



CENTENNIAL OFFICE BUILDING Investigation of Exterior Building Envelope

658 Cedar Avenue
St. Paul, MN 55155



Draft Report
March 17, 2015
WJE No. 2014.5607.0



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TABLE OF CONTENTS

BACKGROUND	1
DOCUMENT REVIEW	1
Original Construction Documents	2
Previous Modifications.....	3
<i>Parking Ramp and Tunnel Addition, 1973</i>	4
Roof Replacement, 1999.....	4
North and East Terrace Wall Repairs, 2000	4
Aluminum Window Replacement, 2001.....	5
West Planter Repair, 2006	5
Replacement of North Exterior Stair, 2010	6
Previous Investigations.....	6
West Curtain Wall Leakage and East Terrace Deterioration, 1997	6
Condition Survey (Phase III): Exterior Stone Cladding System, 1997.....	6
Roofspec, 1999 & 2014	7
West Planter Water Leakage, 2004.....	7
Investigation of Water Leakage and Infiltration, 2012	7
EXTERIOR CONDITION ASSESSMENT	7
Thermal Imaging	7
Exterior Condition Observations	8
Granite-Faced Precast Wall Panels.....	8
Granite Wall Panels	8
Windows	9
Aluminum Spandrel Panels.....	10
West Entry Terrace	10
West Planter.....	11
East Terrace	11
East Terrace Stair.....	11
Rooftop Penthouses	12
Interior Condition Observations.....	12
Inspection Openings	13
Granite Wall Panels	13
East Terrace	14
ENCLOSURE ENERGY PERFORMANCE ANALYSIS.....	15
Thermal Simulations	15
Energy Modeling Report (KFI).....	19
OPINIONS AND RECOMMENDATIONS	19
Repair and Maintenance Recommendations.....	20
Limited Energy Performance Improvements.....	23
Comprehensive Energy Performance Improvements	24
APPENDIX A.....	Error! Bookmark not defined.
ENERGY MODELING REPORT	Error! Bookmark not defined.
APPENDIX A.....	25
ENERGY MODELING REPORT.....	25
APPENDIX B	26
2012 WJE INVESTIGATIVE REPORT	26

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BACKGROUND

At your request, Wiss, Janney, Elstner Associates, Inc. (WJE) has completed an evaluation of the exterior building enclosure of the Centennial Office Building in St. Paul, Minnesota. Our assessment included information gathered from a variety of sources including: a review of documentation from the original construction of the building in 1958, documentation from subsequent repair and remodeling projects, interviews with building and maintenance staff that possess first-hand knowledge of previous instances of air and water leakage, conducting thermal scans of the exterior building enclosure, visually inspecting the condition of the exterior enclosure at arm's length, and the examination of exterior inspection openings. The primary objectives of our investigation were to assess the overall condition of the collective components of the exterior enclosure (excluding the roof covering), to evaluate the energy-efficiency of the building envelope, and to provide recommendations for future maintenance and potential modifications to the enclosure system to improve energy performance.

The Minnesota Centennial Office Building (COB) is located at 658 Cedar Street in St. Paul, Minnesota, on the east extension of the State Capitol Complex. Designed in the modernist architectural style by Thorshov & Cerny Associates of Minneapolis and constructed in 1958 to commemorate the 100 year anniversary of Minnesota's statehood, the building features five stories above grade, atop a ground-level floor that is partially below grade, and a basement level that occupies about half of the building footprint at the south end. The site features a prominent downhill slope that results in increased exposure of the lower two floor levels at the south end of the building, where the basement level is terminated in a loading dock that faces Columbus Avenue. The exterior walls of the basement, exterior planters, and entry terraces are clad in granite-faced precast concrete panels that form a solid visual base for the building. The ground-level and first floor walls are exposed by the sloping topography at the east, south, and west facades, and are clad in polished granite panels that extend to a continuous strip of clerestory ribbon windows at the first floor ceiling level. The primary public entrance is located near the center of the west elevation at a half-level landing between the ground level and the first floor. A secondary entrance is located at the ground level on the east side of the building. An elevated walkway at the first floor level above, and a tunnel below this entrance connect the COB to a parking structure across the service alley to the east. At the second through fifth floor levels, the exterior walls are clad in alternating vertical strips of flame-finished granite panels and aluminum framed windows with insulated aluminum spandrel panels between on a masonry back-up wall supported by a steel superstructure. Overall photographs of the COB are shown in Figures 1 through 4 at the end of this report.

DOCUMENT REVIEW

WJE reviewed a number of documents pertaining to the COB that were provided for our use by the State, including original construction drawings, written reports and records detailing previous investigations of water leakage, and subsequent building modifications that have resulted in the existing, as-built construction. During our document review process, WJE noted the following items:

Original Construction Documents

The original COB design and construction documents were prepared by Thorshov & Cerny Architects and were dated January 20, 1958. The architectural and structural drawings of the original CD set indicated the following construction assemblies which are still in place and relevant to the current building envelope:

1. The building structure consists of cast-in-place concrete foundation walls with a fire protected steel frame superstructure above and a level-surfaced composite roof deck consisting of a 2 1/2 inch concrete topping over a 4 1/2 inch cellular steel deck. Floor slabs also consist of composite deck construction supported by structural steel framing, with a typical floor-to-floor spacing of 13 feet 6 inches.
2. The primary above-grade exterior wall assembly consists of 8 inch thick masonry infill backup walls within the steel superstructure that are clad in a combination of stone and precast concrete panels:
 - a. The plinth of the building is formed by the loading dock, exterior planters, and elevated entry terraces, and is clad in granite-faced precast panels (labeled Type E Stone Facing). The typical type E wall panel is two feet square in size with an evenly spaced pattern of 4-inch square blocks of split-faced granite embedded into the outboard face. Type E panels occur only at the base of the building, where the back-up consists of cast concrete foundation walls. Details indicate the panels are attached to the concrete with steel clips that engage kerfs in the top and bottom edges of the precast. The joints of type E panels were indicated to be mortar-filled.
 - b. The ground level and first floor walls are clad in nominal 4 inch thick polished Rockville Beige granite that was quarried near St. Cloud, Minnesota. (labeled Type A Stone Facing). The polished type A panels are 4 feet wide and extend to a point just below the second floor level, where they are capped by matching granite sill units beneath a continuous strip of clerestory ribbon windows that extend along most of the east, south, and west elevations. Polished black granite (labeled Type B) is used to form a soffit above the clerestory window heads that projects 2 inches beyond the face of the granite cladding of the upper floors above (Figure 5). A 1/4-inch wide drip edge was detailed at the underside of all type B granite cap units, about 1 inch from the outboard edge of the stone.
 - c. Floors two through five are clad in flame-finished Rockville Beige granite panels (also labeled Type A Stone Facing) that are nominally 4 inches thick. Type A panels at the upper walls are typically 8 feet 5 inches wide by 13 feet 6 inches tall. The panels are indicated to be supported by 5-inch wide segments of back-to-back steel clip angles welded at two foot centers to the top flanges of 16 inch deep wide flange beams that are embedded in the back-up walls approximately 20 inches below each finish floor level (Figure 6).
 - d. The granite panels are terminated without a parapet, featuring a gravel stop roof edge condition with the tops of the exterior walls capped by a continuous course of polished black (type B) granite coping units and a gravel stop roof edge.
3. The original exterior wall assembly did not include insulation, and the interior surfaces of the masonry back-up walls were to be coated with plaster. Steel framing members and deck surfaces that are located within the interstitial spaces above the finish ceilings were shown to be protected by cementitious fireproofing on metal lath.
4. The first floor features fixed aluminum-framed clerestory ribbon windows with 1 inch thick IGUs. The ribbon windows extend continuously around the building on the west, south, and east facades.
5. The original windows at floor levels two through five were designed as vertically-oriented strips of fenestration that featured aluminum framed center pivot, operable windows. The window frames were set into a 5 inch wide aluminum decorative track with a 1-1/2 inch wide rib in the center that was originally black in color. The decorative tracks are inserted into a continuous kerf in the granite panels along each window jamb and extend the full height of the building (Figure 7). Decorative extruded aluminum spandrel panels extend between window units and are also integrated with the vertical jamb track. While the original window units have been replaced, the decorative aluminum tracks and spandrel

panels remain intact. The spandrel panels consist of 6 inch wide extruded planks that are ganged together and set into the glazing frames and are backed by a 2 inch deep back pan that is filled with rigid insulation.

6. The west facade features raised planters at each end of the building. The exterior walls of the planters consist of 12 inch thick cast-in-place concrete walls that are clad with 3 inch thick granite-faced precast concrete (type E) panels with a one inch open cavity between. The planter at the north end is located over a crawlspace, while the planter at the south end is located above occupied space in the sub-basement which has experienced leakage as described later in this report.
7. The east facade features a raised terrace at the south end that extends northward to the entry plaza located near the center of the building. Two steps at the north end of the terrace lead down to the entry plaza. The horizontal surfaces of the terrace and entry plaza are covered by 4 foot square granite pavers that are labeled Type C stone paving. The pavers were specified to be approximately 2-1/2 inches thick, resting on a 1 inch thick mortar bed over a 5-ply waterproof membrane that covers the cast concrete structural slab. The slab spans the mechanical spaces below the terrace and the tunnel to the parking ramp that lies beneath the entry plaza, and is detailed to be sloped toward the outboard edge of the terrace. The waterproof membrane is turned down the face of the concrete back-up wall and is shown in the detail to extend about 6 inches down the face of the wall, with no specified means of termination. Incidental water that penetrated the horizontal surface of the terrace was intended to be drained at the top of the wall by a continuous strip of 20 ounce lead-coated copper flashing that is shown in the detail to project beyond the exterior face of the wall and contain a downward-angled drip edge. The east terrace walls were originally clad in type E precast concrete panels. An air cavity of 1 inch thickness was maintained behind the precast panels.
8. The south end of the east terrace features a cantilevered stair consisting of an 8-inch thick conventionally reinforced elevated concrete slab supporting granite pavers and fascia panels. The structural drawings indicate a concrete cover of 1-inch for the reinforcing steel. The waterproofing membrane from the terrace terminates at the base of the upper-most riser so there is no membrane over the concrete structure. The structure supporting the intermediate landing and lower stair cantilevers out from the face of the building. The granite pavers and fascia panels are nominally 2-3/4 inches thick which includes the thickness of the mortar bed for the pavers. The fascia panels are supported by a kerf which rests on galvanized steel angles attached to the concrete slab. Railing pickets are set in holes cored through the granite and the concrete. The joints between the granite panels, and between the railing pickets and the granite, have all been filled with sealant.
9. A similar raised terrace exists at the west entry and serves as a base for the exterior building signage and flag poles. The west terrace is clad and paved in dark gray (type C) granite units with sealant-filled joints.
10. The exterior wall assemblies of the three rooftop equipment penthouses consist of 8 inch thick concrete masonry backup walls that are clad in porcelain enamel-finished steel panels mounted directly to the backup wall. The enameled panels feature a small return (about 1 1/4inch) that was filled with fibrous insulation material. The three penthouses are labeled as the North, Center and South roof structures, and each penthouse features two to three mechanical louver sections in the exterior walls measuring either 4 or 16 feet wide by 16 feet tall. The louvers are fastened directly into the concrete block jamb of the rough opening and sealant is installed at the joint between the enamel panel and the louver jamb at the exterior.

Previous Modifications

Multiple remodeling and material replacement projects have been completed throughout the building's history, altering the original construction of the building envelope to varying degrees. Our document review

included both completed projects and proposals for uncompleted work. Additionally, other work was completed for which project documentation was not available. A chronological list of substantial revisions to the COB includes the following completed projects; related construction documents were reviewed by WJE as available:

Parking Ramp and Tunnel Addition, 1973

In 1973 a concrete parking ramp designed by George E. McGuire Architects was constructed on the parcel of land directly east of the COB at the original location of St. Paul Central Park. The parking ramp was connected to the COB by the addition of a cast-in-place concrete elevated walkway and a subterranean tunnel that resulted in some modification to the foundations and below-grade construction, as well as the demolition of the original entrance enclosure and canopy, and some on the east side of the COB.

Roof Replacement, 1999

The architectural drawings for the “Roof Replacement at the Centennial Office Building” project by Ambe, Ltd. (Ambe), dated May 5, 1999, were reviewed as well as additional project documentation including addendums, meeting minutes, submittals, and construction observation notes. The currently existing roof covering, installed under this project, includes a vapor retarder consisting of two plies of Type IV fiberglass felt set in Type III asphalt over the existing concrete deck, covered with 3-1/2 inches of isocyanurate insulation adhered with Type III asphalt, and a 1/2 inch fiberboard cover. The roof covering is a 4-ply Type IV fiberglass built-up roof (BUR) membrane set in Type III asphalt with an aggregate-based flood coat surfacing over the majority of the main roof. The center area of the south roof, where most of the cooling units are located, received a granular surfaced, reinforced modified bituminous cap sheet in lieu of aggregate surfacing.

- The insulation is typically not tapered, with the exception of within 8 feet of roof drains, where it is sloped to the drain at 1/4 inch per foot. The drawings indicate that an additional 3-1/2 inches of insulation are installed at the roof edge and are tapered at a slope of 1/4 inch per foot away from the gravel stop roof edge.
- Based on the insulation thicknesses indicated by these details, the current roof configuration (if constructed according to the documents) would provide an R-value ranging from R 19.6 for a 3-1/2 inch thickness to R36 at areas of thickened insulation that are indicated near the roof edges. These figures are based on an average assignment of R5.6, which is the value recommended for isocyanurate insulation by the National Roofing Council of America (NRCA). This insulation value is at or near the current minimum of R-23 established by the Minnesota Energy Code for rooftop insulation placed directly above the roof deck.

North and East Terrace Wall Repairs, 2000

Proposal letters and repair drawings for the “Exterior Wall Repairs” project prepared by Berwald Roofing Company, Inc. (Berwald) and Parkos Construction (Parkos) were reviewed. The project was reportedly in response to water infiltration problems beneath the east terrace. No construction period correspondence was available from this repair project, however the project documents indicate the following scope of work, which corresponds with the observed current condition:

- The original type E precast wall panels were removed from the top two feet of the east terrace wall and the north walkway and were replaced with a traditional stucco system, consisting of a 3/4 inch layer of 3-coat stucco on metal lath, applied over a 2 inch thickness of rigid insulation supported by 2 inch Z-furring members with ice and water shield and metal base and head flashing. This modification altered

the drainage path of incidental water from the original position at the top of the wall to a redirected point below the base flashing of the stucco panels.

- The granite coping units were temporarily removed to install metal flashing across the tops of the terrace and planter walls before the coping units were re-set and the joints filled with sealant.
- The existing guard rail and the coping units through which the rail pickets pass were left intact at the raised terrace along the east elevation. The details indicate replacement of the sealant in the rail picket penetrations, but not at the paver joints on the terrace surface.
- The drawings also indicate a new sidewalk and concrete stair at the north facade leading up to the exit door, but it appears that this portion of the work was not completed until the north egress stair was replaced in 2010.

Aluminum Window Replacement, 2001

The exterior windows were replaced sometime around 2001, but no documents for this project were available for review by WJE; therefore, product specifications, specific details, and the exact date of the window replacement are unknown to us at this time. Based on our review of the existing conditions it appears that all of the original windows were replaced, including the clerestory ribbon windows at the first floor and the operable windows of the upper floors, with some additional glass replacement in the entry vestibules. Our current understanding of this alteration includes the following items:

- The original clerestory ribbon windows that encircle the COB at the first floor were removed and replaced with extruded aluminum-framed units featuring fixed IGU's that essentially matched the dimensions (2 feet tall by 4 feet wide) of the original units.
- The original fenestration at the upper floors (levels 2 through 5) consisted of vertically-oriented strips of fenestration featuring operable aluminum-framed windows with extruded aluminum spandrel panels in between. Each window opening contained a pair of center-pivot operable sashes in an extruded aluminum frame that was not thermally broken. The operable windows were removed and replaced with single-sash units featuring a fixed IGU in a thermally-broken aluminum frame that was set into a continuous sub-frame (Figure 8). The current window configuration of a single fixed unit in each opening differs from the original design of paired operable units.
- Possibly in conjunction with this project, the exterior glazing of the east entry vestibule was replaced with an extruded aluminum-framed storefront system containing 1 inch thick IGU glazing. The entry doors were also replaced with similar materials.
- The doors to the west entry vestibule were also replaced at an unknown date, possibly in conjunction with the window replacement project, with new aluminum doors featuring IGU panels; however, the original single pane glazing was left intact for the remainder of the enclosure.

West Planter Repair, 2006

Building Consulting Group, Inc. completed an investigation of the exterior planter on the west facade in response to reported leakage in the interior spaces located below the planter. The result of the investigation was a repair project that incorporated the following:

- The original construction of the west planter was a double basin consisting of a planter box designed to weep into an interstitial space between the planter box and a lower slab basin. The lower basin contained drains but was not waterproofed. In a report dated July 11, 2005, BCG indicated that the cause of the leakage was water migrating through cracks and joints in the lower slab before reaching the drains.
- The repair project essentially relocated the drain from the lower slab basin to the planter box, abandoning the function of the interstitial space. The 1 inch weeps in the planter box were filled with a polymer repair mortar. The existing drains in the lower slab were removed, and new floor drains were

installed in areas of patched concrete in the planter box. The planter box was waterproofed with Carlisle CCW-500R and covered with a protection board.

- Six lambs tongue scuppers were installed through the granite veneer wall to provide overflow drainage.

Replacement of North Exterior Stair, 2010

As-built architectural and structural drawings and specifications for the “Replacement of North Exterior Exit Stair” project by RJ Johnson Architecture & Interiors, Ltd. (RJ Johnson), dated October 20, 2010 were reviewed and consisted of the following:

- Removal of the existing steel stair including all treads, risers, stringers, handrails, and guardrails. Removal of the existing steel guardrail at the end of the stair was also included.
- Installation of a new powder-coated steel stair reconstructed in the same location. The new stair was to utilize the existing steel building structure for stair support and the existing concrete bearing pier. The existing concrete floor, door, door frame, and threshold remained in place.

Previous Investigations

West Curtain Wall Leakage and East Terrace Deterioration, 1997

Bernard Jacob Architects completed an assessment of the west entrance and the east terrace in 1997. The investigation concluded that the east terrace was deteriorated beyond repair and required a redesign of the terrace and south end stair. A full report of their investigation and conclusions was not available for review, however WJE did review preliminary repair documents for the west window replacements and the east terrace modifications. The proposed repair at the east terrace was to essentially abandon the terrace and convert it into a planter similar in construction to the planter at the north end of the west facade. The west curtain wall reportedly experienced water leakage and the proposed repair included options for window replacement on the west facade. This project was never completed.

Condition Survey (Phase III): Exterior Stone Cladding System, 1997

Rieke Carroll Muller Associates, Inc. (RCM) of Minnetonka Minnesota completed an assessment of the stone cladding support system in 1997. This investigation was undertaken due to concerns regarding the condition of the steel anchorage system based on the age of the building and observed deterioration of similar elements at the planter and terrace mezzanine walls. RCM conducted their investigation by drilling a series of investigative holes in the vertical and horizontal joints between the granite panels, through which fiber optic devices were inserted to view the condition of the substrate and anchorage systems. Observations and conclusions established by RCM included:

- The thickness of the wall cavity varied, but the majority of access holes revealed that virtually no air cavity existed between the granite panels and the masonry back-up wall above the second floor.
- The space between the webs of the steel beams within the back-up walls and the inboard surfaces of the granite panels was typically noted to vary from 6 to 8 inches in width.
- Corrosion on the surfaces of the steel panel anchors was noted to be minimal. Rust pitting was present to depths of 1/32 to 1/16 inch and ranged in surface coverage of 5 to 40 percent. The majority of anchorage steel that was viewed by RCM featured the original green paint, with minimal to moderate levels of light surface corrosion that were not deemed significant by RCM.
- RCM noted that areas where the steel exhibited the most corrosion correlated with locations of missing or deteriorated sealant, most notably at the primary seal between the granite and the aluminum window systems. Based on this observation, RCM recommended replacement of the above-grade panel joint sealants.
- RCM also noted some displacement of granite sill units that was attributed to a loss of some holding capacity by the anchor bolts.

Roofspec, 1999 & 2014

West Planter Water Leakage, 2004

BCG completed an investigation of water leakage at the west planter in 2004. The investigation included the removal of soil and plantings, creation of inspection openings at each of the eight floor drains, and water testing to locate the source of the leaks. BCG concluded that water that reaches the lower slab basin via weep holes in the upper planter box is able to migrate through cracks and joints in the lower slab before reaching the drain. A repair project was completed in 2006 as described above.

Investigation of Water Leakage and Infiltration, 2012

WJE completed an investigation of water leakage and infiltration in 2012 that focused on three primary areas of the building, including the east entry plaza and tunnel, the east terrace, and the planter at the south end building on the west facade. A copy of WJE's 2012 report is attached to this document in Appendix B.

