Eastside III

Pittsburgh, PA

Nina Italiano | Lighting + Electrical

Lighting Advisor: Kevin Houser

Electrical Advisor: John Reese

Final Report

April 3, 2017

Image courtesy of PJ Dick, Inc.

Eastside III

East Liberty, Pittsburgh, PA

Nina Italiano | L+E

nui106.wixsite.com

Building Statistics:

Occupancy | Mixed Use
retail + apartments + parking facility
Building Size | 221,000 SF

Number of Stories | 5 stories above grade
Project Cost | $200,000,000
Dates of Construction | June 2014 - June 2016

Project Team:

Owner | The Mosites Company
Architect | The Design Collective
General Contractor | PJ Dick, Inc.

MEP/FP | Allen & Shariff Engineering
Structural | Structural Consulting Assoc.
Interior Designer | RD Jones

Architecture

Eastside III consists of 5 stories with terraces, decks, multiple cladding types, including: storefront curtainwall, brick, fiber cement siding, stucco, and metal panels. The roofing system consists of a white thermoplastic polyolefin

Interiors + Lighting

Eastside III is comprised of mainly LED electric lighting technology and thermally insulated glazing to reduce solar gain from daylight exposure. Custom lighting fixtures are spread throughout Eastside III to compliment the prominent

MEP Features

Eastside III features various sustainability strategies, including: low-absorbing roofing material, high efficiency appliances, low-emitting materials, efficient hot water distribution, water efficient fixtures and proper envelope air

Executive Summary

Eastside III is the final phase of a revitalization project in the heart of the East Liberty neighborhood of Pittsburgh, PA. The 221,000 square foot building is a mixed-use development comprised of 43,000 square feet of mixed-commercial spaces, 175 luxury apartments, and a below grade parking garage. Eastside III brings new market-rate housing and a host of amenities to the neighborhood of East Liberty and contributes to the final portion of a 15-acre development that began in 2001. The entire development is broken up into three separate buildings, constructed in different phases: Buildings A, B and C. This thesis study focuses on Building B of Eastside III, highlighted below in Figure 1. Eastside III was developed jointly with a multi-modal transit hub to reconnect East Liberty to its surrounding neighborhoods and to redefine the residential experience in this trendy Pittsburgh community.

The following report accounts for all analyses, calculations, and design decisions performed during Penn State's Architectural Engineering Senior Thesis. This work includes the redesign of the following systems within Eastside:

- Lighting design within the building's amenity spaces
- Incoming electric distribution voltage supply to the residential units
- Daylighting within the double-height lobby in order to provide visual interest + reduce glare

Additionally, this report includes an assessment of the following items associated with the redesign:

- Construction cost and schedule for the proposed electrical system
- Acoustical impact of the proposed daylighting system in the double-height lobby

In an effort to contribute to the overarching goal of reconnecting Eastside III with its surrounding community, the design decisions performed in this thesis bring to life the uniqueness of Pittsburgh and its driving industrial characteristics. These decisions create an integrated, modern design that moves Eastside III forward into the revitalization of East Liberty, while still holding onto the roots of Pittsburgh's ***industry.***

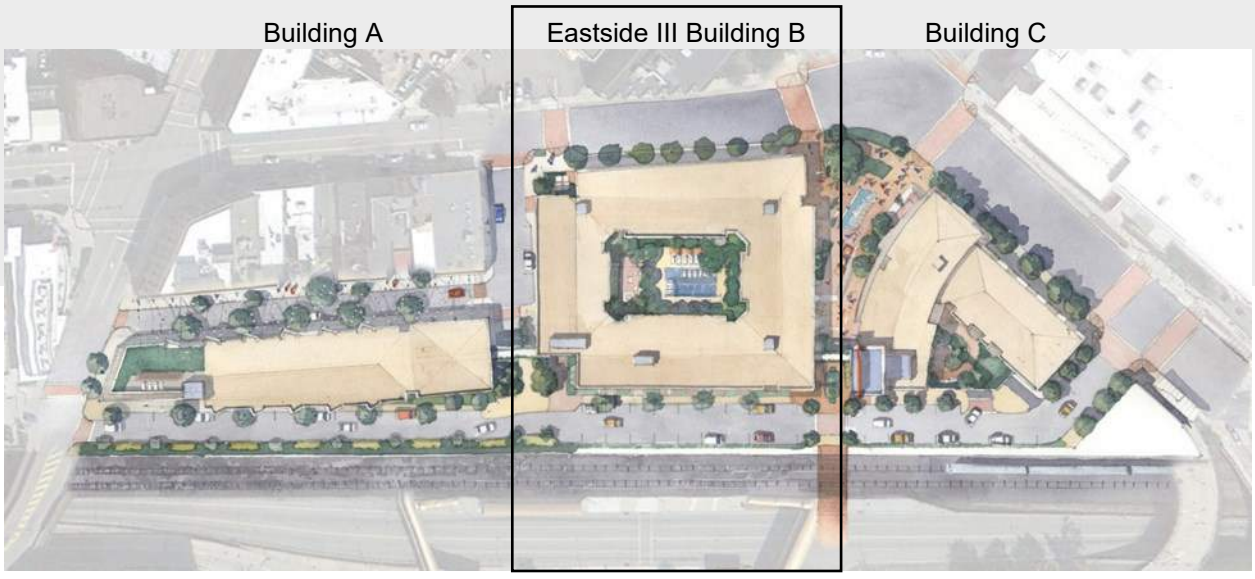

Figure 1 | Aerial view of Eastside III

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Building Statistics

| General Building Data

- Building Name | Eastside III Building B
- Location + Site | East Liberty, Pittsburgh, PA
- Building Occupant Name | Eastside Bond
- Occupancy or Function Type | Mixed Use Development

  Mixed Commercial Spaces

  175 Apartments

  Parking Facility
- Size | 221,000 total sf
- Number of Stories | 5 stories above grade + 2 stories below grade
- Primary Project Team

  Owner | The Mosites Company http://mosites.net/

  General Contractor | PJ Dick, Inc. http://www.pjdick.com/

  Architect | The Design Collective http://www.designcollective.com/

  MEP + FP | Allen & Shariff Engineering http://www.allenshariff.com/

  Structural | Structural Consultants Associates, Inc. http:/www.scaengineers.com/

  Interior Designer | RD Jones http://www.rdjones.com/
- Dates of Construction | June 2014 - June 2016
- Total Contract Price | $42 Million
- Project Delivery Method | Design-Bid-Build

Lighting Design

Depth

Lighting Design Depth

Introduction

This section is dedicated to the proposed final lighting design for Eastside III. The following sections include the proposed design's details, goals and criteria. Additionally, this section will include material descriptions, specified lighting fixtures, calculation summaries and applicable renderings. The spaces analyzed in the lighting design depth include the following:

- Lower Level Lobby + Lounge
- Kitchen + Billiard Room
- Fitness Center + Yoga Room
- Pool Courtyard

Concept Overview

Eastside III is in the final phase of a revitalization project in the heart of the East Liberty neighborhood of Pittsburgh, PA. The City of Pittsburgh and its current gentrification trend has transformed once low value neighborhoods, like East Liberty, into high value metropolitan areas. Eastside III has brought in new market-rate housing and host of amenities to the area.

Though the present and future of Pittsburgh is exciting, new and promising, we cannot forget the roots of such a distinguished industrial and commercial city. The city's **industry** is what *makes Pittsburgh, Pittsburgh*. The steel industry, the bridges, the train tracks, the smog of the 1950's.

The lighting design throughout Eastside III will highlight and bring to life just that - the city, the neighborhood, and the building's **industry**. The strong interior design and architecture within Eastside III speaks for its industrial feel itself, and the lighting will simply *highlight* this prominent identity of Eastside.

Throughout each space, the lighting design will call to attention the materials that gives each space its identity - its **industry**.

| Lighting Design Depth

Lower Level Lobby + Entertainment Lounge

Description

The Lower Level Lobby and its adjacent Entertainment Lounge (E-Lounge) is located on the ground floor of the Eastside III, one floor below what is considered the main lobby the residential area. The Lower Level Lobby is adjacent to retail spaces on the North and an underground parking garage on the South. The lighting in this space is designed to compliment the lobby's double-height ceiling, unique aesthetics features, and functionality of the space.

Dimensions:

Lower Level Lobby

- Area - 1,250 sf
- Height - 29'-6"

E-Lounge

- Area - 416 sf
- Height - 10'-6"

Tasks + Activities:

The primary function of the lobby space and entertainment lounge is for transition and lounge seating areas.

Figure 1.1 | Ground Floor - Existing Lower Level Lobby

Lighting Design Depth

Lower Level Lobby + Entertainment Lounge

Location + Drawings:

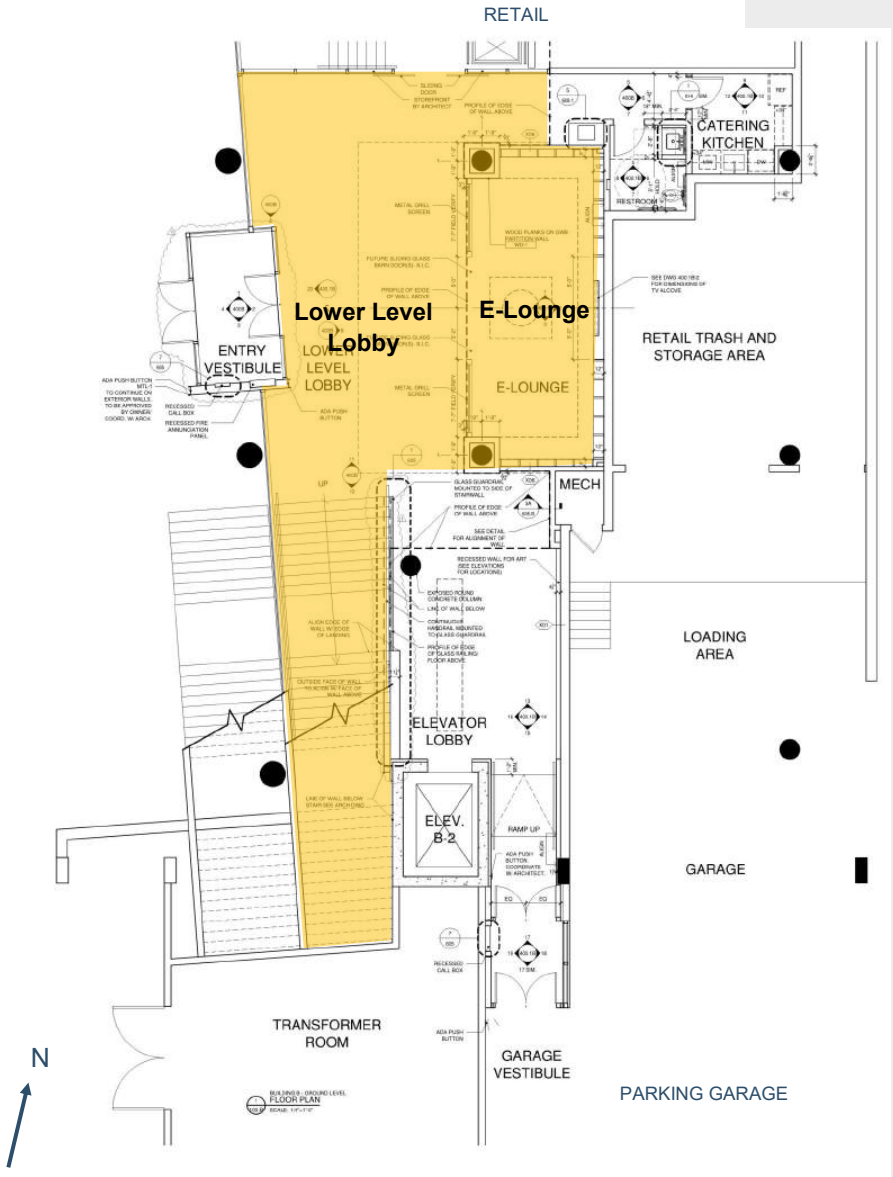
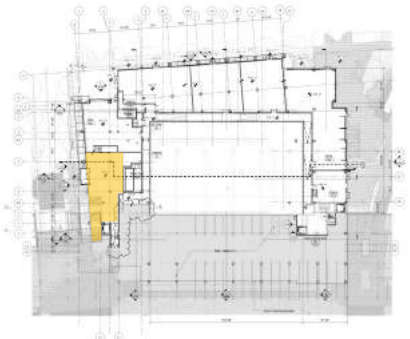


Figure 1.2 | Ground Floor Plan - Lower Level Lobby



Ground Floor Key Plan

Location + Drawings:

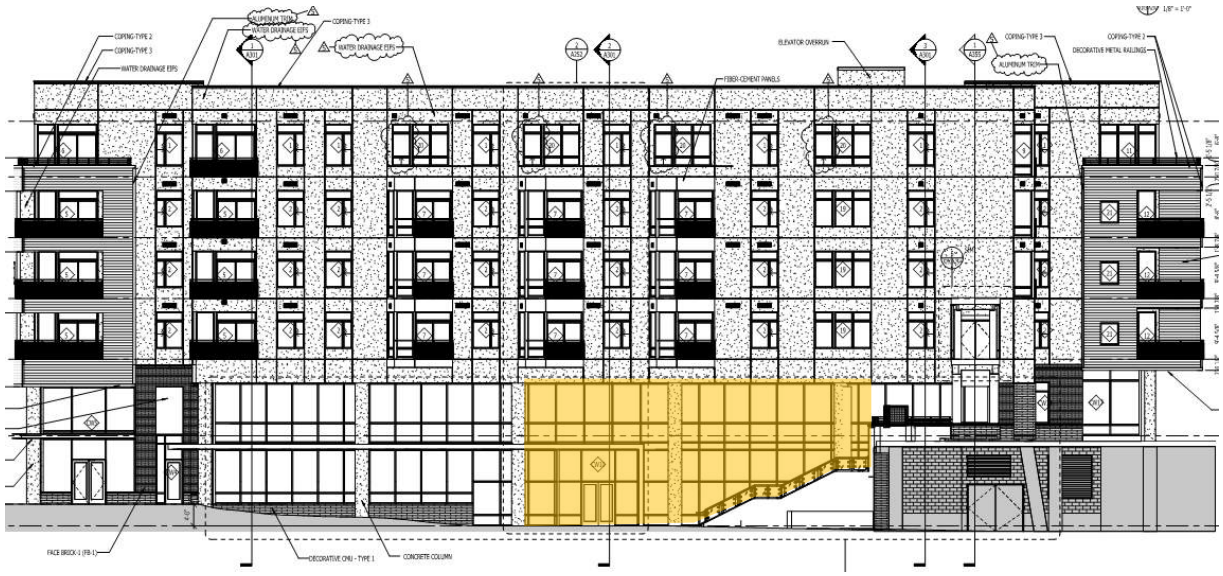


Figure 1.3 | Southwest Elevation - Lower Level Lobby

Materials + Finishes:

The materials in the Lower Level Lobby, and throughout the remaining residential common spaces of Eastside III, are designed to create a modern, industrial feel to signify the steel industry of Pittsburgh. There is a large variety of materials within the space to create this feel - including materials with warm, neutral finishes, warm color tones, and metallic/steel features.

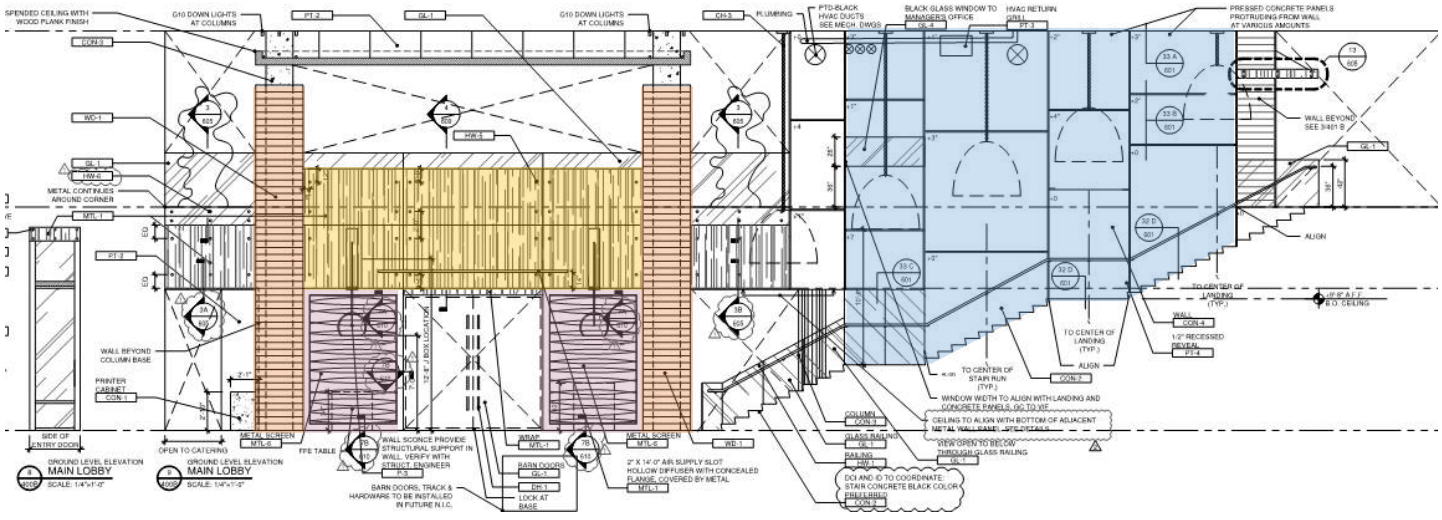


Figure 1.4 | Ground Floor Interior Elevation - Lower Level Lobby

Materials + Finishes:

Table 1.1 | Material Specifications - Lower Level Lobby

Space	Surface Type	Symbol Color	Description	Material Type	Manufacturer	Color	Product Name	Reflectance
Lower Level Lobby	Floor		Ceramic Tile	T-1	Mosaic Tile Co	Matte Black	Evolve Collection	0.3
	Exposed Ceiling		Painted GWB	PT-2	Benjamin Moore	Black	Ultra Spec 500, 2128-10 Black Beauty	0.3
	Suspended Ceiling		Wood Plank Finish	WD-2	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.4
	Walls		Concrete	CON-4	by GC (PJ Dick)	Light Grey	-	0.5
			Metal Grill Screen	MTL-6	Wylie System	Matte Black	Custom Metal Grill	0.3
			Metal Panels	MTL-1	Guitierrez Studios	Grey	Hot Rolled Steel Sheet	0.5
	Columns		Wood Covering	WD-1	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.4
	Curtainwall		Glass	Low-E Glass	Guardian Glass	70/36 + IS-20	ClimaGuard 70/36, 1"	0.68 (trans)

Materials + Finishes:

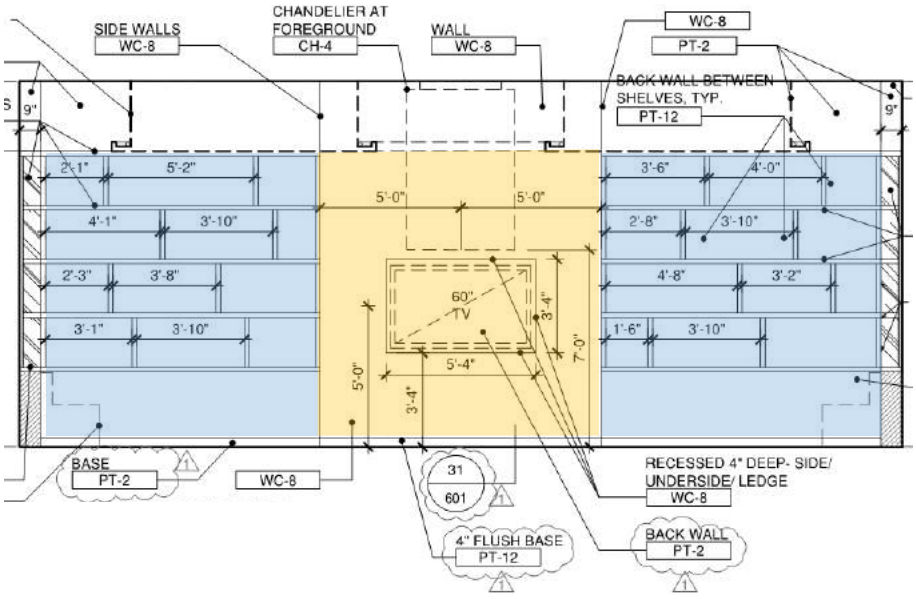


Figure 1.5 | Ground Floor Interior Elevation - Entertainment Lounge

Table 1.2 | Material Specifications - Entertainment Lounge

Space	Surface Type	Symbol Color	Description	Material Type	Manufacturer	Color	Product Name	Reflectance
E-Lounge	Floor		Carpet	CPT-6	J+J Invision	Tan	Revue Modular 7906, 551 Bond	0.3
	Ceiling		Painted GWB	PT-5	Sherwin Williams	Tan	Eco Spec, SW6102 Portabello	0.5
	Ceiling, above sculpture		Painted GWB	PT-2	Benjamin Moore	Black	Ultra Spec 500, 2128-10 Black Beauty	0.3
	Barn Doors		Glass	GL-2	Forms + Surfaces	White	ViviChrome Scribe, 5/16"	0.7
	Walls		Metal Shelves	MTL-4	Chemetal	Dark Grey	Alu Dark	0.3
			Wallcovering Pattern	WC-8	MDC	Red	Pattern #MRA4913, Esquire	0.4

Overall Design Goals

As stated in the lighting concept overview, the lighting within this space is designed to accent the unique materials of the Lower Level Lobby and E-lounge.

Figure 1.6 | Schematic Lighting Design - Lower Level Lobby

Design Criteria + Considerations:

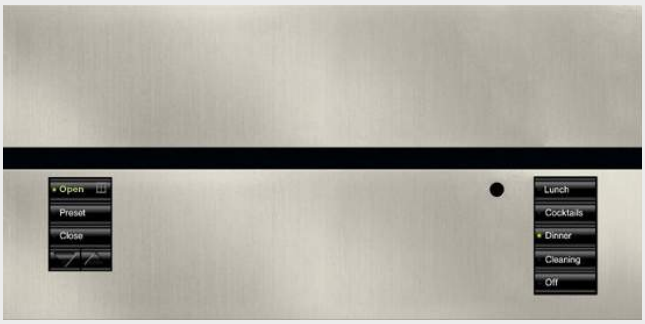
The materials in the Lower Level Lobby, and throughout the remaining residential common spaces of Eastside III, are designed to create a modern, industrial feel to signify the steel industry of Pittsburgh. There is a large variety of materials within the space to highlight in order to create this feel. Specifically, the lighting will be focused on highlighting the protruding concrete wall along the stairs and creating a unique pattern from the custom metal panels - illustrated in the schematic design image above. The metal panel pattern was redesigned to compliment the *industry* concept and correlate with the daylighting and acoustical solutions (see Daylighting Depth + Acoustical Breadth for more information).

Controls:

The lighting within the Lower Level Lobby will be controlled through a Lutron GRAFIK Eye QS interface that is located at the concierge desk in the Main Lobby on the first floor. Every lighting type will be on its own zone and controlled separately from the GRAFIK Eye. The interface will be able to program scenes as desired by the owner.

A time-clock feature will control the general illumination, spotlights within the Entertainment Lounge, and decorative floor lamps at the lobby lounge to be dimmed/off during the day and trigger on at sunset. The remaining zones will have the capability to be on a time-clock as well, if desired.

Occupancy sensors will be placed along the staircase and within the Entertainment Lounge. The E-lounge will also have a smaller interface for personal control while in the space. This will be achieved through a Lutron seeTouch QS keypad that controls the cove lighting and spotlights.



GRAFIK Eye QS:
Concierge Desk | Main Lobby

seeTouch QS Control:
Entertainment Lounge

Glare:

The main concern in the Lower Level Lobby is solar glare in the lounge and seating areas. As discussed earlier in this report, a daylighting analysis was performed to prevent glare in these spaces through tinted glass. The artificial lighting around the seating areas was also designed with glare in mind. The cove lighting in the Entertainment Lounge was designed to ensure that the fixture was hidden from any direct views of the occupants.

Visual Interest:

The daylighting in the Lower Level Lobby, along with the artificial lighting design, was designed to create visual interest within the space. A patterned daylighting panel was designed on a section of the curtain wall to create a unique pattern from sunlight throughout the day and different times of the year. As mentioned in the controls narrative, a similar pattern of light will be controlled during the night in the lobby - through similar patterned panels that are backlit and projects the patterned light onto the floor.

| Lighting Design Depth

Lower Level Lobby + Entertainment Lounge

The aesthetic appeal of this space guided the *qualitative* desires of the lighting design solution, which was previously introduced. In addition to the qualitative design goals, *quantitative* data was explored for the lobby, introduced below.

Illuminance + Uniformity Requirements:

The values found in Table 1.3, represent the recommended illuminance design criteria (measured in lux) by the IES Lighting Handbook for the Lower Level Lobby + Entertainment Lounge. Though these illuminance values are used as a *recommendation* rather than a *requirement,* they are important to achieve in order to fulfill the functions and tasks of the space properly. Since this space is mainly used for circulation, the importance of achieving the uniformity ratio, listed in Table 1.3, is not as crucial as achieving proper illuminance values. This idea is further discussed under the *Uniformity* section of the

Table 1.3 | Illuminance Requirements - Lower Level Lobby

Space	Task	E horizontal (lux)	E vertical (lux)	Avg/Min (Eh)	Daylight
Lower Level Lobby	Circulation: General, Day	100	30	4:1	✓
	Circulation: General, Night	50	20		
	Lounge: Reading/Work Areas on Table	150	50	-	
Entertainment Lounge	Lounge: Reading/Work	150	50	-	✓
Vestibule	Entry, Low Activity: Day	75	30		✓
	Entry, Low Activity: Night	40	15		

Lighting Power Density:

The lighting power density (LPD) was determined using ASHRAE 90.1 2007 standards. The LPD is defined as the allowable watts/square foot for all spaces in the building. This can be calculated using a space-by-space method, or by building type. The LPDs calculated for Eastside III used the space-by-space method. Below is a summary of the Lower Level Lobby's lighting power density. The redesign of this space should exceed ASHRAE 2007 standards and comply with ASHRAE 90.1 2013.

Table 1.4 | LPD Criteria - Lower Level Lobby

Space	Space Description	Allowance (W/SF)
Lower Level Lobby + E-Lounge	Lobby	1.3

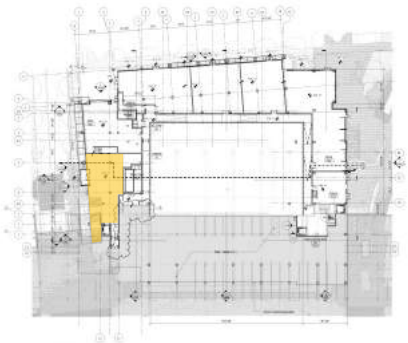
Lighting Layout

Lower Level Lobby RCP:

Refer to the lighting schedule on Table 1.5 for more information on the fixture selection for the Lower Level Lobby.

The main lighting design focus of the Lower Lobby is the suspended wall grazing system, highlighting the protruding concrete wall along the stairs (orange). Also, the lighting solution around the lobby seating provides a sleek and decorative design (red).

In addition to these specialty lighting features within the lobby, general illumination is provided through downlights recessed into the drop ceiling and suspended cylinder fixtures.



Ground Floor Key Plan

Figure 1.7 | Lighting Layout - Lower Level Lobby

Fixture Selection

Table 1.5 provides the fixtures specified for the Lower Level Lobby. Most fixtures were chosen with a 2700K color temperature, to provide warm illumination in the space. This decision was made based on the existing lighting color temperature and the residential aspect of the building. The fixtures that are applied as a grazer, are specified at 3000K to bring greater emphasis and contrast to these surfaces.

Table 1.5 | Lighting Schedule - Lower Level Lobby

Type	Symbol	Image	Description	Manufacturer	Count	Mounting	Lamp	Wattage
L1B			4" Open Downlight, Med-Wide Beam, Specular finish, Clear Aperature and trim, Dimmable	Gotham 4" Evo Downlight	4	Recessed Downlight	LED, 2700K, 750 lms	10 W
L2B			4" Open Cylinder Downlight, 30° Beam, Specular finish, Clear Aperature and trim, Dimmable	Gotham 4" Incito Cylinder	13	Suspended Cylinder Downlight	LED, 2700K, 750 lms	10 W
L3			4' Pendant Asymmetric Wallwasher, 10x30 Bi-Symmetric Optic, Regular Output, Dimmable	Lumenpulse Lumenfacade	12	Suspended Linear Grazer	LED, 3000K, 1730 lms	8.5 W/ft
L4			In-Ground LED Floodlight, Symmetric Distribution	Bega In-Ground	2	Recessed In-Ground	LED, 3000K, 685 lms	13 W
L5			6' Tall Linear LED, Walnut finish, Powder-coated mattle black steel base	Stickbulb 6ft Floor Torch	3	Floor Lamp	LED, 2700K, 397 lms	19.8 W

Lighting Layout

Entertainment Lounge RCP:

The main focus of the Entertainment Lounge is the diamond patterned panels that create a unique lighting pattern during the night. The E-Lounge also features shelf lighting and cove lighting to direct the illumination towards the center seating area.

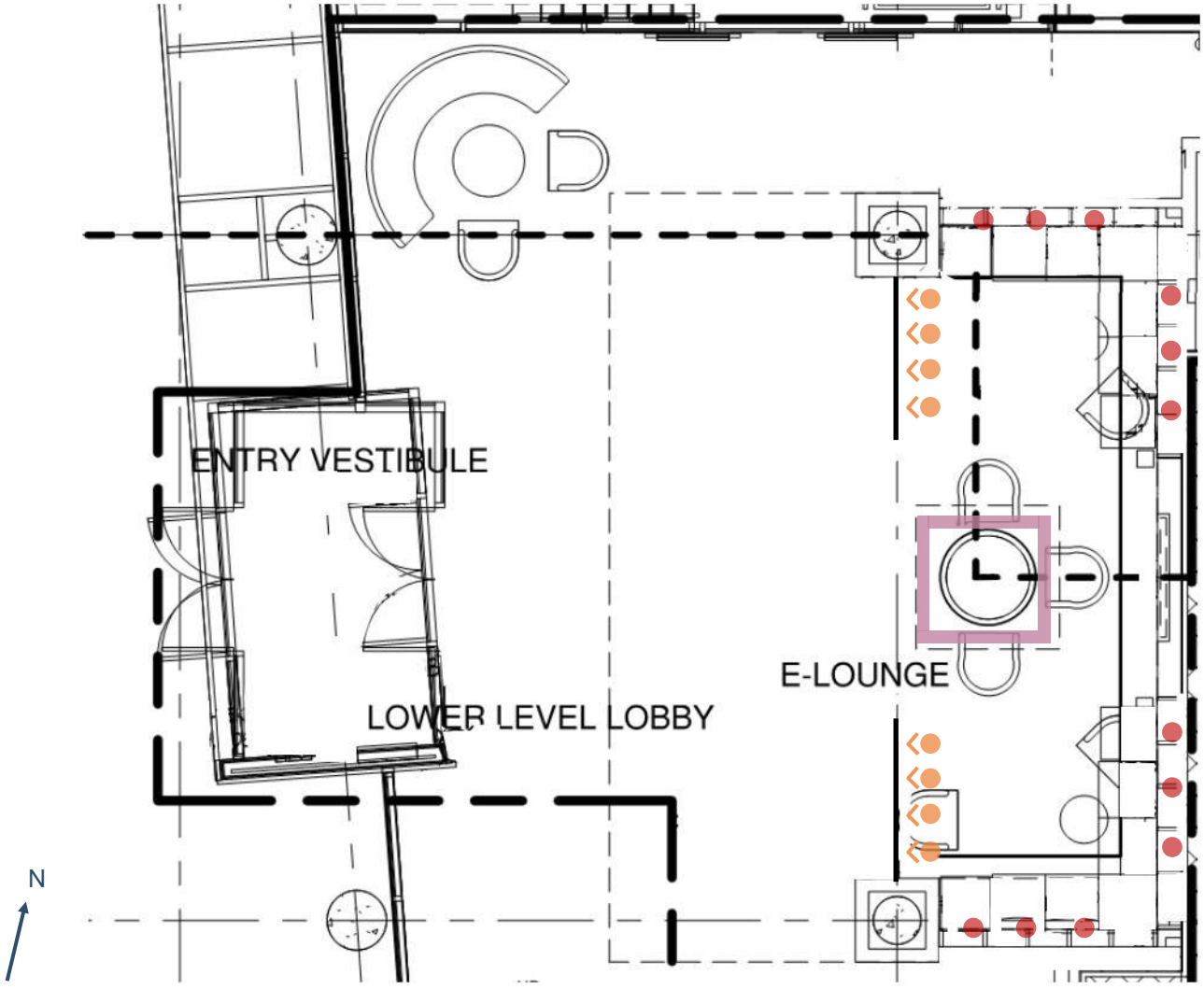
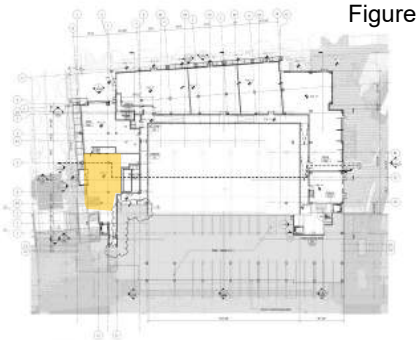


Figure 1.8 | Ground Floor Lighting Layout - Lower Level Lobby + E-Lounge



Ground Floor Key Plan

Fixture Selection

Table 1.6 | Lighting Schedule - Entertainment Lounge

Type	Symbol	Image	Description	Manufacturer	Count	Mounting	Lamp	Wattage
L6			3" Square LED Downlight, Adjustable, 40° Beam Distribution, Dimmable	Lumenpulse Lumenalpha Downlight	8	Recessed Downlight	LED, 2700K, 700 lms	7 W
L7			4' Surface-mount, Asymmetric Uplight, Softening Lens, White finish, Dimmable	LF Illumination EF600 Series	6	Surface Mount Cove Uplight	LED, 2700K, 400 lm/ft	4 W/ft
L8			1.7" Small Scale LED Downlight, Machined Aluminum, Dimmable	Lucifer PUKLED Downlight	48	Recessed in shelves	LED, 2700K, 175 lms	2.5 W

Calculations

Tables 1.7 and 1.8 provide the calculated power density and illuminance levels for both the Lower Level Lobby and Entertainment Lounge - based on ASHRAE 90.1 standards and the IES Handbook recommendations.

Lighting Power Density Calculation:

Table 1.7 | Illuminance Requirements - Lower Level Lobby + Entertainment Lounge

Fixture Type	Total Fixtures	Watts/ Fixture	Total Watts (W)	Area (sf)
L1B	4	10	40	1250
L2B	13	10	130	
L3	12	8.5 W/ft	408	
L4	2	13	26	
L5	3	19.8	59.4	
L6	8	7	56	
L7	6	4 W/ft	96	
L8	48	2.5	120	
		Calculated W/sf		0.748
		Allowed W/sf		1.3
		Pass?		YES
		% below ASHRAE?		42%

Illuminance Summary:

Table 1.8 | Illuminance Levels - Lower Level Lobby + Entertainment Lounge

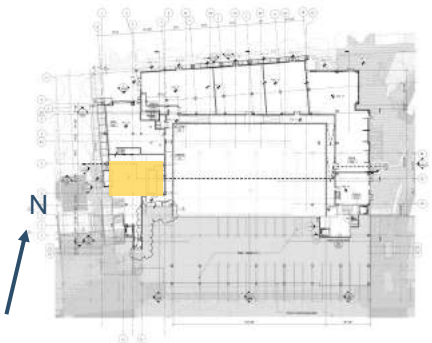
Space	Task	*Recommended Avg. Illuminance (lux)*	Achieved (lux)	*Recommended Avg./Min*	Achieved Avg./ Min
Lower Level Lobby	Circulation: General, Day	100	124	4:1	2.5
	Circulation: General, Night	50	*see note*		-
	Lounge: Reading/Work Areas on Table	150	125	-	1.7
Entertainment Lounge	Lounge: Reading/Work	150	116	-	1.45
Vestibule	Entry, Low Activity: Day	75	73	-	1.5
	Entry, Low Activity: Night	40	*see note*	-	-

Note: The calculated illuminance levels for the circulation spaces were designed to reach *day* recommendations. However, they are designed to be dimmed when daylight is present and at night when half the illuminance levels are recommended.

Lower Level Lobby + Entertainment Lounge

Illuminance Calculations:

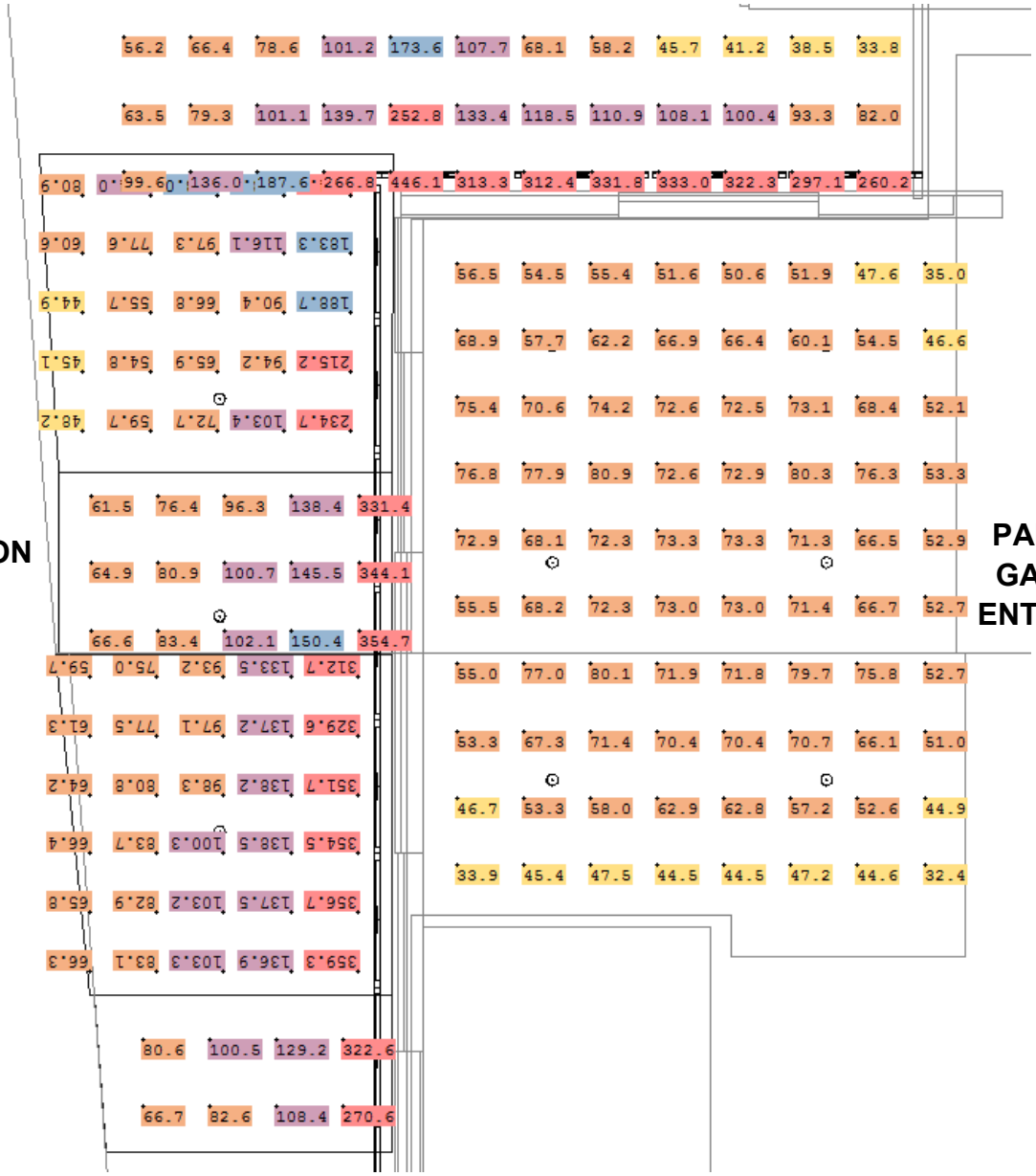
Illuminance Calculation Key	
Colors	Range (lux)
	0 - 50
	50 - 100
	100 - 150
	150 - 200
	200 - 250



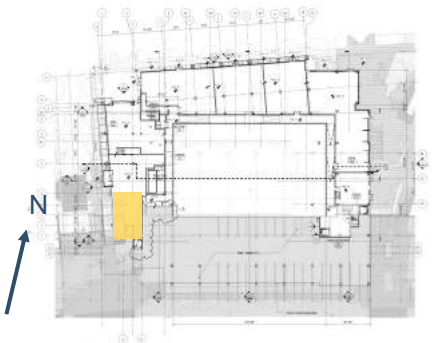
Lighting Design Depth

Lower Level Lobby + Entertainment Lounge

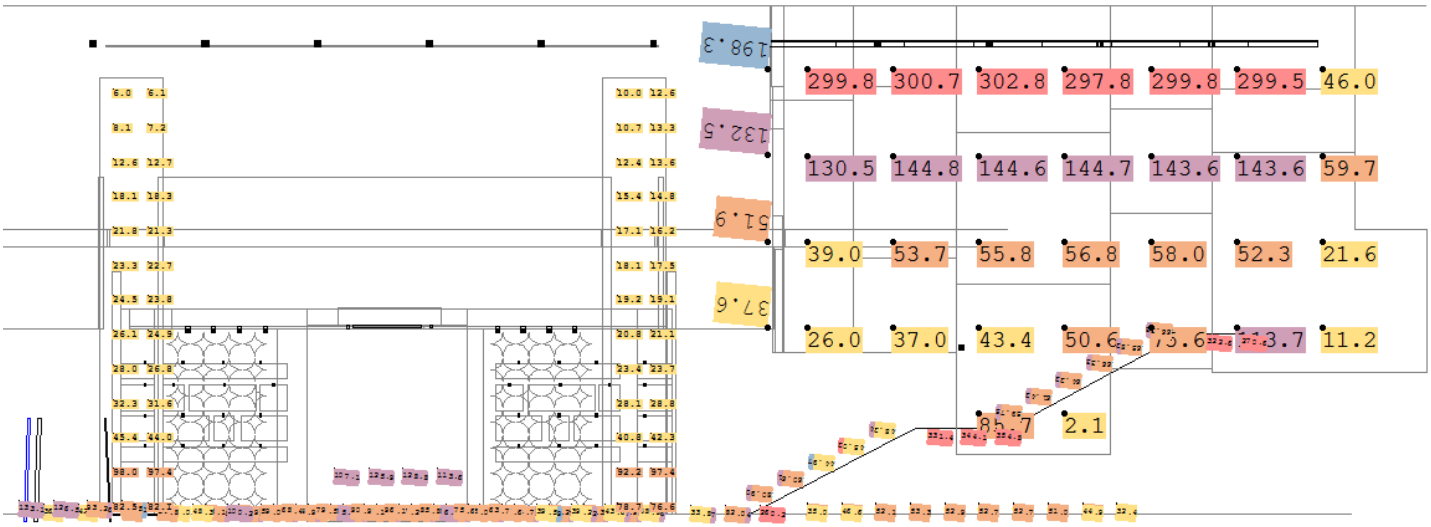
Illuminance Calculations:



Illuminance Calculation Key	
Colors	Range (lux)
	0 - 50
	50 - 100
	100 - 150
	150 - 200
	200 - 250



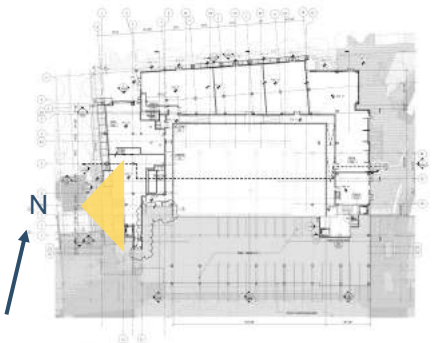
Illuminance Calculations:



E-LOUNGE / METAL PANELS

CIRCULATION STAIRS / TEXTURED CONCRETE WALL

Illuminance Calculation Key	
Colors	Range (lux)
	0 - 50
	50 - 100
	100 - 150
	150 - 200
	200 - 250



AGi32 Renderings

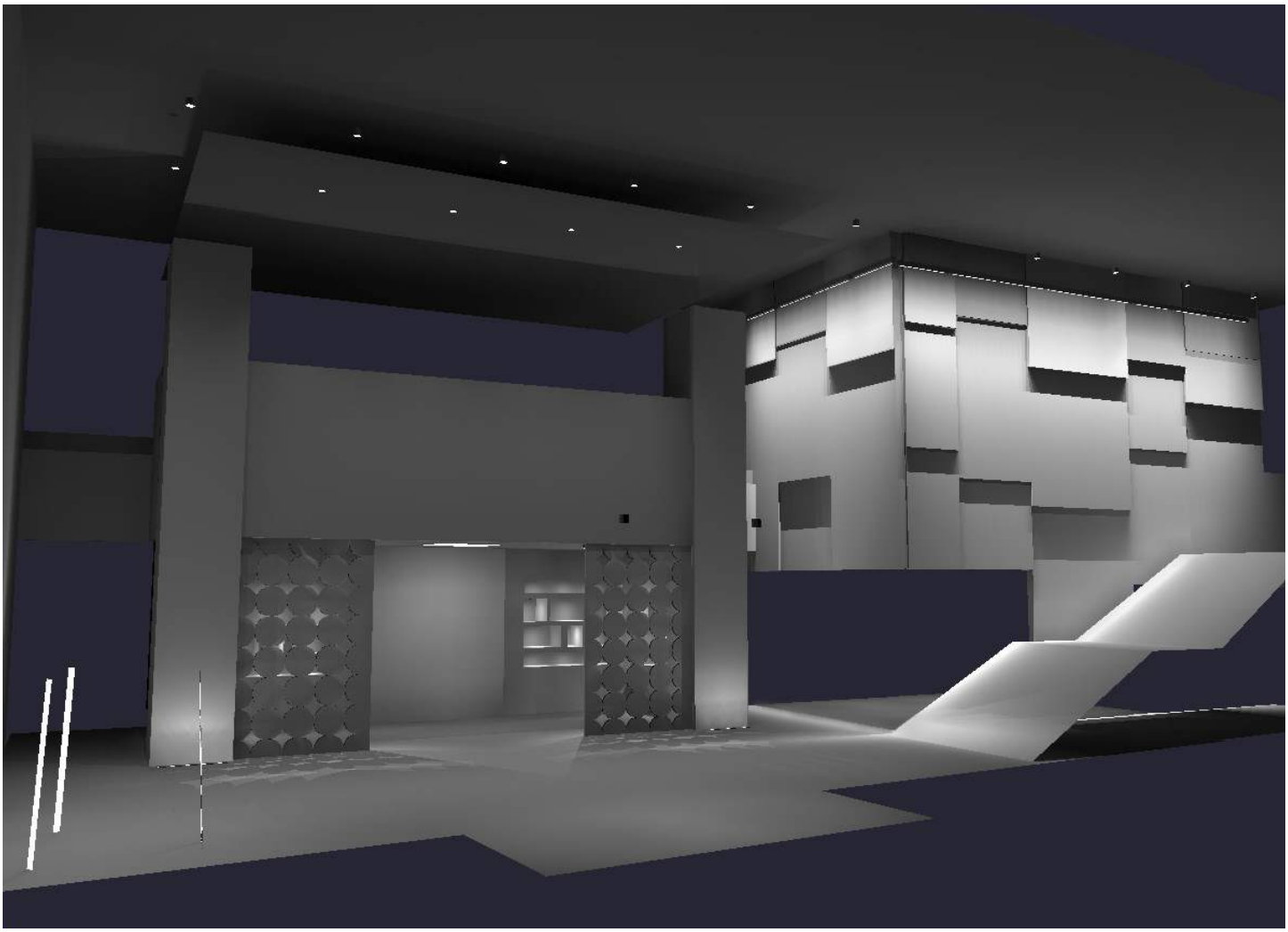
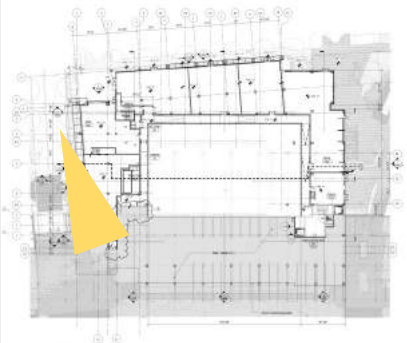


Figure 1.9 | AGi32 Greyscale - Perspective View of Lower Level Lobby + Entertainment Lounge



