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AE 897

Lighting-Electrical Final Thesis Report

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-Luminaire Specification

-Fixture Cutsheets

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Massachusetts Public Library

Construction

Size
- 35,000 SF Renovation
- 70,000 SF Expansion
- 105,000 SF Total

 # Stories
- 3 above grade (6 total)

Original Contract Sum
- $70,000,000

Dates of Construction
-Januaray 2007- April 2009

Project Delivery Method
-Design-Bid-Build

Joint Venture Construction

Electrical

2000 kVA service entrance transformer
-NSTAR Electric
-**480 V** primary
-**208/120 V** secondary

Emergency Power
- Diesel Generator
-**300kW/375kVa, 480 Y/277 V**

Lighting

Daylighting and Occupancy Controls
-in conjunction with **Lutron dimming system**

Over 60 fixture types with a variety of lamps
-fluorescent, HID, LED, and incandescent

Mechanical

Forced air heating and cooling
-with additional fin tube and fan coil units

No units on ceiling (due to code)
-All systems located in main basement
-or located in attaic space
-**5 AHUs total**

Two cooling towers
-hidden in mechanical well on third floor

Architectural

State-of-the-art curtin wall facade
-provides daylight,views and accessibility

New children's wing
-featuring a tree-like ceiling

A young adult area
-with media stations and informal seating

Below grade parking for 70 cars
-allows for above grade green space

Underground auditorium
-provides 230 seats and expands program

Smaller craft and story rooms
-allow for private quiet spaces

Large open stacks/seating
-open floorplan and abundant daylight

Structural

Masonry Wall Construction-(historic)
-Field stone with granite or brownstone

Wood Framing- (historic)
▪ reinfoced with internal steel skeleton
- sits on concrete spread footings
-footings located under a 5" slab on grade

Steel Frame System-(addition)
-with **chvron wind bracing**
-**moment connections** for cantilevered beams

Reinforced Concrete Foundation walls-(addition)
-Used for 3 stories below grade
-CIP formed slabs and beams
-9" or 10" slabs on grade
-concrete spread and strip footings

Sloped Roofing (historic)
-Slate shingles
-A vapor barrier and plywood deck

Flat Roofing (addition)
-Thermoplastic membrane
-Rigid insulation and vapor barrier

Marissa Gesell I Lighting-Electrical I Architectural Engineering

Executive Summary

This architectural engineering thesis senior report summarizes a year-long analysis of the Massachusetts Public Library. Specifically, the report includes the investigation of the building's lighting and electrical system. Altering the dynamics of one building system typically impact the aspects of another, therefore smaller studies were conducted for several other systems throughout the building. The evaluation of analysis throughout these studies includes everything from subjective assessments to more quantitative research involving energy calculations.

The main body of the report focuses on the lighting system which then links to the research other systems. The overall inspiration to the project is "words of light." People go to a library to be enlightened so light is used to guide occupants throughout the library. The new proposed lighting design is not only way-finding but compliments and accentuates the architectural style of the building. Lighting also supports the transparency and connection between spaces to create a cohesive and integral design. Attached to this idea of integration is the analysis of daylighting. The daylighting study of the state-of-the-art curtain wall facade is used to calculate the yearly savings due to dimming and on-off switching of luminaires in the library. The impacts of this research are linked to a smaller mechanical study of the cooling loads in the building. Altering the material of the glass in the curtain wall to enhance the quality of daylight affects the cooling loads. In addition, reductions in lighting loads due to photosensor controls, heavily impact the mechanical loads as well.

Because the building is striving to be LEED certified, energy efficiency is considered throughout the project. An electrical study compares the energy efficiency of an NSTAR transformer to that of the energy efficient Powersmith transformer. The results included energy and cost savings as well as environmental impacts. An additional cost savings analysis was done for the comparison of copper and aluminum feeders throughout the electrical system as well.

The lighting design not only impacts the redesign of the branch circuit distribution within the electrical system, it also influences the choices made in architectural design. When architectural details are changed due to the lighting scheme there is a large impact to the dynamics of the room and acoustics of the space. An acoustical study showed that the position and property of different materials can greatly alter the sound reverberation time of a space.

Overall, this report captures the effects and research analysis of several building systems in the Massachusetts Public Library.

General Building Statistics and Information

Architecture

The Massachusetts Public Library was originally opened in 1889. In 1982, the building was listed as an important landmark on the National Register of Historic Places. Today it is being renovated as a state-of-the-art public library facility. An additional 70,000 square foot expansion is being added to a renovated existing historic library space of 35,000 square feet. The extensive use of a state-of-the-art curtain wall façade in the new design maximizes views of the library's park setting, celebrates the library's openness and accessibility, and provides abundance of daylight. Including on the top floor of the new library addition is a children's wing featuring a tree-like ceiling that connects the space to the canopy of trees in the outdoor park. Separate craft and story rooms are also provided. A young adult area, with media stations and informal seating, is deliberately placed in the old building to bring new vitality to all parts of the project. New below-ground parking for up to 70 cars allows for the park above to be restored and also provides an open green space for the community and the adjacent School. In addition, a new 230-seat underground auditorium, along with a number of smaller conference/ meeting rooms, will provide opportunities for the library to greatly expand is programming for the public.

Construction

The project was awarded to a Joint Venture, during the second time out to public bid. The building is not yet complete; however excavation below grade has begun. A new addition will be constructed of steel, most likely utilizing a 150 ton crawler crane. Because the building, in actuality, is a combination of three different buildings, there are three different construction types in plan. For the existing building, type 3A; for the new addition, type 3A; for the garage type 2C.

Electrical

The building is serviced by a 2000 kVA service entrance transformer by NSTAR Electric, which is then converted to both 480V primary and 208/120V secondary systems. Emergency power is fed from a 300kW/375kVA, Diesel Generator, which outputs power at 480Y/277V. A main transformer provides the power to the main switchboard. The main switchboard is 2000 A, 480Y/277V, 3-Ph, 4 W with a 65K AIC rating.

Lighting

The interior of the two buildings is lit with a comprehensive lighting system utilizing well over 60 different 277V or 120V fixtures that include fluorescent, metal halide, LED and incandescent lamping. Daylighting and occupancy controls in conjunction with a Lutron dimming system allow for event lighting while also contributing to energy savings. Capacity for theatre lighting is also built into the large meeting room in the basement of the Addition.

Mechanical

The mechanical system for both buildings is forced air heating and cooling with additional fin tube and fan coil units spread throughout. All major systems are either located in the main basement mechanical room of the Addition or in the attic space of the historic building (5 AHUs total) due to a directive by the City for not having roof top units, with the exception of two cooling towers hidden in a mechanical well on the third floor of the Addition.

Structural

The structure of the Addition consists of a steel frame system with chevron wind bracing and moment connections for cantilevered beams at both the south facade and the glass connector to the existing historic library. The Addition also extends three stories below grade using a combination of 18" reinforced concrete foundation walls, CIP formed slabs and beams, and 9" or 10" slabs on grade with concrete spread and strip footings below. The historic library has masonry wall construction consisting of a combination of field stone with either granite or brownstone, along with wood floor and roof framing that has been reinforced with an internal steel skeleton that sits on concrete spread footings under a 5" slab on grade.

Fire Protection (active and passive systems as appropriate)

In the existing building there is a typical floor control valve assembly over the fire department valve in cabinet. In contrast, the new building system is exposed and there is a pre-action system. When any of the systems loose regular power then the automatic transfer switch will trip and the power source changes to the emergency generator. There are three automatic transfer switches connected to the emergency generator which are then connected to Emergency Distribution Panels, fire pumps and fire alarm system. The fire protection system also includes electric bell annunciators, exterior flashing signal beacon, fire alarm annunciators, as well as audible and visual alarm signals. A graphic floor map and fire alarm system control panel are located in the main entrance lobby on the first floor of the new building. In the back right-hand corner of the library an emergency staircase is positioned, which provides access to the exterior. All doors are self-closing or automatic closing upon detection of smoke.

Transportation (elevators etc.)

Within the addition, a main staircase is located for transportation between all floors. As mentioned previously, in the back right-hand corner of the library an emergency staircase is positioned, which provides access to the exterior. Adjacent to the main entrance, a third staircase is located to provide access to the basement floors. A large "floating" walkway connects the addition to the historic building. Similar to the addition, the historic building has a main staircase in the middle and a secondary staircase in the far left corner.

Telecommunications

Audio/visual equipment is located throughout the building. Equipment includes jacks for laptop VGA interface, microphone jacks, DVD,VCR, DSP, AAP, 4" color touch screens, LCD projectors, assistive listening transmitters and receivers. Throughout the rooms are ceiling mounted speakers which include two-way loudspeakers as well as subwoofers. Data equipment racks are located in a data closet/server room on the 1st basement floor. This equipment controls data for the entire building.

Special Systems- unique aspects of the building

Conscious efforts have been taken to provide a sustainable building design. The building is attempting to receive LEED certification after it is completed in 2009.

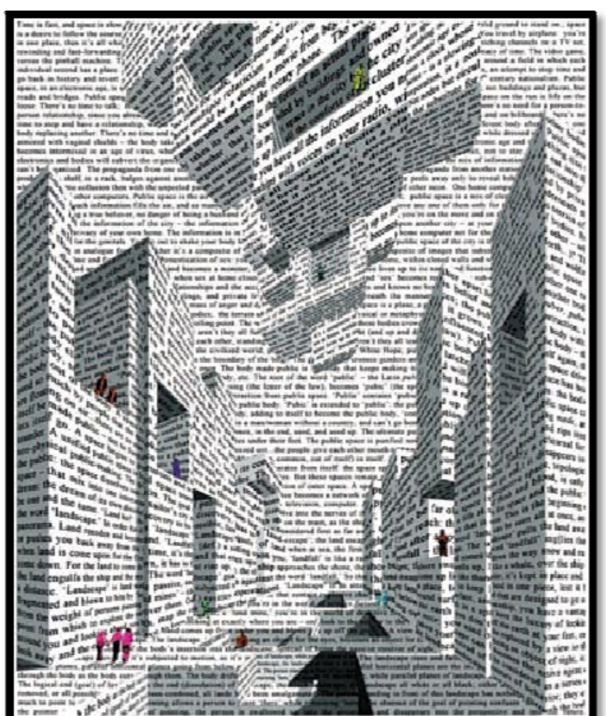
Lighting Depth

The Massachusetts Public Library functions as a gathering place for the community. The four spaces which will be re-designed include the main entrance, exterior space; the 1st floor lobby and hall, circulation space; the 2nd floor stacks and seating, large work space; and the basement meeting area, special purpose room. Though the current lighting design effectively addresses the requirements as stated by the IESNA changes could be made to improve or alter the building's performance.

