulation and composite metal cladding would cost an additional $1,250,000.

(3) The cost of upgrading the transformer for increased electrical capacity has not been included.

RESULTS OF ENERGY ANALYSIS

ENERGY CONSUMPTION

Six different retrofit bundles – one light, three medium, and two deep – were analyzed. The variations within each retrofit path are summarized as follows:

- → **ENCL-1:** Aluminum framed clear glass double-glazed IGUs
- → **ENCL-2:** Aluminum framed clear double-glazed View Glass IGUs
- → **ENCL-3:** Aluminum framed clear triple-glazed IGUs
- → **MECH-1:** Existing atmospheric boilers replaced with high efficiency condensing boilers
- → **MECH-2:** Existing atmospheric boilers replaced with Air-to-Water Heat Pumps. Existing gas-fired condensing boiler used for top-up

The estimated energy consumption for each retrofit path and their variations is summarized in the figure below. The energy consumption due to natural gas and electricity is separated, and the orange line shows the percent of carbon savings.

The difference in glazing type makes a small difference across the medium retrofit paths in terms of both energy consumption and carbon savings.

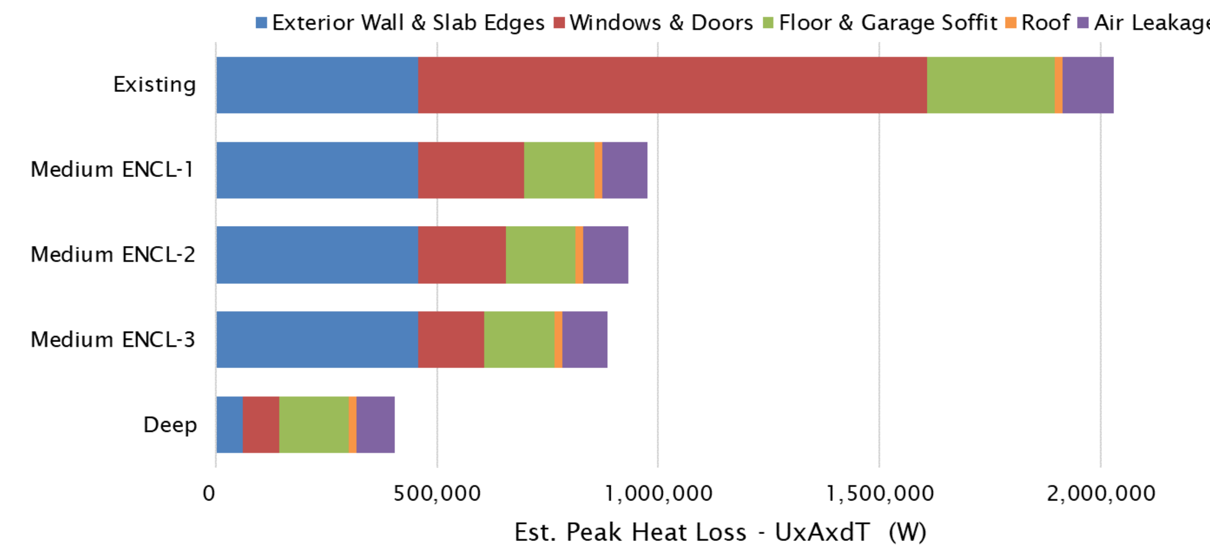
Mechanical Option 2 (air-to-water heat pumps) significantly decreases the natural gas use and is the only option that consumes more electricity than natural gas. We did not calculate estimated operating costs as part of this study, but it should be noted that while Mechanical Option 2 demonstrates significant energy and carbon savings, operating costs may be impacted. Replacing the existing boilers with high-efficiency condensing boilers has substantial carbon savings, and acts as a reasonable compromise of energy and carbon savings compared to the operating cost.