AGi32 Renderings

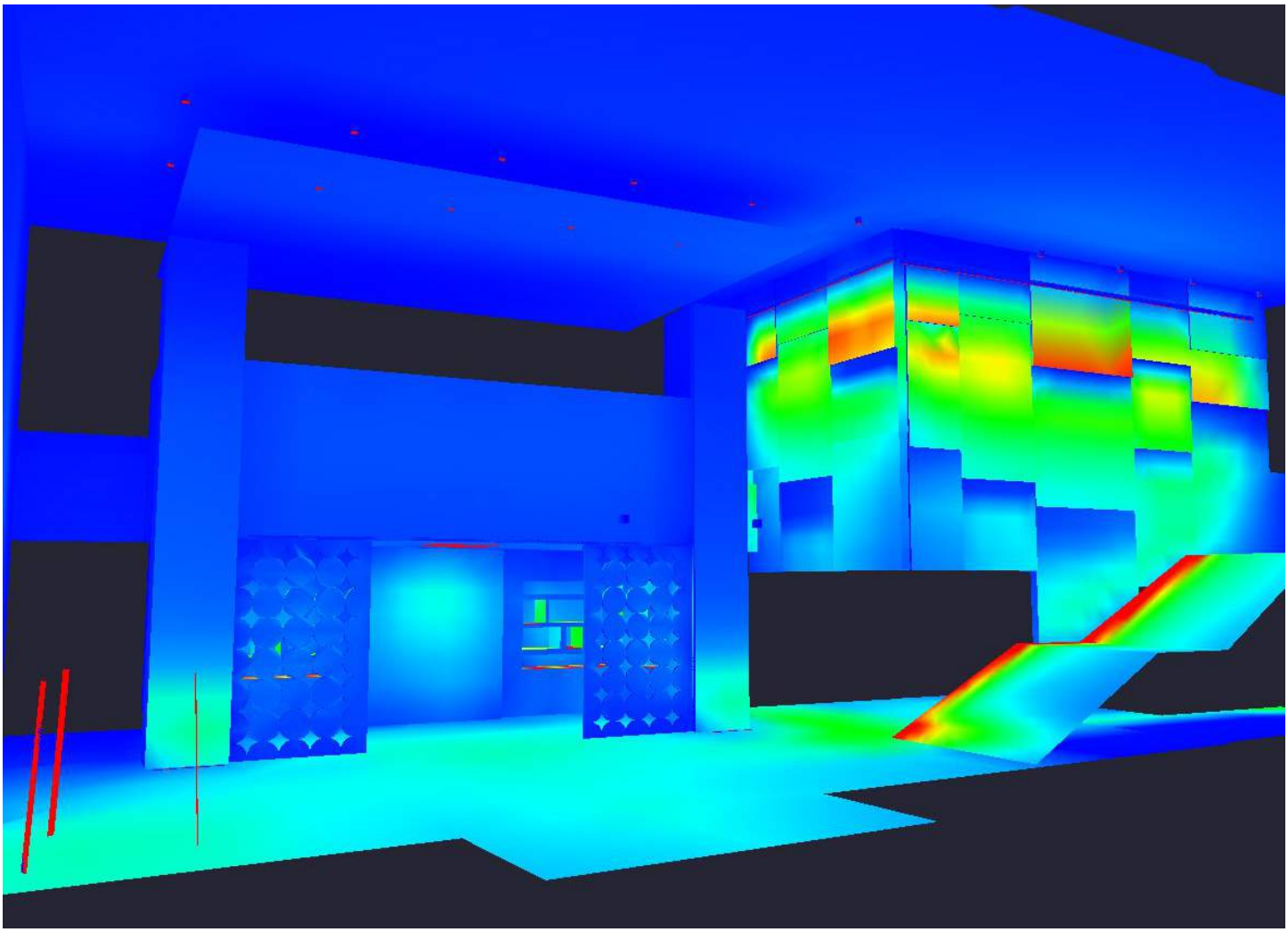
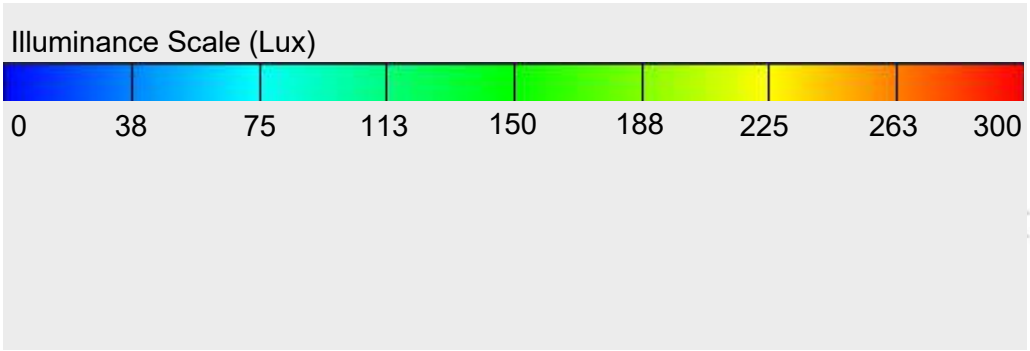
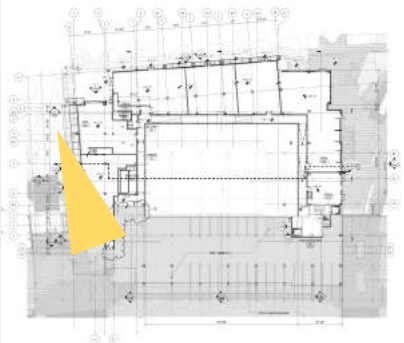


Figure 1.10 | AGi32 Pseudo Color - Perspective View of Lower Level Lobby + Entertainment Lounge





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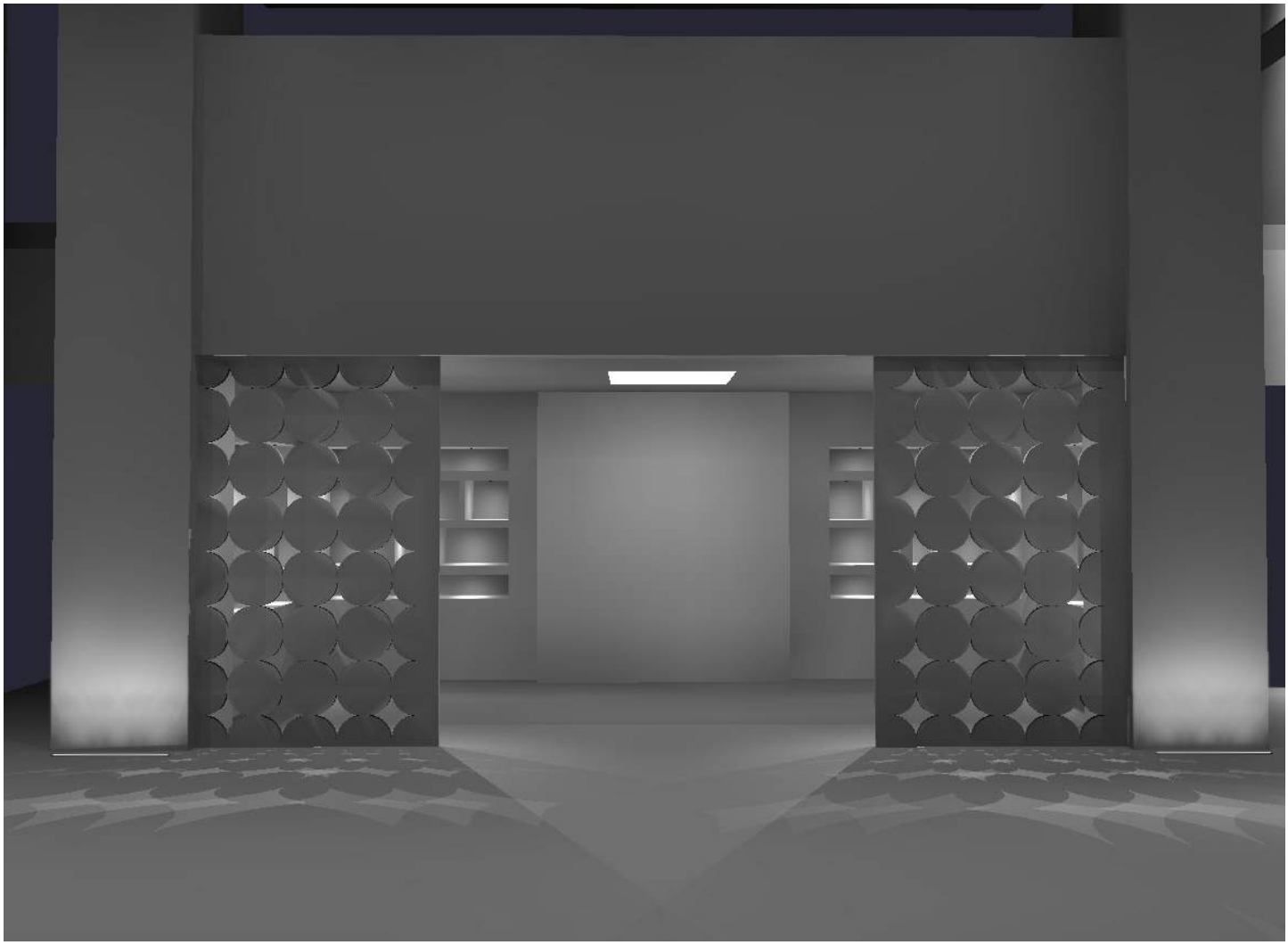
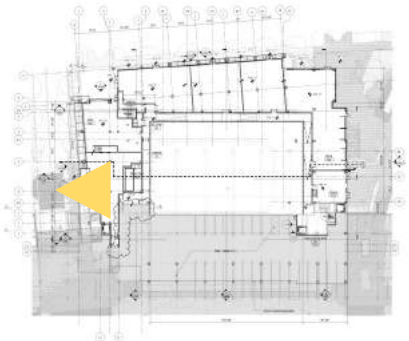


Figure 1.11 | AGi32 Greyscale - Elevation View of Entertainment Lounge



AGi32 Renderings

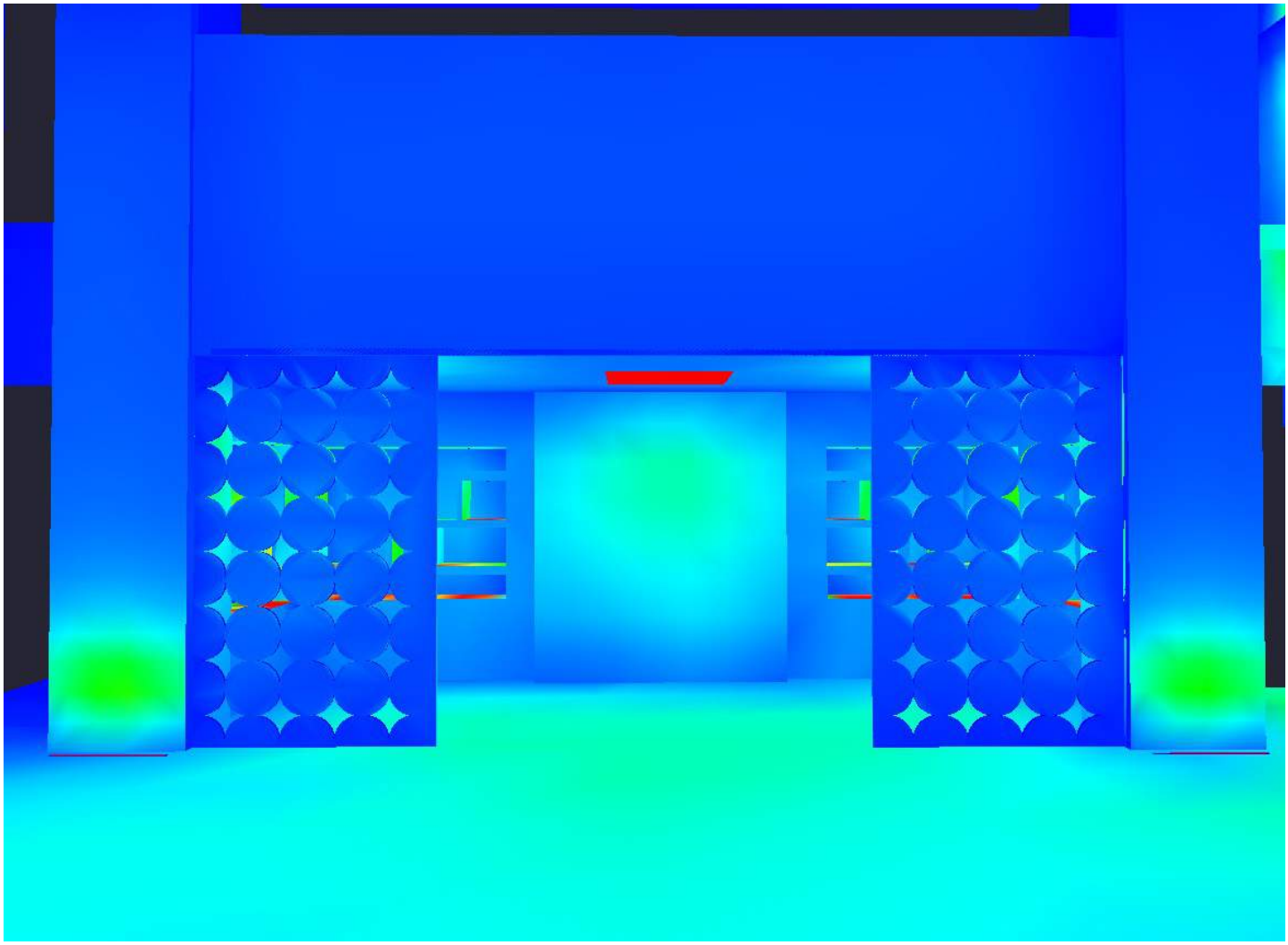
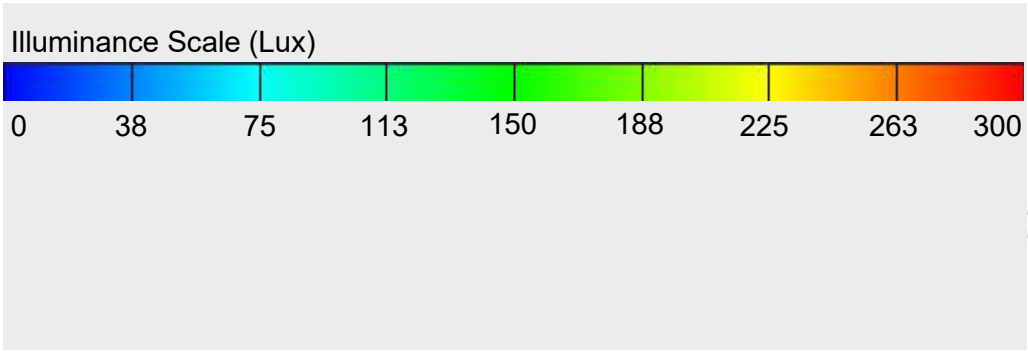
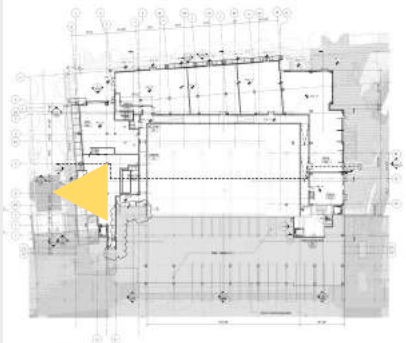


Figure 1.12 | AGi32 Pseudo Color - Elevation View of Entertainment Lounge





Final Renderings

Evaluation

The Lower Level Lobby + Entertainment lounge effectively achieve the qualitative goal of creating visual interest as well as achieving numerical illuminance goals. The design goal of visual interest is achieved through artificial lighting strategies such as: the grazing along the protruding concrete wall along the stairs - which creates levels of contrast and the projected patterns of light onto the lobby floor as a result of the backlit metal panels within the Entertainment Lounge. Visual interest is also achieved through daylighting, with the implementation of similar metal panels of the E-Lounge, placed along the curtain wall to project patterns of sunlight throughout different times of the day. This will be later explained in the Daylighting Depth.

The metal panels in the Entertainment Lounge and along the curtain wall were custom designed to project a particular pattern of light into the space - the symbol for *steel*, which represents the once largest industry of the City of Pittsburgh. Overall, the Lower Level Lobby + Entertainment Lounge compliment the existing aesthetics and materials within Eastside III, while adding its own areas of *industry* to the space.

| Lighting Design Depth

Entertainment Kitchen + Billiard Room

Description

Within the first level of Eastside III, there are multiple amenities offered for the residences of the apartments above. Some of these amenities include an Entertainment Kitchen and Billiard Room, which will be analyzed together as a special purpose space. Though these spaces in and of themselves have separate purposes, their overall lighting concept will compliment one another and provide a psychological impression of a public + private space. Since these spaces are *public* areas within the building, yet their functions hint at providing a *private* feel, the lighting concept will use a combination of both impressions, with the help of lighting placements, levels and controls. Having lighting control capabilities will provide flexibility within the space in order to host a variety of events and activities.

Dimensions:

Kitchen

- Area - 607 sf
- Height - 10’-6”

Billiard Room

- Area - 540 sf
- Height - 10’-6”

Tasks + Activities:

The kitchen serves as a display kitchen, mainly for gathering, lounge, and tabletop tasks. The billiard room will have the task of a club and game room along with perimeter standing bar areas for gathering.

Figure 1.13 | Level 1 - Existing Entertainment Kitchen

Figure 1.14 | Level 1 - Existing Billiard Room

Entertainment Kitchen + Billiard Room

Location + Drawings:

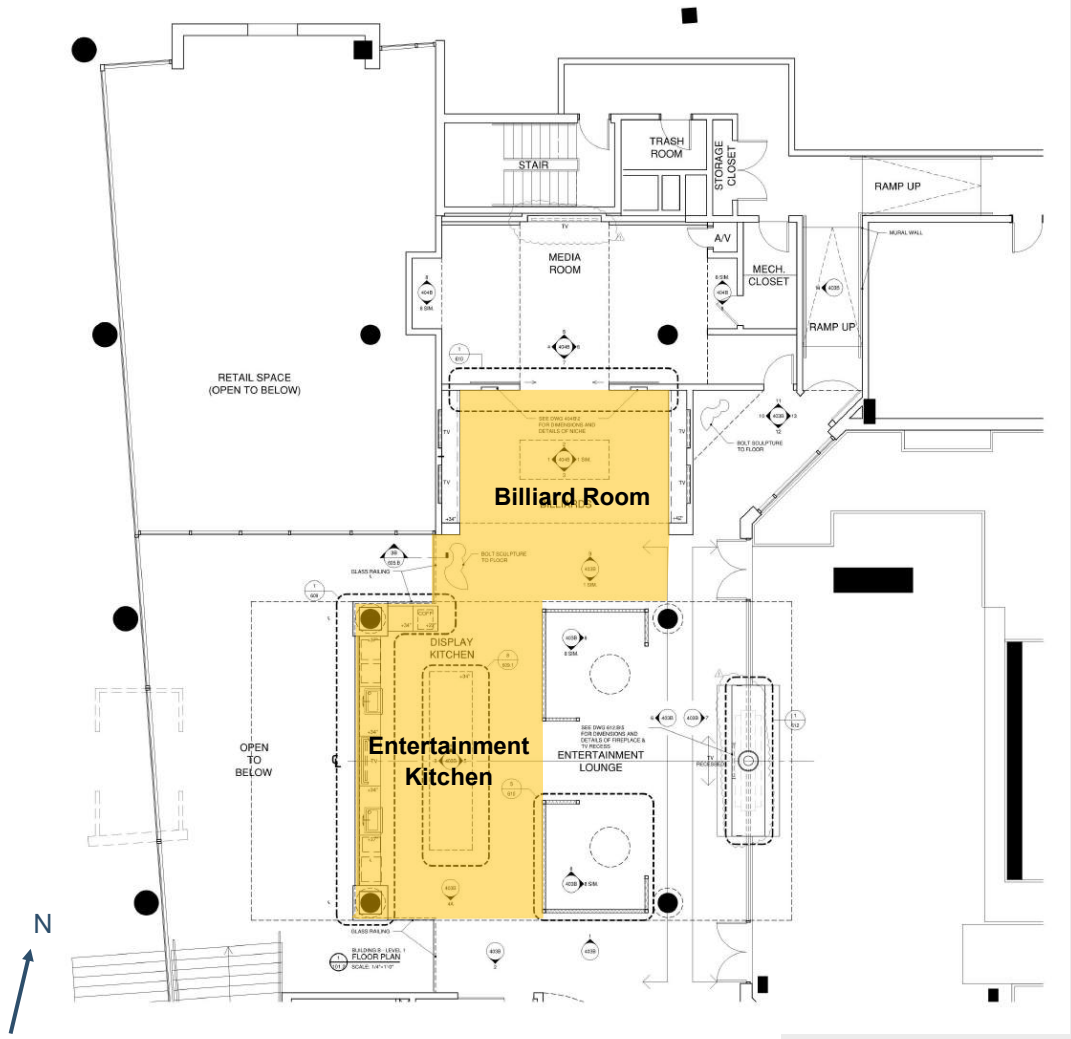
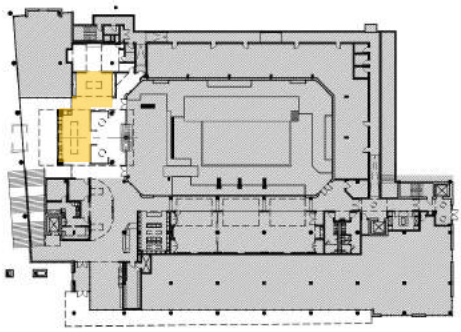


Figure 1.15 | Level 1 Floor Plan - Kitchen + Billiard Room



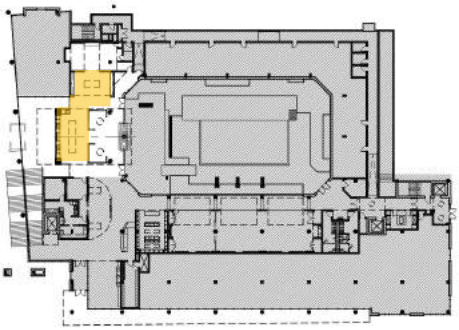
Level 1 Key Plan

Lighting Design Depth

Entertainment Kitchen + Billiard Room

Location + Drawings:

Figure 1.16 | N/S Building Section - Kitchen + Billiard Room



Level 1 Key Plan

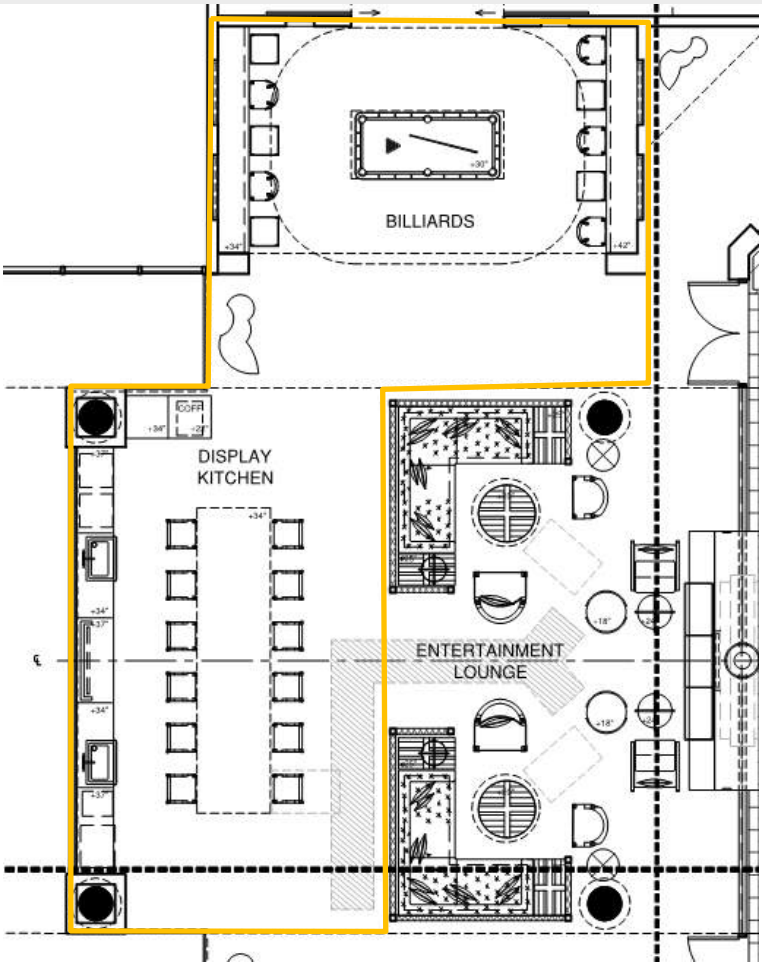


Figure 1.17 | Level 1 Furniture Layout - Kitchen + Billiard Room

Materials + Finishes: *Entertainment Kitchen*

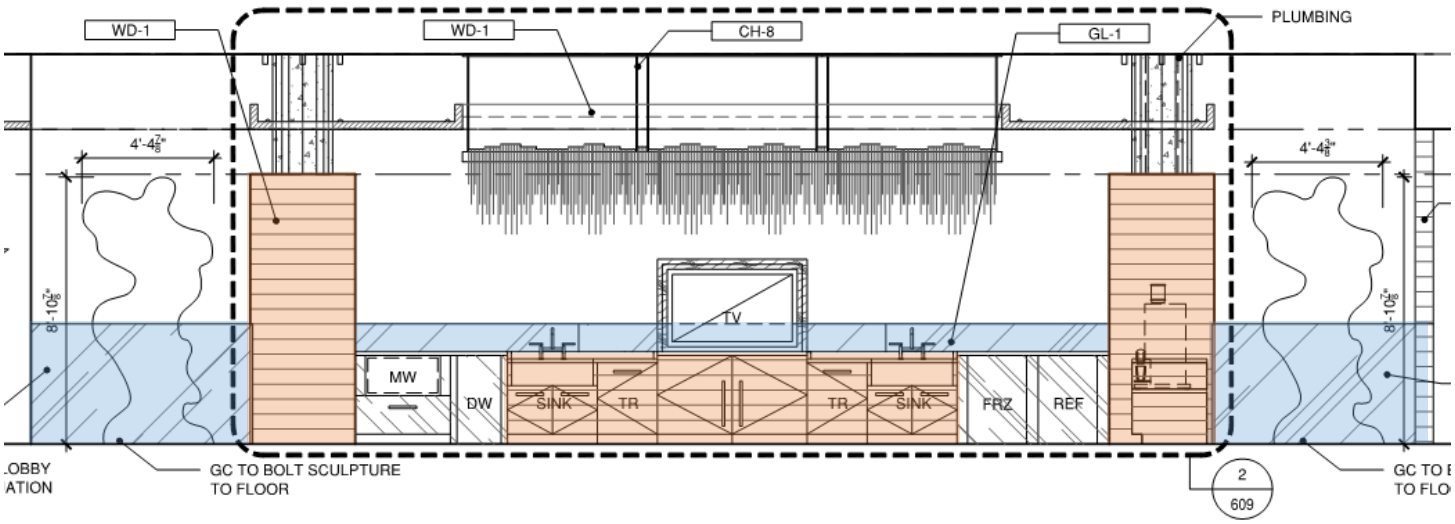


Figure 1.18 | Level 1 Interior Elevation - Entertainment Kitchen

Table 1.9 | Material Specifications - Entertainment Kitchen

Space	Surface Type	Symbol Color	Description	Manufacturer	Color	Product Name	Reflectance
Display Kitchen	Floor		Ceramic Tile	Mosaic Tile Co	Matte Black	Evolve Collection	0.03
	Exposed Ceiling		Painted GWB	Benjamin Moore	Black	Ultra Spec 500, 2128-10 Black Beauty	0.05
	Ceiling		Wood Plank	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.4
	Walls		Wood Finish	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.5
	Interior Glazing		Glass	by GC (PJ Dick)	Clear	Tempered Glass, 5/16"	0.78

Materials + Finishes: *Entertainment Kitchen*

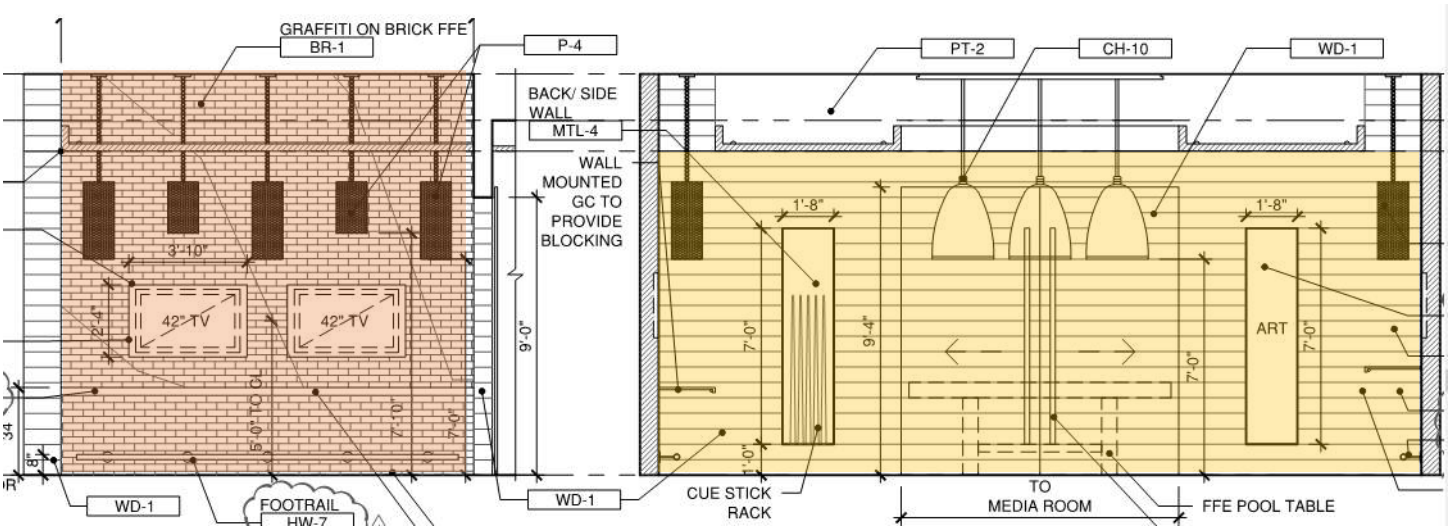


Figure 1.19 | Level 1 Interior Elevation - Billiard Room

Table 1.10 | Material Specifications - Billiard Room

Space	Surface Type	Symbol Color	Description	Manufacturer	Color	Product Name	Reflectance
Billiard Room	Floor		Wood Floor	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.4
	Ceiling		Wood Plank	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.4
	Exposed Ceiling		Painted GWB	Benjamin Moore	Black	Ultra Spec 500, 2128-10 Black Beauty	0.2
	Walls		Wood Finish	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.5
			Brick	L & L Supply Corporation	Aspen White (W804)	Engobe Series, Modular	0.7

Overall Design Goals

Entertainment Kitchen

Figure 1.20 | Schematic Lighting Design - Entertainment Kitchen

Design Criteria + Considerations:

The goal of the lighting in the Entertainment Kitchen is to provide a functional lighting system that creates visual interest and comfort in the space. The psychological impression of *public* was designed for in this space. This impression and the overall concept of *industry* was designed for by highlighting the surrounding materials and surfaces. The materials to highlight in the kitchen include the wood ceiling, metal panels, granite countertops, and wood table.

Billiard Room

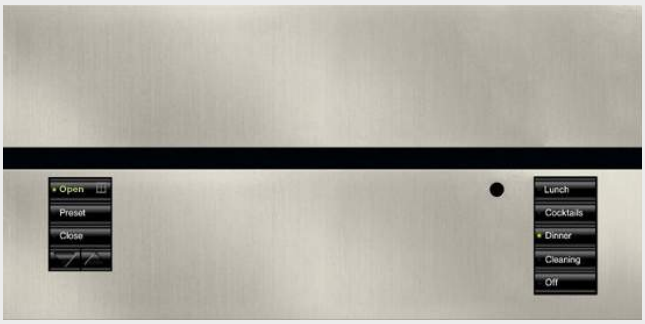
Figure 1.21 | Schematic Lighting Design - Billiard Room

Design Criteria + Considerations:

The goal of the lighting in the Billiard Room is to create the psychological impress of *private* - the opposite impression as the adjacent kitchen space. The strategy for achieving this impression is making the main focus of the space to be the billiards table and having its surrounding spaces at lower light levels. This approach makes the separation of billiards table and bar area, creating a *private* feeling around each area of the room. An important design consideration for this space was to create this psychological impression while providing adequate light levels for the billiards table itself.

Controls:

The lighting within the Entertainment Kitchen + Billiard Room will be also controlled through a Lutron GRAFIK Eye QS interface that is located at the concierge desk in the Main Lobby. Like the Entertainment Lounge on the first level, the Kitchen + Billiard Room will also have a separate interface to allow users of the room to control the lighting zones and levels. Every lighting type will be on its own zone and controlled separately from the GRAFIK Eye. The interface will be able to program scenes as desired by the owner.

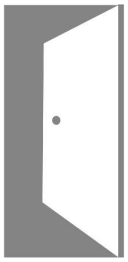


GRAFIK Eye QS:
Concierge Desk | Main Lobby

seeTouch QS Control:
Kitchen + Billiard

Psychological Impression:

The impressions gathered in these spaces contribute to the driving concept that was introduced for the lighting design of Kitchen + Billiard Room. The concept of *public versus private* spaces will be introduced with the lighting between the two spaces. As mentioned, the kitchen was designed to have the impression of *public*, where the Billiard Room will provide the impression of *public*.



The aesthetic appeal of this space guided the *qualitative* desires of the lighting design solution, which was previously introduced. In addition to the qualitative design goals, *quantitative* data was explored for the Kitchen and Billiard Room, introduced below.

Illuminance + Uniformity Requirements:

The values found in Table 1.11, represent the recommended illuminance design criteria (measured in lux) by the IES Lighting Handbook for the Entertainment Kitchen and Billiard Room. Though these illuminance values are used as a *recommendation* rather than a *requirement,* however, they are important to achieve in order to fulfill the functions and tasks of the space properly. However, the tasks within this area are mainly used for social gathering purposes. These spaces will be designed based on the how the space has achieved it's *psychological* impression as well as their desirable illuminance levels.

As mentioned, the Entertainment Kitchen specifically acts as a display kitchen - used for gathering, lounge, and tabletop tasks. With this in mind, it is important to note that the table was assumed to be a lounge work area, and the kitchen countertops were assumed to be serving areas for food rather than food preparation areas.

Table 1.11 | Illuminance Requirements - Kitchen + Billiard Room

Space	Application/Task	E horizontal (lux)	E vertical (lux)	Avg/Min (Eh)	Daylight
Entertainment Kitchen	Lounge: Reading/Work Areas on Table	150	50	-	✓
	Serving Food/Dishwashing on Kitchen Countertop	200	10	-	
Billiard Room	Billiard Table	300	100	-	✓
	Bar Lounge	100	50	4:1	
Corridor	Circulation: General, Day	100	30	4:1	✓
	Circulation: General, Night	50	20		

Lighting Power Density:

The lighting power density (LPD) was determined using ASHRAE 90.1 2007 standards. The LPD is defined as the allowable watts/square foot for all spaces in the building. This can be calculated using a space-by-space method, or by building type. The LPDs calculated for Eastside III used the space-by-space method. A summary of the Special Purposes Spaces' lighting power density can be found in Table 18. The redesign of these should exceed ASHRAE 2007 standards and comply with ASHRAE 90.1 2013.

Table 1.12 | Lighting Power Density - Kitchen + E-Lounge + Billiard Room

Space	Space Description	Allowance (W/SF)
Entertainment Kitchen + Billiard Room	Lounge/Recreation	1.2

Lighting Layout

Kitchen + Billiard RCP:

The lighting within the Kitchen + Billiard Room contribute to their intended psychological impression as well as the overall industrial aesthetic by highlighting the material surfaces.

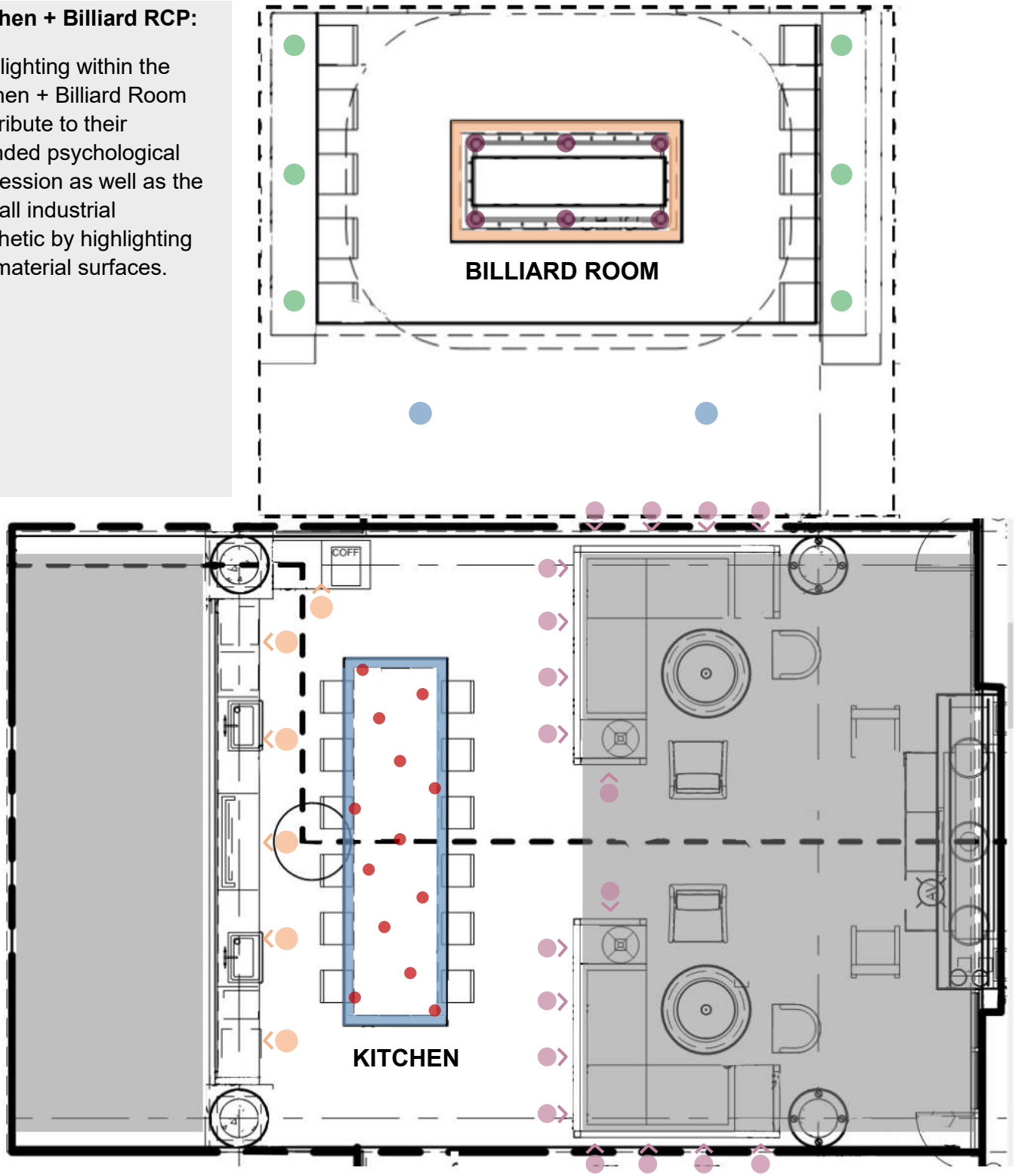


Figure 1.22 | Lighting Layout - Kitchen + Billiard Room

Fixture Selection

Table 1.13 | Lighting Schedule - Billiard Room

Type	Symbol	Image	Description	Manufacturer	Count	Mounting	Lamp	Wattage
-	-		Recessed Linear Cove System, "Zero Edge" Aluminum Dual Channel	LF Illumination, EF200 Dual Channel	-	Recessed Channel System	-	-
L13A			2' Linear LED Unit for EF200 Dual Channel System, Protective Lens, White Finish, Dimmable	LF Illumination EF200 Linear LED Unit	14	Channel Mounted	LED, 2700K, 440 lm/ft	4 W/ft
L13B			3.15" Cylindrical Small LED for EF200 Dual Channel System, Medium 22° Spot, Matte White, Adjustable, Dimmable	LF Illumination EF200 Spotlight Unit	6	Channel Mounted	LED, 2700K, 800 lms	9 W
L8			1.7" Small Scale LED Downlight, Machined Aluminum, Dimmable	Lucifer PUKLED Downlight	10	Recessed Downlight	LED, 2700K, 175 lms	2.5 W
L14			1.5' Linear Under Cabinet, 30° Angled, IP40 Rating, Diffuse Lens, Dimmable	LED Linear Vesta HYDRA SLD3	16	Recessed Under Table	LED, 2700K, 161 lm/unit	1.5 W/unit
L2A			4" Open Cylinder Downlight, 40° Beam, Specular finish, Clear Aperature and trim, Dimmable	Gotham 4" Incito Cylinder	2	Suspended Cylinder Downlight in Corridor	LED, 2700K, 500 lms	6 W

Note: Refer to Page 48 and Appendix A for construction details of the LF Illumination EF200 cove system.

Fixture Selection

Table 1.14 | Lighting Schedule - Entertainment Kitchen

Type	Symbol	Image	Description	Manufacturer	Count	Mounting	Lamp	Wattage
L9			2" Open Wallwasher, Semi-specular finish, and trim, Dimmable	Gotham 2" Incito Wallwasher	8	Recessed Wallwasher	LED, 2700K, 500 lms	7 W
L10			4" Open Adjustable Downlight, 40° Beam, 25° Angle, Specular finish, Clear Aperature and trim, Dimmable	Gotham 4" Adjustable Incito Downlight	6	Recessed Downlight	LED, 2700K, 750 lms	7 W
L11			2' Surface-mount, Asymmetric Uplight, Softening Lens, White finish, Dimmable	LF Illumination EF600 Series	20	Surface Mount Cove Uplight	LED, 2700K, 400 lm/ft	4 W/ft
L12			A19 LED Lamp, Amber Glass, Dimmable	Lighting Science LSPro A19 Filament 'The Roxy'	13	Suspended	LED, 2700K, 553 lms	4.5 W

L13 Cove Detail:

The LF Illumination Dual EF200 cove system was used in the Billiard Room in order to hold true to the design concept and psychological impression of highlighting the materials of the space + creating a focal point in the center of the room for a *private* feel. The construction detail of this system can be seen in Figure 1.23.

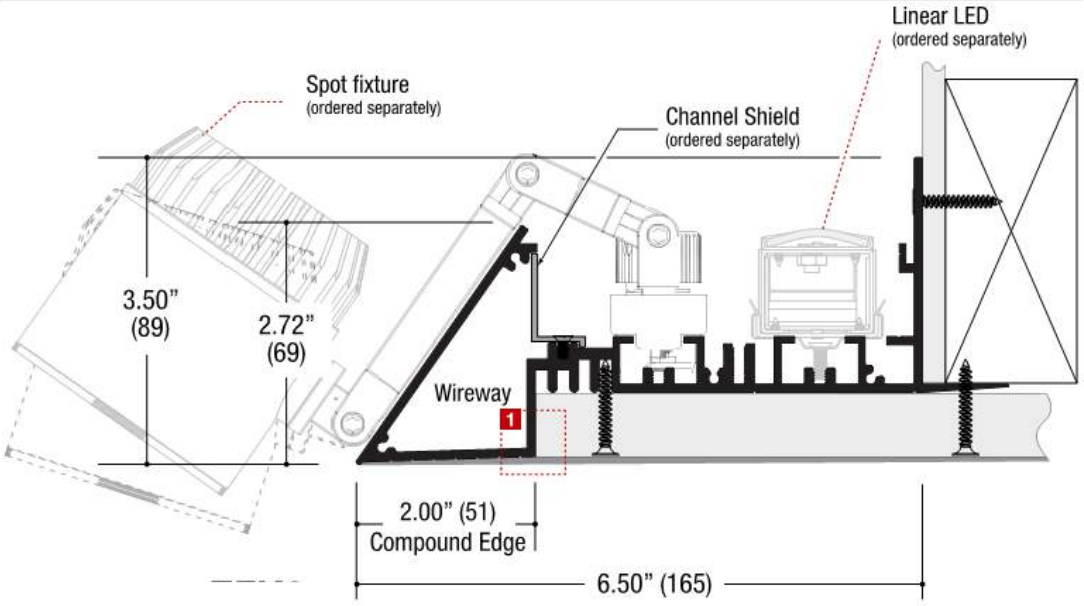


Figure 1.23 | EF200 Cove Section Detail

Calculations

Tables 1.15 and 1.16 provide the calculated power density and illuminance levels for both the Lower Level Lobby and Entertainment Lounge - based on ASHRAE 90.1 standards and the IES Handbook recommendations.

Lighting Power Density Calculation:

Table1.15 | Illuminance Requirements - Kitchen + Billiard Room

Fixture Type	Total Fixtures	Watts/ Fixture	Total Watts (W)	Area (sf)
L9	8	7	56	607
L10	6	7	42	
L11	20	4 W/ft	160	
L12	13	4.5	58.5	
L13A	14	4 W/ft	112	540
L13B	6	9	9	
L8	10	2.5	25	
L14	16	1.5	24	
L2A	2	6	12	
		Calculated W/sf		0.435
		Allowed W/sf		1.2
		Pass?		YES
		% below ASHRAE?		64%

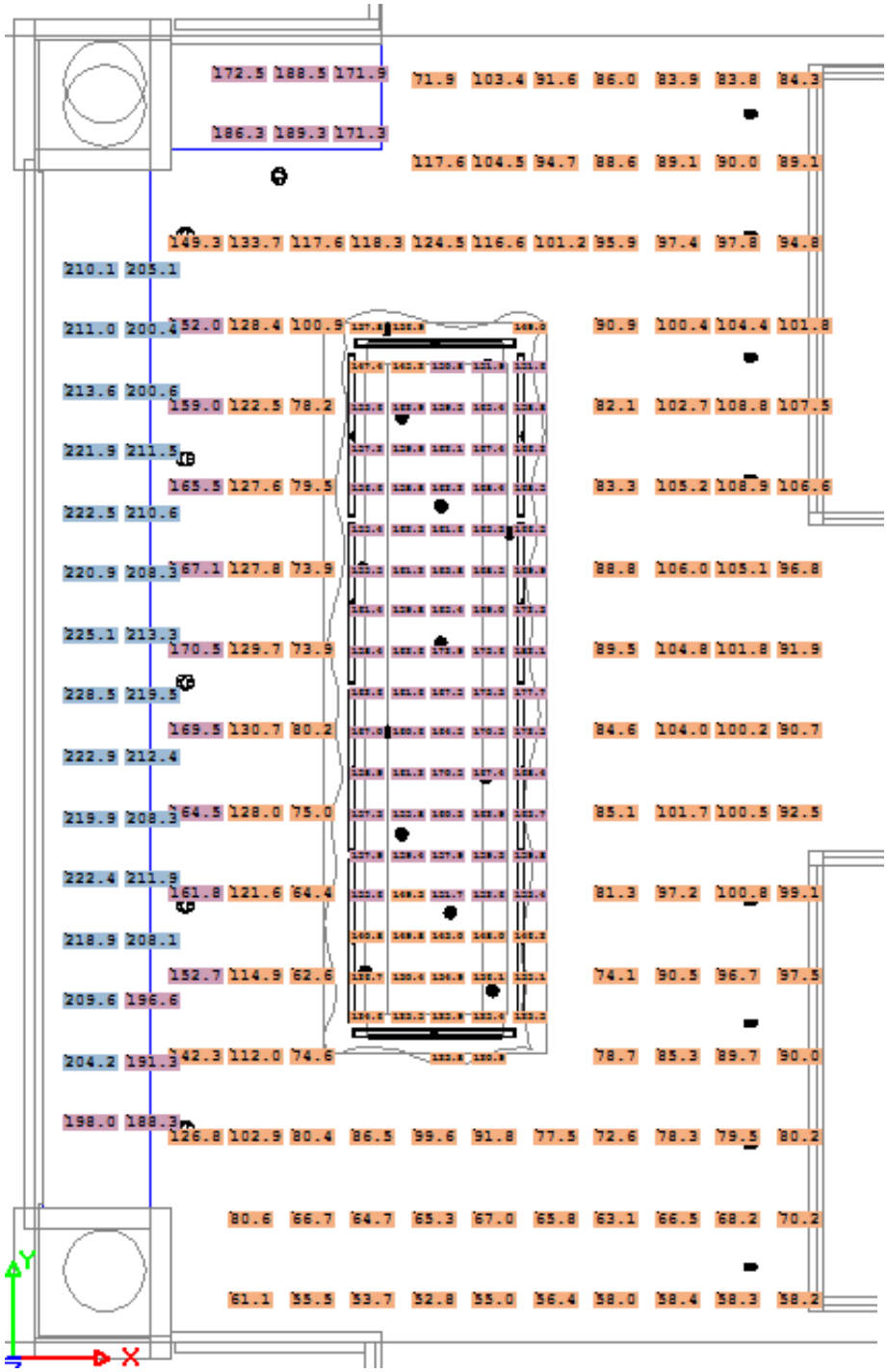
Illuminance Summary:

Table 1.16 | Illuminance Levels - Entertainment Kitchen + Billiard Room

Space	Task	*Recommended Avg. Illuminance (lux)*	Achieved (lux)	*Recommended Avg./Min*	Achieved Avg./ Min
Entertainment Kitchen	Lounge: Reading/Work Areas on Table	150	145	-	1.2
	Serving Food/ Dishwashing on Kitchen Countertop	200	195	-	1.1
Billiard Room	Billiard Table	300	375	-	1.3
	Bar Lounge	100	110	4:1	1.5
Corridor	Circulation: General, Day	100	80	4:1	2.5
	Circulation: General, Night	50	*see note*		-

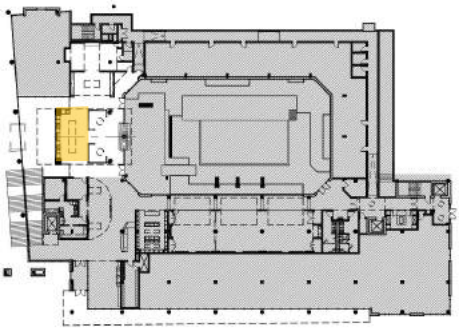
Note: The calculated illuminance levels for the circulation spaces were designed to reach *day* recommendations. However, they are designed to be dimmed when daylight is present and at night when half the illuminance levels are recommended.