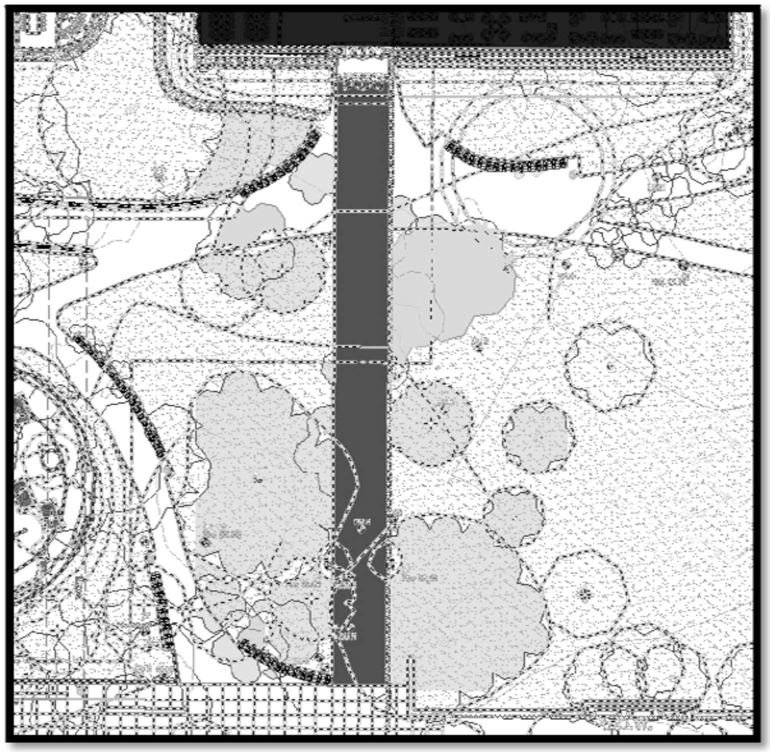
For each space-study the existing architecture is described and a lighting re-design is then proposed and evaluated for the spaces. The overall inspiration to the project is "words of light." People go to the library to be enlightened so light will be used to guide occupants throughout the library. Lighting will also support the transparency and connection between spaces. The lighting equipment will be efficient, and aid in achieving the LEED certification desired for the project.

The new lighting design will compliment and accentuate the architectural style of the building. Included with this report are: illuminance levels, illuminance ratios, light loss factors, lighting plans, fixture schedules, power densities and renderings.

To view cutsheets, specification and lighting plans, please refer to the appendix.



Lighting Depth Study- Exterior Space



Exterior Space: Summary of Space

There are multiple types of trees within the library's park and there are many deciduous and evergreen trees within the existing soil. The park area consists of beech trees and willows. As the building is an addition, the front entrance to the library originally was covered by trees. Now, a large walkway divides the park and aligns the building with the main street to allow for easier public access. At the front of the library is the main entrance to the building, the only task involved here is walking to and from library.

Exterior Space: Design Criteria

IESNA Design Criteria

Outdoor Locations- Gardens (Paths, away from building- Entrance Walkway)

Very Important Criteria:
- Direct Glare
- Light Distribution on Surfaces
- Point(s) of interest
- Source, Task, Eye Geometry
- Surface Characteristics
- **Vertical Illuminance- 3 lux = 0.3 fc**

Important Criteria:
- Appearance of Space and Luminaires
- Color Appearance (and color contrast)
- Light Pollution, Trespass
- Modeling of Faces and Objects
- Peripheral Detection
- Reflected Glare
- Shadows

Somewhat Important Criteria:
- Sparkle/Desirable Reflect Highlights
- **Horizontal Illuminance- 10 lux = 1.0 fc**

Appropriate Design Considerations

- **Light Pollution/Trespass:**
  Outdoor lighting in a medium district brightness area is **Category E3.** This means that the **urban sky glow** should be a maximum ULR of **5%.** Lighting should be placed at angles which do not impede or spill onto surrounding properties. No sources should face upwards.

- **Light Quality and Color Appearance:**
  Entrance pathway lighting should **deter criminal activity; enable people and their intent to be recognized.** The pathway lighting should also provide **decent color rendering** with a higher CRI to distinguish people.

- **Appearance Criteria:**
  Park lighting should be **harmonious with surroundings** (including sidewalk lighting and adjacent buildings of the area) Lighting should present the library well, and be aesthetically pleasing.

- **Maintenance Issues:**
  Due to the location, the outdoor lamps should have very little maintenance issues. The major considerations for outdoor fixtures are **weather, corrosion resistance,**

vandalism, glare, light pollution, and aesthetics reflection. Lamps should maintain good color properties as well.

- **Illuminance Criteria:**
  The pathway should have a horizontal illuminance of 1.0 fc and a vertical illuminance of 0.3 fc.

- **Controls:**
  Luminaires should be on a **time clock** and only set to be utilized during the night.

- **Power Density:**
  The power density for main exterior pathways is **0.2 W/ft^2**.

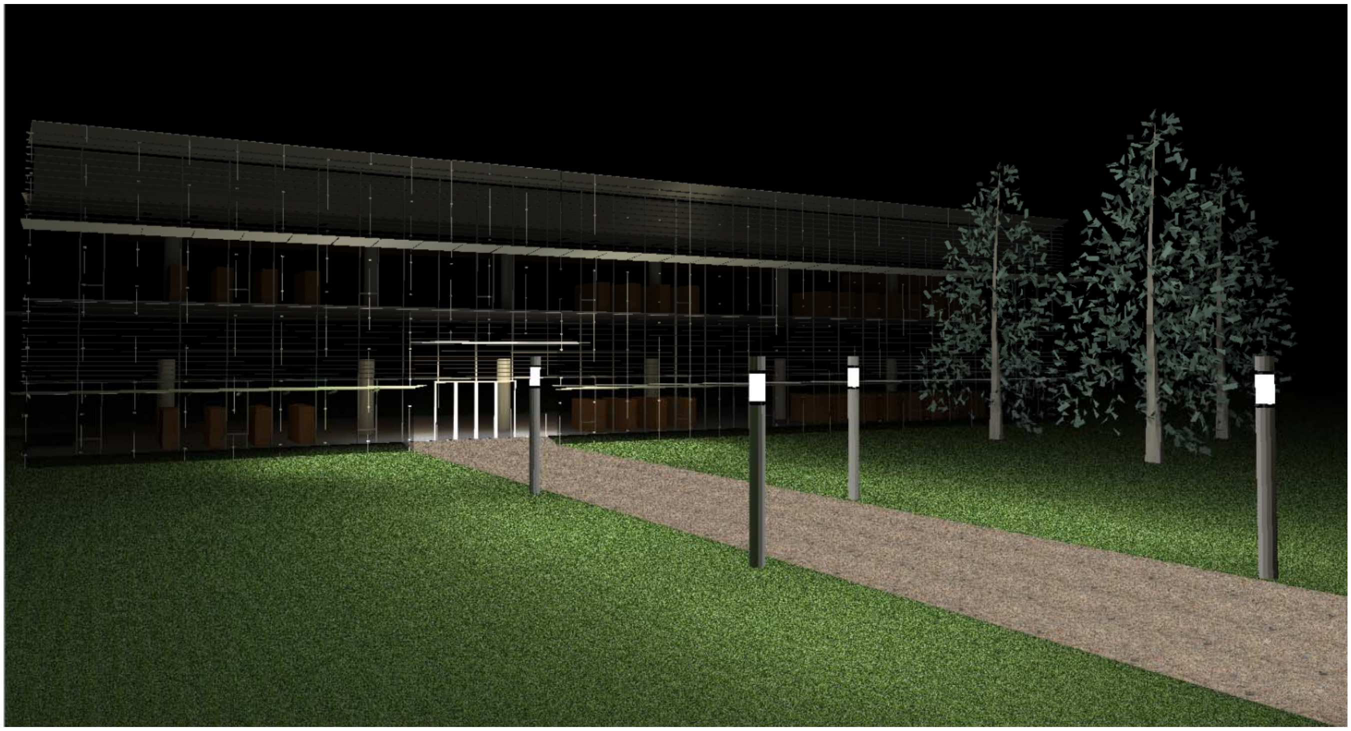
Exterior Space: Lighting Design Concept

In the evenings light should guide occupants to the main entrance and light the pathway. The lighting for this area should be way-finding and provide safety. The entrance lighting must be consistent with the architecture of the building; very linear in appearance. At night the building truly “glows” from within and the exterior lighting should not detract from this.

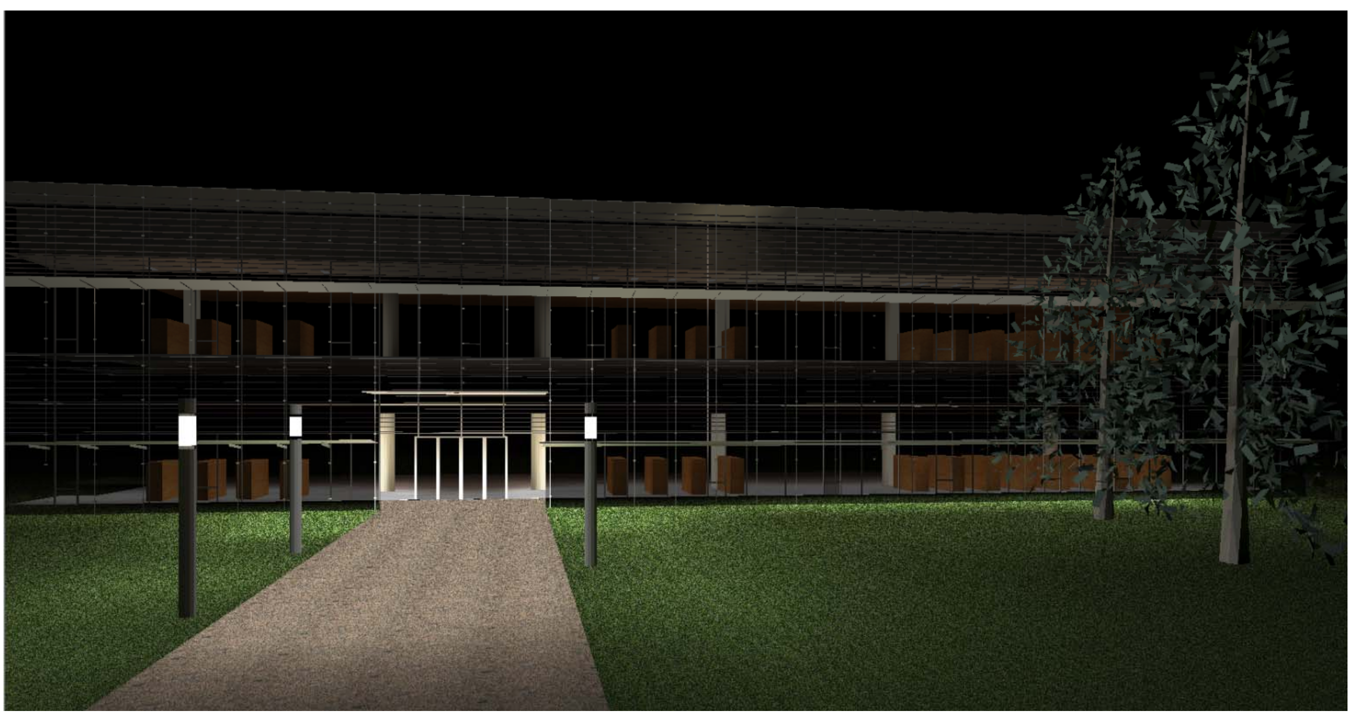
The concept for the exterior develops from idea of book stacks. Walking down the entrance path simulates the feeling of walking down an aisle of stacks with linear columns of light on either side.

