GENIVAR

FINAL REPORT

Energy Audit Report
East Memorial Building
284 Wellington Street
Ottawa, Ontario

SNC LAVALIN O&M Project No. PW129519
GENIVAR Project No. 101-14433-00

Final Report To: **SNC-LAVALIN O&M Inc**
344 Wellington Street
Ottawa, ON K1A 0N3

October 27, 2010

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1.0 EXECUTIVE SUMMARY

SNC-Lavalin O&M retained GENIVAR to conduct an energy audit of the East Memorial Building located at 284 Wellington Street in Ottawa. This work is in keeping with SNCLOM's commitment to the strategic management of the government's real property in an environmentally, socially and economically responsible manner.

The East Memorial Building is located is a federal government building built in 1956 that is primarily occupied by Justice Canada. The building has a total gross floor area of 37,520 m² (403,715 ft²) and an estimated footprint of 4,690 m² (50,470 ft²).[1] It has six floors above grade, two floors below grade and a mechanical penthouse. The original design included two open courtyards, which are now enclosed and covered with skylights as shown in the above. Current building occupancy is estimated to be 854 full time employees (FTEs).

The utility usage shows an overall Building Energy Performance Index (BEPI) of 256 ekWh/m².yr (922 MJ/m².yr) based on a total building gross floor area of 37,524 m² (403,758 ft²). This value is approximately 17% lower than a comparable benchmark.

The electrical energy intensity is 135 kWh/m².yr (486 MJ/m².yr). This value is approximately 16% lower than the comparable benchmark. The efficient lighting and use of variable speed drives (VSDs) on fans and pumps contribute to the lower electrical energy intensity.

The steam energy intensity is 84 ekWh/m².yr (302 MJ/m².yr) which is 16% lower than the comparable benchmark. Table E1 provides a summary of building metrics in addition to the BEPIs listed above.

Table E1: East Memorial Building Metrics

Category	Result
Energy Intensity (MJ/m²)	922
Lighting Energy (W/m²)	~10.9
Air Volume (CFM/m²)	7.6
Fans (W/m²)	16.7
Pumps (W/m²)	~1.0

[1] The building gross area is based on measurements taken from floor plans.

A total of six (6) Energy Efficiency Measures (EEMs) were identified. These measures can potentially achieve total electricity savings of approximately 425,000 kWh/year and steam savings of 3,630 GJ/year with total cost savings of approximately $118,000 per year. This represents an approximate 15% reduction in total energy use. The combined payback period of all the measures is approximately 16.9 years. The long payback period is due to the window replacement measure. The greenhouse gas (GHG) emissions reduction were estimated at 320 Tonnes of eCO_2/year. Table E2 provides a summary of the identified EEMs.

A package of measures that excludes the window replacement would display total energy cost savings of $34,880 and a shorter payback period of 1.6 years.

Table E2: Summary of Proposed Energy Efficiency Measure

MEASURE DESCRIPTION		ANNUAL UTILITY SAVINGS											TOTAL COST	SIMPLE PAYBACK
		TOTAL UTILITY ($)	ELECTRICAL (kW/YR)	ELECTRICAL (kWh/YR)	CHILLED WATER (GJ/YR)	STEAM SPACE HEAT (GJ/YR)	STEAM HUMIDIFICATION (GJ/YR)	STEAM SUMMER REHEAT (GJ/YR)	WATER (m3/YR)	TOTAL (GJ/YR)	CO2e (T/YR)		($)	(YRS)
Lighting Systems														
EEM5	High Performance Fluorescent Lighting (25 W or 28W Lamps)	$13,980	348	120,000						432.0	26.8		$43,080	3.1
Building HVAC and Controls														
EEM1	Advance the Weekday Shutdown of AHUs	$4,500		50,990						183.6	11.4		$0	0.0
EEM2	Operate VAV at Minimum During Weekends and Holidays	$10,500		37,220		330.0				464.0	28.8		$12,000	1.1
EEM3	Repair AHU7 Starter or Relay	$1,200		13,300						47.9	3.0		$1,500	1.3
EEM4	Shutdown all AHUs During the Unoccupied Period	$15,200		90,520		330.0				655.9	40.7		$12,000	0.8
Renewable Onsite Generation														
EEM6	Replacement of Single Pane Windows	$83,100		150,000		3,300.0				3,840.0	238.1		1,935,000	23.3
Measure Totals (all measures)		$117,980	348	424,810	0	3,630	0	0	0	5,159	320		$1,991,580	16.9
Measure Totals (excludes window replacement)		$34,880	348	274,810	0	330	0	0	0	1,319	82		$56,580	1.6

Note: Total cost of EEM5 was calculated assuming an incentive from the ERIP Program for $11,600

ENERGY AUDIT REPORT

2.0 INTRODUCTION

2.1 OBJECTIVES AND METHODOLOGY

This report outlines the results of the diagnostic energy audit and findings for the East Memorial Building in accordance with the SNC Lavalin O&M Terms of Reference defined in the original tender of this work.

GENIVAR conducted interviews with personnel familiar with the facility. Individuals that were interviewed and provided information include:

- Robert Hogan, Technician
- Ross McGregor, Johnson Controls

- The findings of this work will be used to develop an energy reduction work plan and will assist in the implementation of Energy Efficiency Measures (EEM's) to reduce the energy use at the facility.
- Consistent with the TOR, the energy audit included the following activities:
- Undertake an analysis of the historical energy use at the facility for the last two years, including development of a typical year and comparison to benchmark data;
- Develop an energy-end use breakdown as the first step in the calculation of the potential energy savings;
- Undertake an audit of mechanical, electrical and domestic water systems that includes data collection and measurements;
- Investigate and verify the current operating practices and control strategies utilized by the BAS/FMS;
- Create a calibrated DOE2 energy model of the facility
- Develop a list of potential Energy Efficiency Measures (EEMs) and calculate the energy savings and implementation cost for each measure, and
- A "Lights-Out" survey completed afterhours between 5:00 PM and 12:00 PM to determine equipment and lighting that remains in operation during the unoccupied period.

3.0 BUILDING DESCRIPTION

3.1 OVERVIEW

The East Memorial Building located in Ottawa is a federal government building built in 1956 that is primarily occupied by Justice Canada. The building has a total gross floor area of 37,520 m² (403,715 ft²) and an estimated footprint of 4,690 m² (50,470 ft²).[2] It has six floors above grade, two floors below grade and a mechanical penthouse. The original design included two open courtyards, which are now enclosed and covered with skylights as shown in the above photo. Current building occupancy is estimated to be 854 full time employees (FTEs). Table 3.1 provides a summary of the facility information.

A complete mid-life renovation of the building was completed between 1996 and 1998 that included renovation of all floors, enclosure of the courtyards, a new dynamic buffer zone (DBZ) wall cavity and new mechanical equipment and electrical services.

The new design of the mechanical and electrical systems includes a direct-indirect lighting design with pendant fluorescent fixtures that exhibits a low lighting power density (LPD) of 8.6 W/m² (0.8 W/ft²). In addition, all individual offices are equipped with occupancy sensors that turn off the lighting when the space is unoccupied and also controls a digital VAV box that goes to minimum. All VAV air handling units are equipped with variable speed drives (VSDs) and there is a Johnson Controls (JC) Building Automation Systems (BAS) that schedules the operation of all HVAC equipment. The result of this design is good Building Energy Performance Index (BEPI) of 256 ekWh/m².yr (922 MJ/m².yr) that is 17% lower than the comparable benchmark and about 8% lower than the Downtown Portfolio average.

[2] The building gross area is based on measurements taken from floor plans.

Table 3.1: Description of the Facility	
Name of Facility East Memorial Building	**Address** 284 Wellington Street
Owner (if not PWGSC) Government of Canada	**Address**
Building Management	**Address**
Building Name: East Memorial Building	**Building #** 4520432
Address (Street or P.O. Box) 284 Wellington Street	**City, Province/Territory, Postal Code** Ottawa, Ontario
Building Manager (administrator responsible for building) Analia Boisvert	**Bldg. Manager's Phone** (613) 567-2438
Date of Audit July to September 2010	**Type of Facility** Office √ Laboratory ____ Other ____ **Date of construction:** 1956 **Population of Facility:** ~854 full time employees
Original Architects (if known)	**Original Engineers (if known)**
Building Modifications or Changes In Use Anticipated in the next 15 years:	**Remaining Useful life of the building:** 25+ Years
Does the Facility have an ongoing energy management program? *Unknown*	___Yes ___No
Previous Energy Audits Completed? (if yes, give dates) __Yes __No Dates: Energy Audit January 2005 Water Audit January 2005	
Previous Architectural/Engineering Studies Undertaken? (if Yes, Specify) ___Yes ___No Window Thermal Upgrade Study completed in August 2010.	
Name of Utility Suppliers Electricity – Ottawa Hydro Steam and Chilled Water – Public Works and Government Services, Cliff Street Central Heating Plant Water and Sewage – City of Ottawa	

The building uses steam and chilled water from the Cliff Street Central Heating Plant (CHP) for heating and cooling requirements. Steam converters located in the basement are used to generate hot water used in perimeter radiators, and glycol used in heating coils in air handling units. Chilled water is used in air handling units and fan coil units.

The wall construction consists of a cavity wall with exterior limestone and a concrete block finish plus a 150 mm thick terra cotta block wall finish and plaster. A DBZ wall was added during the 1996-1998 building renovation.

There are approximately 386 operable windows throughout the building that consist of single pane glass mounted on a steel frame. The windows are subdivided vertically and horizontally into smaller panes of glass. Window dimensions are approximately 2 x 1.3 meters (6.5 x 4.3 ft). Total window area is approximately 1,003 m² (10,798 ft²).

The ventilation system for the building consists of 17 VAV and CAV air handling units. Six VAV units with a total capacity of 92,980 L/s (~197,000 CFM) meet the comfort and ventilation needs of the occupants on floors 2 to 6. Three CAV units with a total capacity of 30,205 L/s (64,000 CFM) serve the first floor and basement. Two CAV units with a capacity of 12,270 L/s (26,000 CFM) serve the courtyards and two heating only CAV units with a capacity of 4,720 L/s (~10,000 CFM) serve the skylights. Finally, four VAV units with a capacity of 6,800 L/s (14,400 CFM) serve the DBZ.

The washroom and general building exhaust includes 17 exhaust fans that serve the washrooms, photocopy rooms, mechanical rooms and the transformer vault. The largest fans serve the washroom and photocopy rooms with a total combined capacity of 11,880 L/s (25,200 CFM). The fans are located in the basement and penthouse.

Hydro Ottawa provides electricity to building from a 13.2 kV, 5,000 kVA service. This service enters a 600 V, 3,000 Amp distribution switchboard. There is one electrical meter in the building. The electricity consumption is billed under the Business Rate (C1, C2 and C3) with a billing demand of 50 to 1,500 kW.

There is a total of five Thermoplus room air conditioning units serving the data center in Room AA-215. Each unit is rated at 12 tons for a total cooling capacity of 60 tons. These units reject the heat to three air cooled condensers located in the St. Andrews Tower loading dock. The condensers are equipped with 9 fans. Each fan has a 0.5 hp motor.

The lighting consists of direct-indirect pendant fluorescent fixtures equipped with two lamps per fixture. The fluorescent fixtures use standard 4-foot 32 Watt, T8 lamps with electronic ballasts. The lamp currently used is the Sylvania FO32/835/ECO lamp. There are also wall sconces in corridors, recessed fixtures with compact fluorescent lamps and pendant incandescent fixtures at each floor elevator lobby. Finally, a total of 56 metal halide (MH) lamps are used in the courtyards. The average lighting power density in the office space is approximately 8.6 W/m² (0.8 W/ft²). This value climbs to 10.9 W/m² (~1.0 W/ft²) with the architectural lighting (wall sconces and recessed fixtures) and MH lighting in the courtyards. Every office is equipped with a motion detector (occupancy sensor) that is also mapped to the BAS. The BAS also has virtual points that sum the ON status of the motion detectors to provide a surrogate of number of occupants in the building. These points are referred to motion detector status (MDS).

There is minimal exterior lighting which consists of three flood lights on the East exposure and one floodlight located on the northwest corner of the building.

A Johnson Controls Metasys BAS controls all HVAC equipment, 919 digital VAV boxes and the lighting system. All air handling units are scheduled by the BAS to shutdown at the end of occupancy except for three units that operate continuously and provide ventilation in areas occupied by building commissionaires. There are CO_2 sensors in all the two large triangular meeting rooms present on every floor, but no sensors on the return air.

The building domestic hot water (DHW) needs are met with a total of nine 220 L (60 Gal) electric water heating tanks with two tanks per floor. There are a total of 243 bathroom fixtures in the building consisting of 84 water closets, 114 lavatories, 45 urinals. All the fixtures are low flow devices except for the fixtures on the first floor washrooms.

3.2 BUILDING ENVELOPE

The wall construction consists of a cavity wall with exterior limestone and a concrete block finish plus a 150 mm thick terra cotta block wall finish and plaster. A DBZ wall added during the 1996-1998 building renovation pressurizes the wall cavity whenever the outside ambient temperature (OAT) drops below 4°C 39°F) using dry outside air heated to 10°C (50°F).. The DBZ function is to prevent the indoor humidity from migrating and penetrating into the wall cavity and exterior limestone. This in turn will prevent mold growth and structural damage of the limestone exterior finish.

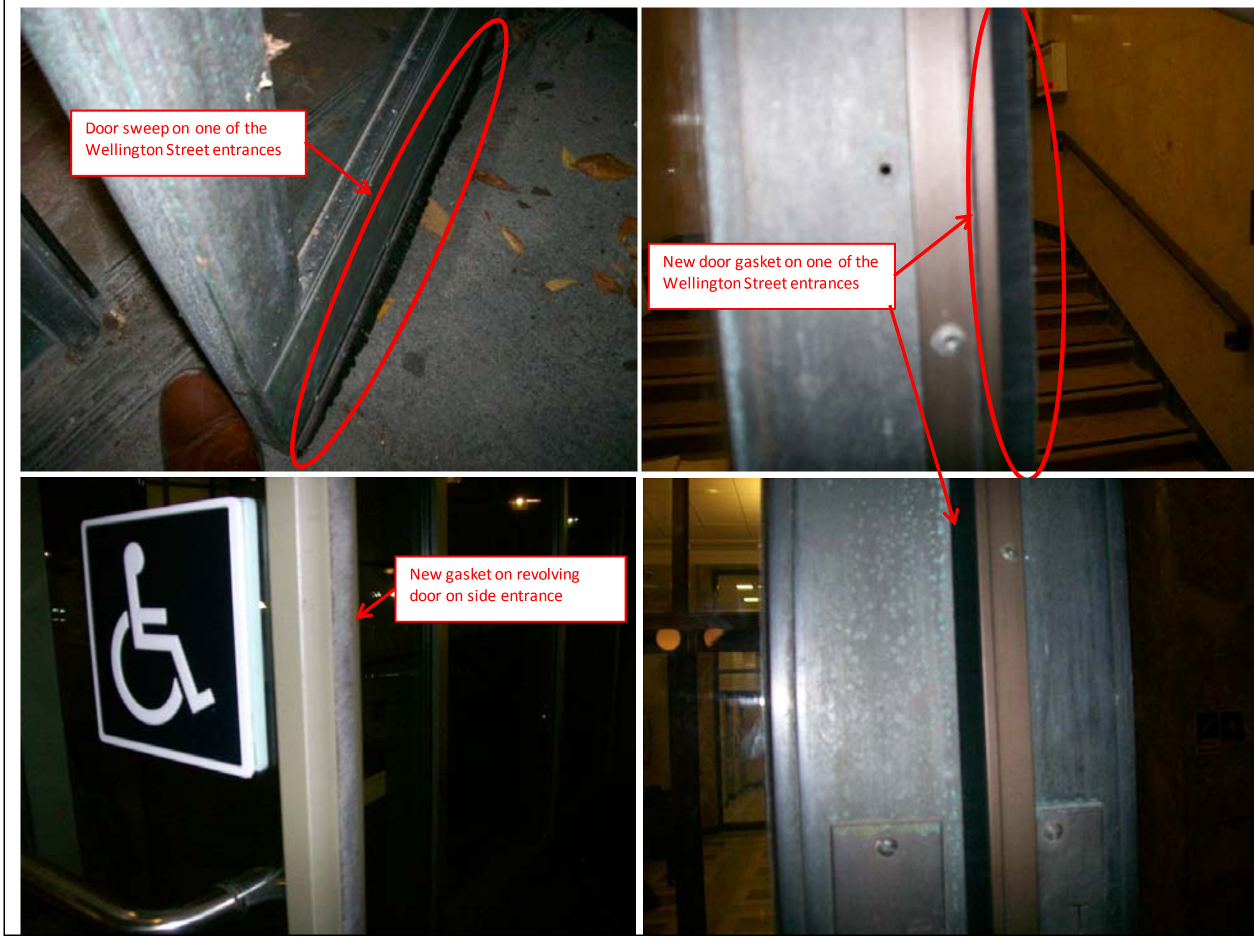
There are approximately 386 operable windows throughout the building that consist of single pane glass mounted on a steel frame. The windows are subdivided vertically and horizontally into smaller panes of glass. Window dimensions are approximately 2 x 1.3 meters (6.5 x 4.3 ft). Total window area is approximately 1,003 m² (10,798 ft²). The window study completed two months ago reported that the windows appear in good condition. The Uvalue of the existing window was reported to be 5.36 W/m².°C. (~1 Btu/hr.ft²°F).

Figure 3.2:
East Memorial Windows

The roof of the building includes a conventional inverted flat roof as well as a copper roof on the slope roof located on the north, east and west perimeters.

All exterior doors were found to have door sweeps and gaskets that were in good condition. This included all access doors on Wellington Street which are not in use anymore. Figure 3.3 shows a series of photos that illustrate the condition of door sweeps and gaskets on revolving and swing doors. As shown one of the swing doors facing Wellington Street has a new gasket and a door sweep that is in good condition. The revolving door located at the side entrance also has a new gasket that provided tight closure.

Figure 3.3:
Condition of Entrance Doors



3.3 SPACE HEATING

Space heating requirements are met with steam from the Cliff Street CHP. Steam is supplied to three Armstrong converters located in the basement. Two converters provide hot water to perimeter radiators and reheat coils at a temperature range of 43 to 93°C (110 to 200°F). The hot water temperature is based on an outside air reset schedule. The third heat exchanger provides glycol at a constant temperature of 93°C (200°F) to air handling unit coils.

There is also a steam to steam Cemline heat exchanger that provides low pressure steam to the humidifiers in the penthouse air handling units. The heat exchanger has a steam capacity of 1,000 Lb/hr at 10 psig.

The converters and steam to steam heat exchanger have a stamped date of 1997. From an equipment condition standpoint the converters and heat exchanger will continue to operate for an additional 12 to 15 years based on typical life expectancies.[3]

[3] 2003 ASHRAE Handbook, HVAC Applications, Owning and Operating Costs, Chapter 36, Table 3.

Figure 3.4:
East Memorial Steam Converters and Steam to Steam Exchanger

	Manufacturer	Model Number	Area Served	Capacity (lbs/hr)
Converter #1 (hot water)	Armstrong	WS-123-2E2	perimeter heating	3,700
Converter #2 (hot water)	Armstrong	WS-83-2E2	reheat coils	3,175
Converter #3 (glycol)	Armstrong	WS-164-2E2	(AHU heating coils)	9,050
Steam to Steam converter	Cemline	H395USG1072	(AHU humidification coils)	1,000 lb/hr.

There are six hot water and glycol circulating pumps associated with the heating system and the converters. All pumps are equipped with variable speed drives (VSDs) and inverter duty motors. The variable speed pumps modulate in response to system demand.

Table 3.5 lists the circulating pumps and associated systems. As shown each system is served by a two pump arrangement with one pump operating as a back-up. The pumps were installed at the time of the 1997 renovation appear in good condition with no visible leaks. Detailed information can be found in **Appendix A**.

Table 3.5:
Space Heating Circulating Pumps

System			Design Flow (L/s)	Motor Size (HP)	Motor Efficiency
Converter 1	P1	Perimeter heating	22.1	10	89.5%
	P2	Perimeter heating (standby)	22.1	10	89.5%
Converter 2	P3	Reheat coils	12.6	10	89.5%
	P4	Reheat coils (standby)	12.6	10	89.5%
Converter 3	P5	AHU heating coils	31.6	25	94.1%
	P6	AHU heating coils (standby)	31.6	25	94.1%

There are also two TACO condensate pumps and a condensate receiver located in the building basement that returns condensate to the Cliff Street Central Heating Plant (CHP). Each pump is rated at 3 hp. The pumps were installed at the time of the 1997 renovation appear in good condition with no visible leaks.

Table 3.6:
Condenser Receiver and Pumps

	Design Flow (L/s)	Motor Size (HP)	Motor Efficiency
Condensate pump	5.6	3	80.5%
Condensate pump	5.6	3	80.5%

There are four new thermo 2000 electric boilers each with a rated capacity of 139 Amps and 491,000 Btu/hr that were installed in 2009 in a mezzanine above the mechanical room where the converters are located. These boilers are connected to a ITT Industry plate heat exchanger to heat glycol for the coils in the air handling units.

Each boiler is equipped with its own 1 hp Bell & Gossett circulating pump. In addition, there are also a total of four 1.5 hp circulating pumps on the glycol side of the plate heat exchangers.

Table 3.7:
New Electric Boilers for Glycol Heating

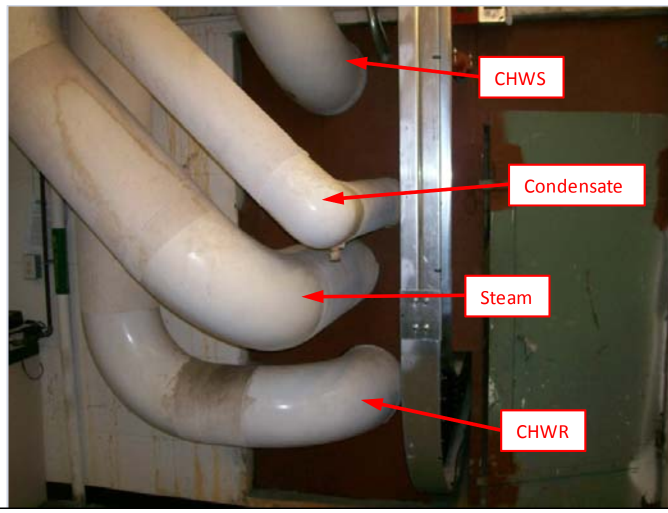
These boilers may have operated between October and December of 2009 since the electrical peak demand was approximately 250 kW higher during that period compared to previous years. This can be seen in the detailed utility usage summary in **Appendix C.**

3.4 BUILDING AIR CONDITIONING

3.4.1 Building Cooling

Space cooling needs are met with chilled water from the Cliff Street Central Heating Plant (CHP), which enters the building via a service tunnel in the basement. The chilled water is used in air handling units and fan coil units.

Figure 3.8:
Chilled Water and Steam Entry Located in the Basement



Based on the billing data from 2007 to 2010, chilled water is supplied to the building between April and November (see the energy use analysis in Section 5). This is an improvement over previous years when chilled water was provided 12 months of the year to supply computer room fan coils. The historical energy use analysis presented in Section 5 shows a 40% reduction in annual chilled water consumption relative to when the building used chilled water for the entire year.

3.4.2 Other Cooling Equipment

There is a total of five Thermoplus room air conditioning units serving the data center in Room AA-215. Each unit is rated at 12 tons for a total cooling capacity of 60 tons. These units reject the heat to three air cooled condensers located in the St. Andrews Tower loading dock. The condensers are equipped with 9 fans. Each fan has a 0.5 hp motor.