Illuminance Calculations:

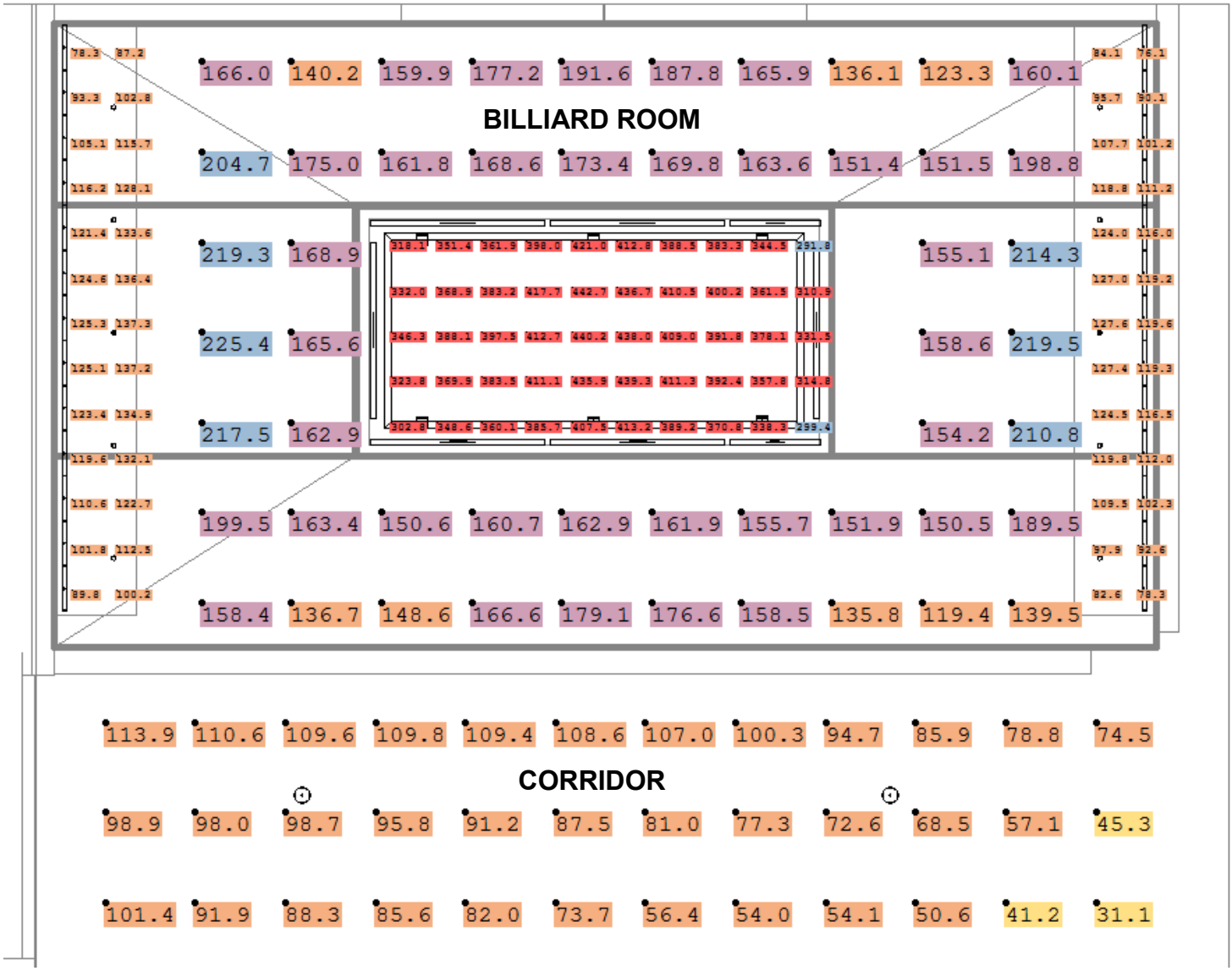


ENTERTAINMENT KITCHEN

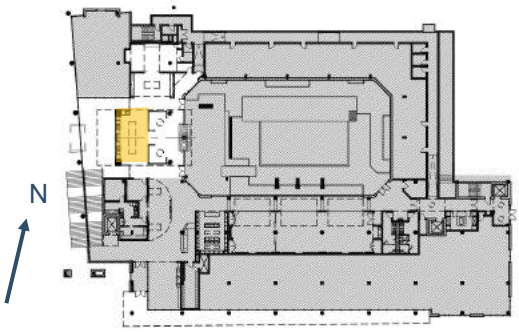
Illuminance Calculation Key	
Colors	Range (lux)
	0 - 50
	50 - 150
	150 - 200
	200 - 300
	300 - 450



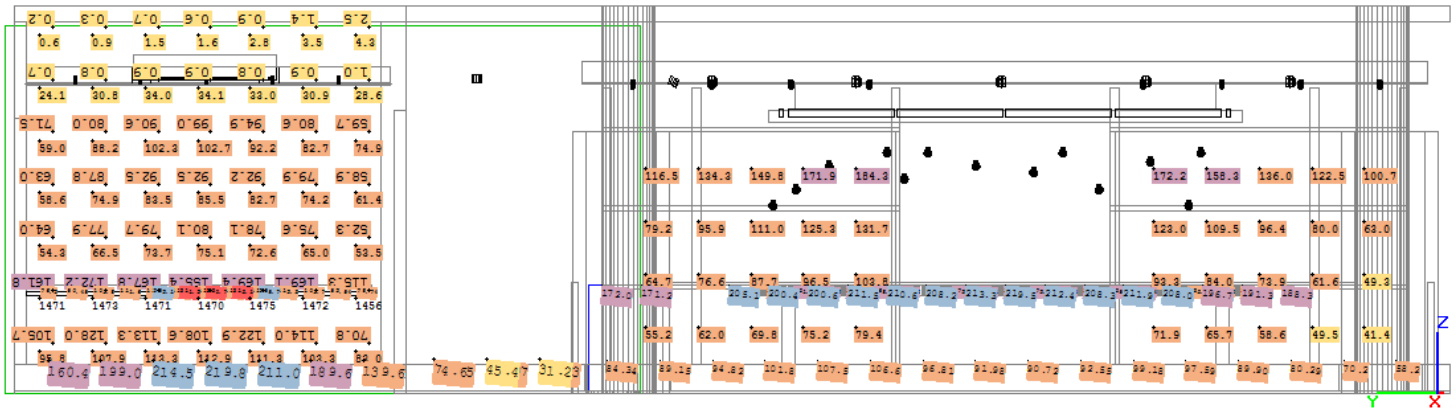
Illuminance Calculations:



Illuminance Calculation Key	
Colors	Range (lux)
	0 - 50
	50 - 150
	150 - 200
	200 - 300
	300 - 400

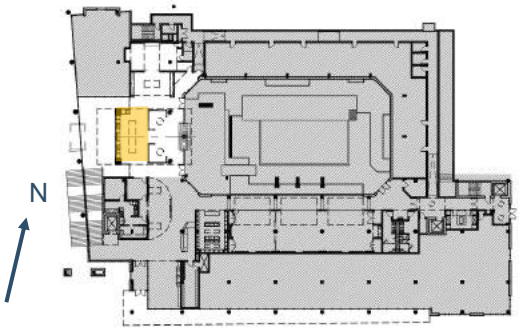


Illuminance Calculations:



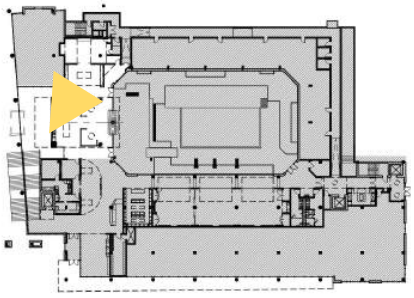
BILLIARD ROOM **ENTERTAINMENT KITCHEN**

Illuminance Calculation Key	
Colors	Range (lux)
	0 - 50
	50 - 150
	150 - 200
	200 - 300
	300 - 400



AGi32 Renderings

Figure 1.24| AGi32 Greyscale - Perspective View Entertainment Kitchen



AGi32 Renderings

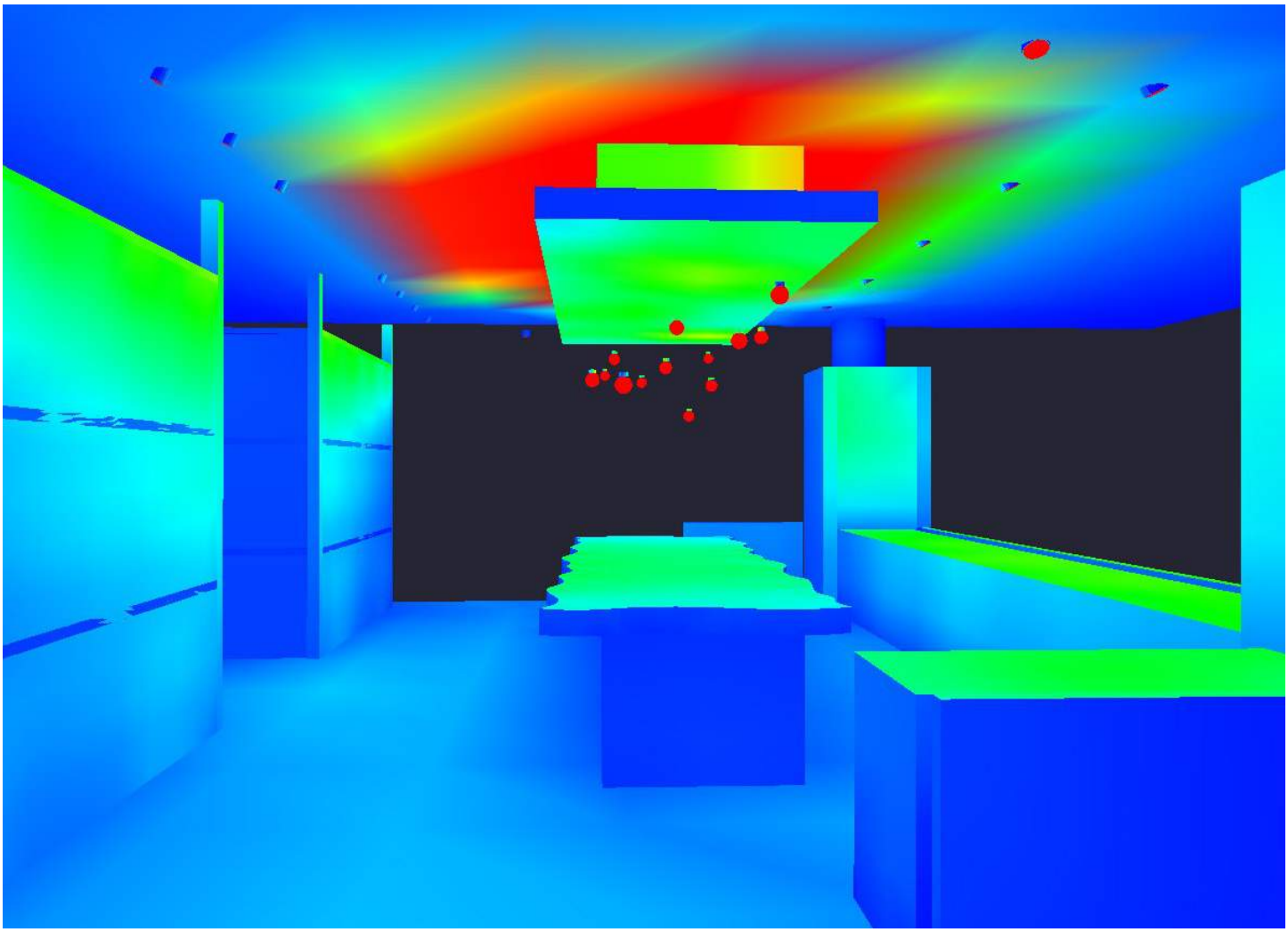
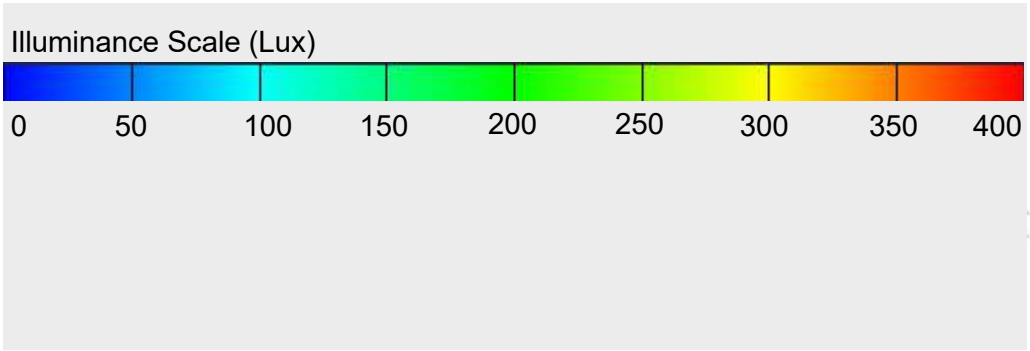
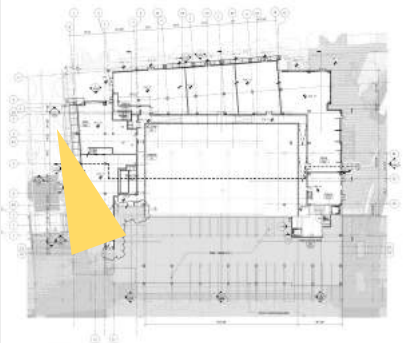


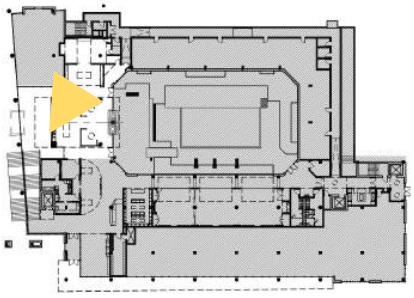
Figure 1.25 | AGi32 Pseudo Color - Perspective View of Entertainment Lounge





AGi32 Renderings

Figure 1.26 | AGi32 Greyscale - Perspective View Billiard Room



AGi32 Renderings

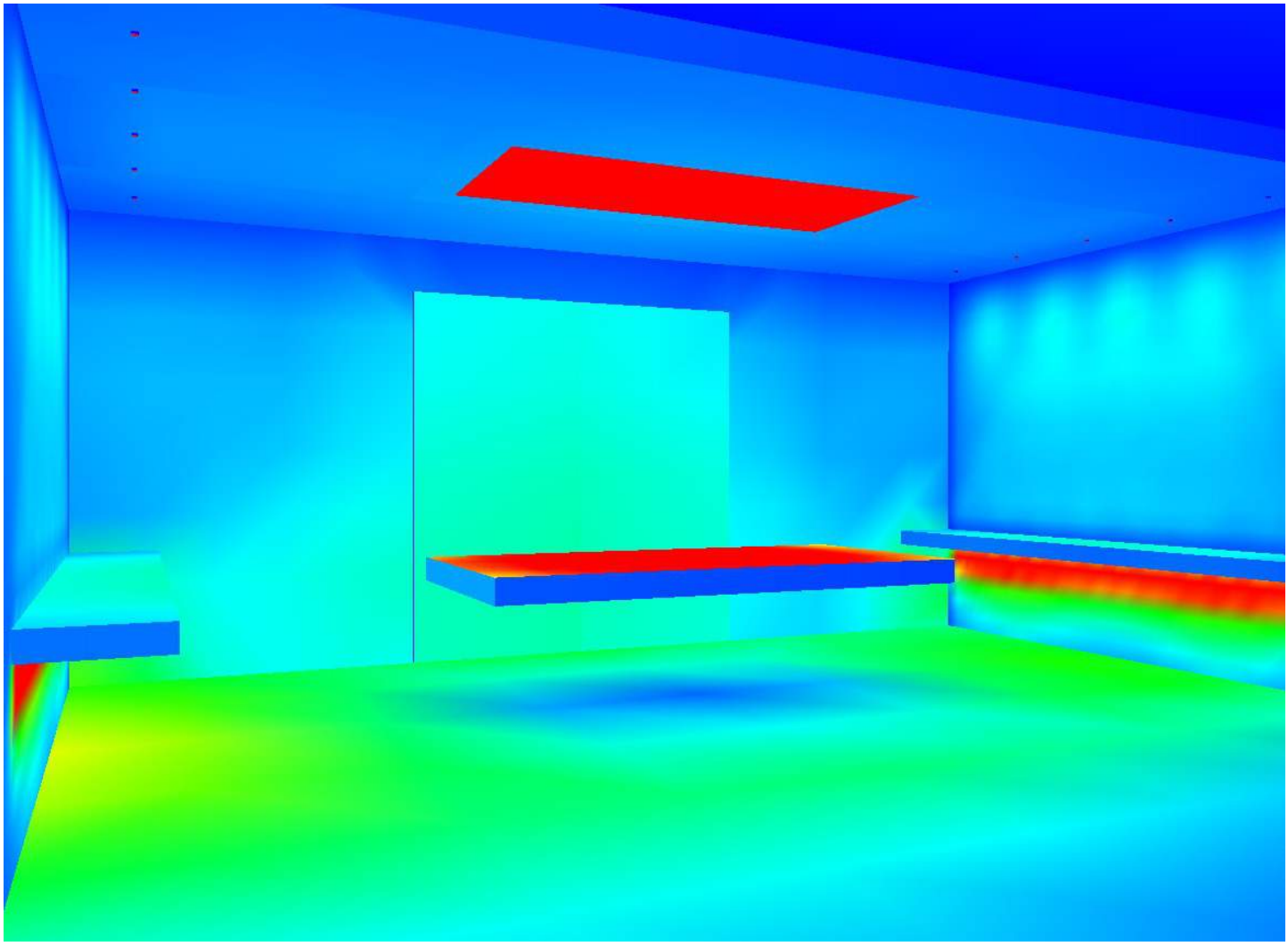
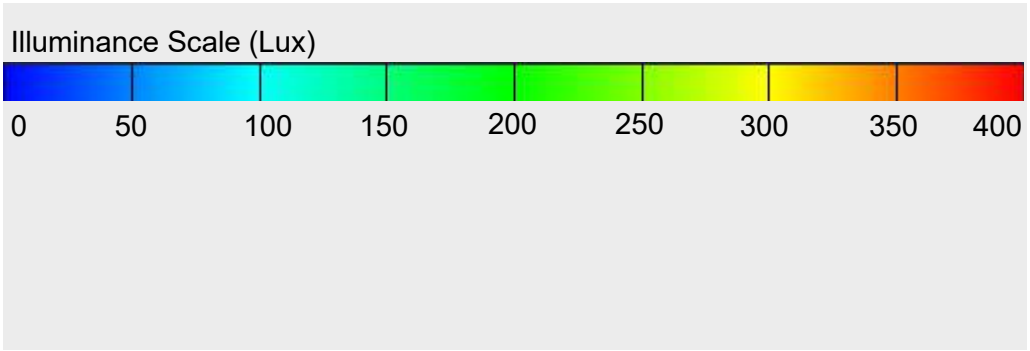
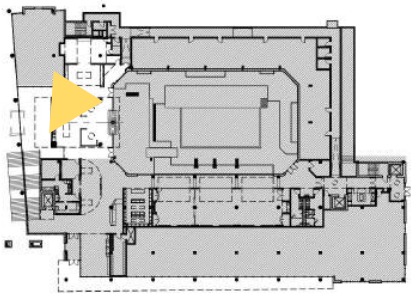


Figure 1.27 | AGi32 Pseudo Color - Perspective View Billiard Room





Final Renderings

Evaluation

The Entertainment Kitchen + Billiard Room effectively achieved their desired psychological impressions as well as the recommended illuminance levels for the activities within the space. The concept of *industry* was also achieved in the spaces by highlighting the unique surface materials. In the kitchen, these impressions were reached through an asymmetric ceiling uplight, wallwashers along the metal panels, and general illumination angled on the countertops - allowing for a contrast between lighting levels as you move through the space while still providing adequate levels for tabletop tasks. This concept and impression were also achieved in the Billiard Room through a cove system that incorporates a linear uplight and adjustable downlights that focus on the table in order to provide adequate illuminance levels for a billiards table. The surrounding dim or “private” feeling in the Billiard Room is attained from low output downlights over the bar tops and under bar linear lighting.

Overall, the contrast between lighting levels created from the psychological impressions of the *public vs. private* Kitchen + Billiard Rooms provide areas of interest as one passes through the amenity spaces of Eastside III.

| Lighting Design Depth

Fitness Center + Yoga Room

Description

The Fitness Center and Yoga Room branch off from the public residential spaces mentioned previously as one walks through the first level. These spaces are adjacent to a daylight-exposed corridor to the exterior center courtyard, which will be analyzed as part of the outdoor lighting redesign. The existing materials and feel of the fitness center are very dark and confined. I am proposing to create a psychological impression of *spaciousness* for the Fitness Center and Yoga Room. This impression will be achieved through the proposed lighting design and adjustments to material reflectances.

Dimensions:

Fitness Center

- Area - 1,350 sf
- Height - 13’-0”

Yoga Room

- Area - 590 sf
- Height - 13’-0”

Courtyard Corridor

- Area - 630 sf

Tasks + Activities:

The primary functions of the fitness center and yoga room are to perform general exercise tasks along with serving circulation purposes.

Figure 1.28 | Level 1 - Existing Fitness Center

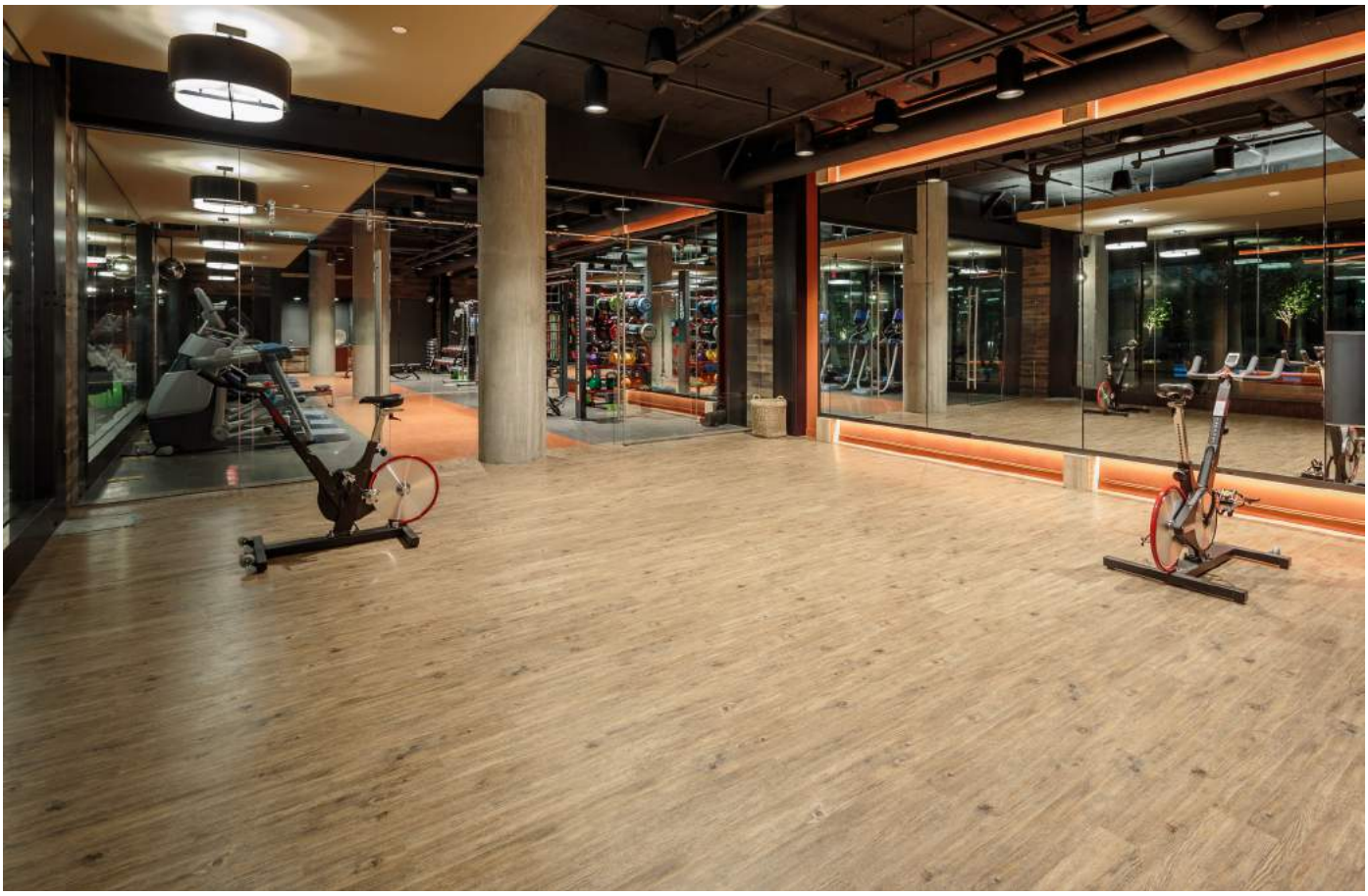


Figure 1.29 | Level 1 - Existing Yoga Room

Location + Drawings:

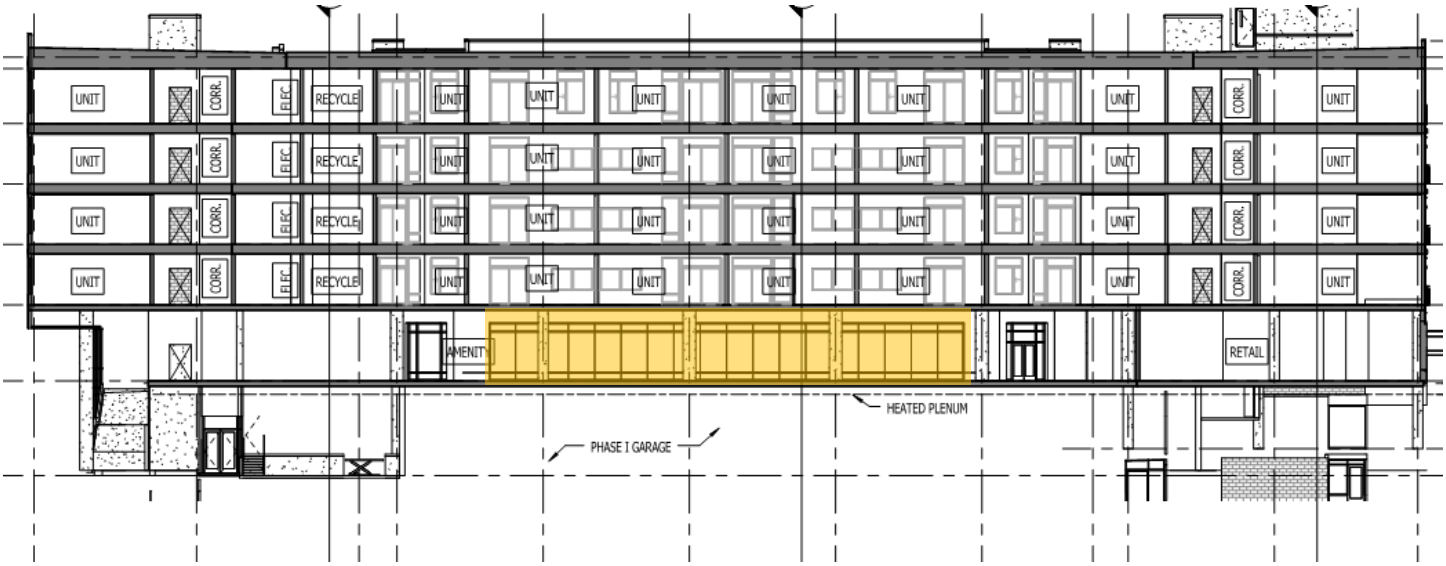


Figure 1.30 | E/W Building Section - Fitness Center + Yoga Room

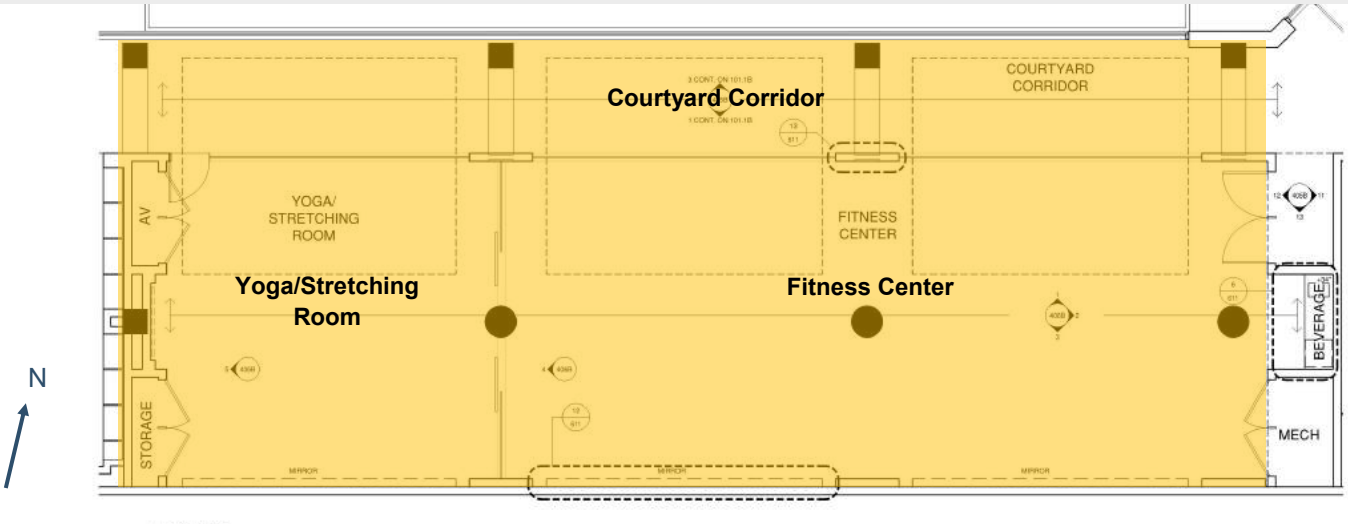
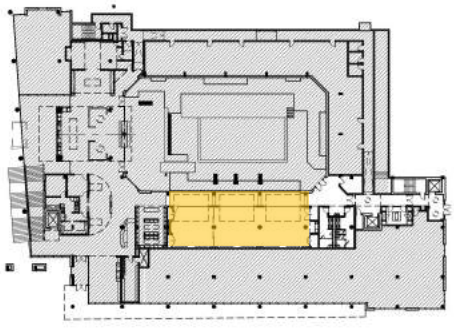
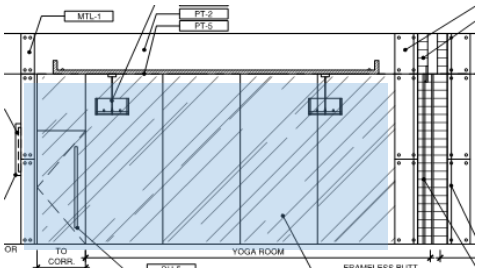


Figure 1.31 | Level 1 Floor Plan - Fitness Center + Yoga Room



Level 1 Key Plan

Materials + Finishes:



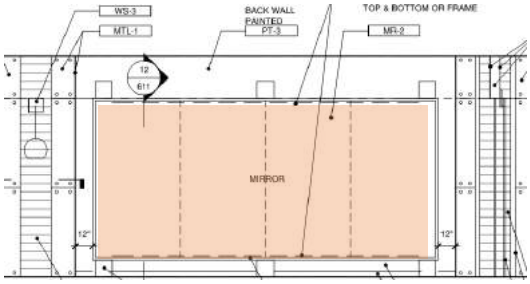


Table 1.16 | Material Specifications - Fitness Center + Yoga Room

Space	Surface Type	Symbol Color	Description	Manufacturer	Color	Product Name	Reflectance
Corridor	Floor		Ceramic Tile	Mosaic Tile Co	Matte Black	Evolve Collection	0.3
	Drop Ceiling		Painted GWB	Sherwin Williams	Light Tan	SW 7531, Canvas Tan	0.7
	Exposed Ceiling		Painted GWB	Benjamin Moore	Black	Ultra Spec 500, 2128-10 Black Beauty	0.3
	Exterior Glazing		Glass	Guardian Glass	70/36 + IS-20	ClimaGuard 70/36	0.68 (trans)
Fitness Center	Floor		Vinyl	Capri Cork	Red	Sequel, Geranium	0.4
					Grey	Sequel, Ebony	0.3
	Drop Ceiling		Painted GWB	Sherwin Williams	Light Tan	SW 7531, Canvas Tan	0.7
	Exposed Ceiling		Painted GWB	Sherwin Williams	White	SW 7004, Snowbound	0.9
	Concrete Columns		Concrete	by GC (PJ Dick)	Grey	Raw Concrete	0.3
	Interior Glazing		Frameless Butt Joint Glass	by GC (PJ Dick)	Clear	Tempered Glass, 5/16"	0.78
	Walls		Wood Finish	Building Salvage Specialist	Oak, Grey	Horse Country Oak	0.5
			Mirrored Covered	-	-	-	0.95
Yoga Room	Floor		Wood Floor	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.4
	Drop Ceiling		Painted GWB	Sherwin Williams	Light Tan	SW 7531, Canvas Tan	0.7
	Exposed Ceiling		Painted GWB	Sherwin Williams	White	SW 7004, Snowbound	0.9
	Concrete Columns		Concrete	by GC (PJ Dick)	Grey	Raw Concrete	0.3
	Interior Glazing		Frameless Butt Joint Glass	by GC (PJ Dick)	Clear	Tempered Glass, 5/16"	0.78
	Walls		Wood Finish	Building Salvage Specialist	Oak, Grey	Horse Country Oak	0.5
			Mirrored Covered	-	-	-	0.95

Overall Design Goals

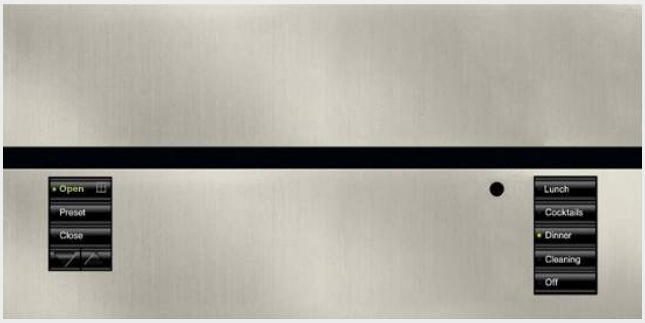
Figure 1.32 | Schematic Lighting Design - Fitness Center

Design Criteria + Considerations:

The goal of the Fitness Center + Yoga Room lighting is to provide a spacious and evenly distributed solution that meets the quantitative considerations for the space. In order to achieve this, the existing exposed ceiling in the fitness center was adjusted in color to allow for a higher reflectance - the ceiling was redesigned as white, rather than the existing black paint finish. Additionally, the drop ceiling within the space was readjusted from two to four panels in order to introduce indirect lighting to the space. Refer to the lighting layout (Figure 1.34) for details on the new ceiling and fixture layout.

Controls:

The lighting within the Fitness Center + Yoga room will be controlled through a Lutron GRAFIK Eye QS interface located at the Concierge Desk in the Main Lobby. Both spaces will be controlled with an occupancy sensor - which will be corner-mounted, facing away from the adjacent corridor. Since it is essential to provide adequate illuminance levels to ensure safety in the Fitness Center, the space will not provide an override control interface for the occupants, only occupancy sensors. The Yoga Room, however, will provide a separate interface to allow users of the room to control the lighting levels and zones of the space. Since this space is used for lower impact activities, the lighting levels can be adjusted to allow for user comfort and preference.



GRAFIK Eye QS:
Concierge Desk | Main Lobby

seeTouch QS Control:
Yoga Room *Only*

A corner-mounted Lutron Radio Powr Savr will be installed in the Fitness Center + Yoga Room to account for energy savings during unoccupied times. It is important to place these sensors facing away from the corridor, since people passing through the walkway would be visible through the glass wall separating the spaces. The passive infrared (PIR) sensor has a 90° range up to 35 - 50 feet away.

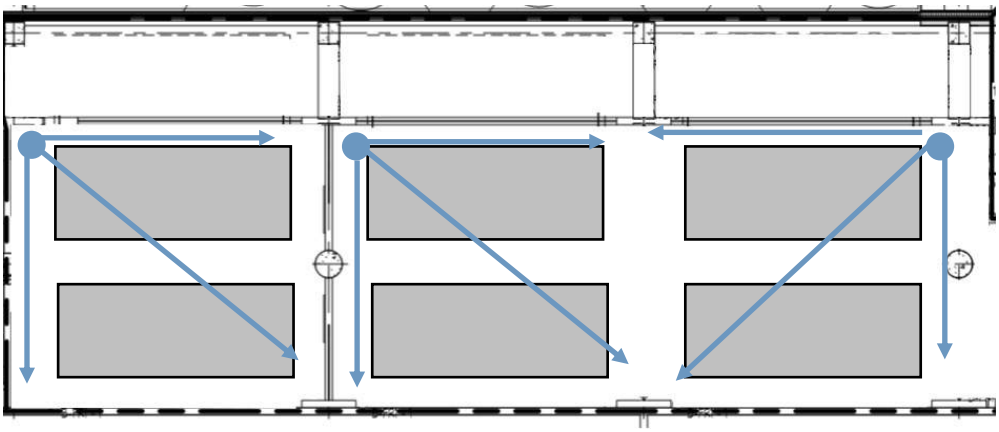


Figure 1.33 | Corner-Mounted Occupancy Sensor Layout - Fitness Center RCP

Illuminance + Uniformity Requirements:

As mentioned, the importance of adequate illumination levels and uniformity within the Fitness Center is crucial to ensure safety and comfort. The values found in Table 1.17, represent the recommended illuminance design criteria (measured in lux) by the IES Lighting Handbook for the Fitness Center and Yoga Room. Another important consideration in the Fitness Center and the Yoga room is to highlight the newly designed ceiling layout in order to make the room feel more open.

Table 1.17 | Illuminance Requirements - Fitness Center + Yoga Room

Space	Application/Task	E horizontal (lux)	E vertical (lux)	Avg/Min (Eh)	Daylight
Fitness Center	Fitness Center: Aerobics	150	40	3:1	✓
	Fitness Center: Strength Training	400	150	3:1	
Yoga Room	Fitness Center: Group Exercise	300	100	3:1	✓
Corridor	Circulation: General, Day	100	30	4:1	✓
	Circulation: General, Night	50	20		

Lighting Power Density:

The lighting power density (LPD) was determined using ASHRAE 90.1 2007 standards. The LPD is defined as the allowable watts/square foot for all spaces in the building. This can be calculated using a space-by-space method, or by building type. The LPDs calculated for Eastside III used the space-by-space method. Below is a summary of the Fitness Center + Yoga Room's lighting power density. The redesign of this space should exceed ASHRAE 2007 standards and comply with ASHRAE 90.1 2013.

Table 1.18 | Lighting Power Density - Fitness Center + Yoga Room

Space	Space Description	Allowance (W/SF)
Fitness Center + Yoga Room	Fitness Area	1.2
Corridor	Corridor/Transition	0.5

Lighting Layout

Fitness Center + Yoga Room RCP:

The newly designed drop ceiling layout provides opportunities for indirect cove uplighting within the Fitness Center + Yoga Room. In addition to the indirect components, downlights are installed to provide additional illumination to achieve recommended light levels for the different tasks of the space.

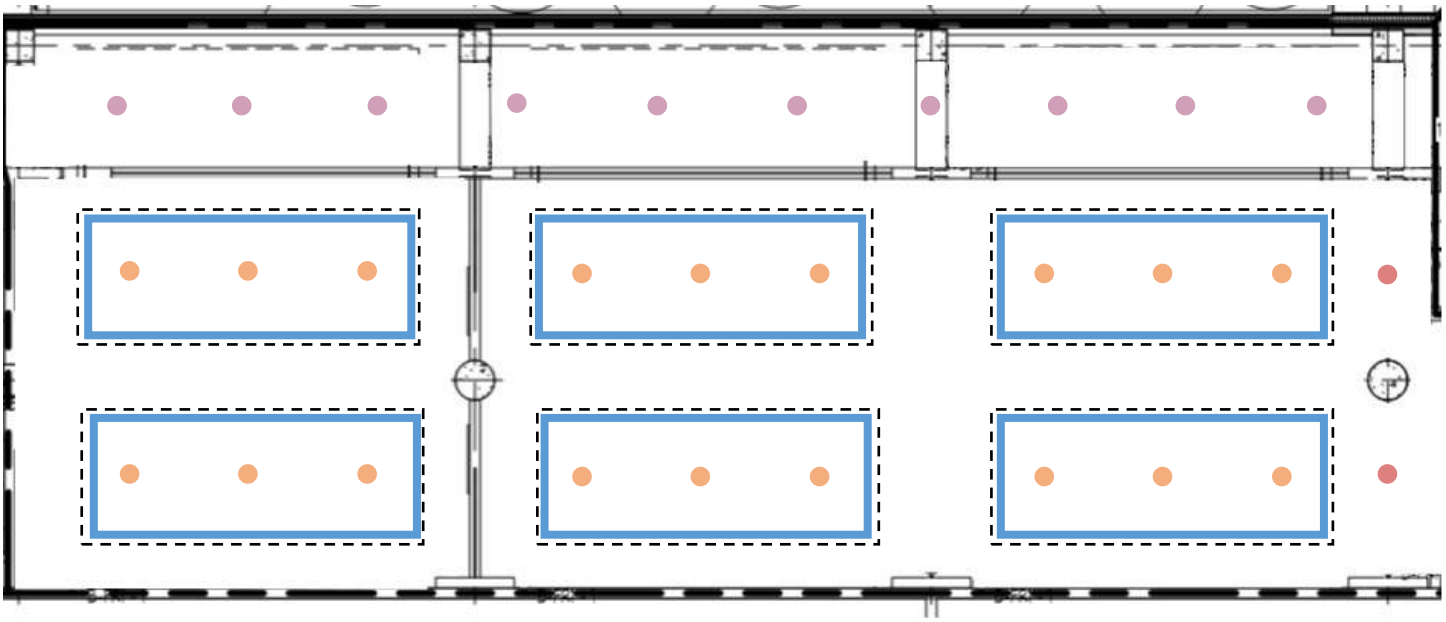
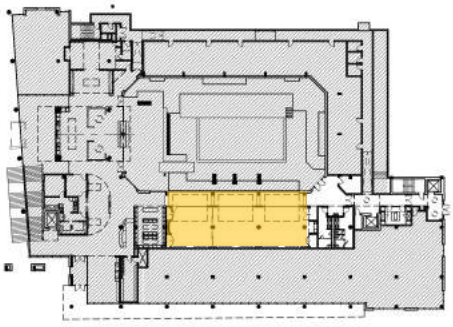


Figure 1.34 | Level 1 Lighting Layout - Fitness Center + Yoga Room



Level 1 Key Plan

Fixture Selection

Table 1.19 | Lighting Schedule - Fitness Center + Yoga Room + Corridor

Type	Symbol	Image	Description	Manufacturer	Count	Mounting	Lamp	Wattage
L1A			4" Open Downlight, Medium Beam, Specular finish, Clear Aperture and trim, Dimmable (Corridor)	Gotham 4" Evo Downlight	10	Recessed Downlight	LED, 2700K, 750 lms	10 W
L1B			4" Open Downlight, Medium Beam, Specular finish, Clear Aperture and trim, Dimmable	Gotham 4" Evo Downlight	18	Recessed Downlight	LED, 2700K, 1500 lms	17 W
L2A			4" Open Cylinder Downlight, 40° Beam, Specular finish, Clear Aperture and trim, Dimmable	Gotham 4" Incito Cylinder	2	Suspended Cylinder Downlight	LED, 2700K, 500 lms	6 W
L11			2' Surface-mount, Symmetric Uplight, Protective Lens, White Finish, Dimmable	LF Illumination EF6500 Series	144	Surface Mount Cove Uplight	LED, 2700K, 440 lm/ft	4 W/ft

Calculations

Tables 1.20 and 1.21 provide the calculated power density and illuminance levels for both the Lower Level Lobby and Entertainment Lounge - based on ASHRAE 90.1 standards and the IES Handbook recommendations.

Lighting Power Density Calculation:

Table 1.20 | Lighting Power Density Calculation - Fitness Center + Yoga Room

Type	Total Fixtures	Watts/ Fixture	Total Watts (W)	Area (sf)
L1B	18	17	306	1940
L2A	2	6	12	
L11	144	4 W/ft	1152	
		Calculated W/sf		0.758
		Allowed W/sf		1.2
		Pass?		YES
		% below ASHRAE?		37%

Table 1.21 | Lighting Power Density Calculation - Fitness Corridor

Type	Total Fixtures	Watts/ Fixture	Total Watts (W)	Area (sf)
L1A	10	10	100	630
		Calculated W/sf		0.159
		Allowed W/sf		0.5
		Pass?		YES
		% below ASHRAE?		68%

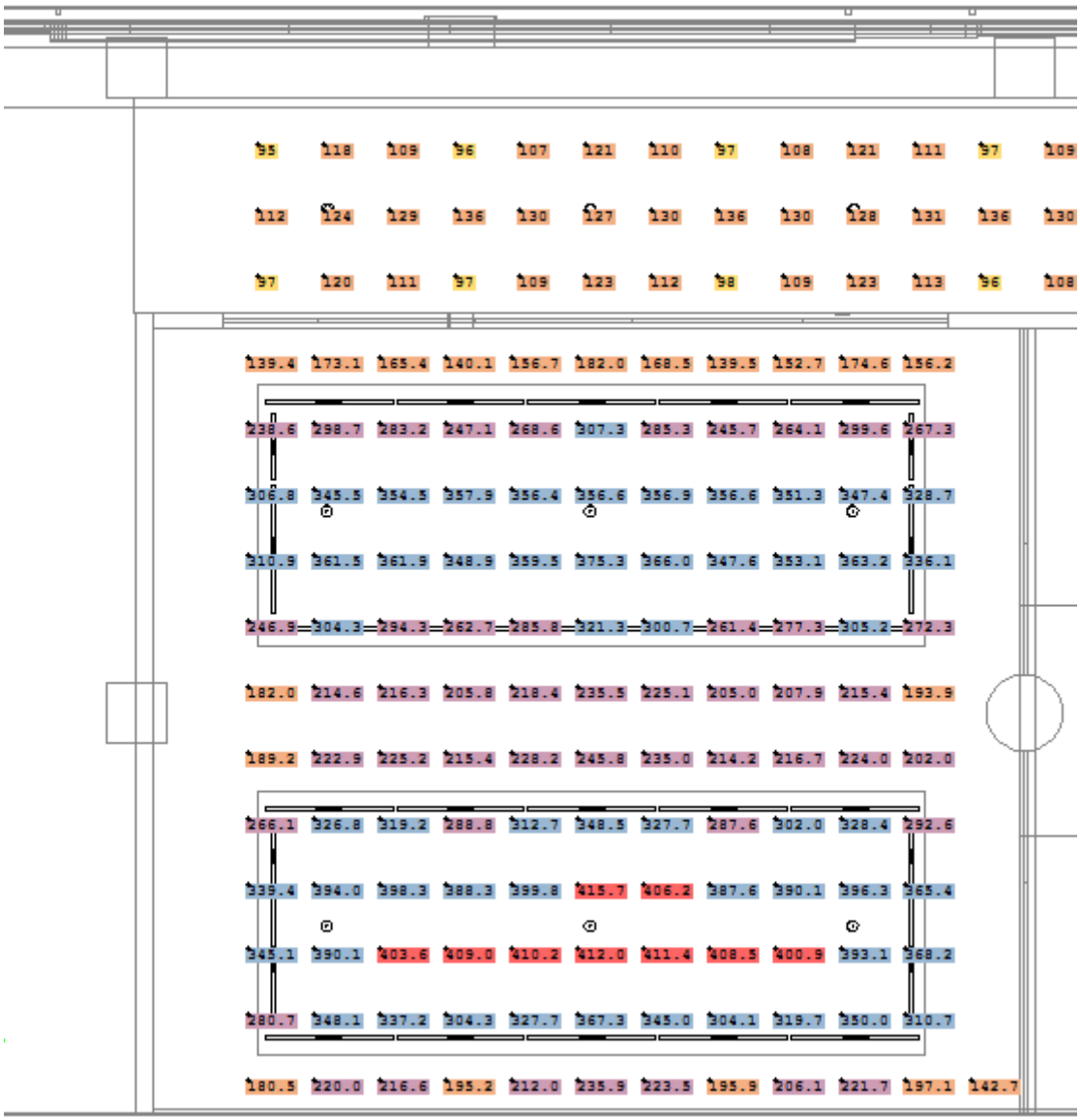
Illuminance Summary:

Table 1.22 | Illuminance Requirements - Fitness Corridor

Space	Task	*Recommended Avg. Illuminance (lux)*	Achieved (lux)	*Recommended Avg./Min*	Achieved Avg./ Min
Fitness Center	Aerobics	150	315	3:1	2
	Strength Training	400	375	3:1	2
Yoga Room	Group Exercise	300	290	3:1	2
Corridor	Circulation: General, Day	100	115	4:1	1
	Circulation: General, Night	50	*see note*		-

Note: The calculated illuminance levels for the circulation spaces were designed to reach *day* recommendations. However, they are designed to be dimmed when daylight is present and at night when half the illuminance levels are recommended.