To view lighting plan please refer to the appendix

Exterior Space: Renderings



Above: Rendering perspective of the library's main entrance with no lights on in interior
Below: Rendering perspective of the main walkway with some lights on in interior to create a "glow"



Exterior Space: Fixture Schedule

Type		Mfr/Catalog #	Lamping	Notes
E1		**Lightolier 8097FCCLP-S7142BU 42W** Description: 7" recessed compact fluorescent downlight with 1-CFTR42W lamp. Optics: acrylic fresnel lens , painted or anodized aluminum parabolic reflector. Ballast: ADVANCE ICF2S26M1LsQs@277-CFTR42W/GX24Q. Voltage: 277V	1 - Osram Sylvania CF42DT/E/IN/830/ECO CFTR42W lamp	Location: Exterior Entrance
E2		**se'lux MTRC-12-1T5-SV** Description: 12' tall asymmetric fluorescent bollard with 1-28W T5 lamp. Ballast: ADVANCE ICN-2S28@ 277. Voltage:277V	1 - Osram Slyvania FP28/830PM/ECO F28T5 (48in) lamps	Location: Exterior Entrance Path

Exterior Space: Light Loss Factors

Assumptions:

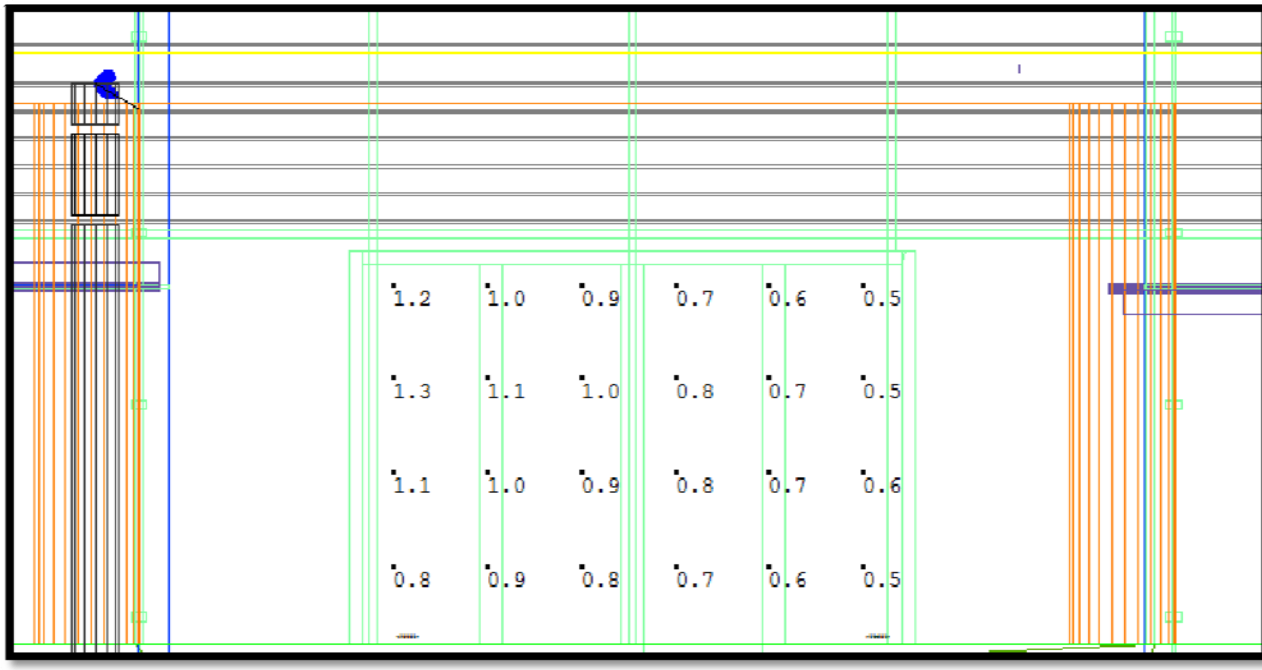
Degree of outdoor Dirt Conditions: Dirty
Months: 12= 1 year

Label	Maintenance Category	Distribution	LDD	LLD Mean/Initial	BF	Total LLF
E1- Down Light	Dirty	Direct	0.9	0.86	0.98	0.76
E2- Bollard	Dirty	Direct-Indirect	0.9	0.9	1.04	0.84

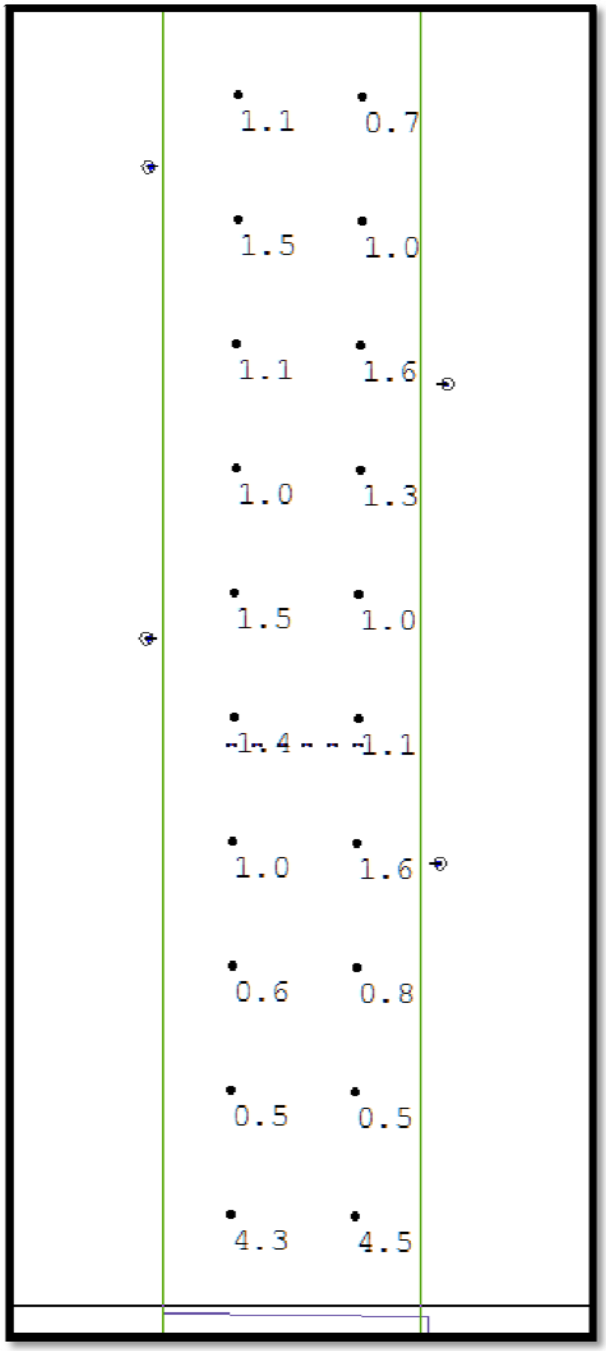
The LDD is based on an outdoor graph given in Ch. 22

Exterior Space: Illuminance Calculations

Description	Location	Orientation	Units	Average	Max	Min	Avg/min	Max/Min
Face Calcs	0'-6" AFF	Vertical	FC	0.82	1.3	0.5	1.64	2.60
Path Calcs	0'-0" AFF	Horizontal	FC	1.41	4.5	0.5	2.82	9.00

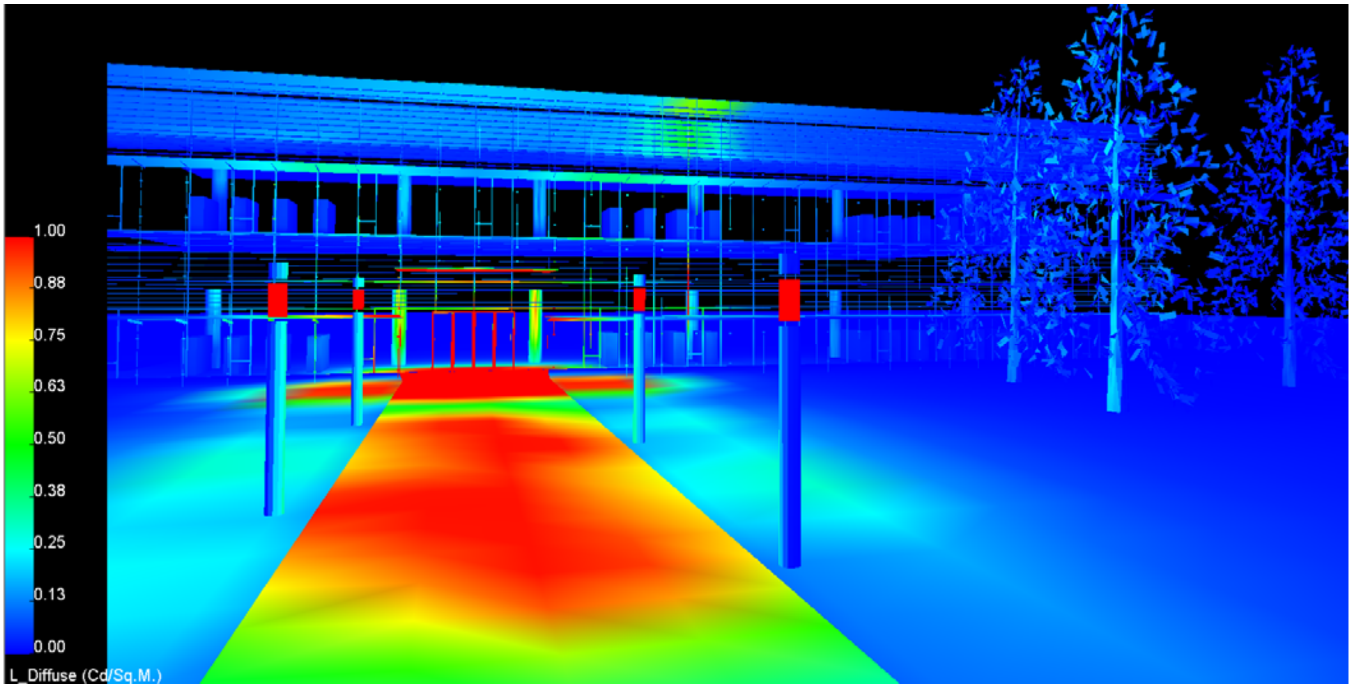


Above: View looking towards main entrance along main pathway, vertical illuminance calculation