EXTERIOR CONDITION ASSESSMENT

Thermal Imaging

Thermal imaging of the building was conducted by WJE on the evening of October 30, 2014 using a hand-held infrared (IR) camera. An IR camera records the intensity of radiation in the infrared portion of the electromagnetic spectrum and converts it to a visible image that displays the temperature distribution of a building facade. IR scanning can serve as a useful, non-invasive procedure to identify locations of energy loss through the exterior enclosure. Thermal images recorded and analyzed by WJE revealed that significant heat loss occurs through a number of components of the exterior envelope (Figure 9), including general areas such as the rooftop penthouse enclosures and the glazed building entry vestibules, as well as specific locations where the materials or the method of construction allow for thermal transfer or air flow.

1. The primary source of heat loss is thermal transfer through the steel panel anchors and air leakage through the sealant filled joints of the granite wall cladding (Figure 10). The granite panels span from floor to floor, bearing on wide flange steel beams that support the floor structure. Because they interrupt the masonry back-up walls and are directly aligned with the panel joints, the beams provide a fairly direct pathway through the enclosure for the exfiltration of conditioned interior air to the exterior.
2. IR scans also detected heat loss through the IGU's as indicated by yellow-orange 'hot spots' of varying intensity at the center of about half of the upper level replacement windows (Figures 10 and 11). The IGU heat loss may be attributed to the general lack of thermal efficiency at the center of the glazing, where R-values are the lowest, but in windows where the IR scans show especially bright spots, it is likely that the IGU seals have failed (Figure 12). IGU seal failure occurs when the sealant that bonds one or both of the glass units to the spacer bar of the IGU fails and allows air and moisture to infiltrate the cavity. This reduces the thermal efficiency of the IGU, and can also lead to the formation of condensation within the IGU cavity, resulting in a fogged appearance. IR scans of the clerestory ribbon windows at the first floor of the building did not indicate IGU seal failures.
3. Heat loss occurs by thermal conductance through the aluminum window frames at all elevations of the building, including the vertically-oriented frames of the window and spandrel panels on floors 2 through 5 (Figure 12), and through the heads of the clerestory ribbon windows at the first floor (Figure 13).
4. Significant heat loss also occurs through the glazed entry vestibules, particularly at the primary building entry vestibule on the west side of the building, where the original single pane glazing remains intact (Figure 14). The west vestibule doors, as well as the east vestibule glazing and doors, have been

subsequently replaced with aluminum frames and IGU panels that perform better than the original vestibule glazing. However, some heat loss was detected at the base of the east entry vestibule where water leakage has previously been attributed to a lack of flashing and closure beneath the sill (Figure 15). This IR scan shown in this figure also indicated that heat loss was occurring through the base of the exterior walls along the pavers of the east terrace, which are set on an uninsulated concrete roof structure above a mechanical enclosure at the basement level below.

5. Other instances of heat loss were noted at the north and south walls of the COB where warm spots measuring about 4 feet tall by 5 feet wide were noted at evenly spaced intervals between the column grids at each upper floor level (2 through 5). Subsequent investigation in the building interior by WJE indicated the source of these warm spots to be escaping heat generated by cabinet wall heaters that were originally installed against the interior plaster wall finish surfaces.

Exterior Condition Observations

A close-up building inspection was conducted by WJE on December 10, 2014 by a team including a professional engineer and an architect, both of whom are currently licensed in the state of Minnesota. Additional members of the inspection team included an architectural associate and a certified rigging supervisor to manage the vertical access systems. Our primary objective during this inspection was to observe and record the existing conditions of the building facades and to provide recommendations for repair, maintenance, and potential for future alterations based on the conditions observed. The building was examined from grade and rooftop levels, and also at arm's length by industrial rope access (rappelling). A total of twelve drops were conducted to examine aspects of the building enclosure at all four primary elevations.

Granite-Faced Precast Wall Panels

1. The precast concrete (type E) wall panels were used only at the base of the building, at the exposed basement and loading dock enclosure at the south end of the building, and also at the base walls of raised exterior planters and terraces. Each panel is nominally 2 feet square and the joints between panels are typically filled with mortar that matches the dark gray color of the precast. Separation cracks were fairly common where the mortar had become debonded from the precast, but most of these did not exceed hairline widths.
2. Periodically spaced vertical expansion joints were present at long expanses of type E panels where sealant was used to fill the joint in place of mortar.
3. The top row of precast panels was replaced with stucco at the east and north side of the building in 2000. The sealant joint along the base of the stucco does not properly drain water that leaks into the substrate from the terraces and planters above, which has caused staining and deterioration of the stucco as well as corrosion of the metal lath.
4. The type E precast panels spanning the loading dock opening at the south elevation are supported by a steel lintel that has been painted yellow (Figure 16). Rust staining was noted along the entire length of the lintel, indicating long-term water collection.

Granite Wall Panels

5. The granite was noted to be in good overall condition, with very few instances of localized distress. Observed instances of distress included small chips, spalls, and cracks at the edges of the panels that did not appear to create potential safety hazards or water leakage sources. The following occurrences of specific granite distress were noted:

- a. A missing spall is present on the west facade along a horizontal joint at the floor line of the fifth floor. The spall measured approximately 2 inches by 2 inches where the granite had fallen away and had been filled with sealant (Figure 17).
 - b. A previously repaired crack was observed along the vertical joint of a panel at the second floor level on the south facade. The crack had been routed out and filled with sealant. The condition of the sealant and stability of the stone isolated by the crack could not be verified (Figure 18).
 - c. An area measuring approximately 8 inches by 10 inches was previously cut out of a granite panel at the base of the wall on the north facade. The area was patched with polished granite and mortar was installed in the joints on three sides, with sealant at the base (Figure 19).
 - d. A crack and incipient spall were noted on the north facade at the base unit of the west corner, and measured roughly 3 inches square. Sealant had previously been installed here to fill the crack.
 - e. A 6 inch tall spall is present on the south facade adjacent to the building loading dock. The spall measured approximately 6 inches tall by two inches wide and is located on the outside corner of a wall separating the loading dock from exit doors (Figure 20).
6. No obvious or pronounced instances of panel displacement were noted in the Type A granite wall panels that covered the first through fifth floors. Based on previously expressed concerns about potential corrosion of the granite panel anchorage system, we examined the panel joints for obvious signs of rust discoloration, but did not observe this condition.
7. The sealant in the joints and primary seals of the granite panels was examined visually and by applying pressure with a steel roller to look for instances of adhesion failure (separation between the sealant and the granite along the bond line), cohesion failure (rupture of the sealant in the middle of the joint caused when joint movement exceeds the expansion capacity of the sealant) and alligatoring (network craze cracking on the surface indicating a loss of elastic properties). The silicone sealant in the panel joints and at the juncture between the granite panels and the aluminum window framing exhibited relatively few instances of failed or missing sealant that included the following:
- a. Sealant was missing between the granite panel and the vertical aluminum track at the right jamb of the exit door on the north façade, and also from the parallel joint between the jamb trim and the vertical accent rib (Figure 21).
 - b. Limited instances of adhesive separations, estimated to comprise less than 10 percent of the total lineal footage, were observed in the sealant installed in the primary seal joint between the granite panels and the vertical aluminum frame (Figure 22).
 - c. Relatively few instances of adhesive or cohesive separations were noted in the horizontal joints between granite panels, though the granite is typically discolored adjacent to most of the joints by the migration of oils and plasticizers from the sealant into the surrounding stone (Figure 23). This condition is referred to as the halo-effect, and its visual impact can vary according to weather and lighting conditions; it is often more prominently visible after a rain, as the surrounding stone absorbs more water than the oil-impregnated stone near the joints.
8. Multiple units of the dark granite (Type B) cap units at the parapet were not level and were vertically displaced up to 1/2 inch. Similarly, multiple units at the head of the ribbon windows where the flame-finished granite panels terminate were vertically displaced up to 1/2 inch. No distress of the units was noted (Figure 24) however, this condition was addressed in the RCM investigation conducted in 1997. In their report, RCM attributed the displacement of these units to a partial loss of holding capacity of the anchor bolts that support the units.

Windows

9. The replacement windows at the first floor clerestory appeared to be in good condition, with no obvious instances of gasket or IGU seal failure observed. The clerestory sills are labeled Type B on the drawings

(indicating black polished granite) however they were noted to match the polished type A panels (Rockville Beige) of the wall cladding. Each stone sill featured a small upturned cove at the base of the clerestory framing, but the slope of the sill units away from the glass was minimal (less than 1/8 inch per foot).

10. The punched window replacement units of the upper floor levels were generally noted to be in fair condition, with a small number of the IGU's (less than 5 percent) exhibiting a fog resulting from spacer bar seal failures.
11. Sealant was from missing portions of the primary seals around a fifth floor window on the east elevation at the third window from the south corner of the building, resulting in continuous, open joints of 1/2 to 3/8 inch widths at the head and left jamb, with displaced shims projecting at the jamb (Figure 25 and Figure 26). This window appeared to have been removed and re-installed at a previous time; this observation was confirmed by Alex Carney of the building maintenance staff, who mentioned that the window had been removed and the opening altered to allow for the installation of a Liebert® custom air handling unit. Mr. Carney also reported to us that interior water leakage had occurred previously around this window. Based on our observations, it appears that the sealant was never replaced after the window was reinstalled, allowing water leakage through the open primary seals.

Aluminum Spandrel Panels

12. Extruded aluminum panels remain intact from the original fenestration at the spandrel locations between windows of the upper floors (levels 2 through 6). The clear anodized finish surface of most aluminum panels had oxidized due to prolonged weathering exposure. Oxidation has not occurred uniformly on all of the aluminum surfaces, resulting in an irregular, variegated appearance (Figure 27). The vertical accent fins along each jamb of the vertical fenestration were originally indicated to be black in color, but have faded to a medium gray.
13. Sealant was noted to be deteriorated or missing at the base of the vertical fenestration strips above the granite wash ledge beneath a number of second floor spandrel locations (Figure 28). Deterioration was more advanced and widespread at this particular location along the small ledge created by the granite cap units below than at the typical panel joint condition within the field of the exterior wall surfaces.

West Entry Terrace

14. The west entry features an elevated terrace that is covered with dark gray colored (type C) granite pavers that match those of the east entry. The existing edge of the terrace features a sealant filled joint that differs from the original detail, which indicated a mortar joint with lead-coated copper flashing to drain incidental water from beneath the pavers. The original detail and the current condition are shown side by side (Figure 29 and Figure 30) for comparison. Water staining was evident at the sealant in this joint, indicating that the sealant is not allowing the paver substrate area to drain to the exterior.
15. A granite paver near the south end of the terrace was broken in two places, with a circular crack at one corner and a continuous crack near the center of the paver. Two additional pavers to the north of the United States flag pole base also featured through-cracks across the approximate center of the units. In addition to the cracked pavers, adhesion failure was commonly observed in the sealant within the paver joints. Water leakage through the failed joints and cracked units has likely resulted in the shifting and displacement of a number of the pavers of the west terrace (Figure 31).
16. Urethane sealant that featured an extensive network of alligator cracking was noted in the joints between the west entry vestibule glazing system and the polished black granite trim (Figure 32).
17. The west entry is covered by a two-tiered roof structure that features a rectangular canopy roof above a smaller roof atop the vestibule itself (Figure 33). The canopy (upper) rooftop is covered with an adhered black EPDM membrane that was installed in 1999. The upper canopy roof appears to be level

and does not include any means of drainage beyond a small overflow scupper located on the east side that drains water to the vestibule roof below. At the time of our site visit the entire surface of the canopy roof was covered with ice resulting from the accumulation of standing water that averaged about 1 inch in depth. The vestibule roof is also covered with an EPDM membrane, and features a roof drain that leads to internal drainage piping. The lower (vestibule) roof of the west entry did not feature any ponded water or ice at the time of our condition survey on December 10.

West Planter

18. The west planter consists of two raised planting areas, separated by the main entry in the center of the west elevation. No incidents of previous water leakage have been reported to WJE in regard to the planter that is located to the north of the main entry. This half of the planter is 4 feet wide by about 90 feet in length and contains mature Juniper bushes that have spread beyond the edges of the planter.
19. The south portion of the west planter is also 4 feet wide, but extends for a distance of about 160 feet along the base of the COB. Previous instances of water leakage into the basement beneath this planter have been investigated by the Building Consulting Group (BCG) as well as WJE (Appendix B). Repairs and drainage modifications were completed on this planter segment under the direction of BCG in 2004. It was also reported to us that the State's grounds keeping department replaced the overburden and plantings in 2014. New plantings consist of smaller Juniper shrubs with shredded bark mulch. Follow-up conversations with Plant Management staff indicated no recent reports of water leakage beneath this section of the planter.

East Terrace

20. The granite pavers of the east terrace were in good condition with no major cracks or spalls. The joints between the granite pavers were filled with sealant that had failed in numerous locations, including adhesive failure separations at over half of the total joint locations. Moss and other plant growth was observed at some locations where the sealant had failed, indicating long-term water intrusion at these locations (Figure 34). Additional sealant failure was observed where the guard rail pickets penetrated the stone pavers (Figure 35).
21. Building maintenance staff indicated to WJE that leakage has continued in the tunnel connecting the COB basement to the adjacent parking structure. Refer to the attached report from WJE's 2012 investigation of water leakage beneath the east plaza for additional details and repair recommendations (Appendix B).
22. Water staining in the form of streaks was commonly observed on the stucco panels installed at the top of the terrace wall. Corrosion staining was typically observed at the bottom of the stucco panels in conjunction with back-pitched metal flashing. Cracked panels and spalls of the finish coat of stucco were also observed.
23. Metal flashing at the edge of the terrace above the stucco panels was not terminated in a downward-angled drip edge. Clusters of moss and other plant life were growing in the gap between the metal flashing and the underside of the stone caps at the top of the wall.

East Terrace Stair

24. Moderate to severe deterioration of the structural concrete slab and reinforcing steel was present along the outer edge of the slab on both the landing and the sloped staircase. Staining, delamination, and spalls were limited to a zone within 8 inches from the edge of the slab (Figure 36).
25. Two generations of repair materials were present along the south edge of the slab soffit beneath the stair landing. These repair materials had rust staining, cracks, and were delaminated from the original

structure (Figure 37). A fragment of the repair material was removed and found to have sustained freeze thaw damage exemplified by horizontal delaminations akin to internal flaking of the material.

26. There were no delaminations or spalls present within the interior of the concrete slab soffit.
27. A concrete fragment was freshly chipped from the concrete and exposed to phenolphthalein, a pH indicator. This test indicated that the concrete had undergone carbonation to a depth of approximately one-half inch. This indicates that the carbonation process has not yet reached depth of the steel reinforcement and therefore the passive alkaline layer of concrete surrounding the steel has not been compromised..
28. Cracks were noted in the stair tread/riser granite sections. These cracks all went through the hole cored in the granite for inserting the railing pickets.
29. Cracks were noted in two of the granite fascia panels. The cracks were at the approximate location of the kerf which was used to support the panel on the galvanized steel angle.
30. There were approximately 10 steel angles supporting the granite fascia panels. Of the 10 angles, 2 had undergone significant section loss.
31. Nearly all sealant joints between adjacent granite panels and between the granite and railing pickets had failed.
32. The granite pavers had shifted since the last resealing job was undertaken. Vertical and horizontal offsets exhibiting past movements up to 1/2-inch were present between adjacent panels.
33. De-icing salt was present on the staircase and large salt deposits were located on vertical surfaces around the perimeter of the staircase (Figure 38).

Rooftop Penthouses

34. Although an assessment of the existing overall roof covering was beyond the scope of our investigation, WJE noted significant ponding that had resulted in the formation of large areas of ice on the main rooftop prior to our condition assessment on December 10, 2014. Rooftop ponding can create structural deflection that leads to increased ponding that imposes additional structural loading. The long-term presence of rooftop water can also foster biological growth, and create hazardous conditions for maintenance personnel during the winter months when ice is present.
35. The rooftop penthouses are clad in porcelain enamel-coated steel panels that are blue-gray in color and slightly darker than the granite wall panels. The bottom row of panels had been removed from all three penthouse enclosures and replaced with prefinished metal wall panels that were medium gray in color.
36. The enamel coating on the steel panels of the rooftop mechanical enclosures was generally noted to be in fair condition; however small areas were commonly noted where corrosion beneath the enamel had caused the finish surface to spall (Figure 39).
37. The mechanical louvers of the penthouses appeared to be original construction. The original clear anodized finish has oxidized, resulting in an irregular, chalky finish of the louvers blades and frames.
38. Adhesion failures were commonly observed along the bond lines between the sealant and the metal panels at the primary seals of the mechanical louvers (Figure 40). Limited instances of adhesive or cohesive failure were observed in the sealant between metal panels.

Interior Condition Observations

WJE reviewed interior conditions of the COB on a number of occasions, including site visits conducted on February 17 and 26, 2015. During these visits the following conditions were observed:

39. The interior wall surfaces have been furred and insulated with batt insulation and a polyethylene vapor retarder that extends from floor slab to the underside of the structure at the floor deck above. Measurements taken at existing conditions suggested that the furring studs and insulation were 1-5/8

inches thick. Evidence of the beneficial effect of the added insulation could be noted when viewing IR scans taken of the north and south walls because the insulation could not be added where existing cabinet heaters were mounted directly against the plaster wall surfaces. Heat flow from the cabinet heaters could be seen escaping the exterior wall surface where there was no added insulation (Figure 41).

40. Batt insulation had been placed along the upper surface of the ceiling grid at the top of the furring strips around the perimeter of the building. The insulation was 6 inches thick and extended to a distance of about 2 feet inboard of the exterior walls.
41. The original detail at the clerestory window heads is shown in Figure 5; however, subsequent modifications have resulted in as-built conditions that differ from the original design. The primary difference is that the interior stone soffit shown in the original detail was removed and replaced with a prefabricated metal window shade pocket that allows the blinds to be concealed above the window heads (INCLUDE PHOTO HERE). The placement of the blind pockets appears to have resulted in the removal of some or all of the insulation that was indicated for this area in the initial details, which has created a pathway for thermal transfer that was detected by the IR scans (Figure 13). A suspended grid acoustical tile ceiling was also installed at a later time, and aligns with the bottom of the shade pocket above the window head.

Inspection Openings

Inspection openings were created by Advanced Masonry Restoration (AMR), a masonry repair contractor retained by WJE, during the week of February 16-20, 2015. Granite wall panels and pavers were removed at a number of locations preselected by WJE to allow inspection of the as-built construction and underlying substrate conditions, and the following observations were made:

Granite Wall Panels

OPENING 1: A flame finished Type A granite wall panel that was 17-1/2 inches wide by 23 inches high was removed from the base of the wall at the second floor line at the northwest corner of the building (Figure reference needed). This panel featured a previously repaired spall at the lower left corner that had been secured in place by silicone sealant. When reviewing Inspection Opening 1, WJE noted the following:

1. The joints between granite wall panels are filled with mortar that has been ground back from the face of the joint to a depth of about 3/4 of an inch and filled with closed cell backer rod and silicone sealant.
2. The original CD drawings indicate that the panels are 4 inches thick, but this appears to be a nominal reference, as the actual panel thickness was measured at 3 1/2 inches.
3. The CD details indicate a mortar-filled collar joint between the granite and the brick back-up walls, but the as-built wall cavity was an open air gap with no mortar present.
4. The as-built panel anchorage system consisted of continuous steel relieving angles along the edges of the wide flange beams. This differs from the original CD detail, which showed periodically spaced angles of 5 inches in length. The granite panels are lipped at the bottom to cover the leading edge of the relieving angle.
5. The structural steel was painted a light green color and exhibited only a minimal amount of surface corrosion that did not affect the structural integrity of the steel and did not appear to be progressive. The relieving angle that supported the removed granite panel featured a strip of corrosion-related surface delamination (pack rust) that extended for the full length of the exposed outboard face of the vertical leg of the angle. The delamination resulted in surface loss that did not appear to exceed 3/32-inch (Figure reference needed here).
6. Lateral structural support was provided by 1/4-inch diameter stainless steel rods that were embedded into periodically spaced, downward-angled holes located approximately 1-1/4 inches below the tops of

the granite panels. The tie rods extended across the wall cavity and through holes drilled into the webs of the wide flange steel beams, where the ends of the rods were threaded and secured to the inboard face of the beam webs. The tie rods were in good condition with no observed deterioration.

- a. The method of attachment of the lateral tie rods, with the nuts fastened to the inboard side of the structural steel, indicates that the granite panels were attached to the steel superstructure prior to the infill placement of the brick masonry back-up walls. This is evident because the presence of the masonry walls would have prevented access to the backside of the steel for attachment of the tie rod nuts.
 - b. The method of wall tie placement described above would have necessitated the installation of the granite panels in a sequence starting at the lower-most panel followed by the installation of each successive panel above in the same method until the panel at the top of the walls was installed.
7. When viewed through the inspection opening, a small portion of previously-applied expanding foam insulation was noted to partially fill the wall cavity below the sill of the northernmost second floor window on the west wall.

OPENING 2: An additional segment of Type A granite was removed on the north facade at the base of the wall to the right of the egress stair (insert figure here). The removed panel measured 14-1/2 inches wide by 9 inches high, and was a previously installed patch of polished granite that matched the color but not the finish of the surrounding granite. Removal of the stone patch revealed two clean-outs in a cast iron pipe of unknown function. Similar conditions were noted at this opening to those observed at Opening A: the structural steel was not significantly corroded and the stainless steel tie rods were also in good condition; the steel relieving angles that support the granite were continuous, and red clay brick masonry was visible at the infill back-up walls above the steel wide flange beams. Prior to re-installing the granite patch, AMR applied a flame-finish texture to better match the surrounding granite.