3.5 VENTILATION SYSTEMS

The ventilation system for the building consists of 17 VAV and CAV air handling units. Six VAV units with a total capacity of 92,980 L/s (~197,000 CFM) meet the comfort and ventilation needs of the occupants on floors 2 to 6. Three CAV units with a total capacity of 30,205 L/s (64,000 CFM) serve the first floor and basement. Two CAV units with a capacity of 12,270 L/s (26,000 CFM) serve the courtyards and two heating only CAV units with a capacity of 4,720 L/s (~10,000 CFM) serve the skylights. Finally, four VAV units with a capacity of 6,800 L/s (14,400 CFM) serve the DBZ. The available combined design air flow of all units serving the occupied space results in air flow per unit floor area of 3.6 L/s/m² (0.71 CFM/ft²). Each system is described in more detail in the following sections.

3.5.1 Interior and Perimeter Units for Floors 2 to 6 (AHUs 1 to 6)

The air handling units that serve the interior and perimeter on floors 2 through 6 consist of six VAV systems. The units have a combined design air flow of 92,980 L/s (~197,000 CFM). The units serve a total floor area of 23,452 m² (252,000 ft²) and can deliver a maximum air flow of ~4.0 L/s.m² (0.78 CFM/ft²). This design air flow does not appear to be reached even above summer design conditions since flow was approximately 63% of maximum design at an OAT of 33°C (91°F).[4]

Each AHU is equipped with a filter section, cooling coil, heating section and mixed air section. The supply fans and return fans are airfoil centrifugal and vane axial fans, respectively. Both fans are equipped with variable speed drives (VSDs). Table 3.9 provides a summary of the characteristics of the units including design air flow and fan motor sizes. **Appendix A** provides more detail of the characteristics, components and operation mode.

Table 3.9:
Characteristics of the Interior and Perimeter AHUS for Floors 2 to 6

Area Served	Type	Design Volume (L/s)	Flow at Summer Design (33°C) (1) (L/s)	Motor Size (hp)	
				Supply Fan	Return Fan
AHU1 North Perimeter	VAV	16,990	11,800	50	40
AHU2 East Perimeter	VAV	12,270	8,100	40	30
AHU3 West Perimeter	VAV	14,160	9,100	50	40
AHU4 South Perimeter	VAV	14,160	8,300	50	40
AHU5 North Interior	VAV	21,240	12,000	75	50
AHU6 South Interior	VAV	14,160	8,900	50	40
		92,980	**58,200**		

(1) Air flow extracted from the BAS during a site visit on Aug 5 when OAT was at 33°C (91°F)

The AHUs are controlled by the Johnson Controls Metasys BAS. The operating schedule and control strategies employed by the BAS are as follows:

- The BAS indicates an operating schedule of 6:00 AM to 8:00 PM Monday through Friday and 8:00 AM to 5:00 PM during weekends and holidays. This schedule is implemented year around. At present however, air handling units AHU2 and AHU5 operate continuously, and AHU4 has been operating continuously since May and did not shut down on the day of the "Lights-Out audit (see Section 4).
- The sequence of operation for the air handling units relies on a supply air temperature (SAT) reset based on return air temperature (RAT). The SAT scheduled is shown in Table 3.10. However, the actual schedule appears to be different since during a site visit, the SAT setpoint was observed to be outside the reset schedule range by 2 to 3°C. Actual SAT and RAT setpoints by air handling unit are shown in Table 3.11.

[4] The OBC summer design conditions for Ottawa is 30°C (86°F) dry-bulb.

Table 3.10: BAS Defined SAT Reset Schedule for AHUs 1 to 6		
RAT °C (°F)	**Interior AHUs**	**Perimeter AHUs**
	SAT Setpoint °C (°F)	**SAT Setpoint °C (°F)**
25 (77)	14 (57)	13 (55)
20 (68	17 (63)	16 (61)

Table 3.11: Actual SAT and RAT Temperatures for AHUs 1 to 6		
AHUs	**RAT °C (°F)**	**SAT Setpoint °C (°F)**
AHU1	21 (70)	18 (64)
AHU2	22 (72)	17 (63)
AHU3	22 (72)	19 (66)
AHU4	22 (72)	18 (64)
AHU5	22 (72)	18 (64)
AHU6	23 (73)	16 (61)

- Supply and return volume control is based on a constant static pressure setpoint. Supply fan static pressure setpoint ranges from 200 to 225 Pa (0.8 to 0.9 in) and the return fan setpoint is from 0 to 25 Pa (0 to 0.1 in).
- Economizer control is dry-bulb based.
- There is no demand control ventilation or CO_2 reset of outside air.
- During the unoccupied period, an air handling unit is started if more than 5 motion detectors on one area of one floor served by an air handling unit are activated.

The operation of the air handling units was observed during multiple site visits including the “Lights-Out” audit. The following operational and control issues were noted:

- The air handling units do not reliably shutdown at the end of occupancy. This occurs because the current control logic starts an air handling unit if more than 5 motion detectors on one area of one floor (i.e., 5th floor East Orientation) show an “occupied” status. This is described in more detail in Section 4.
- There appears to be a problem with the AHU7 supply fan relay or possibly the starter since the fan has been running continuously while the return fan shuts down at the end of occupancy (see Section 4).
- AHU4 was noted to have been running continuously since May. This may be due to the motion detectors in the zones served by this unit, which show an “occupied” status.
- According to Johnson Controls, only AHU2 needs to operate continuously, but not AHU5.
- The fan speed of AHUs that operate during the unoccupied period was observed to drop by only 5 to 10% during the unoccupied period because the VAV boxes remain on “occupied” mode.
- Outside air volume at minimum damper position is estimated to be approximately 16,300 L/s (~34,500 CFM). This translates into a ventilation rate of 24 L/s/occupant (52 CFM/person) based on a prorated 664 occupants located between floors two and six. Table 3.12 provides a breakdown of the outside air flow at minimum damper position based on data collected during a site visit on Aug 5 when OAT was at 33°C (91°F).

**Table 3.12:
Minimum Outside Air Provided by AHUs 1 to 6**

Area Served	Flow at Summer Design (33°C) (1) (L/s)	Calculated OA Volume (%)	Minimum OA Volume (2) (L/s)
AHU1 North Perimeter	11,800	29%	3,422
AHU2 East Perimeter	8,100	47%	3,800
AHU3 West Perimeter	9,100	31%	2,820
AHU4 South Perimeter	8,300	27%	2,240
AHU5 North Interior	12,000	15%	1,800
AHU6 South Interior	8,900	25%	2,225
	58,200		**~16,300**
			24 L/s/occupant

(1) Air flow extracted from the BAS during a site visit on Aug 5 when OAT was at 33°C (91°F)
(2) Reported by the BAS based on the Tmixed equation
(3) The ventilation rate is based on an estimated 664 occupants located on floors 2 to 6.

There is an opportunity to reduce the energy use through modification of the schedules and control strategies as follows:

- Ensure that AHU4 shuts down at the end of occupancy.
- Ensure that AHU5 shuts down at the end of occupancy.
- Consider advancing the shutdown of air handling units to 7:00 PM.
- As an alternative to shutting down the air handling units at the end of occupancy, consider reducing the speed of the air handling units to 30% of full flow during the unoccupied period. This "standby mode" will ensure that air flow is available for those zones that may be occupied, but will minimize the fan energy use. This standby mode could also be maintained during weekends when occupancy would be very light.

3.5.2 First Floor and Basement Air Handling Units (AHUs 9 to 11)

The air handling units that serve the first floor and basement consist of three VAV systems. The units have a combined design air flow of 30,205 L/s (~64,000 CFM). The units serve a total floor area of 14,070 m² (~151,400 ft²) and can deliver a maximum air flow of ~2.1 L/s.m² (0.4 CFM/ft²). This design air flow does not appear to be reached even above summer design conditions since flow was approximately 72% of maximum design at an OAT of 33°C (91°F).[5]

Each AHU is equipped with a filter section, cooling coil, heating section and mixed air section. The supply fans and return fans are airfoil centrifugal and vane axial fans, respectively. Both fans are equipped with variable speed drives (VSDs). Table 3.13 provides a summary of the characteristics of the units including design air flow and fan motor sizes. **Appendix A** provides more detail of the characteristics, components and operation mode.

[5] The OBC summer design conditions for Ottawa is 30°C (86°F) dry-bulb.

Table 3.13:
Characteristics of the Interior and Perimeter AHUs for the First Floor and Basement

Area Served	Type	Design Volume (L/s)	Flow at Summer Design (33°C) (1) (L/s)	Motor Size (hp)	
				Supply Fan	Return Fan
AHU9 Ground Floor West	VAV	9,440	5,100	40	25
AHU10 Basement South & East	VAV	9,440	7,100	40	25
AHU11 Ground East & Basement North	VAV	11,325	9,700	40	25
		30,205	**21,900**		

(1) Air flow extracted from the BAS during a site visit on Aug 5 when OAT was at 33°C (91°F)

The AHUs are controlled by the Johnson Controls Metasys BAS. The operating schedule and control strategies employed by the BAS are as follows:

- The BAS indicates an operating schedule of 6:00 AM to 8:00 PM Monday through Friday and 8:00 AM to 5:00 PM during weekends and holidays. This schedule is implemented year around. At present however, air handling unit AHU11 operates continuously.
- The sequence of operation for the air handling units relies on a supply air temperature (SAT) reset based on return air temperature (RAT). The SAT scheduled is shown in Table 3.14 which based on visual inspection is being maintained.

Table 3.14:
BAS Defined SAT Reset Schedule for AHUs 9, 10 and 11

RAT °C (°F)	Interior AHUs	Perimeter AHUs
	SAT Setpoint °C (°F)	SAT Setpoint °C (°F)
25 (77)	14 (57)	13 (55)
20 (68	17 (63)	16 (61)

- Supply and return volume control is based on a constant static pressure setpoint. Supply fan static pressure setpoint is set to 225 Pa (0.9 in) on all three units and the return fan setpoint is set to 0.
- Economizer control is dry-bulb based.
- There is no demand control ventilation or CO_2 reset of outside air.

The operation of the air handling units was observed during multiple site visits including the “Lights-Out” audit. The following operational and control issues were noted:

- The air handling units do not reliably shutdown at the end of occupancy. As an example, AHU9 did not shutdown on the night of the “Lights-Out” audit and longer trend data shows that the unit shuts down at 8:00 PM, but re-starts within three minutes. This occurred repeatedly during the month of August.
- Outside air volume at minimum damper position is estimated to be approximately 10,733 L/s (~22,700 CFM). This translates into a ventilation rate of 56 L/s/occupant (120 CFM/person) based on a prorated 190 occupants located in the first floor and basement. Table 3.15 provides a breakdown of the outside air flow at minimum damper position based on data collected during a site visit on Aug 5 when OAT was at 33°C (91°F).

Table 3.15: Minimum Outside Air Provided by AHUs 9, 10 and 11			
Area Served	**Flow at Summer Design (33°C)** (1) **(L/s)**	**Calculated OA Volume (%)**	**Minimum OA Volume** (2) **(L/s)**
AHU9 Ground floor West	9,440	33%	3,110
AHU10 Basement South & East	9,440	28%	2,640
AHU11 Ground East & Basement North	11,325	44%	4,983
	30,205		**~10,733**
			56 L/s/occupant

(1) Air flow extracted from the BAS during a site visit on Aug 5 when OAT was at 33°C (91°F)
(2) Reported by the BAS based on the Tmixed equation
(3) The ventilation rate is based on an estimated 190 occupants located on the first floor and basement.

There is an opportunity to reduce the energy use through modification of the schedules and control strategies as follows:

- Ensure that AHU9 shuts down at the end of occupancy.
- Consider advancing the shutdown of air handling units to 7:00 PM.

  As an alternative to shutting down the air handling units at the end of occupancy, consider reducing the speed of the air handling units to 30% of full flow during the unoccupied period. This “standby mode” will ensure that air flow is available for those zones that may be occupied, but will minimize the fan energy use. This standby mode could also be maintained during weekends when occupancy would be very light.

3.5.3 Courtyard Air Handling Units (AHU7, AHU8, AHU16 & AHU17)

Two CAV units with a capacity of 12,270 L/s (26,000 CFM) serve the courtyards and two heating only CAV units with a capacity of 4,720 L/s (~10,000 CFM) serve the skylights. These last units are recirculation units with no outside air.

Each AHU is equipped with a filter section, cooling coil, heating section and mixed air section. The supply fans and return fans on AHU7 and AHU8 are airfoil centrifugal and vane axial fans, respectively. Fans on AHU16 and AHU17 are forward curve centrifugal. Table 3.16 provides a summary of the characteristics of the units including design air flow and fan motor sizes. **Appendix A** provides more detail of the characteristics, components and operation mode.

Table 3.16: Characteristics of the Courtyard AHUs				
Area Served	**Type**	**Design Volume (L/s)**	**Motor Size (hp)**	
			Supply Fan	**Return Fan**
AHU7 West Courtyard	CAV	6,135	20	15
AHU8 East Courtyard	CAV	6,135	20	15
AHU16 West Courtyard Skylight Heating	CAV	2,360	5	
AHU17 East Courtyard Skylight Heating	CAV	2,360	5	

The AHUs are controlled by the Johnson Controls Metasys BAS. The operating schedule and control strategies employed by the BAS are as follows:

- AHU7 and AHU8 have an operating schedule of 6:00 AM to 4:00 PM Monday through Friday and 8:00 AM to 4:00 PM during weekends and holidays . This schedule is implemented year around.

- AHU16 and AHU17 operate whenever the outside air temperature is below 4°C (39°F). The AHUs modulate the heating valve to maintain a glass temperature of 10°C (50°F).
- The sequence of operation for AHU7 and AHU8 relies on a supply air temperature (SAT) reset based on return air temperature (RAT). The SAT scheduled is shown in Table 3.17 which based on visual inspection is being maintained. However, the actual schedule appears to be different since during a site visit, the SAT setpoint was observed to be 4°C higher than the reset schedule.

Table 3.17:
BAS Defined SAT Reset Schedule for AHU7 and AHU8

RAT °C (°F)	SAT Setpoint °C (°F)
25 (77)	13 (55)
20 (68	16 (61)

- Economizer control is dry-bulb based.
- There is no demand control ventilation or CO_2 reset of outside air.

The operation of the air handling units was observed during multiple site visits including the “Lights-Out” audit. The following operational and control issues were noted:
- The air handling units do not reliably shutdown at the end of occupancy. As an example, AHU7 supply fan did not shutdown on the night of the “Lights-Out” audit and longer trend data shows the unit running since August 12 (see Section 4).
- Outside air volume for AHU7 and AHU8 at minimum damper position is estimated to be approximately 1,349 L/s (~2,900 CFM). Table 3.18 provides a breakdown of the outside air flow at minimum damper position based on data collected during a site visit on Aug 5 when OAT was at 33°C (91°F).

Table 3.18:
Minimum Outside Air Provided by AHU7 and AHU8

Area Served	Flow at Summer Design (33°C) (1) (L/s)	Calculated OA Volume (%)	Minimum OA Volume (2) (L/s)
AHU7 West Courtyard	6,135	8%	490
AHU8 East Courtyard	6,135	14%	859
	12,270		**~1,349**

(2) Air flow extracted from the BAS during a site visit on Aug 5 when OAT was at 33°C (91°F)
(3) Reported by the BAS based on the Tmixed equation

There is an opportunity to reduce the energy use through modification of the schedules and control strategies as follows:
- Investigate why the supply fan on AHU7 does not shutdown and make necessary repairs to ensure that it shuts down at the end of occupancy together with the return fan.

3.5.4 Wall-Cavity Pressurization Air Handling Units (AHUs 12 to 15)

Four 100% outside air VAV by-pass air handling units with a capacity of 6,800 L/s (14,400 CFM) serve the dynamic buffer zone (DBZ) wall.

Each AHU is equipped with a filter section, cooling coil, heating section and mixed air section. Table 3.19 provides a summary of the characteristics of the units including design air flow and fan motor sizes. **Appendix A** provides more detail of the characteristics, components and operation mode.

Table 3.19: Characteristics of the AHUs Serving the DBZ

Area Served	Type	Design Volume (L/s)	Motor Size (hp)	
			Supply Fan	Return Fan
AHU12 South-West Perimeter Wall Cavity	VAV by-pass	1,700	5	
AHU13 North-West Perimeter Wall Cavity	VAV by-pass	1,700	5	
AHU14 North –East Perimeter Wall Cavity	VAV by-pass	1,700	5	
AHU15 South-East Perimeter Wall Cavity	VAV by-pass	1,700	5	

The AHUs are controlled by the Johnson Controls Metasys BAS. The operating schedule and control strategies employed by the BAS are as follows:

- In the winter period the units will operate whenever the outside air temperature is below 4°C (39°F) and supply warm air to the DBZ based on the reset schedule shown in Table 3.20.

Table 3.20: BAS Defined SAT Reset Schedule for AHUs Serving the DBZ

OAT °C (°F)	SAT Setpoint °C (°F)
-30 (-22)	30 (86)
15 (59)	15 (59)

- At an OAT between 15 to 25°C (59 to 77°F) provide free cooling to cool the DBZ if the wall cavity temperature is at least 5°C warmer than the OAT.
- The bypass damper modulates to maintain a wall cavity pressure of 40 Pa (0.16 inches).

3.5.5 Fan Coils Serving Elevator Machine (FC8 through FC11)

Four fan coils with a combined capacity of 5,664 L/s (12,400 CFM) provide heating and cooling to elevator machine rooms. Table 3.21 provides a summary of the characteristics of the units including design air flow and fan motor sizes.

Table 3.21: Characteristics of Fan coils Serving the Elevator Machine Room				
Area Served	**Type**	**Design Volume (L/s)**	**Motor Size (hp)**	
			Supply Fan	**Return Fan**
FC8 NW Elevator Machine Room	Fan coil	1,416	3	
FC9 NE Elevator Machine Room	Fan coil	1,416	3	
FC10 SE Elevator Machine Room	Fan coil	1,416	3	
FC11 SW Elevator Machine Room	Fan coil	1,416	3	

The fan coils are controlled by the Johnson Controls Metasys BAS. The control strategies employed by the BAS are as follows:

- The fan coils provide a constant temperature setpoint of 23°C (73°F)
- During the unoccupied period the fan cycles on a cooling or heating demand

The operation of the fan coils was observed during multiple site visits including the "Lights-Out" audit. The following operational and control issues were noted:

- During the "Lights-Out" audit the 3 of the fan coils were operating during the nighttime even though it was mild weather which should have not required heating or cooling.
- The current BAS setpoints are 21°C (70°F) winter and 23°C (73°F) summer which are significantly above and below the original BAS parameters and will cause additional energy use for space heating and cooling.

There is an opportunity to reduce the energy use by relaxing the setpoints to 25 to 26°C (77 to 79°F) during the summer period and 18 to 20°C (64 to 68°F) during the winter period.

3.5.6 Variable Air Volume Boxes

There are an estimated 919 digital, fan powered VAV boxes serving the building. The VAV boxes are fully digital and controlled through the BAS. The original VAV box control strategies outlined in the BAS sequence of operation are as follows:

- During the occupied period VAV boxes modulate air flow and heating valves to maintain a space temperature of approximately 23°C (73°F).
- During the occupied period the BAS sequence of operation states that the minimum flow is equal to 55 to 65% of the VAV maximum flow.
- During the unoccupied period, VAV boxes go to an unoccupied mode when the occupancy status on the floor is also "unoccupied". The VAV boxes will maintain a cooling setpoint of 27°C (81°F) and a heating setpoint of 18°C (59°F) based on a 4.5°C unoccupied bias.

The actual operation of the VAV boxes was observed during multiple site visits. The following operational and control issues were noted:

- In general, VAV boxes do not switch to an "unoccupied mode" because of the high number of motion detectors showing an "occupied" status which keeps floors on an "occupied" mode. A more detailed discussion can be found in Section 4.

- There is no temperature setback during the unoccupied period although inspected VAV boxes do show a 4.5°C unoccupied bias, which according to the sequence of operations, is designed to offset the occupied space temperature in the summer (up by 4.5°C) and winter (down by 4.5°C).

There is an opportunity to reduce the energy use during the unoccupied period through modification of the control strategies as follows:

- Modify the VAV box control so that the control status is based on zone motion detector status (MDS) rather than dependant on the floor occupied status. This will allow VAV boxes to close to minimum position during the unoccupied period and setback the space temperature unless the zone motion detector status (MDS) is “occupied”. Based on the total MDS trend data observed during site visits, it should be possible to get 70 to 80% of the VAV boxes to switch to an unoccupied mode during the unoccupied period and on weekends.

- Ensure that winter period temperature setback is only implemented at OAT>5°C (41°F) because of the single pane windows.

3.5.7 Washroom and General Exhaust Fans

The washroom and general building exhaust includes 17 exhaust fans that serve the washrooms, photocopy rooms, mechanical rooms and the transformer vault. The largest fans (EF1, 2, 5, 6, 7) serve the washroom and photocopy rooms and have a total combined capacity of 11,880 L/s (25,200 CFM). These fans are controlled by the BAS and scheduled to operate between 6:00 AM and 8:00 PM. Table 3:22 provides a summary of the characteristics of the washroom and general exhaust fans.

Table 3.22:
Summary of Characteristics of Washroom and General Exhaust Fans

Area Served	Design Volume (L/s)	Motor Size (hp)
EF1 Washroom Exhaust West	2,780	5
EF2 Washroom Exhaust East	2,410	5
EF3 Smoke Exhaust West Courtyard (1)	16,520	15
EF4 Smoke Exhaust East Courtyard (1)	16,520	15
EF5 Ground Floor Copy Room Exhaust	2,170	3
EF6 Ground Floor Copy Room Exhaust	2,400	3
EF7 Ground Floor Copy Room Exhaust	2,120	3
EF8 Lower Mech. Room Exhaust – West	600	1.25
EF9 Upper Mech. Room Exhaust – East	600	1.25
EF10 Lower Mech. Room Exhaust – East	600	1.25
EF11 7th floor Mech. Room Exhaust – West	700	0.5
EF12 7th floor Mech. Room Exhaust – East	700	0.5
EF13 7th floor Mech. Room Exhaust – North	700	0.5
EF14 7th floor Mech. Room Exhaust – North	700	0.5
EF15 7th floor Mech. Room Exhaust – N/W	700	0.5
EF16 Recycling Room Exhaust	600	0.75
EF17 Transformer Vault Exhaust	3,775	5
These fans are part of the Life Safety system.		

3.6 LIGHTING SYSTEM

The lighting consists of direct-indirect pendant fluorescent fixtures equipped with two lamps per fixture. The fluorescent fixtures use standard 4-foot 32 Watt, T8 lamps with electronic ballasts. The lamp currently used is the Sylvania FO32/835/ECO lamp. There are also wall sconces in corridors, recessed fixtures with compact fluorescent lamps and pendant incandescent fixtures at each floor elevator lobby. Finally, a total of 56 metal halide (MH) lamps are used in the courtyards. The average lighting power density in the office space is approximately 8.6 W/m² (0.8 W/ft²). This value climbs to 10.9 W/m² (~1.0 W/ft²) with the architectural lighting (wall sconces and recessed fixtures) and MH lighting in the courtyards.

Every office is equipped with a motion detector (occupancy sensor) that is also mapped to the BAS. The BAS also has virtual points that sum the ON status of the occupancy sensors to provide a surrogate of number of occupants in the building. These points are referred to motion detector status (MDS). There are an estimated 582 motion detectors controlling lighting in perimeter offices and another 337 sensors serving lighting in interior zones. There are two exceptions as follows:

- Conference rooms have individual light switches;
- corridor lighting operates continuously;

Light levels measured in the space range from 5 to 15 Lux (50 to 150 footcandles) in corridors to 25 to 45 Lux (250 to 450 footcandles in office spaces. Table 3.23 provides a list of randomly surveyed areas. **Appendix B** contains drawings with measured illuminance levels and calculated lighting power densities.