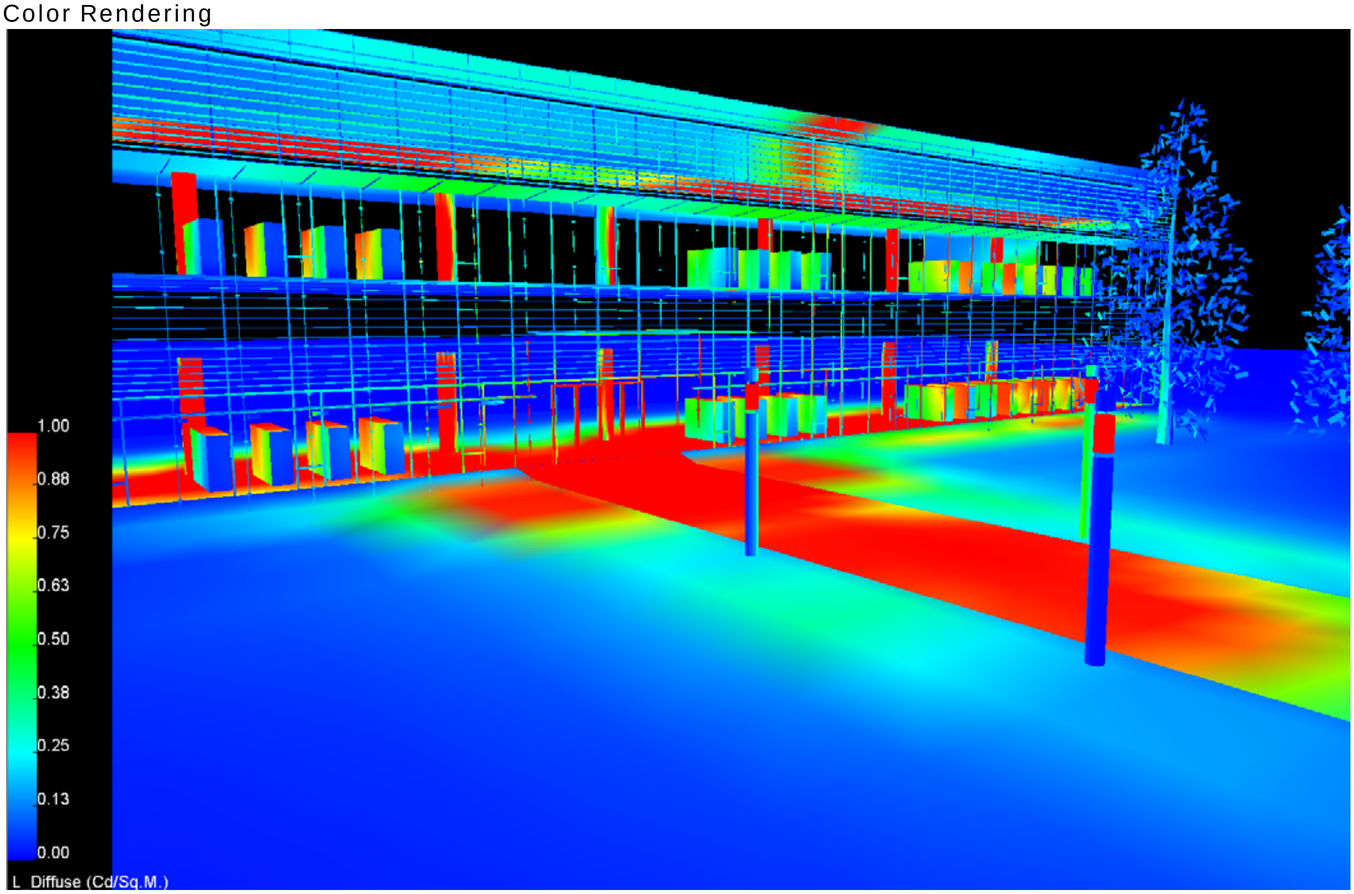


Above: View looking down on main walkway, horizontal illuminance calculations

Exterior Space: Pseudo Color Renderings



Above: View of main entrance, Luminance Pseudo Color Rendering
Below: Side Perspective view of main entrance with lights on in interior, Luminance Pseudo Color Rendering



Exterior Space: Power Density

Fixture	Ballast Watts	Quantity (lamps)	BF	Total Watts
F1	33	19	1.04	652.08
F7	46	12	1.04	574.08
Space Type ASHRAE 90.1			Exterior path	
Area (ft^2)			5145Total	
Allowable LPD (W/ft^2)			0.2	
Allowable Watts			1029	
Actual LPD (W/ft^2)			0.07	
Actual Watts			369	

Analysis was done using the space-by-space method

Exterior Space: Performance Summary

A "glow" from within, due to the interior lights, creates attention for the building at night. Minimal lighting was added to the exterior to assist library patrons going to-and-from the main entrance after sun set. Downlights under the main entrance canopy draw attention to the main doors. Additional pathway column lights are way-finding and provide safety. The 12' tall pole lights provides 0.8 fc vertical illuminance as to deter criminal activity and enable people and their intent to be recognized. The pathway adequately meets the requirements of the 1.0 fc for horizontal illumination, with an average of 1.4 fc. The lighting in the outdoor space meets the requirements for light trespass. All of the fixtures are aimed towards the ground and do not spill onto adjacent buildings. The appearance of the lighting is cohesive with the surroundings. Downlights in the entrance canopy are recessed and the se'lux fixtures appear harmonious with the surroundings, matching the linear lines of the architecture and appearing almost like tree trunks during the day. The se'lux fixture is essentially weather-proof, as well. All se'lux luminaires and poles undergo a five stage intensive pretreatment process where product is thoroughly cleaned and sealed. This power coat provides excellent salt and humidity resistance as well as ultra violet resistance for color retention. The column is also constructed with stainless steel tamper-resistant hardware. A fluorescent lamp is accessible for replacement through the fixture cover which removes by loosening three vandal-resistant, stainless-steel screws. The downlights are also UL listed for wet locations.

Exterior Space: Controls

The exterior luminaires are controlled by a relay. The relay zone is controlled by a time clock which turn lights on after sun set.

Exterior Space: Electrical Characteristics

Panelboard L4NGB serves the branch circuits in the entry lobby. The panelboard is located in the basement electrical closet room B128. The new lighting design is placed on the same circuits as the existing lighting design. The remainder of the panelboard is unknown so some assumptions were made to complete the electrical calculations.

Please refer to the appendix to view the lighting plans.

Label	Location	W	VA	A	PF	QTY	∑VA	∑A	Circuit
E1	Entrance	46	47.09	0.17	0.98	3	141.27	0.51	L4NGB-3
E2	Walkway	33	33.24	0.12	0.98	7	232.68	0.84	L4NGB-3

PANELBOARD SIZING WORKSHEET											
Panel Tag-------------------------->					L4NGB	Panel Location:			Elec. Closet B128		
Nominal Phase to Neutral Voltage------->					277	Phase:			3		
Nominal Phase to Phase Voltage-------->					480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A				0	w	1.00	0	0		
2	A				0	w	1.00	0	0		
3	B	Pathway Lighting	3		374	w	0.98	374	382		
4	B				0	w	1.00	0	0		
5	C				0	w	1.00	0	0		
6	C				0	w	1.00	0	0		
7	A					w	1.00	0	0		
8	A				0	w	1.00	0	0		
9	B				0	w	1.00	0	0		
10	B				0	w	1.00	0	0		
11	C				0	w	1.00	0	0		
12	C				0	w	1.00	0	0		
13	A					w	1.00	0	0		
14	A				0	w	1.00	0	0		
15	B				0	w	1.00	0	0		
16	B				0	w	1.00	0	0		
17	C					w	1.00	0	0		
18	C				0	w	1.00	0	0		
19	A				0	w	1.00	0	0		
20	A					w	1.00	0	0		
21	B				0	w	1.00	0	0		
22	B				0	w	1.00	0	0		
23	C				0	w	1.00	0	0		
24	C					w	1.00	0	0		
25	A				0	w	1.00	0	0		
26	A				0	w	1.00	0	0		
27	B				0	w	1.00	0	0		
28	B				0	w	1.00	0	0		
29	C					w	1.00	0	0		
30	C				0	w	1.00	0	0		
31	A					w	1.00	0	0		
32	A				0	w	1.00	0	0		
33	B					w	1.00	0	0		
34	B					w	1.00	0	0		
35	C					w	1.00	0	0		
36	C					w	1.00	0	0		
37	A					w	1.00	0	0		
38	A					w	1.00	0	0		
39	B					w	1.00	0	0		
40	B					w	1.00	0	0		
41	C					w	1.00	0	0		
42	C					w	1.00	0	0		
PANEL TOTAL								0.4	0.4	Amps=	0.5
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					0.0	0.0		0.0
PHASE TOTAL			B					0.4	0.4	100%	1.4
PHASE TOTAL			C					0.0	0.0		0.0
LOAD CATAGORIES				Connected			Demand				Ver. 1.03
				kW	kVA	DF	kW	kVA	PF		
1		receptacles		0.0	0.0		0.0	0.0			
2		computers		0.0	0.0		0.0	0.0			
3		fluorescent lighting		0.4	0.4		0.4	0.4	0.98		
4		HID lighting		0.0	0.0		0.0	0.0			
5		incandescent lighting		0.0	0.0		0.0	0.0			
6		HVAC fans		0.0	0.0		0.0	0.0			
7		heating		0.0	0.0		0.0	0.0			
8		kitchen equipment		0.0	0.0		0.0	0.0			
9		unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads							0.4	0.4			
Spare Capacity				20%			0.1	0.1			
Total Design Loads							0.4	0.5	0.98	Amps=	0.6

PANELBOARD SCHEDULE												
VOLTAGE: 277Y/480V,3PH,4W SIZE/TYPE BUS: 225A SIZE/TYPE MAIN: 225A			PANEL TAG: L4NGB PANEL LOCATION: Elec. Closet B128 PANEL MOUNTING: SURFACE						MIN. C/B AIC: 35K OPTIONS: PROVIDE FEED THROUGH LUGS			
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
0	0	0	900A/1P	1	*			2	20A/1P	0	0	0
Pathway Lighting	0	374	90A/1P	3		*		4	20A/1P	0	0	0
0	0	0	90A/1P	5			*	6	20A/1P	0	0	0
0	0	0	20A/1P	7	*			8	20A/1P	0	0	
	0	0	20A/1P	9		*		10	20A/1P	0	0	0
		0	20A/1P	11			*	12	20A/1P	0		
0		0	20A/1P	13	*			14	20A/1P	0		
		0	20A/1P	15		*		16	20A/1P	0		
0	0	0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		0
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		0
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		0
0		0	20A/1P	37	*			38	20A/1P	0		
0		0	20A/1P	39		*		40	20A/1P	0		0
0		0	20A/1P	41			*	42	20A/1P	0		0
CONNECTED LOAD (KW) - A		0.00							TOTAL DESIGN LOAD (KW)		0.45	
CONNECTED LOAD (KW) - B		0.37							POWER FACTOR		0.98	
CONNECTED LOAD (KW) - C		0.00							TOTAL DESIGN LOAD (AMPS)		1	

The remainder of the panelboard is unknown so some assumptions were made to complete these electrical calculations. The new electrical circuits are not highlighted because all of the information provided includes the new lighting loads.

Electrical Data:
Main Lugs: 125A
Bottom feed
35K AIC
Incoming conductor(s) per phase:
(1) #5- 250 kcmil

Existing Panelboard Branch Summation
1-90A/1P
22-20A/1P
5-25A/1P

Assumed Total Load:

(20A*22+ 5*25A)*0.7 + (New Design Load: 1 A) = 396.5 A

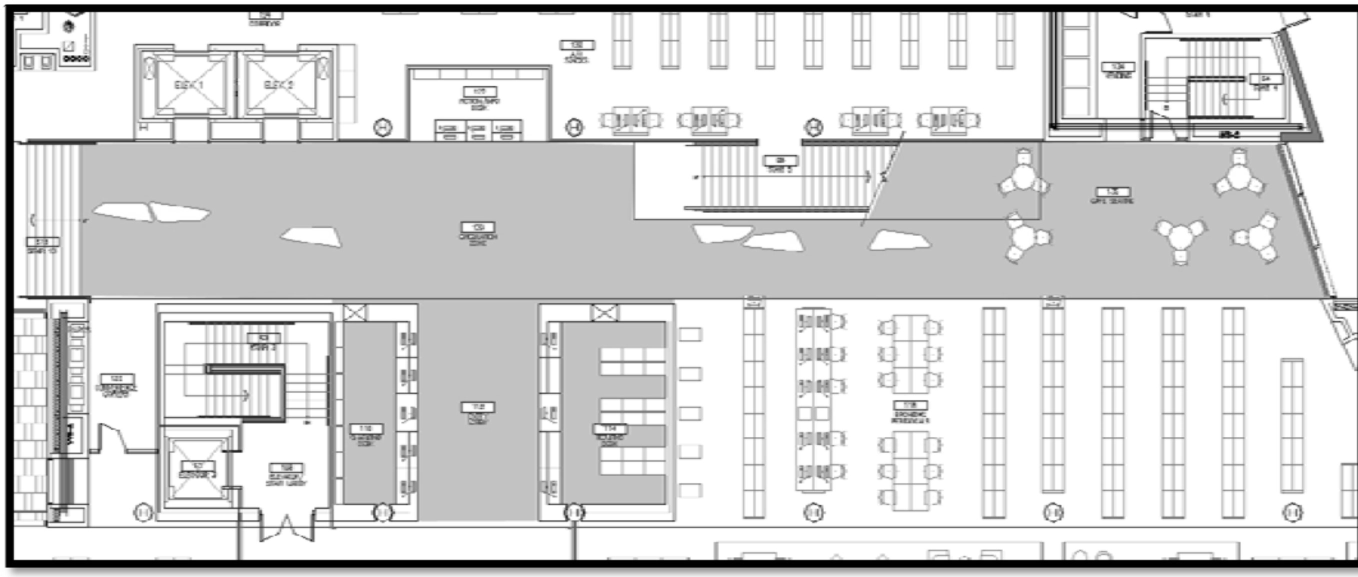
Feeder Size:
600 MCM THW Copper in 3.5" Conduit (420A Capacity)