East Terrace

OPENING 3: A granite paver that measured 36 inches long by 6 inches wide was removed adjacent to the base of the wall on the east terrace, revealing the mortar setting bed below. The setting mortar at this paver location was in good condition, with no friability that would indicate previous freeze-thaw cycling of the mortar while saturated with water at this location. A small area of mortar was chiseled away revealing the waterproofing below, which appeared to be an asphalt-based product as indicated by the original design details. Previous inspection openings were conducted by WJE in 2012 at a location further to the south of the terrace (Appendix B) in this area, two pavers that measured ____ by _____ were removed and the mortar setting bed was noted to be friable, indicating previous exposure to freeze-thaw conditions while the mortar was saturated with water.

OPENING 4: A polished granite wall coping unit was removed from the top of the area well enclosure wall at the east terrace, revealing the back-up wall and substrate conditions behind the Type E precast panels below.

OPENING 5: An existing inspection opening was present near the south end of the east terrace support wall that had been created previously when a deteriorated Type E precast panel had been removed by others and replaced with a painted plywood panel. By removing the plywood cover, WJE was able to inspect the 2 foot square opening in the wall, and observed the following conditions:

ENCLOSURE ENERGY PERFORMANCE ANALYSIS

Infra-red scans conducted by WJE indicated significant patterns of heat loss through the exterior enclosure that were attributable to two primary sources: air leakage through the granite panel joints, and conductive heat loss (thermal bypass) associated with the aluminum window and spandrel frame systems. Less significant sources of building heat loss include numerous failed IGU seals and inefficient entry vestibule systems. The existing building enclosure was analyzed using both thermal and energy modeling software. Proposed modifications to the enclosure were also analyzed in an effort to understand the potential for energy performance improvement of the facility.

Thermal Simulations

To further evaluate the significance of the two primary sources of heat loss, WJE conducted computer thermal simulations of the as-built construction at the granite panel joint condition and at a typical window jamb. Additional simulations were later conducted at these same locations to evaluate the potential for reduced heat transfer that may be realized by adding insulation at various locations and replacing the existing window systems with a high-performing curtain wall system.

Thermal simulations were performed using the computer program THERM to predict cold-weather interior surface temperatures and identify locations that have the potential to develop condensation. THERM was developed at Lawrence Berkeley National Laboratory and is capable of modeling two-dimensional heat-transfer effects in building components such as windows, doors, walls, and roofs. The results of thermal simulations for the existing conditions at the two locations where heat loss is most prominent revealed the following:

1. The first simulation was modeled to represent the existing conditions at a typical panel joint in the exterior granite cladding as detailed in the original construction set at 2/A-26, shown on the left below. The THERM simulation, shown on the right in the figure below, was based on a detail that was revised by WJE to show the as-built condition that includes furred out interior walls with 1-1/2 inches of insulation, a vapor retarder and gypsum board finishes, as well as 6 inches of batt insulation above the perimeter of the suspended ceiling grid. The simulation was conducted using an interior ambient air temperature of 68°F below the ceiling and 65°F above, with an exterior air temperature of 7° F, which is the average low temperature for Minneapolis in the month of January. At the conditions modeled between the ceiling grid and the deck above, which aligns with the panel joint, the dew point temperature is approximately 39°F. Interior surfaces that are colder than the dew point will be subject to the formation of condensation.

The simulation demonstrates that none of the material surfaces that are exposed to the interior of the building will be colder than the dew point at these conditions. Although the steel wide flange is much colder than the dew point, it is covered with cementitious fireproofing on the interior which protects it from moisture-laden interior air. As a result, condensation on the surface of the steel is unlikely.

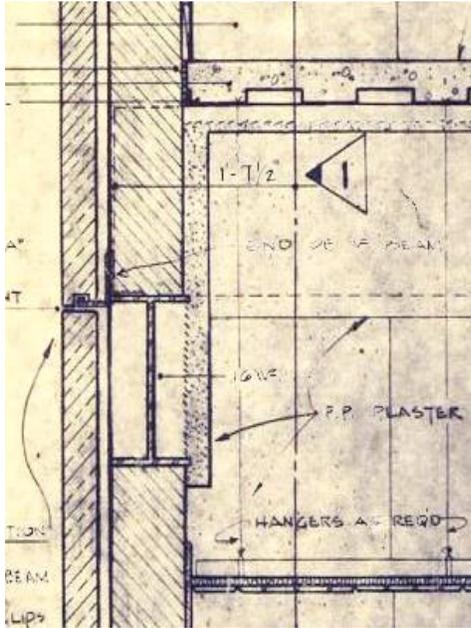


Illustration 1. Original detail at the granite panel joint condition (2/A2-6).

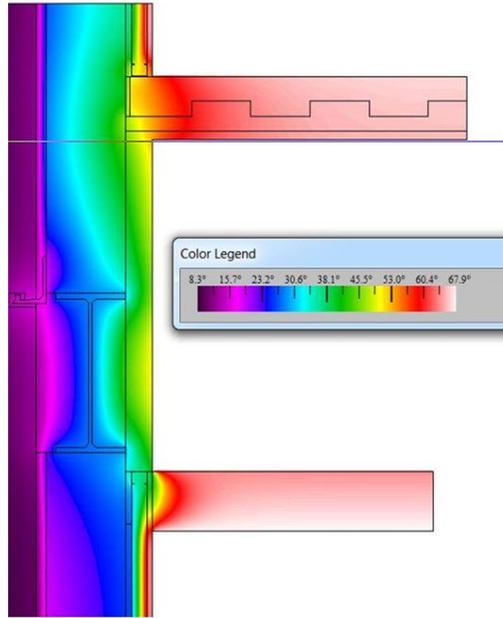


Illustration 2. THERM simulation of the existing granite panel joint condition at exterior air temperature of 7°F.

2. The THERM simulation conducted at the existing panel joint condition and shown in Illustration 2 above indicates that condensation on the surfaces of the structural steel was not a major concern, however thermal bridging was allowing energy transfer through the wall assembly. Based on previously documented IR scan images, uncontrolled air flow through the panel joints was also a contributor to building heat loss at this location. Based on these findings, WJE modified the as-built detail to include SPF insulation in the air cavity and beam pockets between the structural steel / back-up wall assembly and the granite panel cladding. This detail was modeled using THERM to compare to the existing wall performance.

As indicated in the illustration below, air flow through the panel joint and thermal transfer through the wall assembly have been dramatically reduced.

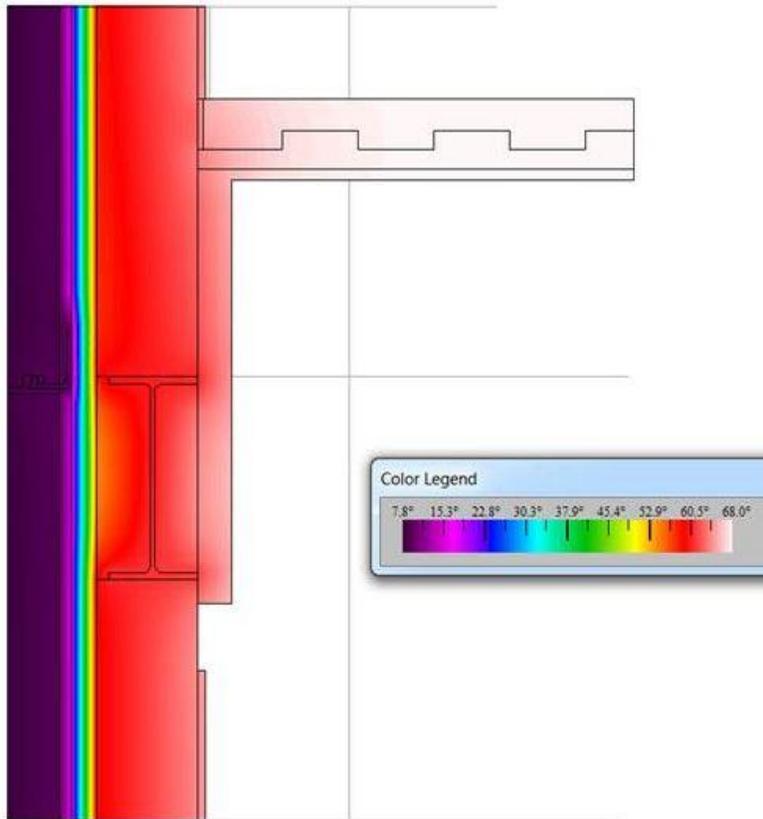


Illustration 3. Adding SPF insulation in the air cavity and beam pockets behind the granite cladding reduces air flow and thermal transfer through the exterior wall assembly.

3. Another major source of building heat loss was determined to be through the aluminum window frames as detailed in the original construction set at 7/A-35, but subsequently modified to the condition shown on the left below. This as-built condition includes a thermally broken replacement window and the addition of about 2 inches of batt insulation along the inboard surface of the back-up wall. The THERM simulation, shown on the right in the figure below, was conducted using the same temperature and humidity ranges previously described for an average low in the month of January in St. Paul.

As indicated by the simulation, thermal bridging occurs through the window frame because the IGU and the frame isolator bar are not aligned with the wall insulation. While the new window is thermally broken, the adjacent decorative aluminum track is not, and in conjunction with the uninsulated jamb of the backup wall, creates an open cavity for thermal transfer.

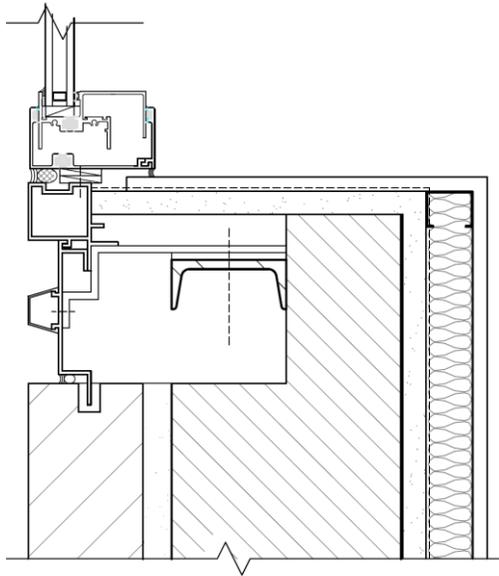


Illustration 4. Existing condition detail at the upper floor window jambs.

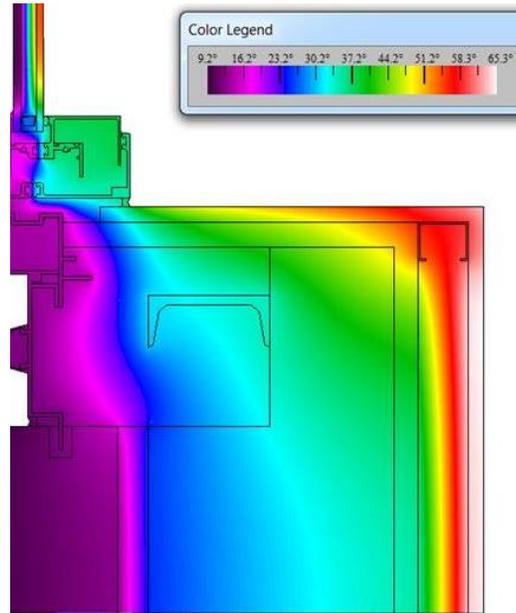


Illustration 5. THERM simulation of existing upper floor window jamb at the average low exterior air temperature for St. Paul, MN in the month of January.

4. A revised detail was created by WJE to examine the benefits of replacing the exterior windows of floors 2 through 5 with a high performing aluminum framed curtain wall and adding SPF insulation in the air cavity between the granite cladding and the back-up masonry. The intent of the added SPF was to align the insulation with the IGU and the isolator bar in the curtain wall frame to reduce thermal bridging. As shown in the revised THERM simulation below, the results of this modification resulted in only slight improvement of the glazing and frame performance; however the overall thermal resistance of the wall assembly is improved by the addition of insulation behind the decorative jamb trim and in the wall cavity.



Illustration 6. Replacement of the existing glazing with a curtain wall system and adding SPF insulation to the jambs and wall cavity resulted in a small improvement in overall energy performance.

Energy Modeling Report (KFI)

At the request of WJE, KFI developed an energy model for the COB to compare the baseline (actual) utility usage for the facility with projected utility usage based on facade upgrades proposed by WJE. Their findings were presented in a report dated March 9, 2015, which is attached for review in Appendix A. KFI identified the following overall results for the energy modeling, presented in the Executive Summary of the report:

- 1.

OPINIONS AND RECOMMENDATIONS

Information gathered through our exterior enclosure assessment, including: thermal imaging; a review of construction documents; an arm's length exterior condition survey; the creation of inspection openings; the analysis of energy modeling data provided by KFI, and thermal/condensation modeling conducted by WJE, demonstrates that the exterior envelope of the COB provides little resistance to the transfer of energy generated by the building mechanical system from the building interior to the exterior, particularly through

the aluminum window frames and the granite panel joints. You have asked that we provide an assessment of the condition of the existing enclosure and also recommend modifications to improve the overall energy performance of the building envelope in accordance with the Minnesota Sustainable Building Guidelines (B3) and the 2030 Challenge, as established by Architecture 2030¹.

While our investigation detected widespread locations of significant heat loss, this condition is not uncommon for a building constructed in the 1950's. Additionally, many of the components of the COB enclosure remain functional, with years of remaining service life if properly maintained. Because the design and construction costs associated with altering the building enclosure to improve energy performance can be significant, the State may prefer to maintain the building in its current configuration. While this approach will minimize improvement costs, the savings will be partially offset by deferred energy-use reduction savings. Energy modeling performed by KFI (included in Appendix A) estimates a maximum potential annual savings of around \$37,800. Furthermore, some costs associated with recommended maintenance and repair will still be incurred and some of these may be duplicated if and when future alterations are made to improve energy performance.

The following section of this report includes a list of basic recommendations for the repair and maintenance of the exterior enclosure components necessary to maintain the COB in its current configuration. At a minimum, WJE recommends that these items should be completed to ensure proper service life. Following the initial phase of recommended repairs we have provided a list of additional options that may be considered to improve the energy performance of the COB enclosure.

Repair and Maintenance Recommendations

Existing condition ratings have been developed for the primary components of the COB enclosure based on the results of our investigation. Major items have been assigned a numerical rating between 0 and 5, with a score of 5 representing "like new" condition and a score of 0 representing total failure or end of life expectancy. Generally, the recommended time frame for maintenance and/or repair for items with a condition rating of 0 to 1 is within the next three years. Items with a condition rating of 2 to 3 are recommended to be addressed within three to seven years, and items with a condition rating of 4 to 5 are recommended for reevaluation after a period of seven to ten years. Repair recommendations are general in nature and should not be used in lieu of detailed design documents such as drawings and specifications. The following list summarizes each of the enclosure components we have evaluated including the numerical condition score and a ballpark cost estimate where appropriate:

1. ROOF COVERING; RATING: 2

As noted in the document review section of this report, the COB roof consists of a multi-ply BUR membrane that has been in service for about 15 years. Built-up roof membranes are considered to be among the most durable roof membranes in use today, with an average expected useful service life of approximately 20 years. Although the roof covering was not included in our scope of services, we have completed a cursory review of the design, age, and condition of the existing roof and, although

¹ The 2030 Challenge seeks to reduce greenhouse gas emissions (GHG) by designing new and renovating existing buildings to reduce dependence on the use of GHG-emitting fossil fuels to a progressively increasing standard that is compared to the regional average energy use for buildings of a similar type. New construction projects that follow the Minnesota SB2030 requirements must be designed to use 70% less energy compared to an estimate of a similar building's 2003 energy usage. This energy savings level is adjusted for partial renovation projects that do not include lighting and mechanical system renovations. However, energy efficiency and energy conservation are high priorities with any SB2030 project.

significant areas of ponding were noted, we were not made aware of any water leakage issues and we estimate that the roof covering will be viable in its current state for at least five more years. The ballpark cost estimate for replacing the roof covering at current construction costs is approximately \$1.2M.

2. EAST ENTRY PLAZA; RATING: 1

Water leakage has been traced to a lack of flashing at the base of the east entry vestibule glazing, and IR scans also revealed significant localized heat loss at this area (Figure 15). WJE previously investigated the water leakage at the east terrace and issued a report dated June 12, 2012 which recommended a number of repair options. For reference our previous report is attached as Appendix B. The repair recommendations contained therein are estimated to cost approximately \$45,000 and include the following steps:

- a. Temporarily remove and salvage granite pavers for reinstallation, replacing pavers that are cracked or broken with new, matching units.
- b. Remove and dispose of all substrate materials, including existing mortar setting bed and asphalt-impregnated waterproofing down to the existing concrete slab over the tunnel enclosure below.
- c. Temporarily remove the storefront glazing and entry system of the exterior wall of the East entry vestibule. Remove and replace the cast concrete curb at the vestibule sill.
- d. Prep the concrete slab of the entry plaza and install hot fluid-applied rubberized asphalt waterproofing (American Hydrotech or similar) that extends up and over the new glazing curb and extends to all site walls and perimeter surfaces of the entry plaza.
- e. Install a continuous strip of stainless steel or similar flashing material extending over the top of the glazing curb, continuing down the outboard face and lapping over the membrane covering the exterior concrete slab.
- f. Reinstall the salvaged storefront glazing and entry system.
- g. Reinstall the granite pavers on a mortar setting bed as originally configured.

3. EAST TERRACE; RATING: 1

Over half of the linear footage of sealant placed in the paver joints of the east terrace has failed, allowing water to leak onto the mortar setting bed and the waterproofing membrane below. Inspection openings created under direction of WJE in 2012 and 2015 revealed varying conditions of the mortar setting bed; however, the waterproofing appeared to be in fair condition. Modifications to the top of the terrace walls have fundamentally altered the drainage path, trapping water at the edge of the terrace and resulting in deterioration of the stucco panels and possible water intrusion. The design of the existing railing introduces numerous additional joints in the granite pavers which have introduced water to the top of the terrace wall. To maintain the east terrace in its current condition we recommend the following procedures, for a ballpark cost estimate of \$85,000:

- a. Remove and dispose of existing railing.
- b. Temporarily remove and salvage the outer row of granite pavers for reinstallation. Saw cut salvaged pavers at a point two to three inches from the existing holes cored for the railing pickets, or to sound stone.
- c. Remove the existing stucco panels at the terrace wall and replace with a drained cavity system that matches the original construction details. It is our understanding that the original panels are no longer commercially available, so replacement options may include stone or precast panels that are compatible with the existing type E wall panels below.
- d. Prep the edge two feet of the terrace and install hot fluid-applied rubberized asphalt waterproofing tied in to the existing waterproofing. Terminate the waterproofing with metal flashing with a downward-angled drip edge at the top of the precast panel, similar to the original detail.
- e. Reinstall salvaged granite pavers and install new granite pavers at the edge of the terrace.

- f. Install new guardrail. The selected guardrail should have minimal penetrations through the granite, and anchoring will require further evaluation for compatibility with the waterproofing system.
- g. Replace sealant in all paver joints and guardrail penetrations with new silicone and closed cell backer rod.

4. EAST TERRACE STAIR; RATING: 1

Based on our limited review of the construction, the observed distress to the paver system, and the distress observed around the perimeter of the structural slab, it is probable that the structural slab concealed by the paver system has undergone significant deterioration due to corrosion. The corrosion present is a result of long term water and de-icing salt exposure which was accelerated by the failed sealant joints allowing water to infiltrate to and through the porous mortar bed and saturate the concrete. The ongoing exposure to salt saturated water leads to the conclusion that the upper surfaces of the structural concrete beneath the stair treads are likely in poor condition. As part of the base approach to building maintenance and repairs, we recommend the following at a minimum, for a ballpark cost estimate of \$15,000:

- a. Remove sections of damaged and unsound concrete. Assess condition of exposed reinforcing steel; clean existing steel that is determined to be sound.
- b. Clean and prep remaining sound concrete. Install supplemental rebar as required and hand-pack replacement concrete to rebuild the edges of the structural slab at the underside of the stair.
- c. Remove and replace all sealant in the joints of the pavers, treads, and risers,

The above repair does not resolve the potential structural issues with the stair, and should be considered a cosmetic repair option. The long-term solution to the deteriorated concrete would be to temporarily remove the granite pavers and waterproofing to allow for extensive structural repairs to the concrete below. Alternatively, if the terrace and stair do not serve as an egress path, the terrace could be converted into a green roof/planter and the stair removed.

5. WEST TERRACE; RATING: 2

The sealant filler in the paver joints of the west terrace exhibits widespread adhesion failure, which has allowed water to leak onto the mortar setting bed and the waterproofing membrane below. A number of pavers were displaced at the elevated terrace near the flag pole bases (INSERT FIGURE). Expand here...

6. EXTERIOR WALL PANELS; RATING: 4

The granite wall panels were noted to be in good condition, with very few instances of distress. The stone panels themselves can be expected to deliver decades of remaining service life; however, other components of the stone panel cladding including the anchorage system and the joint fillers present a more finite service life and will eventually require maintenance:

- a. It is assumed that the silicone sealant in the stone panel joints has been in place for just over ten years if replaced during the window replacement project. When properly maintained, silicone can deliver a useful service life in excess of 20 years. Based on our observations, WJE recommends the following repair and replacement schedule:
 - (1) Spot repairs should be completed within the next 3 to 5 years at localized areas of distress where adhesion failure, surface crazing, and cohesion failure are noted, as well as in locations where sealant is missing including the base of granite at the second floor level and the fifth level window at the southeast corner of the building. We estimate that 3000 lineal feet of sealant is in need of repair at this time, which is projected to cost about \$30,000.