Table 3.23:
Summary of Illuminance Levels

Area Surveyed	Illuminance Lux (footcandles)
2nd Floor open office area	20 to 45 (200 to 450)
2nd floor open office area	15 to 25 (150 to 250)
2nd floor open office area	30 to 35 (300 to 350)
2nd Floor interior office	30 (300)
2nd floor interior office	32 (320)
2nd Floor corridor	6 to 17 (60 to 170)
3rd Floor conference room	24 to 38 (240 to 380)
3rd Floor open office area	20 to 35 (200 to 350)
3rd Floor interior office	22 (220)
3rd floor perimeter office	35 (350)
3rd Floor corridor	6 to 12 (60 to 120)
4th floor open office area	25 to 50 (250 to 500)
4th floor perimeter office	25 (250)
4th floor interior office	37 (376)
5th Floor elevator Lobby	6 to 15 (60 to 150)
5th Floor open office area	32 (320)
5th Floor corridor	3 to 20 (30 to 200)
5th Floor perimeter office	35 (350)
6th Floor perimeter office	45 (450)
6th Floor corridor	5 to 15 (50 to 150)
6th Floor open office area	15 to 25 (150 to 250)

The existing F32 T8 lamps could be replaced with new generation 28W T8 lamps that also offer a longer lamp life of 30,000 hours. This option will provide an approximate 10% reduction in demand and energy use, but only a small reduction in light levels thanks to a higher lumen maintenance factor of the better lamp. This reduced wattage fluorescent lamp technology is making significant inroads in the marketplace and steadily replacing the standard 32 Watt lamp.

3.7 DOMESTIC HOT WATER & PLUMBING SYSTEMS

The building domestic hot water (DHW) needs are met with a total of nine 220 L (60 Gal) electric water heating tanks with two tanks per floor. There are a total of 243 bathroom fixtures in the building consisting of 84 water closets, 114 lavatories, and 45 urinals.

All the fixtures are low flow except for the fixtures on the first floor washrooms. The water closets are rated at 6 litres per flush, the urinals have a rating of 3.8 litres per flush and most lavatory faucets are equipped with a 2 GPM faucet aerator.

4.0 LIGHTS-OUT AUDIT (UNOCCUPIED PERIOD SURVEY)

This section presents the findings of the Lights Out Audit (LOA) conducted between 5:00 PM and midnight on September 14, 2010. A survey of the mechanical rooms, HVAC equipment, lighting on all floors, the building exterior and a review of the BAS was conducted during the audit. The findings are presented in four separation sections including building occupancy, lighting equipment, HVAC equipment and the building exterior.

4.1 NUMBER OF OCCUPANTS DURING THE UNOCCUPIED PERIOD

The following observations are provided in regards to building occupancy during the unoccupied period:

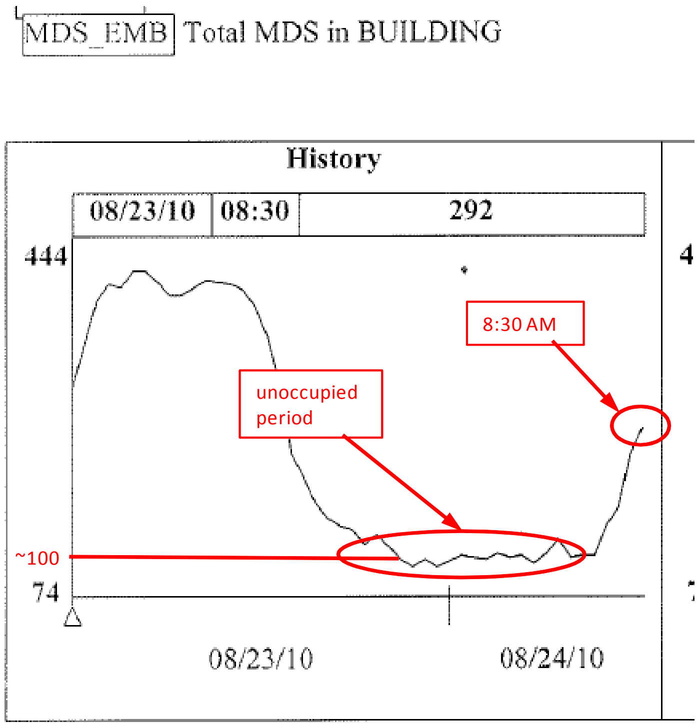
- The daytime occupancy on the day of the LOA was just under 500 occupants as reported by the BAS motion detector status.
- The occupancy dropped to approximately 20 people based on a walk-through of the space started at 6:00 PM. By 9:00 PM all occupants had left the building with the possible exception of two people on the first floor. The breakdown by floor is presented in Table 4.1.

Table 4.1:
Occupants Remaining in the Building After 6:00 PM
(Tuesday September 14, 2010)

	6:00 PM to 7:00 PM	**After 9:00 PM**
1st floor	3 + commissionaires	2 + commissionaires
2nd floor	2	0
3rd floor	4	0
4th floor	4	0
5th floor	4	0
6th floor	1	0
Total	**~20**	**~5**

- After 6:00 PM, the BAS motion detector status (MDS) reported a count of approximately 100 sensors showing an "occupied" status. This count remained constant throughout the night and matches values noted on August 23 (see Figure 4.2). The difference between actual occupancy and the constant MDS value of 100 cannot be explained without an in-depth review of every single motion sensor to identify sensors that are reporting an ON condition. A discussion with Johnson Controls (JC) revealed that this survey was conducted a few years ago. Visual inspection during the walk-through showed no more than five individual offices per floor and a few open office areas where lights remained on. Without review of the JC report, the explanations proposed here include sensors that have been replaced with a conventional light switch or newer sensors as noticed in a few offices and in two photocopy rooms. JC also stated that a large number of sensors in the basement areas have been replaced with light switches. Finally, ceiling mounted sensors used in open office areas seem to be affected by air flow from diffusers which is also adding to the "occupied" counts. This situation needs to be rectified because presently most air handling units are enabled in the unoccupied period by the high count of sensors reporting an "occupied" status (see Section 4.3 below).
- No cleaning staff was present after hours.
- One tenant entered the building at 10:00 PM confirming that the building and the library are used after hours.

Figure 4.2:
Trend of Motion Detector Status (MDS) from BAS



4.2 LIGHTING OPERATION DURING THE UNOCCUPIED PERIOD

The following observations are provided in regards to lighting operation during the unoccupied period:

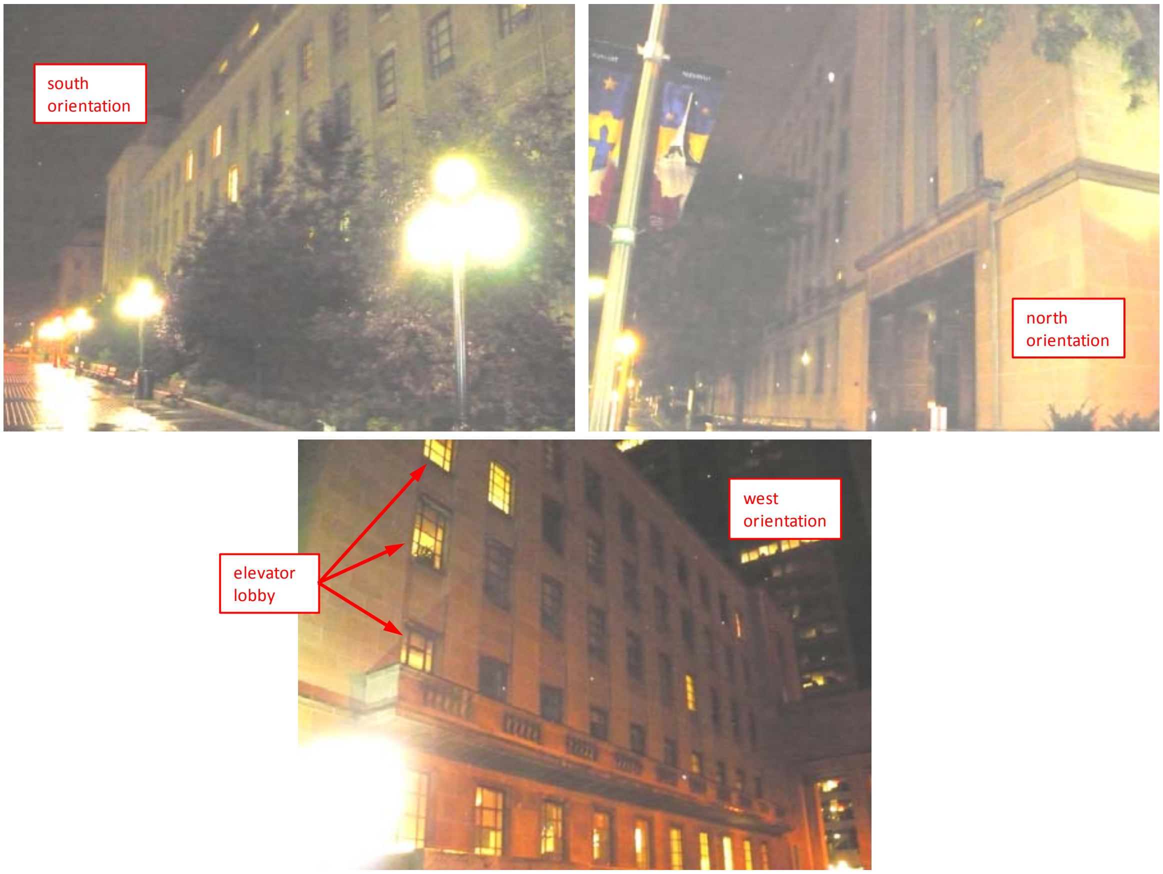
- There are an estimated 582 motion sensors serving individual perimeter offices. These sensors account for approximately 63% of the total. Over 95+% of the sensors were observed to switch off the lights based on two walkthroughs performed at 6:00 and 9:00 PM. By 9:00 PM, lighting in all individual offices was shut down with exception of 2 to 5 offices per floor that were noticed to have new sensors or individual light switches. Figure 4.3, supports the lack of lighting around the building perimeter since few windows are shown to be lit and some of these, located at the building corners (west elevation photo), are elevator lobbies. Other windows located at the centre of the façade are open office spaces that tend to have night lighting operating continuously.

- Lighting in two large photocopy rooms located near the mail rooms on the 2nd and 5th floors was observed to be operating. A conventional light switch was noticed while the same rooms on other floors had ceiling mounted motion sensors.

- Sensors serving boardrooms were also noticed to switch off the lighting. Only one boardroom equipped with an occupancy sensor had the lighting still on at 6:00 PM and this is likely because the occupants had just left and the sensor had not yet timed-out. The two large boardrooms present on every floor are an exception since these boardrooms are not equipped with occupancy sensors and lighting in two of these boardrooms was still operating.

- Washrooms are not equipped with occupancy sensors and all washroom lighting was observed to be in operation except for the handicapped washrooms on the first floor.

Figure 4.3:
Nightime Building Exterior (11:00 PM)



- Lighting in the library (1st basement level) was operating. The space is not equipped with motion sensors except for a few small areas. According to the commissionaires, the library is frequently used at night and as a result, the lighting needs to operate continuously. Based on discussions with Johnson Controls, a large number of sensors in the lower basement have been replaced with light switches and a number of these areas remain in operation during the unoccupied period.

- The decorative architectural lighting on the walls of the interior courtyards was also on.

- Only lighting in corridors, some open office areas, the four elevator lobbies, night lighting and the library remain on during the unoccupied period. Based on the LOA survey and drawing take-offs, this lighting load is equivalent to 98 to 138 kW out of an estimated total connected lighting load of 322 kW. For comparison purposes, demand interval data shows a typical demand difference of 300 kW between the occupied and unoccupied period, primarily from lighting and HVAC equipment shutdown (see Section 5.4) and would suggest that the lighting load during the unoccupied period would be in the range of 150 kW. Table 4.4 provides a breakdown of the estimated connected lighting load that remains on during the unoccupied period.

Table 4.4: Lighting Load That Remains During the Unoccupied Period		
	Unoccupied Period Lighting Load (kW)	
	(LOA survey and take-offs)	**(from Interval data)**
Corridors	22 to 26	
Night Lighting	16 to 32	
Library	40	
Lower basement lighting	20 to 40	
Total	**98 to 138**	**~150**

4.3 HVAC EQUIPMENT

The following observations are provided in regards to HVAC operation during the unoccupied period:

- AHU1 through AHU11 are scheduled to shutdown at 8:00 PM except for AHUs 2, 5 and 11, which operate continuously. By 11:00 PM six air handling units were still in operation. Table 4.5 lists the air handling units and the status at 8:30 and 11:00 PM. Text in red denotes units that should not be operating. AHU7 only achieved a partial shutdown. Records from longer trend data for the month of August are also included in the last column. The LOA only provides a snapshot of one day of operation while the trend data shows a longer timeframe. During the month of August most AHUs ran during the unoccupied period at one time or another, with only three out of eleven units shutting down.

Table 4.5: List of AHUs Operating During the Unoccupied Hours			
	Status of AHUs at 8:30 PM	**Status of AHUs at 11:00 PM**	**BAS Trend Data (August)**
AHU1 North Perimeter	OFF	OFF	ON
AHU2 East Perimeter	continuous operation	continuous operation	continuous operation
AHU3 South Perimeter	OFF	OFF	OFF
AHU4 West Perimeter	ON	ON	ON (unit ran continuously from May to middle of August
AHU5 North Interior	continuous operation	continuous operation	continuous operation
AHU6 South interior	OFF	OFF	ON
AHU7 West Courtyard	Supply fan ON, Return Fan OFF	Supply fan ON, Return Fan OFF	Supply fan has been running since August 12
AHU8 East Courtyard	OFF	OFF	OFF
AHU9 Ground Floor west	ON	ON	ON
AHU10 Basement South and East	OFF	OFF	OFF
AHU11 Ground East & Bsmt North	continuous operation	continuous operation	continuous operation
AHU16 West Courtyard Skylight	OFF	OFF	Unknown
AHU17 East Courtyard Skylight	OFF	OFF	Unknown

- From an electrical demand standpoint the three units that were in operation at the time of the LOA account for approximately 65 KW and the five units highlighted by the longer trend data would account for approximately 140 kW. As a result, the unoccupied period electrical demand and energy use is higher than it should be. This occurs because the current control logic, as discussed in Section 3, starts the AHUs if five or more occupancy sensors are activated. This logic was designed to deal with after hour occupancy. However, based on the observations from the LOA, there is very limited after hours occupancy and the AHU operation is driven by the inordinately high number of occupancy sensors that still show an occupied status. This condition forces the AHUs to continue running even after all occupants have left the building.

- In regards to the units that presently operate continuously, discussions with Johnson Controls revealed that in the past, only AHUs 2 and 11 operated continuously. AHU2 serves the commissionaires desk on the first floor and so its needs to operate to provide ventilation. AHU11 serves an IT room and needs to provide air conditioning around-the-clock. However, AHU5 can be shutdown.

- The fan speed of AHUs was observed to drop by only 5 to 10% during the unoccupied period with most units staying at 50% speed. This occurs for two reasons. First, the VAV boxes are currently not programmed to go on unoccupied mode and setback temperature even though the JC control sequence states that the boxes will go on this mode, if the floor goes on an “unoccupied” mode. As a result, the VAV boxes do not go to minimum flow. The second reason relates to the high minimum position air flows on VAV boxes. As an example, most VAV boxes inspected at the BAS have minimum positions of 40 L/s (85 CFM). Table 4.6 lists the sampled VAV boxes. This is a high air flow for a VAV box that serves a single occupant. Correcting this condition so that speed decreases to a range of 30 to 35% during the unoccupied period, would achieve fan energy savings. These energy savings could be in the range of 53,000 KWh/year (see EEM4).

- All major exhaust fans were observed to shutdown at 8:00 PM.

4.4 BUILDING EXTERIOR

The following observations are provided in regards to the building exterior:

- The exterior lighting is limited to four ground mounted metal halide (MH) spot lights on the east orientation and one spot light on the west orientation.

- As shown in Figure 4.3, the building contributes very little to “light pollution” since few windows are lit and there is little exterior lighting.

Table 4.6: List of Randomly Inspected VAV Box Settings at the BAS		
	Maximum Flow (CFM)	**Minimum Flow (CFM)**
VV1-047 Basement S&E VAV Box	250	40
VV1-054 Basement S&E VAV Box	100	40
VV4-058 2nd Floor East Perimeter	140	40
VV4-062 2nd Floor East Perimeter	80	40
VV4-074 2nd Floor South Interior	65	20
VV4-075 2nd Floor South Interior	160	40
VV4-082 2nd Floor South Interior	110	85
VV5-104 3rd Floor West Perimeter	120	40
VV5-107 3rd Floor West Perimeter	140	40
VV5-136 3rd Floor West Perimeter	110	20
VV6-071 4th Floor East Perimeter	120	40
VV6-077 4th Floor East Perimeter	135	40
VV6-082 4th Floor South interior	70	25
VV6-090 4th Floor South Interior	60	20
VV8-003 6th Floor North Perimeter	110	40
VV8-098 6th Floor South Perimeter	120	40
VV8-104 6th Floor South Perimeter	120	40

5.0 ENERGY USE ANALYSIS

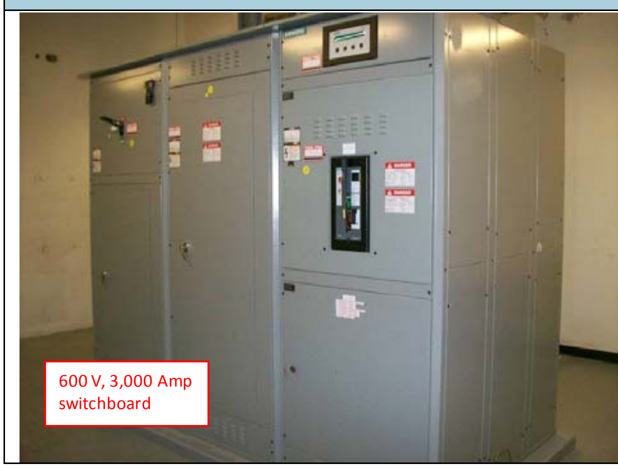
5.1 UTILITY USAGE ANALYSIS

This section presents an analysis of all utilities in use at the facility, covering the period 2007 to early 2010. Data provided by SNC LAVALIN O&M including chilled water, steam and electricity consumption (kWh) with their respective costs, was used to derive three years of historical energy. SNC LAVALIN O&M also provided 21 months of electricity demand and power factor for 2008 and 2009. Tables containing the three years of data and calculated electrical and natural gas energy and water intensities are presented in **Appendix C**.

SNC LAVALIN O&M also provided access to the Hydro Ottawa interval data website to download interval data for a full year. This data was used to derive typical daily demand profiles for weekday and weekend operation in the winter, summer and shoulder months. This data is further reviewed in Section 5.4.

Hydro Ottawa provides electricity to building from a 13.2 kV, 5,000 kVA service. This service enters a 600 V, 3,000 Amp distribution switchboard which is shown in Table 5.1. On the day of the site visit the switchboard showed a power demand ranging from 740 to 800 kW.

Table 5.1:
East Memorial Distribution Switchboard and Electrical Meter



There is one electrical meter in the building. The electricity consumption is billed under the Business Rate (C1, C2 and C3) with a billing demand of 50 to 1,500 kW. Under the current rate (effective May 2010), demand is charged at $9.63/kW. Energy is charge at a flat rate of 7.5 cents/kWh plus regulatory and debt repayment charges of 1.38 cents/kWh. Table 5.2 provides a summary of the charges under the current rate.

Table 5.2:
Summary of Charges for Rate C4 and Small Business Rates (C1, C2 and C3)

Service	Description		Charge
Rate C4 for the 347/600V distribution	Demand	1,500 to 5,000 kW	$9.63/kW
	Energy	Energy charge	7.5 cents/kWh
		Regulatory and debt repayment	1.38 cents/kWh
Information from Hydro Ottawa website http://www.hydroottawa.com/business/index.cfm?lang=e&template_id=36 Accessed on September 8, 2010..			

Steam and chilled water is supplied by the Cliff Street Central Heating Plant (CHP).

5.2 TYPICAL YEAR ENERGY USE AND COMPARISON TO BENCHMARK DATA

A typical year energy use for the facility was derived using data from 2007 to early 2010. Table 5.3 provides a tabular summary of the typical year energy use. Total electricity consumption is 5,056,259 kWh. Total steam consumption is 11,345 GJ. Total chilled water consumption is 5,047 GJ. Finally, total domestic water consumption is 10,276 m^3. The annual cost for all utilities is $820,136.

From an end-use perspective, electricity used for HVAC equipment (fans and pumps), lighting, and office equipment accounts for approximately 53% of the total consumption. The second largest energy use component is steam used for space heating, which accounts for approximately 32% of the total consumption. Chilled water used for space cooling represents an estimated 15% of the total consumption. Finally, steam use for domestic hot water represents less than 1% of the total consumption.

As shown at the bottom of Table 5.3, the Building Energy Performance Index (BEPI) is 256 ekWh/m^2.yr (922 MJ/m^2.yr) based on a total building gross floor area of 37,524 m^2 (403,758 ft^2).[6] This value is approximately 17% lower than the comparable benchmark of 306 kWh/m^2.yr (1,102 MJ/m^2.yr). This is due to an efficient lighting design and low lighting power density that resulted from the major renovation completed between 1996 and 1998. The efficient lighting design also reduces the internal heat gain and chilled water energy use. Further improvements in energy use seem to have been achieved since 2003 with a reduction in annual steam and chilled water consumption, which also contributes to the lower facility energy use. This is further described in Section 5.3.

The electrical energy intensity is 135 kWh/m^2.yr (486 MJ/m^2.yr). This is approximately 16% lower than the comparable benchmark. The efficient lighting and use of variable speed drives (VSDs) on fans and pumps contribute to the lower electrical energy intensity.

The steam energy intensity is 84 ekWh/m^2.yr (302 MJ/m^2.yr), which is also 16% lower than the comparable benchmark.

The electrical peak demand is 26 W/m^2 (2.4 W/ft^2) which is significantly lower than the comparable benchmark. This is due to the absence of chillers since the building's air conditioning needs are met with chilled water from the Cliff CHP.

The average load factor is 65% which is high for a facility with non-continuous occupancy and believed to be due to the current control logic employed by the air handling units which are started during the unoccupied period on a call from space occupancy sensors. This results in a number of air handling units operating during the unoccupied period.

Finally, domestic water use is also shown in Table 5.3. The water consumption index of 0.27 m^3/m^2.yr is lower than the typical BOMA office building value and the Public Works and Government Services (PWGSC) office standard. The low value is achieved due the use of low flow bathroom fixtures

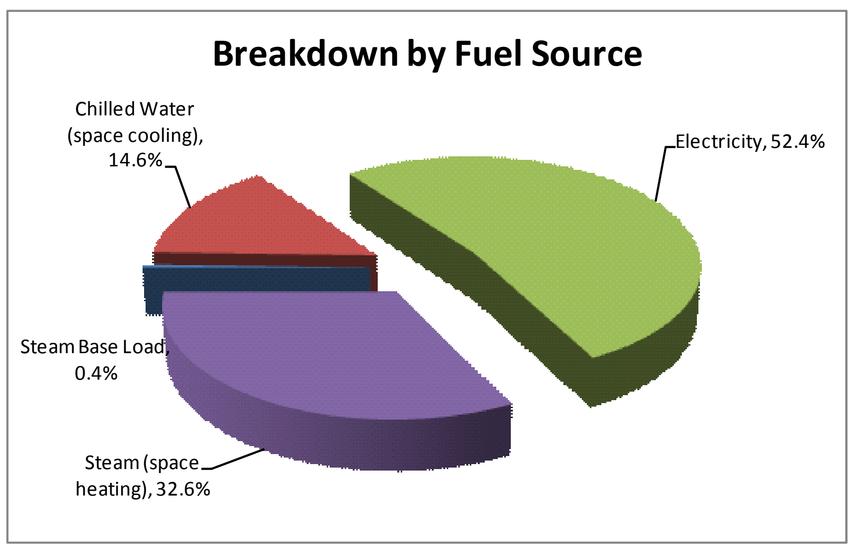
[6] The building gross area is based on measurements taken from floor plans.