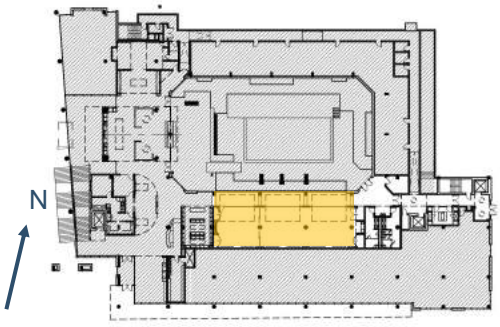
Illuminance Calculations:



FITNESS CORRIDOR

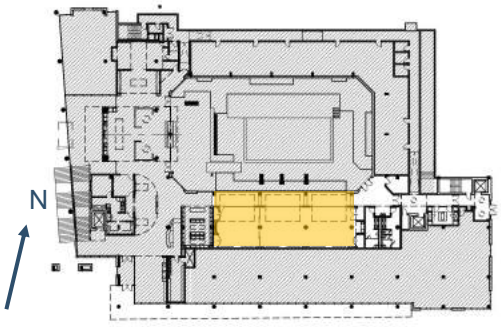
YOGA ROOM

Illuminance Calculation Key	
Colors	Range (lux)
	0 - 100
	100 - 200
	200 - 300
	300 - 400
	400 - 500



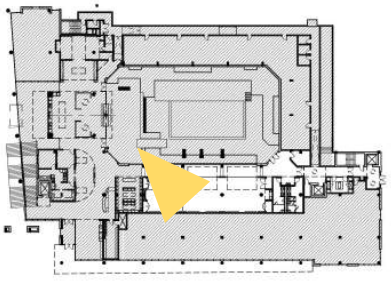
Illuminance Calculations:

Illuminance Calculation Key	
Colors	Range (lux)
	0 - 100
	100 - 200
	200 - 300
	300 - 400
	400 - 500



AGi32 Renderings

Figure 1.35 | AGi32 Greyscale - Perspective View Fitness Center



AGi32 Renderings

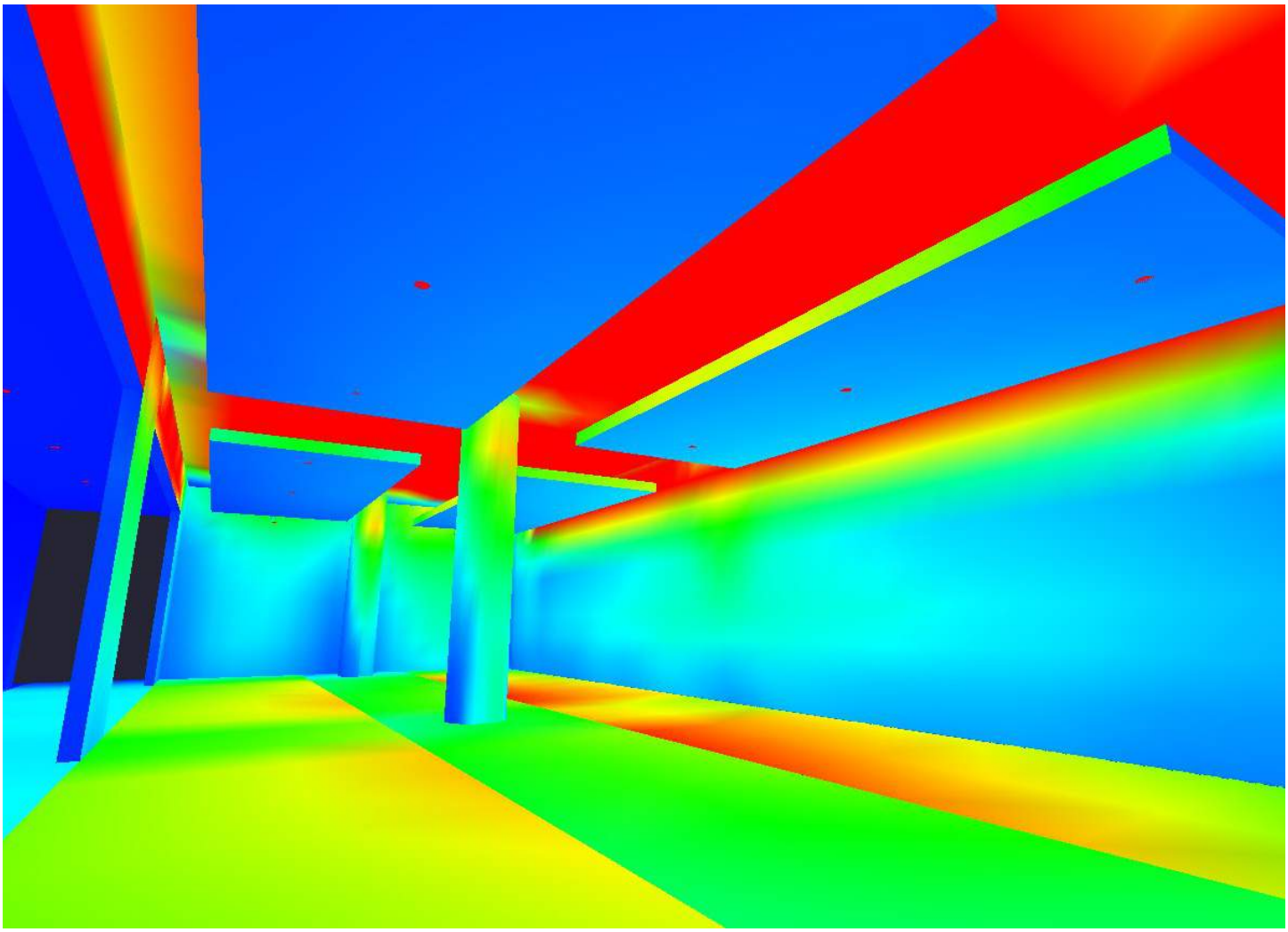
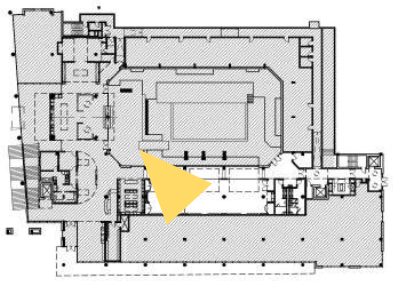


Figure 1.36 | AGi32 Pseudo Color - Perspective View Fitness Center



AGi32 Renderings

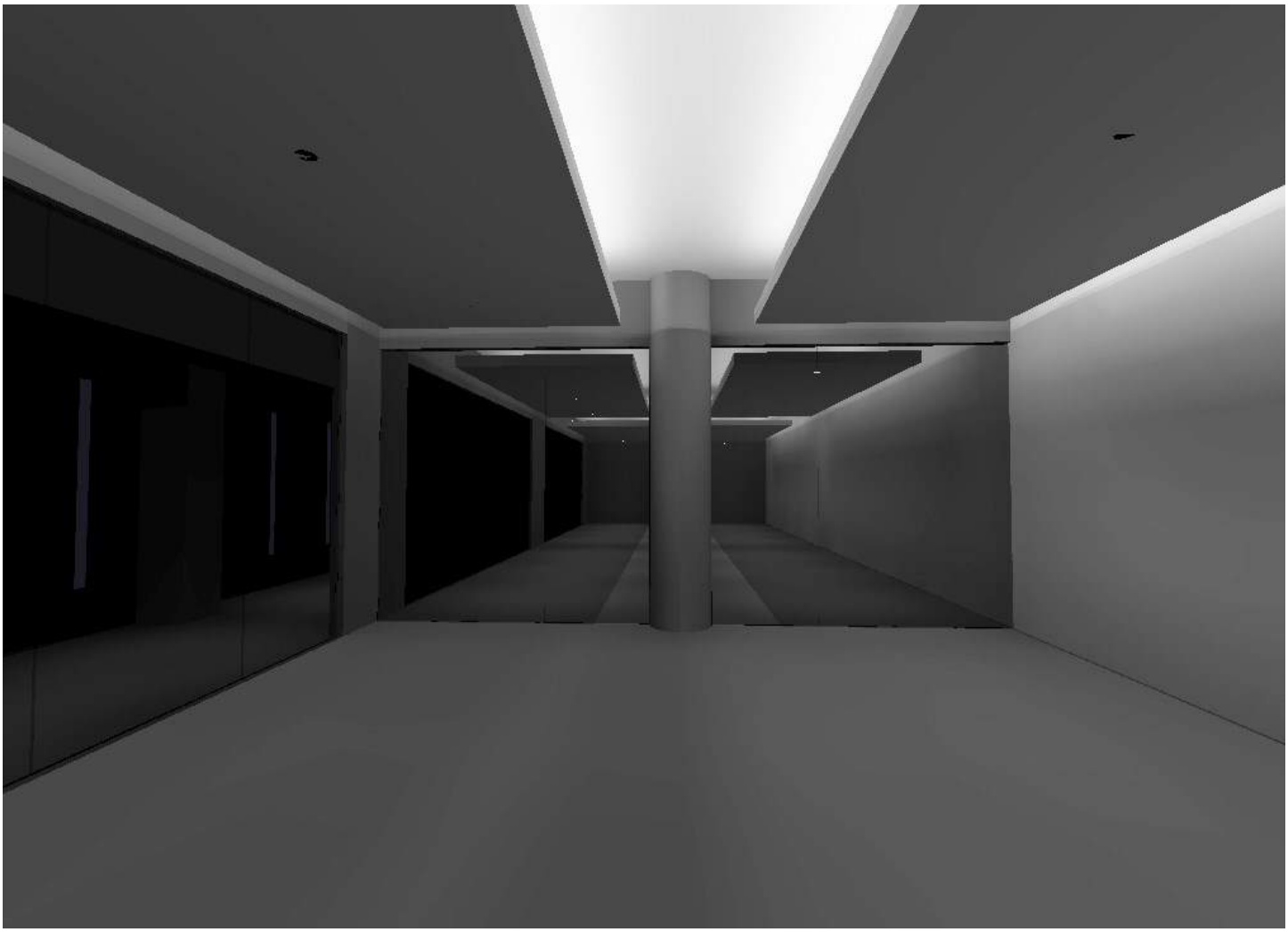
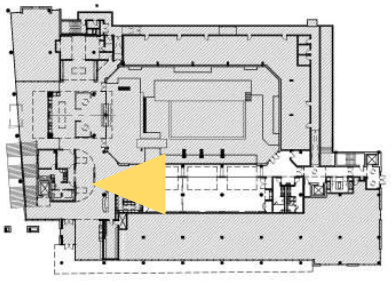


Figure 1.37 | AGi32 Greyscale - Perspective View Yoga Room



AGi32 Renderings

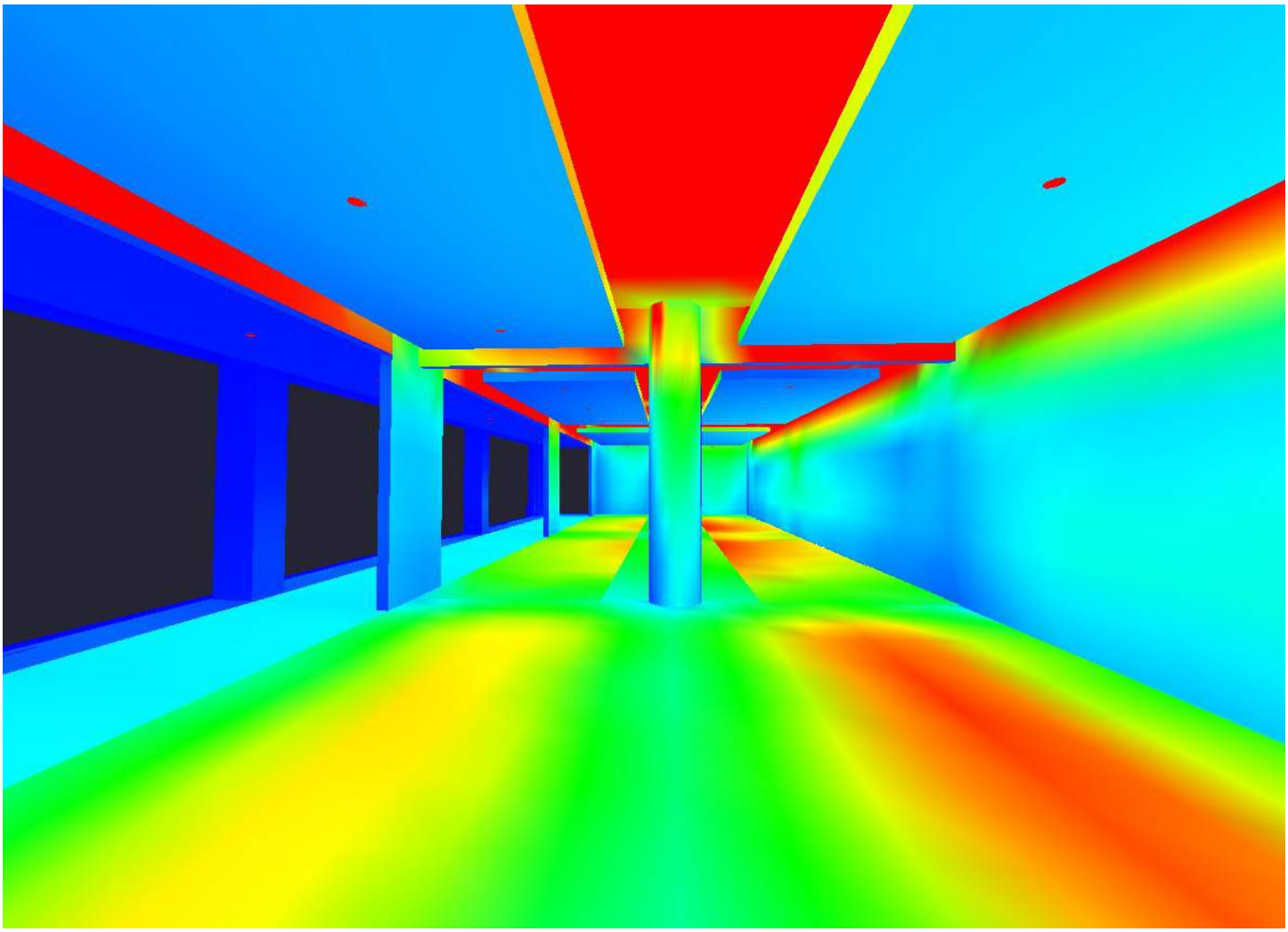
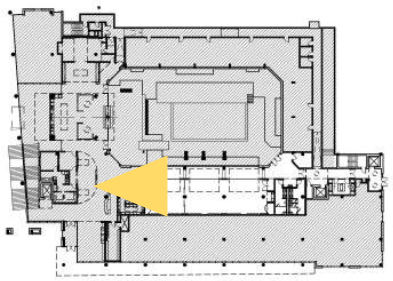


Figure 1.38 | AGi32 Pseudo Color - Perspective View Fitness Center



Final Rendering

Figure 1.39 | Revit Rendering - Perspective View Fitness Center

Evaluation

The lighting solution for the Fitness Center + Yoga Room effectively meet the design goals for the space. The redesign of the drop ceiling and exposed ceiling contribute immensely to the achievement of spaciousness within the room. The drop ceiling and indirect lighting system allows the lighting to reflect off the exposed ceiling and fill the space with even illumination. Along with meeting qualitative design goals, the lighting solution meets all required and recommended illuminance levels for the exercise tasks performed in the space.

Additionally, the control interface provided for in the Yoga Room gives flexibility in lighting levels for the space. Since this space is used for lower impact activities, the lighting levels can be adjusted to allow for user comfort and preference.

| Lighting Design Depth

Pool Courtyard

Description

The outdoor Pool Courtyard space is accessible to all residents who live in the Eastside III building. The outdoor lounge area, pictured below, will be redesigned for this lighting study. This space includes an outdoor fire pit, table and seating areas, and a brick dividing wall between the lounge and pool area.

Dimensions:

Pool Courtyard

- Area - 1,000 sf

Tasks + Activities:

The tasks within the courtyard are mainly circulation and lounging. The pool itself has the tasks of swimming for day and night occupancy. For the purpose of this lighting study, only the outdoor lounge area will be addressed.

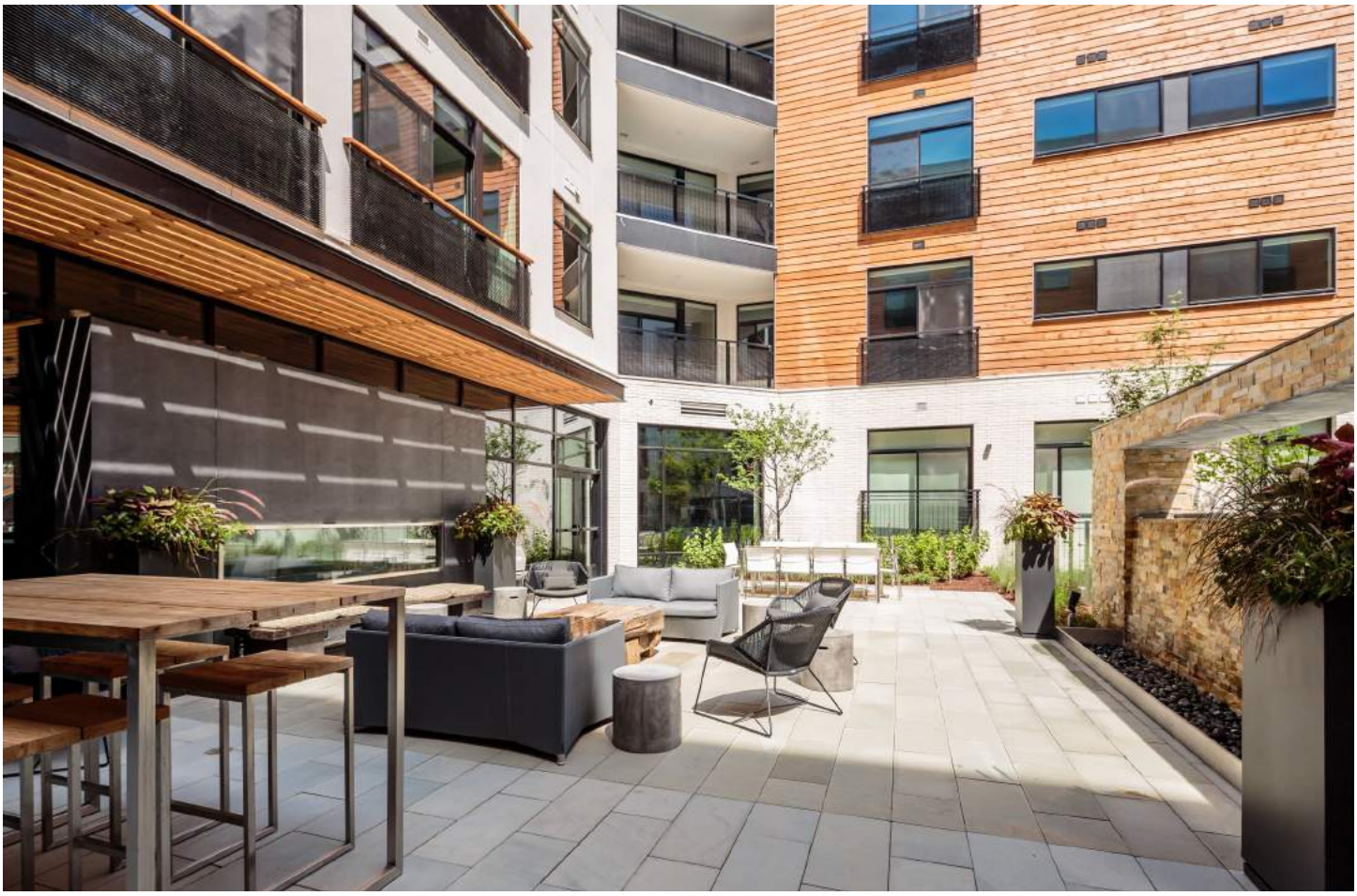


Figure 1.40 | Level 1 - Existing Outdoor Courtyard

Pool Courtyard

Location + Drawings:

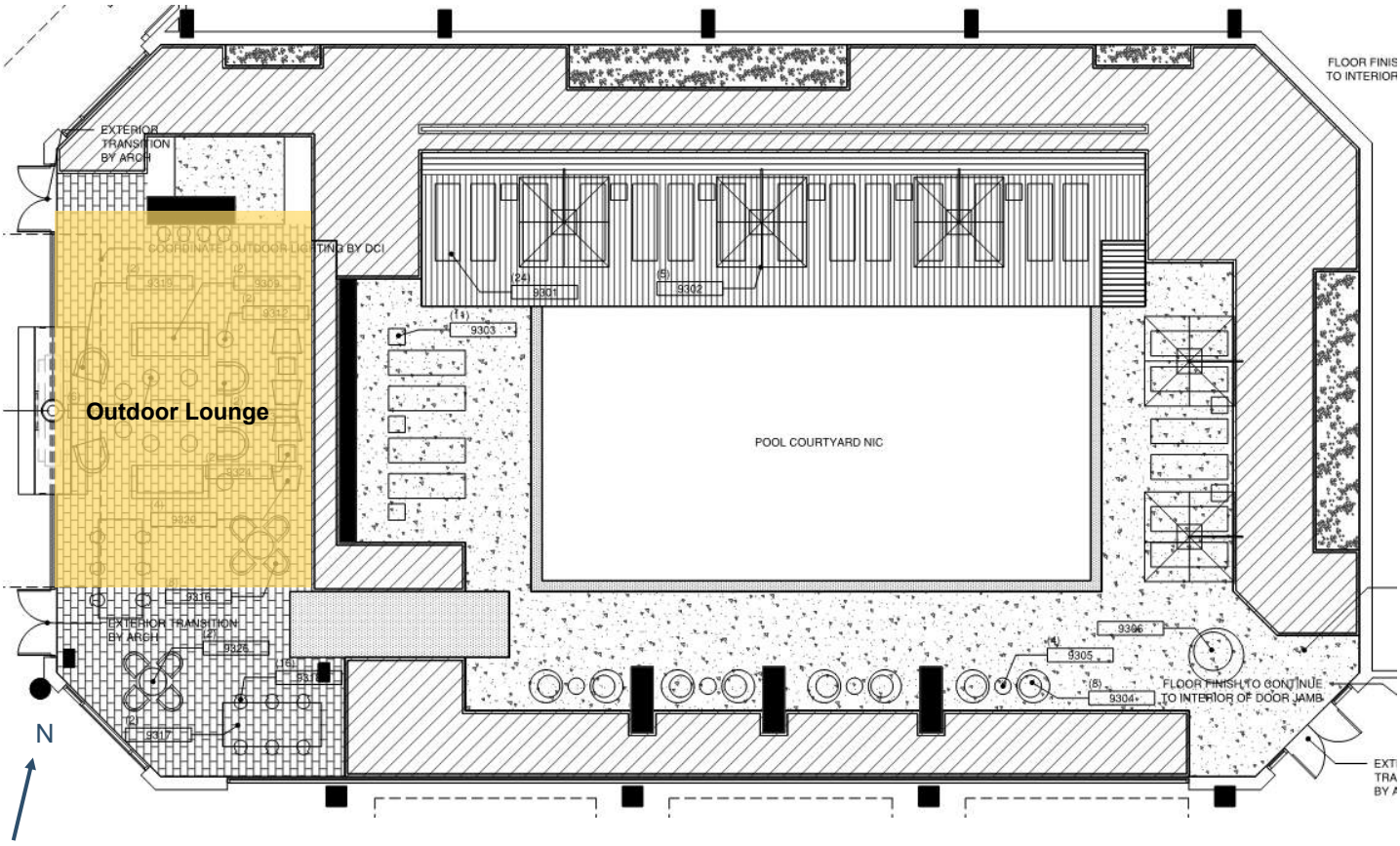
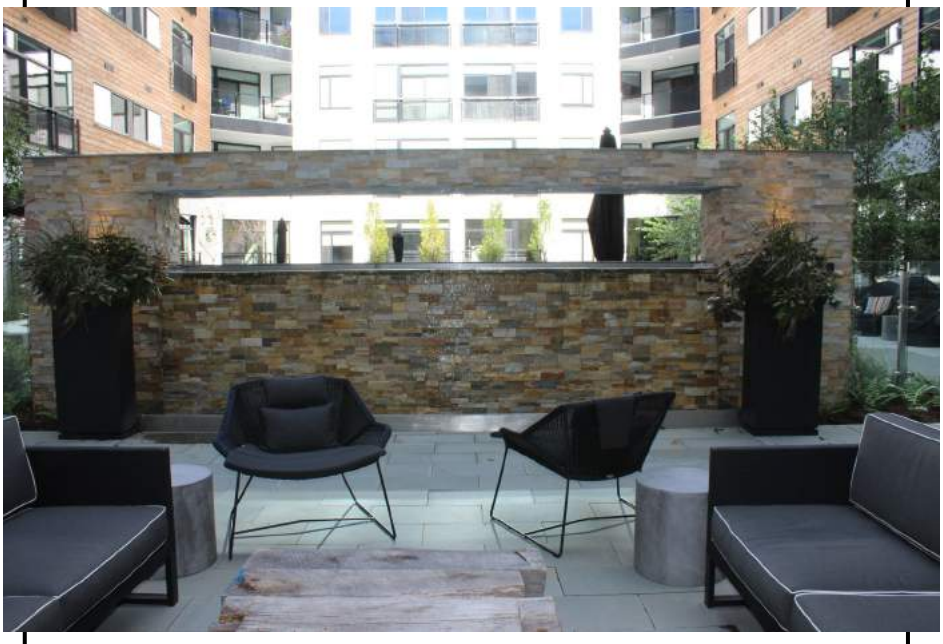
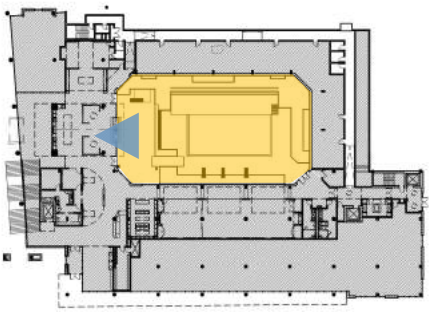


Figure 1.41 | Level 1 Furniture Plan - Pool Courtyard

Brick Dividing Wall





Level 1 Key Plan

Materials + Finishes:

Table 1.23 | Material Specifications - Pool Courtyard

Space	Surface Type	Description	Material Type	Manufacturer	Color	Product Name	Reflectance
Outdoor Seating	Floor	Multi-Colored Concrete Block	CON-1	by GC (PJ Dick)	Grey	Stained Concrete, No Gloss	0.5
	Ceiling	Wood Plank	WD-2	Building Salvage Specialist	Oak, Grey Face	Horse Country Oak	0.4
	Wall Divider	Brick	BR-1	L & L Supply Corporation	Aspen White (W804)	Engobe Series, Modular	0.7
	Glass Divider	Glass	GL-1	by GC (PJ Dick)	Clear	Tempered Glass, 5/16"	0.78

Outdoor Lounge

Overall Design Goals

Figure 1.42 | Schematic Lighting Design - Pool Courtyard

Design Criteria + Considerations:

The goal of the lighting in the Pool Courtyard is to create a comfortable + fun space to gather at night, while still bringing to life the *industry* and materials that are present in the lounge. The unique materials present in this space include the wood slats above the fireplace and the brick diving wall that creates a boundary for the lounge area.

The aesthetic appeal of this space guided the *qualitative* desires of the lighting design solution, which was previously introduced. In addition to the qualitative design goals, *quantitative* data was explored for the courtyard to ensure adequate lighting levels for circulation in the space.

Illuminance + Uniformity Requirements:

The values found in Table 1.24, represent the recommended illuminance design criteria (measured in lux) by the IES Lighting Handbook for the outdoor Pool Courtyard. The lighting was designed for nighttime conditions, since daylight would be present during the day.

Table 1.24 | Illuminance Requirements - Pool Courtyard

Space	Application/Task	E horizontal (lux)	E vertical (lux)	Avg/Min (Eh)	Daylight
Outdoor Seating	Exterior Social Area: Low Activity, Moderate Ambient Light	4	1	4:1	✓

Lighting Power Density:

The lighting power density (LPD) was determined using ASHRAE 90.1 2007 standards. The LPD is defined as the allowable watts/square foot for all spaces in the building. This can be calculated using a space-by-space method, or by building type. The LPDs calculated for Eastside III used the space-by-space method. Below is a summary of the Lower Level Lobby's lighting power density. The redesign of this space should exceed ASHRAE 2007 standards and comply with ASHRAE 90.1 2013.

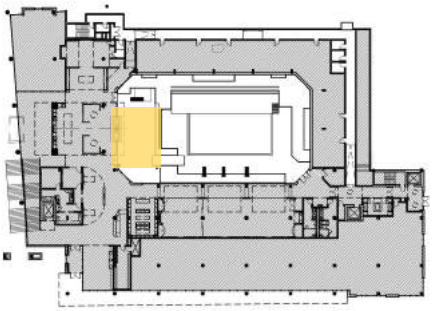
Table 1.25 | LPD Criteria - Pool Courtyard

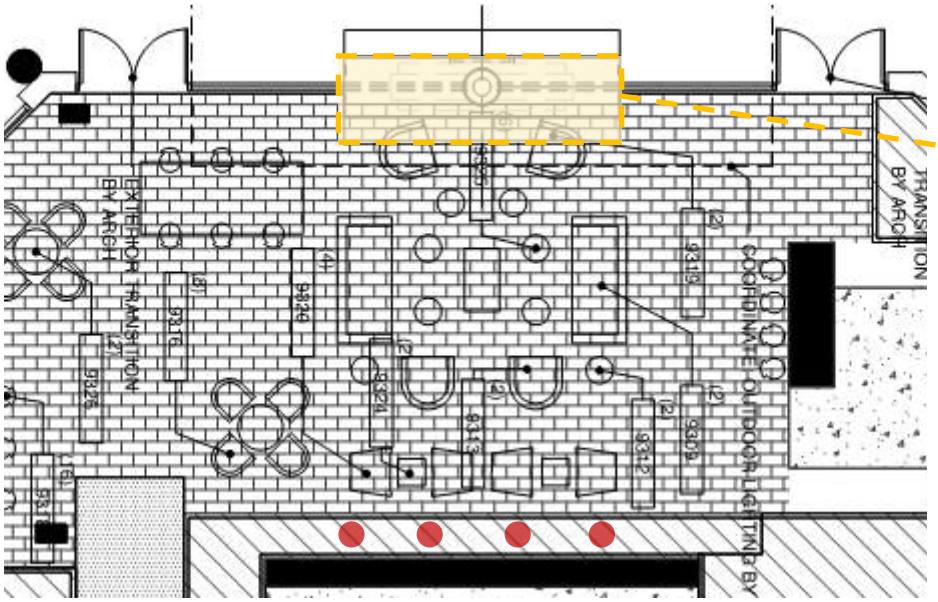
Space	Space Description	Allowance (W/SF)
Pool Courtyard	Building Grounds: Special Feature Area	0.2

Lighting Layout

Pool Lounge:

As stated, the lighting layout of the Pool Courtyard was designed to create a comfortable and fun seating area for the residents of Eastside III while highlighting the materials of the lounge and providing enough illumination for circulation at night.





See *elevation view* on Page 81 for the additional lighting fixtures and layout of the outdoor lounge.

Fixture Selection

Table 1.26 | Lighting Schedule Part 1 - Courtyard Lounge

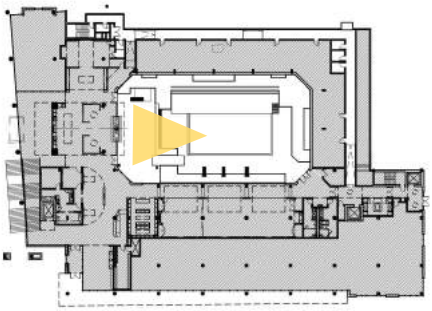
Type	Symbol	Image	Description	Manufacturer	Count	Mounting	Lamp	Wattage
L15			1.8" In-Ground Single LED Wallwash, Aluminum Finish, Wet Location, 50° Optic, Frosted Glass Diffuser	ACDC, Galli In-Ground Wallwash	4	Recessed In-Ground	LED, 2700K, 146 lms	2.5 W

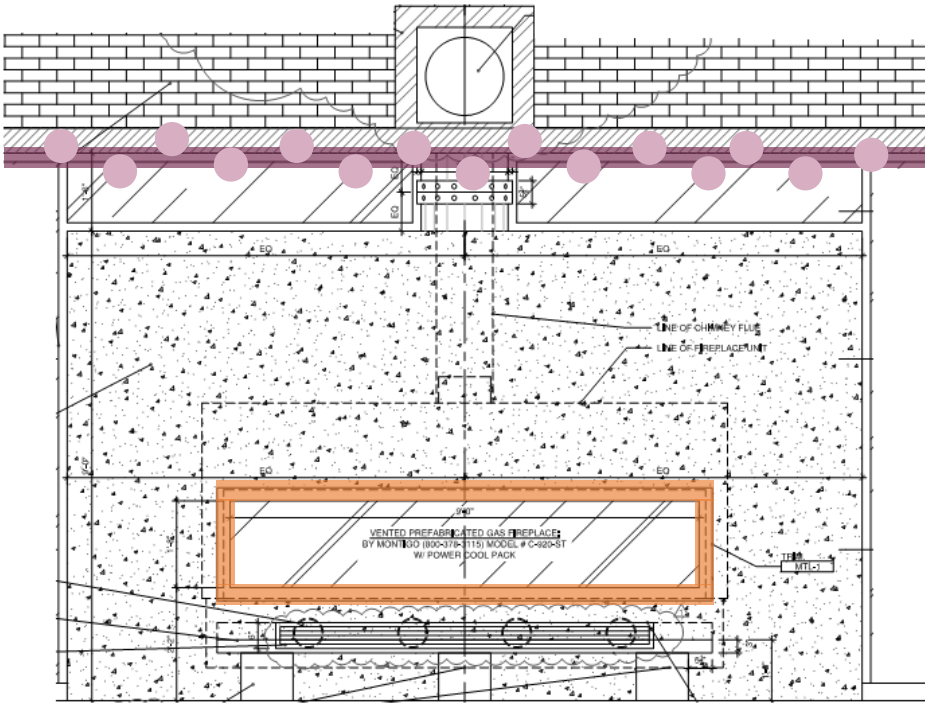
Note: A mock-up would be recommended to determine the placement and fixture count desired for grazing the brick dividing wall.

Lighting Layout

Pool Lounge *Continued*:

The fixture placement below illustrates the placement of the festoon lighting and linear LED tape placed around the perimeter of the fireplace. All fixtures in the lounge area wet location rated.





Fixture Selection

Table 1.27 | Lighting Schedule 2 - Courtyard Lounge

Type	Symbol	Image	Description	Manufacturer	Count	Mounting	Lamp	Wattage
L16			0.5" Wide Linear LED Tape, Wet Location IP67, Diffuse Cover	LED Linear Tape	26	Recessed around Perimeter, Fireplace	LED, 2500K, 176 lm/W	2.5 W/ft
L17			Decorative Festoon Lighting, Wet Location, Cable-Mounted	California Accent Lighting, marketLITE ML2000	50	Suspended, Mounting Aircraft Cable	LED, 2700K, 15 lms	0.5 W

Calculations

Tables 1.28 and 1.29 provide the calculated power density and illuminance levels for both the outdoor lounge area - based on ASHRAE 90.1 standards and the IES Handbook recommendations.

Lighting Power Density Calculation:

Table 1.28 | Lighting Power Density Calculation - Pool Courtyard

Fixture Type	Total Fixtures	Watts/ Fixture	Total Watts (W)	Area (sf)
L15	4	2.5	10	1000
L16	26	2.5W/ft	52	
L17	50	0.5	25	
		Calculated W/sf		0.087
		Allowed W/sf		0.2
		Pass?		YES
		% below ASHRAE?		57%

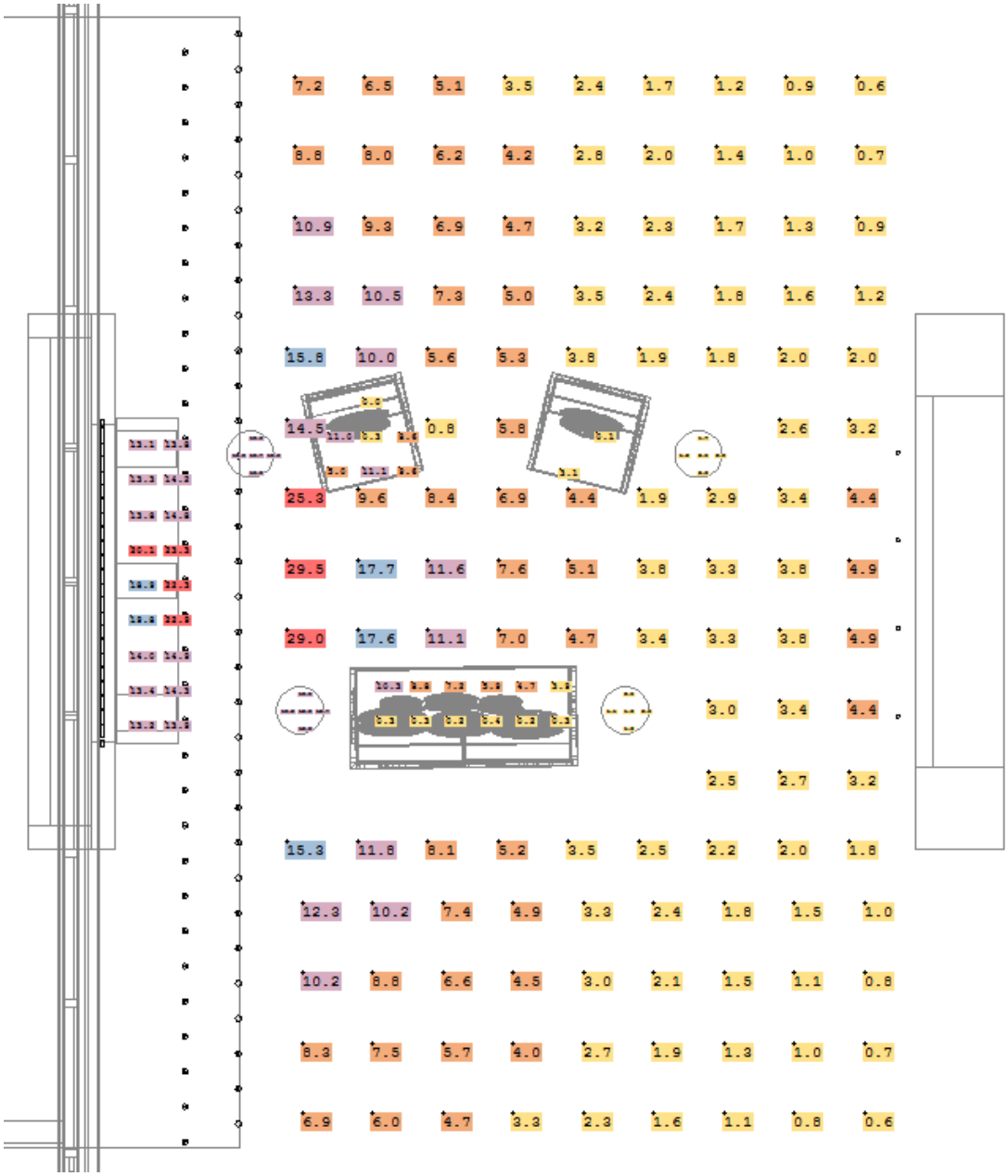
Illuminance Summary:

Table 1.29 | Illuminance Levels - Pool Courtyard

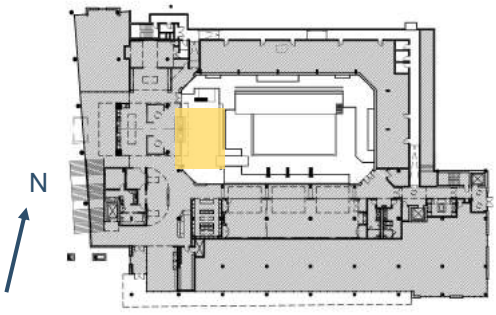
Space	Task	*Recommended Avg. Illuminance (lux)*	Achieved (lux)	*Recommended Avg./Min*	Achieved Avg./ Min
Outdoor Seating	Exterior Social Area: Low Activity, Moderate Ambient Light	4	10	4:1	5

The illuminance values calculated for the outdoor seating area exceeds illuminance and uniformity recommendations, however the calculations did not account for adjacent ambient light from the surrounding corridors - which are visible through curtain walls on all sides of the outdoor lounge.

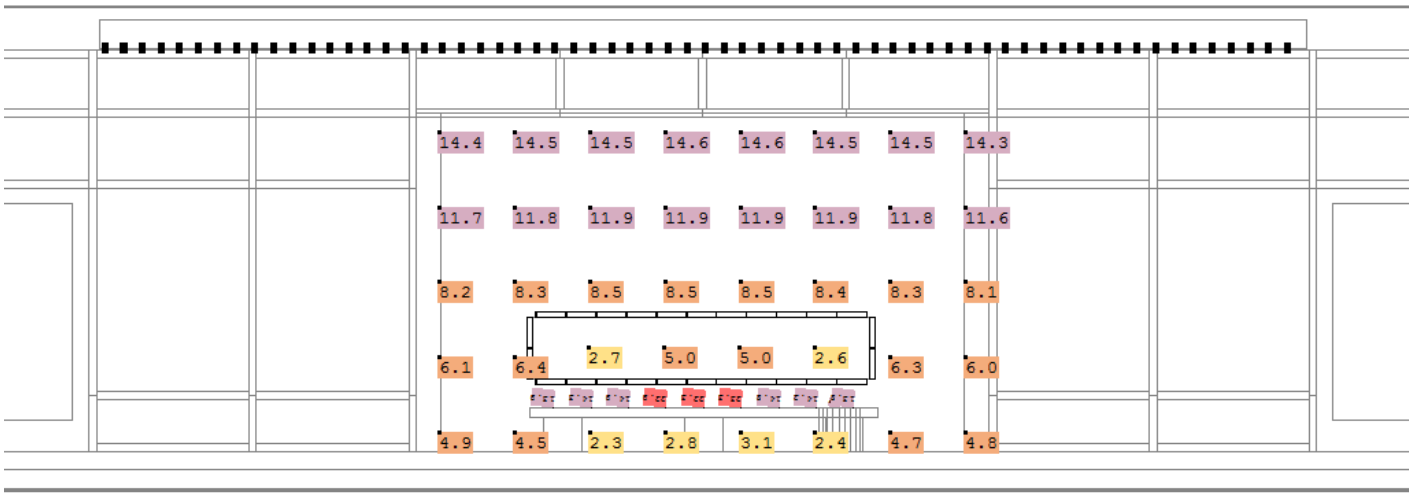
Illuminance Calculations:



Illuminance Calculation Key	
Colors	Range (lux)
	0 - 4
	4 - 10
	10 - 15
	15 - 20
	20 - 40

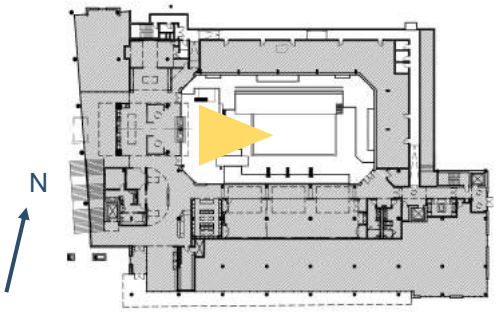


Illuminance Calculations:



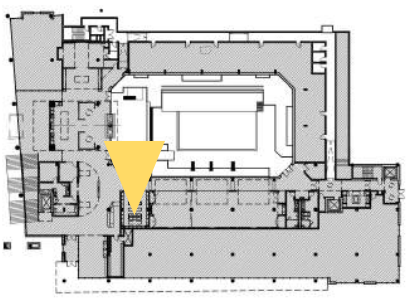
***Elevation View* - FIREPLACE**

Illuminance Calculation Key	
Colors	Range (lux)
	0 - 4
	4 - 10
	10 - 15
	15 - 20
	20 - 40



AGi32 Renderings

Figure 1.43| AGi32 Greyscale - Perspective View Courtyard Lounge



AGi32 Renderings

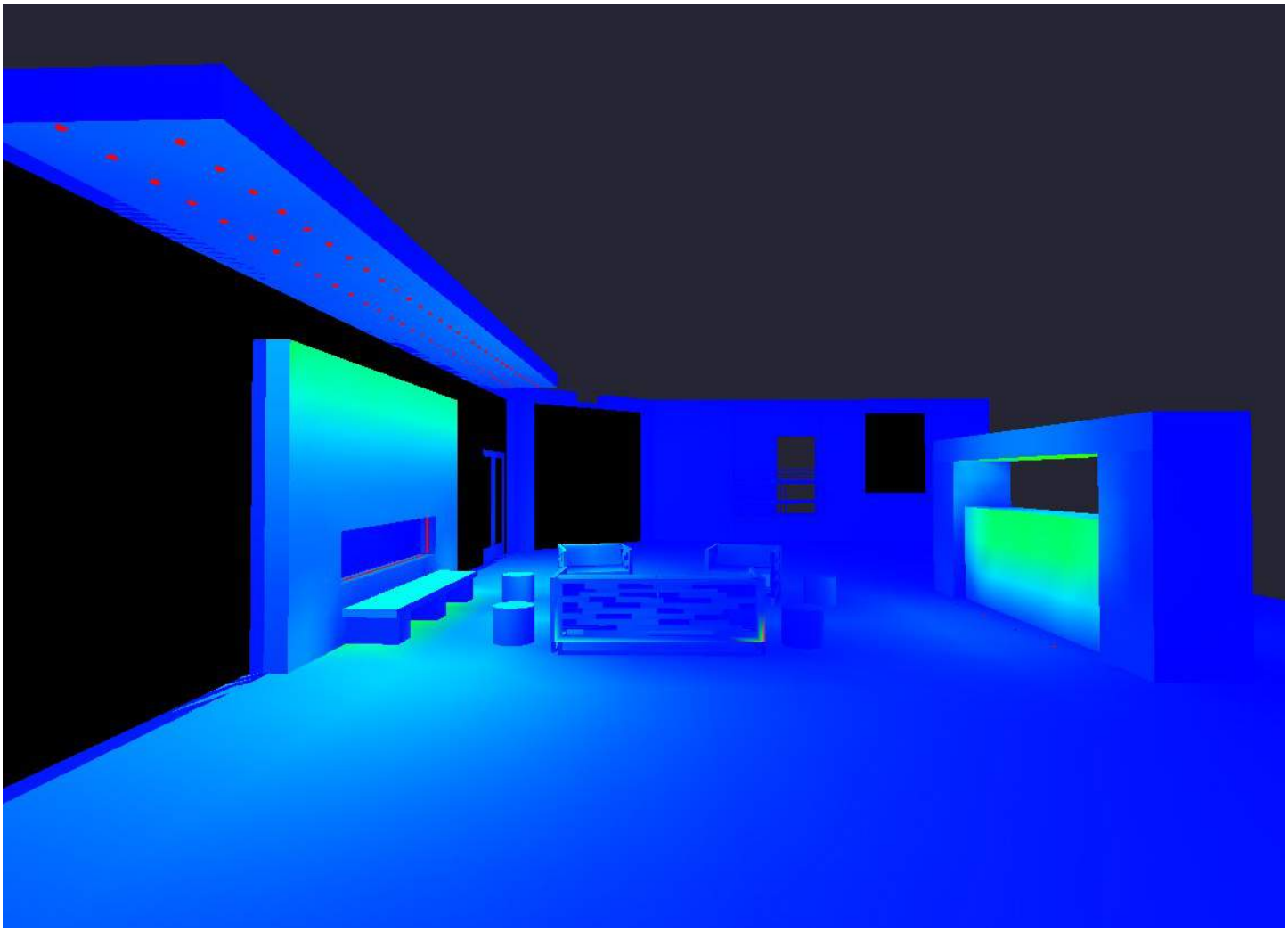
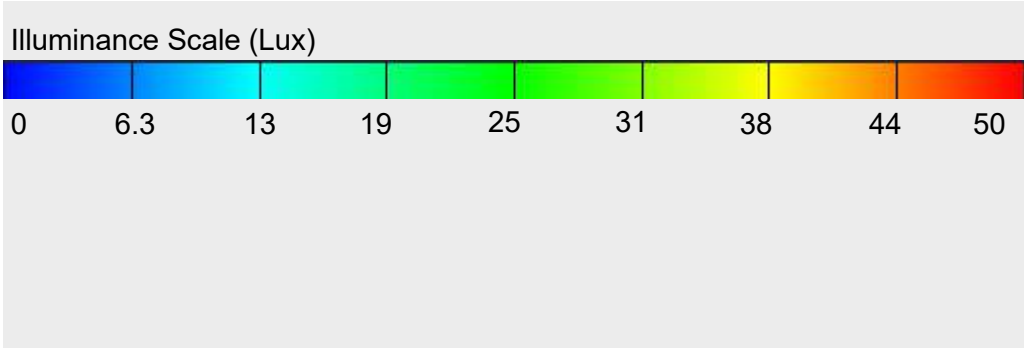
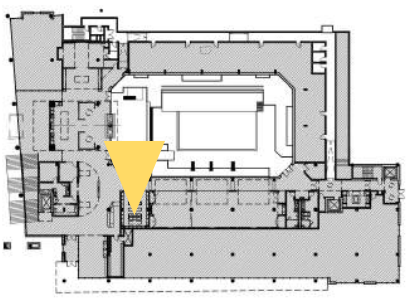