- (2) The silicone sealant in the panel joints that is currently in good condition is estimated to have a remaining service life of between 7 to 10 years before it will need to be replaced. Sealant replacement at that time will likely encompass all granite panel joints above grade, estimated to be about 20,000 lineal feet and projected to cost about \$240,000 at current construction costs.
- b. Based on our thermal simulations, condensation-related corrosion of the steel framing and panel anchorage does not appear likely to be prevalent. Although some rust was revealed at the steel relieving angles at the limited amount of inspection openings, this did not appear to be a significant source of deterioration.

7. EXTERIOR WINDOW SYSTEMS; RATING: 3

As they were replaced in 2001, the exterior windows are still in relatively good condition, but visual review and thermal imaging detected fairly common instances of IGU seal failure that have compromised the insulating value of the glass, and the surrounding frames allow for thermal bridging because the IGU's are located outboard of the wall insulation. Nevertheless, if properly maintained, the windows are capable of delivering another 10 to 15 years in their current configuration. As with the granite wall panels, the service life of associated components will not provide the same longevity as the windows themselves:

- a. Sealant in the joints between the windows and the aluminum panels and at the primary seal between the windows and the granite panels are about ten years of age and appear to be in acceptable condition. Estimated remaining service life is between 7 to 10 years before the sealant will need to be replaced. Sealant replacement at the primary seal between the windows and the granite was included in the estimated total above in item 6.a.2. Sealant replacement at the remaining joints between the windows and vertical decorative tracks of the upper floors will involve about 15,000 lineal feet and is projected to cost about \$180,000 at current construction costs.
- b. The finish surface of the extruded aluminum spandrel panels between the upper floor windows has deteriorated to the point that many of the panels feature an unsightly appearance. However, the panels were one of the few original building components that featured insulation, and they do not significantly contribute to the overall building heat loss. The aluminum itself can be expected to last another 50 years or longer, meaning that they would only need to be replaced if their appearance becomes objectionable, or if improved resistance to energy transfer is desired.

Limited Energy Performance Improvements

Based on our understanding of the method of attachment of the granite wall panels, determined by a combination of document review and examination of as-built conditions through multiple inspection openings, temporary removal of the granite to allow for the installation of an air and water-resistive barrier and a new layer of insulation at the outboard side of the back-up wall system is likely to be a costly procedure that may result in damage to a number of the panels. Conversely, the vertical strips of aluminum-framed window and spandrel panels should not be as logistically challenging to replace, and the energy-savings realized by replacing the fenestration with a more efficient system would make this a more cost-efficient option for improving the enclosure's energy performance. Based on these observations, a suggested approach to improving the energy performance of the COB enclosure without removing the granite panels would consist of the following steps:

1. Remove and dispose of all existing vertical fenestration strips at floor levels 2 through 5, consisting of fixed IGU's and extruded spandrel panels, and replace with a high-performing curtain wall system that extends from the black granite soffit below the second floor level to the parapet caps (approximately 58 feet in height).

2. After the existing fenestration has been removed from the upper floor levels, the jamb condition at the sides of each opening will be open to view for the full height of the building. Prior to installing the curtain wall glazing, spray polyurethane foam (SPF) insulation can be applied to the outboard surfaces of the steel wide flanges and relieving angles at the granite panel bases beneath floor levels 2 through 5 to reduce air flow through the back-up walls. By applying the SPF with extension wands from the jambs at each side of the 8 foot 5 inch wide granite panels, the back side of the granite panels and exposed steel could be continuously insulated, extending between the jambs of the new curtain wall framing.
3. Replace the removed vertical strip fenestration with high-performing aluminum framed curtain wall systems with SPF insulation in the void spaces that currently exist at the jambs of the strip windows.
4. Seal off interior connections to the rooftop penthouse enclosures - gaskets and sweeps on doors, other means of separating interior include...

Comprehensive Energy Performance Improvements

The primary sources of energy loss through the building enclosure are unrestricted air flow permitted by the absence of a complete and continuous air barrier, and thermal transfer (heat loss) due to a lack of building insulation. The most effective method of addressing these conditions would be to remove the exterior cladding and fenestration to install a continuous air and water-resistive barrier (WRB) and add a continuous layer of exterior wall insulation before replacing the cladding and window systems. While this option would result in a marked improvement in energy performance, with a projected reduction in annual energy costs of as much as \$38,000, the resulting building enclosure would still not be likely to comply with the voluntary minimum efficiency standards outlined in the 2030 Challenge. Additionally, construction costs and the impact on building inhabitants will be more substantial than with the limited scope of improvements proposed in the limited energy performance improvements.

FIGURES



Figure 1. Overall view of the COB from the northwest corner of the site. At the north end of the building only floors 2 through 5 are exposed above grade.



Figure 2. Overall view of the COB from southwest corner of the site. The sub-basement walls are clad in granite-faced precast concrete panels (white arrow), the walls of the basement and first floor levels are clad in polished granite panels (red arrow) and the walls of levels 2 through 5 are clad in flame-finished granite panels (yellow arrow).



Figure 3. Overall view of the COB from the southeast corner of the site. The loading dock can be seen at the south elevation.



Figure 4. Overall view of the COB from northeast corner of the site.

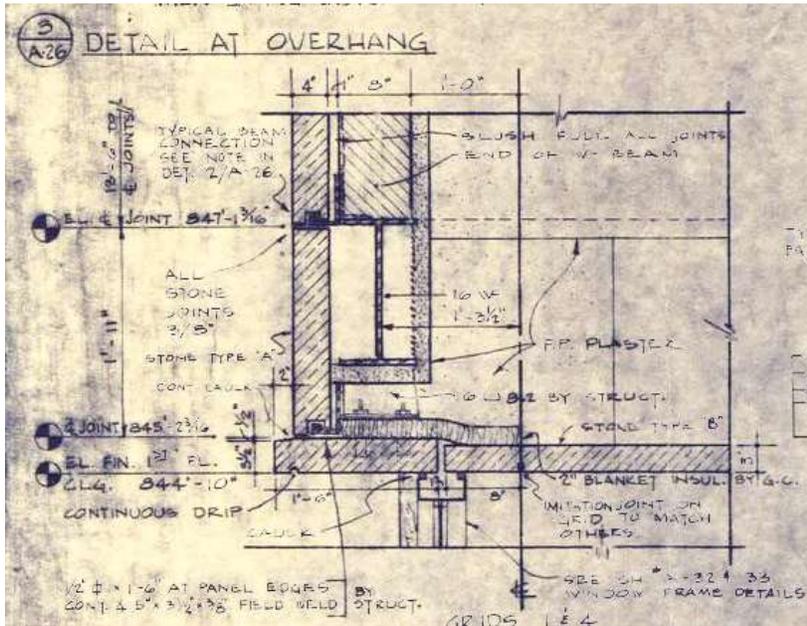


Figure 5. Original CD detail 3/A-26 depicts the soffit / overhang condition at the base of the type A granite wall panels below the second floor level.

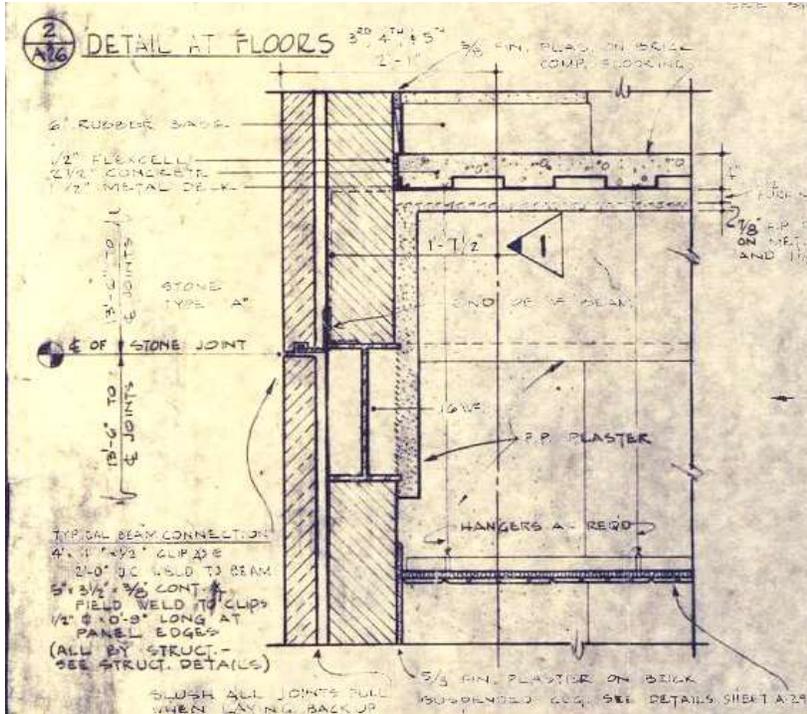


Figure 6. Original CD detail 2/A-26 depicts the typical bearing condition of the type A granite wall panels.

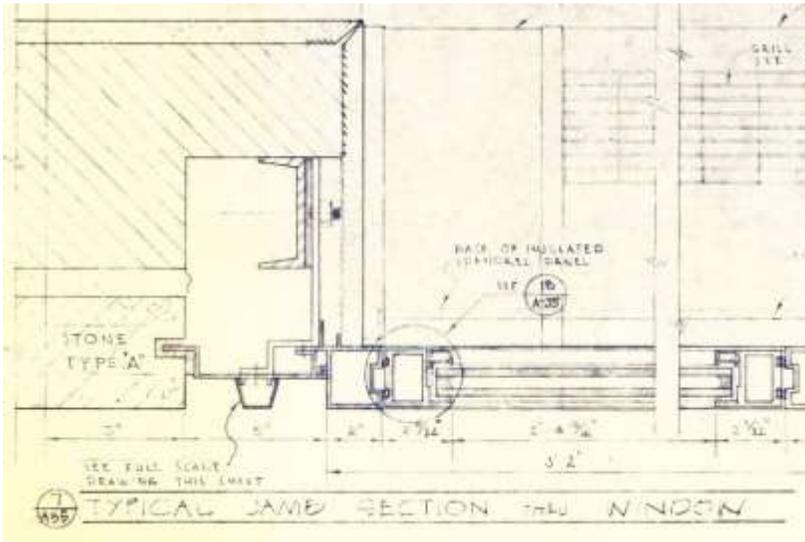


Figure 7. Original CD detail 7/A-35 depicts the original window jamb condition.

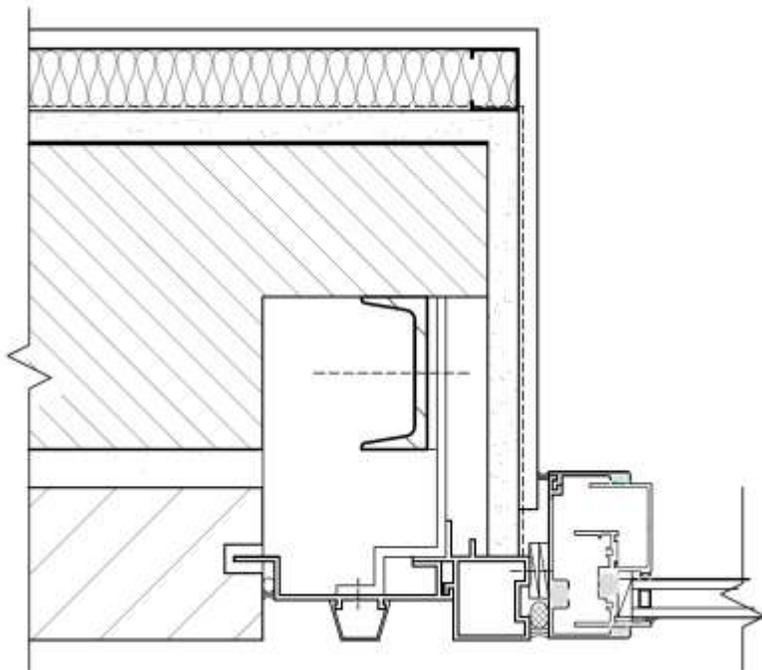


Figure 8. The existing window jamb detail includes replacement windows in a receptor frame, as well as a furred interior finish wall that includes insulation and a vapor retarder.



Figure 9. Overall IR scan of the COB taken from the northwest, reveals heat loss through the central and south rooftop penthouses (green boxes) and also at the window frames, and the granite panel joint locations (black arrows).



Figure 10. Heat loss at the panel joints beneath the fifth floor level are evident in this IR scan (green box). Elevated IGU heat loss was noted in 5 of the 9 windows visible in this scan, most notably at the fifth floor window on the right (black arrow).



Figure 11. Heat loss was detected at the window frames, which appear bright yellow in color. Heat loss also was identified in over half of the IGU's visible in this image, indicated by the glowing spot at the center area of the windows. IGU seal failure is likely in cases where the heat loss is elevated (black arrows).

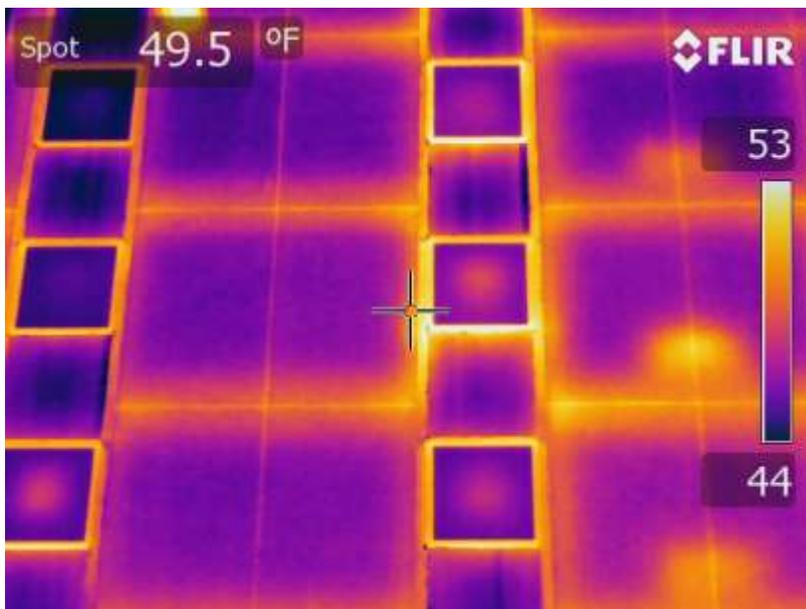


Figure 12. This image shows heat loss through the aluminum window and spandrel panel frames, and also at 4 of the 6 IGU's shown.



Figure 13. Heat loss was detected by this IR scan of the east elevation at the clerestory windows just below the first level ceilings (arrows).



Figure 14. Heat loss was detected at the west entry vestibule, which features the original construction, single pane glazing.



Figure 15. The east vestibule glazing is more efficient than the original glazing intact at the west entry; however localized heat loss was detected beneath the vestibule sills (arrows). Significant heat loss was also noted along the east terrace (green box).



Figure 16. Corrosion was present along both edges of the steel lintel above the loading dock opening. Type E precast panels are shown above the yellow lintel.

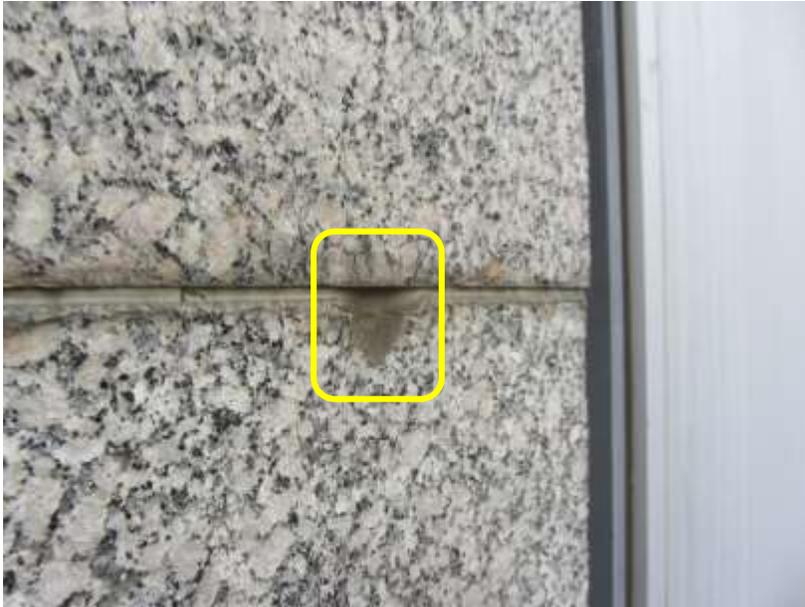


Figure 17. A missing spall that measured about 2 inches square had been filled with sealant on the fifth floor level of the west elevation (yellow box)..

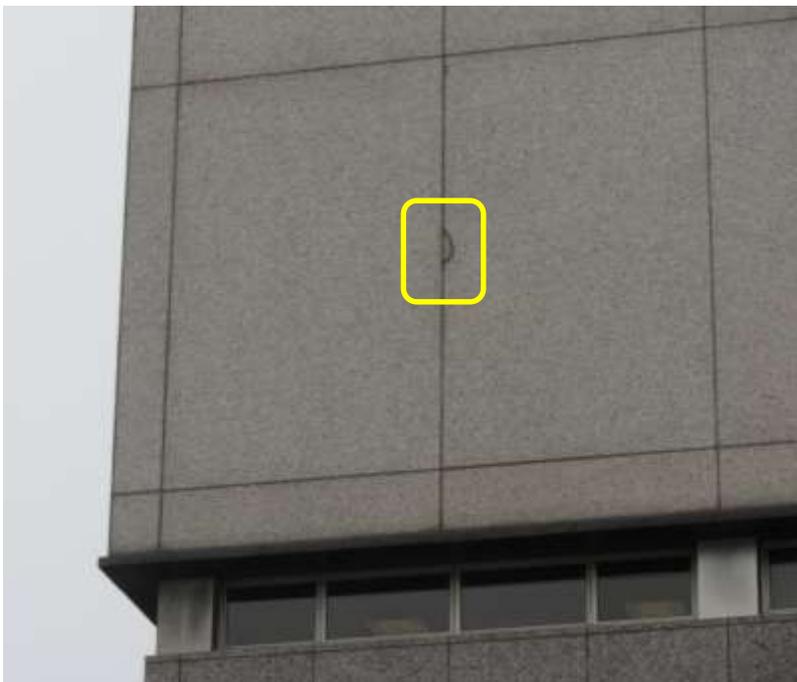


Figure 18. A crack in a second floor level granite panel at the south elevation was previously filled with sealant (yellow box).



Figure 19. A previous patch of polished granite panel at the base of the north wall did not match the finish of the surrounding stone.



Figure 20. A missing spall in a granite panel at the south end of the building, near the loading dock.



Figure 21. Missing sealant two parallel joints in aluminum transom panel above the north egress door extends to the concrete walk surface below.



Figure 22. Adhesion failure at the primary seal between a fifth floor window and the granite wall panels along the west elevation (yellow box).



Figure 23. Oils and plasticizers from the sealant have migrated into the granite, discoloring the stone around the joints.



Figure 24. Displacement of the granite cap stones was noted along the tops of the walls (red box). None of the displaced units were noted to be loose.



Figure 25. Sealant was missing at the head and jamb of this fifth floor window on the east elevation.



Figure 26. Detail view of the sealant missing from the window head shown in the previous detail, resulting in an open gap of about 1/4 inch width.



Figure 27. Oxidization of the aluminum spandrel panels has resulted in a deteriorated and irregular finish surface, and the original black color of the jamb accent has faded to gray (arrow).



Figure 28. Adhesion failure was commonly noted at the base of the aluminum frames at the second floor level (arrows).

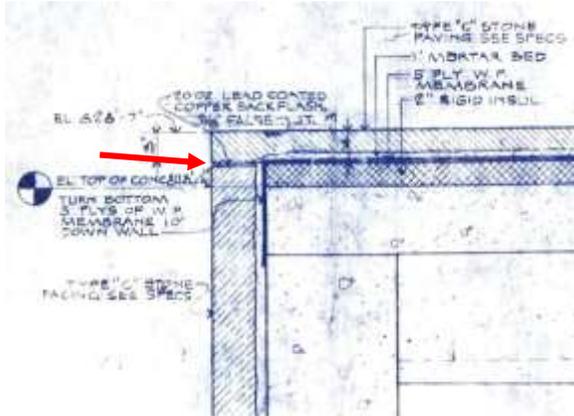


Figure 29. The original terrace edge detail included a through-wall flashing at the edge of the wall (red arrow).



Figure 30. The existing condition at the terrace edge features sealant that impedes drainage and the flashing has been removed or covered. Trapped water underneath the pavers has caused displacement of some units as seen here.



Figure 31. This paver at the west entry terrace has become displaced by freeze-thaw expansion of trapped water that leaked through the failed sealant joints (arrows).



Figure 32. Detail view of the west entry vestibule showing single pane glazing (red arrow) and alligatored urethane sealant (yellow arrow).