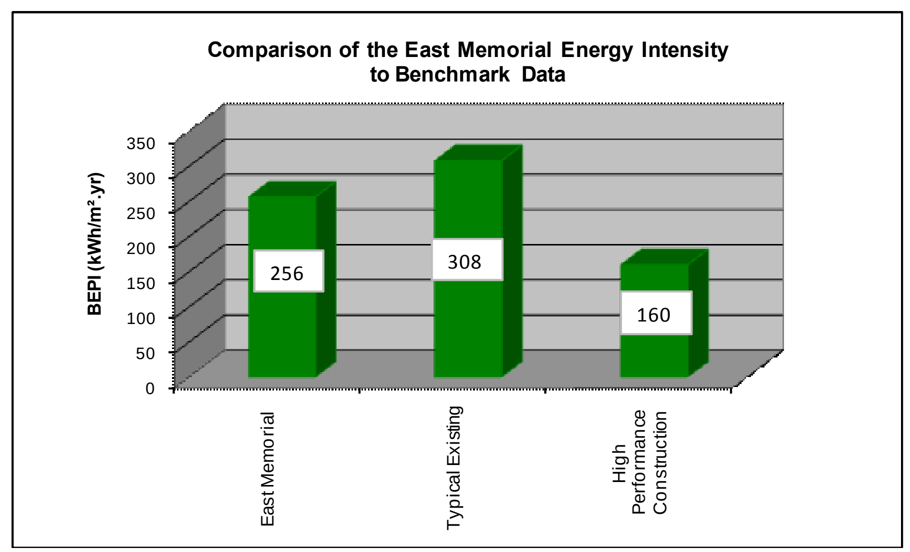
Table 5.3: Typical Year Energy Use and Energy Intensities

Typical Year	Electricity							Chilled Water				
	Energy Use (kWh)	Electrical Demand (kW)	Power Factor (%)	Load Factor (%)	Bill ($)	Electrical Intensity (kWh/m²)	Cost Index ($/m²)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m²)	Cost Index ($/m²)
Jan	435,785	883	95%	68%	$41,867	11.6	1.12	0	0	$0	0.0	0.00
Feb	404,632	876	95%	63%	$38,984	10.8	1.04	0	0	$0	0.0	0.00
Mar	429,368	878	95%	67%	$37,368	11.4	1.00	0	0	$0	0.0	0.00
Apr	389,075	841	93%	63%	$33,248	10.4	0.89	170	47,315	$3,739	1.3	0.10
May	404,609	834	92%	66%	$34,761	10.8	0.93	490	136,204	$10,849	3.6	0.29
Jun	410,728	862	93%	65%	$38,998	10.9	1.04	1,029	285,833	$22,634	7.6	0.60
Jul	423,795	842	93%	69%	$38,144	11.3	1.02	1,205	334,630	$26,327	8.9	0.70
Aug	420,029	822	93%	70%	$38,310	11.2	1.02	1,224	340,093	$26,865	9.1	0.72
Sep	403,055	841	92%	66%	$35,807	10.7	0.95	679	188,519	$14,956	5.0	0.40
Oct	431,457	948	96%	62%	$40,884	11.5	1.09	220	61,111	$4,993	1.6	0.13
Nov	447,289	993	96%	62%	$39,868	11.9	1.06	30	8,333	$682	0.2	0.02
Dec	440,107	994	96%	61%	$41,964	11.7	1.12	0	0	$0	0.0	0.00
Total	**5,039,927**				**$460,203**	**134.3**	**12.26**	**5,047**	**1,402,037**	**$111,045**	**37.4**	2.96

Typical Year	Steam					Water & Sewage	
	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m²)	Cost Index ($/m²)	Usage (m^3)	Bill ($)
Jan	2,487	690,729	$53,474	18.4	1.43	929	$2,233
Feb	2,106	584,965	$45,671	15.6	1.22	1,053	$2,565
Mar	1,922	533,889	$41,662	14.2	1.11	777	$1,933
Apr	931	258,519	$20,555	6.9	0.55	760	$1,757
May	243	67,500	$5,291	1.8	0.14	1,010	$2,382
Jun	26	7,130	$556	0.2	0.01	799	$1,937
Jul	3	926	$75	0.0	0.00	965	$2,298
Aug	4	1,019	$82	0.0	0.00	818	$2,008
Sep	16	4,537	$351	0.1	0.01	960	$2,265
Oct	448	124,352	$9,648	3.3	0.26	511	$1,219
Nov	1,008	280,093	$22,583	7.5	0.60	910	$2,149
Dec	2,234	620,463	$48,940	16.5	1.30	785	$1,897
Total	**11,427**	**3,174,121**	**$248,888**	**84.6**	6.63	**10,276**	**$24,643**

Typical Year	Totals				Weather Data	
	Totals Usage (ekWh)	Energy Intensity (ekWh/m²)	Total Bill ($)	Cost Index ($/m²)	HDD (@ 18°C)	CDD (@ 18°C)
Jan	1,126,514	30	$95,341	$2.54	891.4	0
Feb	989,597	26	$84,655	$2.26	755.6	0
Mar	963,257	26	$79,030	$2.11	632	0
Apr	694,908	19	$57,542	$1.53	369	0.8
May	608,312	16	$50,901	$1.36	155.2	13.1
Jun	703,691	19	$62,187	$1.66	41.3	49
Jul	759,350	20	$64,546	$1.72	7.3	98.5
Aug	761,140	20	$65,257	$1.74	21.7	68.6
Sep	596,110	16	$51,114	$1.36	124.2	14.2
Oct	616,920	16	$55,525	$1.48	317.5	0.4
Nov	735,715	20	$63,133	$1.68	510.7	0
Dec	1,060,570	28	$90,904	$2.42	776.5	0
Total	**9,616,085**	**256**	**$820,136**	**$21.86**	**4,602.4**	**244.6**





	East Memorial	Benchmark
Electrical Energy Intensity (kWh/m².yr)	134	160
Chilled Water Energy Intensity (ekWh/m².yr)	37	48
Steam Energy Intensity (ekWh/m².yr)	85	100
BEPI (ekWh/m².yr)	256	308
Peak Demand intensity (W/m²)	26	50 to 55
Water Consumption Index (m³/m².yr)	0.27	1.1 to 1.75

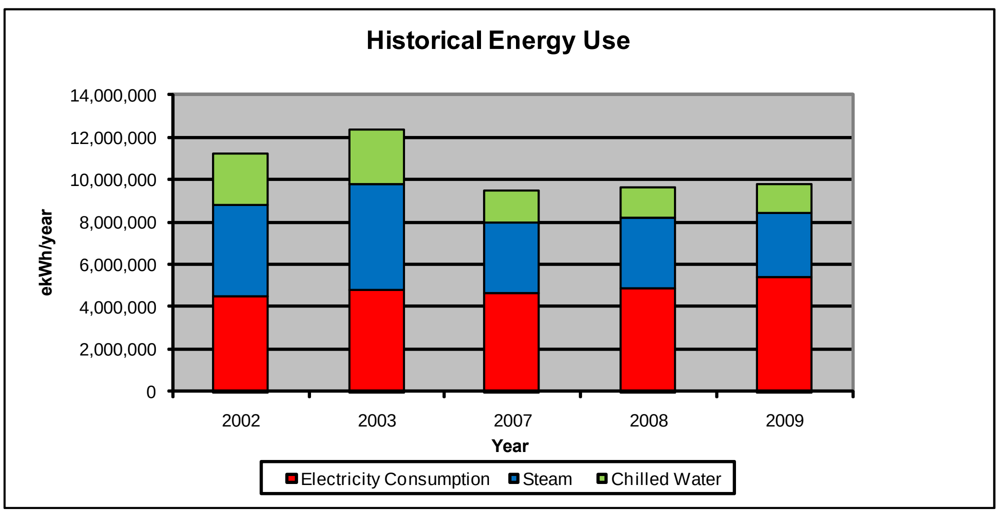
5.3 HISTORICAL ENERGY USE ANALYSIS

Table 5.4 provides a historical energy use of the facility based on three years of available data plus data from 2002 and 2003. Total energy use has declined from an average of 11.8 million ekWh/year, seven years ago to almost 9.8 million ekWh/year in 2009. This represents a 17% reduction in total energy use and GHG emissions. Most of the reduction is from steam and chilled water. Part of the reduction in steam use appears to be from elimination of summer reheating which in 2002 and 2003 accounted for a significant amount of steam use during the summer months. The 2007 to 2009 available billing data shows that this practice is no longer occurring.

During the same period however, electricity consumption has steadily increased with the largest annual consumption recorded in 2009, resulting in a 20% overall increase since 2002. Monthly billing data shows that the most recent increase started in September 2009 with a 200 kW increase in peak billing demand seen in the last three months of 2009 (see **Appendix C**). The increase in peak demand is also accompanied by an approximate 40,000 to 80,000 kWh in additional monthly consumption. The increase is believed to be due to four new electric boilers installed in 2009 in a mezzanine of the basement mechanical room. These boilers appear to provide supplemental glycol heating.

Table 5.4:
East Memorial Historical Energy Use

	Electricity Consumption (kWh)	Steam (ekWh)	Chilled Water (ekWh)	Total (ekWh)
2002	4,480,833	4,327,222	2,462,500	11,270,555
2003	4,799,444	4,983,611	2,592,778	12,375,833
2007	4,673,373	3,339,167	1,451,389	9,463,929
2008	4,882,626	3,338,889	1,425,556	9,647,071
2009	5,416,798	3,049,722	1,329,167	9,795,687



Further detail of the historical energy use from 2007 to 2009 can be found in **Appendix C**. Data is presented in tabular format and includes monthly electricity, steam, chilled water consumption, domestic water consumption and the respective costs of each utility.

5.4 REVIEW OF UTILITY INTERVAL DATA

Electrical interval data from 2009 was analyzed for one winter month, two shoulder periods (spring and fall) and one summer months to create 24 hour demand profiles. Profiles were derived for a typical weekday and weekend day. Figure 5.5 shows a series of five 24 hour profiles corresponding to each season. The following information can be derived from the hourly profiles:

- Weekday daytime peak demand is approximately 800 to 850 kW. The daytime peak demand is constant throughout the year since there is no cooling plant in the building that would increase the summer peak demand. October and December show a slightly higher daytime peak demand of 850 kW, which is believed to be from new electric boilers.
- Unoccupied period peak demand is approximately 500 kW in the spring and summer and 550 kW in the fall and winter. A possible reason for the higher unoccupied demand in October and December is due to the new electric boilers.
- Weekend daytime peak demand is approximately 600 kW which is 100 kW higher than unoccupied peak demand. The higher demand is believed to be due to the air handling units operation which is the same for both weekday and weekends.
- Demand starts to increase at 5:30 AM which is consistent with the equipment operating schedule extracted from the BAS.
- Demand decrease is gradual and appears to start at 5:00 PM which is consistent with the equipment operating schedule.

5.5 ENERGY END-USE ANALYSIS

Table 5.6 below presents a breakdown of the electrical energy consumption by end use for the typical year.

A description of how each value was derived is provided below.

- Lighting electrical consumption is based on an overall lighting power density (LPD) on the office floors of 11 W/m² (1 W/ft²).
- HVAC equipment electrical consumption is based on the inventory of all fans and pumps that includes the equipment power draw plus operating schedules based on the site survey. **Appendix A** provides a detailed tabulation of fans and pumps electricity consumption.
- Plug loads and office equipment is based on 868 occupants, a power use of 125 W/occupant for computer and miscellaneous plug loads and 3,000 hours per year. This results in a plug load of 0.3 W/ft² which is low and would not match the energy model peak demand. As a result, the plug load was increased to 0.5 W/ft²

Figure 5.5:
East Memorial Hourly Electricity Demand Profiles (Based on Jan to Dec 2009 Interval data)

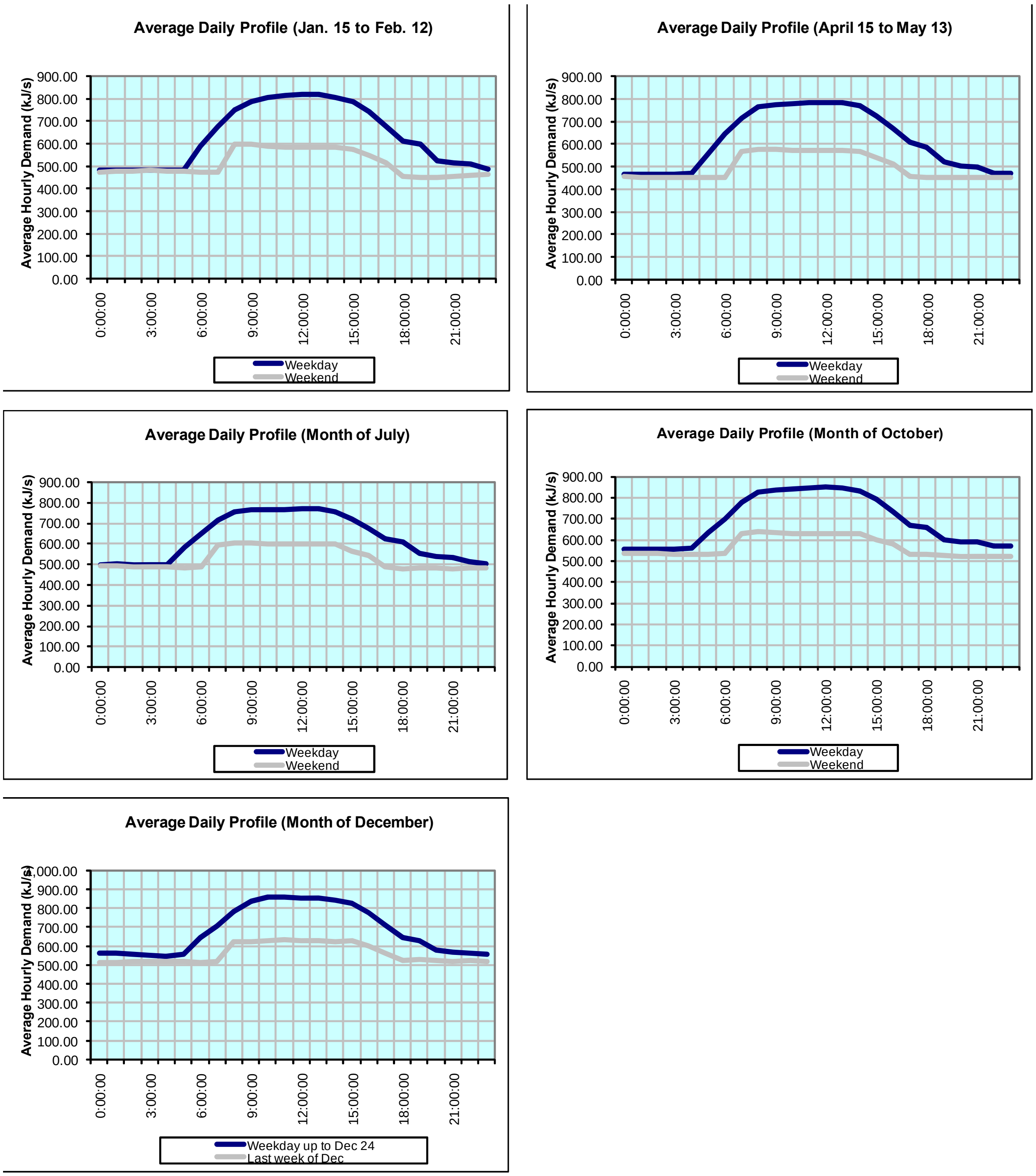


Table 5.6: Breakdown of Energy Use by End-Use		
End Use	**Consumption (ekWh/year)**	**Percent**
Lighting	2,095,000	40%
HVAC Equipment (fans)	1,840,000	36%
HVAC Equipment (pumps)	35,000	1%
Other (DHW)	181,000	4%
Plug loads and office equipment	995,000	19%
Total	**5,146,000**	**100%**

6.0 CALIBRATED DOE 2 ENERGY MODEL

An hourly energy model of the East Memorial Building was constructed using VisualDOE, a program that uses DOE2.1E. The energy model was built with the building characteristics described in Section 3 as follows:

- A building with a total floor area of 36,730 m² (395,200 ft²) which is 2% smaller than the actual building size. The slight difference in areas is due to rounding off the building length and width. The building is modeled as two thermal blocks with one block representing the two basement levels and the second block representing floors 1 to 6. The penthouse and attic roof were ignored.
- An exterior envelope with 1,002 m² (10,800 ft²) of window area consistent with the actual number of widows and dimensions, which results in a window to wall ratio (WWR) of 11.1%.
- Overall lighting power density of 10.9 W/m² (~1.0 W/ft²).
- A total occupancy of 854 FTEs.
- A fan and pump power that matches the total connected load and iteratively adjusted to achieve a peak demand close to the actual demand.
- Minimum fan flow was set at 49%, which is in line with the average minimum flows of 50% seen during the "Lights-Out" audit (see Section 4).
- Custom schedules that are as close as possible to the actual operating schedules.

A summary of the energy use comparison between the base year and the VisDOE model is shown in Table 6.1 and graphical in Figure 6.2. A summary output from VisDOE is also included in **Appendix D**.

Table 6.1:
Comparison of Actual vs. Modelled Energy Use

	Typical Year (2007-2010 Average)			Energy Model		
	Electricity		Steam	Electricity		Steam
	Demand	Energy		Demand	Energy	
	(kW)	(kWh)	(GJ)	(kW)	(kWh)	(GJ)
Jan.	883	435,785	2,487	860	441,009	2,099
Feb.	876	404,632	2,106	863	400,245	2,082
March	878	429,368	1,922	860	445,678	1,765
April	841	389,075	931	864	421,024	704
May	834	404,609	243	872	433,845	207
June	862	410,728	26	919	428,581	47
July	842	423,795	3	922	437,044	24
Aug.	822	420,029	4	924	443,610	43
Sept.	841	403,055	16	902	419,455	158
Oct.	948	431,457	448	871	431,593	501
Nov.	993	447,289	1,008	855	419,688	935
Dec.	994	440,107	2,234	859	439,248	2,030
Total		**5,039,927**	**11,427**		**5,161,020**	**10,594**
Building Energy Use (GJ/year)			**29,571**			**29,173**
Difference						**1.3%**

The following observations are provided:

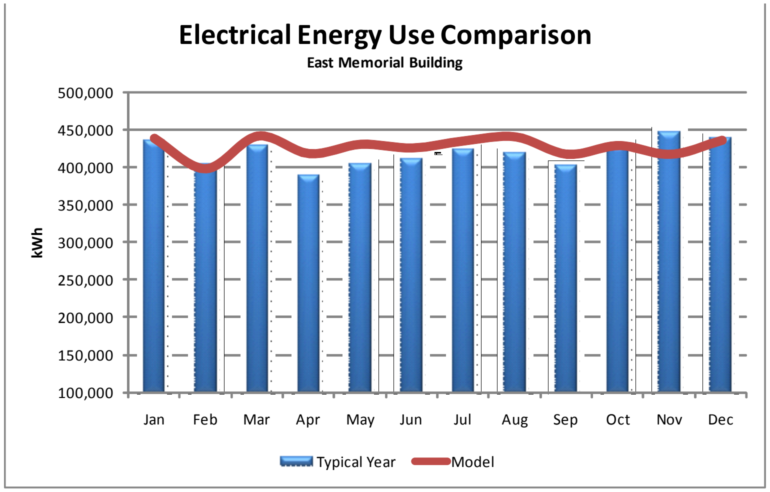
- Overall, the model is reporting a predicted energy use that is 1.3% less than the base year energy use. There is also good agreement in terms of electricity and steam monthly consumption.

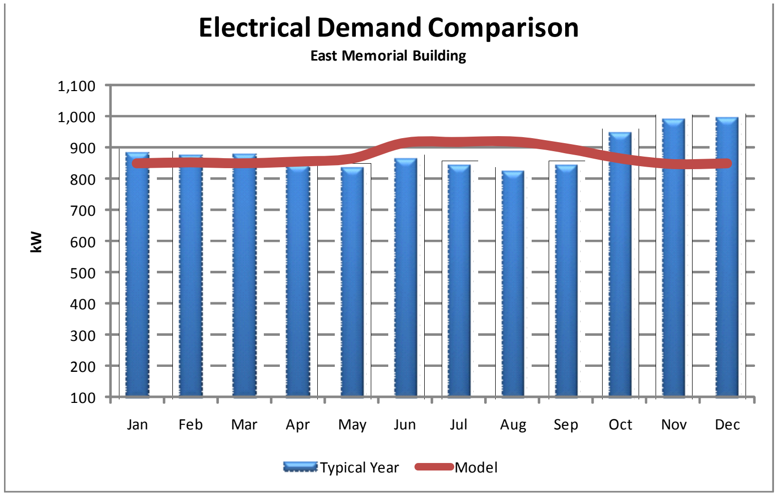
- At the electricity level the model is reporting an electricity consumption that is 2.3% higher than the "Typical Year" consumption. This is mostly from the model slightly overestimating the summer electricity consumption (see Figure 6.2

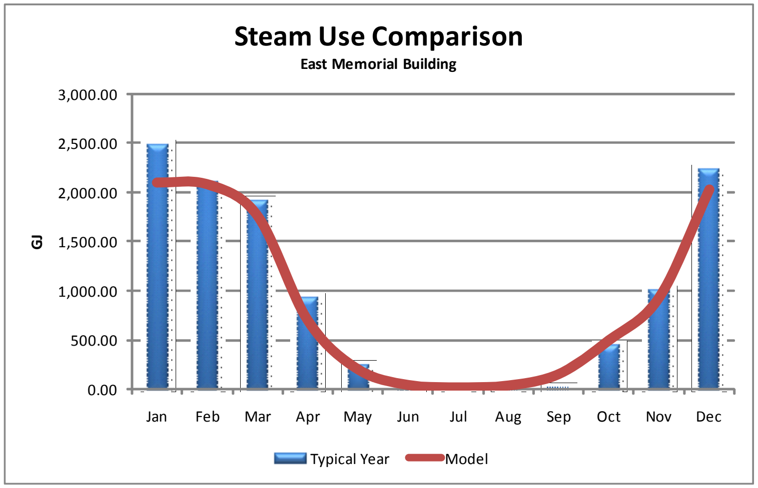
- At the level of steam consumption, the energy model is 7.2% below the "Typical Year" consumption principally from the model's inability to match the steam consumption in January and December. As shown in Figure 6.1 the predicted steam consumption in these two months is 10% lower than the actual.

The energy model cooling energy use was disregarded by using a chiller performance of 0 kW/Ton because the model cannot report district cooling energy use.

Figure 6.1:
Comparison Of Annual Energy Use Profile vs. Predicted Monthly Consumption







7.0 RECOMMENDATIONS FOR ENERGY MANAGEMENT

This section lists six recommended Energy Efficiency Measures (EEMs). Four measures address new and modified control strategies that could be implemented through the Building Automation System (BAS). One lighting measure recommends replacement of the T8 32W lamps with reduced wattage 28W long life lamps. Finally, the last measure describes the cost and benefits of improving the performance of the single pane windows based on the study completed by Bryden Martel Architects.

Table 7.1 at the end of this section provides a summary of the savings, cost and payback period. Details of each measure are provided in **Appendix E** including a detailed description of the proposed measures, description of the implementation, energy savings calculations and project cost summary.