Figure 1.44 | AGi32 Pseudo Color - Perspective View Courtyard Lounge





AGi32 Renderings

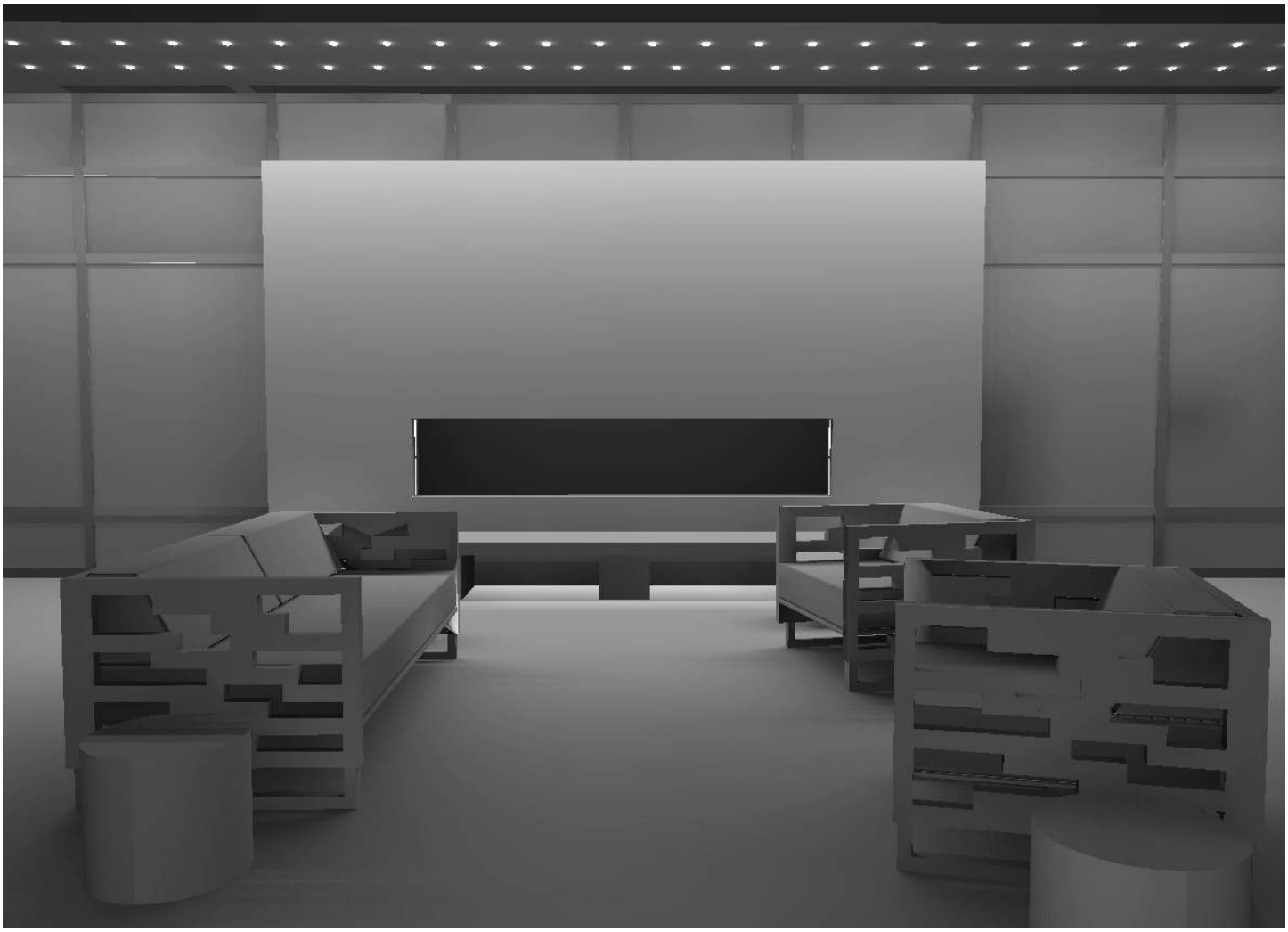
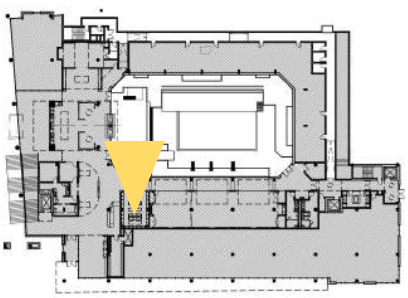


Figure 1.45 | AGi32 Greyscale - Perspective View Courtyard Lounge at Fireplace



AGi32 Renderings

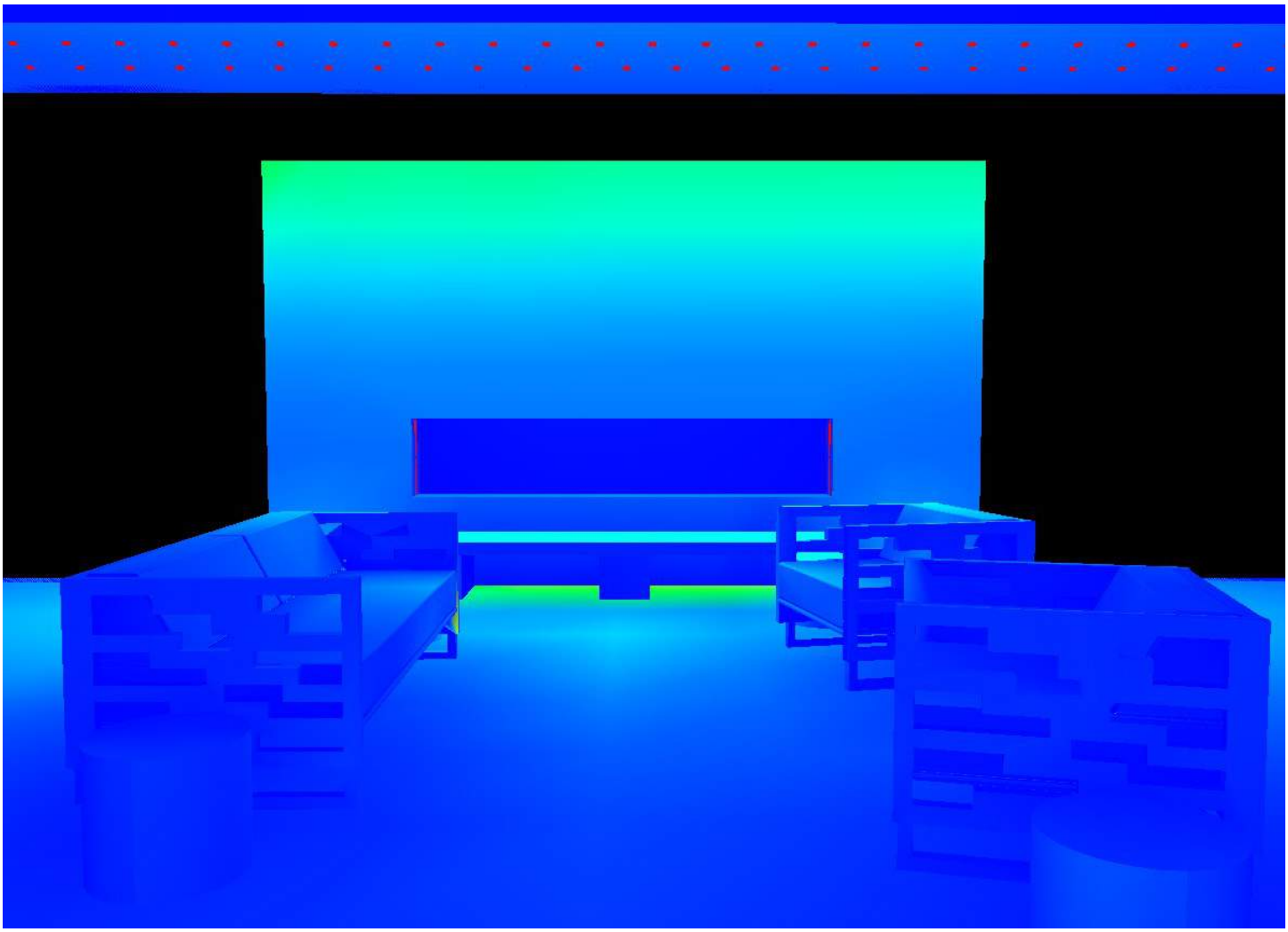
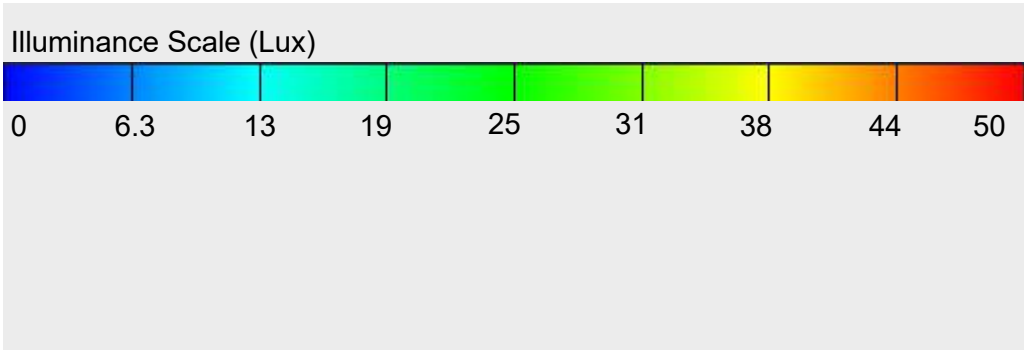
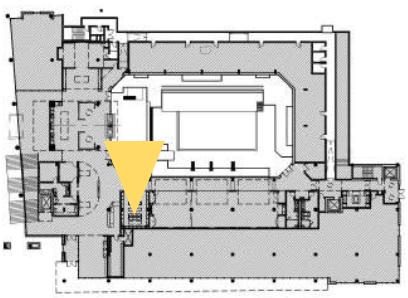


Figure 1.46 | AGi32 Pseudo Color - Perspective View Courtyard Lounge at Fireplace





Evaluation

The lighting design for the outdoor seating area provides a fun and flexible solution to the low illuminated space. Though the lighting levels in some areas of the lounge exceed recommended levels, the ambient lighting from the surrounding corridors will even out the contrast of the courtyard's illuminance values.

The festoon lighting hung along the wooden slats gives the space its fun and relaxing characteristics. Additionally, the perimeter lighting around the fireplace and grazing on the brick diving wall contribute to the overall lighting design concept for Eastside III - highlighting the materials present in the space to celebrate its *industry*.

Electrical Design

Depth

Introduction

This section is dedicated to the proposed redesign of the electrical utilization voltage system serving Eastside III. The following sections include an introduction to the existing electrical system, preliminary analyses and calculations, and a final system redesign solution.

Additionally, this section will include a detailed cost estimate of the proposed vs. existing electrical system, in terms of material, equipment and labor costs. This cost estimate introduces further studies performed in the Construction Breadth section of this report, that includes labor hour considerations and a construction schedule estimating the duration needed to construct the proposed electrical design.

Overview

For the electrical analysis of this report, the utilization voltage of the residential portion of Eastside III will be converted from a 208/120V system to a 480/277V system. The existing incoming 208/120V service transformer will be removed and the input voltage to the residential and commercial portions of the building will both be served from the 480/277V transformer only. This change will remove the existing residential switchboard and the commercial switchboard will be resized to consider the added load from the dwelling units. In addition to resizing the switchboard, this change will require the resizing of all feeders from the residential area, resizing the feeders from the input voltage to the switchboard, and installing a transformer for each meter of the residential section that serves the units' individual panelboards. The current feeder and equipment costs will be compared to the new cost of equipment and the electrical rooms on the second floor will be resized to account for the new residential transformers.

Existing Electrical System

As mentioned, Eastside III is a mixed-use building comprised of retail spaces, residential amenity spaces and residential units within. The existing electrical system was designed to follow this separation between the *residential* areas and *commercial* areas, which has been found to be a typical approach for mixed-use buildings like Eastside. The electrical service company, Duquesne Light Co., provides two incoming voltage systems to the building:

System 1:

- A 480/277V, three-phase incoming voltage system serves the retail and residential amenity spaces to account for large electrical, mechanical, and special equipment loads
- This system also includes a 480/277V to 208/120V transformer to account for small loads such as lighting and receptacles within the *commercial* section of Eastside III

System 2:

- A 208/120V, three-phase incoming voltage system serves into *residential* portion of the building and supplies power for the dwelling unit metering system
- A 208/120V, single-phase power serves the dwelling units of Eastside III from the meters to supply the apartment's individual electrical and mechanical loads

Preliminary Analyses + Calculations

Preliminary Dwelling Unit Load Calculation without Mechanical Loads:

This preliminary calculation represents the estimated loads and their appropriate demand factors for the Dwelling Units of Eastside III according to NEC 2011 Article 220. The calculation is based on the *largest apartment unit* size of 1,340 SF. The unit load of 3 VA/SF, according to Table 220.12 of NEC 2011, was used to calculate the general apartment Lighting + Receptacle loads seen in Table 2.1. Table 2.2 represents the calculation for the total dwelling unit loads using an optional demand factor method, according to section 220.82 (B): Dwelling Units General Loads of NEC 2011 *before* mechanical loads were accounted for.

Table 2.1 | Preliminary Dwelling Unit Load Calculation

Appliance Type	Load Type	Equipment Load (VA)	# of Equipment	Allowable Load (VA)
General Apartment	Lighting + Receptacle	4,020		4,020
	Small Appliances	1,500	2	3,000
	Washer	1,500	1	1,500
	Dryer	5,000	1	5,000
	Range	8,000	1	8,000
Fastened Appliances	Disposal	900	1	900
	Microwave	1,200	1	1,200
	Dishwasher	1,200	1	1,200
	Water Heater	4,500	1	4,500
			Total*	**29,320 VA**

* Total allowable load before demand factor calculation (see Table 1.3)

Table 2.2 | Dwelling Unit Load Calculation - Optional Method

Allowable Load	Load (VA)	Demand Factor	Adjusted Load
First 10kVA	10,000	100%	10,000
Remainder	19,320	40%	7,728
		Total	**17,729 VA**

Preliminary Dwelling Unit Load Calculation with Mechanical Loads:

Each apartment unit in Eastside III utilizes a heat pump. An estimated 1,500 VA was used to account for the mechanical load of the heat pump. The **total dwelling unit load** calculation was determined by adding the mechanical load to the calculated total load, found in Table 1.3. The final load, calculated and highlighted in yellow below, was used to size the feeders and circuit breaker serving the dwelling units' panelboards.

Eq. 1 | 17,729 VA + **1,500 VA** (*heat pump)* = **19,229 VA**

Dwelling Unit Panelboard Sizing Calculation:

The dwelling units are being served with a 208/120 V, single-phase power. Equation 2 was used to size the feeder and circuit breaker size for the panelboards:

Eq. 2 | 19,229 VA / 208 V = 92 Amps → **100 A Circuit Breaker**

A **100 A circuit breaker** with **three #2 AWG** copper wire was estimated to serve the dwelling unit power loads, according to Table 310.15(B)(16) in NEC 2011 for sizing conductors. The temperature rating of 60° C was assumed for this estimate.

Redesigned Electrical System

Based on the previous preliminary calculations, the following section introduces the newly designed electrical system that will serve the *residential* and *commercial* sections of Eastside III solely from one 480/277 V incoming voltage transformer. It is important to note that due to this system redesign, Duquesne Light Co. would be responsible for resizing the incoming voltage transformer to account for the larger load on the main switchboard and based on the new incoming feeder size.

For the purpose of this depth, the following load and equipment sizing calculations were performed with this assumption in mind, starting from the incoming transformer, serving into the main switchboard.

In order to design and size the new electrical system, the following steps were completed and will be described in detail in the following sections:

1. Size the 480/277V → 208/120V transformer, based on the total dwelling unit load serving each meter
2. Calculate the Full Load Current (F.L.C.) on the *primary* and *secondary* sides of the transformer
3. Size the Over-Current Protector (O.C.P.) for the *primary* and *secondary* sides of the transformer
4. Size the circuit breakers on the *primary* and *secondary* sides of the transformer
5. Size the *primary* and *secondary* feeders, ground wires and conduit
6. Re-size the *commercial* switchboard
7. Re-size the incoming voltage feeder from the building utilization transformer into the new switchboard

Step 1: Dwelling Unit Transformer Sizing Calculation:

The utilities of the 175 apartment units of Eastside III were submetered onto four separate meters, located in the NW, SW, NE, SE electrical closets on Floors 2 and 4. These meters serve the individual dwelling unit panelboards on each floor and will be served into the main 480/277 V *commercial* switchboard located on the ground level. Table 2.3 below calculates the total loads on each meter. The *total dwelling unit load* value seen in Table 2.3 was calculated *without* the optional method demand factors accounted for but *with* mechanical loads accounted for. Equation 3 shows how this value was determined:

Eq. 3 | 29,320 VA + 1,500 VA (*heat pump load*) = **30,820 VA**

The demand factors in Table 2.3 were determined from Table 220.84: Demand Factors for Multifamily Dwelling Units in NEC 2011.

Table 2.3 | Meter Loads

Meter Type	Total Dwelling Unit Load (VA)	# of Apartment Units per Meter	Demand Factor	Total Load per Meter (VA)
NW	**30,820**	36	30%	316,656
SW		48	26%	365,914
NE		55	25%	403,150
SE		36	30%	316,656

Based off the Total Load per Meter calculated in Table 2.3, a **500 kVA** transformer will serve *each* meter from the 480/277V switchboard.

500 kVA Transformer

There will be (4) 500 kVA transformers installed into the *residential* portion of Eastside III to step down from 480/277 V to 208/120 V. The location of these transformers can be found in Figure 2.1.

Figure 2.1 represents a simplified, zoomed-in version of the *proposed* system's riser diagram showing the connection between the residential meters, the transformers serving the meters, and the commercial switchboard located on the Ground Level of Eastside III. The full riser diagram for the redesigned system can be found in Appendix B.

Step 2: Dwelling Unit Primary + Secondary Full Load Current (F.L.C.) Calculation:

The *primary* side of each transformer serves the 480/277 V, 3-phase switchboard into the commercial section of Eastside III. Equation 4 below calculates the Full Load Current for the *primary* side based off the previously calculated transformer sizes.

Eq. 4 | 500,000 VA / (480 V * √3) = **601 Amps**

The *secondary* side of each transformer serves the Dwelling Units of Eastside III at 208/120, 3-phase power. Equation 5 calculations the Full Load Current for the *secondary* side based off the previously calculated transformer sizes.

Eq. 5 | 500,000 VA / (208 V * √3) = **1387 Amps**

Step 3: Dwelling Unit Primary + Secondary Over Current Protection (O.C.P.) Calculation:

The *primary* and *secondary* Over Current Protections were sized based of the previously calculated Full Load Current calculations in Equations 6 and 7. The demand factors of 150% for *primary* and 125% for *secondary* were determined from Table 450.3(B) of NEC 2011 and from input from my electrical advisor. Equations 6 and 7 below calculate the OCP for the *primary* side (Eq. 6) and *secondary* sides (Eq. 7) of the transformer.

***Primary:* Eq. 6 |** 601 A x 1.50 = **901.5 A**

***Secondary:* Eq. 7 |** 1387 A x 1.24 = **1733.75 A**

Step 4: Sizing the Circuit Breakers:

The previously calculated primary and secondary OCP sizes determined the breaker sizes, highlighted in the yellow boxes below.

901.5 A	→	**1000 A Circuit Breaker**
1733.75 A	→	**2000 A Circuit Breaker**

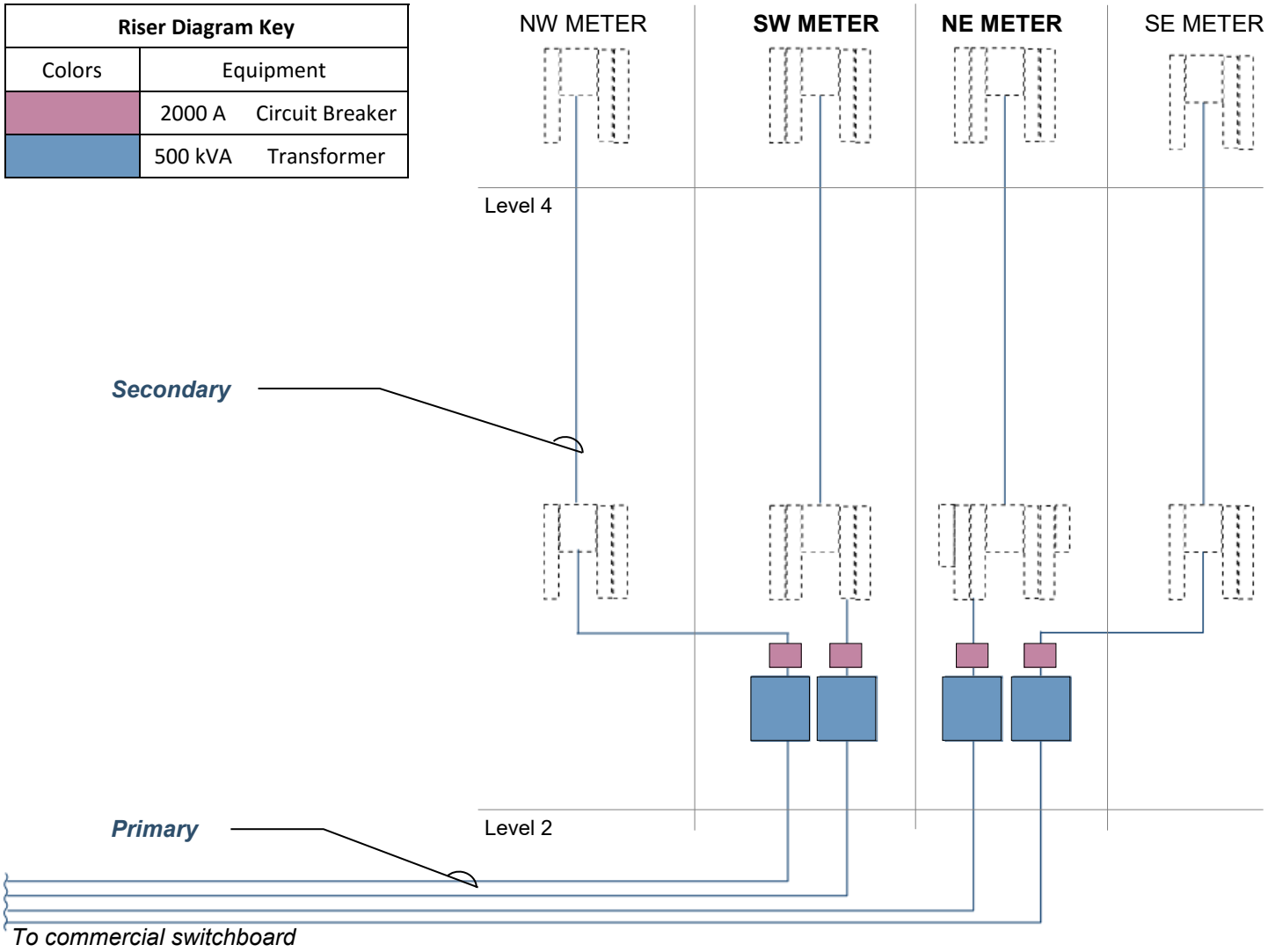


Figure 2.1 | Redesigned Electrical Riser Diagram

Step 5: Dwelling Unit Primary + Secondary Feeder + Conduit Sizing Calculation:

The feeders serving the *primary* and *secondary* sides of each transformer are determined from Table 310.15(B)(16) of NEC 2011 and based off of the previously calculated circuit breaker sizes. A 75°C copper conductor temperature rating was assumed. The grounding wires were found from Table 250.122 and the conduit sizes were found from Annex C, Table C.1 in NEC 2011.

- ***Primary:*** Provide (3) sets of (4#500 kcmil copper + 1#2/0 AWG copper ground in 3.5" conduit)
- ***Secondary:*** Provide (5) sets of (4#600 kcmil copper + 1#250 kcmil ground in 4" conduit)

Step 6: Commercial Switchboard Resize:

The additional loads from the dwelling units were added to the *commercial* 480/277 V, 3-phase switchboard located on the ground floor of the commercial section of Eastside III. The residential loads were added to the existing 2500A *commercial* switchboard and resized in Equation 8 below.

Eq. 8 | $\frac{30{,}820 \text{ VA} * 175 \text{ Units} * 0.23}{480 \text{ V} * \sqrt{3}} + 2500 \text{ A} = 3992 \text{ Amps}$ → **4000 A Switchboard**

Step 7: Switchboard Feeder Resize:

The feeders serving the 4000 A *commercial* switchboard from the input utility transformer were sized from Table 310.15(B)(16) of NEC 2011. A 75°C copper conductor temperature rating was assumed. The grounding wire was found from Table 250.122 and the conduit size was found from Annex C, Table C.1 in NEC 2011.

- ***Input:*** Provide (10) sets of (4#600 kcmil copper + 1#500 kcmil copper ground in 4" conduit)

Equipment Details

As previously stated, a 500 kVA transformer was sized to serve each residential meter from the 480/277 V *commercial* switchboard. There are (4) 500 kVA transformers that will be installed with the proposed electrical design. These transformers will be placed in the NE and SW electrical rooms on the second level - two transformers in each room. Figures 2.3 and 2.4 show the NE and SW electrical room layout, with the new transformers and circuit breakers installed and the appropriate clearances for each equipment type.

The transformer specified is a GE TransforMore general purpose transformer, shown below, with fan-assisted cooling incorporated within. The size of the transformers are: 3'-3" W x 3'-9" H x 2'-9" D. For more information on the transformer, refer to Appendix C for the manufacturer cutsheet.

Resizing Electrical Rooms

The North East and South West electrical rooms, located on the second floor, were resized based on the newly installed 500 kVA transformers and 2000 A secondary circuit breakers to the redesigned system. Two transformers and two circuit breakers will be installed in each electrical room. These additions will increase the size of the existing electrical rooms and create other areas for considerations, which are discussed on the following page.

Electrical Room Layout - *Notes + Assumptions:*

- All walls should be 2-hour fire since transformer is larger than 112.5 kVA
- (2) doors are needed that swing outward + have panic hardware, due to the 2000 A circuit breaker
- These doors should be placed on opposite ends of the room
- The 2000 A circuit breaker must be installed within 10 feet of the transformer it serves
- The transformer must be at least 6" from the wall
- There needs to be at least 1 foot (more preferably) between transformers for wiring pulling
- Each panelboard requires shoulder's width space (30") for clearance from side to side, this width clearance can be shared with adjacent panelboards
- Each panelboard must have 3 feet in clearance, coming out from the front of the panel
- The 2000 A circuit breaker is 2' x 2' in size
- The 500 kVA transformers 3'-3" W x 3'-9" H x 2'-9" D in size

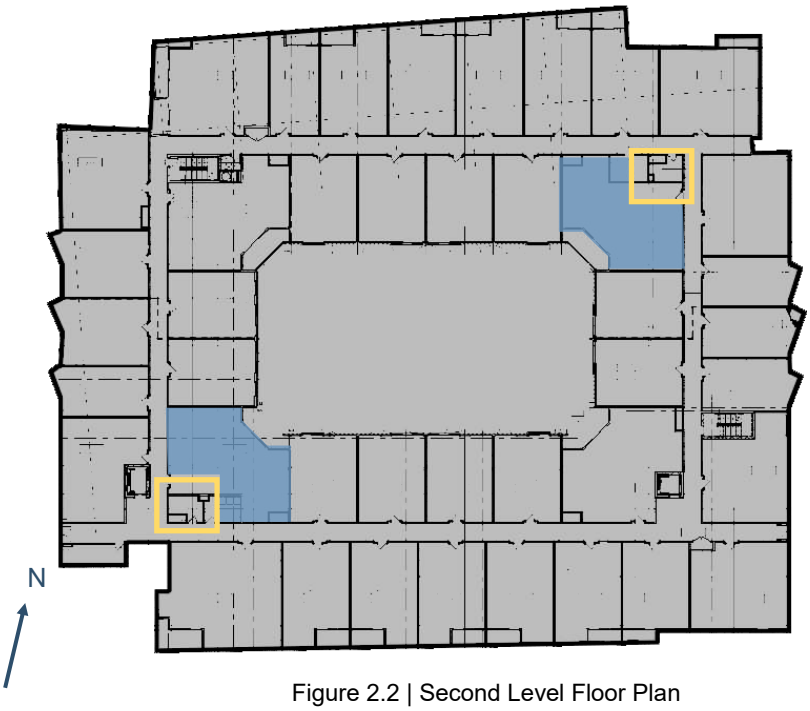


Figure 2.2 | Second Level Floor Plan

***Existing* Electrical Room Layout:**

Rooms outlined in *yellow* represent the existing NE and SW electrical rooms on the second level of Eastside III. Both electrical rooms are directly adjacent to apartment units - highlighted in *blue*.

The existing electrical rooms consist of panelboards, dwelling unit meters, and small transformers that serves lighting loads to the corridors.

Since each electrical room will be adding (2) 500 kVA transformers + (2) 2000 A circuit breakers, the room will not only need to be doubled in size, but acoustical and mechanical considerations will rise to ensure resident comfort and proper cooling to the space.

New Electrical Room Layouts

Northeast Electrical Room:

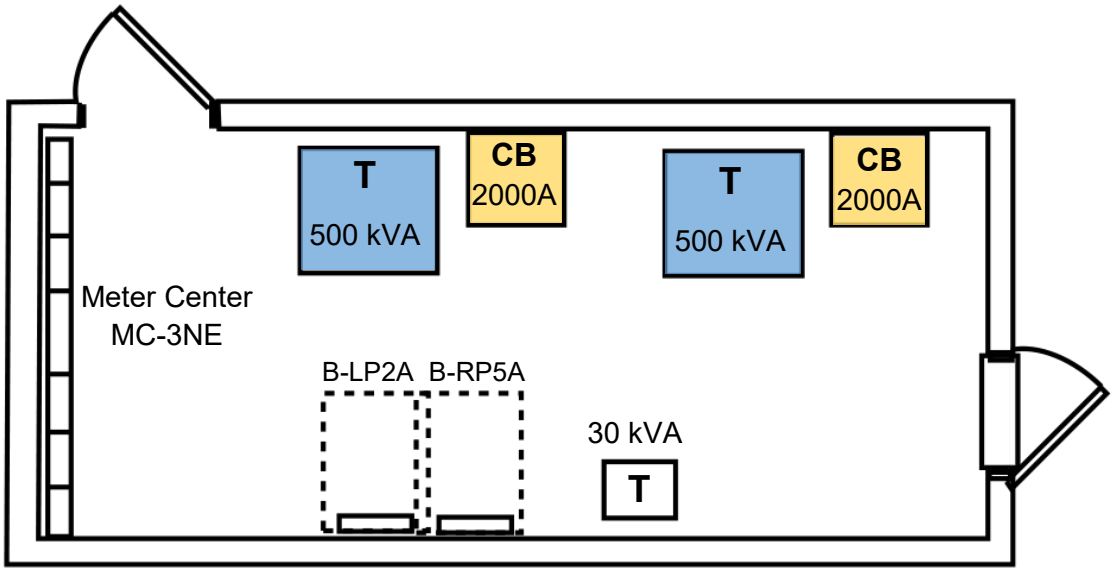


Figure 2.3 | Second Level - New NE Electrical Room Layout

Southwest Electrical Room:

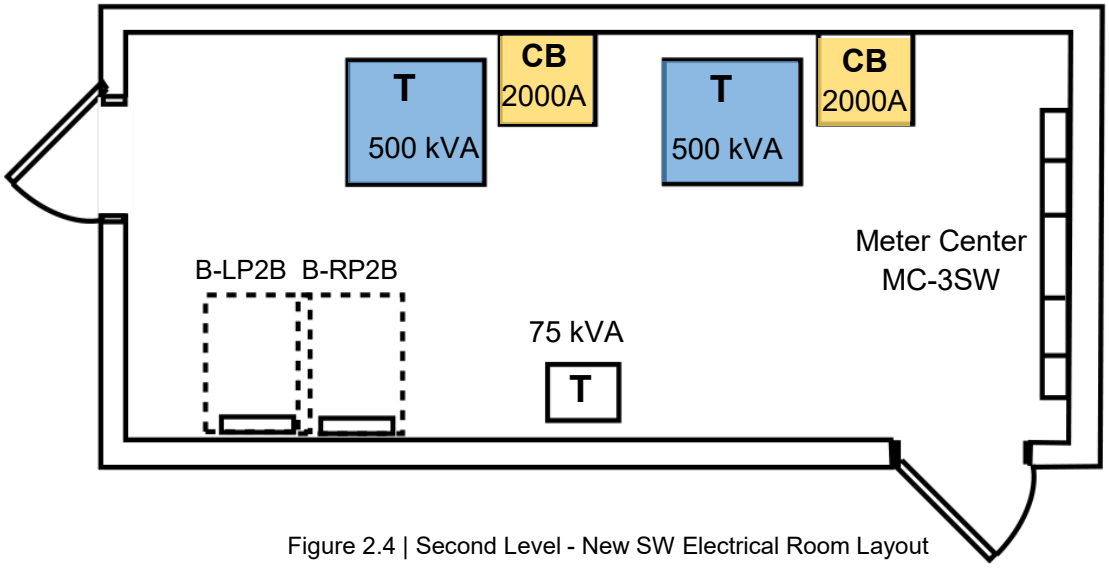


Figure 2.4 | Second Level - New SW Electrical Room Layout

Other Considerations

HVAC Considerations:

Due to the small size of electrical equipment in the existing NE and SW electrical rooms, there is no cooling needed for the space. The rooms are simply being exhausted, which is a sufficient solution for the 30kVA and 75kVA transformers. However, in order to install (2) 500 kVA transformers to the room, cooling loads need to be addressed to account for the significant amount of heat that the transformers will produce. The following calculation was performed to estimate the tons of cooling that would be required for the redesigned electrical rooms. It was estimated that a 500 kVA transformer produces 25 W/kVA.

500 [kVA] * 25 [W/kVA] = 12500 [W]

12.5 [kW] * 3412.142 [(BTU/hr) / kW] = 43504.81 [BTU/hr]

43504.81 [BTU/hr] / 12,000 = **3.63 tons**

The NE and SW electrical rooms would need **3.63 tons of cooling** in order to account for the new transformer heating loads.

Acoustical Considerations:

In addition to mechanical considerations in the electrical rooms from the 500 kVA transformers, acoustical concerns and solutions should also be considered. It is estimated that a 500 kVA transformer produces 60 decibels of sound. An example of a 60 dB noise source would be: conversation at a restaurant, noise in an office building, background music, or an air-conditioning unit at 100 feet away.

Since the NE and SW electrical rooms border private residential units, the equipment noise from these transformers is a large concern. In order to prevent unwanted noise from the electrical rooms, it is recommended to avoid room placement near residential units all together. This coordination would be completed during the *planning* phase of design early on. Planning is one of the best ways to reduce problems with background noise levels - this can be done by *isolating* quiet areas from the noisier areas. There must be a buffer zone between the electrical rooms and dwelling units to avoid noise transfer - the best solution for a buffer zone would be a corridor. If a buffer zone cannot be provided for the electrical room and dwelling unit, the acoustic characteristics of the separation wall must be adjusted to account for the excess sound transmission. A high STC rating and Noise Criteria value of approximately 25-35 would be required for the dividing wall between the electrical room and residential unit.

Cost Analysis

Existing Electrical System:

The following calculations and equipment cost estimations were determined from RS Means Building Construction Cost 2017. The *existing* electrical systems cost analysis includes the cost estimation of the *primary* feeder, grounding wire, and conduit serving the residential portion of Eastside III from the existing 208/120 V, 2500A *residential* switchboard. In addition, the costs of the feeder, grounding, and conduit types from the *input voltage* were calculated serving both the 208/120 V, 4000A *residential* switchboard and 480/277 V, 2500A *commercial* switchboard. Lastly, the estimated cost for each existing switchboard was determined.

Tables 2.4 and 2.5 show the detailed calculation used to determine the *existing* cost of the incoming 480/277V and 208/122V transformers from Duquesne Lighting Co. that serve the commercial and residential sections of Eastside III. Table x.xx on the next page describes the *existing* wire costs for the *primary* side of the existing 208/120 V, 2500A *residential* switchboard. These wire cost analyses show the calculated costs of the feeders, ground, and conduit for this system. Refer to the existing riser diagram in Appendix 2 to further understand the location and distribution of the equipment within the building.

Table 2.4 | Existing 480/277V Input Transformer (2500A Commercial Switchboard) Wire Cost Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	RS Means Feeder Cost (per C.L.F.)	Feeder Total/ C.L.F ($)	Ground Type	RS Means Ground Cost (per C.L.F.)	Ground Total/ C.L.F ($)	Conduit Type	RS Means Conduit Cost (per L.F.)	Conduit Total/ L.F. ($)
Input Voltage	Main Elec, Ground	1	8	4	400 kcmil Cu	1011	$32,352.00	350 kcmil	622	$4,976.00	3.5"	37.45	$29,960.00
					Feeder Cost		$268,880.64	**Ground Cost**		$51,949.44	**Conduit Cost**		$312,782.40

Table 2.5 | Existing 208/122V Input Transformer (4000A Residential Switchboard) Wire Cost Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	RS Means Feeder Cost (per C.L.F.)	Feeder Total/ C.L.F ($)	Ground Type	RS Means Ground Cost (per C.L.F.)	Ground Total/ C.L.F ($)	Conduit Type	RS Means Conduit Cost (per L.F.)	Conduit Total/L.F. ($)
Input Voltage	Main Elec, Ground	1	10	4	600 kcmil Cu	1300	$52,000.00	500 kcmil	1178	$11,780.00	4"	32.3	$32,300.00
					Feeder Cost		$353,232.64	**Ground Cost**		$68,705.44	**Conduit Cost**		$375,042.40

*Assume input voltage transformer located 100 feet away from main electrical room

Table 2.6 | Existing Primary Wire Cost Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	RS Means Feeder Cost (per C.L.F.)	Feeder Total/ C.L.F ($)	Ground Type	RS Means Ground Cost (per C.L.F.)	Ground Total/ C.L.F ($)	Conduit Type	RS Means Conduit Cost (per L.F.)	Conduit Total/ L.F. ($)
2	SW	0.39	4	6	400 kcmil Al	522	$4,885.92	350 kcmil	622	970.32	4"	37.45	$5,842.20
2	NW	1.31	4	6	400 kcmil Al	522	$16,411.68	350 kcmil	622	3259.28	4"	37.45	$19,623.80
2	SE	2.35	4	6	400 kcmil Al	522	$29,440.80	350 kcmil	622	5846.8	4"	37.45	$35,203.00
2	NE	1.86	4	6	400 kcmil Al	522	$23,302.08	350 kcmil	622	4627.68	4"	37.45	$27,862.80
4	SW	0.61	4	6	400 kcmil Al	522	$7,642.08	350 kcmil	622	1517.68	4"	37.45	$9,137.80
4	NW	1.53	4	6	400 kcmil Al	522	$19,167.84	350 kcmil	622	3806.64	4"	37.45	$22,919.40
4	SE	2.57	4	6	400 kcmil Al	522	$32,196.96	350 kcmil	622	6394.16	4"	37.45	$38,498.60
4	NE	2.08	4	6	400 kcmil Al	522	$26,058.24	350 kcmil	622	5175.04	4"	37.45	$31,158.40
					Feeder Cost		$159,105.60	**Ground Cost**		$31,597.60	**Conduit Cost**		$190,246.00

Total Feeder Cost	$401,996.32	Total Ground Cost	$76,940.72	Total Conduit Cost	$424,626.20

Existing Electrical System *Continued:*

Table 2.7 below show the detailed calculation used to determine the *residential* and *commercial* switchboards. The cost for these systems were determined from RS Means.

Table 2.7 | Existing Residential + Commercial Switchboard Cost Analysis

Type	Switchboard Size	No. of SWBD	RS Means XFMR Cost
120/208 V Residential	2500 A	1	$7,475.00
277/480 V Commercial	4000 A	1	$9,725.00
Total Switchboard Cost			**$17,200.00**

Proposed Electrical System:

The following calculations and equipment cost estimations were determined from RS Means Building Construction Cost 2017. The *proposed system* cost estimation was determined for the *primary* and *secondary* sides of the new 500kVA transformers serving into the new 4000A *commercial* switchboard. The *primary* and *secondary* feeder, grounding wire, and conduit costs were calculated as well as the new transformer and switchboard costs. In addition, the costs of the feeder, grounding, and conduit types from the *input voltage* were calculated serving the new 480/277 V, 4000A *commercial* switchboard. Tables 2.8 - 2.12, provide greater detail of the specific *proposed* system cost analyses.

Table 2.8 | New 480/277V Input Transformer (4000A Switchboard) Wire Cost Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	RS Means Feeder Cost (per C.L.F.)	Feeder Mtrl & Labor/ C.L.F ($)	Ground Type	RS Means Ground Cost (per C.L.F.)	Ground Total/C.L.F ($)	Conduit Type	RS Means Conduit Cost (per L.F.)	Conduit Total/L.F. ($)
Input Voltage	Main Elec, Ground	1	10	4	600 kcmil Cu	1300	$52,000.00	500 kcmil	1178	$11,780.00	4"	37.45	$37,450.00
					Feeder Cost		$166,920.00	**Ground Cost**		$24,796.90	**Conduit Cost**		$120,214.50

*Assume input voltage transformer located 100 feet away from main electrical room

Table 2.9 | New Primary Wire Cost Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	RS Means Feeder Cost (per C.L.F.)	Feeder Mtrl & Labor/ C.L.F ($)	Ground Type	RS Means Ground Cost (per C.L.F.)	Ground Total/ C.L.F ($)	Conduit Type	RS Means Conduit Cost (per L.F.)	Conduit Total/ L.F. ($)
2	SW	0.22	3	4	400 kcmil Cu	1011	$2,669.04	2/0 AWG	405	$267.30	3.5"	32.3	$2,131.80
2	SW	0.22	3	4	400 kcmil Cu	1011	$2,669.04	2/0 AWG	405	$267.30	3.5"	32.3	$2,131.80
2	NE	1.74	3	4	400 kcmil Cu	1011	$21,109.68	2/0 AWG	405	$2,114.10	3.5"	32.3	$16,860.60
2	NE	1.74	3	4	400 kcmil Cu	1011	$21,109.68	2/0 AWG	405	$2,114.10	3.5"	32.3	$16,860.60
					Feeder Cost		$47,557.44	**Ground Cost**		$4,762.80	**Conduit Cost**		$37,984.80

Table 2.10 | New 480/277V Input Transformer (4000A Switchboard) Wire Cost Analysis													
Type	**Elec Room**	**Linear Feet (C.L.F)**	**No. of sets**	**No. of wires**	**Feeder Type**	**RS Means Feeder Cost (per C.L.F.)**	**Feeder Mtrl & Labor/ C.L.F ($)**	**Ground Type**	**RS Means Ground Cost (per C.L.F.)**	**Ground Total/C.L.F ($)**	**Conduit Type**	**RS Means Conduit Cost (per L.F.)**	**Conduit Total/L.F. ($)**
Input Voltage	Main Elec, Ground	1	10	4	600 kcmil Cu	1300	$52,000.00	500 kcmil	1178	$11,780.00	4"	37.45	$37,450.00
					Feeder Cost		$166,920.00	**Ground Cost**		$24,796.90	**Conduit Cost**		$120,214.50

*Assume input voltage transformer located 100 feet away from main electrical room

Table 2.11 | New Primary Wire Cost Analysis													
Floor	**Elec Room**	**Linear Feet (C.L.F)**	**No. of sets**	**No. of wires**	**Feeder Type**	**RS Means Feeder Cost (per C.L.F.)**	**Feeder Mtrl & Labor/ C.L.F ($)**	**Ground Type**	**RS Means Ground Cost (per C.L.F.)**	**Ground Total/ C.L.F ($)**	**Conduit Type**	**RS Means Conduit Cost (per L.F.)**	**Conduit Total/ L.F. ($)**
2	SW	0.22	3	4	400 kcmil Cu	1011	$2,669.04	2/0 AWG	405	$267.30	3.5"	32.3	$2,131.80
2	SW	0.22	3	4	400 kcmil Cu	1011	$2,669.04	2/0 AWG	405	$267.30	3.5"	32.3	$2,131.80
2	NE	1.74	3	4	400 kcmil Cu	1011	$21,109.68	2/0 AWG	405	$2,114.10	3.5"	32.3	$16,860.60
2	NE	1.74	3	4	400 kcmil Cu	1011	$21,109.68	2/0 AWG	405	$2,114.10	3.5"	32.3	$16,860.60
					Feeder Cost		$47,557.44	**Ground Cost**		$4,762.80	**Conduit Cost**		$37,984.80

Table 2.12 | New Secondary Wire Cost Analysis													
Floor	**Elec Room**	**Linear Feet (C.L.F)**	**No. of sets**	**No. of wires**	**Feeder Type**	**RS Means Feeder Cost (per C.L.F.)**	**Feeder Mtrl & Labor/ C.L.F ($)**	**Ground Type**	**RS Means Ground Cost (per C.L.F.)**	**Ground Total/C.L.F ($)**	**Conduit Type**	**RS Means Conduit Cost (per L.F.)**	**Conduit Total/L.F. ($)**
2	SW	0	5	4	600 kcmil Cu	1300	$0.00	250 kcmil	589	$0.00	4"	37.45	$0.00
2	NW	0.62	5	4	600 kcmil Cu	1300	$16,120.00	250 kcmil	589	$1,825.90	4"	37.45	$11,609.50
2	SE	0.62	5	4	600 kcmil Cu	1300	$16,120.00	250 kcmil	589	$1,825.90	4"	37.45	$11,609.50
2	NE	0	5	4	600 kcmil Cu	1300	$0.00	250 kcmil	589	$0.00	4"	37.45	$0.00
4	SW	0.22	5	4	600 kcmil Cu	1300	$5,720.00	250 kcmil	589	$647.90	4"	37.45	$4,119.50
4	NW	0.84	5	4	600 kcmil Cu	1300	$21,840.00	250 kcmil	589	$2,473.80	4"	37.45	$15,729.00
4	SE	0.84	5	4	600 kcmil Cu	1300	$21,840.00	250 kcmil	589	$2,473.80	4"	37.45	$15,729.00
4	NE	0.22	5	4	600 kcmil Cu	1300	$5,720.00	250 kcmil	589	$647.90	4"	37.45	$4,119.50
					Feeder Cost		$87,360.00	**Ground Cost**		$9,895.20	**Conduit Cost**		$62,916.00

Total Feeder Cost	**$249,922.04**	**Total Ground Cost**	**$33,327.75**	**Total Conduit Cost**	**$185,202.80**

Proposed Electrical System *Continued:*

Tables 2.13 and 2.14 below show the detailed calculation used to determine the resized 4000 A *commercial* switchboard and the new 500 kVA transformers added to the SW and NE electrical rooms on the second floor. The cost for these systems were determined from RS Means.

Table 2.13 | 3 Phase, 480/277V Switchboard Cost Analysis

Switchboard Size	No. of SWBD	RS Means XFMR Cost
4000 A	1	$9,725.00
Total Switchboard Cost		**$9,725.00**

Table 2.14 | 3 Phase, 480/277V Primary, 120/208V Secondary Transformer Cost Analysis

Transformer Size	No. of XFMR	RS Means XFMR Cost
500 kVA	4	$18,130.00
Total Transformer Cost		**$72,520.00**

Cost Comparison:

As mentioned, the *proposed* design removed the existing *residential* switchboard and the commercial switchboard was be resized to consider the added load from the dwelling units - resulting in one 480/277 V, 4000A *commercial* switchboard.

The previously calculated *existing* and *proposed* electrical designs were compared in Table 2.15 below. A total savings of approximately **$276,100** was calculated in equipment and labor costs by switching all loads to serve from a 480/277 V input system.

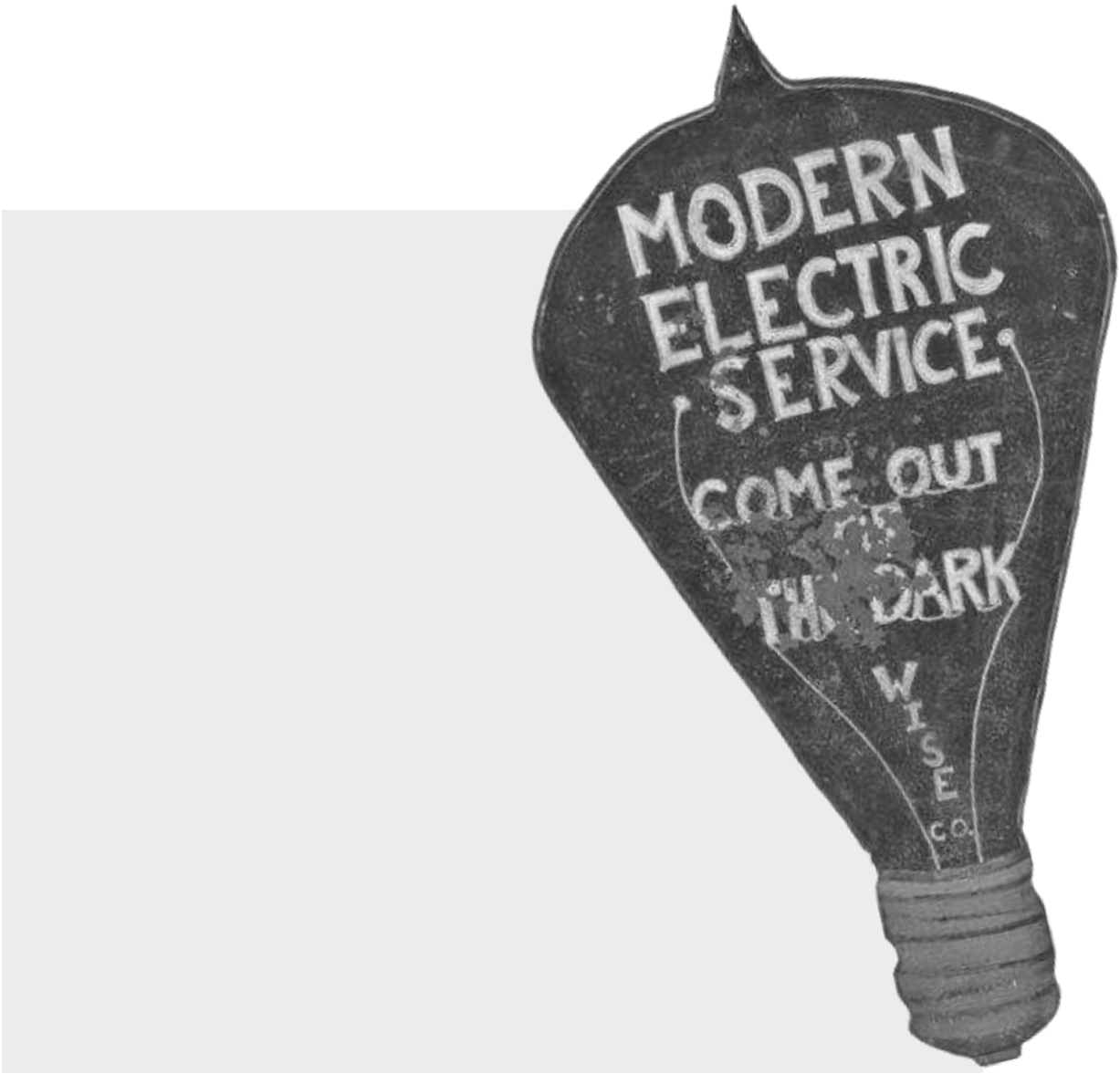
Table 2.15 | Existing vs. Proposed Cost Comparison

Equipment	Existing Design ($)	Proposed Design ($)	Savings ($)
Feeders	$401,996.32	$301,837.44	$100,158.88
Ground	$76,940.72	$39,454.90	$37,485.82
Conduit	$424,626.20	$221,115.30	$203,510.90
Transformers	$0.00	$72,520.00	-$72,520.00
Switchboards	$17,200.00	$9,725.00	$7,475.00
		Total Savings	**$276,110.60**

Evaluation

As discussed, the existing electrical system was designed to follow this separation between the *residential* areas and *commercial* areas, which has been found to be a typical approach for mixed-use buildings like Eastside III. However, as this Electrical Depth has shown, a significant savings in material and labor costs, as well as construction time (see Construction Breadth), would have been achieved if the building utilization system was solely supplied from a 480/277 V transformer.