Lighting Depth Study- Entry Lobby

Entry Lobby: Summary of Space

As an occupant follows the quartzite pavers into the entry lobby they are greeted by the librarians. To the left is the charging desk area where librarians have several computers on a long, natural finish, maple-wood desktop. For personal convenience, at the center of the desk is a lowered, self check-out desk. Behind this small standing area is an interior glass wall system and dropped ceiling. Mimicking this counter space, on the right, are the returns desks. This space is very similar in layout but slightly larger with shelving behind the counter. The ceiling over this area consists of wood ceiling panels. If a patron continues walking into the space and is unsure where to go, directly in front is an information desk, similar to the desks of the entry lobby. A librarian at this desk can guide the guest both to the left and up the stairs to a sky walk bridge via the elevators or to the center floating staircase to the left. This floating staircase feels translucent as it is shielded by transparent glass panels. If a patron is hungry they may choose to travel further to the left down the corridor into the cafe seating. Flanking both sides of the corridor are rooms filled with stacks and desks. The corridor has a playful feeling with a 15 foot vibrant red ceiling. In total, the space is about 156 feet in length and 58 feet in width.

Location	Material/Tag	Description/Color	Reflectance
Flooring	CPT 1- Carpet 1 Flooring	Light Gray Color	0.33
Furniture	Book Shelves, Chairs and Desks	Maple Wood (Tan/Brown Color with Reddish Tint)	0.22
Window Facade	Structural Insulated Glass System (08920 ENG.SYS. 1)	Low-E, Low-Iron glass	Transmittance- 0.7
Ceiling over stacks	Wood Ceiling Panels (09515)	Maple Wood	0.22
Ceiling in main entry	Glossy white COLOR 2 (09515)	Perforated Acoustical Aluminum Ceiling Panels with White Powdercoated finish	0.74
Walls	PTD GWB Gypsum Wall Board (09522)	White Painted- Gypsum Wall Board	0.76
Ceiling in corridor	Aluminum Ceiling COLOR 1 (09515)	Red	0.21



Entry Lobby: Design Criteria

<u>IESNA Design Criteria</u>

Hotel Lobby (Reading and Work Areas - Reading Areas in Entry Lobby)

Important Criteria:
- Appearance of Space and Luminaires
- Color Appearance (and color contrast)
- Direct Glare
- Light Distribution on Surfaces
- Light Distribution on Task Plane (Uniformity)
- Luminance of Room Surfaces
- Reflected Glare

Somewhat Important Criteria:
- Flicker (and Strobe)
- Shadows
- Source, Task, Eye Geometry
- **Horizontal Illuminance- Category D- 30 fc**

Hotel Lobby (Reading/Desk Work - Charging Desk and Returning Desk)

Important Criteria:
- Direct Glare
- Light Distribution on Task Plane (uniformity)
- Reflected Glare
- Source, Task, Eye Geometry

Somewhat Important:
- Color Appearance (and Color Contrast)

Hotel Lobby (Corridors, Elevators, Stairs)

Important Criteria:
Daylighting Integration and Control
Light Distribution on Surfaces
Luminance of Room Surfaces
Somewhat Important Criteria:
Color Appearance (and Color Contrast)
Direct Glare
Light Distribution on Task Plane (Uniformity)
Modeling of Faces or Objects
Reflected Glare
Horizontal Illuminance- 10 fc

Appropriate Design Considerations

- **<u>Psychological Aspects:</u>**
Because this space is adjacent to the main entrance, the **appearance of space and luminaires** is very important as it is viewed by all public occupants. The circulation space should appear **welcoming and interesting.** The entrance lobby is similar to that of a book cover; it should attract attention so the read desires to continue reading. For this reason, the impression created for this space intriguing. The addition is an enormous difference in comparison to the historic building and the lobby should emphasize the contrast. All luminaires should retain a **modern shape** and **style** to compliment the architecture.

- **<u>Aesthetic Criteria:</u>**
Decorative lighting or **"sparkle"** could be considered within this area. The architecture tends to lend itself to a modern **young vibrant feel** which could be complimented with decorative lighting of that style. The red ceiling and trapezoidal chairs draw attention. The unique pendants/chandeliers could compliment the usage of other distinctive elements. The tall ceiling in the hall allows for pendants to hang in this area.

- **<u>Appearance Criteria:</u>**
Due to the variety of ceilings and flooring in this space, different lighting schemes should be used to **compliment** each of these materials. Even though a variety of lighting schemes should be used from space-to-space, they must also be a **similar style** and **cohesive** in the open lay- out.

- **<u>Luminance Ratios:</u>**
While remaining **unique**, the lighting throughout the circulation space should be **way-finding.** The areas in which guests can find guidance must be well illuminated. For this reason, the help desks must be differentiated from the surrounding. Lighting the horizontal surfaces and shelving around the desk areas will assist with the contrast.

- **<u>Illuminance:</u>**
As IESNA stated, the horizontal illuminance should be around **30 fc** and **uniformly** light the work plane.

- **Controls:**
  Simple switching should be considered for ease of usage by librarians. A **time clock** should be used to shut off all luminaires at night. The main entrance lobby lights should be on a different schedule so the **entry can "glow"** from an exterior night view. **Master switches** for the library circulation space should be located either behind the reception desk or check-out counter to avoid public tampering.

- **Light Quality and Color Appearance:**
  Also listed by IESNA, is the importance of **color appearance.** As most of the interior consists of wood, the luminaires should have a warmer **CRI and CCT.**

- **Illuminance Criteria:**
  Similar to the shelving in the 2nd floor stacks the shelving behind the charging and return desk must have a vertical illuminance of 30 fc. Luminaires must be strategically positioned over bookshelves to minimize shadows. Creating a large quantity of ambient lighting in the shelving area will diminish shelving shadows. It is important for the titles and code numbers to be easily read on books.

- **Aesthetic Night Light:**
  To create an appealing view a night, the building facade should "glow" from within. Because the geometry of the facade is very linear and uniform the **glow** should enhance the buildings linearity. The main entry is the only part of the circulation space which should have lighting at night. A few lobby luminaires should be on a different schedule for night usage. A night glow can be created by illuminating the steel structure of the main entrance vestibule from within. The illumination of the entrance should be similar to that of the entire facade so the building appears uniform.

- **Power Density:**
  The power density for a lobby is **1.3 W/ft^2** + and extra **1.0 W/ft^2** allowed for decorative lighting.

Entry Lobby: Lighting Design Concept

The lighting in the lobby and main hall is important because it will create a first impression of the library for most building visitors. An entrance lobby is similar to that of the cover of a book; it should create a big impact. The most important areas of this space are the stairs, elevators, and help desks and should be highlighted to create visual hierarchy. Lighting within the room should enhance the flow of openness in the space.

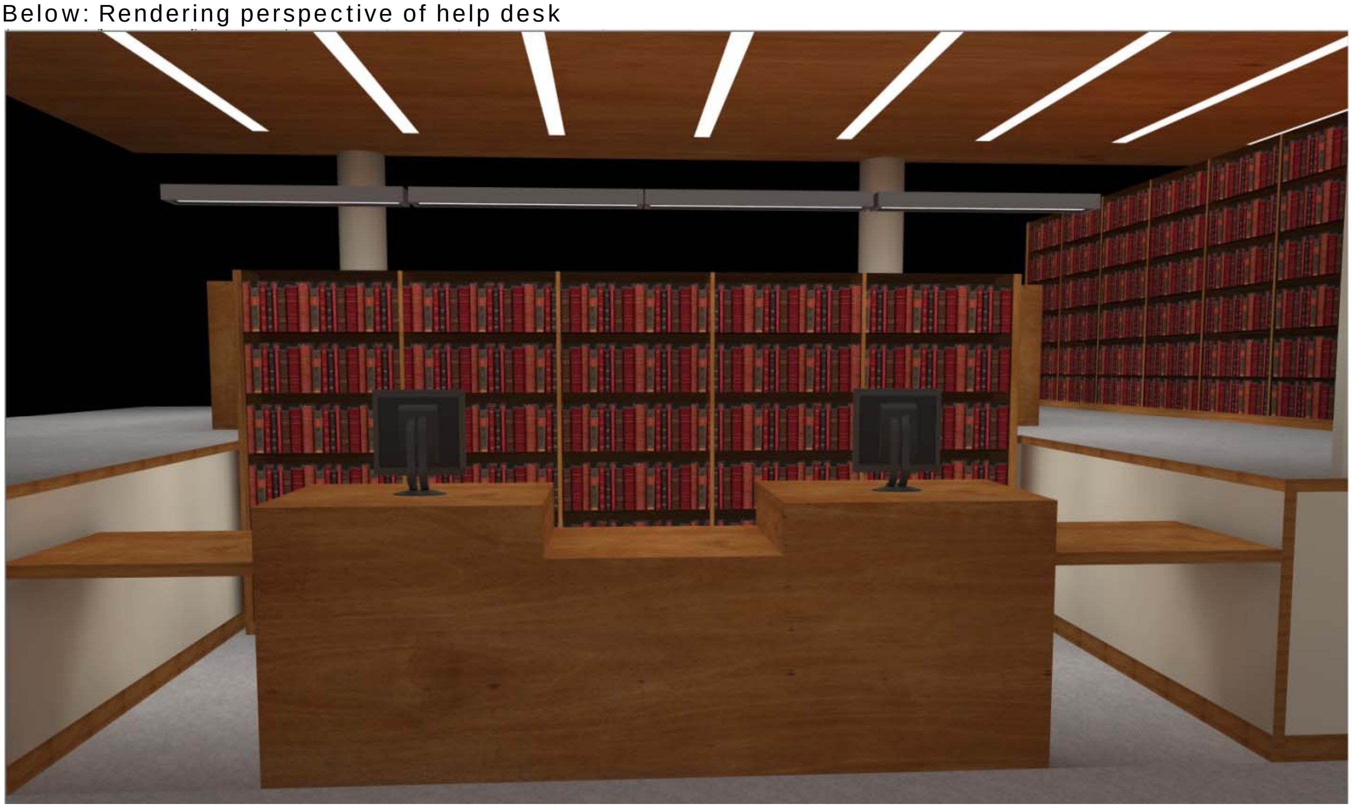
To create the initial impact, Louis Poulsen surface-mounted lights draw attention to the red ceiling of the corridor. This unique luminaire brightens the red ceiling and conforms to the sophisticated lines of the architecture. The Kurt Versen downlight assists in calling attention to the help desks, elevators, and stairwell. Electrix cove lights contribute to indirectly lighting the white ceiling in the entrance lobby creating an open bright environment. Additional downlights are added in the café area to provide enough horizontal illuminance on the tables. The Linear Lighting wall washer provides some peripheral emphasis in the space.