Figure 33. The west entry is covered by a two-tiered roof featuring an upper canopy (red arrow) above the vestibule roof (yellow arrow). The canopy roof was covered with a 1 inch thick layer of ice during our condition assessment.



Figure 34. Plant growth in a failed sealant joint at the east terrace indicates long-term water leakage.



Figure 35. Missing sealant at the joint surrounding the guard rail pickets of the east terrace allows water penetration.



Figure 36. Spalling and delaminated concrete has exposed the corroded reinforcing steel along the east edge of the stair structure.



Figure 37. Previous repairs at the south end of the stair landing have begun to deteriorate (yellow arrows).



Figure 38. Calcification at the interface between the stair landing and the precast (Type E) wall panels at the south end of the stair.



Figure 39. Rust staining at a surface spall and along the edges of a sealant joint in the enamel finish of the rooftop penthouse cladding.



Figure 40. Adhesion failures were common in the primary sealant joint between the rooftop penthouse louvers and the adjacent metal panels.

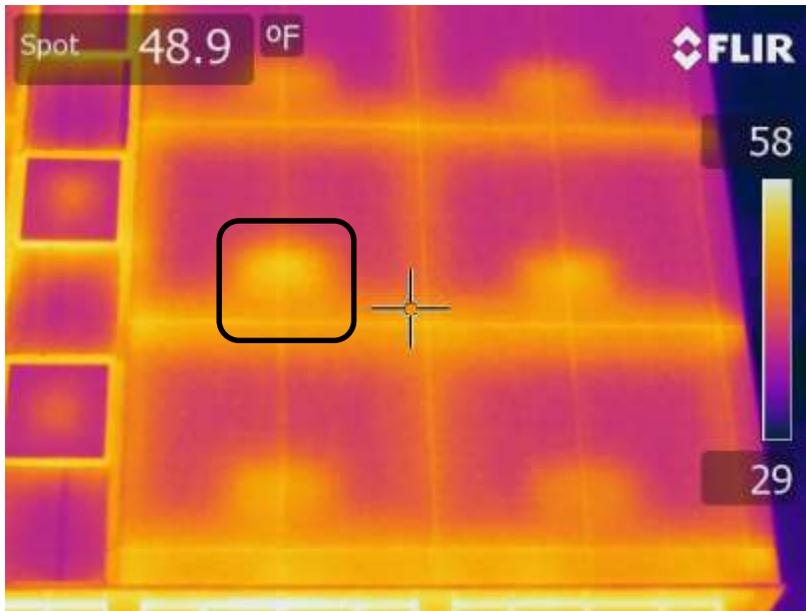


Figure 41. Warm spots in this IR scan indicate heat loss from cabinet heaters that interrupt the wall insulation (box).

APPENDIX A
ENERGY MODELING REPORT



Centennial Office Building Energy Model Report

Project Number: 14-369
March 9, 2015



ST. PAUL, MN IOWA CITY, IA FARGO, ND ST. CROIX FALLS, WI

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Title Page

Building Information

Building Owner:	State of Minnesota
Building Name:	Centennial Office Building
Modeled building square footage:	312,238 sf
Location:	658 Cedar St, St. Paul, MN

KFI Energy Modeler Information

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Table of Contents

Title Page	1
Table of Contents	2
Executive Summary	3
Introduction	4
Methodology	5
Energy Modeling Software	5
Weather Data	5
Utility Description.....	5
Modeled Building Parameters	6
Envelope Construction	6
Thermal Zones	6
Occupancy	6
Lighting and Receptacle Loads	7
Building HVAC Systems	11
Modeled Energy Conservation Opportunities	12
Window replacement.....	12
Infiltration reduction	12
Metal panel replacement.....	12
Granite renovation.....	12
Panel replacement, infiltration reduction, window replacement.....	12
All ECOs without infiltration reduction	12
All ECOs.....	13
Results	14
Calibration of Existing Building Model	14
Energy Conservation Opportunity Results	18
Appendix A	22
Utility Structure	22
Appendix B	31
Thermal zones used in energy model	31

Executive Summary

Karges-Faulconbridge, Inc. (KFI) was contracted to perform an energy analysis of the Centennial Office Building (COB) in St. Paul, MN by Wiss, Janney, Elster Associates, Inc.

KFI developed an energy model for the project based on the properties of the existing building. This baseline model was compared to actual utility usage for the facility. The baseline model was then adjusted to reflect potential control and/or equipment upgrades to the facility. The models of the energy conservation options (ECOs) were compared to the baseline energy model to identify expected energy and cost savings.

Table 1 provides results for the comparison between the modeled baseline and modeled potential ECOs

TABLE 1: ECO RESULT SUMMARY

	Energy Use [10 ⁶ Btu/year]	Energy Cost [\$/year]	Cost Savings [\$/year]	Energy Savings [%]	Cost Savings [%]
Baseline existing building	26,972	\$568,105	NA	NA	NA
Window replacement	26,524	\$562,170	\$5,935	1.7%	1.0%
Infiltration reduction	25,091	\$555,506	\$12,600	7.0%	2.2%
Granite façade upgrade	24,799	\$552,716	\$15,389	8.1%	2.7%
Metal panel replacement	26,814	\$566,405	\$1,700	0.6%	0.3%
Panel & window replacement with infiltration reduction	24,394	\$546,405	\$24,245	9.6%	3.7%
All ECOs without infiltration reduction	24,169	\$539,555	\$28,550	10.4%	5.0%
All ECOs	22,507	\$530,273	\$37,833	16.6%	6.7%

Introduction

This report details the parameters and results of the building energy model created for the Centennial Office Building (COB) in St. Paul, MN.

KFI was contracted to develop an energy model of the facility. The model was built based on the existing facility and the results were compared to the actual utility usage. This calibration process improves the accuracy of the project energy savings by assuring that the energy consumption patterns modeled are similar to the actual energy consumption pattern.

An energy model is an analytical tool, designed to provide an estimate of the total energy consumed by a building over the course of a year. It includes thermodynamic models of the building envelope and equipment and calculates the building's response to typical weather data. The energy model is dependent on the internal load parameters such as occupancy estimates, lighting schedules, and equipment schedules which are likely to vary for the actual usage of the building. Changes to any of the parameters as described in this report will result in changes to the energy consumption predicted by the model. **This energy model is not a guarantee of building performance.**

Methodology

This energy and cost savings identified in this report are based on the comparison of two energy models: a baseline calibrated to the existing energy usage of the facility and a proposed design with the new equipment efficiencies or control strategies. The baseline model is created first and adjusted to follow the actual usage patterns. The proposed model uses the same occupancy and building characteristics as the baseline, but is adjusted to represent each proposed energy conservation opportunity (ECO).

Energy Modeling Software

This project utilizes Trane Air Conditioning Economics version 6.2.10, or TRACE™ 700 v6.2.10. TRACE™ is a design-and-analysis tool that helps HVAC professionals optimize the design of a building's heating, ventilating, and air-conditioning system based on energy utilization and lifecycle cost. TRACE™ 700 calculations apply techniques recommended by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The program is tested in accordance with ASHRAE Standard 140-2010, "Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs," and it meets the requirements for simulation software set by ASHRAE Standard 90.1-2010.

Weather Data

Weather data published by the National Renewable Energy Laboratory (NREL), available at http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3, were used. This weather information is based on data collected over a 30 year period and contains typical solar radiation and meteorological data for Minneapolis/St. Paul, MN (726580TY.csv).

Utility Description

The electric, hot water, and chilled water utility rate structures used for this project was based utility information provided by the state of Minnesota. Details of these rate structures are provided in Appendix A.

Modeled Building Parameters

Envelope Construction

The existing building has a granite façade with metal panels. Based on existing architectural details, the building was modeled with the following characteristics:

- Granite wall u value = 0.19 (4" stone/brick, air space, 8" LW CMU, 5/8" gypsum, interior and exterior surface resistance)
- Metal panel u value = 0.111 (metal siding, air space, 2" insulation, 5/8" gypsum, interior and exterior surface resistance)
- Roof u value = 0.0395, assembly R value = 25.3 (asphalt, sheathing, 3.5" polyisocyanurate insulation, 6" concrete, air space, 0.5" gypsum, interior and exterior surface resistance).
- Glazing assembly u value = 0.651, SC = 0.537 (SHGC = 0.467, grey tinted float glass, double pane, aluminum frames – no break, u center of glass = 0.463)

Based on details of the glazing assembly and infrared scans of the building, there appear to be some areas of significant thermal loss around the windows granite panels so the building was modeled with high infiltration (0.2 cfm/sf exterior wall area).

Thermal Zones

The building was modeled with block zones based on usage type and orientation of exterior walls. Most of the building was modeled with a fifteen foot perimeter zone and an interior core zone. These zones were further separated by occupancy type. Details of the modeled building zoning are provided in Appendix B. A summary of the modeled building usage types is provided in Table 2 below.

TABLE 2: MODELED AREA BY USAGE TYPE

Space Type	Modeled Area (sf)
Cafeteria	6,066
Corridor	18,376
Data center	4,885
Mechanical/electrical rooms	12,232
Office	236,887
Storage	33,792
Total:	312,238

Occupancy

The building is modeled with a peak occupancy of 1,073 people. The schedule shown in Figure 1 below modifies the peak weekday occupancy. The building is modeled as unoccupied on weekends.

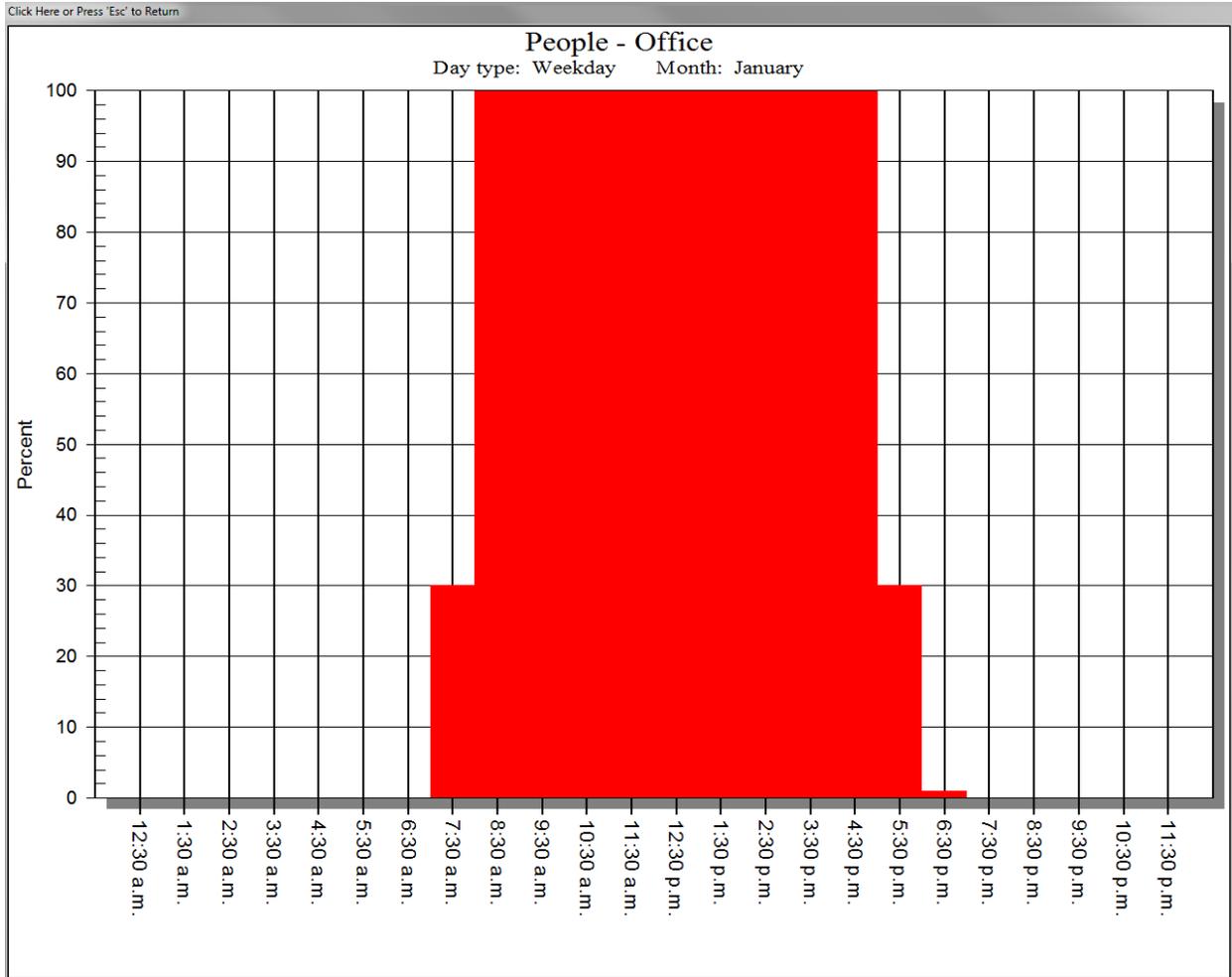


FIGURE 1: WEEKDAY OCCUPANCY SCHEDULE

Lighting and Receptacle Loads

Lighting and plug loads were adjusted during the energy model calibration process. The internal loads included in the model are provided in Table 3. Lighting was modeled off on weekends. Data center loads were modeled as constant 24/7. No exterior lighting was modeled for this project.

TABLE 3: LIGHTING AND PLUG LOADS

Space Type	Lighting power density (W/sf)	Plug/process load (W/sf)
Cafeteria	1.5	2
Corridor	1	0
Data center	1	65
Mechanical/electrical rooms	1	0
Office	1	1
Office core	1	0.75
Press corps	1	1.5
Storage	1	0

All lighting and receptacle loads were modified by the schedules in Figure 2 through Figure 4 below.