Ultimately, the pros outweigh the cons with this system redesign. Though the mechanical and acoustical systems were not redesigned for the purpose of this thesis, the implementation of all systems would be coordinated at the beginning of planning for the project. This coordination would avoid the additional concerns that the newly designed electrical system introduced within this Electrical Depth. With these additional considerations aside, the proposed 480/277 V utilization voltage system would be recommended for Eastside III.



Daylight

Depth

Daylighting Depth

Lower Level Lobby - Daylight Panel + Glare Study

Introduction

The daylighting depth studied for Eastside III focuses on the daylight-plentiful Lower Level Lobby on the ground level. The double height space has a southwest facing curtain wall that extends the length of the room and along the staircase that leads to the first floor. Though the lobby mainly serves as a circulation space within Eastside III, there are lounge and seating areas placed next to the curtain wall that would be exposed to unwanted glare. As stated in the Lighting Design Depth, the main design considerations for the lobby was to bring visual interest and occupant comfort to the space. These goals were achieved through daylighting and artificial light within the Lower Level Lobby.

The first priority of the space was to ensure visual comfort by studying the glare exposure throughout the year. Secondly, visual interest was introduced to the space by taking advantage of the natural light source available to the space - the sunlight. These goals were attained through a custom solar panel installed onto the curtain wall that not only created areas of visual interest in the space, but also contributed to the reduction of glare and acoustical reverberation within the space.

Daylighting Depth

Lower Level Lobby - Daylight Panel + Glare Study

Overview

Eastside III lies in the heart of the East Liberty neighborhood of Pittsburgh, PA - which experiences on average 162 days of sunshine throughout the year. The Lower Level Lobby, located on the southwest façade, is oriented 20° degrees west of north and will experience most of its direct sunlight in the afternoon hours.

Location + Drawings:

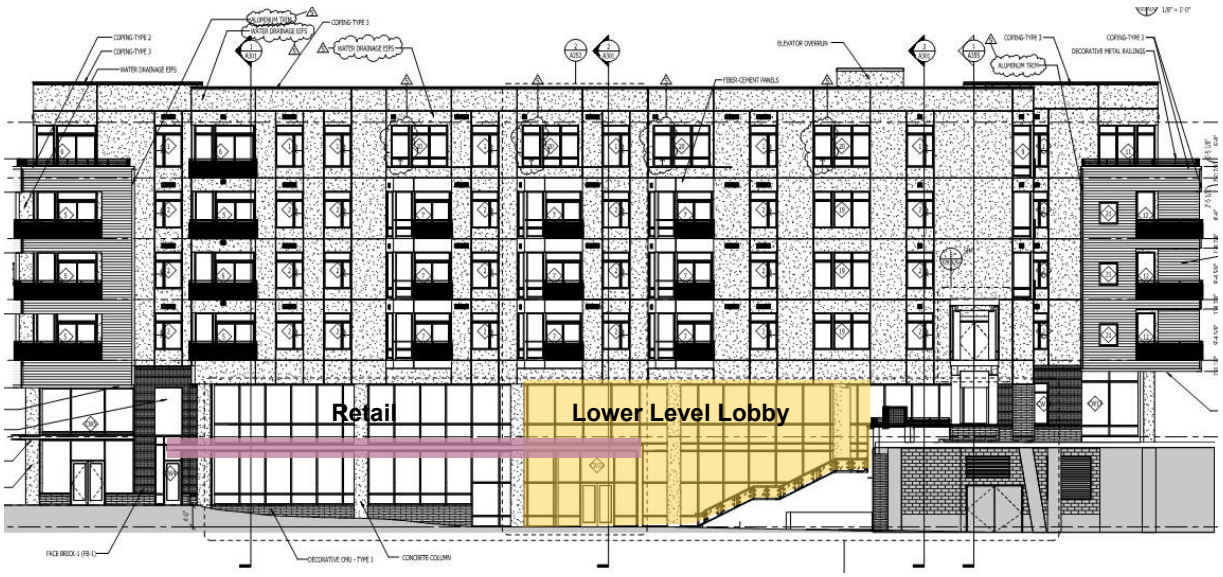


Figure 3.1 | Southwest Elevation - Lower Level Lobby

The existing southwest façade in the Lower Level Lobby is composed of a double height, 26 foot tall curtain wall with low-e 1" *ClimaGuard* glazing that has a transmittance of 68%. The space itself is roughly 1,250 SF and has an adjacent 415 SF lounge, with a 10'-6" high ceiling, connected to the lobby. As mentioned, this space is mainly a circulation area with seating areas in the SW corner of the lobby and in the adjacent lounge - seating areas are highlighted in blue in Figure 3.2 below. These areas will serve as the most crucial areas to reduce glare, specifically the seating area in the SW corner of the lobby.

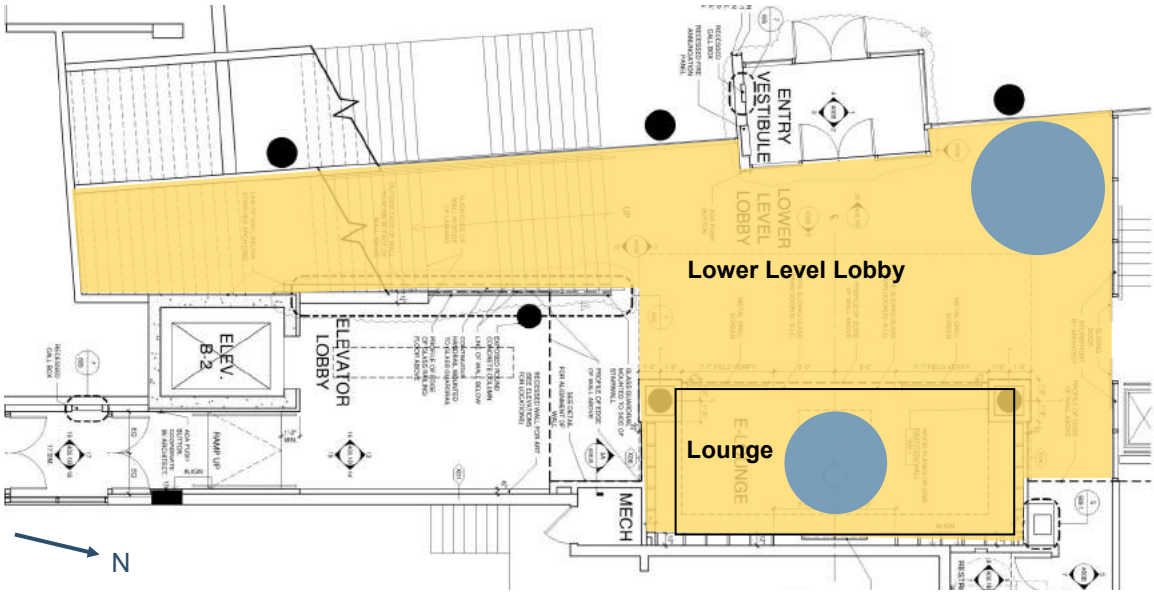


Figure 3.2 | Floor Plan - Lower Level Lobby

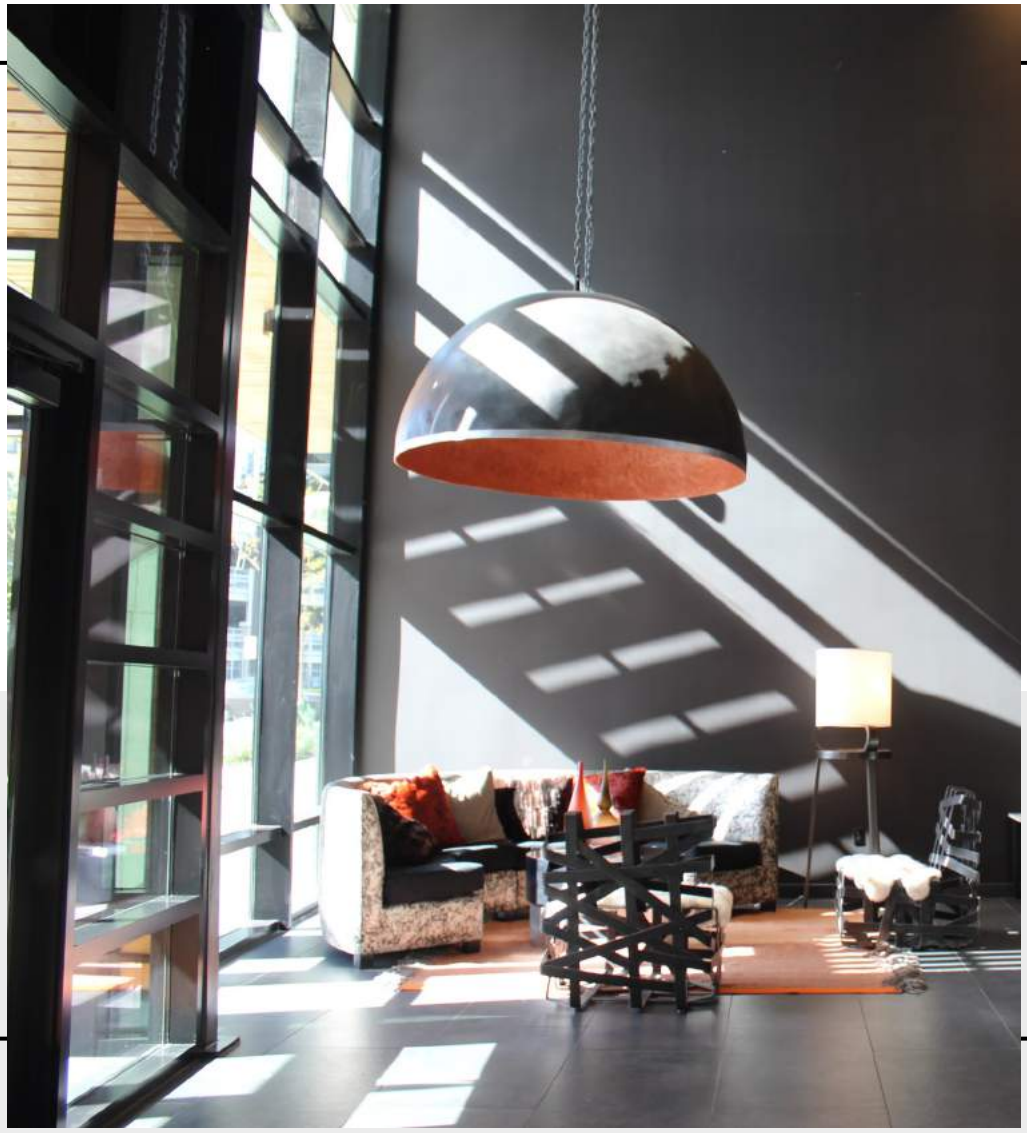
Location + Drawings:

Figure 3.3 | East/West Building Section

The building itself creates an overhang for the Lower Level Lobby in order to block direct sunlight, in addition to the glass vestibule and roof overhang that extends from the vestibule to the edge of the retail space - this overhang is highlighting in *purple* in figure 3.1 on the previous page. The vestibule and curtain wall are highlighted in *blue* in figure 3.3 above. The residential footprint above the lobby extends 7 feet from the edge of the curtainwall and begins 26 feet above the ground level.

Preliminary Study - *Site Visit*

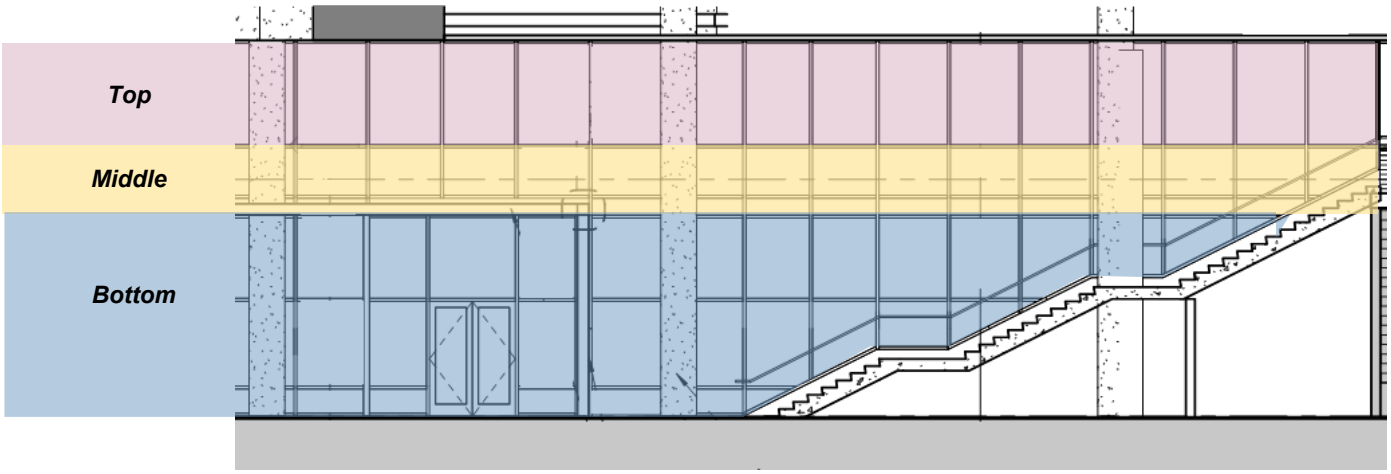
The initial idea for this study came from a site visit that I took on September 11, 2016. My parents and I visited Eastside III in the afternoon and we noticed two distinct things about the Lower Level Lobby – there was uncomfortable glare around 4 PM at the SW corner seating area in the lounge, and the mullions of the curtain wall created a unique and interesting pattern on the far wall. Below is an image that I took of the lounge and seating area located in the SW corner of the lobby, where not only can you see the potential of glare but also the pattern from the sunlight in the space. This prompted my idea to study which areas of the curtain wall could be used to reduce glare, which areas could be used to create visual interest, and which areas could be left as is.



September 11, 2016 - 4 PM | Lower Lobby Lounge Area

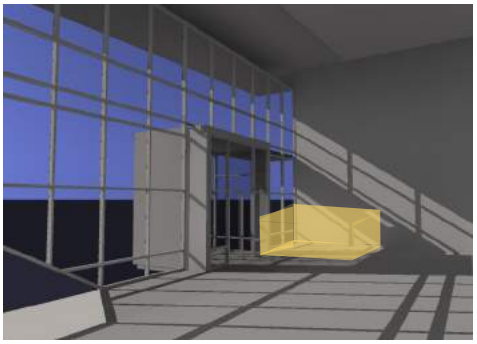
Preliminary Study - *AGi32 Study*

My site visit prompted the first daylighting study for the space A simplified AGi32 model was created to study how sunlight enters the space at different times of the year. These simulations determined which sections of the curtainwall would contribute to unwanted glare in the lounging areas, like the SW lounge pictured on the previous page. In order to study this, the curtain wall was divided into three sections:

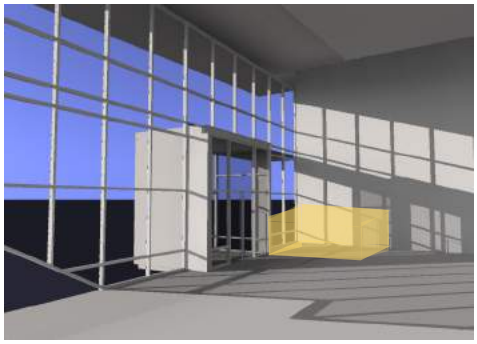


Within AGi32, each portion of the curtain wall illustrated above was sectioned off at three different times of the year: Winter Solstice (12/22), Summer Solstice (6/22), and the Equinox (9/22). The separate portions of the curtain wall were modeled on their own to determine in which part of the space they were contributing the most direct sunlight. The results from this study allowed me to determine which sections of the curtain wall could be used to create visual interest without distracting occupants in the seating areas and which portions should solely focus on reducing glare in those seating areas.

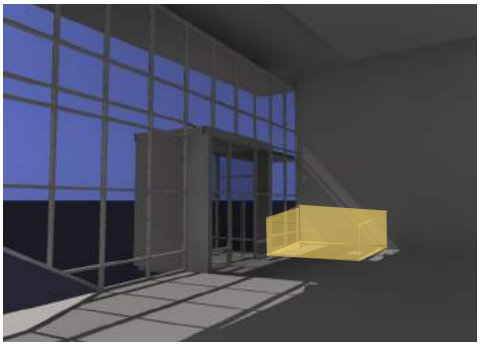
Full Curtainwall - Shadow Study



December 22, 3 PM



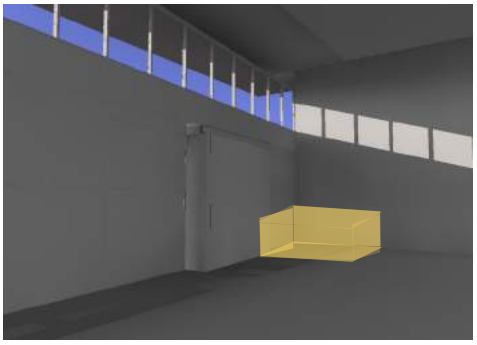
September 22, 3 PM



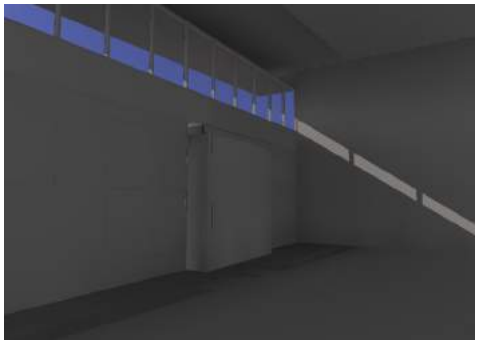
June 22, 3 PM

The shadow study above illustrates the fully exposed curtain wall at the three different times of the year. As mentioned, the following AGi32 studies will isolate one of the three curtain wall sections on its own to determine the shadow individual effects in the lounge space, highlighted in *yellow* above. This lounge area acts as the main focus for the purpose of this daylighting study - to reduce glare on the seating space and to avoid direct shadows on the seating area from the daylight panels that will be designed to create visual interest in the surrounding space.

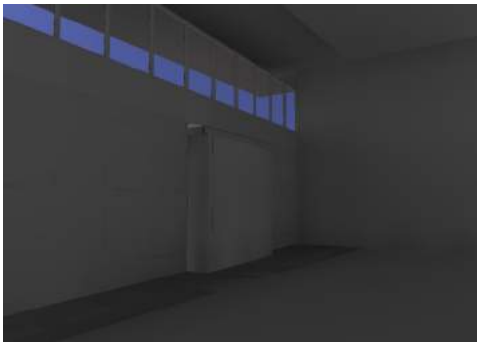
Top Curtainwall Only - Shadow Study



December 22, 3 PM

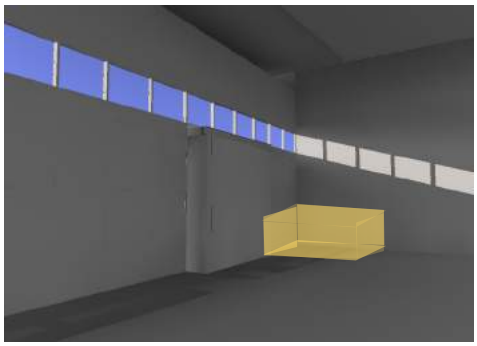


September 22, 3 PM

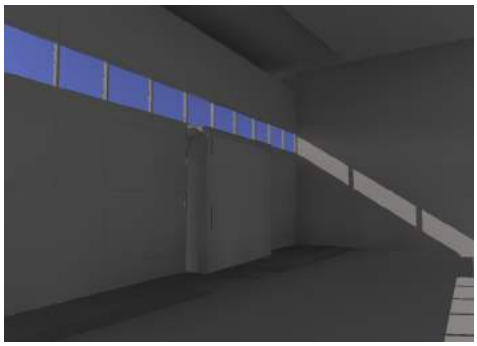


June 22, 3 PM

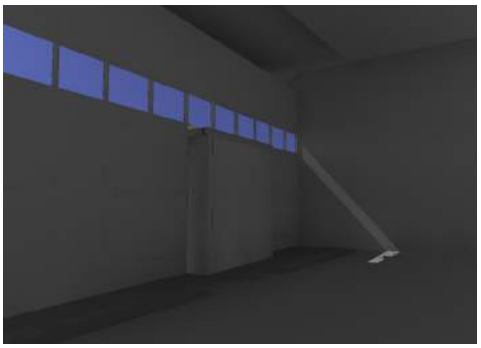
Middle Curtainwall Only - Shadow Study



December 22, 3 PM

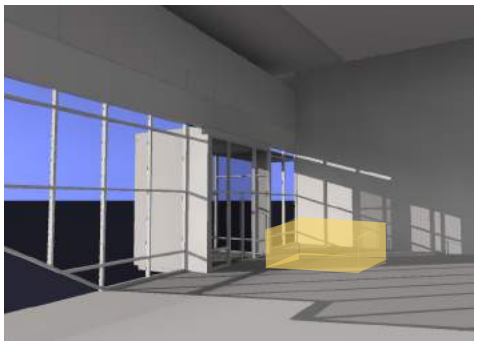


September 22, 3 PM

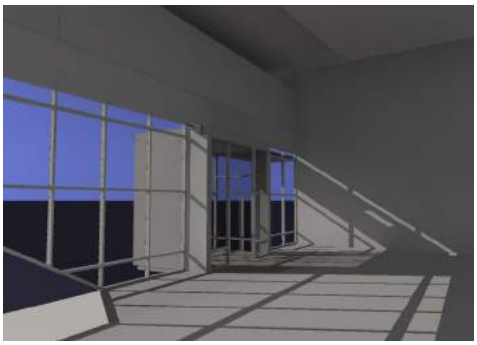


June 22, 3 PM

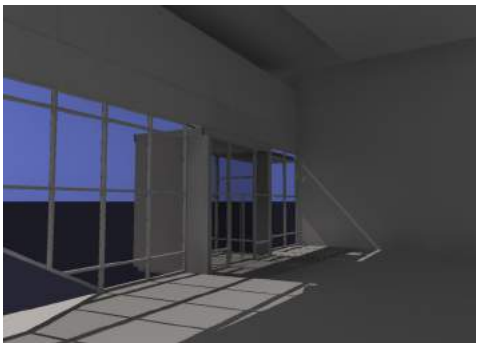
Bottom Curtainwall Only - Shadow Study



December 22, 3 PM



September 22, 3 PM



June 22, 3 PM

Evaluation of AGi32 Preliminary Study:

As expected, it was determined from the AGi32 study that the bottom section of the curtain wall contributed the most direct sunlight to the seating area of the lounge. Secondly, the middle section of the curtain wall was shown to mostly avoid direct penetration onto the seating area while creating unique shadows on the back wall. Lastly, the top section of the curtain wall was found to avoid direct sunlight on the seating area all together. From this, the following criteria was established in order to complete the daylighting study for the Lower Level Lobby:

Top Section - no change needed

Middle Section - potential area for sunlight panel to create visual effect

Bottom Section - crucial area to reduce glare

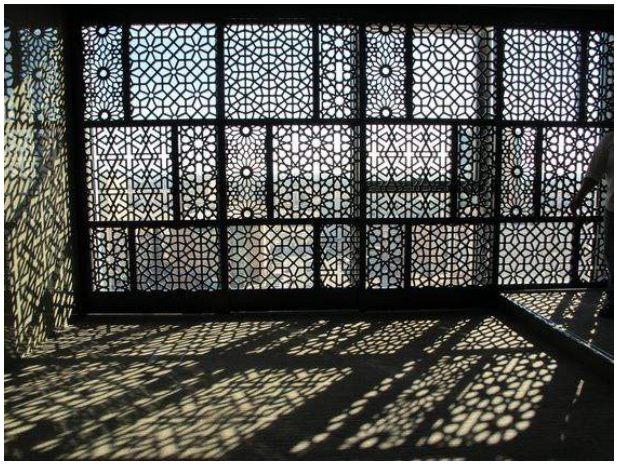
Daylighting Redesign - *Research*

Design Criteria + Considerations:

Based on the preliminary evaluation and the overall design goal to create visual interest and comfort to the seating areas, the following criteria was established.

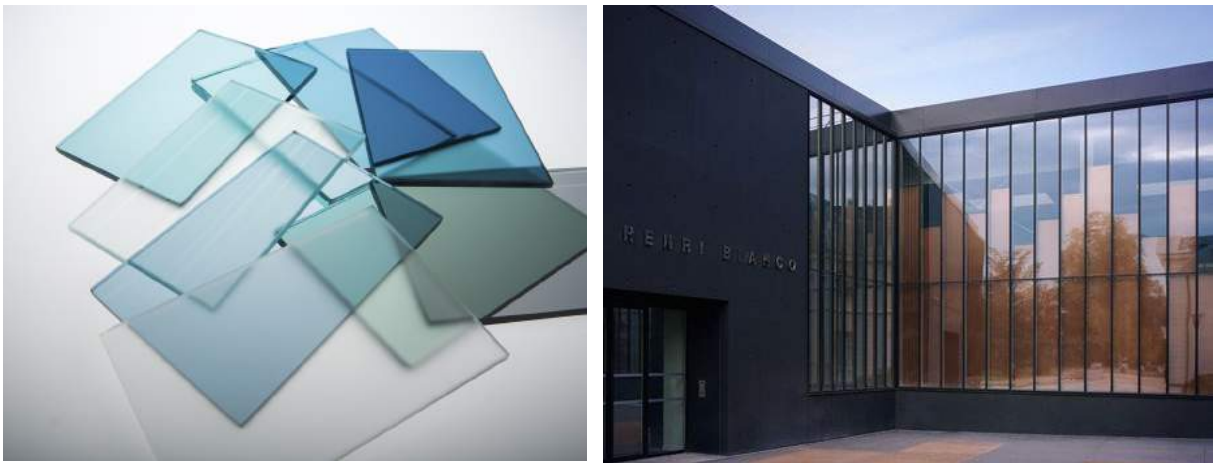
1. Reduce glare on the seating lounge seating area without obstructing views out of the building
2. Create visual interest in the space while avoiding distraction onto the seating area

Preliminary research was done to find precedents images of the type of visual effects wanted for the space. A continuous Pinterest page was kept throughout the year for design inspiration for Eastside III - below are some of the inspiration images found for the daylighting portion of this study:


Daylighting Pattern Inspiration

It was found from the preliminary study of the existing curtain wall design that an overhang would not block enough direct sunlight into the space unless it was placed lower on the curtainwall - which could potentially block views. From this, the design decision was made to find a glare reduction solution that would be flushed with the façade. This prompted research on different glass types including tinted and fritted glass. Keeping the importance of views in mind, from the interior and exterior, fritted glass was ruled out since the combination of reflective and translucent material restricts views in or out, depending on which side of the wall is reflecting sunlight or electric light. It was decided to study the effects of tinted glass for the reduction of glare within the space.



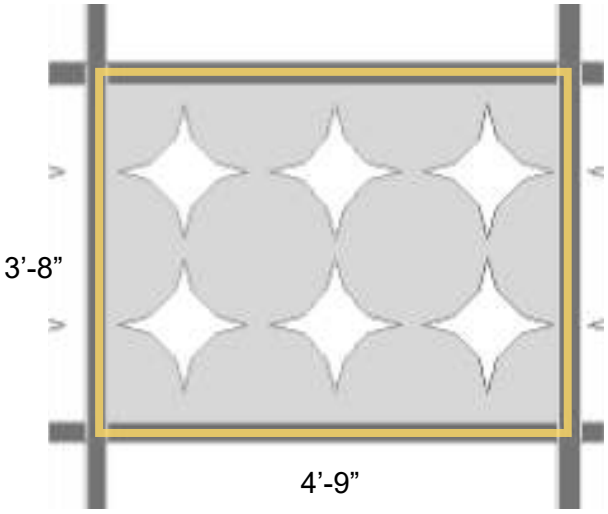
Tinted Glass Inspiration

A combination of tinted glass and daylight pattern panels will be studied in order to create visual interest and occupant comfort within the Lower Level Lobby.

Redesign - *Daylight Panel*

Daylight Panel Design:

The patterned daylighting panel was designed to fit between the vertical mullions of the *middle* section of the curtain wall. A custom pattern was designed to fit the overall lighting concept for Eastside III: to celebrate the ***industry*** of the building and the City of Pittsburgh. The panel and custom pattern below was created to represent the once largest and most well known *industry* of Pittsburgh - steel. The “diamonds” are cutout of the perforated metal material. As explained in the Acoustical Breadth of this report, the custom panel will double as a sound absorptive material to reduce sound reflection in the double height lobby. Refer to Figure 3.4 for further details of this panel.



Diamond Pattern Size | 1’-4” x 1’-4”

Daylight Panel Design *Continued*:

The panel is approximately 2 inches thick and 3-8” x 4’-9” in size, in order to fit between the vertical curtain wall mullions. As seen in Figure x.xx, this thickness is composed of a 2 inch acoustic absorptive backing and a thin layer of stainless steel perforated metal that will face the interior of the lobby. The dark grey acoustical absorptive material will double as *daylight* absorptive material in order to avoid harsh reflections from the metal material into the space. The panel is placed on the interior side of the curtain wall in order to serve its acoustic sound absorbing purpose. The section below shows the installation of the panel onto the curtain wall. The panels will be installed using a mechanical clips and bracket that attach to the horizontal mullions. Since the horizontal mullions are sized to account for all dead load from the individual sections of the curtain wall, the added weight of the daylighting panels will not affect the performance of the mullions. The panels themselves weigh approximately 0.48 psf. For more information about the acoustical performance and installation, refer to the Acoustics Breadth and Appendix _.

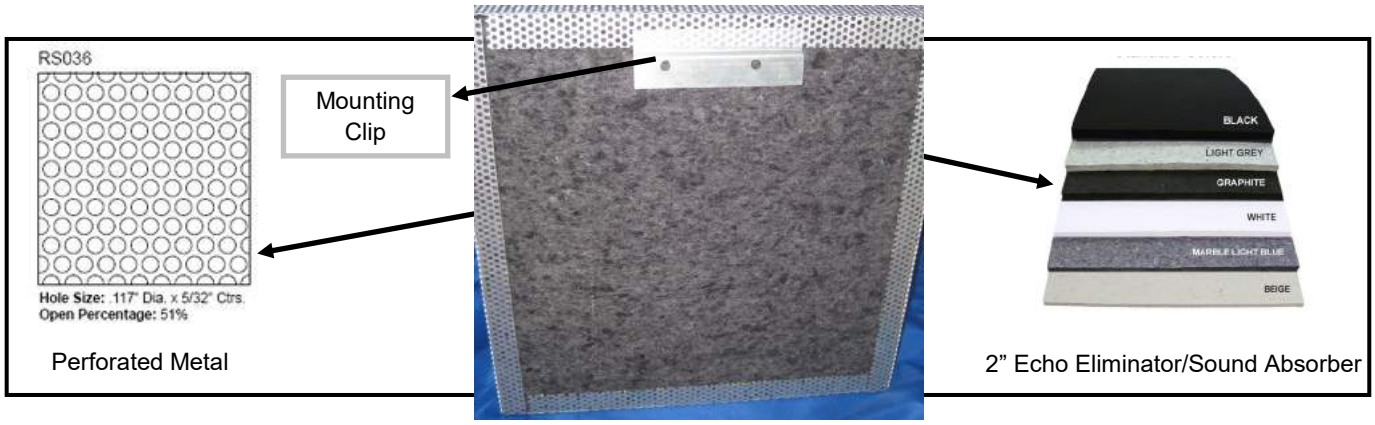


Figure 3.4 - Daylighting + Acoustical Panel Details

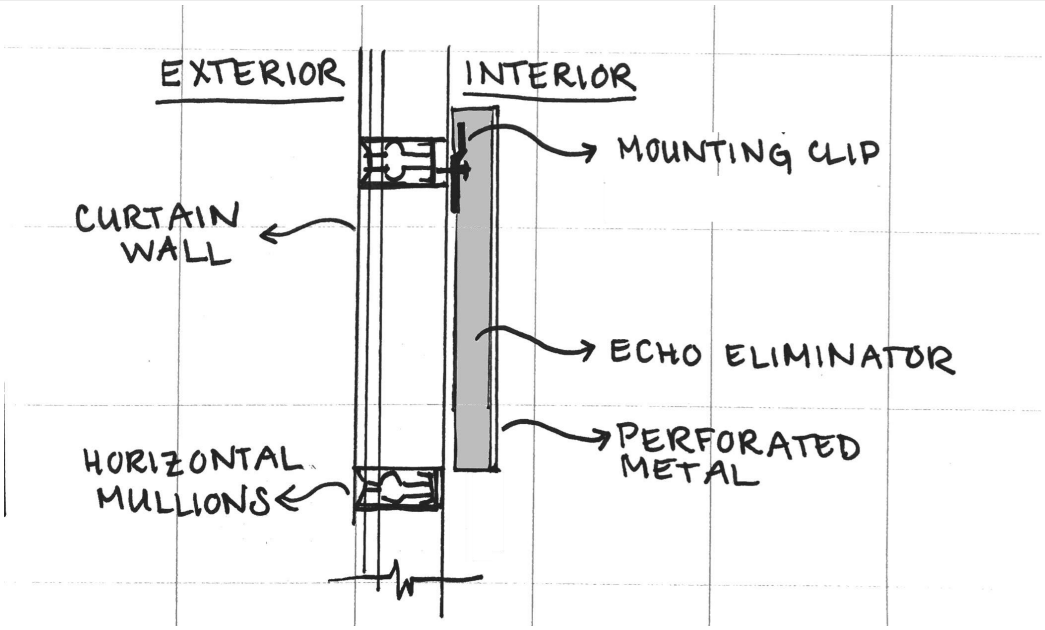


Figure 3.5 - Section Detail | Daylighting + Acoustical Panel Curtainwall Mounting

Daylighting Depth

Lower Level Lobby - Daylight Panel + Glare Study

Daylight Panel Mock-Up:

A half scale mock-up of the daylighting panel was created to finalize the cut-out pattern and diamond layout. The mock-up was also used to study how sunlight would effect the patterns created within a room when mounted on a window. The images of the mock-up on below show the sun patterns from the panel when placed along a West facing façade, from 4 PM to 6 PM. Special thanks to my good friend Cory for the construction and mock-up help!



Mock-Up Construction *featuring* Cory Mosco, 5th year CM

March 31st - 4 to 6 PM, west facing window


3:50 PM


4:20 PM


4:40 PM


5:00 PM


5:20 PM


6:00 PM

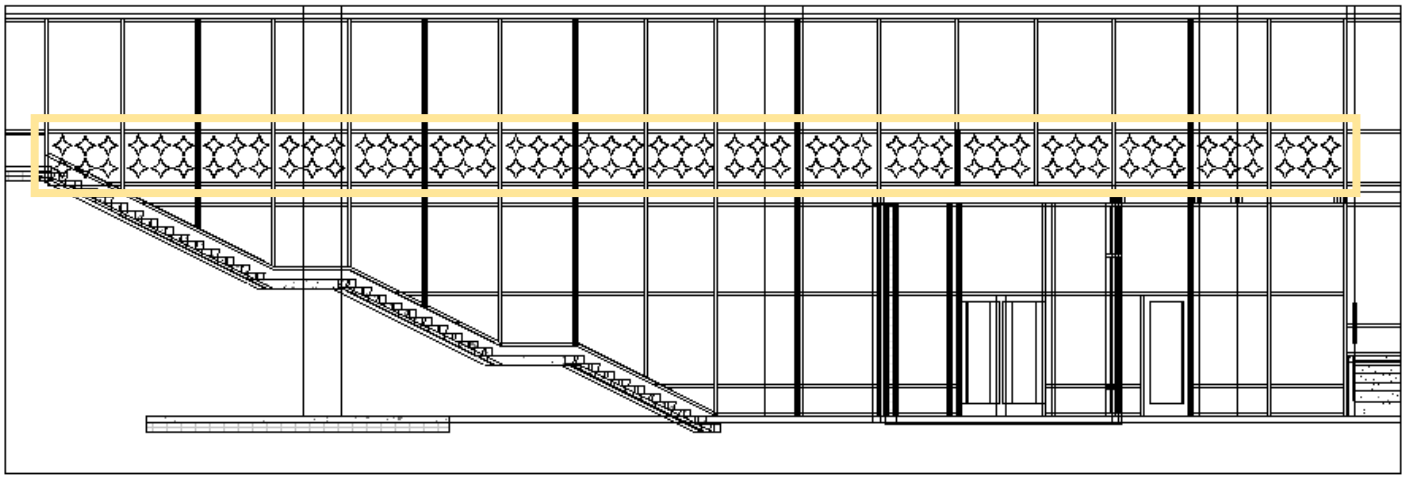


Figure 3.6 | Daylight Panel Placement - *Middle* Section of Curtainwall

Figure 3.6 above indicates where this diamond daylighting panel will be placed on the curtainwall. As previously mentioned, it will be placed in the *middle* section of the curtainwall, where sunlight rarely penetrates the lounge area of the lobby directly. This will allow for the pattern to be projected on the floor and walls within the lobby at different times of the day, while avoiding distraction onto the seating area.

Redesign - *Glare Study*

Overview:

In addition to the daylighting panel design for the Lower Level Lobby curtainwall, the glazing type for the *bottom* section of the curtainwall was also analyzed to reduce glare in the lobby lounge. The following section will compare the original design and redesigned iterations performed for the lobby. There were four iterations completed for this study:

1. *Original design* - overhang + 68% trans low-e glazing
2. *Redesign 1*- Original design + diamond panel on *middle* section
3. *Redesign 2* - Original design on *top* section + diamond panel on *middle* section + 47% tinted glass on *bottom*
4. *Redesign 3* - Original design on *top* section + diamond panel on *middle* section + 38% tinted glass on *bottom*

The following glazing types were specified for Redesign 2 + Redesign 3. For more information on the particular glass types, refer to Appendix C.

Table 3.1 | Glazing Types for Glare Study

Manufacturer	Glass Type	T_{vis}	U-Value		Solar Heat Gain Coef. (SHGC)	Light to Solar Gain (LSG)
			Winter	Summer		
PPG Glass	Solarban 70XL (2) + Optigray + Clear	47	0.28	0.26	0.24	1.96
PPG Glass	Solargray + Sungate 400 (3)	38	0.29	0.27	0.32	1.19

Annual Glare calculations and Daylight Glare Probability (DGP) for a particular point in time were calculated for each iteration using DIVA for Rhino. In addition, the Daylight Autonomy (DA), Spatial Daylight Autonomy (sDA) and Annual Sun Exposure (ASE) results were calculated and compared.

DIVA for Rhino:

As mentioned, the daylighting calculations previously mentioned were performed using DIVA for Rhino. In order to complete these calculations, the Eastside III Revit model was exported to AutoCAD and exported again into Rhino. The Rhino model was simplified and the Lower Level Lobby was built with its appropriate materials and reflectances, determined in the Lighting Design Depth. For the purpose of quicker calculations, the remaining areas of Eastside III were simply modeled as a mass, as well as the connecting buildings that would effect afternoon sun into the southwest facing lobby. The surrounding building on the southwest side, Building A, and the connecting bridge between the two buildings were designed as masses for this daylighting study. The height of Building A extends to the third floor of Eastside III and sits on the same ground plane as the *first floor* of Eastside III. Recall that the Lower Level Lobby sits on the *ground* floor of the building, so it was important to consider the mass of Building A when analyzing the sun exposure into the lobby below.

Annual Glare + DGP Point-in-Time Calculations:

In DIVA, Annual Glare simulations calculate glare during each hour in the year by using an annual DAYSIM prediction in order to calculate vertical eye illuminance. The results are given by the Daylight Glare Probability (DGP) metric which measures the comfort evaluation in the space based on the scale shown below. Ambient calculations are turned off to predict contrast from direct light within the space. Ultimately, an annual evaluation of occupant comfort within the space is produced with Annual Glare.

Point-in-time glare calculations are used to determine the visual comfort of an occupant at a particular camera view point within the space - by producing a fisheye image of the viewpoint. For both Annual Glare and Point-in-time calculations, the camera each iteration was placed facing the curtain wall within the lobby, near the lounge seating area. Like Annual Glare, point-in-time glare uses the DGP metric to determine the level of glare in the space. Areas of high contrast (3x the average luminance) are highlighted in color in the fisheye images. However, it is important to note that the results should solely be based on the DGP number produced and *not* by the colors shown in the image. The colors showing high contrast are not directly comparable between simulations, since DIVA adjusts the exposure for each individual iteration. The Daylight Glare Probability scale seen below was used to determine the level of glare in both the Annual Glare and Point-in-Time calculations.

Daylight Glare Probability		
Scale	DGP (%)	
Imperceptible Glare	<	35%
Perceptible Glare	35	40
Disturbing Glare	40	45
Intolerable Glare	>	45%

Annual Sun Exposure (ASE):

Annual Sun Exposure was calculated for each *test* iteration. ASE describes how much of the space receives *too much* direct sunlight - showing areas on the work plane with glare potential. In DIVA, the ASE is measured by the percentage of the floor area that receives *at least* 1000 lux for *at least* 250 occupied hours per year. Overall, a percentage of floor area will be given for the entire floor. However, the individual node calculation points that DIVA produces, will show the exact number of hours that a particular point exceeds 1000 lux.

Spatial Daylight Autonomy (sDA):

The Spatial Daylight Autonomy describes how much of the space receives sufficient daylight by calculating the percentage of the floor that receives *at least* the target illuminance value for *at least* 50% of the annual occupied hours. The target illuminance for the Lower Level Lobby was set to be 150 lux.

Daylight Autonomy (DA):

Daylight Autonomy measures the percentage of occupied hours that receive sufficient daylight based on the target illuminance level - in the case of the lobby, this value is 150 lux.

Rhino Model:

Figure 3.7 shows a perspective view of an isolated portion of the Rhino model. This figured illustrates where the calculation plane was selected to run the DIVA daylighting calculations - in *yellow*

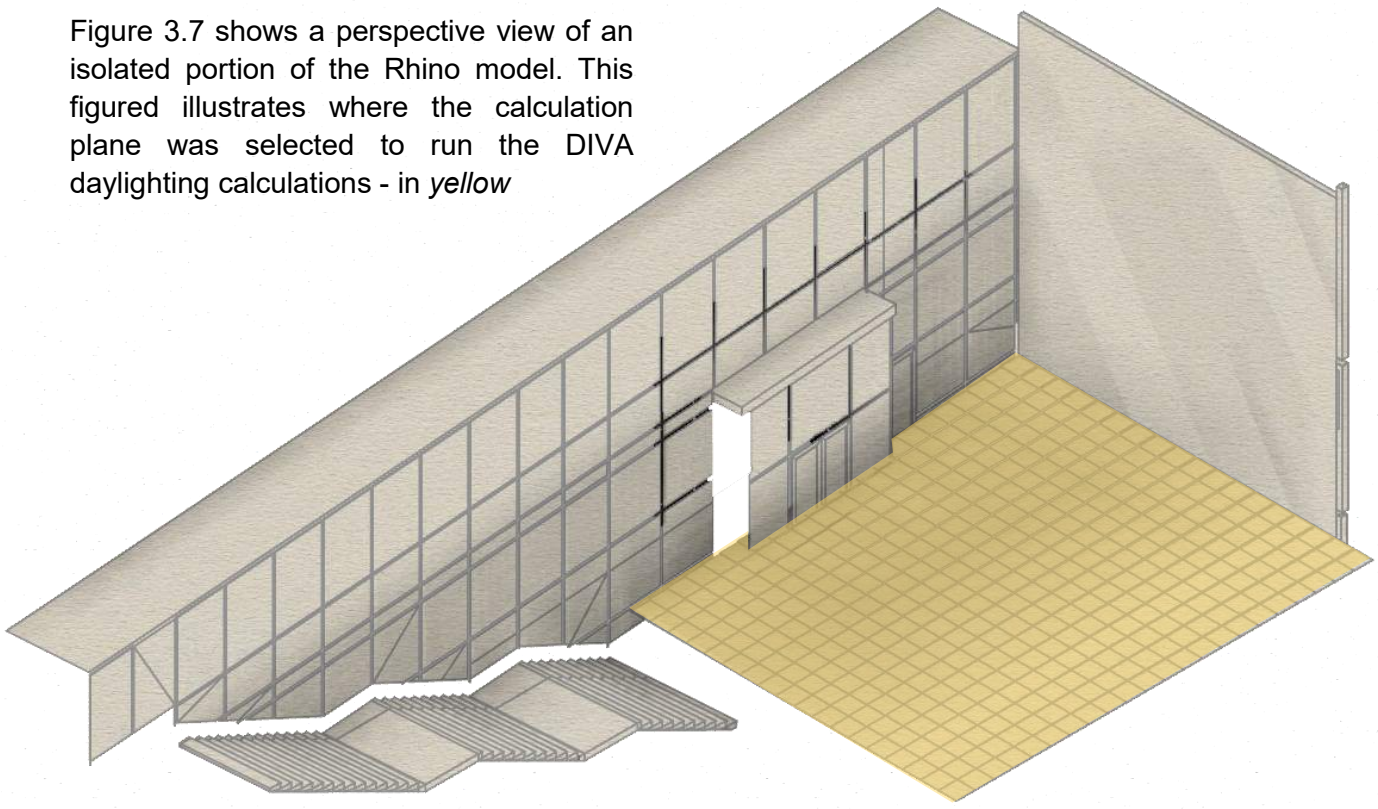


Figure 3.7| Perspective Rhino View - Floor Area for DIVA Calculations

Original Design

Annual Glare:

Figure 3.8 shows the Annual Glare results for the original design of the Lower Level Lobby. The glazing was modeled as a low-e glass with 0.68 transmittance and the materials within the space were modeled off their reflectances determined in the Lighting Design Depth.

Daylight Glare Probability		
Scale	DGP (%)	# of Hours
Imperceptible Glare	< 35%	8400
Perceptible Glare	35 - 40 %	42
Disturbing Glare	40 - 45 %	37
Intolerable Glare	> 45%	281

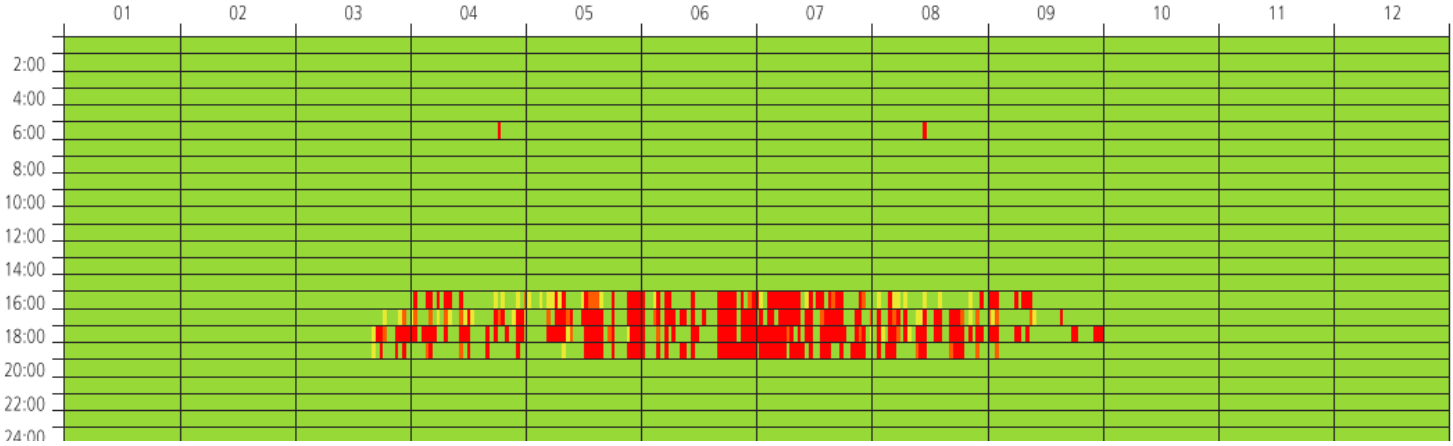
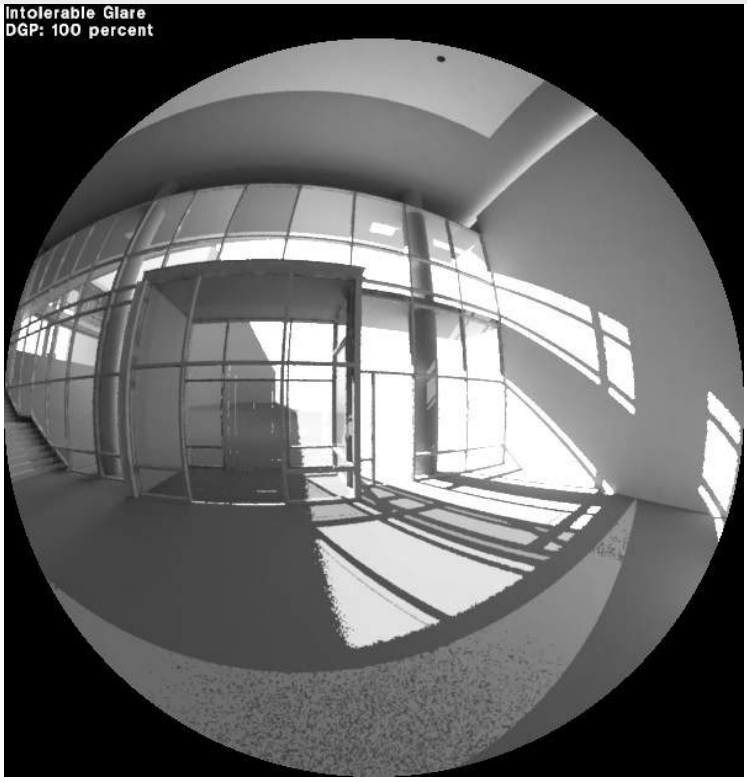


Figure 3.8 | Annual Glare in DGP - Original Design



Point-in-Time Glare:

The fisheye glare image to the left was calculated for **September 11, at 3:30 PM.** At this time of the year, the original curtainwall has **100% DGP** - meaning the areas of high contrast on the windows are producing *intolerable glare.*

The following iterations will study the daylighting glare potential at the same view and same time of the year. This date was chosen based on the annual glare results. This point in time was an example of a date that depicted intolerable glare. The date was also chosen because it happened to be the exact date and time that I personally experienced glare in the Lower Level Lobby at Eastside III, as explained on Page 111.