Please refer to the appendix to view lighting plans.

Entry Lobby: Renderings

Above: Rendering perspective of corridor

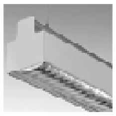
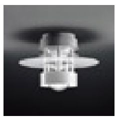
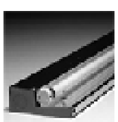
Above: Rendering perspective of return desk
Below: Rendering perspective of help desk



Above: Rendering perspective of entrance lobby desks
Below: Rendering Elevator area

Above: Rendering perspective of cafe area below stairs

Entry Lobby: Fixture Schedule

Type		Mfr/Catalog #	Lamping	Notes
F1		**Elliptipar 3036-T128-X-01-2-EK-0-VE-S-99-48-0** Description: Suspended pendant 28W T5 linear fluorescent stack light. Cable mounted from ceiling. Optics are asymmetric with 6% uplight. Ballast:Lutron EC5-T528-J-UNV-1. Voltage: 277	1 - Osram Slyvania FP28/830PM/ECO F28T5 (48in) lamps	Location: 2nd Floor- Between Tall Stacks Suspended 8' AFF
F7		**Louis Poulsen SAT-MAX 1/42W/CF GX24q-3/4-277V-NATPAINTALU** Description: Surface-mounted compact fluorescent up/downlight with 1-CFTR42W lamp. 14% up/86% down. Ballast:ICF2S26M1LsQs@277-CFTR42W/GX24Q Voltage: 277	1 - Osram Sylvania CF42DT/E/IN/830/ECO CFTR42W lamp	Location: 1st Floor Entry Lobby
F8		**Kurt Versen P932** Description: 7" recessed compact fluorescent downlight with 1-CFTR42W lamp. Optics: anodized aluminum ellipsoidal reflector. Ballast:ICF2S26M1LsQs@277-CFTR42W/GX24Q Voltage: 277	1 - Osram Sylvania CF42DT/E/IN/830/ECO CFTR42W lamp	Location: 1st Floor Entry Lobby
F9		**Linear Lighting WW4-D-1ET5-277-NS-R-EC-4'** Description: 6" recessed fluorescent wallwasher with 1-F28T5 (48in) lamp (in cross-section). Optics: reflector , single. Ballast: ADVANCE ICN-2S28@277-F28T5 Voltage: 277V	1 - Osram Slyvania FP28/830PM/ECO F28T5 (48in) lamp (in cross-section)	Location: 1st Floor Entry Lobby
F10		**Electrix illumination EX-28-S1-2-E-46-SD** Description: Low profile cove luminaire with 1-28WT5 lamp. Ballast: ADVANCE ICN-2S28@277-F28T5 Voltage: 277V	1 - Osram Slyvania FP28/830PM/ECO 1-28WT5	Location: 1st Floor Entry Lobby Mount: Cove mounted in entry desk overhang. See Details.

Entry Lobby: Light Loss Factors

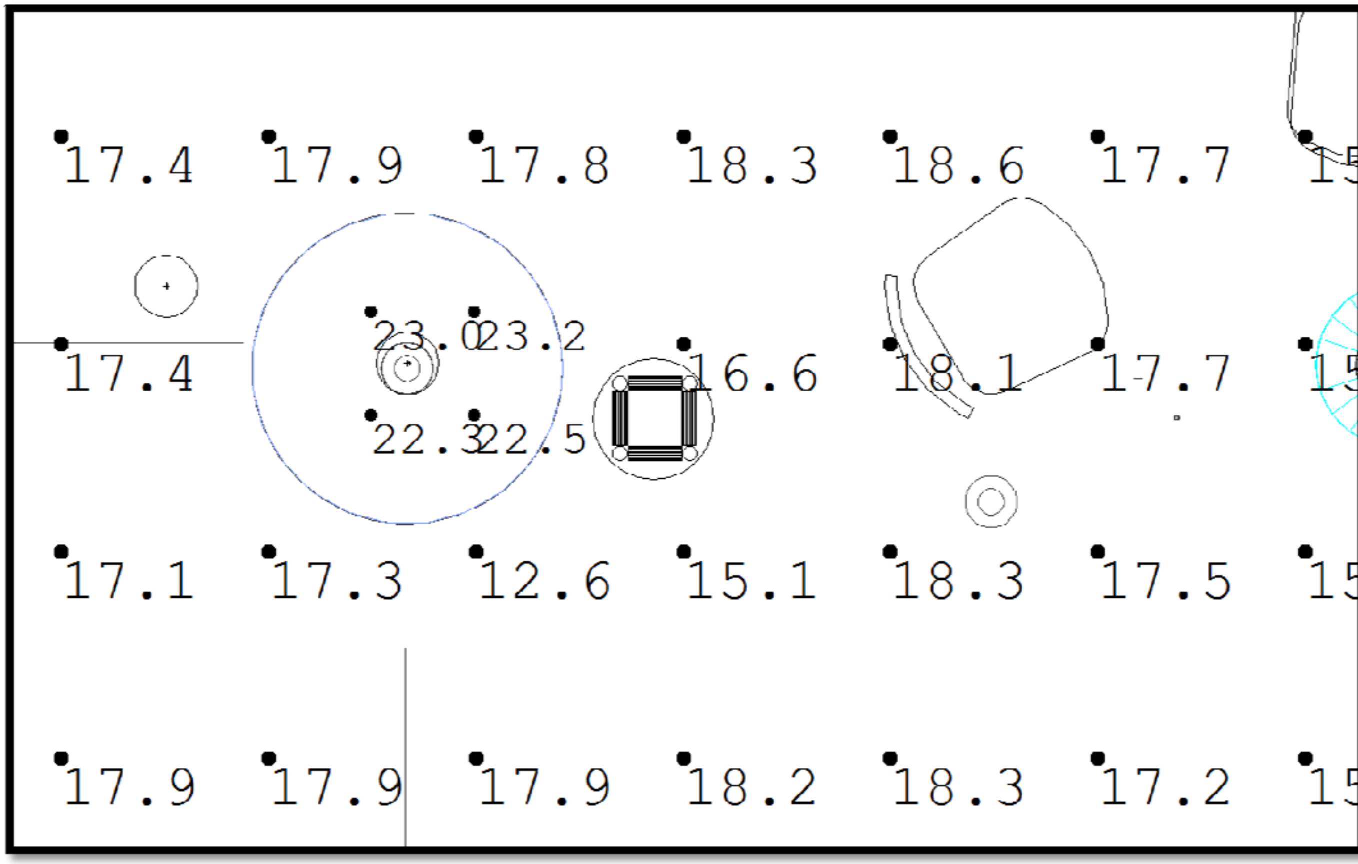
Assumptions:

Degree of Dirt Conditions: Very Clean
Months: 12

Label	Maintenance Category	Distribution	LDD	LLD Mean/Initial	BF	Total LLF
F1- Stack Light	III	Direct-Indirect	0.93	0.9	1.04	0.87
F7- Surface mount	V	Direct-Indirect	0.94	0.86	0.98	0.79
F8- Down Light	V	Direct	0.94	0.86	0.98	0.79
F9- Wall Washer	V	Direct	0.94	0.9	1.04	0.88
F10- Cove Light	VI	Indirect	0.92	0.9	1.04	0.86

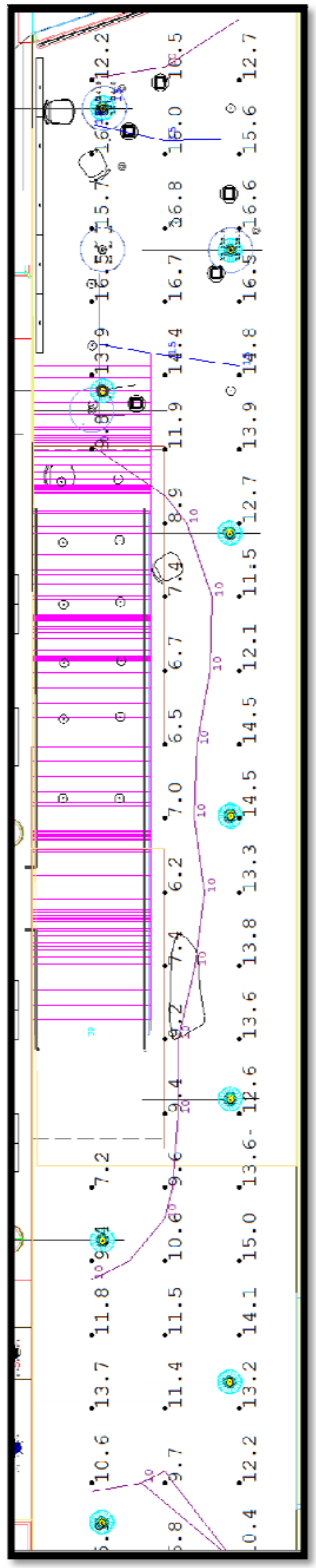
Entry Lobby: Illuminance Calculations

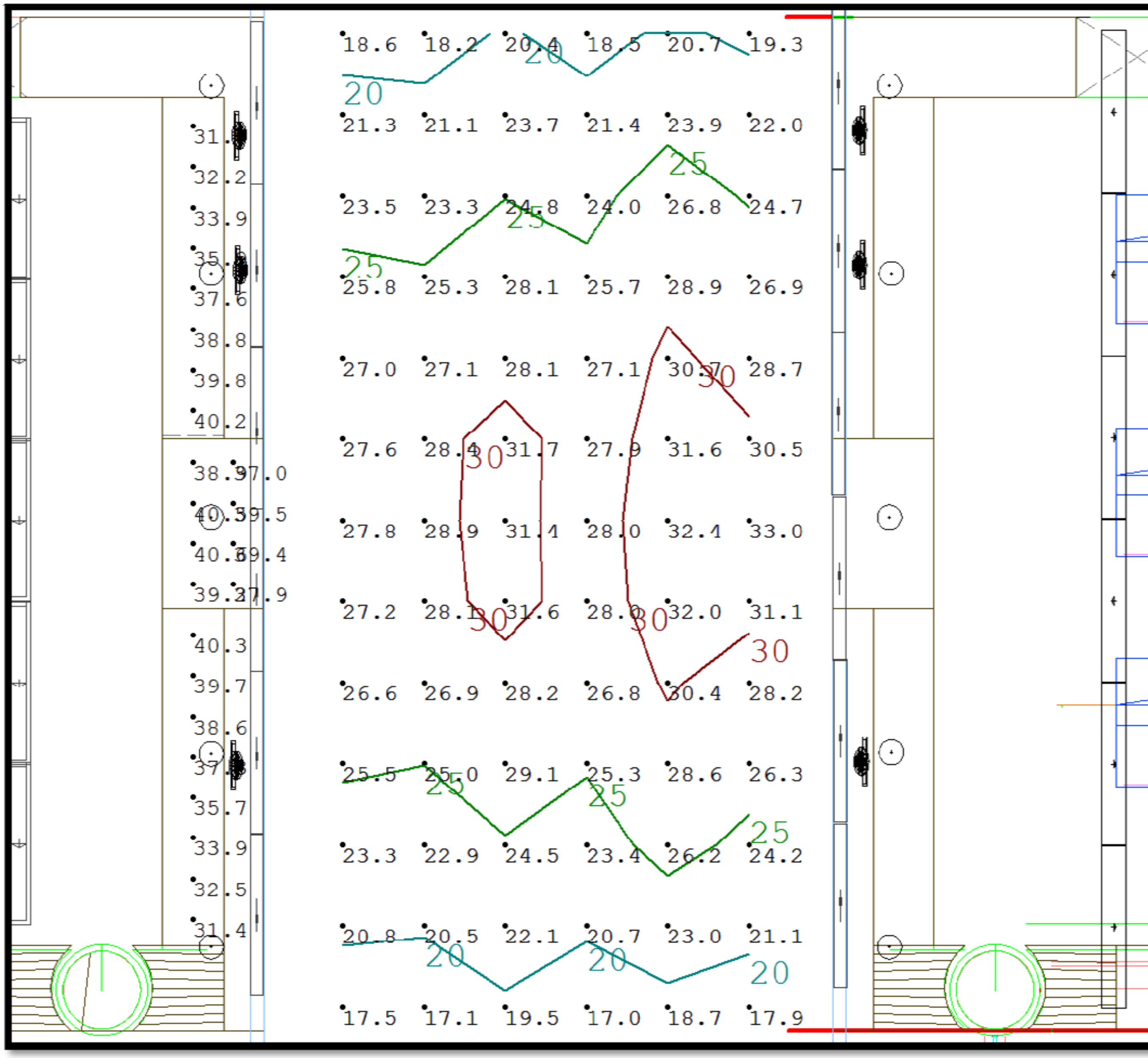
Description	Location	Orientation	Units	Average	Max	Min	Avg/min	Max/Min
Desk Surface	3.5'-0" AFF	Horizontal	FC	31.56	35.0	27.2	1.16	1.29
Café Table	3.5'-0" AFF	Horizontal	FC	22.75	23.2	22.3	1.02	1.04
Corridor Floor	0'-0" AFF	Horizontal	FC	10.99	18.9	1.8	2.8	7.5
Main Entrance Floor	0'-0" AFF	Horizontal	FC	24.26	30.5	16.4	1.48	1.86