PEAK HEAT LOSS

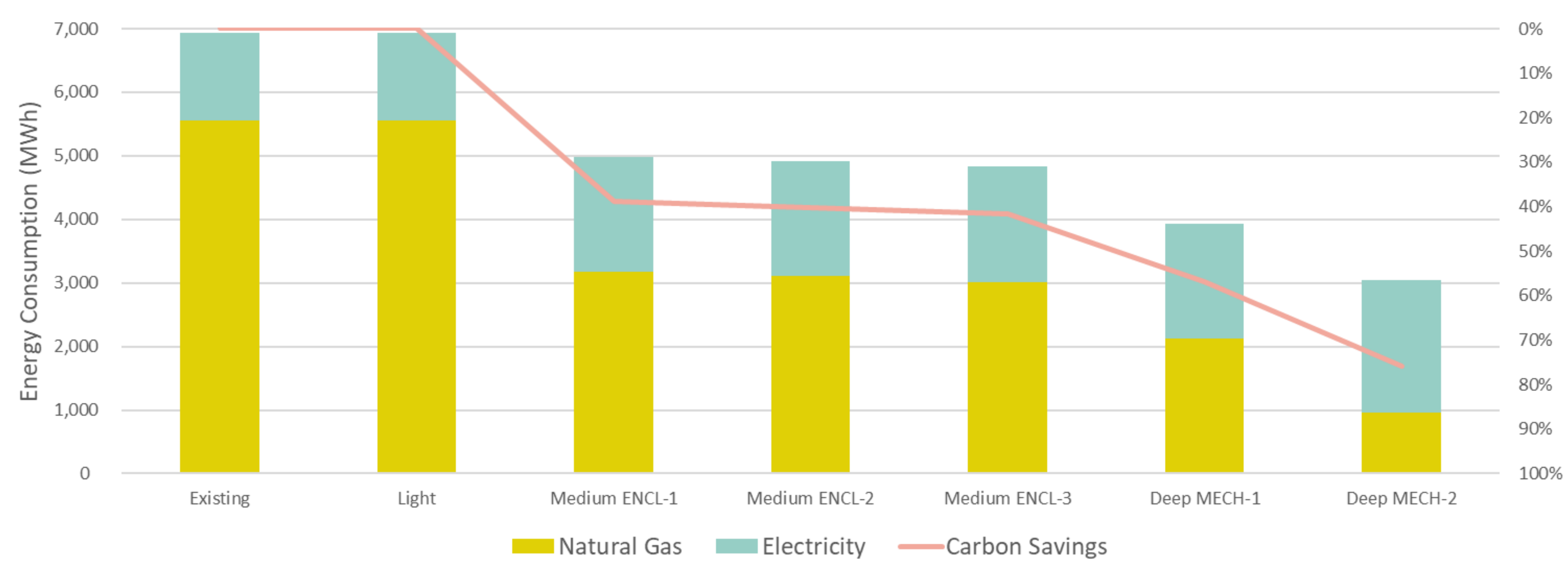
The estimated peak heat loss through the enclosure for each retrofit path is summarized in the figure on the right.

There is only one deep option as the mechanical variation does not affect the enclosure. The medium retrofit options have 50-60% less heat loss, while the deep retrofit shows 80% less heat loss through the enclosure on a peak design day.

In the medium retrofit option, the Enclosure Option 3 has the greatest reduction in heat loss through the windows, due to the aluminum framed clear triple-glazed IGUs.



ESTIMATED HEAT LOSS THROUGH THE ENVELOPE FOR EACH RETROFIT PATH



NATURAL GAS, ELECTRICITY USE AND CARBON SAVINGS FOR EACH RETROFIT PATH

CONCLUSIONS

BENEFITS AND DRAWBACKS

The benefits and drawbacks comparison of the existing building and the light, medium, and deep retrofit paths are summarized in the table below.