Annual Sun Exposure:

The sections shown in pink indicate potential areas for glare - based off the number of hours the area is exposed to over 1000 lux for more than 250 hours of the year.

***7.6%** of the floor reaches more than 1000 lux for more than 250 hours of the year

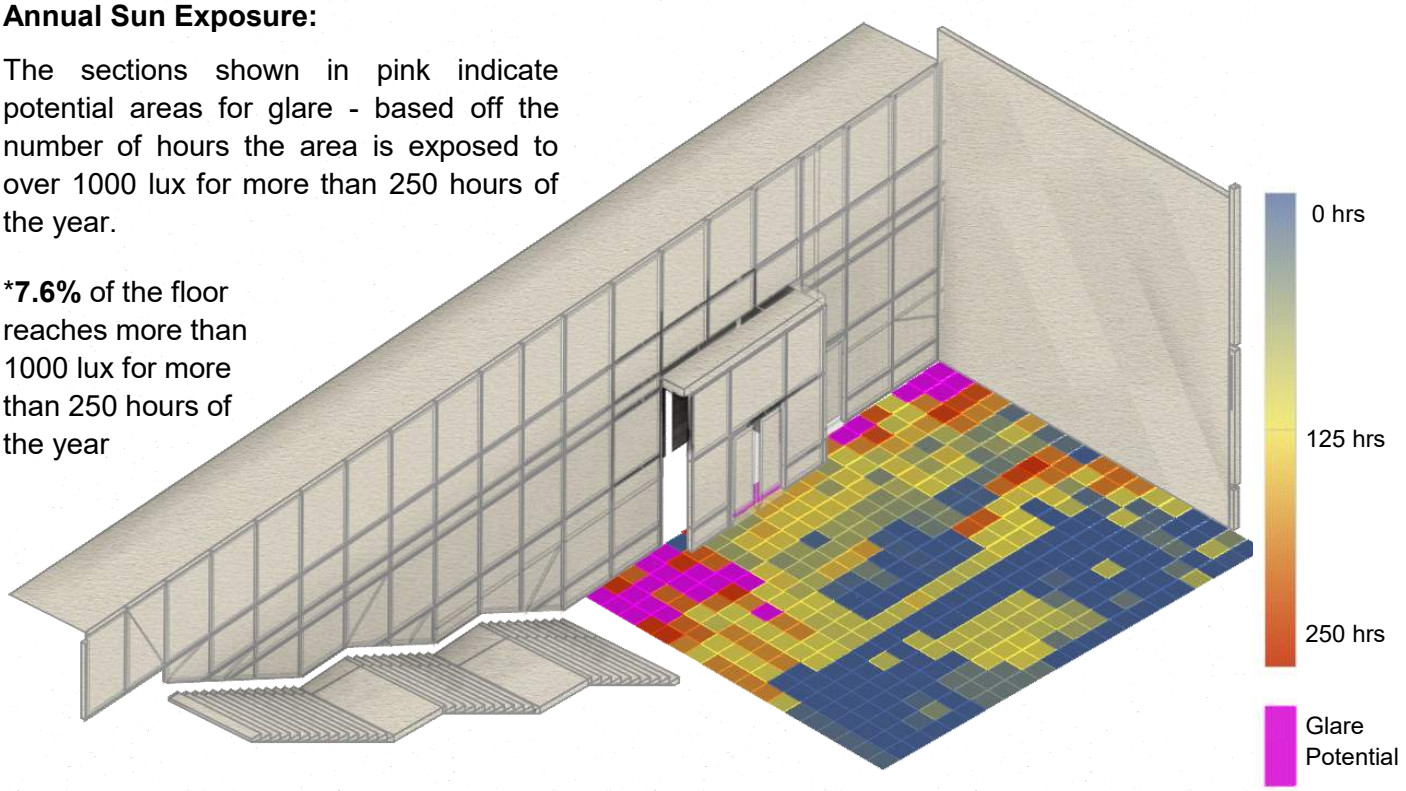


Figure 3.9 | ASE Perspective View - Original Design

Daylight Autonomy:

The colored sections below show the areas, determined in % of occupied hours that the space receives sufficient daylight - at least 150 lux. Areas in dark orange receive at least 150 lux 100% of the occupied hours.

***74.44%** of the annual occupied hours receive sufficient daylight

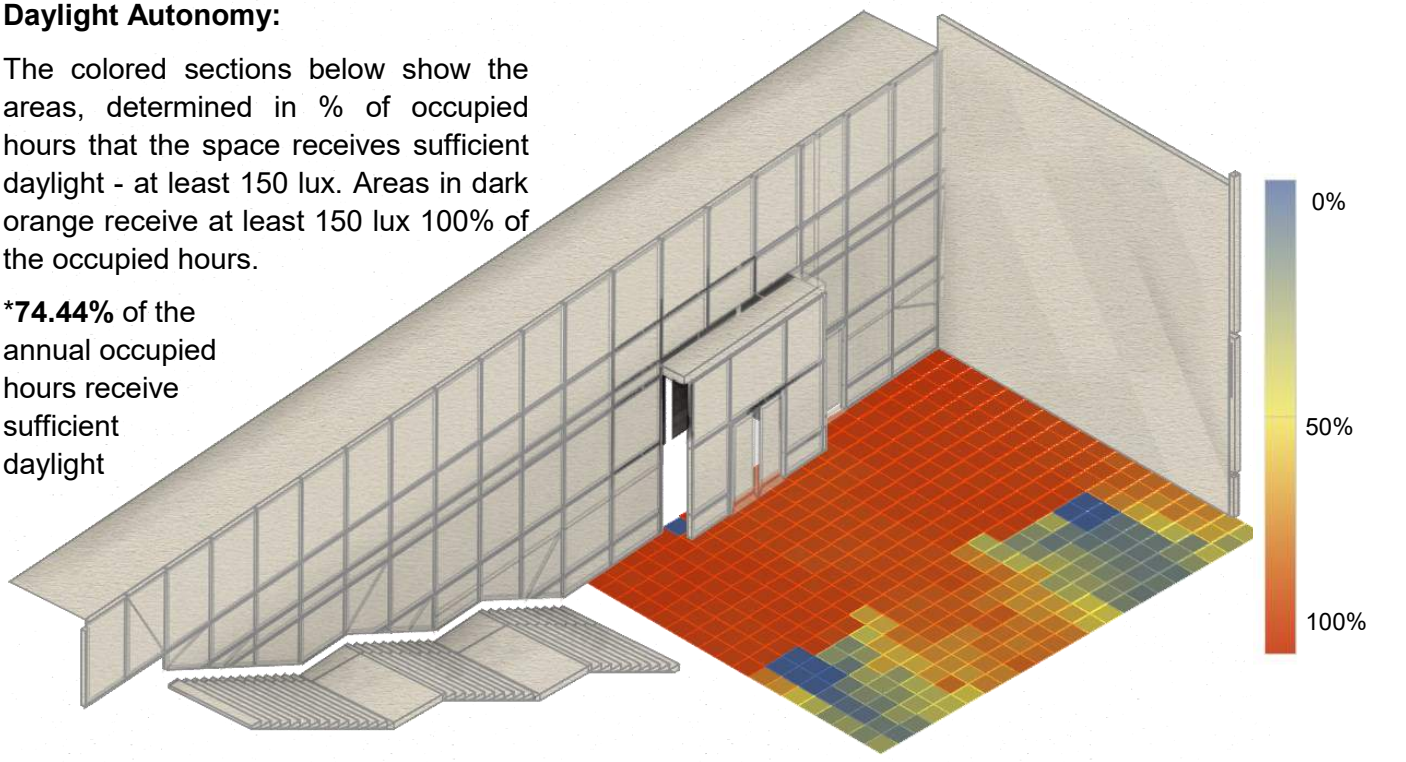


Figure 3.10 | DA Perspective View - Original Design

Redesign 1 - Daylight Panel Only

Annual Glare:

Figure 3.11 shows the Annual Glare results for Redesign 1, which includes only the addition of the diamond daylight panel on the *middle* section of the curtain wall. With the daylight panel alone, the intolerable glare reduces by **31%** of the original.

Daylight Glare Probability		
Scale	DGP (%)	# of Hours
Imperceptible Glare	< 35%	8477
Perceptible Glare	35 - 40 %	50
Disturbing Glare	40 - 45 %	39
Intolerable Glare	> 45%	194

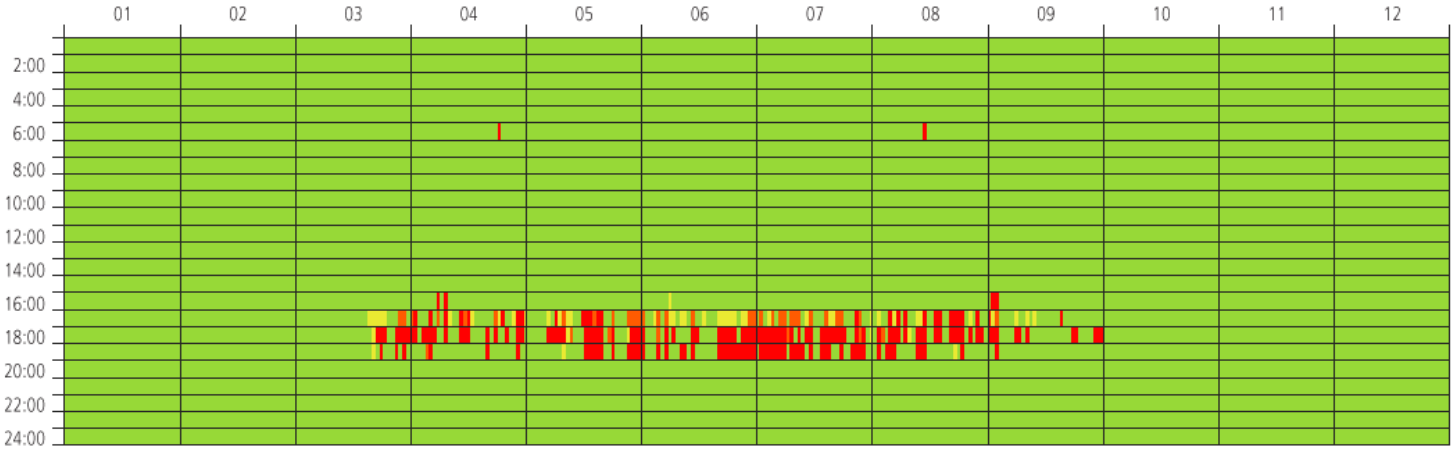
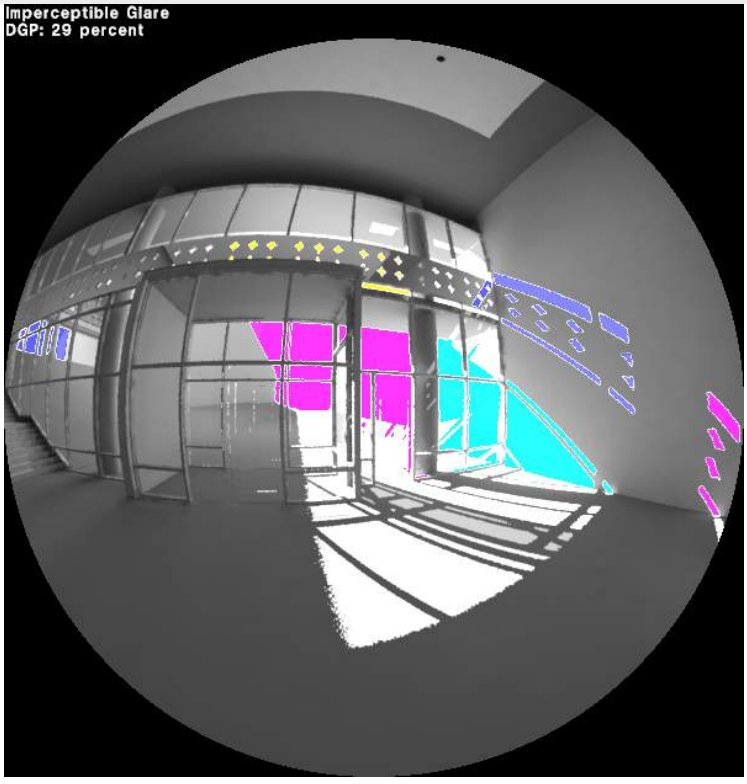


Figure 3.11 | Annual Glare in DGP - Redesign 1, Daylight Panel Only



Point-in-Time Glare:

The fisheye glare image to the left was calculated for **September 11, at 3:30 PM.** At this time of the year, Redesign 1 has **29% DGP** - which means any areas of high contrast on the surface would be imperceptible.

As previously mentioned, the colors highlighted in the fisheye represent areas of high contrast, but they don't have any direct correlation to particular values.

Annual Sun Exposure:

The sections shown in pink indicate potential areas for glare - based off the number of hours the area is exposed to over 1000 lux for more than 250 hours of the year.

***7.8%** of the floor reaches more than 1000 lux for more than 250 hours of the year

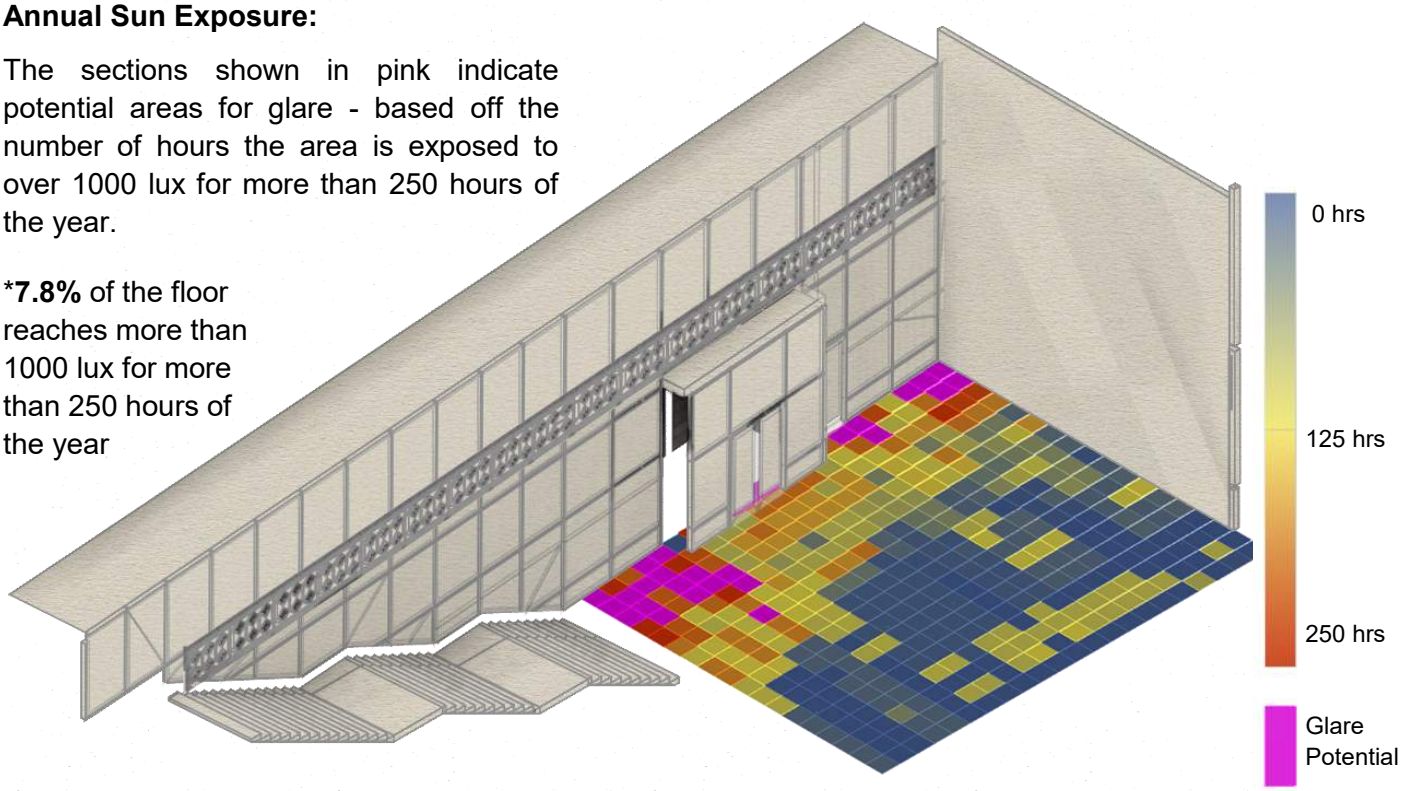


Figure 3.12 | ASE Perspective View - Redesign 1, Daylight Panel Only

Daylight Autonomy:

The colored sections below show the areas, determined in % of occupied hours that the space receives sufficient daylight - at least 150 lux. Areas in dark orange receive at least 150 lux 100% of the occupied hours.

***74.21%** of the annual occupied hours receive sufficient daylight

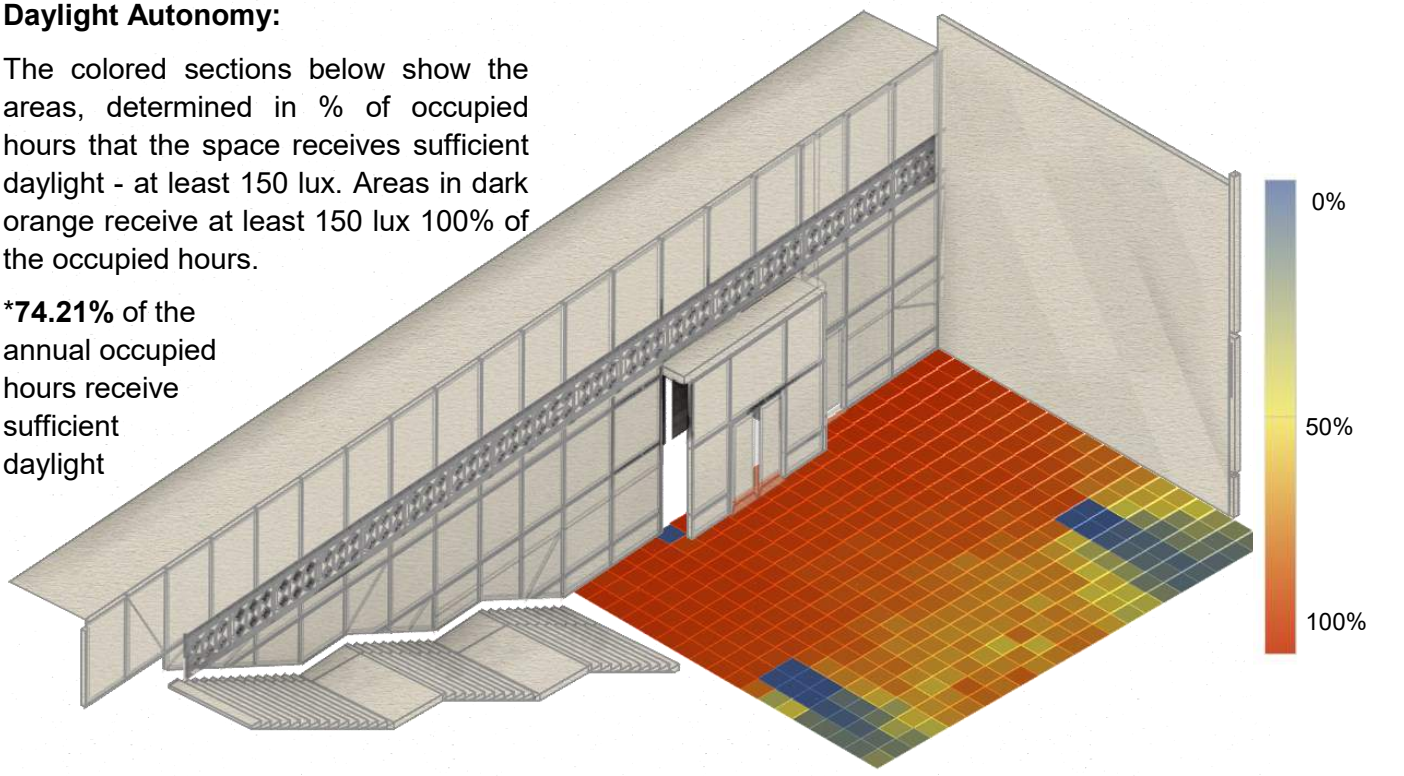


Figure 3.13 | DA Perspective View - Redesign 1, Daylight Panel Only

Redesign 2 - Daylight Panel + 0.47 T_{vis}

Annual Glare:

Figure 3.14 shows the Annual Glare results for Redesign 2, which includes the addition of the daylight panel on the *middle* section with 47% transmittance tinted glass on the *bottom* section of the curtain wall. With this design, the intolerable glare reduces by **49%** of the original.

Daylight Glare Probability		
Scale	DGP (%)	# of Hours
Imperceptible Glare	< 35%	8577
Perceptible Glare	35 - 40 %	25
Disturbing Glare	40 - 45 %	12
Intolerable Glare	> 45%	146

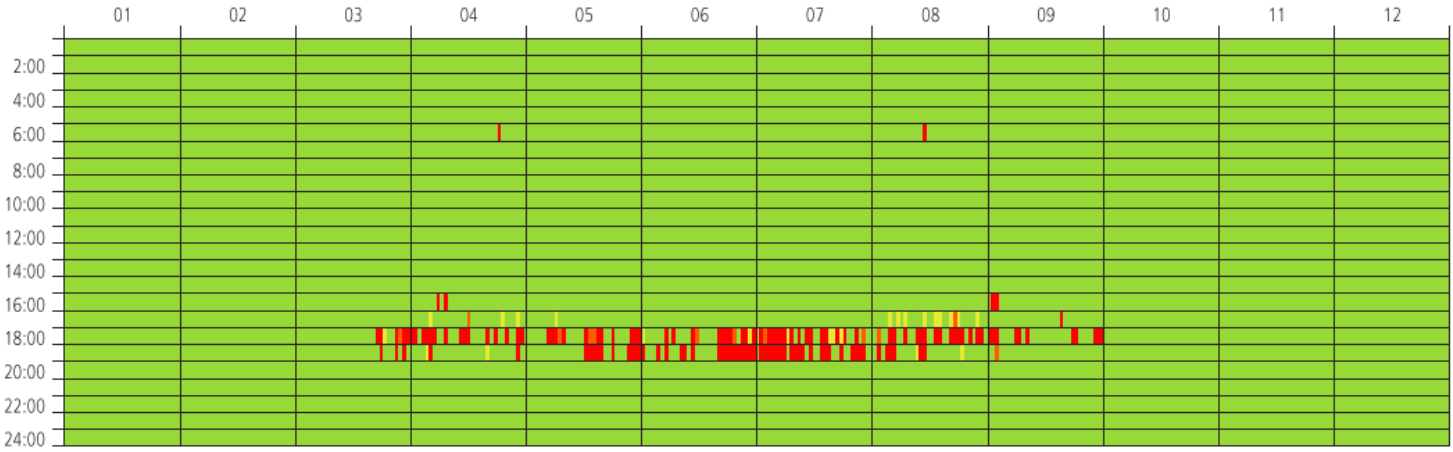
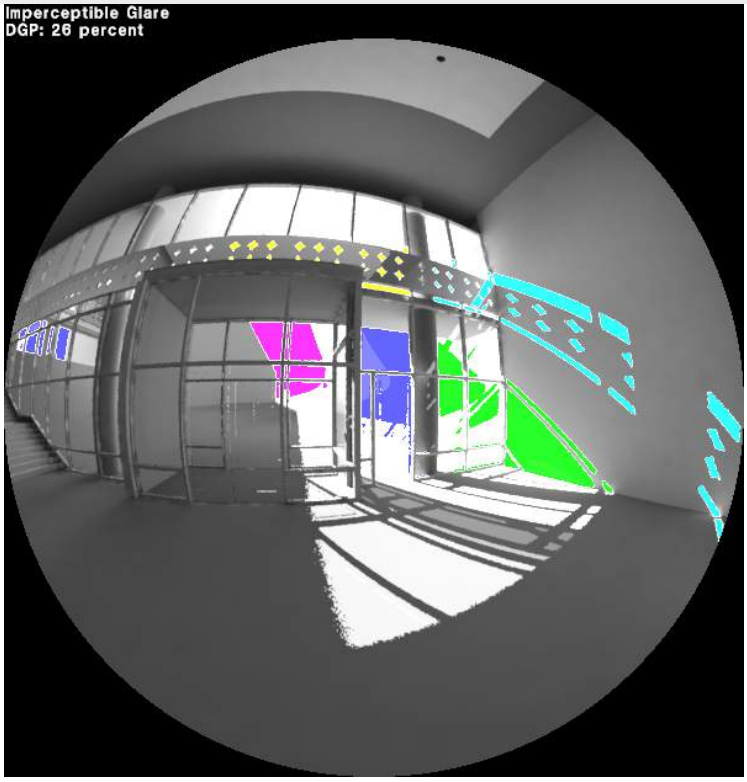


Figure 3.14 | Annual Glare in DGP - Redesign 2, Daylight Panel + 0.47 Tinted Glass



Point-in-Time Glare:

The fisheye glare image to the left was calculated for **September 11, at 3:30 PM.** At this time of the year, Redesign 2 has **26% DGP** - which means any areas of high contrast on the surface would be imperceptible.

As previously mentioned, the colors highlighted in the fisheye represent areas of high contrast, but they don't have any direct correlation to particular values.

Annual Sun Exposure:

The sections shown in pink indicate potential areas for glare - based off the number of hours the area is exposed to over 1000 lux for more than 250 hours of the year.

***6.3%** of the floor reaches more than 1000 lux for more than 250 hours of the year

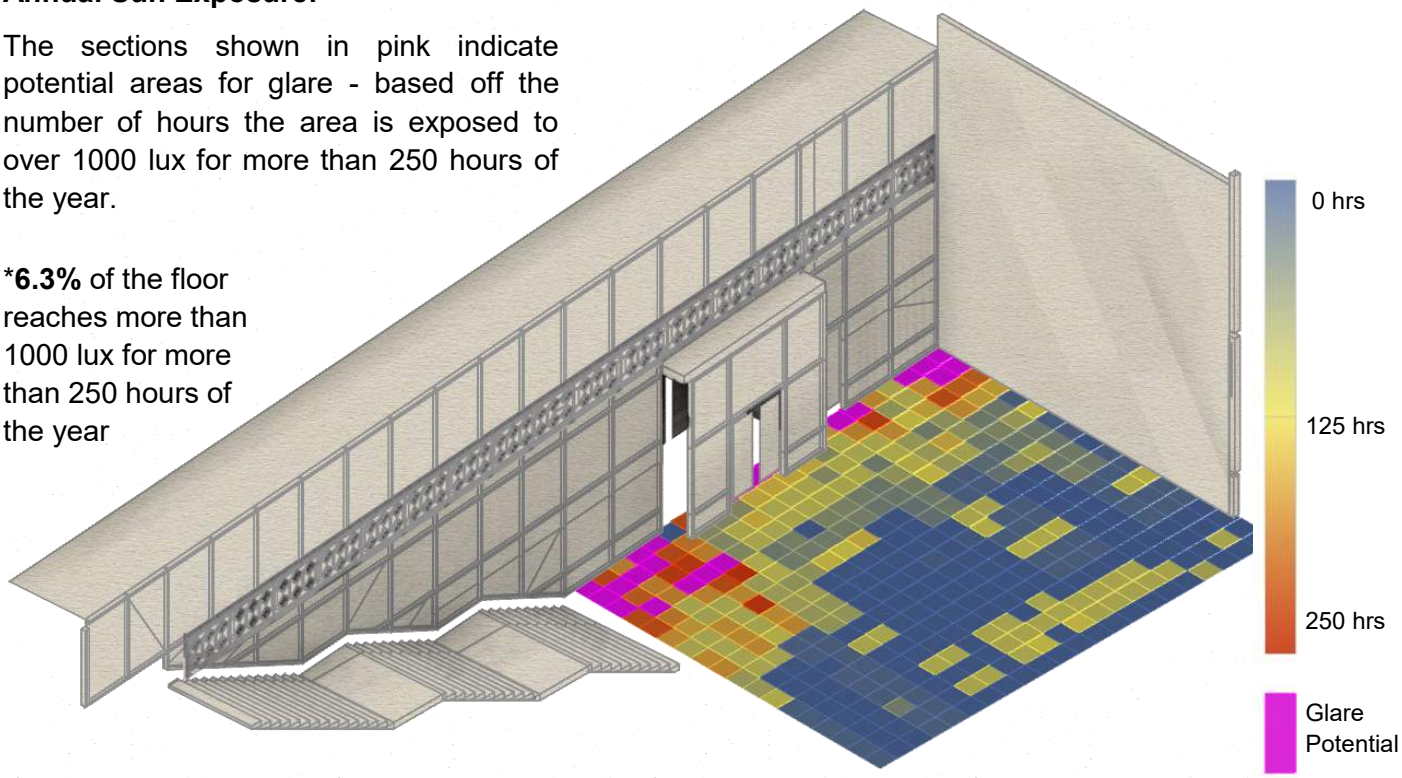


Figure 3.15 | ASE Perspective View - Redesign 2, Daylight Panel + 0.47 Tinted Glass

Daylight Autonomy:

The colored sections below show the areas, determined in % of occupied hours that the space receives sufficient daylight - at least 150 lux. Areas in dark orange receive at least 150 lux 100% of the occupied hours.

***64.95%** of the annual occupied hours receive sufficient daylight

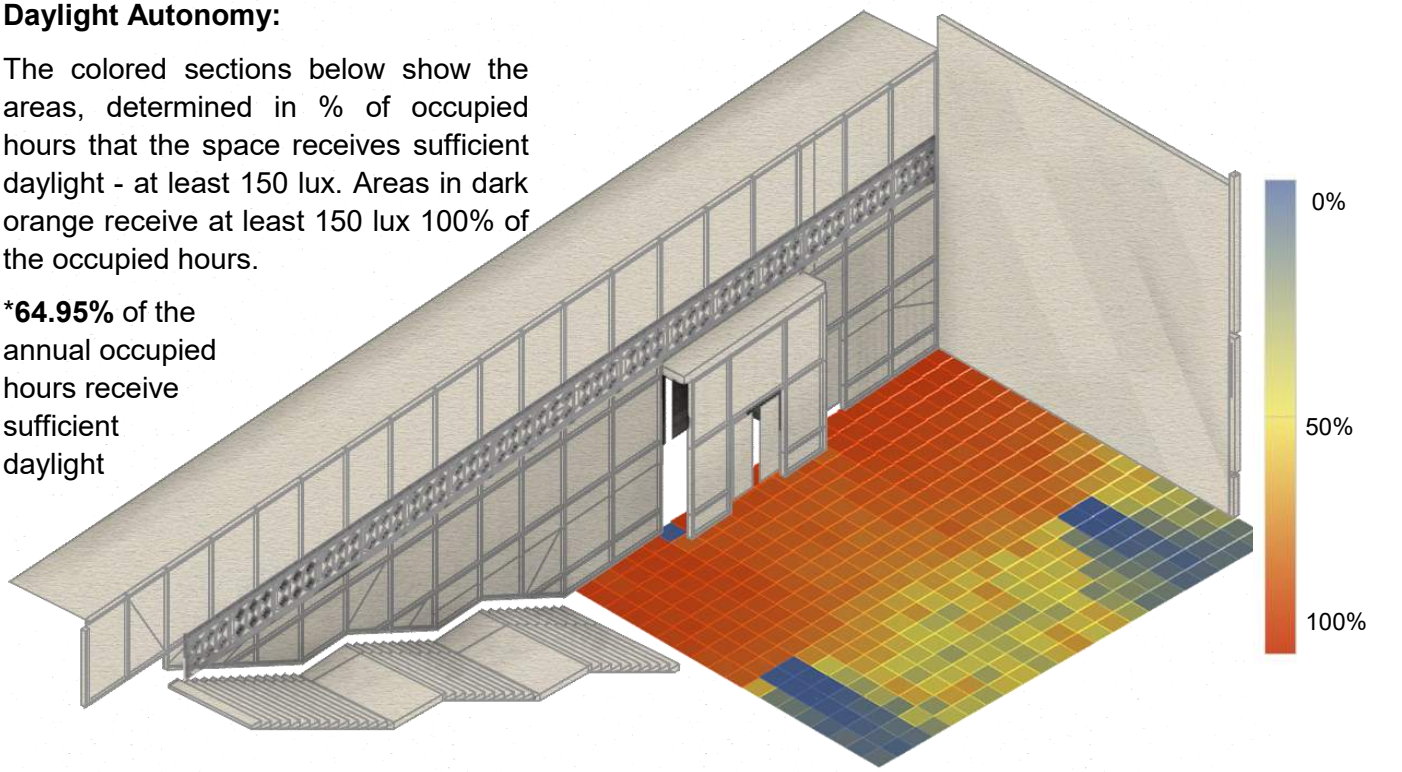


Figure 3.16 | DA Perspective View - Redesign 2, Daylight Panel + 0.47 Tinted Glass

Redesign 3 - Daylight Panel + 0.38 T_{vis}

Annual Glare:

Figure 3.17 shows the Annual Glare results for Redesign 3, which includes the addition of the daylight panel on the *middle* section with 38% transmittance tinted glass on the *bottom* section of the curtain wall. With this design, the intolerable glare reduces by **59%** of the original.

Daylight Glare Probability		
Scale	DGP (%)	# of Hours
Imperceptible Glare	< 35%	8604
Perceptible Glare	35 - 40 %	14
Disturbing Glare	40 - 45 %	26
Intolerable Glare	> 45%	116

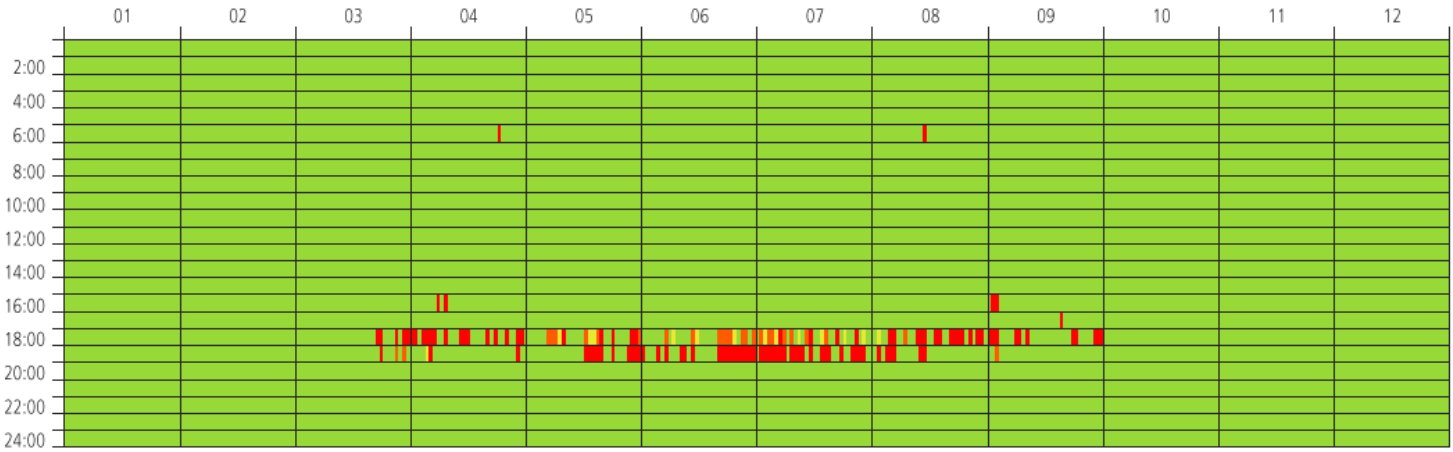
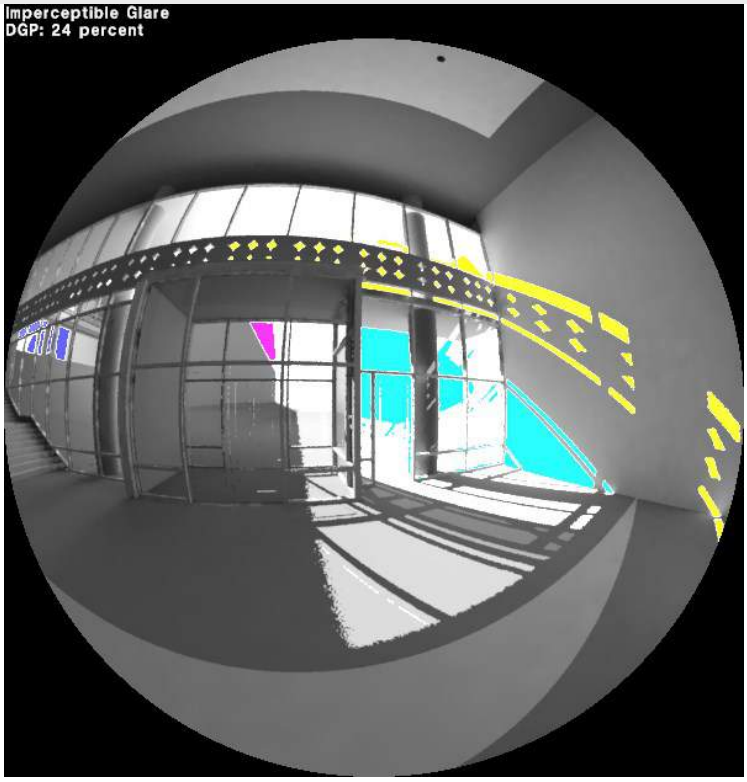


Figure 3.17 | Annual Glare in DGP - Redesign 3, Daylight Panel + 0.38 Tinted Glass



Point-in-Time Glare:

The fisheye glare image to the left was calculated for **September 11, at 3:30 PM.** At this time of the year, Redesign 3 has **24% DGP** - which means any areas of high contrast on the surface would be imperceptible.

As previously mentioned, the colors highlighted in the fisheye represent areas of high contrast, but they don't have any direct correlation to particular values.

Annual Sun Exposure:

The sections shown in pink indicate potential areas for glare - based off the number of hours the area is exposed to over 1000 lux for more than 250 hours of the year.

***6.3%** of the floor reaches more than 1000 lux for more than 250 hours of the year

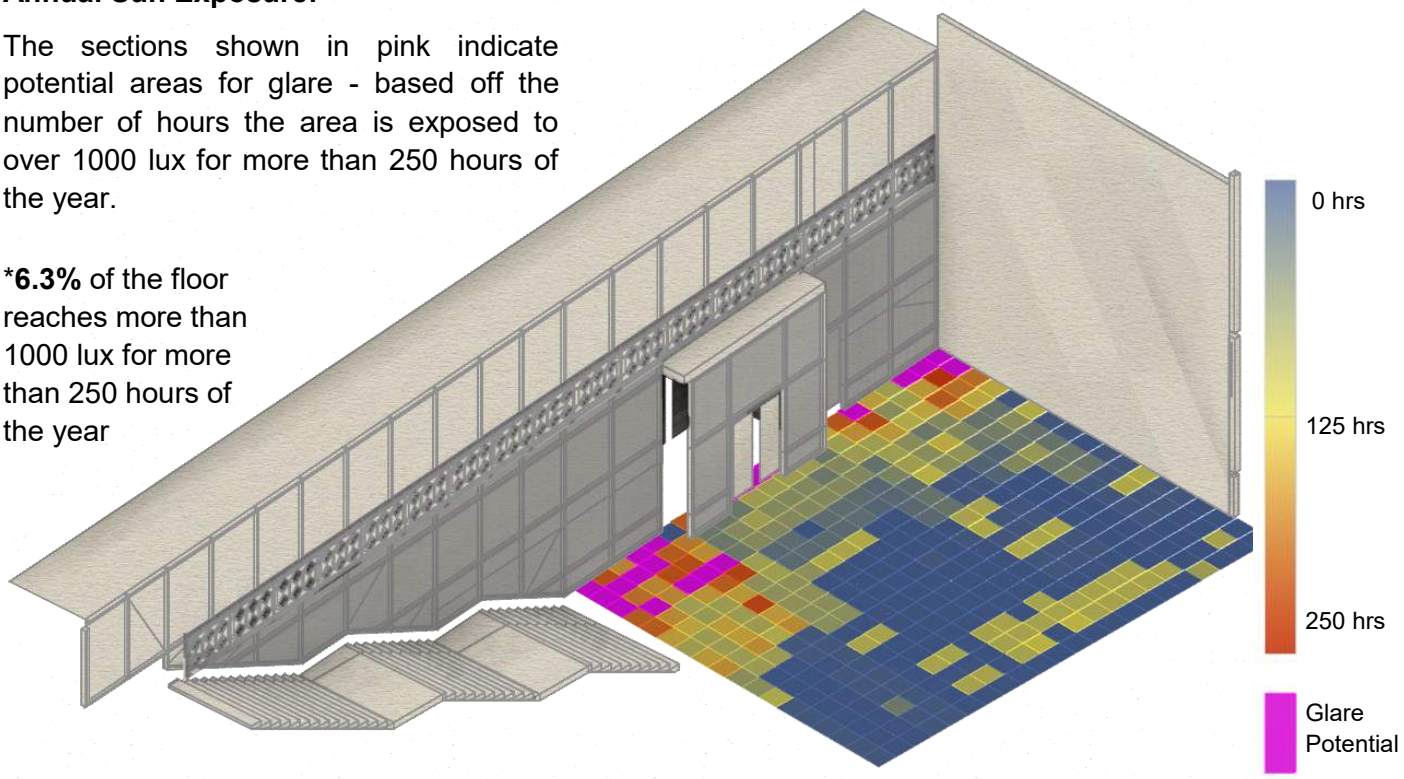


Figure 3.18 | ASE Perspective View - Redesign 3, Daylight Panel + 0.38 Tinted Glass

Daylight Autonomy:

The colored sections below show the areas, determined in % of occupied hours that the space receives sufficient daylight - at least 150 lux. Areas in dark orange receive at least 150 lux 100% of the occupied hours.

***64.95%** of the annual occupied hours receive sufficient daylight

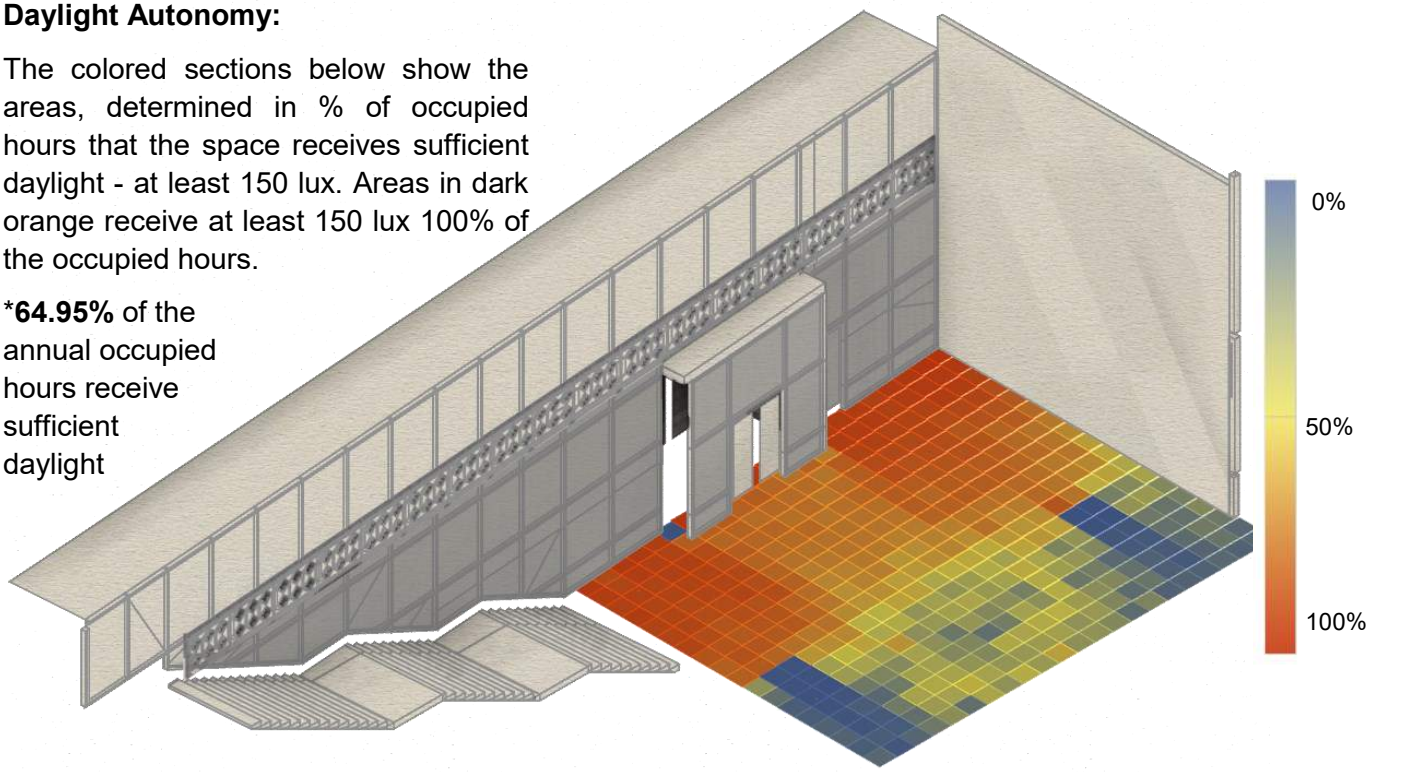


Figure 3.19 | DA Perspective View - Redesign 3, Daylight Panel + 0.38 Tinted Glass

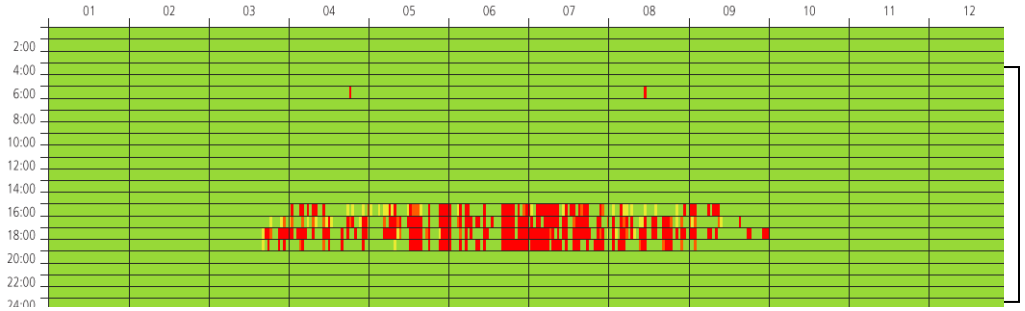
| Daylighting Depth

Lower Level Lobby - Daylight Panel + Glare Study

Redesign Comparisons

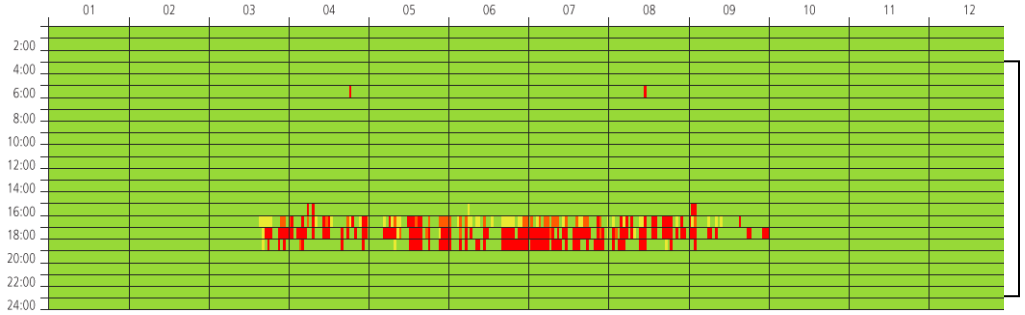
Original Design - *Base Case*

Intolerable Glare	ASE %	DA %
281 hours	**7.6%**	**74.4%**



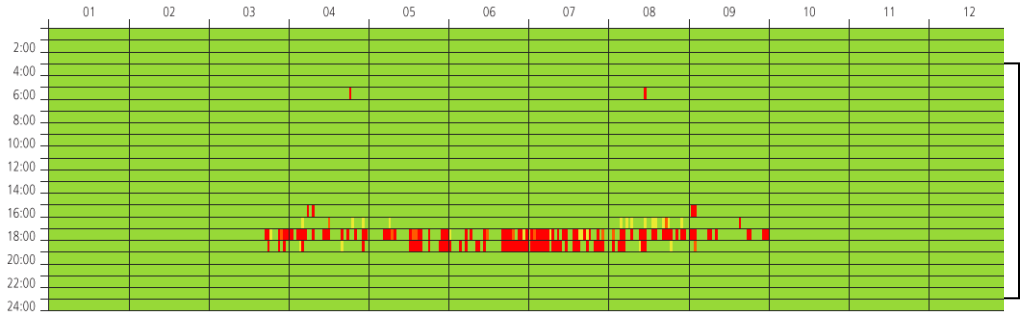
Redesign 1 - Panel Only

Intolerable Glare	ASE %	DA %
194 hours,	**7.8%**	**74.2%**
31% ↓	↑	—



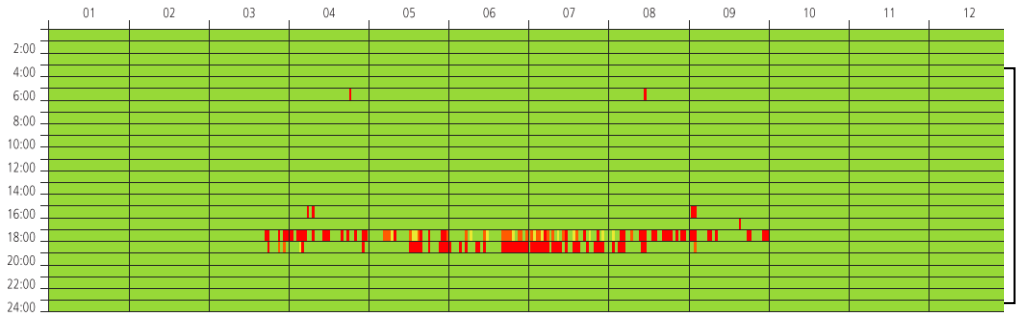
Redesign 2 - Panel + 0.47 T_{vis}

Intolerable Glare	ASE %	DA %
146 hours,	**6.3%**	**64.9%**
49% ↓	↓	—



Redesign 3 - Panel + 0.38 T_{vis}

Intolerable Glare	ASE %	DA %
116 hours,	**5.8%**	**58 %**
59% ↓	↓	↓



Evaluation of Daylighting Redesign

Comparing the three redesigned systems to the original curtainwall design in the Lower Level Lobby, it was found that Redesign 2 + Redesign 3 work best at meeting both design goals - to reduce glare in the lounge area of the lobby and to create visual interest through daylighting, while avoiding direct penetration from the patterned sunlight into the lounge. Though the daylighting panel alone (Redesign 1) achieved its goal to create visual interest, the reduction of glare only decreased slightly and would not be a recommended solution for both design considerations by itself. That being said, the reduction of intolerable glare and a decrease in ASE is preferred, however, it is important not to reduce DA by too much - this would decrease the amount of sufficient daylight to the space. With this in mind, Redesign 2 would be recommended for the Lower Level Lobby in order to reduce glare, while still taking advantage of daylight from the curtainwall.