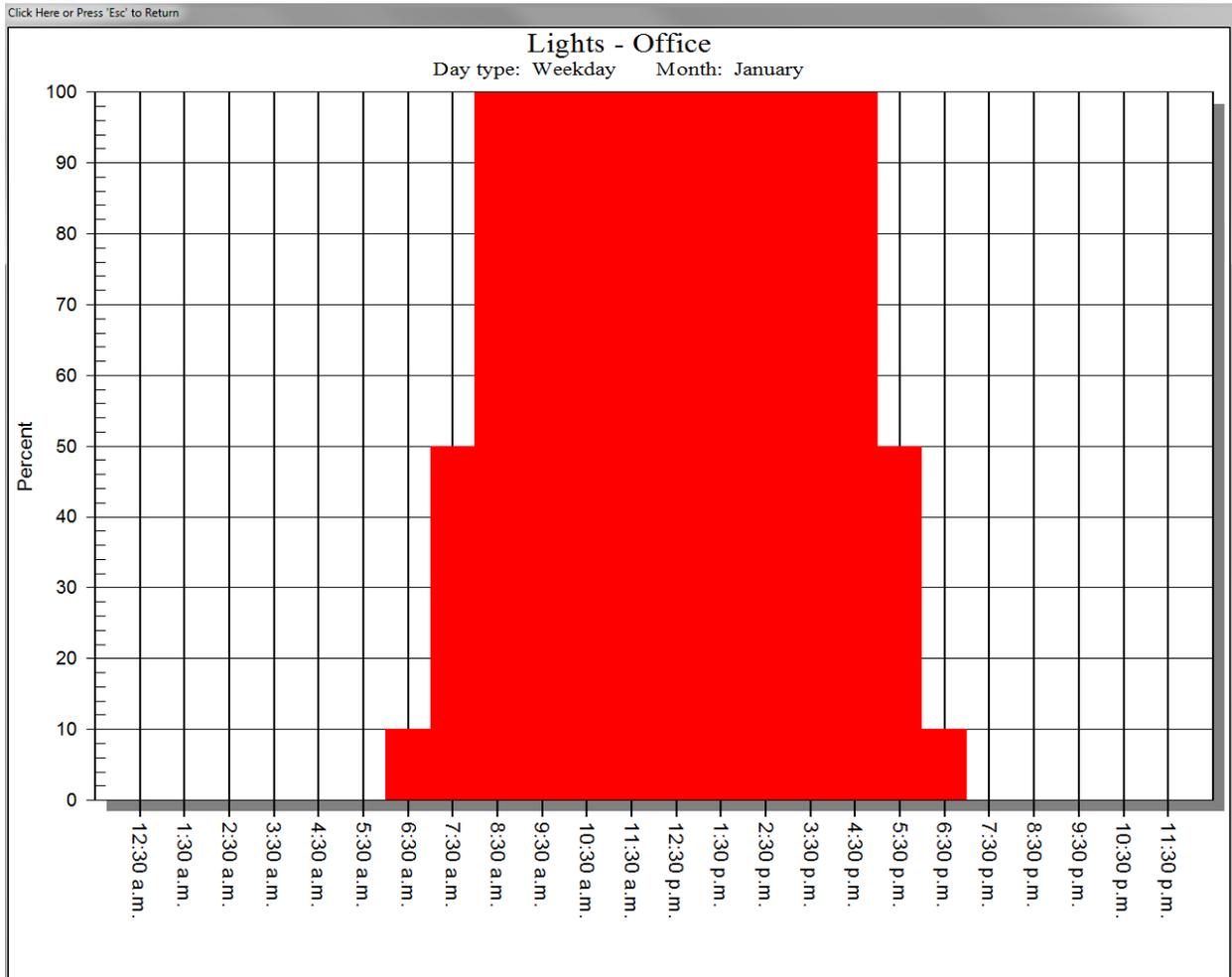


FIGURE 2: WEEKDAY LIGHTING SCHEDULE

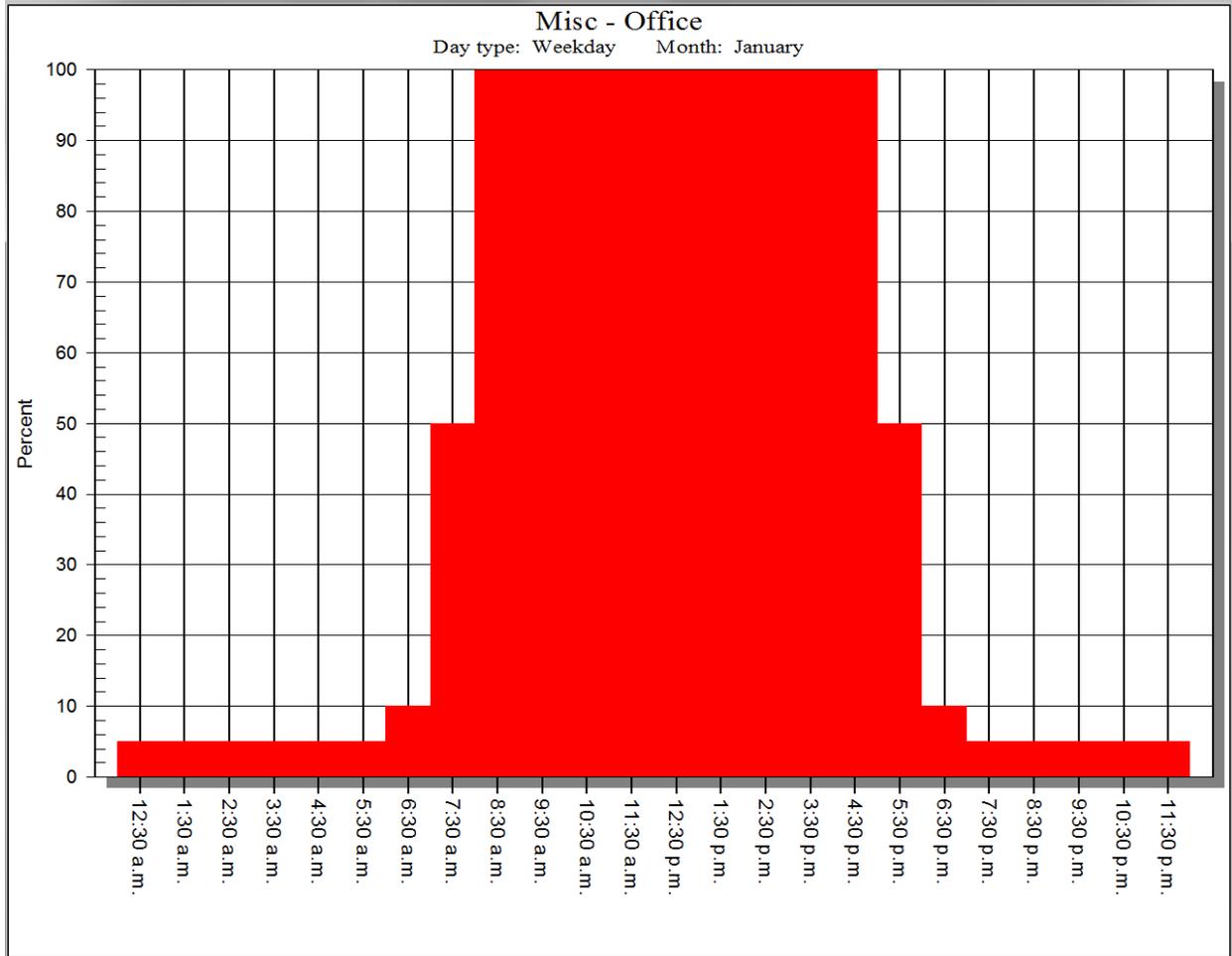


FIGURE 3: WEEKDAY PLUG LOAD SCHEDULE

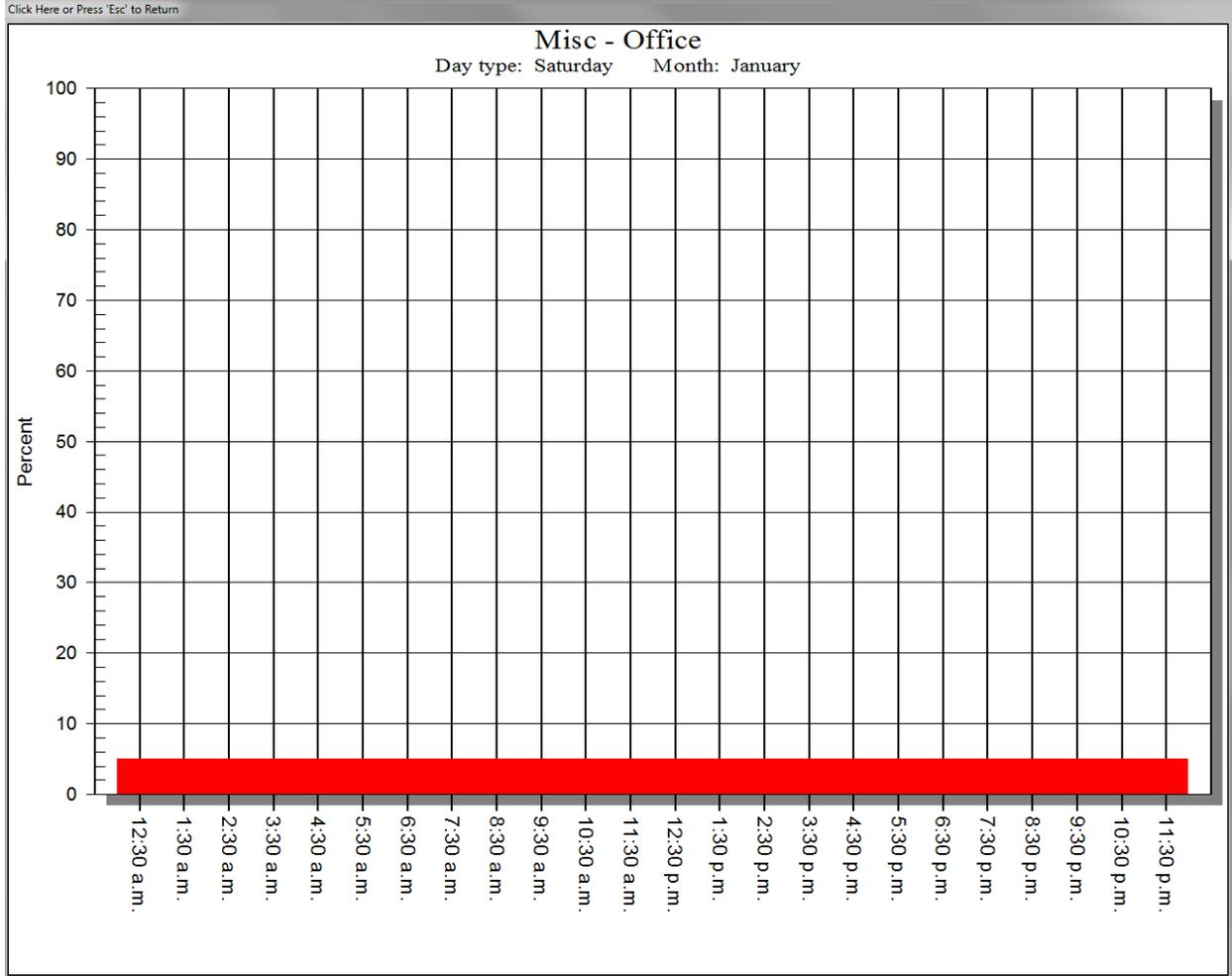


FIGURE 4: WEEKEND PLUG LOAD SCHEDULE

Building HVAC Systems

The majority of the building was modeled as conditioned by a series fan powered VAV system. The system was modeled with a minimally code compliant level of outdoor air and enthalpy controlled economizer.

Cooling and heating for the primary building system is provided by District Energy. Thus, chilled water and hot water was modeled with an efficiency of 100% to model the total energy usage at the building level.

The data center was modeled with a separate constant volume system. The data center plant is modeled as a water cooled chiller with an efficiency of 0.885 kW/ton.

Modeled Energy Conservation Opportunities

KFI created 7 energy models with potential ECOs or combinations of ECOs. Each model was compared to the calibrated existing building model as a baseline comparison. The ECO models are described below. The ECOs were each modeled individually to examine their relative impact even when it is likely that the ECOs would not be implemented individually.

Window replacement

- Cardinal Glass Low E² 270 IGU (assembly u = 0.397, COG u = 0.287, SHGC = 0.346, SC = 0.398, aluminum thermally broken frames)
- All other parameters same as baseline

Infiltration reduction

- Infiltration reduced by half
- All other parameters same as baseline

Metal panel replacement

- Metal panel u value = 0.0682 (metal siding, air space, 2" polyisocyanurate insulation, 5/8" gypsum, interior and exterior surface resistance)
- All other parameters same as baseline

Granite renovation

- Granite wall u value = 0.0538 (4" stone/brick, air space, 4" insulation, 8" LW CMU, 5/8" gypsum, interior and exterior surface resistance)
- All other parameters same as baseline

Panel replacement, infiltration reduction, window replacement

- Metal panel u value = 0.0682 (metal siding, air space, 2" polyisocyanurate insulation, 5/8" gypsum, interior and exterior surface resistance)
- Cardinal Glass Low E² 270 IGU (assembly u = 0.397, COG u = 0.287, SHGC = 0.346, SC = 0.398, aluminum thermally broken frames)
- Infiltration reduced by half
- Roof and granite walls same as baseline

All ECOs without infiltration reduction

- Granite wall u value = 0.0538 (4" stone/brick, air space, 4" insulation, 8" LW CMU, 5/8" gypsum, interior and exterior surface resistance)
- Cardinal Glass Low E² 270 IGU (assembly u = 0.397, COG u = 0.287, SHGC = 0.346, SC = 0.398, aluminum thermally broken frames)
- Metal panel u value = 0.0682 (metal siding, air space, 2" polyisocyanurate insulation, 5/8" gypsum, interior and exterior surface resistance)
- Infiltration same as baseline
- Roof same as baseline

All ECOs

- Granite wall u value = 0.0538 (4" stone/brick, air space, 4" insulation, 8" LW CMU, 5/8" gypsum, interior and exterior surface resistance)
- Cardinal Glass Low E² 270 IGU (assembly u = 0.397, COG u = 0.287, SHGC = 0.346, SC = 0.398, aluminum thermally broken frames)
- Metal panel u value = 0.0682 (metal siding, air space, 2" polyisocyanurate insulation, 5/8" gypsum, interior and exterior surface resistance)
- Infiltration reduced by half
- Roof same as baseline

Results

Calibration of Existing Building Model

The Centennial Office Building occupancy and usage has changed significantly over the past several years. In particular, the building electricity usage has changed as a portion of the data center was decommissioned and renovated as office space.

Occupancy and internal load usage patterns were adjusted in the baseline existing building model with the goal of modeling the most recent utility years.

The hot water, electricity, and chilled water usage of the Centennial Office Building from 2008 through 2014 are presented with the energy model results in Figure 5, Figure 6, and Figure 7 below.

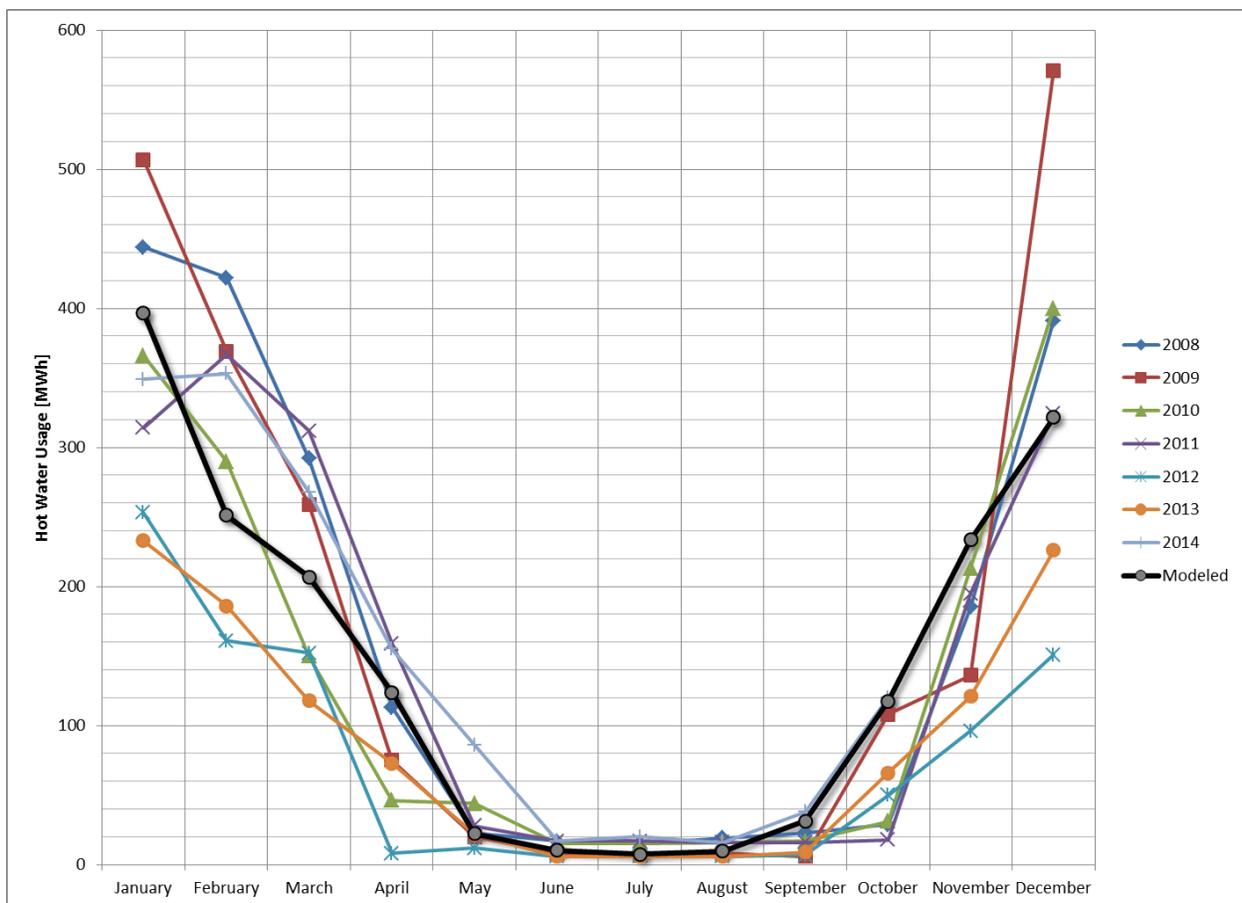


FIGURE 5: HOT WATER CALIBRATION RESULTS

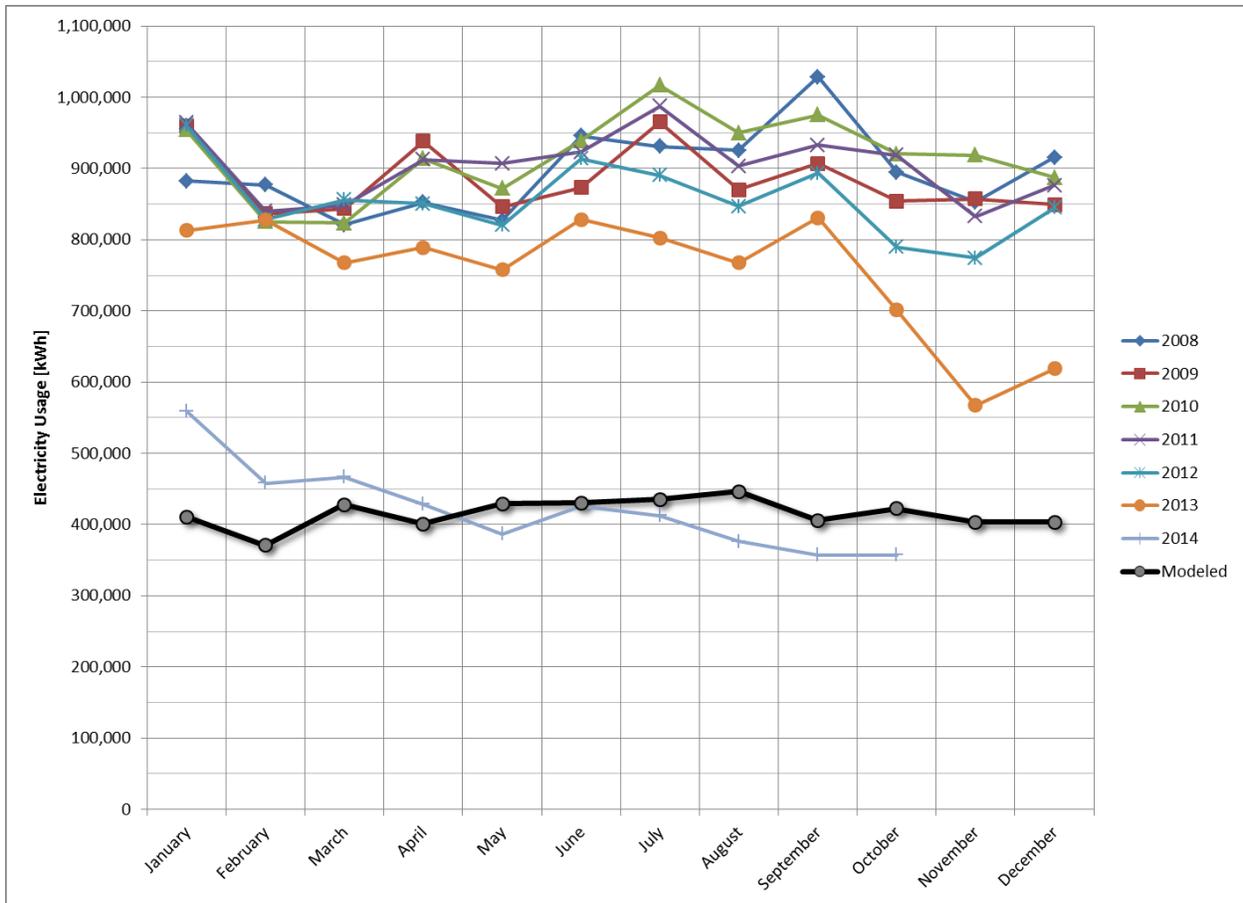


FIGURE 6: ELECTRICITY CALIBRATION RESULTS

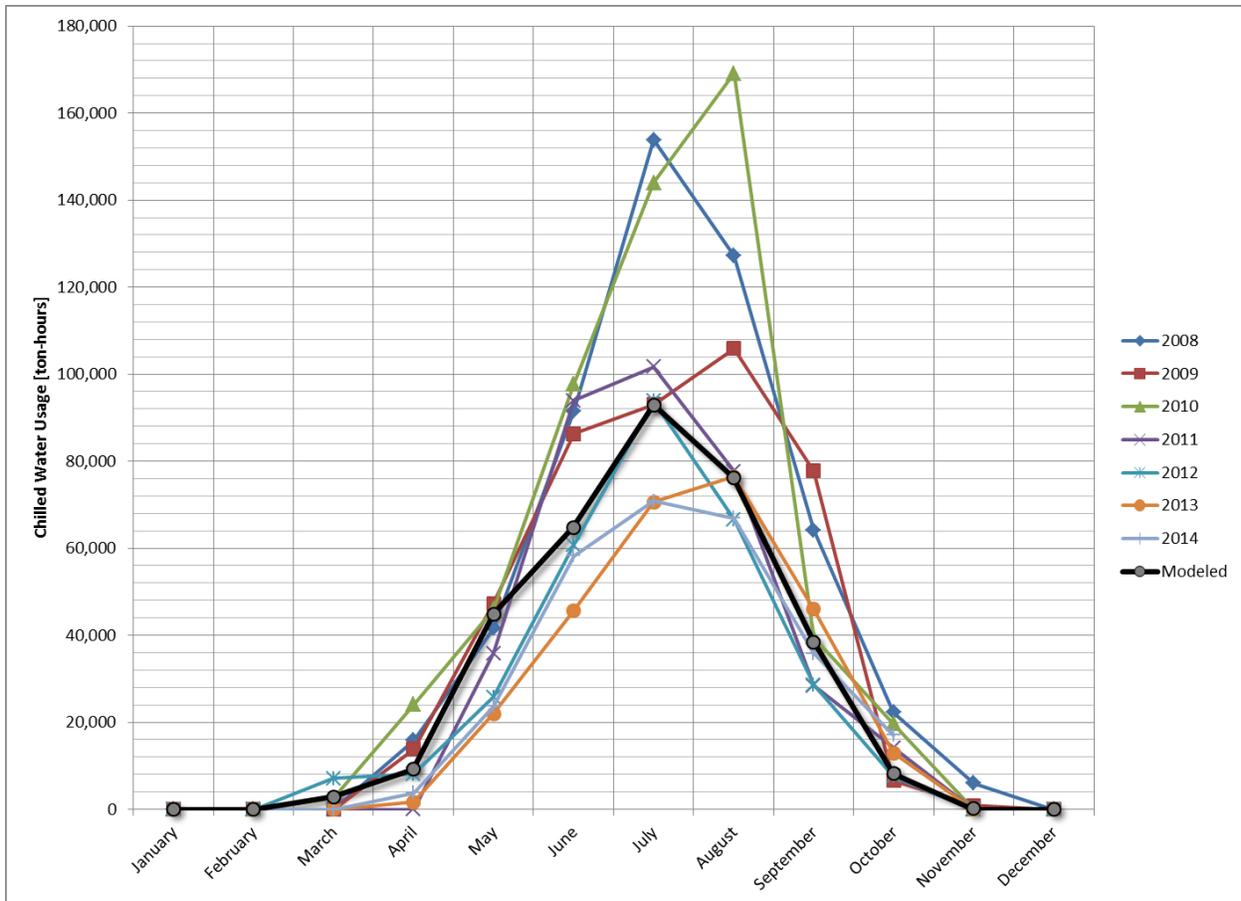


FIGURE 7: CHILLED WATER CALIBRATION RESULTS

Note that the chilled water usage in the utility data provided by the state was in kWh under the wholesale chilled water agreement from District Energy. The modeled amount is the actual chilled water usage at the building. In order to compare these, the kWh of chilled water usage in the utility data was converted to ton-hours of water usage by dividing by 0.765 kWh/ton-hour (see Appendix A for details of the wholesale chilled water agreement).

Natural gas use in the building is limited to kitchen loads. This utility usage is shown in Figure 8 below. Typically kitchen gas usage is used in hooded kitchen equipment and it does not affect nor is it affected by changes to the building envelope. Thus, this usage was not included in the energy model.

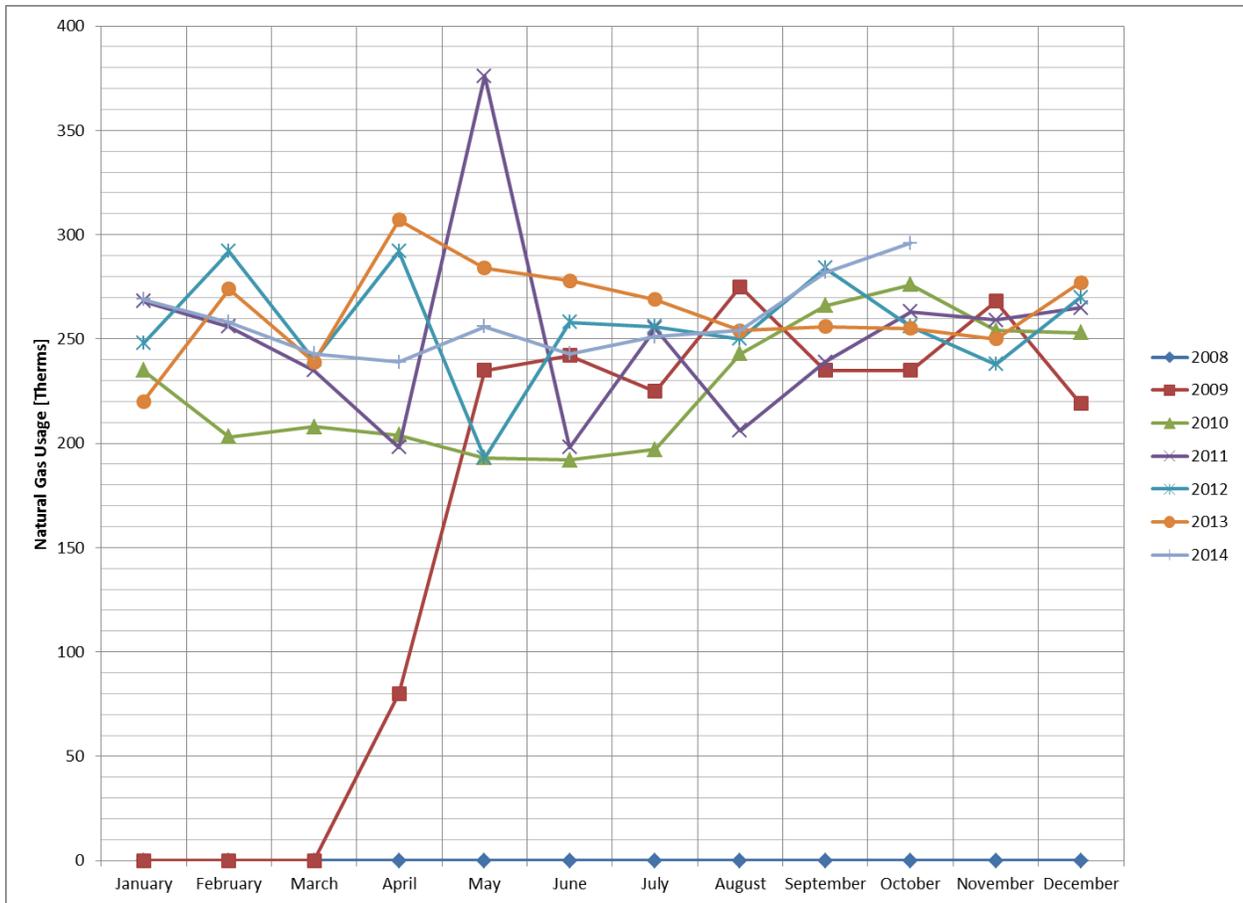


FIGURE 8: BUILDING NATURAL GAS USAGE

Energy Conservation Opportunity Results

The energy savings predicted by each ECO model is provided below in Figure 9. The savings percentages are compared to the calibrated baseline model.