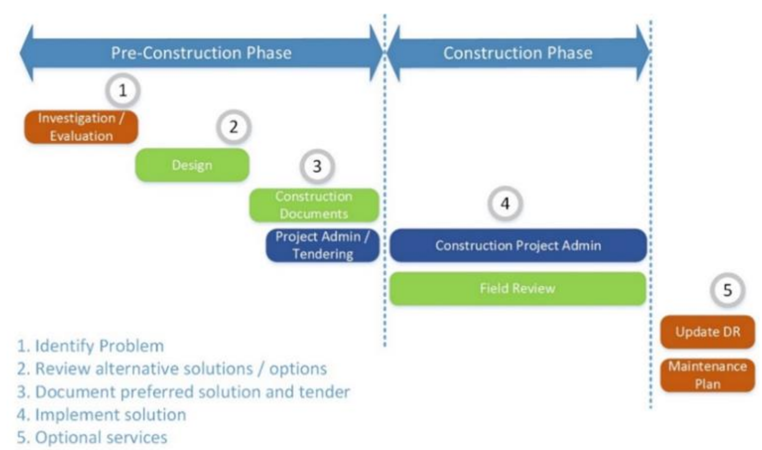
	BENEFITS	DRAWBACKS
EXISTING	- No immediate capital cost	- No aesthetic improvement - No thermal performance improvement to overall building performance and occupant comfort - High maintenance frequency - The replacement of failed IGUs will need to be considered - High GHG emissions associated with significant natural gas consumption - which may be costly in the future with carbon taxes
LIGHT	- Minor interior distruption to tenants - Low capital cost - Enclosure work can be completed by swing stage - Reduced maintenance	- No aesthetic improvement - Minimal improvement to overall building performance and occupant comfort - High maintenance frequency
MEDIUM	- Good cost-benefit with respect to window thermal performance - Enclosure work can be completed by swing stage - Some flexibility with new window design and aesthetic - Improved ventilation provided in-suite - Potential for increased resiliency with in-suite cooling (if included) - Reduced maintenance	- Significant interior distruption to tenants. - Long construction period - High capital cost
DEEP	- Long term improvement to overall building thermal performance and occupant comfort. - Flexibilty with new façade design. - Unitized construction (may help with phasing construction) - Significant improvement to energy consumption and GHG emissions - Reduced maintenance	- Significant interior distruption to tenants - Long construction period - High capital cost - Potential for higher utility costs when shifting heating from natural gas to electricity

NEXT STEPS

This report presents conceptual-level recommendations with respect to rehabilitation and renewal activities. It is important to understand that these recommendations do not provide a basis for implementing remedial work. Conceptual recommendations need to be developed, refined, and documented in detail before the construction work can be tendered to contractors.

The next step typically begins with the design process where the consultant assists you in making decisions with respect to specifics of the rehabilitation program. Once decisions are made, the selected design is developed and documented in greater detail using drawings and specifications. These documents describe the exact extent and nature of the remedial work, materials to be used, etc.

The drawings and specifications are used to obtain bids from pre-qualified contractors and to obtain a building permit to carry out the work. Once a contractor has been selected, the project can move into the construction stage. During this stage, the remedial work program that has been designed by the consultant (with owner involvement and agreement) is implemented, and repair and reconstruction takes place on-site. The consultant administers the construction contract and undertakes periodic field review of construction as the work proceeds. It is also common for the consultant to provide a maintenance and renewals plan (or update an existing plan) for the rehabilitated enclosure assemblies upon completion of the construction.



CLOSURE

The analysis completed for this report was based on information provided by the Minto team, visual assessments made during RDH's site visit, and correspondence with the Minto team.

Where required information was not explicitly defined in the information provided, assumptions were made based on previous experience. We can discuss these assumptions upon request

We trust this ***Retrofit Roadmap*** provides the type of information that will help Minto understand and plan retrofit strategies for the Castleview building. Please do not hesitate to contact us if you require any further information.

Yours truly,
RDH Building Science Inc.

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APPENDIX A

SUMMARY OF DATA

23954.000 - 1755 Frobisher Lane (Castleview)

Summary of Data

TABLE A-1 SUMMARY OF ENERGY AND GREENHOUSE GAS EMISSIONS SAVINGS

	EXISTING	LIGHT	MEDIUM ENCL-1	MEDIUM ENCL-2	MEDIUM ENCL-3	DEEP MECH-1	DEEP MECH-2
NATURAL GAS (kWh)	6,910,000	6,910,000	3,960,000	3,870,000	3,760,000	2,650,000	1,200,000
ELECTRICITY (kWh)	1,380,000	1,380,000	1,810,000	1,810,000	1,810,000	1,800,000	2,080,000
% CO2 SAVINGS	0%	0%	40%	40%	40%	60%	80%
% ENERGY SAVINGS	0%	0%	30%	30%	30%	50%	60%
EUI (kWh/m^2)	435	435	303	298	292	233	172
GHG (kg CO2e)	1,090,000	1,090,000	670,000	660,000	640,000	480,000	270,000
GHGI (kg CO2e/m^2)	70	70	40	40	40	30	20

All data including pool building baseload.