7.1 EEM 1: Advance the Weekday Shutdown of Air Handling Units to 6:00 PM or 7:00 PM

This measure proposes shutting down the air handling units one to two hours earlier with no impact to occupant comfort because of the space occupancy feedback that presently exists. Electricity savings of 50,990 kWh/year and cost savings of approximately $4,500/year could be achieved.

7.2 EEM 2: Operate VAV AHUs at Minimum During the Occupied Period on Weekends and Holidays

This measure proposes operating the air handling units on a “standby mode” and minimum air flow and ensuring that all VAV boxes go to an “unoccupied” mode for those zones with an “unoccupied” status. Electricity savings of 37,220 kWh/year and cost savings of approximately $3,300/year could be achieved. Steam savings of 330 GJ and cost savings of $7,200 could also be achieved.

7.3 EEM 3: Repair AHU7 Supply Fan Starter or Relay to Ensure that the Fan Shuts Down Together with the Return Fan

This measure proposes repairing the fan starter or relay to ensure that at the end of occupancy the AHU7 supply fan shuts down. Electricity savings of 13,300 kWh/year and cost savings of approximately $1,200/year could be achieved.

7.4 EEM 4: Shutdown All Air Handling Units During the Unoccupied Period Except for Units that operate Continuously

This measure proposes to bring all air handling units still in operation at 8:00 PM to a “standby mode” and minimum flow, and further ensuring that all VAV boxes go to an “unoccupied” mode. Combined electricity savings of 90,520 kWh/year and cost savings of approximately $8,000/year could be achieved.

7.5 EEM 5: High Performance Fluorescent Lighting System

This measure proposes replacement of the existing F32 T8 lighting system with new generation lower wattage T8 lamps that also offer a longer lamp life of 30,000 hours. This option will achieve a reduction in demand and energy use, but only a small reduction in light levels thanks to a higher lumen maintenance factor of the better lamp. Electricity savings of 120,000 kWh/year and cost savings of approximately $13,980/year could be achieved. Additionally, an incentive from the ERIP program may be available for approximately $11,600.

7.6 EEM 6: Replacement of Single Pane Windows with Double Pane Windows

This measure proposes adding a new double pane window behind the existing single pane window based on analysis conducted by Bryden Martel Architects. Electricity and natural gas savings of 3,300 GJ/year with overall cost savings of approximately $83,000/year could be achieved.

Table 7.1:
Summary of Proposed Energy Efficiency Measure

MEASURE DESCRIPTION		ANNUAL UTILITY SAVINGS TOTAL UTILITY ($)	ELECTRICAL (kW/YR)	ELECTRICAL (kWh/YR)	CHILLED WATER (GJ/YR)	STEAM SPACE HEAT (GJ/YR)	STEAM HUMIDIFICATION (GJ/YR)	STEAM SUMMER REHEAT (GJ/YR)	WATER (m3/YR)	TOTAL (GJ/YR)	CO2e (T/YR)	TOTAL COST ($)	SIMPLE PAYBACK (YRS)
Lighting Systems													
EEM5	High Performance Fluorescent Lighting (25 W or 28W Lamps)	$13,980	348	120,000						432.0	26.8	$43,080	3.1
Building HVAC and Controls													
EEM1	Advance the Weekday Shutdown of AHUs	$4,500		50,990						183.6	11.4	$0	0.0
EEM2	Operate VAV at Minimum During Weekends and Holidays	$10,500		37,220		330.0				464.0	28.8	$12,000	1.1
EEM3	Repair AHU7 Starter or Relay	$1,200		13,300						47.9	3.0	$1,500	1.3
EEM4	Shutdown all AHUs During the Unoccupied Period	$15,200		90,520		330.0				655.9	40.7	$12,000	0.8
Renewable Onsite Generation													
EEM6	Replacement of Single Pane Windows	$83,100		150,000		3,300.0				3,840.0	238.1	1,935,000	23.3
Measure Totals (all measures)		$117,980	348	424,810	0	3,630	0	0	0	5,159	320	$1,991,580	16.9
Measure Totals (excludes window replacement)		$34,880	348	274,810	0	330	0	0	0	1,319	82	$56,580	1.6

Note: Total cost of EEM5 was calculated assuming an incentive from the ERIP Program for $11,600

8.0 REFERENCES

1) 2005 ASHRAE Handbook – Fundamentals. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, Georgia.

2) Energy Standard for Buildings Except Low-Rise Residential Buildings. 2004 ANSI/ASHRAE/ IESNA Standard 90.1-2004

3) Knebel, D. 1983. Simplified Energy Analysis Using The Modified Bin Method. ASHRAE, Atlanta, Georgia.

4) CBECS 1999 Energy Use Benchmark Data. www.eia.doe.gov/emeu/cbecs/set3.html.

APPENDIX A

Summary of Air Handling Unit Operating Parameters and Equipment Tabulations

Summary of Air Handling Unit Operating Parameters

AHU		Component	Type	Minimum OA	Design Volume CFM	Motor Size (HP)	Heating Coil (y/n)	Cooling Coil (y/n)	Humid. Coil (y/n)	Terminal Reheat (y/n)	Hours of Operation			Control Mode	Recorded Values
											Week	Saturday	Sunday		
Interior and Perimeter Air Handling Units for Floors 2 to 6	AHU1 North Perimeter	Supply Fan	VAV	7,251	36,000	50	y	y	y	n	6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM	SAT reset based on RAT with a range of 13 to 16°C. Fan control via fixed static pressure	SAT higher than the reset shcedule by 2 to 3°C.
		Return Fan	VAV			40					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	AHU2 East Perimeter	Supply Fan	VAV	8,052	25,999	40	y	y	y	n	continuous	continuous	continuous	SAT reset based on RAT with a range of 13 to 16°C. Fan control via fixed static pressure	SAT higher than the reset shcedule by 2 to 3°C.
		Return Fan	VAV			30					continuous	continuous	continuous		
	AHU3 West Perimeter	Supply Fan	VAV	5,975	30,003	50	y	y	y	n	6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM	SAT reset based on RAT with a range of 13 to 16°C. Fan control via fixed static pressure	SAT higher than the reset shcedule by 2 to 3°C.
		Return Fan	VAV			40					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	AHU4 South Perimeter	Supply Fan	VAV	4,746	30,003	50	y	y	y	n	6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM	SAT reset based on RAT with a range of 13 to 16°C. Fan control via fixed static pressure	SAT higher than the reset shcedule by 2 to 3°C.
		Return Fan	VAV			40					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	AHU5 North Interior	Supply Fan	VAV	3,814	45,005	75	y	y	y	y	continuous	continuous	continuous	SAT reset based on RAT with a range of 14 to 17°C. Fan control via fixed static pressure	SAT higher than the reset shcedule by 2 to 3°C.
		Return Fan	VAV			50					continuous	continuous	continuous		
	AHU6 South Interior	Supply Fan	VAV	4,714	30,003	50	y	y	y	n	6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM	SAT reset based on RAT with a range of 14 to 17°C. Fan control via fixed static pressure	SAT higher than the reset shcedule by 2 to 3°C.
		Return Fan	VAV			40					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
First Floor and Basement Air Handling Units	AHU9 Ground floor West	Supply Fan	VAV	6,590	20,002	40	y	y	y	n	6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM	SAT reset based on RAT with a range of 14 to 17°C. Fan control via fixed static pressure	
		Return Fan	VAV			25					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	AHU10 Basement South & East	Supply Fan	VAV	5,594	20,002	40	y	y	y	n	6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM	SAT reset based on RAT with a range of 14 to 17°C. Fan control via fixed static pressure	
		Return Fan	VAV			25					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	AHU11 Ground East & Basement North	Supply Fan	VAV	10,558	23,996	40	y	y	y	n	continuous	continuous	continuous	SAT reset based on RAT with a range of 14 to 17°C. Fan control via fixed static pressure	
		Return Fan	VAV			25					continuous	continuous	continuous		

Summary of Air Handling Unit Operating Parameters (continued)

AHU		Component	Type	Minimum OA	Design Volume CFM	Motor Size (HP)	Heating Coil (y/n)	Cooling Coil (y/n)	Humid. Coil (y/n)	Terminal Reheat (y/n)	Hours of Operation: Week	Hours of Operation: Saturday	Hours of Operation: Sunday	Control Mode	Recorded Values
Courtyard Air Handling Units	AHU7 West Courtyard	Supply Fan	CAV	1,038	12,999	20	y	y	y	y	6:00AM to 4:00PM	8:00AM to 4:00PM	8:00AM to 4:00PM	SAT reset based on RAT with a range of 13 to 16°C.	
		Return Fan	CAV			15					6:00AM to 4:00PM	8:00AM to 4:00PM	8:00AM to 4:00PM		
	AHU8 East Courtyard	Supply Fan	CAV	1,820	12,999	20	y	y	y	n	6:00AM to 4:00PM	8:00AM to 4:00PM	8:00AM to 4:00PM	SAT reset based on RAT with a range of 13 to 16°C.	
		Return Fan	CAV			15					6:00AM to 4:00PM	8:00AM to 4:00PM	8:00AM to 4:00PM		
Wall Cavity Pressurization air Handling Units	AHU12 South-West Perimeter Wall Cavity	Supply Fan	VAV by-pass		3,602	5	y	n	n	n	Unit operates when OAT <4°C and at OAT between 15 & 25°C if wall cavity is 5°C warmer than OAT			SAT reset based on OAT with a range of 15 to 30°C.	
	AHU13 North-West Perimeter Wall Cavity	Supply Fan	VAV by-pass		3,602	5	y	n	n	n	Unit operates when OAT <4°C and at OAT between 15 & 25°C if wall cavity is 5°C warmer than OAT			SAT reset based on OAT with a range of 15 to 30°C.	
	AHU14 North-East Perimeter Wall Cavity	Supply Fan	VAV by-pass		3,602	5	y	n	n	n	Unit operates when OAT <4°C and at OAT between 15 & 25°C if wall cavity is 5°C warmer than OAT			SAT reset based on OAT with a range of 15 to 30°C.	
	AHU15 South-East Perimeter Wall Cavity	Supply Fan	VAV by-pass		3,602	5	y	n	n	n	Unit operates when OAT <4°C and at OAT between 15 & 25°C if wall cavity is 5°C warmer than OAT			SAT reset based on OAT with a range of 15 to 30°C.	
Courtyard Skylight Heating Units	AHU16 West Courtyard Skylight Heating	Supply Fan	CAV	no OA	5,001	5	y	n	n	n	Unit operates when OAT <4°C			Heating coil valve is modulated to maintain a glass surfae tmeprature of 10°C.	
		Return Fan													
	AHU17 East Courtyard Skylight Heating	Supply Fan	CAV	no OA	5,001	5	y	n	n	n	Unit operates when OAT <4°C			Heating coil valve is modulated to maintain a glass surfae tmeprature of 10°C.	
		Return Fan													
Elevator Machine Rm Fan Coils	FC8 NW Elevator Machine Rm	Fan	Fan coil	na	3,000	3	y	y	n	n	Fan operate to maintain a constant temperature of 23°C.				
	FC9 NE Elevator Machine Rm	Fan	Fan coil	na	3,000	3	y	y	n	n	Fan operate to maintain a constant temperature of 23°C.				
	FC10 SE Elevator Machine Rm	Fan	Fan coil	na	3,000	3	y	y	n	n	Fan operate to maintain a constant temperature of 23°C.				
	FC11 SW Elevator Machine Rm	Fan	Fan coil	na	3,000	3	y	y	n	n	Fan operate to maintain a constant temperature of 23°C.				
Major Washroom and Building Exhaust	EF1 Washroom Exhaust West		constant		5,890	5					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	EF2 Washroom Exhaust West		constant		5,106	5					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	EF5 1st floor Photocopy Rm Exhaust		constant		4,598	3					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	EF6 1st floor Photocopy Rm Exhaust		constant		5,085	3					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		
	EF7 1st floor Photocopy Rm Exhaust		constant		4,492	3					6:00AM to 8:00PM	8:00AM to 5:00PM	8:00AM to 5:00PM		

HVAC Equipment (Fans and Pumps Tabulations (continued)

System	Reference Number	Description of Equipment	Qty	Volts (V)	Volts (actual)	Amps (nameplate)	Amps (actual)	Phase	Load %	HP (nameplate)	HP (calculated)	Total (kW)	Hours per Week	Hours per Year	Total (kWh/year)
AHU1 North Perimeter	Supply Fan	VAV Fan	1	575				3	50%	50	25.0	18.6	88	4,600	85,756
	Return Fan	VAV Fan	1	575				3	40%	40	16.0	11.9	88	4,600	54,884
AHU2 East Perimeter	Supply Fan	VAV Fan, continuous operation	1	575				3	50%	40	20.0	14.9	168	8,760	130,647
	Return Fan	VAV Fan, continuous operation	1	575				3	40%	30	12.0	8.9	168	8,760	78,388
AHU3 West Perimeter	Supply Fan	VAV Fan	1	575				3	50%	50	25.0	18.6	88	4,600	85,756
	Return Fan	VAV Fan	1	575				3	40%	40	16.0	11.9	88	4,600	54,884
AHU4 South Perimeter	Supply Fan	VAV Fan	1	575				3	50%	50	25.0	18.6	88	4,600	85,756
	Return Fan	VAV Fan	1	575				3	40%	40	16.0	11.9	88	4,600	54,884
AHU5 North Interior	Supply Fan	VAV Fan, continuous operation	1	575				3	50%	75	37.5	28.0	168	8,760	244,962
	Return Fan	VAV Fan, continuous operation	1	575				3	40%	50	20.0	14.9	168	8,760	130,647
AHU6 South Interior	Supply Fan	VAV Fan	1	575				3	50%	50	25.0	18.6	88	4,600	85,756
	Return Fan	VAV Fan	1	575				3	40%	40	16.0	11.9	88	4,600	54,884
AHU9 Ground Floor West	Supply Fan	VAV Fan	1	575				3	50%	40	20.0	14.9	88	4,600	68,604
	Return Fan	VAV Fan	1	575				3	40%	25	10.0	7.5	88	4,600	34,302
AHU10 Basement South & Eas	Supply Fan	VAV Fan	1	575				3	50%	40	20.0	14.9	88	4,600	68,604
	Return Fan	VAV Fan	1	575				3	40%	25	10.0	7.5	88	4,600	34,302
AHU11 Ground East & Basement North	Supply Fan	VAV Fan, continuous operation	1	575				3	50%	40	20.0	14.9	168	8,760	130,647
	Return Fan	VAV Fan, continuous operation	1	575				3	40%	25	10.0	7.5	168	8,760	65,323
AHU7 West Courtyard	Supply Fan	CAV Fan	1	575		20	13.0	3	65%	20	13.0	9.7	66	3,441	33,362
	Return Fan	CAV Fan	1	575		15	10.0	3	65%	15	9.8	7.3	66	3,441	25,021
AHU8 East Courtyard	Supply Fan	CAV Fan	1	575		20	13.0	3	65%	20	13.0	9.7	66	3,441	33,362
	Return Fan	CAV Fan	1	575		15	10.0	3	65%	15	9.8	7.3	66	3,441	25,021

HVAC Equipment (Fans and Pumps Tabulations (continued)

System	Reference Number	Description of Equipment	Qty	Volts (V)	Volts (actual)	Amps (nameplate)	Amps (actual)	Phase	Load %	HP (nameplate)	HP (calculated)	Total (kW)	Hours per Week	Hours per Year	Total (kWh/year)
AHU12 South-West Perimter Cavity	Supply Fan	VAV by-pass	1	575		5	3.0	3	60%	5	3.0	2.2		2,500	5,593
AHU13 North-West Perimter Cavity	Supply Fan	VAV by-pass	1	575		5	3.0	3	65%	5	3.3	2.4		3,000	7,271
AHU14 North-East Perimter Cavity	Supply Fan	VAV by-pass	1	575		5	3.0	3	65%	5	3.3	2.4		3,000	7,271
AHU15 South-East Perimter Cavity	Supply Fan	VAV by-pass	1	575		5	3.0	3	65%	5	3.3	2.4		3,000	7,271
AHU16 West Courtyard Skylight Heating	Supply Fan	CAV Fan	1	575				3	65%	5	3.3	2.4		3,000	7,271
AHU17 East Courtyard Skylight Heating	Supply Fan	CAV Fan	1	575				3	65%	5	3.3	2.4		2,400	5,816
Major Exhaust Fans	EF1	Washroom Exhaust West	1	575				3	85%	5	4.3	3.2	-	4,600	14,578
	EF2	Washroom Exhaust East	1	575				3	85%	5	4.3	3.2	-	4,600	14,578
	EF5	1st Floor Photocopy Rm Exhaust	1	575				3	85%	3	2.6	1.9	-	4,600	8,747
	EF6	1st Floor Photocopy Rm Exhaust	1	575				3	85%	3	2.6	1.9	-	4,600	8,747
	EF7	1st Floor Photocopy Rm Exhaust	1	575				3	85%	3	2.6	1.9	-	4,600	8,747
Converter 1	P1	Perimeter Heating	1	575				3	55%	1.5	0.8	0.6	-	5,040	3,101
	P2	Perimeter Heating (standby)	1	575				3	55%	1.5	0.8	0.6	-	-	-
Converter 2	P3	Reheat Coils	1	575				3	55%	5	2.8	2.1	-	5,040	10,335
	P4	Reheat Coils (standby)	1	575				3	55%	7.5	4.1	3.1	-	-	-
Converter 3	P5	AHU Heating Coils	1	575				3	55%	5	2.8	2.1	-	5,040	10,335
	P6	AHU Heating Coils (standby)	1	575				3	55%	7.5	4.1	3.1	-	-	-
Condensate Pump		Condensate Pump	1	575				3	85%	3	2.6	1.9	-	3,000	5,705
		Condensate Pump (standby)	1	575				3	85%	3	2.6	1.9	-	-	-
Total												**339**			**1,840,927**

APPENDIX B

Floor Space Drawings with Lighting Levels and Lighting Power Densities

BASEMENT (LEVEL AA) FLOOR PLAN
SCALE= 1:125

SYMBOL LEGEND
ELECTRICAL – FLUO. LIGHT FIXT. – HIDDEN
ELECTRICAL – FLUO. LIGHT FIXT. – SIZE VARIES
ELECTRICAL – INCAND. LIGHT FIXT. – CEILING MOUNTED
ELECTRICAL – INCAND. LIGHT FIXT. – WALL MOUNTED
LIFE–SAFETY – FIRE ALARM PULL STATION
LIFE–SAFETY – FIRE EXTINGUISHER
LIFE SAFETY – EMERGENCY EVACUATION SPEAKER
LIFE SAFETY – EMERGENCY EXIT SIGN
LIFE SAFETY – FIRE BELL \ BUZZER
LIFE SAFETY – FIRE FIGHTER'S HAND PHONE
LIFE SAFETY – HEAT DETECTOR
LIFE SAFETY – SPRINKLER HEAD
LIFE SAFETY – STANDPIPE CABINET C\W FIRE HOSE
MECHANICAL – RETURN AIR GRILL – SIZE VARIES
MECHANICAL – SUPPLY AIR DIFFUSER – SIZE VARIES
MECHANICAL – THERMOSTAT
SECURITY – MOTION DETECTOR

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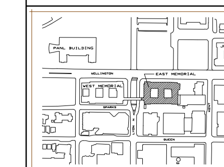

KEY PLAN
PLAN–REPÈRE
N.T.S.

revision	date
SIM UPDATE (J.FAIR)	APR.2003
AMENDED (J.FAIR)	MAR.2003
SIM UPDATE (J.FAIR)	FEB.2003

A detail no. / no. du détail
B location drawing no. / no. de localisation
C drawing no. / no. du dessin

project / projet
EAST MEMORIAL BUILDING
284 Wellington St. Ott. Ont.

drawing / dessin
SECOND BASEMENT MASTER DRAWING

designed / conçu
date
drawn / dessiné: JWFR
date
reviewed / revisé
date
approved / approuvé
date
tender / soumission
Project Manager / Administrateur de projets
project no. / no. du projet
drawing no. / no. du dessin: A1 OF

BLJC A0

0mm 10 20 40 60 80 100 120 140 160 180 200 mm

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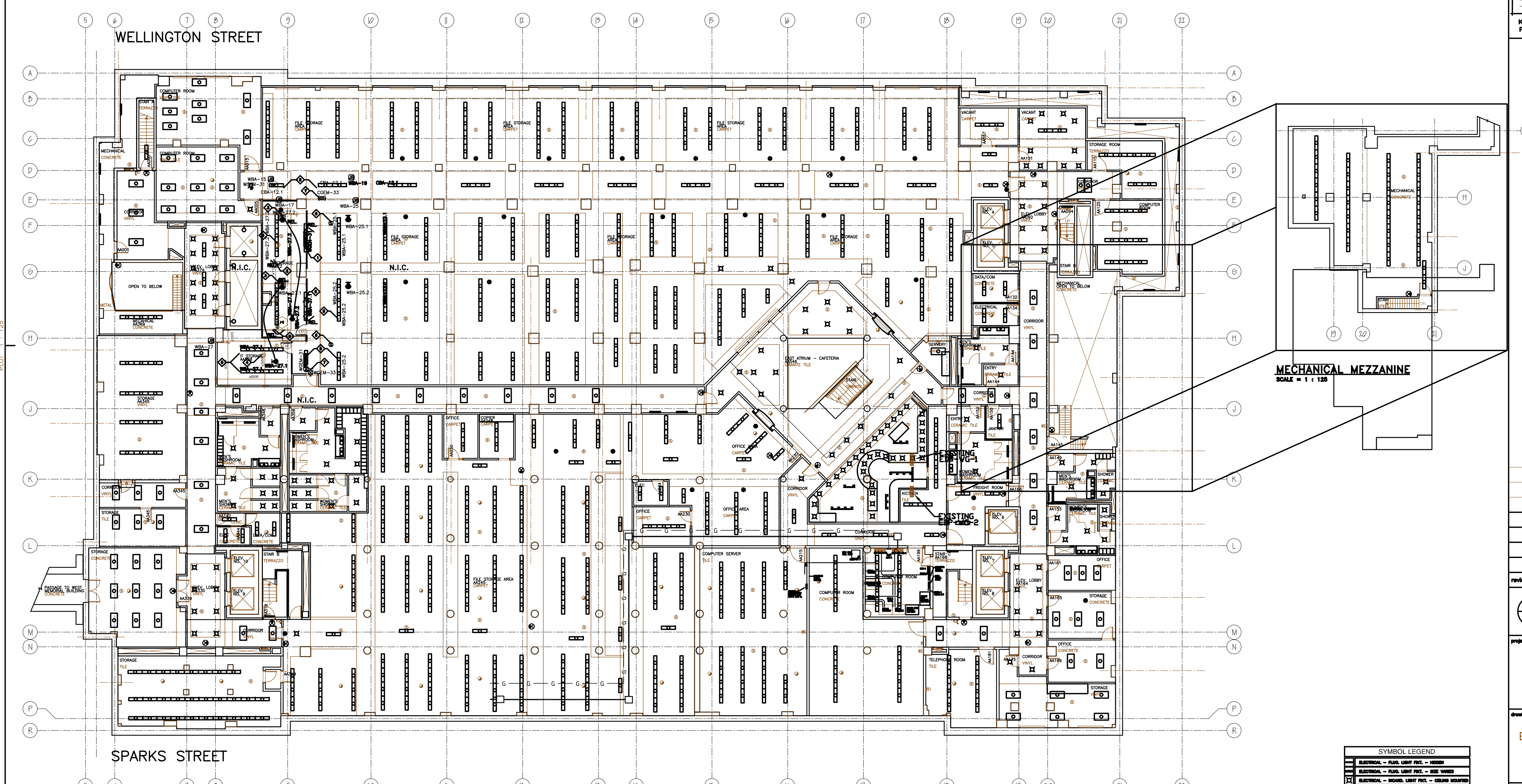
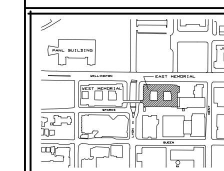