Above: View over café table, horizontal illuminance calculation

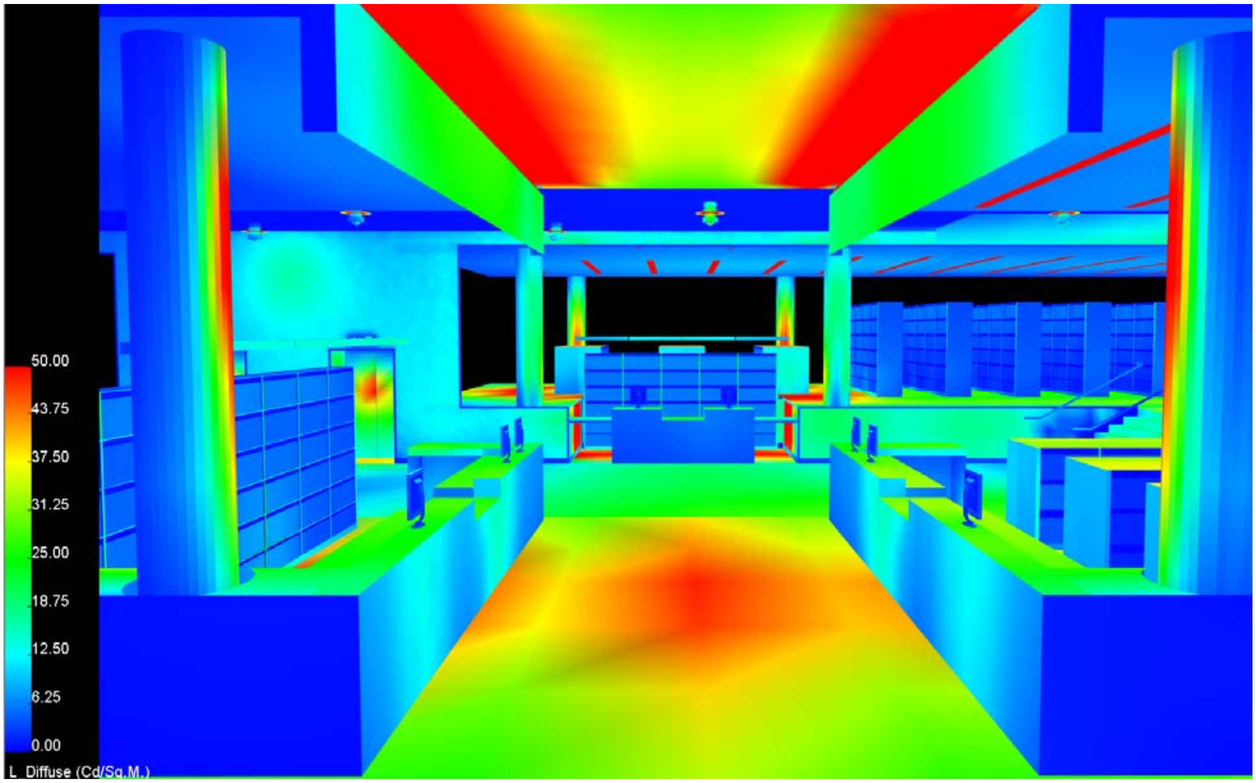
To the right: View over corridor, horizontal illuminance calculation



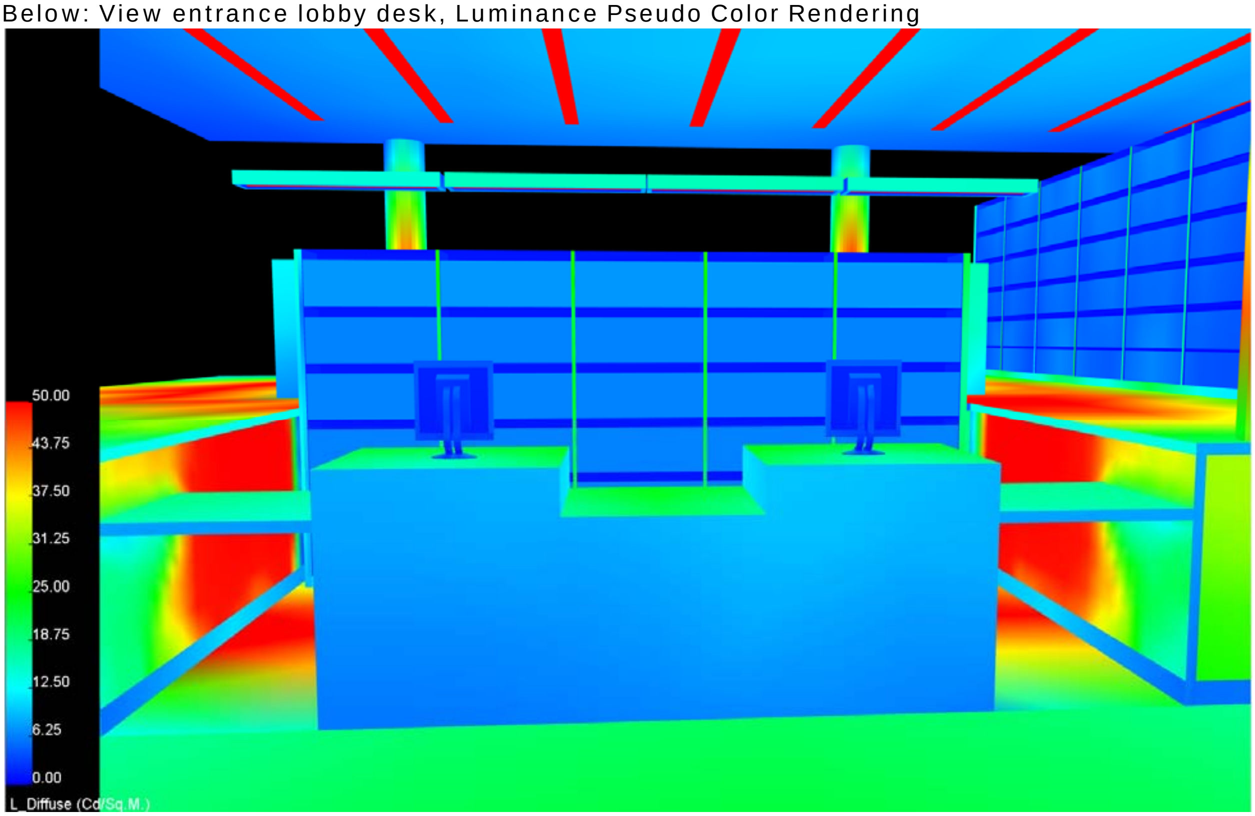


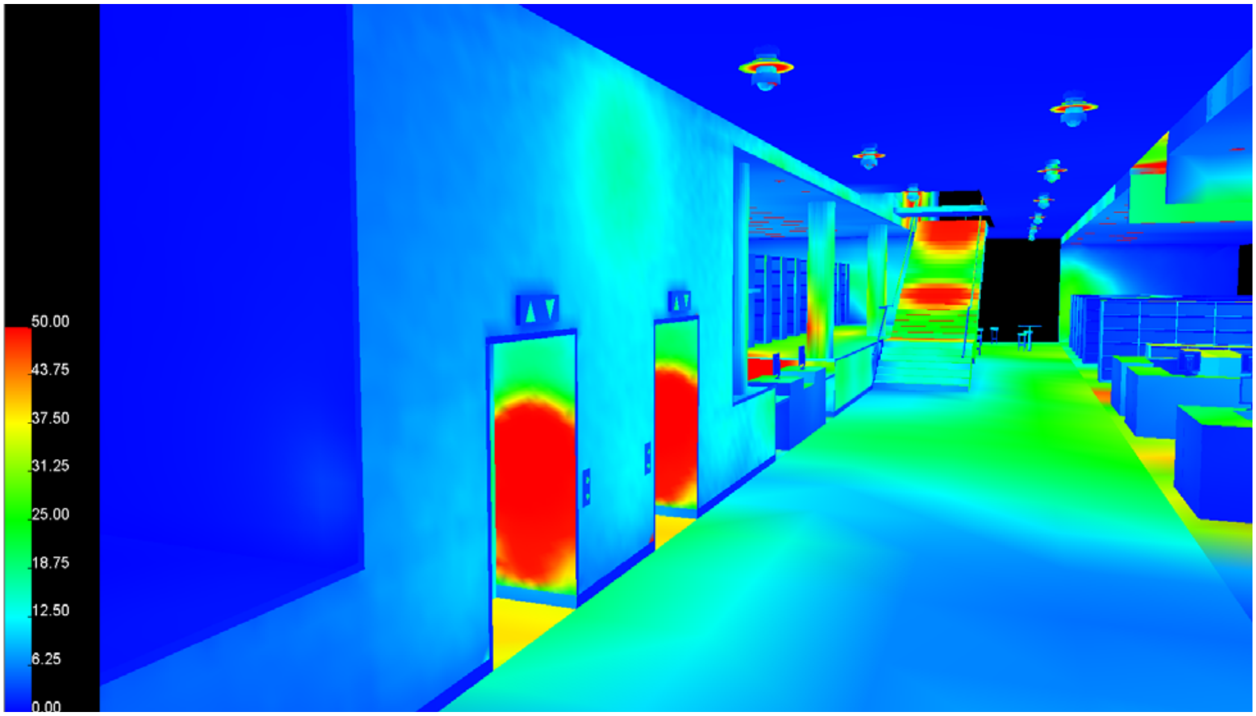
Above: View over lobby desk area, horizontal illuminance calculation