TABLE A-2 SUMMARY OF COMPONENT HEAT LOSS FOR AN ASHRAE DESIGN DAY

		% HEAT LOSS FOR AN ASHRAE DESIGN DAY					
SYSTEM	AREA m^2	EXISTING %	LIGHT (Same as Existing) %	MEDIUM OPTION 1 %	MEDIUM OPTION 2 %	MEDIUM OPTION 3 %	DEEP %
EXTERIOR WALLS	5,720	12%	12%	25%	27%	26%	5%
SLAB EDGE	310	8%	8%	17%	19%	18%	1%
BALCONY CURB	240	3%	3%	5%	6%	5%	9%
WINDOWS - FIXED	190	2%	2%	2%	1%	2%	2%
WINDOWS - OPERABLE	720	19%	19%	8%	5%	7%	6%
BALCONY SLIDING DOORS	1,390	36%	36%	15%	10%	13%	12%
FLOOR	540	8%	8%	16%	17%	16%	38%
CONCRETE SOFFITS	240	7%	7%	0%	0%	0%	1%
ROOF	780	1%	1%	2%	2%	2%	4%
AIR LEAKAGE	9,110	6%	6%	10%	12%	11%	21%

TABLE A-3 SUMMARY OF TOTAL HEAT LOSS FOR AN ASHRAE DESIGN DAY

	AREA	EXISTING	LIGHT (Same as Existing)	MEDIUM OPTION 1	MEDIUM OPTION 2	MEDIUM OPTION 3	DEEP
UxAxdT (W)	N/A	2,030,000	2,030,000	970,000	880,000	930,000	410,000

TABLE A-4 TWO-YEAR AVERAGE ANNUAL UTILITY DATA BASED ON WEATHER-NORMALIZED UTILITY INFORMATION

	Calculated Natural Gas Consumption (MWh)	Utility Bill Electricity Consumption (MWh)
JANUARY	1,030	140
FEBRUARY	810	110
MARCH	740	120
APRIL	530	100
MAY	250	100
JUNE	110	110
JULY	90	130
AUGUST	90	120
SEPTEMBER	140	100
OCTOBER	380	100
NOVEMBER	610	110
DECEMBER	760	130

APPENDIX B
CLASS D COSTING

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23954.000 - 1755 Frobisher Lane (Castleview)

Enclosure Costing Estimates

Overall Summary of Non-Combustible Targeted + Full Rehab Project Costs

Construction Costs		LIGHT	MEDIUM	DEEP
Scaffolding/Swing Stage Access		$ 102,000	$ 120,000	$ 800,000
Punched Window Replacement		$ -	$ 1,129,000	$ 1,278,000
Balcony Sliding Door Replacement		$ -	$ 1,526,000	$ 1,755,000
Roof Replacement		$ 653,000	$ 653,000	$ 653,000
Penthouse Balcony Coating		$ 30,000	$ 30,000	$ 30,000
Exterior Sealant Joints		$ 192,000	$ 121,000	
Interior Finishes		$ -	$ 847,000	$ 847,000
Underground Parking Garage Soffit Insulation		$ -	$ 26,000	$ 51,000
Targeted Concrete Restoration		$ 20,000	$ 20,000	$ 20,000
Precast and Penthouse Overclad				$ 2,600,000
Stucco Overclad				$ 870,000
Insulated Balcony Curb				$ 181,000
GC/CM Fees		$ 150,000	$ 671,000	$ 1,363,000
Sub-total Construction Budget		$ 1,147,000	$ 5,143,000	$ 10,448,000
General Conditions	10%	$ 114,700	$ 514,300	$ 1,044,800
Construction Costs (GC's + Restoration Costs)		$ 1,261,700	$ 5,657,300	$ 11,492,800
Project Contingency	10%	$ 126,170	$ 565,730	$ 1,149,280
Total - Construction Costs		$ 1,387,870	$ 6,223,030	$ 12,642,080
Project Costs				
Total Construction Costs		$ 1,387,870	$ 6,223,030	$ 12,642,080
HST on Construction	13%	180,423	808,994	1,643,470
Building Permit Fee Allowance	1%	$ 13,879	$ 62,230	$ 126,421
Project Costs Requiring Funding		**$ 1,590,000**	**$ 7,100,000**	**$ 14,420,000**

NOTES:
Budget does not include any allowance for hazardous materials removal (asbestos or lead abatement).