BASEMENT (LEVEL AA) FLOOR PLAN
SCALE: 1:125



KEY PLAN
PLAN–REPÈRE
N.T.S.

revision		date
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	PWGSCD56088 -JSP	NOV-04
	SIM UPDATE (J.FAIR)	APR.2003
	AMENDED (J.FAIR)	MAR.2003
	SIM UPDATE (J.FAIR)	FEB.2003

A detail no. / no. du détail
B location drawing no. / no. de localisation
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project / projet
EAST MEMORIAL BUILDING
284 Wellington St. Ott. Ont.

drawing / dessin
BASEMENT (LEVEL AA)
MASTER DRAWING

designed / conçu
date
drawn / dessiné JWFR
date
reviewed / revisé
date
approved / approuvé
date
tender / soumission
Project Manager / Administrateur de projets
project no. / no. du projet
drawing no. / no. du dessin
A1 OF

SYMBOL LEGEND

	ELECTRICAL – FLUO. LIGHT FIXT. – HIDDEN
	ELECTRICAL – FLUO. LIGHT FIXT. – SIZE VARIES
	ELECTRICAL – INCAND. LIGHT FIXT. – CEILING MOUNTED
	ELECTRICAL – INCAND. LIGHT FIXT. – WALL MOUNTED
	LIFE–SAFETY – FIRE ALARM PULL STATION
	LIFE–SAFETY – FIRE EXTINGUISHER
	LIFE SAFETY – EMERGENCY EVACUATION SPEAKER
	LIFE SAFETY – EMERGENCY EXIT SIGN
	LIFE SAFETY – FIRE BELL \ BUZZER
	LIFE SAFETY – FIRE FIGHTER'S HAND PHONE
	LIFE SAFETY – HEAT DETECTOR
	LIFE SAFETY – SPRINKLER HEAD
	LIFE SAFETY – STANDPIPE CABINET C\W FIRE HOSE
	MECHANICAL – RETURN AIR GRILL – SIZE VARIES
	MECHANICAL – SUPPLY AIR DIFFUSER – SIZE VARIES
	MECHANICAL – THERMOSTAT
	SECURITY – MOTION DETECTOR

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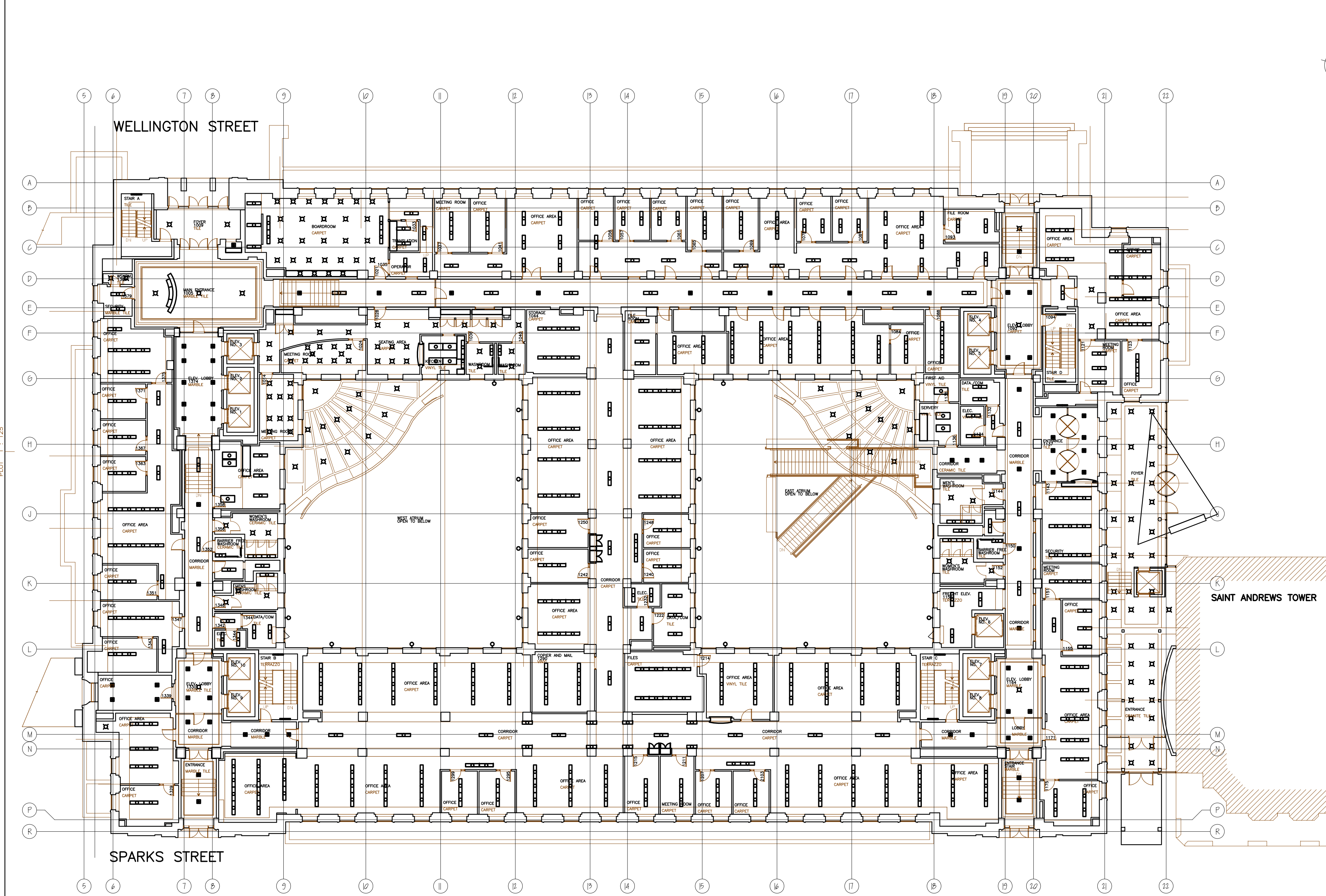

FIRST FLOOR PLAN
SCALE: 1:125

SYMBOL LEGEND
ELECTRICAL – FLUO. LIGHT FIXT. – HIDDEN
ELECTRICAL – FLUO. LIGHT FIXT. – SIZE VARIES
ELECTRICAL – INCAND. LIGHT FIXT. – CEILING MOUNTED
ELECTRICAL – INCAND. LIGHT FIXT. – WALL MOUNTED
LIFE-SAFETY – FIRE ALARM PULL STATION
LIFE-SAFETY – FIRE EXTINGUISHER
LIFE SAFETY – EMERGENCY EVACUATION SPEAKER
LIFE SAFETY – EMERGENCY EXIT SIGN
LIFE SAFETY – FIRE BELL \ BUZZER
LIFE SAFETY – FIRE FIGHTER'S HAND PHONE
LIFE SAFETY – HEAT DETECTOR
LIFE SAFETY – SMOKE DETECTOR
LIFE SAFETY – SPRINKLER HEAD
LIFE SAFETY – STANDPIPE CABINET C\W FIRE HOSE
MECHANICAL – RETURN AIR GRILL – SIZE VARIES
MECHANICAL – SUPPLY AIR DIFFUSER – SIZE VARIES
MECHANICAL – THERMOSTAT
SECURITY – CAMERA
SECURITY – MOTION DETECTOR

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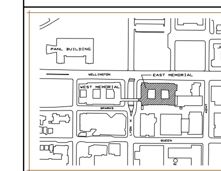

KEY PLAN
PLAN–REPÈRE
N.T.S.

revision		date
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03	SIM UPDATE (J.FAIR)	APR.2003
02	AMENDED (J.FAIR)	MAR.2003
01	SIM UPDATE (J.FAIR)	FEB.2003

A detail no. / no. du détail
B location drawing no. / no. de localisation
C drawing no. / no. du dessin

project / projet
EAST MEMORIAL BUILDING
284 Wellington St. Ott. Ont.

drawing / dessin
FIRST FLOOR
MASTER DRAWING

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drawn / dessiné: JWFR
date
reviewed / revisé
date
approved / approuvé
date
tender / soumission
Project Manager / Administrateur de projets
project no. / no. du projet
drawing no. / no. du dessin: A1 OF

PLOT 1 : 125

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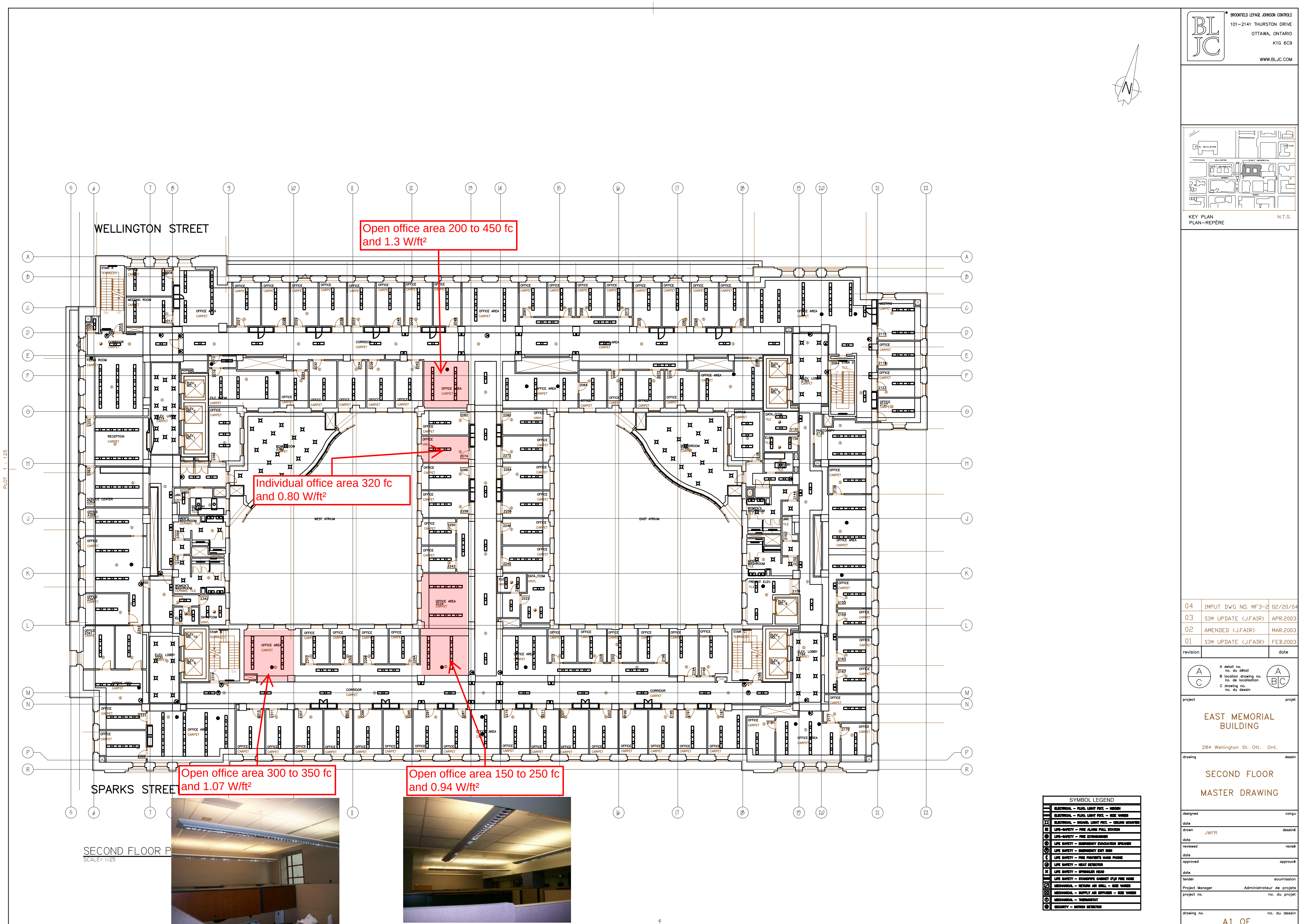
WELLINGTON STREET
SPARKS STREET
Open office area 200 to 450 fc and 1.3 W/ft²
Individual office area 320 fc and 0.80 W/ft²
Open office area 300 to 350 fc and 1.07 W/ft²
Open office area 150 to 250 fc and 0.94 W/ft²
WEST ATRIUM
EAST ATRIUM
SECOND FLOOR P
BROOKFIELD LEPAGE JOHNSON CONTROLS
101-2141 THURSTON DRIVE
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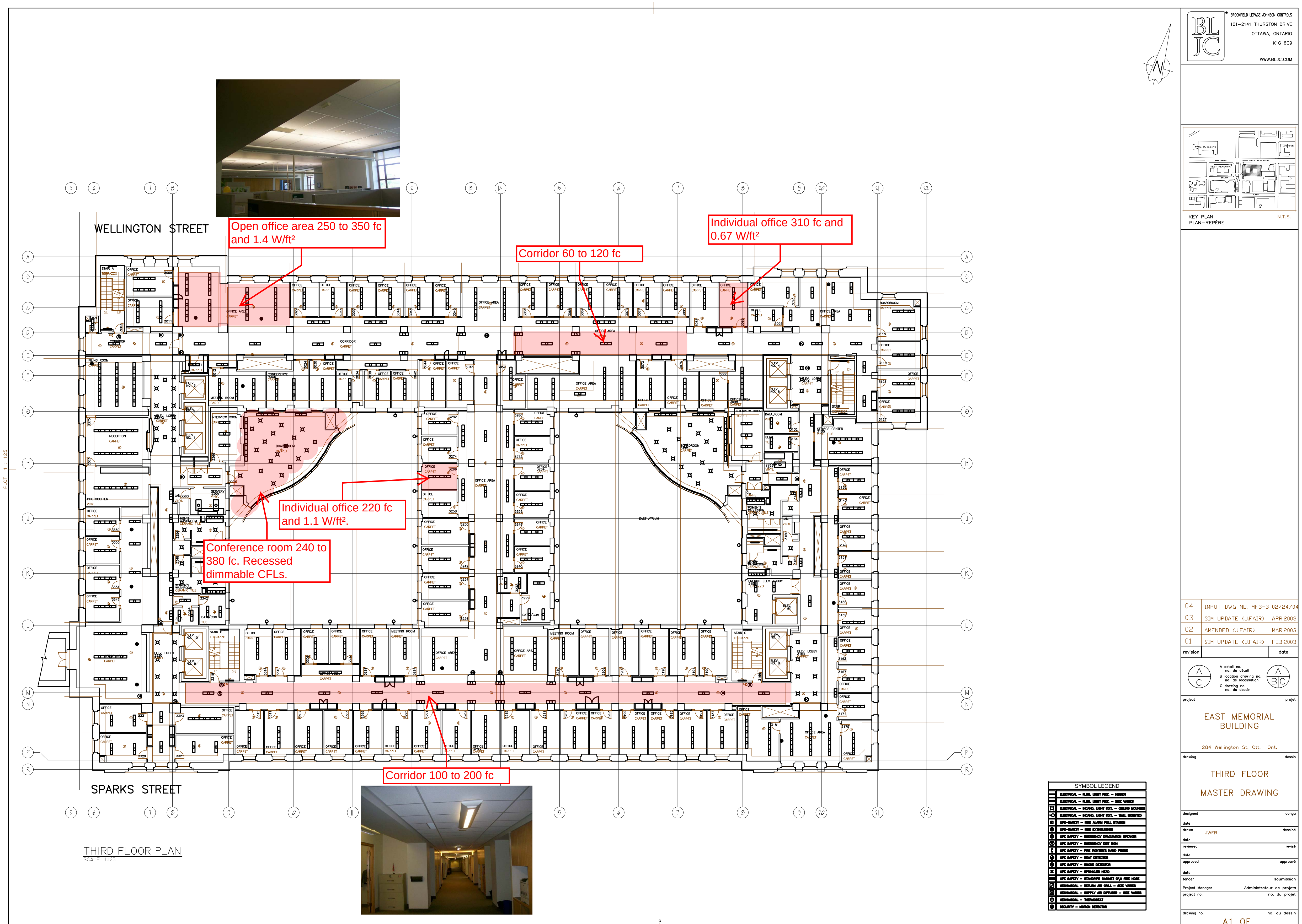
KEY PLAN
PLAN-REPÈRE
N.T.S.
SYMBOL LEGEND
EAST MEMORIAL BUILDING
284 Wellington St. Ott. Ont.
SECOND FLOOR
MASTER DRAWING
A1 OF



WELLINGTON STREET
Open office area 250 to 350 fc and 1.4 W/ft²
Corridor 60 to 120 fc
Individual office 310 fc and 0.67 W/ft²
Individual office 220 fc and 1.1 W/ft².
Conference room 240 to 380 fc. Recessed dimmable CFLs.
Corridor 100 to 200 fc
SPARKS STREET
THIRD FLOOR PLAN
SYMBOL LEGEND
BROOKFIELD LEPAGE JOHNSON CONTROLS
101–2141 THURSTON DRIVE
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KEY PLAN
PLAN–REPÈRE
N.T.S.
04 IMPUT DWG NO. MF3-3 02/24/04
03 SIM UPDATE (J.FAIR) APR.2003
02 AMENDED (J.FAIR) MAR.2003
01 SIM UPDATE (J.FAIR) FEB.2003
revision date
A detail no. no. du détail
B location drawing no. no. de localisation
C drawing no. no. du dessin
project projet
EAST MEMORIAL BUILDING
284 Wellington St. Ott. Ont.
drawing dessin
THIRD FLOOR
MASTER DRAWING
designed conçu
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approved approuvé
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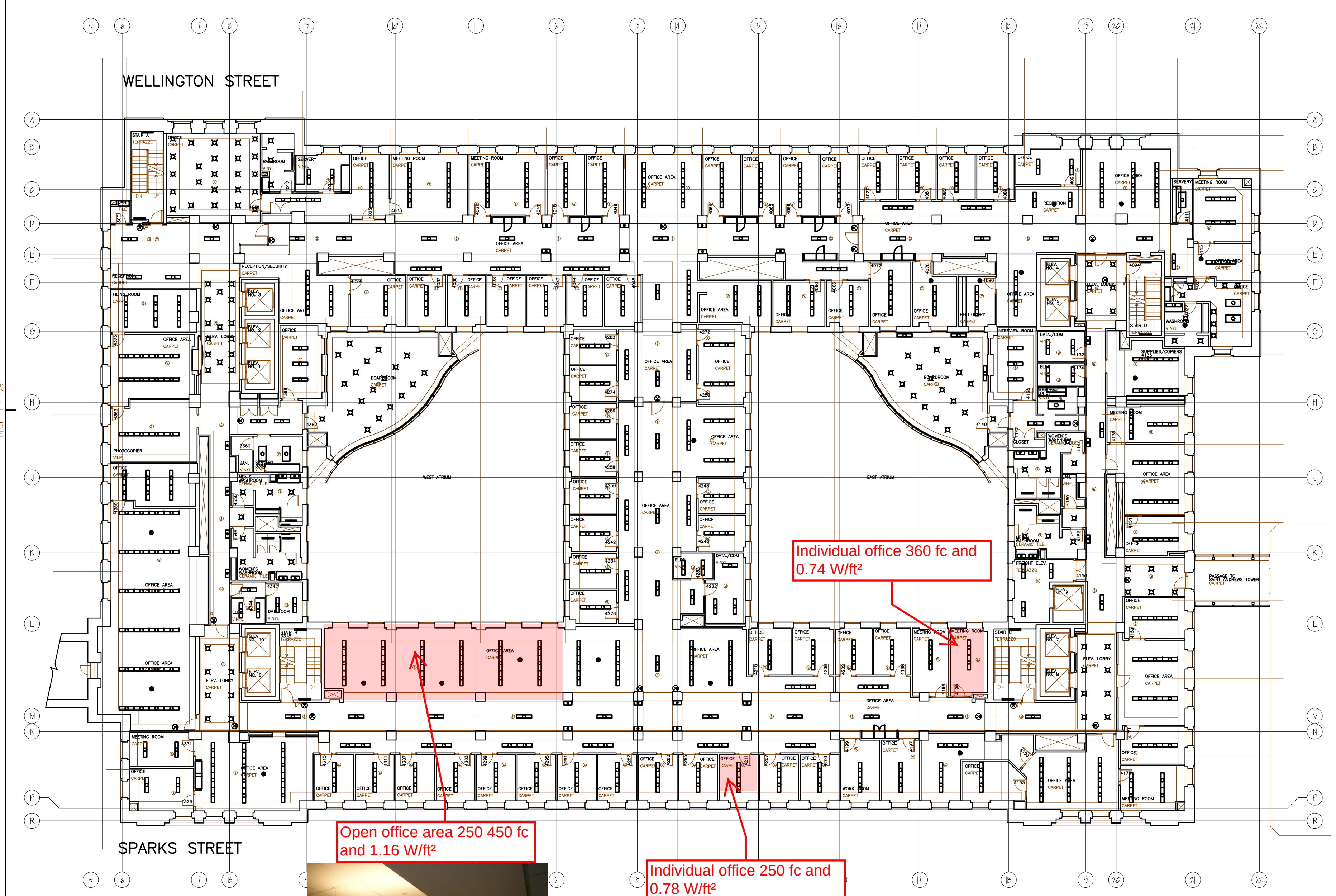
Project Manager Administrateur de projets
project no. no. du projet
drawing no. no. du dessin
A1 OF



FOURTH FLOOR PLAN

SCALE: 1:125

BROOKFIELD LEPAGE JOHNSON CONTROLS
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KEY PLAN
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04	INPUT DWG NO. MF3-4	02/26/04
03	SIM UPDATE (J.FAIR)	APR.2003
02	AMENDED (J.FAIR)	MAR.2003
01	SIM UPDATE (J.FAIR)	FEB.2003
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EAST MEMORIAL BUILDING

284 Wellington St. Ott. Ont.

drawing / dessin

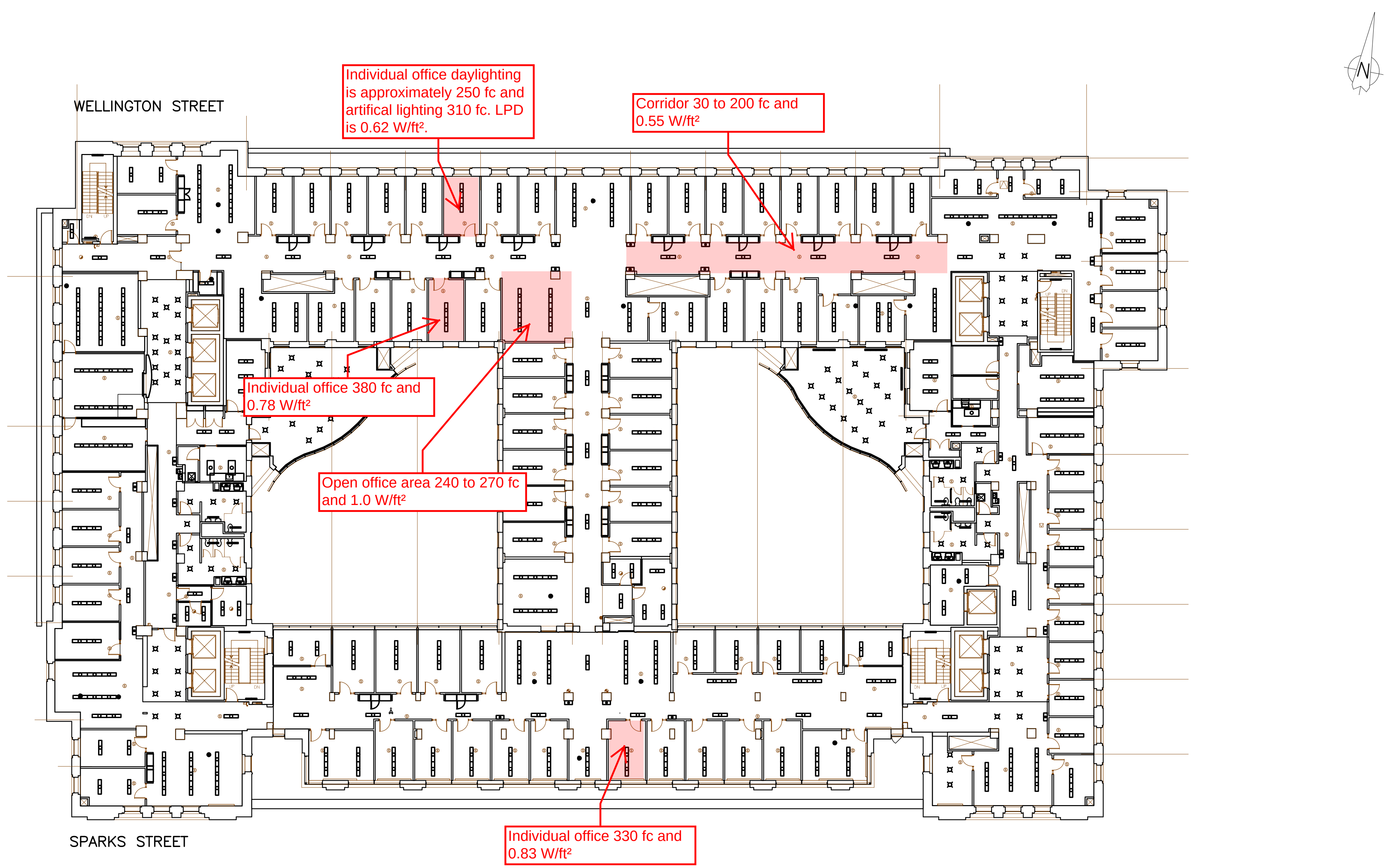
FOURTH FLOOR MASTER DRAWING

drawn: JWFR

drawing no. / no. du dessin

A1 OF

SYMBOL LEGEND



FIFTH FLOOR PLAN
SCALE = 1 : 125

BROOKFIELD LEPAGE JOHNSON CONTROLS
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KEY PLAN
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N.T.S.

revision		date
04	IMPUT DWG NO. MF3-5	02/??/04
03	SIM UPDATE (J.FAIR)	APR.2003
02	AMENDED (J.FAIR)	MAR.2003
01	SIM UPDATE (J.FAIR)	FEB.2003

A detail no. / no. du détail
B location drawing no. / no. de localisation
C drawing no. / no. du dessin

project / projet
EAST MEMORIAL BUILDING
284 Wellington St. Ott. Ont.