Construction

Breadth

Construction Breadth

Cost Analysis + Construction Schedule

The following breadth will continue the a cost analysis of the proposed electrical system redesign with the consideration of estimated labor hours needed to construct the new system. In addition, a construction schedule was produced to account for the labor hours and time of construction for this proposed design.

Recall from the Electrical Depth, this redesign refers to the conversion of the existing 208/120V residential + 480/277V commercial system to a 480/277V system for the entire building. The cost analysis of the redesigned electrical system was performed using RS Means cost data and the schedule was designed using Microsoft Project, according to the installation durations within RS Means as well.

Labor Hours + Construction Schedule

A construction schedule was included in this breadth to describe the sequence of installation for the *proposed* electrical system. In order to calculate installation durations for the schedule, labor hours were calculated based off RS Means values for the specific equipment types.

Existing *Primary Wire* Labor Hour Analysis:

As stated, the labor hours to install each electrical equipment type were determined from RS Means labor hour values. Tables 4.1 - 4.13 below and on the following page show a detailed cost take-off of man hours to install the *existing primary wires*.

These tables are broken up to represent the feeders, ground and conduit for each system separately for a better understanding of their individual contributions for the final construction schedule.

Table 4.1 | Existing Primary Feeder Labor Hour Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	Total C.L.F. of Feeder	RS Means Labor Hours	Total Labor Hours
2	SW	0.39	4	6	400 kcmil Al	9.36	3.48	32.57
2	NW	1.31	4	6	400 kcmil Al	31.44	3.48	109.41
2	SE	2.35	4	6	400 kcmil Al	56.4	3.48	196.27
2	NE	1.86	4	6	400 kcmil Al	44.64	3.48	155.35
4	SW	0.61	4	6	400 kcmil Al	14.64	3.48	50.95
4	NW	1.53	4	6	400 kcmil Al	36.72	3.48	127.79
4	SE	2.57	4	6	400 kcmil Al	61.68	3.48	214.65
4	NE	2.08	4	6	400 kcmil Al	49.92	3.48	173.72
						Total Labor Hours		1,060.70
						Total Labor Days		132.588

Table 4.2 | Existing Primary Ground Labor Hour Analysis								
Floor	**Elec Room**	**Linear Feet (C.L.F)**	**No. of sets**	**No. of wires**	**Ground Type**	**Total C.L.F. of Ground**	**RS Means Labor Hours**	**Total Labor Hours**
2	SW	0.39	4	6	350 kcmil	1.56	3.33	5.19
2	NW	1.31	4	6	350 kcmil	5.24	3.33	17.45
2	SE	2.35	4	6	350 kcmil	9.4	3.33	31.30
2	NE	1.86	4	6	350 kcmil	7.44	3.33	24.78
4	SW	0.61	4	6	350 kcmil	2.44	3.33	8.13
4	NW	1.53	4	6	350 kcmil	6.12	3.33	20.38
4	SE	2.57	4	6	350 kcmil	10.28	3.33	34.23
4	NE	2.08	4	6	350 kcmil	8.32	3.33	27.71
						Total Labor Hours		169.16
						Total Labor Days		21.1

Table 4.3 | Existing Primary Conduit Labor Hour Analysis								
Floor	**Elec Room**	**Linear Feet (C.L.F)**	**No. of sets**	**No. of wires**	**Conduit Type**	**Total L.F. of Con-duit**	**RS Means Labor Hours**	**Total Labor Hours**
2	SW	0.39	4	6	4"	39	0.229	8.93
2	NW	1.31	4	6	4"	131	0.229	30.00
2	SE	2.35	4	6	4"	235	0.229	53.82
2	NE	1.86	4	6	4"	186	0.229	42.59
4	SW	0.61	4	6	4"	61	0.229	13.97
4	NW	1.53	4	6	4"	153	0.229	35.04
4	SE	2.57	4	6	4"	257	0.229	58.85
4	NE	2.08	4	6	4"	208	0.229	47.63
						Total Labor Hours		290.83
						Total Labor Days		36.35375

Existing *480/277V Input Voltage* Labor Hour Analysis:

Tables 4.4 - 4.6 below show a detailed cost take-off of *existing 480/277V* Duquesne Lighting Co. *input transformer* man power hours.

These tables are broken up to represent the feeders, ground and conduit for each system separately for a better understanding of their individual contributions for the final construction schedule.

Table 4.4 | Existing Input 480/277V XFMR Feeder Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	Total C.L.F. of Feeder	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	8	4	400 kcmil Cu	32	4.70	150.40
						Total Labor Hours		150.40
						Total Labor Days		18.8

Table 4.5 | Existing Input 480/277V XFMR Ground Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Ground Type	Total C.L.F. of Ground	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	8	4	350 kcmil	8	4.20	33.60
						Total Labor Hours		33.60
						Total Labor Days		4.2

Table 4..6 | Existing Input 480/277V XFMR Conduit Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Conduit Type	Total L.F. of Conduit	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	8	4	3.5"	100	0.2	20.00
						Total Labor Hours		20.00
						Total Labor Days		2.5

Existing *208/120V Input Voltage* Labor Hour Analysis:

Tables 4.7 - 4.9 below show a detailed cost take-off of *existing 208/120V* Duquesne Lighting Co. *input transformer* man power hours.

These tables are broken up to represent the feeders, ground and conduit for each system separately for a better understanding of their individual contributions for the final construction schedule.

Table 4.7 | Existing Input 208/122V XFMR Feeder Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	Total C.L.F. of Feeder	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	10	4	600 kcmil Cu	40	6.00	240.00
						Total Labor Hours		240.00
						Total Labor Days		30

Table 4.8 | Existing Input 208/122V XFMR Ground Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Ground Type	Total C.L.F. of Ground	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	10	4	500 kcmil	10	6.60	66.00
						Total Labor Hours		66.00
						Total Labor Days		8.3

Table 4.9 | Existing Input 208/122V XFMR Conduit Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Conduit Type	Total L.F. of Conduit	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	10	4	4"	100	0.229	22.90
						Total Labor Hours		22.90
						Total Labor Days		2.8625

Existing *Switchboard* Labor Hour Analysis:

Table 4.10 below show a detailed cost take-off of *existing* residential and commercial switchboards and their appropriate labor hours of installation.

Table 4.10 | Existing Switchboard Labor Hour Analysis

Type	SWBD Size	No. of SWBD	RS Means Labor Hours	Total Labor Hours
120/208 V Residential	2500 A	1	26.67	26.67
277/480 V Commercial	4000 A	1	30.77	30.77
		Total Labor Hours		57.44
		Total Labor Days		7.2

Proposed *Primary Wire* Labor Hour Analysis:

Tables 4.11 - 4.13 below and on the following page show a detailed cost of man hours to install the *proposed primary wires*.

Table 4.11 | Proposed Primary Feeder Labor Hour Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	Total C.L.F. of Feeder	RS Means Labor Hours	Total Labor Hours
2	SW	0.22	3	4	400 kcmil Cu	2.64	4.70	12.41
2	SW	0.22	3	4	400 kcmil Cu	2.64	4.70	12.41
2	NE	1.74	3	4	400 kcmil Cu	20.88	4.70	98.14
2	NE	1.74	3	4	400 kcmil Cu	20.88	4.70	98.14
						Total Labor Hours		221.09
						Total Labor Days		27.6

Proposed *Primary Wire* Labor Hour Analysis *Continued:*

Table 4.12 | Proposed Primary Ground Labor Hour Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Ground Type	Total C.L.F. of Ground	RS Means Labor Hours	Total Labor Hours
2	SW	0.22	3	4	2/0 AWG	0.66	2.42	1.60
2	SW	0.22	3	4	2/0 AWG	0.66	2.42	1.60
2	NE	1.74	3	4	2/0 AWG	5.22	2.42	12.63
2	NE	1.74	3	4	2/0 AWG	5.22	2.42	12.63
						Total Labor Hours		28.46
						Total Labor Days		3.6

Table 4.13 | Proposed Primary Conduit Labor Hour Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Conduit Type	Total L.F. of Conduit	RS Means Labor Hours	Total Labor Hours
2	SW	0.22	3	4	3.5"	22	0.2	4.40
2	SW	0.22	3	4	3.5"	22	0.2	4.40
2	NE	1.74	3	4	3.5"	174	0.2	34.80
2	NE	1.74	3	4	3.5"	174	0.2	34.80
						Total Labor Hours		78.40
						Total Labor Days		9.8

Proposed *Secondary Wire* Labor Hour Analysis:

Tables 4.14 - 4.15 below and on the following page show a detailed cost of man hours to install the *proposed secondary wires*.

Table 4.14 | Proposed Secondary Feeder Labor Hour Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	Total C.L.F. of Feeder	RS Means Labor Hours	Total Labor Hours
2	SW	0	5	4	600 kcmil Cu	0	6.00	0.00
2	NW	0.62	5	4	600 kcmil Cu	12.4	6.00	74.40
2	SE	0.62	5	4	600 kcmil Cu	12.4	6.00	74.40
2	NE	0	5	4	600 kcmil Cu	0	6.00	0.00
4	SW	0.22	5	4	600 kcmil Cu	4.4	6.00	26.40
4	NW	0.84	5	4	600 kcmil Cu	16.8	6.00	100.80
4	SE	0.84	5	4	600 kcmil Cu	16.8	6.00	100.80
4	NE	0.22	5	4	600 kcmil Cu	4.4	6.00	26.40
						Total Labor Hours		403.20
						Total Labor Days		50.4

Table 4.15 | Proposed Secondary Ground Labor Hour Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Ground Type	Total C.L.F. of Ground	RS Means Labor Hours	Total Labor Hours
2	SW	0	5	4	250 kcmil	0	3.33	0.00
2	NW	0.62	5	4	250 kcmil	3.1	3.33	10.32
2	SE	0.62	5	4	250 kcmil	3.1	3.33	10.32
2	NE	0	5	4	250 kcmil	0	3.33	0.00
4	SW	0.22	5	4	250 kcmil	1.1	3.33	3.66
4	NW	0.84	5	4	250 kcmil	4.2	3.33	13.99
4	SE	0.84	5	4	250 kcmil	4.2	3.33	13.99
4	NE	0.22	5	4	250 kcmil	1.1	3.33	3.66
						Total Labor Hours		55.94
						Total Labor Days		7.0

Proposed *Secondary Wire* Labor Hour Analysis *Continued*:

Tables 4.16 - 4.17 below and on the following page show a detailed cost of man hours to install the *proposed secondary wires*.

Table x.x | Proposed Secondary Conduit Labor Hour Analysis

Floor	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Conduit Type	Total L.F. of Conduit	RS Means Labor Hours	Total Labor Hours
2	SW	0	5	4	4"	0	0.229	0.00
2	NW	0.62	5	4	4"	62	0.229	14.20
2	SE	0.62	5	4	4"	62	0.229	14.20
2	NE	0	5	4	4"	0	0.229	0.00
4	SW	0.22	5	4	4"	22	0.229	5.04
4	NW	0.84	5	4	4"	84	0.229	19.24
4	SE	0.84	5	4	4"	84	0.229	19.24
4	NE	0.22	5	4	4"	22	0.229	5.04
						Total Labor Hours		76.94
						Total Labor Days		9.618

Proposed *480/277V Input Voltage* Labor Hour Analysis:

Tables 4.18 - 4.20 below show a detailed labor hour analysis for the *redesigned 480/277V* Duquesne Lighting Co. *input transformer.*

Table 4.18 | Proposed Input 480/277V XFMR Feeder Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Feeder Type	Total C.L.F. of Feeder	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	10	4	600 kcmil Cu	40	6.00	240.00
						Total Labor Hours		240.00
						Total Labor Days		30

Proposed *480/277V Input Voltage* Labor Hour Analysis *Continued*:

Table 4.19 | Proposed Input 480/277V XFMR Ground Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Ground Type	Total C.L.F. of Ground	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	10	4	500 kcmil	10	6.60	66.00
						Total Labor Hours		66.00
						Total Labor Days		8.3

Table 4.20 | Proposed Input 480/277V XFMR Conduit Labor Hour Analysis

Type	Elec Room	Linear Feet (C.L.F)	No. of sets	No. of wires	Conduit Type	Total L.F. of Conduit	RS Means Labor Hours	Total Labor Hours
Input Voltage	Main Elec, Ground	1	10	4	4"	100	0.229	22.90
						Total Labor Hours		22.90
						Total Labor Days		2.8625

Proposed *Transformer + Switchboard* Labor Hour Analysis:

Table 4.21 | Proposed Transformer Labor Hours Analysis

XFMR Type	No. of XFMRs	RS Means Labor Hours	Total Labor Hours
500 kVA	4	44.44	177.76
	Total Labor Hours		177.76
	Total Labor Days		22.22

Table 4.22 | Proposed Switcboard Labor Hours Analysis

SWBD Type	No. of SWBD	RS Means Labor Hours	Total Labor Hours
4000 A	1	30.77	30.77
	Total Labor Hours		30.77
	Total Labor Days		3.8

Labor Hour Comparison:

As noticed from the cost comparison performed in the Electrical Depth of this report, comparing the existing and redesigned electrical systems, a savings from the *proposed* design was found in labor + materials. As one could assume, this cost savings also results in a savings in labor hours for installation. This savings is shown in Table 4.23 below.

A total savings of approximately **709 hours** or **88 days** was calculated in labor hours be switching to the *proposed* electrical system design.

Table 4.23 | Existing vs. Proposed Labor Hour Comparison

Equipment	Existing Labor Hours	Proposed Labor Hours	Labor Hour Savings
Feeders	1,451.10	864.29	586.82
Ground	268.76	150.40	118.36
Conduit	333.73	178.24	155.49
Transformers	0	177.76	-177.76
Switchboards	57.44	30.77	26.67
		Total Savings (Hours)	**709.57**
		Total Savings (Days)	**88.70**

Schedule:

The previously calculated labor hours were used to produce a construction schedule showing the sequence of installation of each electrical equipment type. The schedule was designed to include the *proposed* electrical design only. The schedule also includes further detail in the estimated installation hours with the assumption to include rough-ins, wire pull and termination, branch power installation, in addition to the previously calculated layout and installation hours.

The construction schedule can be found on the next page. Items shown in red indicate items along the project's *critical path* - if these items are delayed, the entire schedule will be delayed.

ID	Task Name	Duration	Start	Finish	Predecessors
1	Switchboard In-Place	0 days	Thu 3/23/17	Thu 3/23/17	
2	Utility XFMR Installed	0 days	Thu 3/23/17	Thu 3/23/17	
3	Level 1 & 2 Accessible	0 days	Thu 3/23/17	Thu 3/23/17	
4	**Ground Level Distribution Input**	**40 days**	**Thu 3/23/17**	**Wed 5/17/17**	
5	Input Feeder Rough-in	25 days	Thu 3/23/17	Wed 4/26/17	
6	Install Switchboard	5 days	Thu 4/27/17	Wed 5/3/17	5
7	Input Feeder Wire Pull / Term.	15 days	Thu 4/27/17	Wed 5/17/17	5
8	**Residential - SW Electrical Room**	**70 days**	**Thu 5/18/17**	**Wed 8/23/17**	**3**
9	Residential Feeder Hanger Layout/Install (SW Elec. Room)	5 days	Thu 5/18/17	Wed 5/24/17	3,7
10	Residential Feeder Rough-in (SW Elec Room)(Primary)	10 days	Thu 5/25/17	Wed 6/7/17	9
11	Install SW1 and SW2 XFMRs/CKT Breakers	15 days	Thu 6/8/17	Wed 6/28/17	10
12	Feeder Wire Pull / Term (SW Elec. Room)(Primary)	5 days	Thu 6/29/17	Wed 7/5/17	11
13	Power Available from SW Electrical Room	0 days	Wed 7/5/17	Wed 7/5/17	12
14	Secondary Rough-in	15 days	Thu 7/6/17	Wed 7/26/17	12
15	Pull Secondary Side Wire	10 days	Thu 7/27/17	Wed 8/9/17	14
16	Terminate Secondary Side	10 days	Thu 8/10/17	Wed 8/23/17	15
17	Permanent Branch Power Available	0 days	Wed 8/23/17	Wed 8/23/17	16
18	**Residential - NE Electrical Room**	**70 days**	**Thu 7/6/17**	**Wed 10/11/17**	
19	Residential Feeder Hanger Layout/Install (NE Elec. Room)	5 days	Thu 7/6/17	Wed 7/12/17	13
20	Residential Feeder Rough-in (NE Elec Room)(Primary)	10 days	Thu 7/13/17	Wed 7/26/17	19
21	Install NE1 and NE2 XFMRs/CKT Breakers	15 days	Thu 7/27/17	Wed 8/16/17	20
22	Feeder Wire Pull / Term (NE Elec. Room)(Primay)	5 days	Thu 8/17/17	Wed 8/23/17	21
23	Power Available from NE Electrical Room	0 days	Wed 8/23/17	Wed 8/23/17	22
24	Secondary Rough-in	15 days	Thu 8/24/17	Wed 9/13/17	22
25	Pull Secondary Side Wire	10 days	Thu 9/14/17	Wed 9/27/17	24
26	Terminate Secondary Side	10 days	Thu 9/28/17	Wed 10/11/17	25
27	Permanent Branch Power Available	0 days	Wed 10/11/17	Wed 10/11/17	26

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Critical Split
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline	Progress
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Critical	Manual Progress

Acoustics

Breadth

| Acoustics Breadth

Reverberation + Reflection Study - Lower Level Lobby

The following breadth will explore the echoes and reverberation time within the acoustically sensitive Lower Level Lobby and its direct connection to the open Entertainment Kitchen + Billiard Room on the first level of Eastside III. The surface materials within the Lower Level Lobby will be adjusted in order to reduce reverberation time and ultimately reduce the directional distribution of reflections into the amenity spaces above.

Defining Reverberation + Echoes

Reverberation and echoes differ slightly from one another. Reverberation is a *smooth decrease* in the energy content of successive reflections, in order for the reflections to be imperceptible. Where an echo consists of one or more relatively *strong reflections* within the general reverberation process that is heard separately. Reverberation refers to *direct sound* and echoes create *unfavorable acoustics* within a space.

Defining the Problem

It is important to note that the goal of the Lower Level Lobby's acoustics is to provide a diffuse sound field in order to reduce the number of reflections into the Entertainment Kitchen above and vice versa. The connection between the two rooms is shown in the building section below in Figure 5.1.

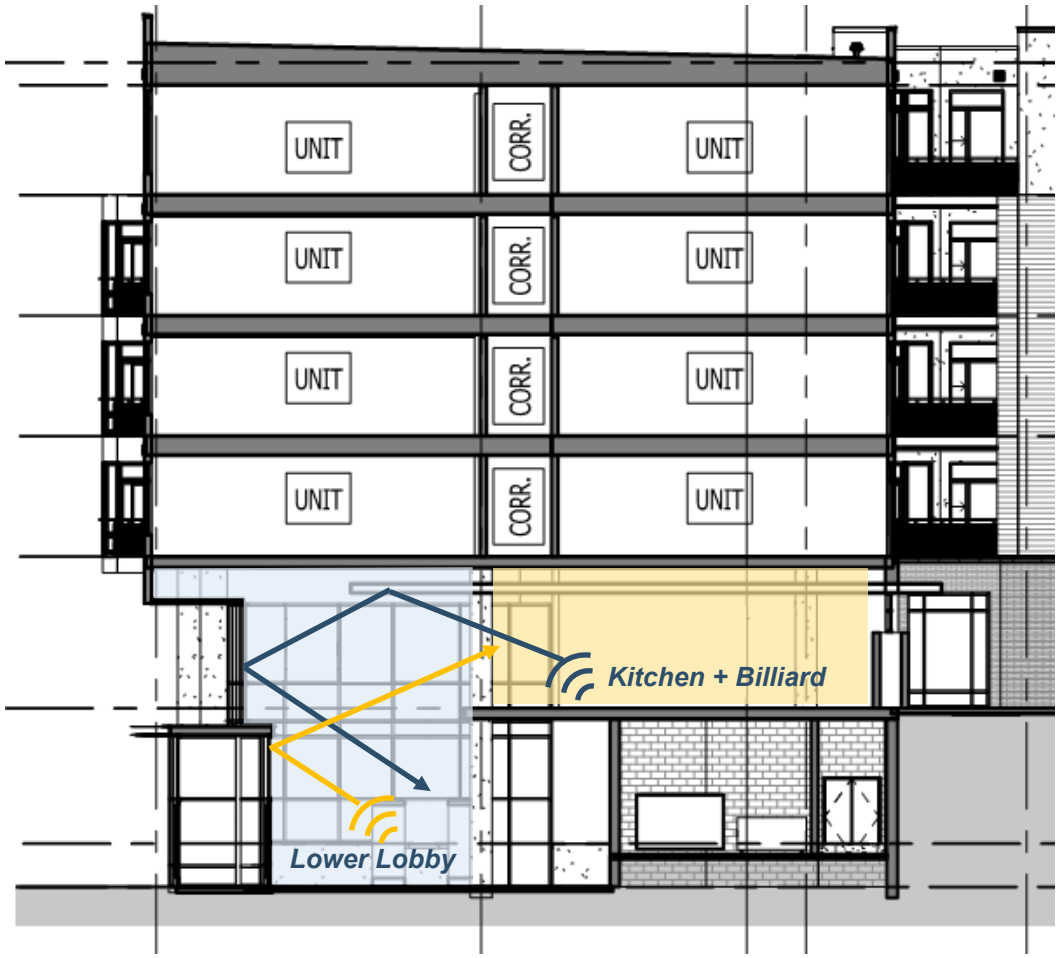


Figure 5.1 | Building Section - Acoustical Connections of Lower Lobby + E-Kitchen

Determining Appropriate Reverberation Time

In order to ensure the reduction of sound reflections between these spaces, the reverberation time was studied and ultimately reduced. The optimum reverberation time (RT) for Lower Level Lobby was first determined in order to complete this study. According to Figure 5.2, and the assumption that the Lower Level Lobby should be designed somewhere between a space with *speech* and *music* in mind, a target RT of **1.0 seconds** was established. The volume used for this calculation is approximately **54,816 ft^3.**

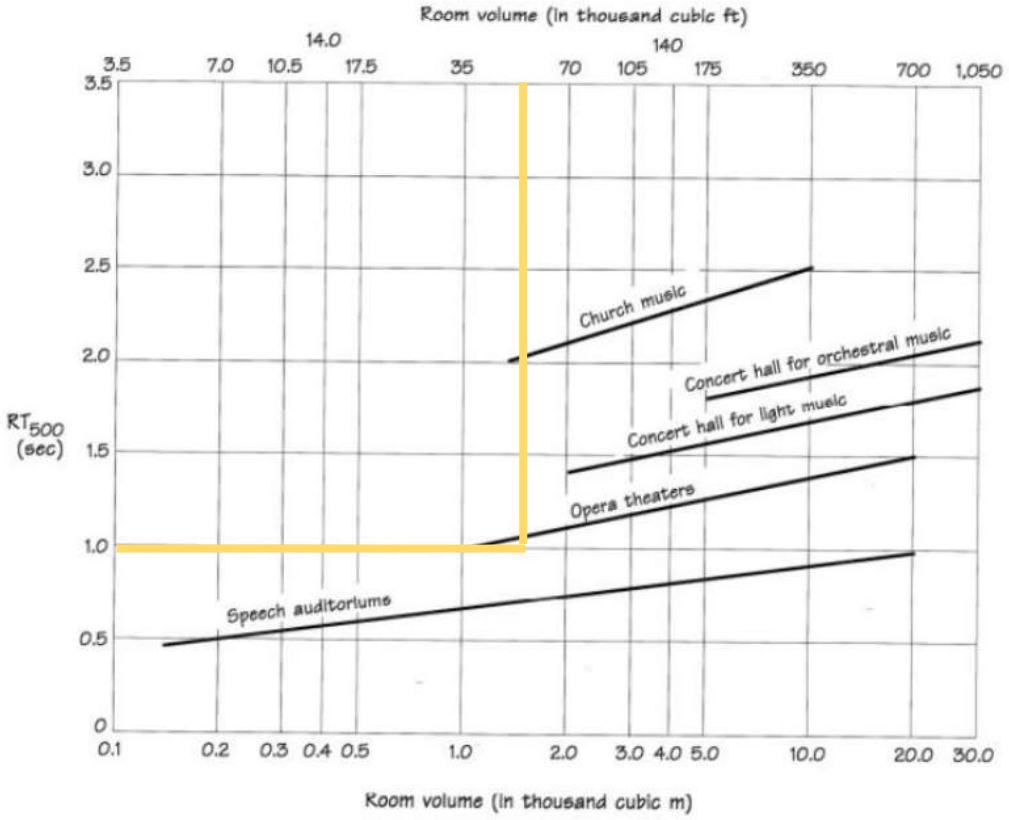


Figure 5.2 | Suggested Optimum Reverberation Times at 500 Hz

Reverberation Time Analysis

The Sound Absorption Coefficients (α) was found for each material within the Lower Level Lobby for each octave band from 125 to 4,000 Hz. These values were used to calculate the average absorption and reverberation times for each frequency. The following equations were used to calculate reverberation time:

Sabine Equation | $$RT = \frac{BV}{S_T \propto +4a_a V}$$

Norris-Eyring Equation | $$RT = \frac{BV}{-S_T \ln(1-\bar{\propto}) + 4a_a V}$$

Where,

B = 0.049

V = Volume

S_T = Total Surface Area

α = Absorption Coefficient

a_a = Air Absorption

If the average α < 0.20, the Sabine equation was used to calculate RT. If the average α > 0.20, the Norris -Eyring equation was used. The sound absorption coefficients seen in Table x.xx on the next page were found using Appendix H of the *Architectural Acoustics Principles and Design* (Mehta) and from various sources provided by our acoustics professor.

Existing Acoustic Design:

Table 5.1 shows the reverberation time calculation for the *existing* design of the Lower Level Lobby. As previously stated, the RT was calculated for a frequency of 500 Hz and a desired optimum reverberation time of 1.0 seconds in the lobby.

Table 5.1 | Reverberation Time - Existing Acoustics

Surface Type	SA (ft^2)	Description	Sound Absorption Coefficient, α						S*α (sabins)					
			Frequency (Hz)						Frequency (Hz)					
			125	250	500	1000	2000	4000	125	250	500	1000	2000	4000
Walls:														
Curtain Wall	**2172**	Glass	0.35	0.25	0.18	0.12	0.07	0.04	760.2	543.0	391.0	260.6	152.0	86.9
Metal Coverings	**333**	Perforated Metal	0.18	0.73	1.14	1.06	0.97	0.93	59.9	243.1	379.6	353.0	323.0	309.7
Diamond Screen	**150**	Perforated Metal	0.18	0.73	1.14	1.06	0.97	0.93	27.0	109.5	171.0	159.0	145.5	139.5
Wood Walls	**506**	Wood	0.15	0.11	0.1	0.07	0.06	0.07	75.9	55.7	50.6	35.4	30.4	35.4
Concrete Wall	**1150**	Painted Concrete	0.1	0.05	0.06	0.07	0.09	0.08	115.0	57.5	69.0	80.5	103.5	92.0
Side Walls	**572**	5/8" GWB paint finish	0.14	0.06	0.04	0.03	0.03	0.03	80.1	34.3	22.9	17.2	17.2	17.2
Columns	**270**	Plywood Paneling w/Airspace	0.38	0.24	0.17	0.1	0.08	0.05	102.6	64.8	45.9	27.0	21.6	13.5
Glass Railings	**120**	Plywood Paneling w/Airspace	0.38	0.24	0.17	0.1	0.08	0.05	45.6	28.8	20.4	12.0	9.6	6.0
E-lounge Walls	**75**	5/8" GWB paint finish	0.14	0.06	0.04	0.03	0.03	0.03	10.5	4.5	3.0	2.3	2.3	2.3
E-lounge Wallpaper	**103**	1/2" GWB with wallpaper	0.15	0.08	0.06	0.05	0.04	0.04	15.5	8.2	6.2	5.2	4.1	4.1
E-lounge Shelves	**296**	Metal book shelves	0.38	0.24	0.17	0.1	0.08	0.05	112.5	71.0	50.3	29.6	23.7	14.8
Ceiling:														
Exposed Ceiling	**1895**	1/2" Gyp. Bd. Ceiling	0.11	0.11	0.05	0.06	0.04	0.05	208.5	208.5	94.8	113.7	75.8	94.8
Suspended Ceiling	**764**	Wood	0.15	0.11	0.1	0.07	0.06	0.07	114.6	84.0	76.4	53.5	45.8	53.5
E-lounge Ceiling	**405**	1/2" Gyp. Bd. Ceiling	0.11	0.11	0.05	0.06	0.04	0.05	44.6	44.6	20.3	24.3	16.2	20.3
Floor:														
Lobby Tile	**1490**	Vinyl Tile or Linoleum on Concrete	0.02	0.03	0.03	0.03	0.03	0.02	29.8	44.7	44.7	44.7	44.7	29.8
E-lounge Carpet	**405**	Carpet, heavy, on concrete	0.05	0.06	0.14	0.37	0.6	0.65	20.3	24.3	56.7	149.9	243.0	263.3
Stairs	**405**	Concrete or Terrazzo Flooring	0.01	0.01	0.01	0.02	0.02	0.02	4.1	4.1	4.1	8.1	8.1	8.1
Misc.														
Lounge Chairs	**90**	Unnocupied heavily upholstered seats	0.72	0.79	0.83	0.84	0.83	0.79	64.8	71.1	74.7	75.6	74.7	71.1

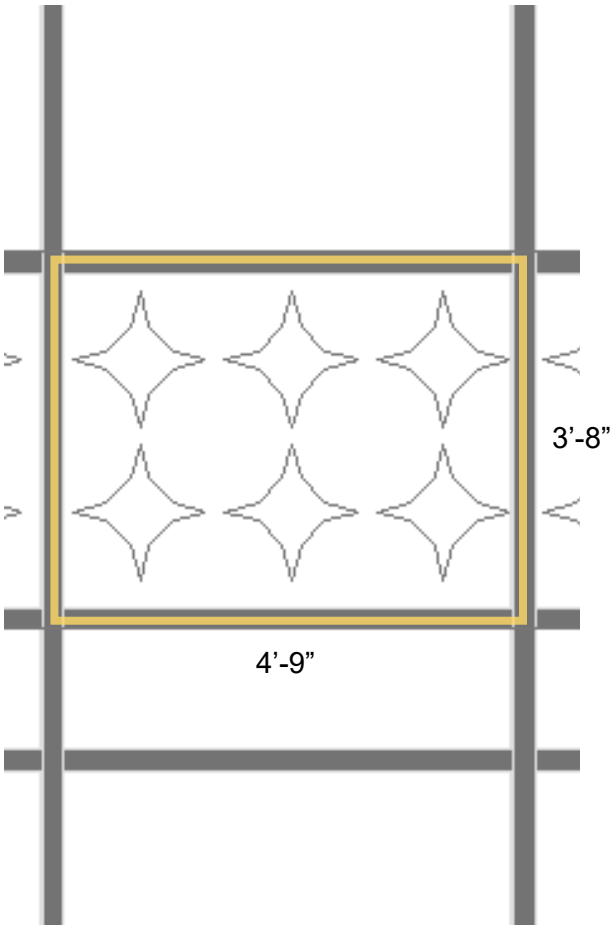
∑Sα=	1891	1702	1581	1451	1341	1262
Avg.α =	0.17	0.15	0.14	0.13	0.12	0.11
Air absorption for 20 °C, 30% RH	0.00	0.00	0.00	0.00	0.004	0.012
Sabine RT: (s)	1.42	1.58	1.70	1.76	1.21	0.69
Norris-Eyring RT: (s)	1.30	1.46	1.58	1.65	1.17	0.68
Calculated RT (s)	**1.42**	**1.58**	**1.70**	**1.76**	**1.21**	**0.69**

Revised Acoustic Design - *Lighting Solution:*

The revised acoustics study was integrated into part of the daylighting and artificial lighting solution for the Lower Level Lobby, as seen in the Daylighting Depth and Lighting Depth. The pattern, illustrated below, is comprised of an acoustic metal panel material, called *Acoustimetal,* that adds sound absorption to the space.

Noise S.T.O.P Acoustimetal Product Information:

- Material | 0.40 clear anodized perforated aluminum
- Metal Coating | Stainless steel
- Installation (see detail) | Mechanical clips
  - Daylighting panel installed into horizontal mullion + placed between vertical mullions
  - Entertainment lounge panel installed from floor to ceiling, (4) panels each
- Opening % | 50% custom opening
- Acoustic Fill Material | 1” Sound Silencer
  - Blocks + absorbs sound
- Panel Size | 3’-8” x 4’-9”
- Diamond Pattern Size | 1’-4” x 1’-4”



Revised Acoustic Design - *Lighting Solution* Continued*:*

Figure 5.3 below provides a perspective view of the Lower Level Lobby, showing the location of the "diamond" patterned *Acoustimetal* panels for both the daylighting and lounge applications.

For specifics about the acoustic panel and its application features within Eastside III, refer to Appendix D for the manufacturer specifications and the Daylighting Depth for specific installation details. The reverberation time for the Lower Level Lobby was recalculated to account for the absorption characteristics of the *Acoustimetal* panels. This can be seen in Table 5.2 on the next page.

Figure 5.3 | Lower Level Lobby - Acoustical Customs Panels

Table 5.2 | Reverberation Time - Revised Design (Lighting)

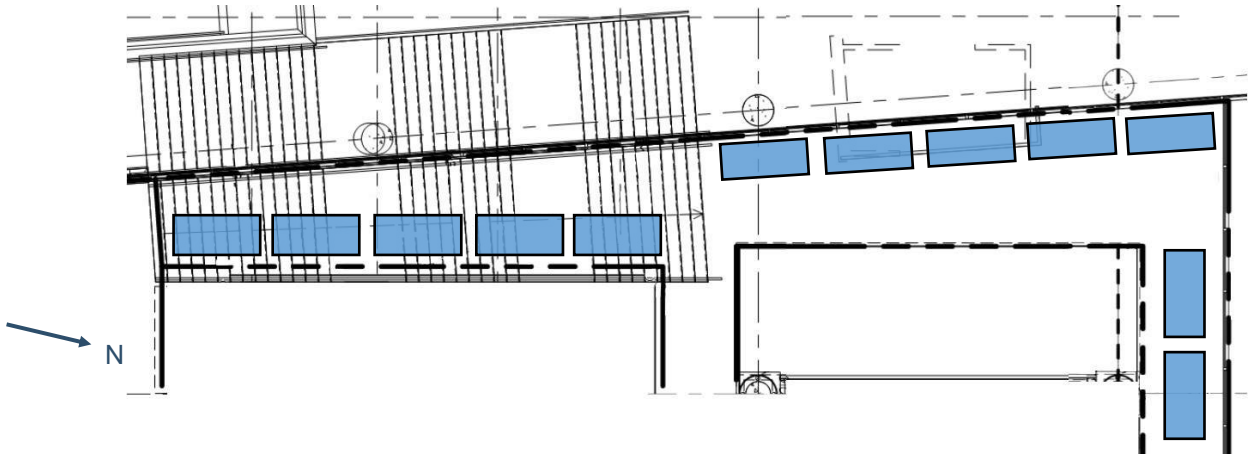
Surface Type	SA (ft^2)	Description	Sound Absorption Coefficient, α						S*α (sabins)					
			Frequency (Hz)						Frequency (Hz)					
			125	250	500	1000	2000	4000	125	250	500	1000	2000	4000
Walls:														
Curtain Wall	**2172**	Glass	0.35	0.25	0.18	0.12	0.07	0.04	760.2	543.0	391.0	260.6	152.0	86.9
Metal Coverings	**333**	Perforated Metal	0.18	0.73	1.14	1.06	0.97	0.93	59.9	243.1	379.6	353.0	323.0	309.7
Diamond Screen	**150**	Perforated Metal							0.0	0.0	0.0	0.0	0.0	0.0
Wood Walls	**506**	Wood	0.15	0.11	0.1	0.07	0.06	0.07	75.9	55.7	50.6	35.4	30.4	35.4
Concrete Wall	**1150**	Painted Concrete	0.1	0.05	0.06	0.07	0.09	0.08	115.0	57.5	69.0	80.5	103.5	92.0
Side Walls	**572**	5/8" GWB paint finish	0.14	0.06	0.04	0.03	0.03	0.03	80.1	34.3	22.9	17.2	17.2	17.2
Columns	**270**	Plywood Paneling w/Airspace	0.38	0.24	0.17	0.1	0.08	0.05	102.6	64.8	45.9	27.0	21.6	13.5
Glass Railings	**120**	Plywood Paneling w/Airspace	0.38	0.24	0.17	0.1	0.08	0.05	45.6	28.8	20.4	12.0	9.6	6.0
E-lounge Walls	**75**	5/8" GWB paint finish	0.14	0.06	0.04	0.03	0.03	0.03	10.5	4.5	3.0	2.3	2.3	2.3
E-lounge Wallpaper	**103**	1/2" GWB with wallpaper	0.15	0.08	0.06	0.05	0.04	0.04	15.5	8.2	6.2	5.2	4.1	4.1
E-lounge Shelves	**296**	Metal book shelves	0.38	0.24	0.17	0.1	0.08	0.05	112.5	71.0	50.3	29.6	23.7	14.8
E-Lounge Pattern	**185**	Noise S.T.O.P Acoustimetal	0.42	0.86	0.7	0.93	0.98	1	77.7	159.1	129.5	172.1	181.3	185.0
Curtain Wall Pattern	**150**	Noise S.T.O.P Acoustimetal	0.42	0.86	0.7	0.93	0.98	1	63.0	129.0	105.0	139.5	147.0	150.0
Ceiling:														
Exposed Ceiling	**1866**	1/2" Gyp. Bd. Ceiling	0.11	0.11	0.05	0.06	0.04	0.05	205.3	205.3	93.3	112.0	74.6	93.3
Suspended Ceiling	**704**	Wood	0.15	0.11	0.1	0.07	0.06	0.07	105.6	77.4	70.4	49.3	42.2	49.3
E-lounge Ceiling	**405**	1/2" Gyp. Bd. Ceiling	0.11	0.11	0.05	0.06	0.04	0.05	44.6	44.6	20.3	24.3	16.2	20.3
Floor:														
Lobby Tile	**1866**	Vinyl Tile or Linoleum on Concrete	0.02	0.03	0.03	0.03	0.03	0.02	37.3	56.0	56.0	56.0	56.0	37.3
E-lounge Carpet	**405**	Carpet, heavy, on concrete	0.05	0.06	0.14	0.37	0.6	0.65	20.3	24.3	56.7	149.9	243.0	263.3
Stairs	**405**	Concrete or Terrazzo Flooring	0.01	0.01	0.01	0.02	0.02	0.02	4.1	4.1	4.1	8.1	8.1	8.1
Misc.														
Lounge Chairs	**90**	Unnocupied heavily upholstered seats	0.72	0.79	0.83	0.84	0.83	0.79	64.8	71.1	74.7	75.6	74.7	71.1

∑Sα=	1911	1882	1649	1609	1530	1459
Avg.α =	0.16	0.16	0.14	0.14	0.13	0.12
Air absorption for 20 °C, 30% RH	0.00	0.00	0.00	0.00	0.004	0.012
Sabine RT: (s)	1.41	1.43	1.63	1.60	1.12	0.66
Norris-Eyring RT: (s)	1.29	1.31	1.51	1.49	1.07	0.64
Calculated RT (s)	**1.41**	**1.43**	**1.63**	**1.60**	**1.12**	**0.66**

Revised Acoustic Design - *Lighting + Acoustical Solution:*

As seen from the revised reverberation time calculation, the existing diamond metal panels were replaced by the *Acoustimetal* diamond panels, which increased absorption. In addition, the daylighting *Acoustimetal* diamond panels were added onto part of the curtain wall (see figure 5.3). With these small acoustical changes, the reverberation time decreased slightly but did not reach the desired optimum reverberation time. In order to achieve this desired RT of 1.0 seconds, additional absorption materials must be added to the Lower Level Lobby. In order to maintain the desired aesthetics and materials of the lobby, acoustical ceiling panels were added to the exposed ceiling in order to blend in with the interior design.

A product called *Fabrisorb* was used to increase absorption in the lobby space. The panels are designed to be installed onto the exposed ceiling, in *black* fabric to match the paint color. The reverberation time was recalculated to account for the material specific absorption coefficients. This calculation can be seen on Table 5.3 on the next page. The panels are 4’ x 10’ x 2” and installed in the following ceiling layout:



Noise S.T.O.P Fabrisorb Product Information:

- Material | 6 lb. density glass fiber w/ woven fabric + microperforated vinyl facings
- Pattern | Flat faced w/ square, beveled, or radiused edges
- Installation | Adhesive, fasteners, mechanical clips, impaling clips, magnetic clips, splines

Table 5.3 | Reverberation Time - Revised Design (Lighting + Acoustical)

Surface Type	SA (ft^2)	Description	Sound Absorption Coefficient, α						S*α (sabins)					
			Frequency (Hz)						Frequency (Hz)					
			125	250	500	1000	2000	4000	125	250	500	1000	2000	4000
Walls:														
Curtain Wall	**2172**	Glass	0.35	0.25	0.18	0.12	0.07	0.04	760.2	543.0	391.0	260.6	152.0	86.9
Metal Coverings	**333**	Perforated Metal	0.18	0.73	1.14	1.06	0.97	0.93	59.9	243.1	379.6	353.0	323.0	309.7
Wood Walls	**506**	Wood	0.15	0.11	0.1	0.07	0.06	0.07	75.9	55.7	50.6	35.4	30.4	35.4
Concrete Wall	**1150**	Painted Concrete	0.1	0.05	0.06	0.07	0.09	0.08	115.0	57.5	69.0	80.5	103.5	92.0
Side Walls	**572**	5/8" GWB paint finish	0.14	0.06	0.04	0.03	0.03	0.03	80.1	34.3	22.9	17.2	17.2	17.2
Columns	**270**	Plywood Paneling w/Airspace	0.38	0.24	0.17	0.1	0.08	0.05	102.6	64.8	45.9	27.0	21.6	13.5
Glass Railings	**120**	Plywood Paneling w/Airspace	0.38	0.24	0.17	0.1	0.08	0.05	45.6	28.8	20.4	12.0	9.6	6.0
E-lounge Walls	**75**	5/8" GWB paint finish	0.14	0.06	0.04	0.03	0.03	0.03	10.5	4.5	3.0	2.3	2.3	2.3
E-lounge Wallpaper	**103**	1/2" GWB with wallpaper	0.15	0.08	0.06	0.05	0.04	0.04	15.5	8.2	6.2	5.2	4.1	4.1
E-lounge Shelves	**296**	Metal book shelves	0.38	0.24	0.17	0.1	0.08	0.05	112.5	71.0	50.3	29.6	23.7	14.8
E-Lounge Pattern	**185**	Noise S.T.O.P Acoustimetal	0.42	0.86	0.7	0.93	0.98	1	77.7	159.1	129.5	172.1	181.3	185.0
Curtain Wall Pattern	**150**	Noise S.T.O.P Acoustimetal	0.42	0.86	0.7	0.93	0.98	1	63.0	129.0	105.0	139.5	147.0	150.0
Ceiling:														
Exposed Ceiling	**1866**	1/2" Gyp. Bd. Ceiling	0.11	0.11	0.05	0.06	0.04	0.05	205.3	205.3	93.3	112.0	74.6	93.3
Suspended Ceiling	**704**	Wood	0.15	0.11	0.1	0.07	0.06	0.07	105.6	77.4	70.4	49.3	42.2	49.3
E-lounge Ceiling	**405**	1/2" Gyp. Bd. Ceiling	0.11	0.11	0.05	0.06	0.04	0.05	44.6	44.6	20.3	24.3	16.2	20.3
Acoustic Panels	**480**	Noise S.T.O.P Fabrisorb	0.22	0.81	1	1	1	1	105.6	388.8	480.0	480.0	480.0	480.0
Floor:														
Lobby Tile	**1866**	Vinyl Tile or Linoleum on Concrete	0.02	0.03	0.03	0.03	0.03	0.02	37.3	56.0	56.0	56.0	56.0	37.3
E-lounge Carpet	**405**	Carpet, heavy, on concrete	0.05	0.06	0.14	0.37	0.6	0.65	20.3	24.3	56.7	149.9	243.0	263.3
Stairs	**405**	Concrete or Terrazzo Flooring	0.01	0.01	0.01	0.02	0.02	0.02	4.1	4.1	4.1	8.1	8.1	8.1
Misc.														
Lounge Chairs	**90**	Unnocupied heavily upholstered seats	0.72	0.79	0.83	0.84	0.83	0.79	64.8	71.1	74.7	75.6	74.7	71.1

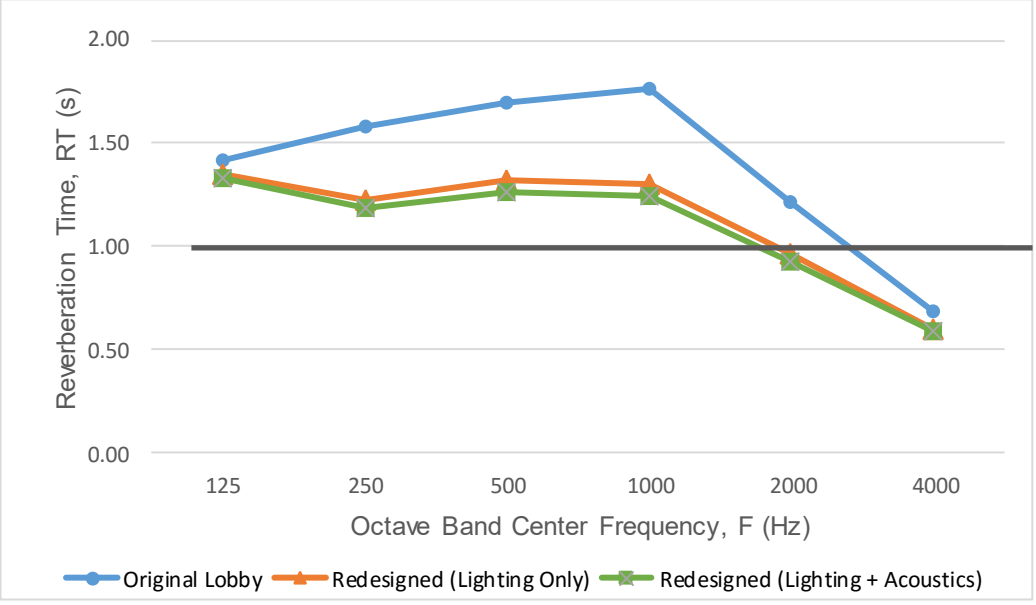
∑Sα=	2017	2271	2129	2089	2010	1939
Avg.α =	0.17	0.19	0.18	0.17	0.17	0.16
Air absorption for 20 °C, 30% RH	0.00	0.00	0.00	0.00	0.004	0.012
Sabine RT: (s)	1.33	1.18	1.26	1.24	0.93	0.59
Norris-Eyring RT: (s)	1.22	1.07	1.15	1.14	0.87	0.57
Calculated RT (s)	**1.33**	**1.18**	**1.26**	**1.24**	**0.93**	**0.59**

Breadth Evaluation:

By installing the acoustic ceiling panels, the reverberation time was decreased to slighting from 1.35 to 1.26 seconds, which falls close to the recommended range of plus or minus 20% of the optimum reverberation time, according to *Architectural Acoustics Principles and Design* (Mehta). Table 5.4 below shows the comparison between a. original acoustics, b. redesign with lighting solution only, and c. redesign with lighting and acoustical solutions - the target level is shown by the horizontal grey line. Since the difference between option b. and c. is minimal, it would ultimately come down to a design team and owner decision based on cost, aesthetics, and desired solution.

Table 5.4 | Calculated Reverberation Times

Room	Whole Octave Band Reverberation Times (s)					
	Frequency (Hz)					
	125	250	500	1000	2000	4000
Original Lobby	**1.42**	**1.58**	**1.70**	**1.76**	**1.21**	**0.69**
Redesigned (Lighting Only)	**1.35**	**1.22**	**1.32**	**1.30**	**0.96**	**0.60**
Redesigned (Lighting + Acoustics)	**1.33**	**1.18**	**1.26**	**1.24**	**0.93**	**0.59**



Conclusion

Acknowledgements

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The list could go on forever, so I'll end it now. But if you read (or scrolled) up until this point ***thank you.***

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Software

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AutoDesk AutoCAD 2017

AGi32

Rhinoceros / DIVA

Adobe Photoshop CS6