OPTIONS:*			LIGHT	MEDIUM	DEEP
ENCL-2	Aluminum framed View Glass double glazed	add	N/A	$ 3,110,000	N/A
ENCL-3	Aluminium Triple Glazed	add	N/A	$ 480,000	N/A
Overclad	Exterior minteral wool insulation and compos	add	N/A	N/A	$ 1,250,000

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Mechanical Costing Estimates

Overall Summary of Targeted + Full Rehab Project Costs

Construction Costs		LIGHT	MEDIUM	DEEP
Heating		$ -	$ -	$ 130,000
Ventilation		$ 30,000	$ 530,000	$ 530,000
Plant Heating		N/A	N/A	$ 320,000
In-Suite Heating		N/A	N/A	$ 1,590,000
Sub-total Construction Budget		$ 30,000	$ 530,000	$ 2,570,000
General Conditions	10%	$ 3,000	$ 53,000	$ 257,000
Construction Costs (GC's + Restoration Costs)		$ 33,000	$ 583,000	$ 2,827,000
Project Contingency	10%	$ 3,300	$ 58,300	$ 282,700
Total - Construction Costs		$ 36,300	$ 641,300	$ 3,109,700
Project Costs				
Total Construction Costs		$ 36,300	$ 641,300	$ 3,109,700
HST on Construction & Engineering	13%	$ 4,719	$ 83,369	$ 404,261
Building Permit Fee Allowance	1%	$ 363	$ 6,413	$ 31,097
Project Costs Requiring Funding		**$ 50,000**	**$ 740,000**	**$ 3,550,000**

OPTIONS:*		LIGHT	MEDIUM	DEEP
MECH-2 PLANT HEATING - Replace existing boilers wit	add	N/A	N/A	$ 590,000

APPENDIX C

SUMMARY OF CHANGES FROM DRAFT REPORTS ISSUED DEC 4, 2020 AND DECEMBER 14, 2020

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SUMMARY OF CHANGES FROM DRAFT REPORTS ISSUED DEC 4, 2020 AND DEC 14, 2020

PAGE	CONTEXT	DESCRIPTION OF CHANGE
Throughout	Content Updated	Modified the client name to Minto Apartment Limited Partnership
Project Overview	Added Content	Added Project Limitations section.
Baseline Results for Castleview	Utility Bill Data	Graph updated
Retrofit Roadmap	Graphic Updated	Graphic updated to reflect modified GHG Savings.
Mechanical & Electrical Retrofit Matrix	LED and Low Flow Water Fixtures	Removed LED and low flow water fixtures from the matrix as the existing building already has these features. Updated description of light retrofit path.
Mechanical & Electrical Retrofit Matrix	Content Updated	Corrected the description of the existing plant to reflect both atmospheric and condensing boilers. Modified the description of the Deep Retrofit options to reflect retaining condensing boilers.
Results Overview & Throughout	Energy Metrics	Updated all text, tables, and graphs related to the energy and carbon savings results. These values changed slightly due to updates made to the energy model (updated number of suites, removing the LED lighting updates and low-flow water fixture energy conservation measures, rounding, etc.).
Results Overview	Discussion	Added discussion of energy consumption of the existing building. Added commentary on various enclosure retrofits.
Class D Costing *(Previously Results Overview & Class D Costing)*	Costing	Updated costing values for enclosure and mechanical retrofit options (updated number of suites, removing the LED lighting updates and low-flow water fixture energy conservation measures, etc.).
Results of Energy Analysis	Medium Retrofit Path Analysis	Commentary on the medium retrofit option with the greatest reduction in heat loss clarified.
Appendices	Additional Information	Added energy analysis data, costing breakdowns, and a summary of changes appendices to the report.
Appendix A - Summary of Data	Round EUIs	Updated EUIs in Table A-1