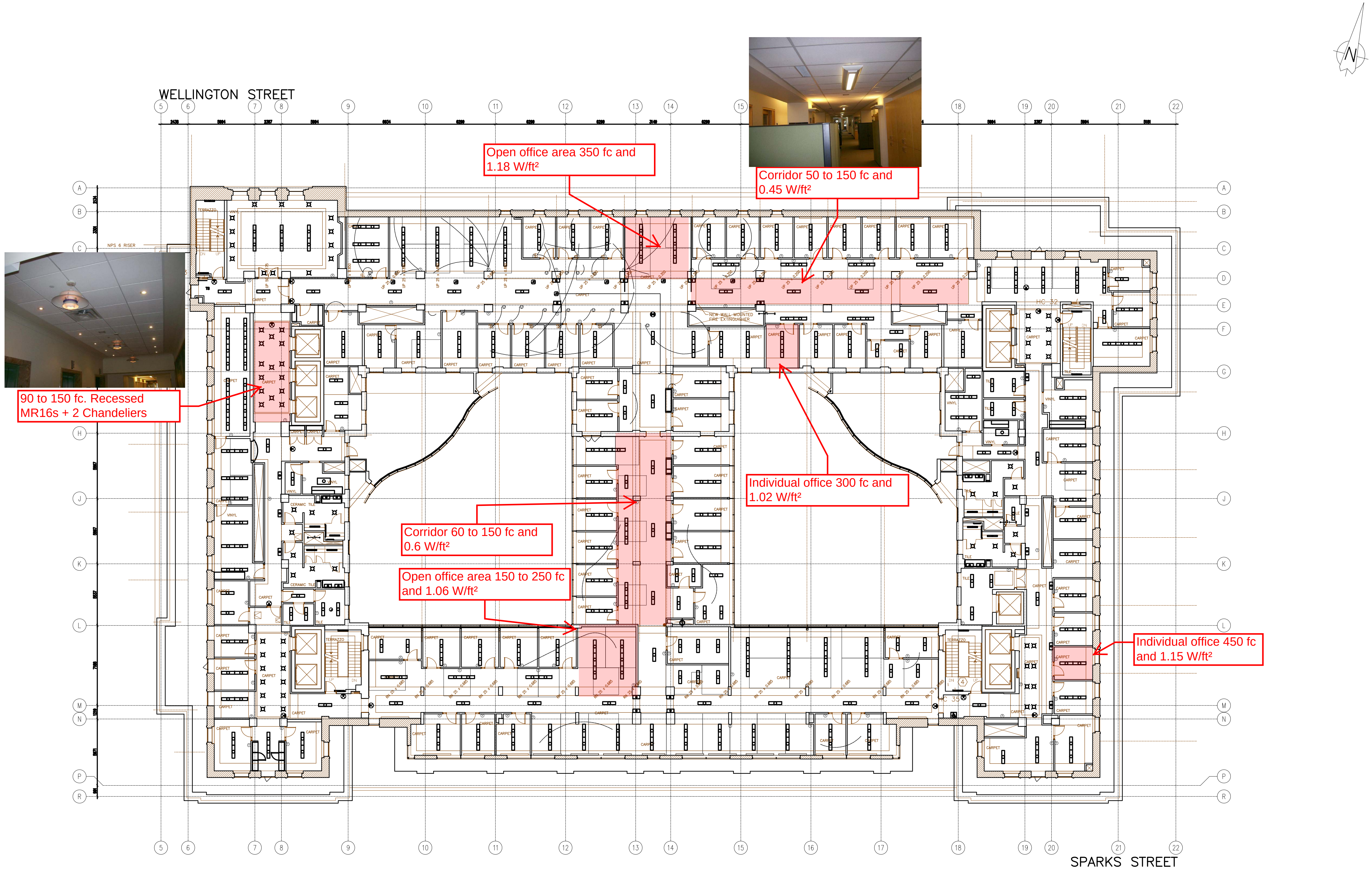
drawing / dessin
FIFTH FLOOR
MASTER DRAWING

designed / conçu
date
drawn / dessiné: JWFR
date
reviewed / revisé
date
approved / approuvé
date
tender / soumission
Project Manager / Administrateur de projets
project no. / no. du projet
drawing no. / no. du dessin
A1 OF

SYMBOL LEGEND

BLJC A0

NOTE 1 – TITLE BLOCK HAS BEEN SCALED TO FIT BUILDING SIZE
– ALL SYMBOLS ARE DRAWN 1 : 100



SIXTH FLOOR PLAN
SCALE = 1 : 125

SYMBOL LEGEND
BARRIER FREE – HANDICAP SYMBOLE
ELECTRICAL – FLUO. LIGHT FIXT. – HIDDEN
ELECTRICAL – FLUO. LIGHT FIXT. – SIZE VARIES
ELECTRICAL – INCAND. LIGHT FIXT. – CEILING MOUNTED
LIFE-SAFETY – FIRE ALARM PULL STATION
LIFE-SAFETY – FIRE EXTINGUISHER
LIFE SAFETY – EMERGENCY EVACUATION SPEAKER
LIFE SAFETY – EMERGENCY EXIT SIGN
LIFE SAFETY – FIRE FIGHTER'S HAND PHONE
LIFE SAFETY – HEAT DETECTOR
LIFE SAFETY – SMOKE DETECTOR
LIFE SAFETY – SPRINKLER HEAD
LIFE SAFETY – STANDPIPE CABINET C\W FIRE HOSE
MECHANICAL – RETURN AIR GRILL – SIZE VARIES
MECHANICAL – SUPPLY AIR DIFFUSER – SIZE VARIES
MECHANICAL – THERMOSTAT
SECURITY – MOTION DETECTOR

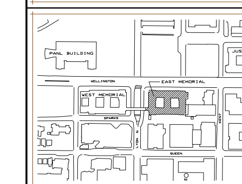
Public Works and Government services Canada / Travaux publics et Services gouvernementaux Canada

Professional and Technical Sector
Architectural and Engineering Services
Real Property Services Branch
Geomatics

Secteur professionnels et techniques
Services d'architecture et genie
Direction générale des services immobiliers
Géomatique

Building Information Management BIM
Architectural base plans
National Capital Area
350 King Edwards
Ottawa, Ontario
K1A 0X1

Gestion des plans d'immeuble
Plan architectural de base
Région de la capitale nationale
350 King Edwards
Ottawa, Ontario
K1A 0X1



KEY PLAN N.T.S.
PLAN–REPÈRE

revision		date
04	SIM UPDATE (M. Malouin)	FEB 2006
03	SIM UPDATE (J. FAIR)	APR. 2003
02	AMENDED (J. FAIR)	MAR. 2003
01	SIM UPDATE (J. FAIR)	FEB. 2002

A detail no. / no. du détail
B location drawing no. / no. de localisation
C drawing no. / no. du dessin

project / projet
BASE BUILDING
PLAN DE BASE
284 WELLINGTON STREET

drawing / dessin
SIXTH
FLOOR PLAN
EAST MEMORIAL BLDG.

measured / mesuré: P.COCHRANE G.GUILBEAULT — date: JUNE, 1998
drawn / dessiné: P.COCHRANE B.BULTER G. GUILBEAULT — date: 1998
reviewed / examiné: STEPHANE MAINVILLE — date: MAY 2003
approved / approuvé: I.BISHOP — date: MAY 2003
tender / soumission
PWC Project Manager / Administrateur de projets TPC
project no. / no. du projet: 276079
drawing no. / no. du dessin: A–9 of/de 12

Scale 1 : 125

PRINTED: Oct 20,2010 – 4:14PM BY: giuliano.todesco

PWGSC / TPSGC A0

APPENDIX C

Utility Usage Summary
from
2005 to 2006

Utility Usage Summary – East Memorial Building

Year 2007	Electricity							Chilled Water					Steam					Water & Sewage		Totals				Weather Data	
	Energy Use (kWh)	Electrical Demand (kW)	Power Factor (%)	Load Factor (%)	Bill ($)	Electrical Intensity (kWh/m^2)	Cost Index ($\$/m^2$)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m^2)	Cost Index ($\$/m^2$)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m^2)	Cost Index ($\$/m^2$)	Usage (m^3)	Bill ($)	Totals Usage (ekWh)	Energy Intensity (ekWh/m^2)	Total Bill ($)	Cost Index ($\$/m^2$)	HDD (@ 18°C)	CDD (@ 18°C)
Jan	420,493												2,591											891.4	0
Feb	390,000												2,175											755.6	0
Mar	410,297												1,996											632	0
Apr	371,182				$31,289	9.9	0.83	166	46,111	$4,002	1.2	0.11	1,052	292,222	$25,383	7.8	0.68	1,183	$2,412	709,516	19	$60,674	$1.62	369	0.8
May	386,025				$30,844	10.3	0.82	571	158,611	$13,726	4.2	0.37	208	57,778	$5,006	1.5	0.13	1,167	$2,514	602,414	16	$49,576	$1.32	155.2	13.1
Jun	382,112				$35,727	10.2	0.95	1,066	296,111	$25,646	7.9	0.68	16	4,444	$397	0.1	0.01	690	$1,532	682,668	18	$61,770	$1.65	41.3	49
Jul	389,792				$34,183	10.4	0.91	1,075	298,611	$25,856	8.0	0.69	2	556	$53	0.0	0.00	1,144	$2,499	688,959	18	$60,091	$1.60	7.3	98.5
Aug	391,683				$35,363	10.4	0.94	1,204	334,444	$28,963	8.9	0.77	1	278	$24	0.0	0.00	341	$793	726,405	19	$64,350	$1.71	38	98
Sep	371,255				$31,061	9.9	0.83	724	201,111	$17,406	5.4	0.46	7	1,944	$179	0.1	0.00	1,236	$2,694	574,310	15	$48,645	$1.30	94	48
Oct	382,665				$35,308	10.2	0.94	372	103,333	$8,947	2.8	0.24	281	78,056	$6,772	2.1	0.18	622	$1,391	564,054	15	$51,027	$1.36	234	13
Nov	378,046				$32,550	10.1	0.87	47	13,056	$1,141	0.3	0.03	1,403	389,722	$33,853	10.4	0.90	1,159	$2,530	780,824	21	$67,544	$1.80	516	0
Dec	399,823				$37,007	10.7	0.99	0	0	$0	0.0	0.00	2,290	636,111	$54,734	17.0	1.46	700	$1,555	1,035,934	28	$91,741	$2.44	776	0
Total	**4,673,373**				**$303,332**	**124.5**	**8.08**	**5,225**	**1,451,389**	**$125,686**	**38.7**	**3.35**	**12,021**	**3,339,167**	**$126,401**	**89.0**	**3.37**	**8,242**	**$17,919**	**6,365,083**	**170**	**$555,419**	**$14.80**	**4,509.8**	**320.4**

Year 2008	Electricity							Chilled Water					Steam					Water & Sewage		Totals				Weather Data	
	Energy Use (kWh)	Electrical Demand (kW)	Power Factor (%)	Load Factor (%)	Bill ($)	Electrical Intensity (kWh/m^2)	Cost Index ($\$/m^2$)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m^2)	Cost Index ($\$/m^2$)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m^2)	Cost Index ($\$/m^2$)	Usage (m^3)	Bill ($)	Totals Usage (ekWh)	Energy Intensity (ekWh/m^2)	Total Bill ($)	Cost Index ($\$/m^2$)	HDD (@ 18°C)	CDD (@ 18°C)
Jan	405,488				$32,498	10.8	0.87	0	0	$0	0.0	0.00	2,274	631,667	$54,342	16.8	1.45	1,336	$2,908	1,037,155	28	$86,839	$2.31	754	0
Feb	381,039				$35,563	10.2	0.95	0	0	$0	0.0	0.00	2,179	605,278	$52,064	16.1	1.39	1,184	$2,580	986,317	26	$87,627	$2.34	765	0
Mar	389,578				$38,108	10.4	1.02	0	0	$0	0.0	0.00	2,041	566,944	$48,786	15.1	1.30	740	$1,641	956,523	25	$86,894	$2.32	709	0
Apr	381,500	822	91%	64%	$34,195	10.2	0.91	220	61,111	$4,618	1.6	0.12	675	187,500	$14,118	5.0	0.38	171	$453	630,111	17	$52,931	$1.41	309	12
May	400,113	824	91%	67%	$29,118	10.7	0.78	370	102,778	$7,770	2.7	0.21	240	66,667	$5,011	1.8	0.13	904	$2,140	569,558	15	$41,900	$1.12	199	10
Jun	414,937	863	91%	66%	$45,568	11.1	1.21	1,009	280,278	$21,170	7.5	0.56	10	2,778	$201	0.1	0.01	776	$1,864	697,992	19	$66,939	$1.78	42	75
Jul	433,194	850	91%	70%	$40,930	11.5	1.09	1,352	375,556	$28,386	10.0	0.76	8	2,222	$172	0.1	0.00	794	$1,909	810,972	22	$69,488	$1.85	18	92
Aug	412,579	784	91%	72%	$31,785	11.0	0.85	1,131	314,167	$23,735	8.4	0.63	8	2,222	$176	0.1	0.00	1,154	$2,741	728,967	19	$55,696	$1.48	40	71
Sep	398,377	822	91%	66%	$36,764	10.6	0.98	761	211,389	$15,982	5.6	0.43	27	7,500	$569	0.2	0.02	861	$2,060	617,266	16	$53,315	$1.42	109	38
Oct	420,448	824	95%	70%	$34,396	11.2	0.92	256	71,111	$5,372	1.9	0.14	583	161,944	$12,194	4.3	0.32	792	$1,902	653,503	17	$51,963	$1.38	324	3
Nov	401,560	865	95%	64%	$33,972	10.7	0.91	33	9,167	$689	0.2	0.02	1,435	398,611	$30,011	10.6	0.80	873	$2,089	809,338	22	$64,671	$1.72	502	0
Dec	443,814	868	95%	70%	$36,870	11.8	0.98	0	0	$0	0.0	0.00	2,540	705,556	$53,136	18.8	1.42	944	$2,266	1,149,369	31	$90,006	$2.40	788	0
Total	**4,882,626**				**$429,766**	**130.1**	**11.45**	**5,132**	**1,425,556**	**$107,722**	**38.0**	**2.87**	**12,020**	**3,338,889**	**$270,780**	**89.0**	**7.22**	**10,529**	**$24,553**	**9,647,071**	**257**	**$808,269**	**$21.54**	**4,559.0**	**301.0**

Utility Usage Summary – East Memorial Building (continued)

	Electricity							Chilled Water					Steam					Water & Sewage		Totals				Weather Data	
Year 2009	Energy Use (kWh)	Electrical Demand (kW)	Power Factor (%)	Load Factor (%)	Bill ($)	Electrical Intensity (kWh/m²)	Cost Index ($/m²)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m²)	Cost Index ($/m²)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m²)	Cost Index ($/m²)	Usage (m^3)	Bill ($)	Totals Usage (ekWh)	Energy Intensity (ekWh/m²)	Total Bill ($)	Cost Index ($/m²)	HDD (@ 18°C)	CDD (@ 18°C)
Jan	435,497	883	95%	68%	$43,331	11.6	1.15	0	0	$0	0.0	0.00	2,907	807,500	$60,794	21.5	1.62	900	$2,332	1,242,997	33	$104,125	$2.77	973	0
Feb	398,961	876	95%	62%	$33,270	10.6	0.89	0	0	$0	0.0	0.00	2,170	602,778	$45,389	16.1	1.21	945	$2,450	1,001,739	27	$78,659	$2.10	706	0
Mar	431,016	878	95%	67%	$30,712	11.5	0.82	0	0	$0	0.0	0.00	1,951	541,944	$40,805	14.4	1.09	947	$2,461	972,960	26	$71,516	$1.91	602	0
Apr	414,542	860	94%	66%	$34,260	11.0	0.91	125	34,722	$2,597	0.9	0.07	1,065	295,833	$22,165	7.9	0.59	926	$2,407	745,098	20	$59,022	$1.57	333	8
May	427,687	844	93%	69%	$44,322	11.4	1.18	530	147,222	$11,051	3.9	0.29	281	78,056	$5,855	2.1	0.16	959	$2,493	652,965	17	$61,228	$1.63	185	11
Jun	435,136	860	94%	69%	$35,698	11.6	0.95	1,012	281,111	$21,086	7.5	0.56	51	14,167	$1,070	0.4	0.03	930	$2,416	730,414	19	$57,854	$1.54	69	57
Jul	448,398	834	94%	74%	$39,319	11.9	1.05	1,187	329,722	$24,739	8.8	0.66	0	0	$0	0.0	0.00	957	$2,485	778,121	21	$64,058	$1.71	34	59
Aug	455,826	860	94%	73%	$47,783	12.1	1.27	1,338	371,667	$27,896	9.9	0.74	2	556	$46	0.0	0.00	959	$2,492	828,049	22	$75,725	$2.02	38	92
Sep	439,533	860	93%	70%	$39,597	11.7	1.06	551	153,056	$11,480	4.1	0.31	15	4,167	$305	0.1	0.01	782	$2,042	596,755	16	$51,381	$1.37	123	24
Oct	491,257	1,071	96%	63%	$52,947	13.1	1.41	32	8,889	$659	0.2	0.02	479	133,056	$9,979	3.5	0.27	118	$366	633,202	17	$63,585	$1.69	356	0
Nov	562,261	1,120	96%	69%	$53,081	15.0	1.41	10	2,778	$218	0.1	0.01	187	51,944	$3,884	1.4	0.10	697	$1,827	616,983	16	$57,183	$1.52	416	0
Dec	476,684	1,120	96%	58%	$52,016	12.7	1.39	0	0	$0	0.0	0.00	1,871	519,722	$38,950	13.9	1.04	713	$1,869	996,406	27	$90,966	$2.42	757	0
Total	**5,416,798**				**$506,337**	**144.4**	**13.49**	**4,785**	**1,329,167**	**$99,726**	**35.4**	**2.66**	**10,979**	**3,049,722**	**$229,239**	**81.3**	**6.11**	**9,833**	**$25,639**	**9,795,687**	**261**	**$835,302**	**$22.26**	**4,592.0**	**251.0**

	Electricity							Chilled Water					Steam					Water & Sewage		Totals				Weather Data	
Year 2010	Energy Use (kWh)	Electrical Demand (kW)	Power Factor (%)	Load Factor (%)	Bill ($)	Electrical Intensity (kWh/m²)	Cost Index ($/m²)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m²)	Cost Index ($/m²)	Usage GJ	Usage (ekWh)	Bill ($)	Energy Intensity (ekWh/m²)	Cost Index ($/m²)	Usage (m^3)	Bill ($)	Totals Usage (ekWh)	Energy Intensity (ekWh/m²)	Total Bill ($)	Cost Index ($/m²)	HDD (@ 18°C)	CDD (@ 18°C)
Jan	481,662				$49,773	12.8	1.33	0	0	$0	0.0	0.00	2,175	604,167	$45,287	16.1	1.21	550	$1,459	1,085,829	29	$95,060	$2.53	786	0
Feb	448,528				$48,118	12.0	1.28	0	0	$0	0.0	0.00	1,900	527,778	$39,561	14.1	1.05	1,030	$2,664	976,306	26	$87,679	$2.34	653	0
Mar	486,580				$43,284	13.0	1.15	0	0	$0	0.0	0.00	1,700	472,222	$35,397	12.6	0.94	644	$1,695	958,802	26	$78,680	$2.10	461	0
Apr																									
May																									
Jun																									
Jul																									
Aug																									
Sep																									
Oct																									
Nov																									
Dec																									
Total	**1,416,770**				**$141,175**	**37.8**	**3.76**	**0**	**0**	**$0**	**0.0**	**0.00**	**5,775**	**1,604,167**	**$120,244**	**42.8**	**3.20**	**2,224**	**$5,818**	**3,020,937**	**81**	**$261,419**	**$6.97**	**1,900.0**	**0.0**

APPENDIX D

VisualDOE Energy Model Outputs

Project Information

Name: East Memorial Building
Address: Address
Description:
Analysis done by: G. Todesco @ Genivar
Weather File: Ottawa
Project File: c:\visualdoe\east memorial\east memorial.gph
Calculation Engine: DOE-2.1E-119

Electrical Use Summary

Alternative	Lights	Equip.	Heating	Cooling	Pumps/Aux.		Fans	DHW	Total
Electrical End-use Totals (kWh)									
Base Case	2,096,952	998,442	56,229	9,788	62,144	35,168	1,879,184	23,202	5,161,109

Fuel Use Summary

Alternative	Heating	Total
Fuel End-Use Totals		
Base Case - Steam (Therm)	99,594	99,594

Energy Cost Summary ($/y)

Alternative	Total Electric	Total Fuel	Total Utility	Incremental First Cost	PV Life Cycle Cost*
Total Energy Cost ($/y)					
Base Case	$469,653	$230,460	$700,113	$0	$5,960,457

* 20 year life cycle w/ 10% discount rate.