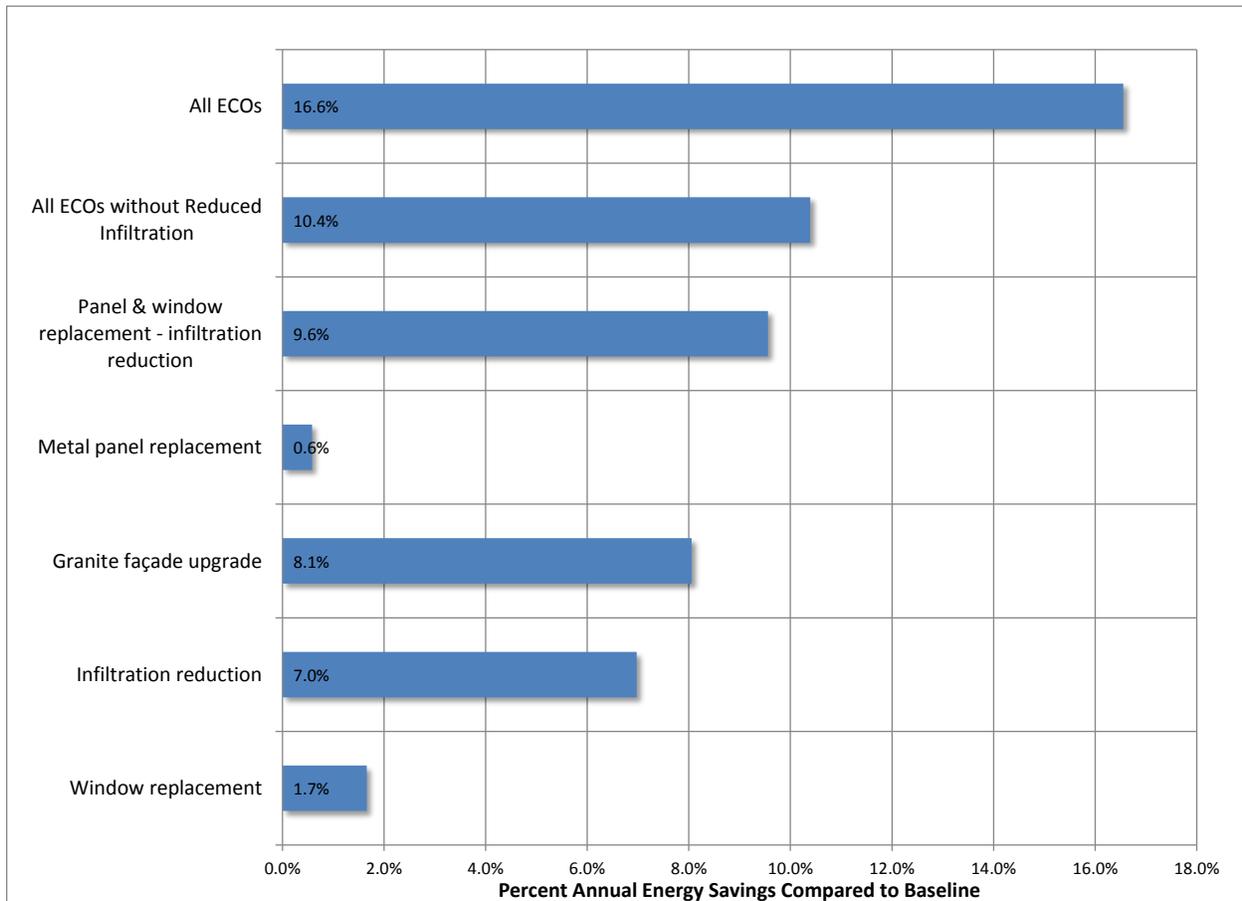


FIGURE 9: ENERGY SAVINGS PERCENT

Total annual energy use predicted for each model (including the baseline case) is shown in Figure 10. The options with the largest energy savings achieve most of the savings in their reduction of heating energy. The percent savings by end use for each ECO model is provided in Table 4 below. ECOs that reduce infiltration or increase wall insulation show a very small increase in cooling energy. This is because more of the heat of internal loading is kept inside the building to be cooled mechanically. However, this increase in cooling energy is typically much smaller than the energy savings in heating.

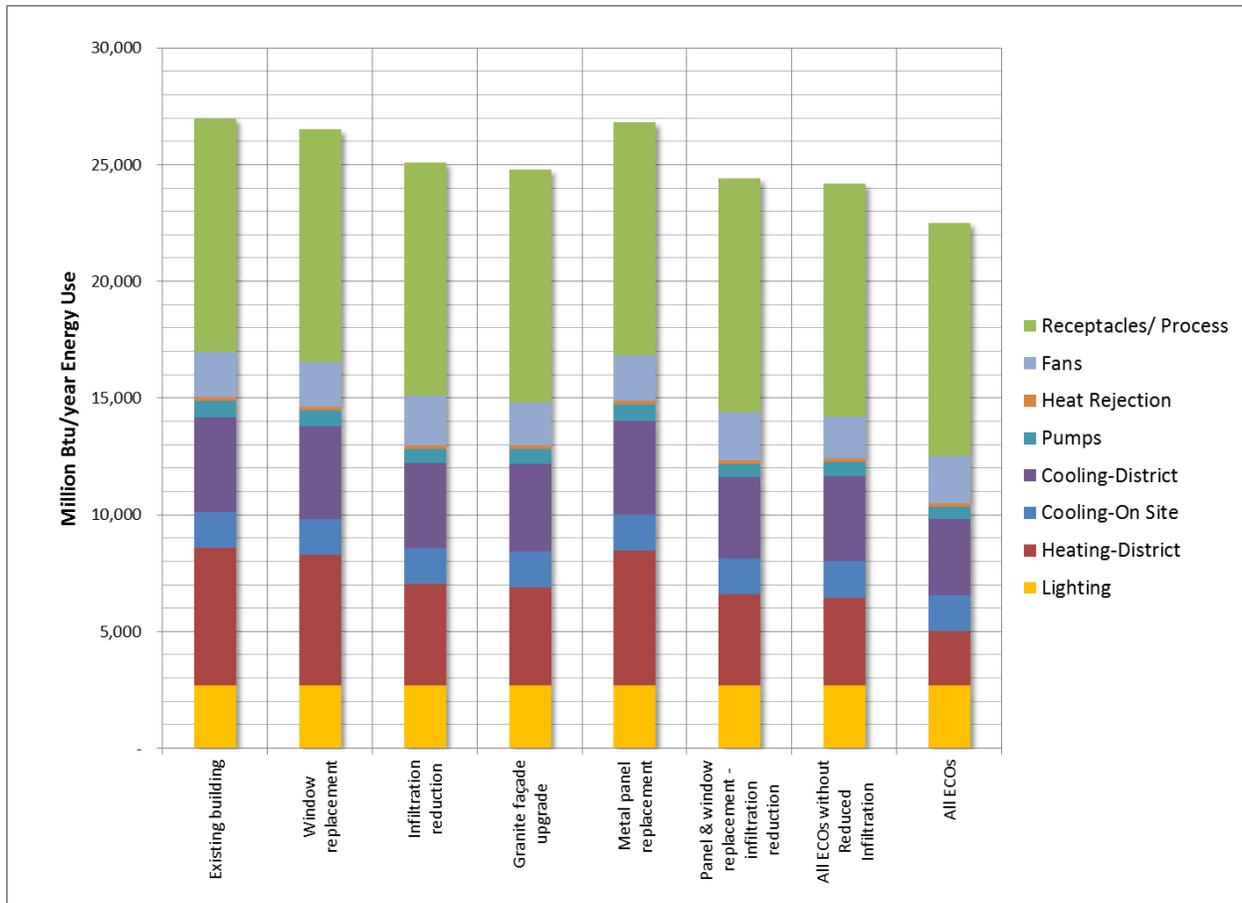


FIGURE 10: ECO ENERGY USAGE BY END USE

TABLE 4: PERCENT ENERGY SAVINGS BY END USE

	Window replacement	Infiltration reduction	Granite façade upgrade	Metal panel replacement	Panel & window replacement - infiltration reduction	All ECOs without Reduced Infiltration	All ECOs
Lighting	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Space Heating	4.9%	26.3%	28.9%	2.1%	34.0%	36.1%	60.6%
Space Cooling	0.0%	-0.3%	-0.5%	-0.1%	-0.4%	-0.5%	-0.8%
Space Cooling	2.0%	10.5%	7.1%	0.5%	14.0%	9.8%	19.8%
Pumps	1.8%	11.5%	9.6%	0.5%	14.5%	12.5%	21.5%
Heat Rejection	0.0%	0.7%	-0.2%	0.0%	0.7%	-0.2%	0.5%
Fans	3.1%	-9.0%	6.0%	0.6%	-4.9%	9.8%	-3.0%
Receptacles	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total:	1.7%	7.0%	8.1%	0.6%	9.6%	10.4%	16.6%

Energy cost savings percentages do not always correspond directly to energy savings percentages because of the cost difference between natural gas and electricity and between district hot water and district chilled water.

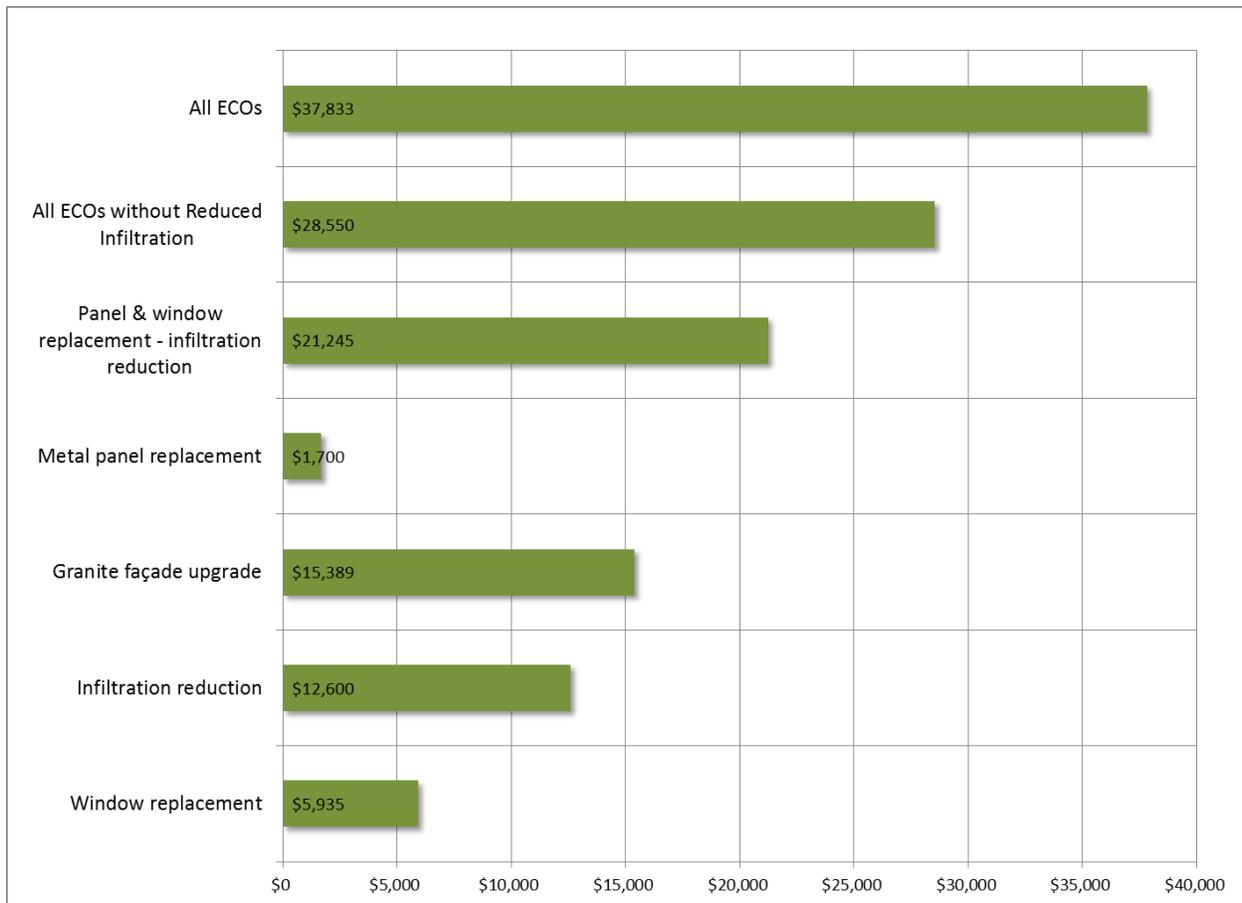


FIGURE 11: ECO ENERGY COST SAVINGS COMPARED TO BASELINE MODEL

A summary of the energy and cost results is provided in Table 5.

TABLE 5: ECO RESULTS SUMMARY

	Energy Use [10 ⁶ Btu/year]	Energy Cost [\$/year]	Cost Savings [\$/year]	Energy Savings [%]	Cost Savings [%]
Baseline existing building	26,972	\$568,105	NA	NA	NA
Window replacement	26,524	\$562,170	\$5,935	1.7%	1.0%
Infiltration reduction	25,091	\$555,506	\$12,600	7.0%	2.2%
Granite façade upgrade	24,799	\$552,716	\$15,389	8.1%	2.7%
Metal panel replacement	26,814	\$566,405	\$1,700	0.6%	0.3%
Panel & window replacement with infiltration reduction	24,394	\$546,405	\$24,245	9.6%	3.7%
All ECOs without infiltration reduction	24,169	\$539,555	\$28,550	10.4%	5.0%
All ECOs	22,507	\$530,273	\$37,833	16.6%	6.7%

Appendix A

Utility Structure

From: Bergstrom, Mark (ADM)
Sent: Tuesday, December 09, 2014 2:02 PM
To: Peterman, Gene (ADM)
Subject: RE: COB Kick-off meeting minutes

For simple calculations, the COB's average unit costs for FY14 were as follows:

Electricity - \$0.091 per KWH
Natural Gas - \$0.83 per Therm
District Hot Water - \$57 per MWH
District Chilled Water - \$0.13 per TonHour

For more complicated calculations, additional information is below and sample invoices are attached:

Electricity

The Centennial Building is one of twelve buildings served from our main Capitol Complex Electric Loop Account with Xcel Energy Company. The electric tariff that our Loop is served under is the Peak Controlled Time of Day Service Rate A24. We are a Primary Voltage, Tier 1 customer.

Natural Gas

The Centennial Building is served directly by Xcel for Natural Gas. The applicable tariff is Small Commercial Firm Service.

District Hot Water

The Centennial Building is served directly by District Energy for Hot Water.

A significant portion of every monthly bill is the Demand component. However, it is not a traditional demand that is based on peak monthly demand. Instead, it is established by District Energy each year beginning in October, based on the previous year's weather-normalized usage. The demand level remains fixed for 12 months. Changes in a building's weather-normalized usage will affect the Demand level, but with a 1 year lag.

District Chilled Water

The Centennial Building is served from our Capitol Complex Chilled Water Loop, which is served under a fairly complex Wholesale Service Agreement with District Cooling.

The monthly cooling charges are based on the actual Loop monthly Peak Demand (Tons) and usage (TonHours). Per the wholesale agreement, District Cooling converts these amounts to KW and KWH based on contractual factors of 0.765 KW/Ton and 0.765 KWH/TonHour, and then applies Xcel electric rate factors to calculate the monthly cooling charges.

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MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2

PEAK CONTROLLED TIME OF DAY SERVICE
RATE CODE A24

Section No. 5
13th Revised Sheet No. 44

AVAILABILITY

Available to any non-residential customer for general service who agrees to control demand to a predetermined level whenever required by Company. Availability is restricted to customers with a minimum controllable demand of 50 kW.

AVAILABILITY-MANDATORY

Effective November 1, 2007, this rate schedule is mandatory for any Peak Controlled customer having a 15-minute measured demand equal to or greater than 1000 kW for at least 4 of the past 12 consecutive months. Customer will remain on this rate schedule on a mandatory basis unless their demand remains below 1000 kW for 12 consecutive months.

AVAILABILITY-OPTIONAL

This rate schedule is optional for any non-residential customer for general service where customer is not required to be on a time-of-day rate.

DETERMINATION OF CUSTOMER BILLS

Customer bills shall reflect energy charges (if applicable) based on customer's kWh usage, plus a customer charge (if applicable), plus demand charges (if applicable) based on customer's kW billing demand as defined below. Bills may be subject to a minimum charge based on the monthly customer charge and / or certain monthly or annual demand charges. Bills also include applicable riders, adjustments, surcharges, voltage discounts, and energy credits. Details regarding the specific charges applicable to this service are listed below.

RATE

Customer Charge per Month	\$55.00	R
Service at Secondary Voltage		
Energy Charge per kWh		
On Peak Period Energy	\$0.04049	R
Off Peak Period Energy	\$0.02224	R
Energy Charge Credit per Month per kWh		
All kWh in Excess of 400 Hours Times the Sum of All On Peak Period Billing Demands, Not to Exceed 50% of Total kWh	\$0.0120	R

(Continued on Sheet No. 5-45)

Date Filed: 11-02-12 By: David M. Sparby Effective Date: 12-01-13
President and CEO of Northern States Power Company, a Minnesota corporation
Docket No. E002/GR-12-961 Order Date: 09-03-13

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MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2

**PEAK CONTROLLED TIME OF DAY SERVICE
 (Continued)
 RATE CODE A24**

Section No. 5
 20th Revised Sheet No. 45

RATE (Continued)

	<u>Tier 1</u>	<u>Tier 2</u>
Demand Charge per Month per kW		
On Peak Period Demand		
Firm Demand		
June - September	\$12.86	\$12.86
Other Months	\$8.98	\$8.98
Controllable Demand (Jan-Dec)		
Level A: < 65% PF	Not Available	\$7.17
Level B: ≥ 65% and < 85% PF	\$5.78	\$6.45
Level C: ≥ 85% PF	\$5.22	\$5.97
Short Notice Rider	\$4.72	Not Available
Off Peak Period Demand in Excess of On Peak Period Demand (Jan-Dec)	\$2.25	\$2.25
	<u>January - December</u>	
Voltage Discounts per Month	<u>Per kW</u>	<u>Per kWh</u>
Primary Voltage	\$0.90	\$0.00090
Transmission Transformed Voltage	\$1.60	\$0.00262
Transmission Voltage	\$2.25	\$0.00273

INTERIM RATE ADJUSTMENT

A 6.61% Interim Rate Surcharge will be applied to rate components specified in the "Interim Rate Surcharge Rider" to service provided beginning January 3, 2014.

N
 N
 N

In addition, customer bills under this rate are subject to the following adjustments and/or charges.

FUEL CLAUSE

Bills are subject to the adjustments provided for in the Fuel Clause Rider.

RESOURCE ADJUSTMENT

Bills are subject to the adjustments provided for in the Conservation Improvement Program Adjustment Rider, the State Energy Policy Rate Rider, the Renewable Development Fund Rider, the Transmission Cost Recovery Rider, the Renewable Energy Standard Rider and the Mercury Cost Recovery Rider.

ENVIRONMENTAL IMPROVEMENT RIDER

Bills are subject to the adjustments provided for in the Environmental Improvement Rider.

SURCHARGE

In certain communities, bills are subject to surcharges provided for in a Surcharge Rider.

(Continued on Sheet No. 5-46)

Date Filed:	11-04-13	By:	David M. Sparby	Effective Date:	01-03-14
			President and CEO of Northern States Power Company, a Minnesota corporation		
Docket No.	E002/GR-13-868			Order Date:	01-02-14

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MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2

PEAK CONTROLLED TIME OF DAY SERVICE
(Continued)
RATE CODE A24

Section No. 5
10th Revised Sheet No. 46

LOW INCOME ENERGY DISCOUNT RIDER

Bills are subject to the adjustment provided for in the Low Income Energy Discount Rider.