Monthly Electrical Usage (kWh)

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Base Case	441,009	400,245	445,678	421,024	433,845	428,581	437,044	443,610	419,455	431,593	419,688	439,248

Monthly Electrical Power Demand (kW)

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Base Case	860	863	860	864	872	919	922	924	902	871	855	859

Monthly Fuel Usage

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Base Case - Steam (Therm)	19,818	19,666	16,640	6,594	1,882	382	169	344	1,441	4,689	8,797	19,171

APPENDIX E

Energy Efficiency Measures

EEM 1: Advance the Weekday Shutdown of Air Handling Units to 7:00 PM or 6:00 PM

1.0 CURRENT CONDITION

The current weekly schedule for air handling units is from 6:00 AM to 8:00 PM. The units will shutdown if the space is unoccupied, otherwise, they will continue to operate.

2.0 PROPOSED MEASURE DESCRIPTION

Consider shutting down the air handling units at 7:00 PM or even 6:00 PM during weekdays. There would be no impact to occupant comfort because the units would only shutdown if the MDS status shows the space to be unoccupied. If the MDS shows an occupied condition, the units would continue to operate. This proposed measure excludes the unit that are operating continuously.

It is also important to note that there is no after hours cleaning staff that would be affected by the measure.

3.0 MEASURE IMPLEMENTATION

This measure can be implemented by changing the operating schedule at the BAS by an SNC Lavalin O&M technician or operator. There is no implementation cost.

4.0 CALCULATION OF ENERGY SAVINGS

Electrical energy savings were calculated assuming an average VSD speed of 50%, which would be equivalent to a 35% motor load based on collected data part load data. Table E1 provides a tabulation of all unit motor loads.

Table E1:
Calculated Hp at 35% Motor Load

Air Handling Unit	Combined Supply and Return Fan hp	Hp at 35% Motor Load
AHU1	90	31
AHU3	90	31
AHU4	90	31
AHU5	125	43
AHU6	90	31
AHU7	35	26 (1)
AHU8	35	26 (1)
AHU9	65	22
AHU10	65	22
		263

AHU7 and AHU8 are CAV units and the actual motor load is based on amperage readings

Electrical energy savings based on advancing the shutdown by 1 hr were calculated using the equation shown below.

$$Electricty\ Savings = \left[\frac{263\,hp}{}\right]\left[\frac{0.7457\,kWh}{hp.hr}\right]\left[\frac{5\,hrs}{week}\right]\left[\frac{52\,weeks}{year}\right]$$

$$\sim \quad 50{,}990\,kWh/year$$

5.0 PROJECT COST SUMMARY

The cost savings based on an electricity cost of 8.9 cents/kWh are approximately $4,500/year.

There is no implementation cost since the operating schedule change can be implemented by an SNC Lavalin O&M technician or operator. Table E2 presents the cost savings, implementation cost and payback period.

Table E2:
Project Cost Summary

Energy Savings (kWh/year)	Cost Savings ($)	Implementation Cost ($)	Simple Payback (years)
50,990	$4,500	0	Immediate

EEM 2: Operate VAV AHUs at Minimum During the Occupied Period on Weekends and Holidays

1.0 CURRENT CONDITION

The current weekend and holiday operating schedule of air handling units is from 8:00 AM to 5:00 PM regardless of occupancy.

The design of the HVAC equipment and VAV boxes includes a feedback from the space via motion detectors status (MDS) that provides an indication of occupancy. During unoccupied periods when there is light occupancy, this design can allow VAV boxes to control the space temperature and provide adequate air flow for those zones where the motion detectors report an "occupied" status.

2.0 PROPOSED MEASURE DESCRIPTION

It is not necessary to maintain the building at a fully occupied status during weekends and holidays when there is low occupancy.

The air handling units supply and return fans could be operate at a minimum flow of 30 to 35% and allow VAV boxes to maintain comfort and flow only for those zones that show an "occupied" status. This will provide electrical savings since fans will only be at 30 to 35% flow as opposed to 50% flow.

All remaining VAV boxes serving unoccupied areas would switch to an unoccupied status mode, setback the space temperature and close the dampers to their minimum position.

3.0 MEASURE IMPLEMENTATION

This measure will require a modification of the VAV box software to switch to an "unoccupied" mode during weekends and holidays as opposed to reliance on the floor occupancy status that is currently used by the BAS.

As VAV boxes switch to minimum, the static pressure control should automatically ramp the VSDs down. However, programming code may also be needed to get the fans to slow down to a range of 30 to 35% of flow. This uncertainty requires a fair amount of commissioning and "shake-down" to derive the proper control sequence.

4.0 CALCULATION OF ENERGY SAVINGS

Electrical energy savings were calculated assuming an unoccupied VSD speed of 30% and a 25% motor load during weekend and holidays vs. a current motor load of 35%. Table E3 provides a tabulation of motor loads under current and proposed operating conditions.

Table E3: Comparison of Motor Load Under Current and Proposed Operating Conditions			
Air Handling Unit	**Combined Supply and Return Fan hp**	**Hp at 35% Motor Load**	**Hp at 25% Motor Load**
AHU1	90	31	22
AHU3	90	31	22
AHU4	90	31	22
AHU5	125	43	31
AHU6	90	31	22
AHU7	35	26 (1)	26
AHU8	35	26 (1)	26
AHU9	65	22	16
AHU10	65	22	16
		263	**203**
AHU7 and AHU8 are CAV units and the actual motor load is based on amperage readings			

Electrical energy savings based on operating the units at the reduced speed and motor load were calculated using the equation shown below.

$$Electricty\ Savings \quad = \quad \left[\frac{(263-203)\ hp}{}\right]\left[\frac{0.7457\ kWh}{hp.hr}\right]\left[\frac{16\ hrs}{week}\right]\left[\frac{52\ weeks}{year}\right]$$

$$\sim \quad 37{,}220\ kWh/\ year$$

Additional energy savings in the form of steam can be realized from setting back the space temperature. During the unoccupied period to 20°C (68°F) at outside air temperature (OATs) above 5°C (41°f). At lower temperatures, the single pane windows will potentially not allow fast recovery of the space. A reduction of 3% in total steam energy use or 330 GJ is assumed in this analysis as opposed to relying on the energy model. The OAT dependent measure cannot be calculated by the energy model since the model would calculate the energy savings for the entire winter period regardless of OAT.

5.0 PROJECT COST SUMMARY

The cost savings based on an electricity cost of 8.9 cents/kWh are approximately $3,300/year. The steam savings based on a cost of $21.94/GJ are approximately $7,240.

The cost for new programming to add the new software code is estimated to be approximately $10,000 to $12,000 for a Johnson Controls BAS Technician to implement this measure over a period of 10 days. This cost includes time to modify the control strategies of 919 VAV boxes plus commissioning and real time monitoring during the unoccupied period to see how the VAV boxes and air handling units respond to the operation changes. Table E4 presents the cost savings, implementation cost and payback period.

Table E4: Project Cost Summary			
Energy Savings	**Cost Savings ($)**	**Implementation Cost ($)**	**Simple Payback (years)**
37,220 kWh/year	$3,300	$10,000 to $12,000	0.9 to 1.1
330 GJ	$7,200		

EEM 3: REPAIR AHU7 SUPPLY FAN STARTER TO ENSURE THAT IT SHUTS DOWN AT THE SAME TIME AS THE RETURN FAN

1.0 CURRENT CONDITION

AHU7 supply fan did not shutdown on the night of the "Lights-Out" audit and longer trend data shows the unit running since August 12 (see Section 4 in main report) while the return fan is shutting down.

2.0 PROPOSED MEASURE DESCRIPTION

Investigate why the supply fan on AHU7 does not shutdown at the same time as the return fan and make necessary repairs to ensure that it shuts down at the end of occupancy.

3.0 MEASURE IMPLEMENTATION

This measure may require checking the condition of the supply fan starter, relay or the BAS software to determine the reason why the fan is not shutting down at the end of occupancy.

4.0 CALCULATION OF ENERGY SAVINGS

Electrical energy savings were calculated assuming that the fan will continue to run for the remainder of the year since the last time it shut down on August 11. For simplification purposes it is assumed that this represents 4 months. Electrical energy savings were calculated using the equation shown below and a measured amperage draw of 13 Amps which is equivalent to 11 kW.

$$Electricty\ Savings = \left[\frac{11\ kW}{}\right]\left[\frac{10\ hrs}{day}\right]\left[\frac{30.4\ days}{month}\right]\left[\frac{4\ months}{year}\right]$$

$$\sim\ 13{,}400\ kWh/year$$

5.0 PROJECT COST SUMMARY

The cost savings based on an electricity cost of 8.9 cents/kWh are approximately $1,200/year.

The implementation cost is unknown since it may depending on a simple replacement of a relay or a complete motor starter. The implementation cost can range from 0 to $1,500 for a 25 hp rated motor starter (R.S. Means). Table E5 presents the cost savings, implementation cost and payback period.

Table E5: Project Cost Summary

Energy Savings (kWh/year)	Cost Savings ($)	Implementation Cost ($)	Simple Payback (years)
13,400	$1,200	$0 to $1,500	Immediate to 1.3

EEM 4: SHUTDOWN ALL AIR HANDLING UNITS DURING THE UNOCCUPIED PERIOD EXCEPT FOR UNITS THAT OPERATE CONTINUOUSLY

1.0 CURRENT CONDITION

AHU1 through AHU11 are scheduled to shutdown at 8:00 PM except for AHUs 2, 5 and 11, which operate continuously. By 11:00 PM six air handling units were still in operation. Table E6 lists the air handling units and the status at 8:30 and 11:00 PM. Text in red denotes units that should not be operating. AHU7 only achieved a partial shutdown. Records from longer trend data for the month of August are also included in the last column. The LOA only provides a snapshot of one day of operation while the trend data shows a longer timeframe. During the month of August most AHUs ran during the unoccupied period at one time or another, with only three out of eleven units shutting down. This occurs because most air handling units are enabled in the unoccupied period by the high count of motion detectors reporting an "occupied" status (see Section 4.3 in the main report).

Table E6:
List of AHUs Operating During the Unoccupied Hours

	Status of AHUs at 8:30 PM	Status of AHUs at 11:00 PM	BAS Trend Data (August)
AHU1 North Perimeter	OFF	OFF	ON
AHU2 East Perimeter	continuous operation	continuous operation	continuous operation
AHU3 South Perimeter	OFF	OFF	OFF
AHU4 West Perimeter	ON	ON	ON (unit ran continuously from May to middle of August
AHU5 North Interior	continuous operation	continuous operation	continuous operation
AHU6 South interior	OFF	OFF	ON
AHU7 West Courtyard	Supply fan ON, Return Fan OFF	Supply fan ON, Return Fan OFF	Supply fan has been running since August 12
AHU8 East Courtyard	OFF	OFF	OFF
AHU9 Ground Floor west	ON	ON	ON
AHU10 Basement South and East	OFF	OFF	OFF
AHU11 Ground East & Bsmt North	continuous operation	continuous operation	continuous operation
AHU16 West Courtyard Skylight	OFF	OFF	Unknown
AHU17 East Courtyard Skylight	OFF	OFF	Unknown

2.0 PROPOSED MEASURE DESCRIPTION

The problem with the high counts of motion detector status goes back a number of years. Furthermore, repeated attempts to correct the problem have been unsuccessful.

The proposed approach to try and implement this measure is based on a two layered approach where air handling units that are still operating after 8:00 PM go to a standby mode with VSDs slowing down to 30% and VAV boxes switching to an unoccupied mode.

This will apply to AHU4, AHU9. AHU5 is also assumed to be shutdown since in the past only AHU2 and AHU11 operated continuously.

3.0 MEASURE IMPLEMENTATION

This measure will require a modification of the VAV box software to switch to an "unoccupied" mode during weekends and holidays as opposed to reliance on the floor occupancy status that is currently used by the BAS.

As VAV boxes switch to minimum, the static pressure control should automatically ramp the VSDs down. However, programming code may also be needed to get the fans to slow down to a range of 30 to 35% of flow. This uncertainty requires a fair amount of commissioning and "shake-down" to derive the proper control sequence.

4.0 CALCULATION OF ENERGY SAVINGS

The energy savings were calculated assuming that AHU4, AHU5 and AHU9 will operate at a speed of 30 to 35% during the unoccupied period and a 25% vs. a current motor load of 35%. Table E7 provides a tabulation of motor loads under current and proposed operating conditions.

Table E7:
Comparison of Motor Load Under Current and Proposed Operating Conditions

Air Handling Unit	Combined Supply and Return Fan hp	Hp at 35% Motor Load	Hp at 25% Motor Load
AHU4	90	31	22
AHU5	125	43	31
AHU9	65	22	16
		96	**69**

Electrical energy savings based on operating the units at the reduced speed and motor load were calculated using the equation shown below.

$$Electricty\ Savings = \left[\frac{(96-69)\ hp}{}\right]\left[\frac{0.7457\ kWh}{hp.hr}\right]\left[\frac{10\ hrs}{week}\right]\left[\frac{265\ days}{year}\right]$$

$$\sim 53{,}300\ kWh/year$$

5.0 PROJECT COST SUMMARY

The cost savings based on an electricity cost of 8.9 cents/kWh are approximately $4,700/year.

The cost for new programming to add the new software code is estimated to be approximately $10,000 to $12,000 for a Johnson Controls BAS Technician to implement this measure over a period of 10 days. This cost includes time to modify the control strategies of 919 VAV boxes plus commissioning and real time monitoring during the unoccupied period to see how the VAV boxes and air handling units respond to the operation changes. This work was also been recommended as part of EEM2. As a result, Table E8 presents the cost savings, implementation cost and payback period for both EEMs.

Table E8: Project Cost Summary			
Energy Savings (kWh/year)	**Cost Savings ($)**	**Implementation Cost ($)**	**Simple Payback (years)**
EEM2 37,220	$3,300	$10,000 to $12,000	1.1 to 1.3
EEM4 53,300	$4,700		

EEM 5: HIGH PERFORMANCE FLUORESCENT LIGHTING SYSTEM

1.0 CURRENT CONDITION

The lighting consists of direct-indirect pendant fluorescent fixtures equipped with two lamps per fixture. The fluorescent fixtures use standard 4-foot 32 Watt, T8 lamps with electronic ballasts. The lamp currently used is the Sylvania FO32/835/ECO lamp. There are also wall sconces in corridors, recessed fixtures with compact fluorescent lamps and pendant incandescent fixtures at each floor elevator lobby. Finally, a total of 56 metal halide (MH) lamps are used in the courtyards. The average lighting power density in the office space is approximately 8.6 W/m² (0.8 W/ft²). This value climbs to 10.9 W/m² (~1.0 W/ft²) with the architectural lighting (wall sconces and recessed fixtures) and MH lighting in the courtyards.

2.0 PROPOSED MEASURE DESCRIPTION

There is a potential to decrease the connected lighting load by approximately 10% through use of new generation lower wattage T8 lamps that also offer a longer lamp life of 30,000 hours. This option will achieve a reduction in demand and energy use, but only a small reduction in light levels thanks to a higher lumen maintenance factor of the better lamp. This reduced wattage fluorescent lamp technology is being installed in other government facilities including Le Terraces de la Chaudiere (LTC) and tested at Place du Portage Phase III. The power draw per 2-lamp fixture is shown in Table E9.

Table E9: Connected Power For a 2-Lamp Luminaries

Option	Power Draw (Watts)
Basecase (T8 – 32W lamp)	59
28 W Lamp	53 (9% savings)

3.0 MEASURE IMPLEMENTATION

The lighting retrofit that is being contemplated would use a reduced wattage 28W lamp with the existing electronic ballast. The measure would consist of replacement of the existing lamps with a new low wattage lamp.

The option of replacing the current lighting system with linear LED lamps was also investigated. However, the current LED lamps have a luminous efficacy of approximately 94 lumens/watt, which is on par with current generation T8 lamps. Therefore to achieve an equivalent light output, the LED lamps would draw the same amount of power as T8 fluorescents. Even though they are quoted as lasting 50,000 hours compared with 30,000 for T8, the project would produce an unattractively long payback period due to the high implementation cost.

4.0 CALCULATION OF ENERGY SAVINGS

Table 4.1 provides a summary of the demand and energy savings. The energy savings were calculated using an operating time of 80 hours/week or 4,160 hrs/year and a building floor area of 37,520 m² (~403,715 ft²). Savings of 9% were assumed and were calculated as shown below.

$$= \left[\frac{0.8\ W}{ft^2}\right]\left[\frac{403{,}715\ \ ft^2}{}\right]\left[\frac{4{,}160\ hrs}{year}\right]\left[\frac{kW}{1000\ W}\right]\left[\frac{9\%\ savings}{}\right]$$

$$\sim 120{,}000\ \ kWh/year$$

5.0 ELECTRICITY RETROFIT INCENTIVE PROGRAM (ERIP)

The Electricity Retrofit Incentive Program offers incentives for retrofit projects that choose the most electricity efficient technologies. ERIP focuses on the areas of lighting, motors, heating ventilation and air conditioning and overall electricity systems. **Applications must be received by Hydro Ottawa before December 31, 2010 and the projects must be completed prior to December 1, 2011**.

There are two ways to apply to the program:

PRESCRIPTIVE TRACK

This track has predefined technologies with corresponding per-unit or performance-basis savings measures. These projects will tend to involve replacements and upgrades to existing systems. The incentive is based on what is installed.

CUSTOM TRACK

This track is for businesses using a more specific solution to electricity efficiency retrofitting. For these projects, all technology equipment and systems are evaluated on the basis of their power and energy performance improvement. The incentive offered is based specifically on the level of improvement. The incentives are based on the results of calculations from each track's specific worksheet.

The following list identifies the Predefined Technologies approved for the program:

ALTERNATIVE ENERGY MEASURES FOR SERVICE HOT WATER

- Solar hot water heating
- Drain water heat recovery
- Non-electric tank and instantaneous water heating

ALTERNATIVE ENERGY MEASURES FOR SPACE COOLING

- Ground-source heat pumps
- Desiccant dehumidification
- Absorption and engine-driven chillers

COOLING EQUIPMENT

- Unitary A/C units up to 25 TONS that are Energy Star-Qualified or CEE compliant

LIGHTING

- Fluorescent Lighting Systems (T8, T5, CFL)
- High Intensity Discharge Lighting Systems
- LED "EXIT" Signs
- Occupancy sensors

MOTORS

- Three-phase premium-efficiency motors 1-200 HP

Since the building already has T8 lighting installed, a custom project would need to be pursued. Custom projects for lighting receive the lesser of (the greater of $400/kW and $0.05/kWh) OR 40% of the Custom Project cost. It is important to note that for custom projects, pre-approval is required from Hydro Ottawa before letting contracts, releasing purchase orders, purchasing equipment or starting work.

The estimated incentive based on 29 kW of demand savings is $11,600. The estimated incentive based on 120,000 kWh of consumption savings is $6,000. The estimated incentive based on 40% of the project cost is $21,900. Therefore, the estimated incentive would be $11,600.

5.0 PROJECT COST SUMMARY

The cost savings were calculated using an electricity cost of 8.9 cents/kWh and a demand charge of $9.63/kW.

The implementation costs were calculated assuming 4,000 luminaries or 8,000 lamps and a price of $3.50 lamp. Labour cost is approximately $26,680 assuming a contractor can relamp 6 fixtures/hour and a labour cost of $40/hour. Table E10 presents the cost savings, implementation cost, ERIP incentive and payback period.

Table E10: Project Cost Summary 28W Lamp Option

	Savings	Cost Savings ($)	Implementation Cost ($)	Simple Payback (years)
Energy (kWh/year)	120,000	$10,680		
Demand (kW)	348 *	$3,300		
Incentive (ERIP)			$11,600	
Total		$13,980	$43,080 **	3.1

* 29 kW/month for 12 months

** Total implementation cost = labour + materials - incentive

EEM 6: REPLACEMENT OF SINGLE PANE WINDOWS WITH DOUBLE PANE WINDOWS

1.0 CURRENT CONDITION

There are approximately 386 operable windows throughout the building that consist of single pane glass mounted on a steel frame. The windows are subdivided vertically and horizontally into smaller panes of glass. Window dimensions are approximately 2 x 1.3 meters (6.5 x 4.3 ft). Total window area is approximately 1,003 m^2 (10,798 ft^2). The Uvalue of the existing window was reported to be 5.36 $W/m^2.°C$. (~1 $Btu/hr.ft^2°F$).

2.0 PROPOSED MEASURE DESCRIPTION

A study completed approximately two months ago by Bryden Martel Architects was aimed at investigating options to upgrade the windows.[7]

The study recommended the installation of an internal window in lieu of the existing single pane window which would reduce the heat loss by 65% (2^{nd} paragraph in page 19). The study further stated that the overall thermal performance of the new internal window and existing window would be equivalent to an overall window Uvalue of 1.36 $W/m^2.°C$. (~0.24 $Btu/hr.ft^2°F$).

3.0 MEASURE IMPLEMENTATION

Due to the heritage nature of the building the approach suggested in the Bryden Martel report is to add a new double pane window behind the existing single pane window.

4.0 CALCULATION OF ENERGY SAVINGS

The Bryden Martel Architects reported stated that the recommended addition of a new internal window would achieve an equivalent thermal transmittance of 1.36 $W/m^2.°C$. (~0.24 $Btu/hr.ft^2°F$), which is extremely low. For purposes of calculating the energy savings this value was increased to 1.59 $W/m^2.°C$. (~0.28 $Btu/hr.ft^2°F$) and the energy savings modeled in VisDOE.

The VisDOE model calculated energy savings of 150,000 kWh/year, mostly in the form of fan energy savings and a reduction in steam use of 3,300 GJ/year with annual cost savings of $83,000. The VisualDOE output is attached at the end of this EEM.

5.0 PROJECT COST SUMMARY

The cost savings were calculated by VisDOE and estimated to be approximately $83,100/year.

The implementation costs are given in the Bryden Martel report and estimated to be $1,935,000 Table E11 presents the cost savings, implementation cost and payback period.

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[7] East Memorial Building Thermal Upgrade Study. Bryden Martel Architects and Brook Van Dalen & Associates. August 2010.

Table E5: Project Cost Summary			
Energy Savings GJ/year)	**Cost Savings ($)**	**Implementation Cost ($)**	**Simple Payback (years)**
~3,850	$83,100	$1,935,000	23

Project Information

Name: East Memorial Building
Address: Address
Description:
Analysis done by: G. Todesco @ Genivar
Weather File: Ottawa
Project File: c:\visualdoe\east memorial\east memorial.gph
Calculation Engine: DOE-2.1E-119

Electrical Use Summary

Alternative	Lights	Equip.	Heating	Cooling	Pumps/Aux.		Fans	DHW	Total
Electrical End-use Totals (kWh)									
Base Case	2,096,952	998,442	56,229	9,788	62,144	35,168	1,879,184	23,202	5,161,109
Better Windows	2,096,952	998,442	39,497	8,975	57,821	29,645	1,753,022	23,202	5,007,556
Incremental Electrical Savings (kWh) (compared with previous alternative, negative savings represent increases)									
Better Windows	0	0	16,732	813	4,323	5,523	126,162	0	153,553

Fuel Use Summary

Alternative	Heating	Total
Fuel End-Use Totals		
Base Case - Steam (Therm)	99,594	99,594
Better Windows - Steam (Therm)	69,719	69,719
Incremental Fuel Savings (compared with previous alternative, negative savings represent increases)		
Better Windows - Steam (Therm)	29,875	29,875

Energy Cost Summary ($/y)

Alternative	Total Electric	Total Fuel	Total Utility	Incremental First Cost	PV Life Cycle Cost*
Total Energy Cost ($/y)					
Base Case	$469,653	$230,460	$700,113	$0	$5,960,457
Better Windows	$455,676	$161,329	$617,005	$0	$5,252,911
Incremental Energy Cost Savings ($/y) (compared with previous alternative, negative savings represent increases)					
Better Windows	$13,977	$69,131	$83,108	$0	$707,546

* 20 year life cycle w/ 10% discount rate.