The following are terms and conditions for service under this tariff.

LATE PAYMENT CHARGE

Any unpaid balance over \$10.00 is subject to a 1.5% late payment charge or \$1.00, whichever is greater, after the date due. The charge may be assessed as provided for in the General Rules and Regulations, Section 3.5.

DEFINITION OF PEAK PERIODS

The on peak period is defined as those hours between 9:00 a.m. and 9:00 p.m. Monday through Friday, except the following holidays: New Year's Day, Good Friday, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day. When a designated holiday occurs on Saturday, the preceding Friday will be designated a holiday. When a designated holiday occurs on Sunday, the following Monday will be designated a holiday. The off peak period is defined as all other hours. Definition of on peak and off peak period is subject to change with change in Company's system operating characteristics.

DEFINITION OF PERFORMANCE FACTOR (PF)

Performance factor is defined in percentage terms as the average of the July and August calendar month unadjusted maximum Controllable Demand occurring from 1 p.m. to 7 p.m. on weekdays, or which has been permanently shifted out of normal control period times, divided by the unadjusted maximum annual Controllable Demand. Customers claiming permanent load shifts must provide verification to Company, based on NSP established criteria.

DETERMINATION OF DEMAND

Maximum Actual On Peak Period Demand in kW shall be the greatest 15-minute load for the on peak period during the billing month.

Adjusted On Peak Period Demand in kW for billing purposes shall be determined by dividing the Maximum Actual on peak demand by the power factor expressed in percent but not more than 90%, multiplying the quotient so obtained by 90%, and rounding to the nearest whole kW.

Maximum Actual Off Peak Period Demand in kW shall be the greatest 15-minute load for the off peak period during the billing month rounded to the nearest whole kW. In no month shall the off peak period demand for billing purposes be considered as less than the current month's actual off peak period demand in kW.

Off Peak Period Demand in Excess of On Peak Period Demand in kW to be billed shall be determined by subtracting the billing on peak period demand from the actual off peak period demand only if the off peak period demand is greater.

(Continued on Sheet No. 5-47)

Date Filed:	11-02-12	By: David M. Sparby	Effective Date:	12-01-13
		President and CEO of Northern States Power Company, a Minnesota corporation		
Docket No.	E002/GR-12-961	Order Date:	09-03-13	

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MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2

**PEAK CONTROLLED TIME OF DAY SERVICE
(Continued)
RATE CODE A24**

Section No. 5
5th Revised Sheet No. 47

Predetermined Demand shall be specified and agreed to by the customer and Company. Customer's adjusted on peak demand must not exceed the predetermined demand level (PDL) during a control period.

Standard PDL customers must agree to a fixed demand level and limit load to that level during a control period.

Optional PDL customers must agree to reduce demand by a fixed amount during a control period. Customer's Firm Demand will vary from month-to-month while the Controllable Demand remains fixed each month. The Firm Demand will be the Adjusted Demand (based on the Maximum Actual Demand for the month) less the fixed amount of Controllable Demand. Customer's PDL will be the monthly adjusted on peak demand less the fixed load reduction. Customers selecting the Optional PDL must either be equipped with back-up generation to provide the fixed load reduction or have a specific load that can be separately sub-metered and has an annual load factor of 90% or greater.

Firm Demand for the billing month shall be the lesser of Predetermined Demand or Adjusted on Peak Period Demand, except in months when customer fails to control load to Predetermined Demand Level when requested by Company. In these months, Firm Demand shall be the adjusted on peak period demand established during the control period. For Optional PDL customers, Firm Demand shall be Adjusted On Peak Demand less Controllable Demand, except in months when customer fails to control the full amount of their fixed Controllable Demand. In the months the Firm Demand shall be the Adjusted On Peak Period Demand less the amount of Demand that was controlled as shown by meter measurement.

Controllable Demand shall be the difference between Adjusted on Peak Period Demand during the billing month and the greater of Predetermined Demand or firm demand, but never less than zero.

Minimum On Peak Demand to be billed each month as either Firm Demand Controllable Demand or combination of both shall not be less than the current month's Adjusted on Peak Period Demand in kW.

POWER FACTOR

The power factor for the month shall be determined by permanently installed metering equipment.

ANNUAL MINIMUM DEMAND CHARGE

The Annual Minimum Demand Charge shall be no less than six times the average monthly Firm Demand Charge per kW times the predetermined demand, plus six times the Controllable Demand Charge per kW times the maximum Controllable Demand.

(Continued on Sheet No. 47.1)

Date Filed:	11-02-12	By: David M. Sparby	Effective Date:	12-01-13
		President and CEO of Northern States Power Company, a Minnesota corporation		
Docket No.	E002/GR-12-961		Order Date:	09-03-13

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MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2

PEAK CONTROLLED TIME OF DAY SERVICE (Continued)
RATE CODE A24

Section No. 5
4th Revised Sheet No. 47.1

TIER 1 ENERGY CONTROLLED SERVICE

Tier 1 Energy Controlled Service is available under this schedule subject to the provisions contained in the Tier 1 Energy Controlled Service Rider.

TIER 1 PEAK CONTROLLED SHORT NOTICE

Tier 1 Peak Controlled Short Notice option is available under this schedule subject to the provisions contained in the Tier 1 Peak Controlled Short Notice Rider.

COMPETITIVE SERVICE

Competitive Service is available under this schedule subject to the provisions contained in the Competitive Response Rider.

T

OTHER PROVISIONS

Peak Controlled Time of Day Service is also subject to provisions contained in Rules for Application of Peak Controlled Services.

TERMS AND CONDITIONS OF SERVICE

1. Alternating current service is provided at the following nominal voltages:
 - a. Secondary Voltage: Single or three phase from 208 volts up to but not including 2,400 volts,
 - b. Primary Voltage: Three phase from 2,400 volts up to but not including 69,000 volts,
 - c. Transmission Transformed Voltage: Three phase from 2,400 volts up to but not including 69,000 volts, where service is provided at the Company's disconnecting means of a distribution substation transformer, or
 - d. Transmission Voltage: Three phase at 69,000 volts or higher.

Service voltage available in any given case is dependent upon voltage and capacity of Company lines in vicinity of customer's premises.

2. Transmission Transformed Service is available only to customers served by an exclusively dedicated distribution feeder. Customer will be responsible for the cost of all facilities necessary to interconnect at the Company's disconnecting means of a distribution substation transformer.
3. Transmission Service is available at transmission voltage, subject to the terms and conditions contained in the Company's General Rules and Regulations, Section 5.1(B).

Date Filed:	11-02-12	By:	David M. Sparby	Effective Date:	12-01-13
			President and CEO of Northern States Power Company, a Minnesota corporation		
Docket No.	E002/GR-12-961			Order Date:	09-03-13

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**RULES FOR APPLICATION OF PEAK CONTROLLED
SERVICES**

Section No. 5
5th Revised Sheet No. 48

1. Customer has the responsibility of controlling own load to Predetermined Demand Level.
2. Customer must allow Company to inspect and approve the load control installation and equipment provided by customer.
3. If controlled demand is 10,000 kW or larger, Company may require customer to:
 - a. Provide auxiliary contacts for remote indication of position of switch or circuit breaker used to control demand and wire auxiliary contacts into a connection point designated by Company,
 - b. Install the remote breaker indication equipment provided by Company, and
 - c. Provide a continuous 120 volt AC power source at the connection point for operation of the Company remote breaker indication equipment.
4. Company will endeavor to give customer one hour notice of commencement of control period, and as much additional notice as is practical. However, control period may be commenced without notice should Company determine such action is necessary.
5. Failure to Control Charge: An additional charge of \$8.00 (\$10.00 for Tier 1) per kW will apply during each Company specified control period to the amount by which customer's Maximum Adjusted Demand or Maximum Adjusted On Peak Period Demand exceeds their predetermined demand level. After three such customer failures to control load to their Predetermined Demand Level, Company reserves the right to increase the Predetermined Demand Level, or transfer customer to General Service or General Time of Day Service and apply the cancellation charge specified in customer's Electric Service Agreement.
6. The duration and frequency of control periods shall be at the discretion of Company. Control periods will normally occur when:
 - a. Company expects a reasonable possibility of system load levels surpassing the level for which NSP has sufficient accredited capacity under the Midwest Reliability Organization (MRO) or any successor organization, including reserve requirements, or
 - b. In Company's opinion, the reliability of the system is endangered.

(Continued on Sheet No. 5-49)

Date Filed:	11-02-12	By: David M. Sparby	Effective Date:	12-01-13
		President and CEO of Northern States Power Company, a Minnesota corporation		
Docket No.	E002/GR-12-961		Order Date:	09-03-13

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MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2

RULES FOR APPLICATION OF PEAK CONTROLLED SERVICES (Continued)

Section No. 5
4th Revised Sheet No. 49

7. Customer must execute an Electric Service Agreement with Company which will include:

Peak Controlled Service - Tier 1

- a. A minimum initial 10 year term of service which includes a one year trial period and a three year cancellation notice effective after the initial term of service,
- b. The Predetermined Demand Level, or the fixed Controllable Demand if Optional PDL is selected which may be revised subject to approval by Company,
- c. Maximum 150 hours of interruption,
- d. Cancellation charge terms, and
- e. Control period notice.

Peak Controlled Service - Tier 2

- a. A minimum initial five year term of service which includes a one year trial period and a six month cancellation notice effective after the initial term of service,
 - b. The Predetermined Demand Level, or the fixed Controllable Demand if Optional PDL is selected which may be revised subject to approval by Company,
 - c. Maximum 80 hours of interruption,
 - d. Cancellation charge terms, and
 - e. Control period notice.
8. Peak Controlled Service customers choosing the Tier 1 rate option will be subject to an additional monthly charge for a Company approved and installed two-way communications system. The system equipment allows NSP to determine remotely customer load levels and to notify customers of control periods.
9. Minimum Controllable Demand during the Company's peak season shall be 50 kW.
10. Company shall not be liable for any loss or damage caused by or resulting from any interruption of service.
11. Company will determine, at a service location designated by Company, the number of services supplied. Customers requesting special facilities will be charged the additional costs incurred for such facilities.

(Continued on Sheet No. 5-50)

Date Filed:	11-02-12	By: David M. Sparby	Effective Date:	12-01-13
		President and CEO of Northern States Power Company, a Minnesota corporation		
Docket No.	E002/GR-12-961		Order Date:	09-03-13

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MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2

**RULES FOR APPLICATION OF PEAK CONTROLLED
SERVICES (Continued)**

Section No. 5
4th Revised Sheet No. 50

12. Customers choosing the Predetermined Demand Level option requiring a fixed demand reduction will be subject to an additional charge for metering and billing when additional metering equipment is necessary. The additional charge is \$17.00 per month for an application using a single meter in close proximity to customer's service point. The additional charge for more complex applications will be based on the actual costs of the specific application.
13. Company will maintain Firm Demand Charge rates at the General Service and General Time of Day Service levels, whichever is applicable.
14. Any customer with generating equipment which is operated in parallel with Company must comply with all requirements associated with parallel operations as specified in the General Rules and Regulations of the Company.
15. Any load served by customer generation during Company requested control periods must be served by Company at all other times.
16. Customers selecting Peak Controlled Services will normally remain at a specific Performance Factor level for a minimum of one year, subject to the Company's discretion. The Company may transfer customers between Performance Factor levels following verification of a customer's performance, as defined in the applicable rate schedule and as specified in the customer's Electric Service Agreement. This rate contemplates that increases in summer Controllable Demand, which thereby affect a customer's Performance Factor level, will be at sufficient consumption levels to yield a July and August calendar month load factor of 34% or greater. The Company reserves the right to limit the customer's eligibility to be on a higher Performance Factor level due to the above restriction.

Date Filed:	11-02-12	By: David M. Sparby	Effective Date:	12-01-13
		President and CEO of Northern States Power Company, a Minnesota corporation		
Docket No.	E002/GR-12-961		Order Date:	09-03-13

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Appendix B

Thermal zones used in energy model

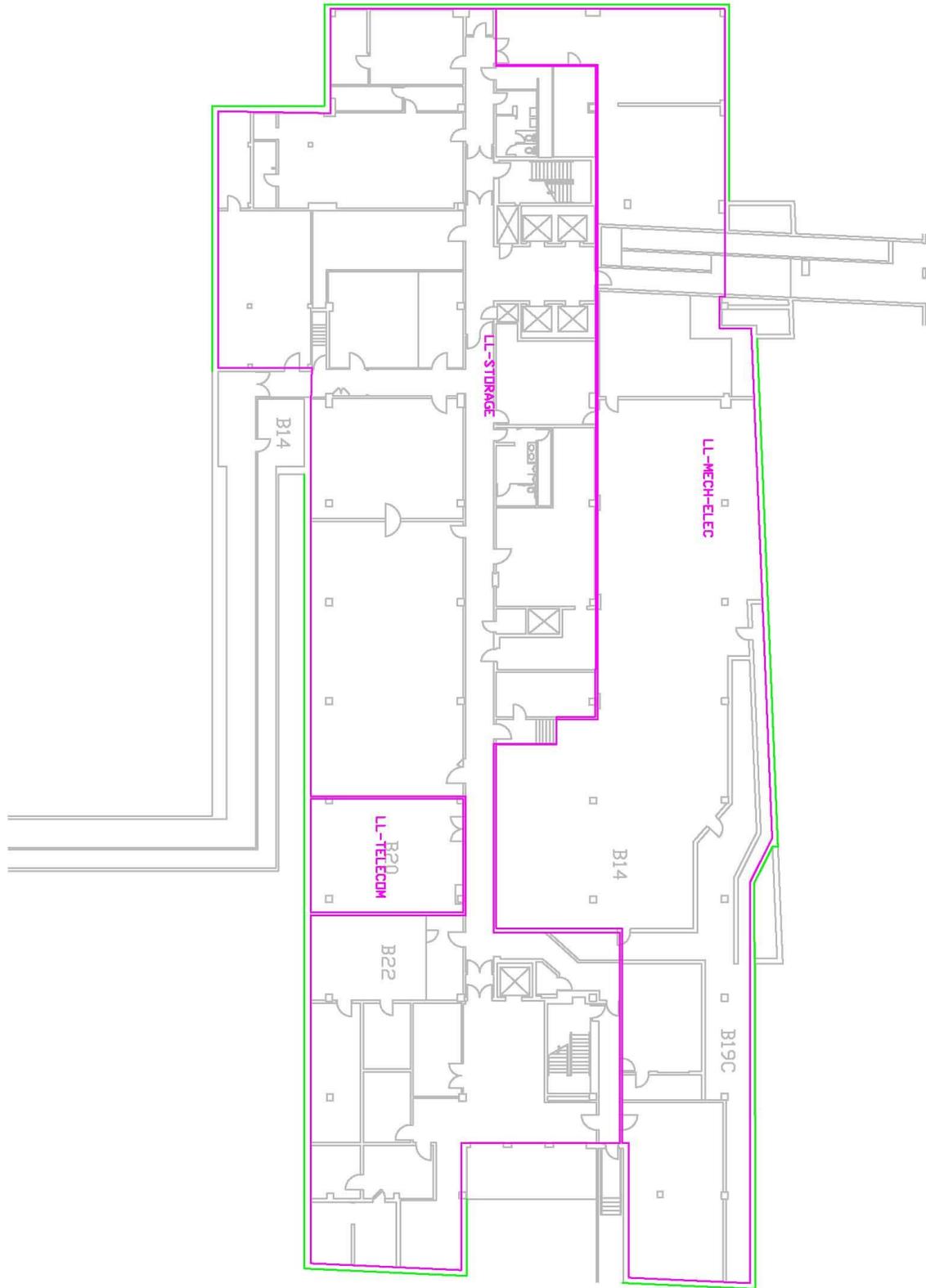


FIGURE 12: MODELED LOWER LEVEL ZONES

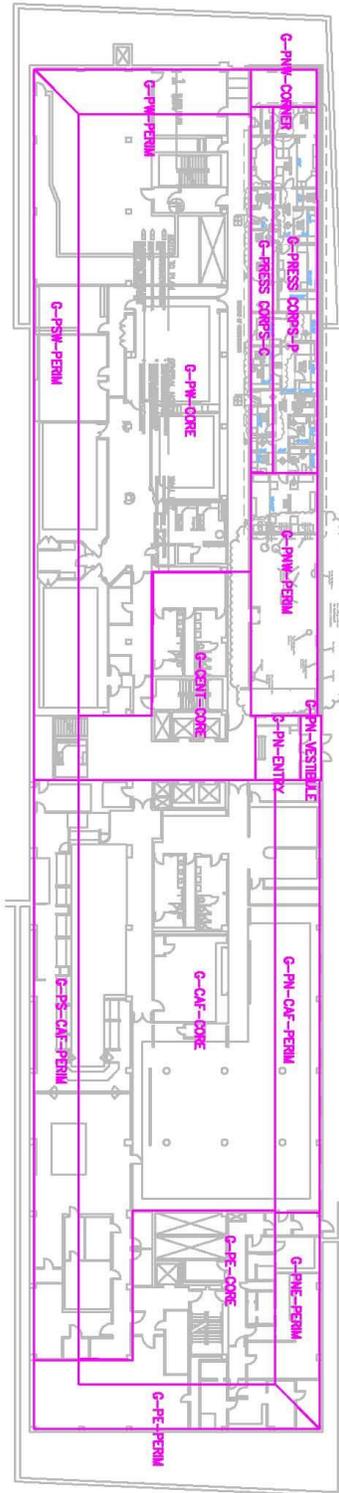


FIGURE 13: MODELED GROUND FLOOR ZONES

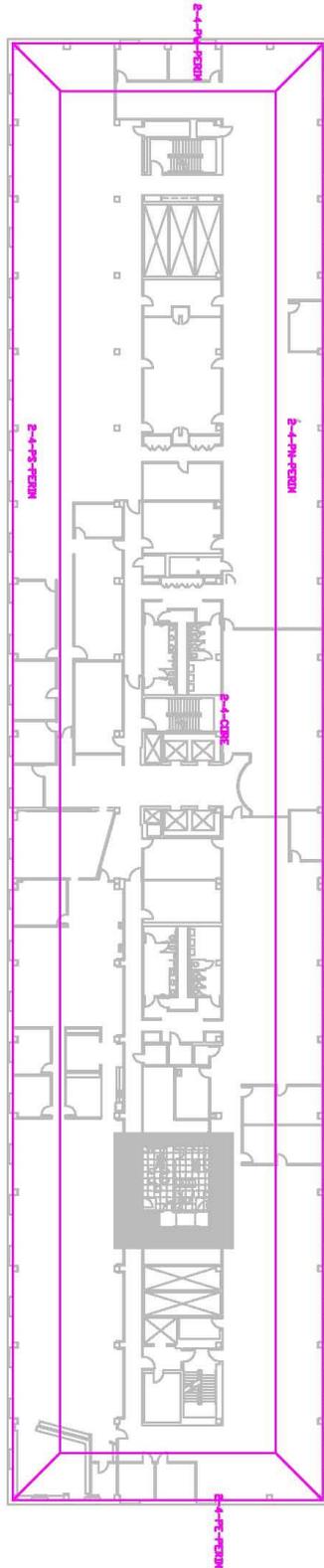


FIGURE 15: MODELED 2ND, 3RD, AND 4TH FLOOR ZONES

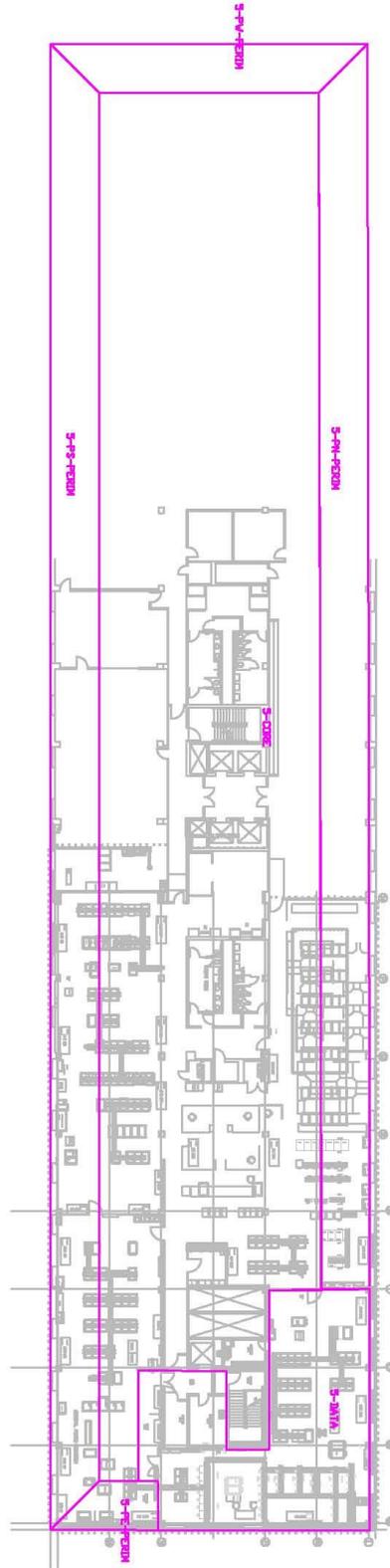


FIGURE 16: MODELED 5TH FLOOR ZONES