Entry Lobby: Pseudo Color Renderings

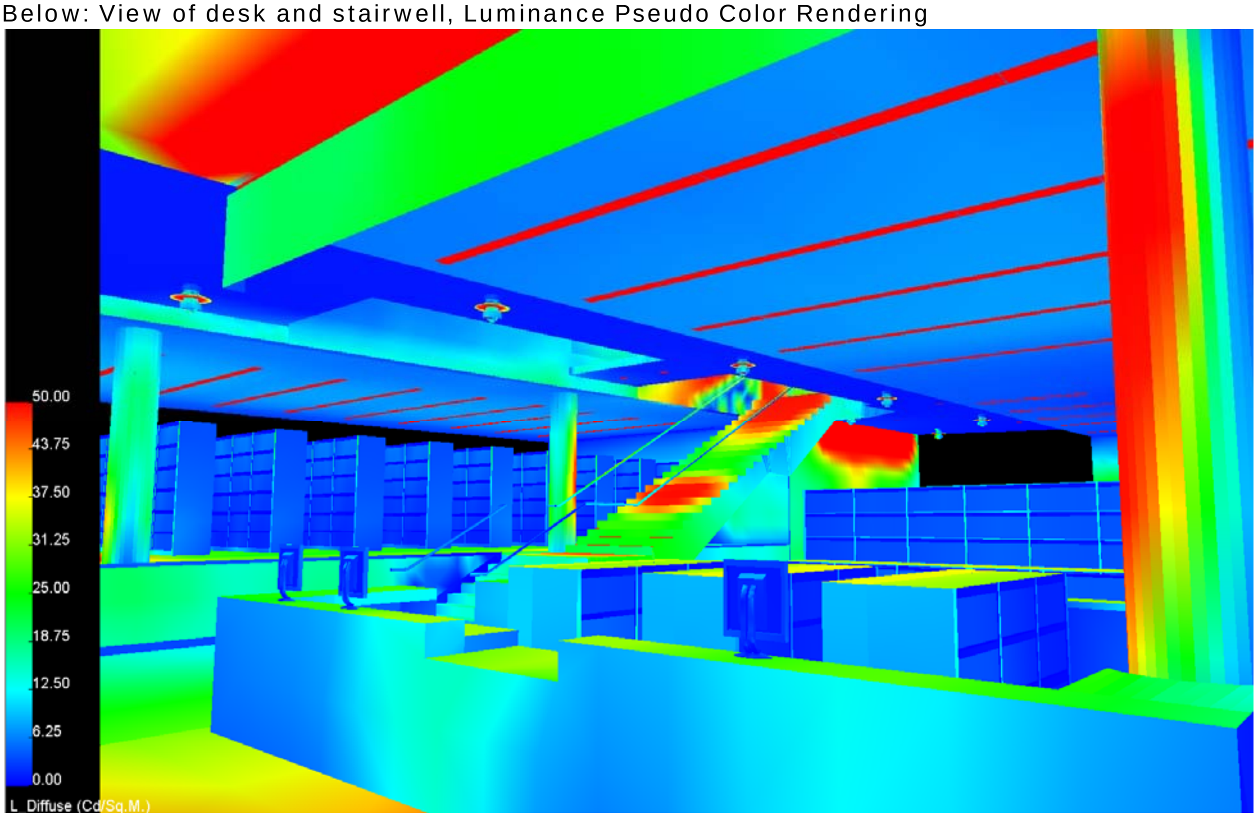


Above: View of entrance lobby desks, Luminance Pseudo Color Rendering
Below: View entrance lobby desk, Luminance Pseudo Color Rendering





Above: View of corridor looking towards stairs, Luminance Pseudo Color Rendering
Below: View of desk and stairwell, Luminance Pseudo Color Rendering



Entry Lobby: Power Density

Fixture	Ballast Watts	Quantity (lamps)	BF	Total Watts
F1	33	19	1.04	652.08
F7	46	12	1.04	574.08
F8	46	19	0.98	856.52
F9	33	6	1.04	205.92
F10	33	12	1.04	411.84
Space Type ASHRAE 90.1			Lobby	
Area (ft^2)			4,032 Total	
Allowable LPD (W/ft^2)			1.3+1.0 (decorative)	
Allowable Watts			5241.6+4032	
Actual LPD (W/ft^2)			0.67	
Actual Watts			2700	

Analysis was done using the space-by-space method

Entry Lobby: Performance Summary

The first impression created in the entrance lobby is that of a warm and inviting environment. The warm comforting tones of the red ceiling and wood finishes are rendered nicely with the warmer choices of CRI and CCT. Automatically, the occupants know how to travel throughout the space due to the way-finding light. Building occupants can easily identify the areas with the highest luminance values, which are the elevators, help desks, and stairwell. The architecture remains spacious and flows from one area to the next seamlessly, due to mostly recessed fixtures. The Louis Pouslen surface mounted luminaire adds to the punch of red in the corridor. The circular glass ring complements the usage of glass throughout the space. The glass ring also prevents halos of red light due to indirect light. The cafe area has additional downlights to provide adequate illumination over the tables. Wallwashers, along the café, supply some peripheral wall emphasis. Librarians can easily control the light with the master switches behind the desks. The lighting power density of the entrance lobby is less than half the required. The power density for a lobby is 1.3 W/ft^2 + an extra 1.0 W/ft^2 allowed for decorative lighting. The actual calculated power density for the space is only 0.6 W/ft^2. The entrance lobby also meets all the required illuminance values. The desks for reading and writing all meet a horizontal illuminance of approximately 30 fc. The corridor floor has a horizontal illuminance of about 11 fc and the main entrance floor has a higher illuminance value of approximately 25 fc. The cafe seating area has a horizontal illuminance of approximately 23 fc which is tolerable for an eating area.

Entry Lobby: Controls

The room is controlled by simple switching which the librarians can easily access behind the main entrance desks. The entire library is controlled by a relay system which is connected to an astronomical time clock to shut off lights after hours.

Entry Lobby: Electrical Characteristics

Panelboard L4NMA serves the branch circuits in the entry lobby. The panelboard is located in the basement electrical closet room B128. The new lighting design is placed on the same circuits as the existing lighting design. Circuit 25 is not used with the new design. The remainder of the panelboard is unknown so some assumptions were made to complete the electrical calculations.

Please refer to the appendix to view the lighting plans.

Load Calculations

Label	Location	W	VA	A	PF	QTY	∑VA	∑A	Circuit
F7	Corridor Ceiling	46	47.09	0.17	0.98	12	565.08	2.04	L4NMA-41,39
F8	Desks/ Stairs	46	47.09	0.17	0.98	19	894.71	3.23	L4NMA-20,7,36,13,24,37
F9	Café	33	33.24	0.12	0.98	6	199.44	0.72	L4NMA-42
F10	Lobby Ceiling	33	33.24	0.12	0.98	12	398.88	1.44	L4NMA-39,40
F1	Book Shelves	33	33.24	0.12	0.98	19	631.56	2.28	L4NMA-17,200.98,7

PANELBOARD SIZING WORKSHEET

Panel Tag-------------------------->	L4NMA	Panel Location:	Elec. Closet B128
Nominal Phase to Neutral Voltage------->	277	Phase:	3
Nominal Phase to Phase Voltage-------->	480	Wires:	4

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A				0	w	1.00	0	0	
2	A				0	w	1.00	0	0	
3	B				0	w	1.00	0	0	
4	B				0	w	1.00	0	0	
5	C				0	w	1.00	0	0	
6	C				0	w	1.00	0	0	
7	A	Desk Light	3		387.8	w	0.98	388	396	6- Bookshelf, 4 Desk
8	A				0	w		0	0	
9	B				0	w		0	0	
10	B				0	w	1.00	0	0	
11	C				0	w		0	0	
12	C				0	w		0	0	
13	A	Elevator	3		94.18	w	0.98	94	96	
14	A				0	w		0	0	
15	B				0	w		0	0	
16	B				0	w		0	0	
17	C	Book Shelf	3		133	w	0.98	133	136	
18	C				0	w		0	0	
19	A				0	w		0	0	
20	A	Desk Light	3		282.5	w	0.98	283	288	
21	B				0	w		0	0	
22	B				0	w		0	0	
23	C				0	w		0	0	
24	C	Stairs	3		94	w	0.98	94	96	
25	A				0	w		0	0	EMPTY-UNUSED
26	A				0	w		0	0	
27	B				0	w		0	0	
28	B				0	w		0	0	
29	C				0	w		0	0	
30	C				0	w		0	0	
31	A				0	w		0	0	
32	A				0	w		0	0	
33	B				0	w		0	0	
34	B				0	w		0	0	
35	C				0	w		0	0	
36	C	Desk Light	3		94	w	0.98	94	96	
37	A	Café	3		141	w	0.98	141	144	
38	A				0	w		0	0	
39	B	Corridor	3		274	w	0.98	274	280	3-Corridor, 4 Cove
40	B	Lobby	3		266	w	0.98	266	271	
41	C	Corridor	3		424	w	0.98	424	433	
42	C	Café	3		199.4	w	0.98	199	203	
PANEL TOTAL								2.4	2.4	Amps= 2.9

PHASE LOADING		kW	kVA	%	Amps
PHASE TOTAL	A	0.9	0.9	38%	3.3
PHASE TOTAL	B	0.5	0.6	23%	2.0
PHASE TOTAL	C	0.9	1.0	39%	3.4

LOAD CATAGORIES			Connected			Demand				Ver. 1.03
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		2.4	2.4		2.4	2.4	0.98		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
	Total Demand Loads					2.4	2.4			
	Spare Capacity		20%			0.5	0.5			
	Total Design Loads					2.9	2.9	0.98	Amps=	3.5

Default Power Factor = 0.80
Default Demand Factor = 1.00

PANELBOARD SCHEDULE

VOLTAGE: 277Y/480V,3PH,4W SIZE/TYPE BUS: 125A SIZE/TYPE MAIN: 125A	PANEL TAG: L4NMA PANEL LOCATION: Elec. Closet B128 PANEL MOUNTING: SURFACE	MIN. C/B AIC: 35K OPTIONS: PROVIDE FEED THROUGH LUGS

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
0	0	0	20A/1P	1	*			2	20A/1P	0	0	0
0	0	0	20A/1P	3		*		4	20A/1P	0	0	0
0	0	0	20A/1P	5			*	6	20A/1P	0	0	0
Desk Light	0	388	20A/1P	7	*			8	20A/1P	0	0	
	0	0	20A/1P	9		*		10	20A/1P	0	0	0
		0	20A/1P	11			*	12	20A/1P	0		
Elevator		94	20A/1P	13	*			14	20A/1P	0		
		0	20A/1P	15		*		16	20A/1P	0		
Book Shelf	0	133	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	283		Desk Light
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	94		Stairs
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	94		Desk Light
Café		141	20A/1P	37	*			38	20A/1P	0		
Corridor		274	20A/1P	39		*		40	20A/1P	266		Lobby
Corridor		424	20A/1P	41			*	42	20A/1P	199.4		Café

CONNECTED LOAD (KW) - A	0.91	TOTAL DESIGN LOAD (KW)	2.87
CONNECTED LOAD (KW) - B	0.54	POWER FACTOR	0.98
CONNECTED LOAD (KW) - C	0.94	TOTAL DESIGN LOAD (AMPS)	4

The remainder of the panelboard is unknown so some assumptions were made to complete these electrical calculations. The new electrical circuits are not highlighted because all of the information provided includes the new lighting loads.

Electrical Data:
Main Lugs: 125A
Bottom feed
35K AIC
Incoming conductor(s) per phase:
(1) #5- 250 kcmil

Existing Panelboard Branch Summation
42- 20A/1P

Assumed Total Load:
42- 20A/1P - 11-20A/1P = 31-20A/1P Existing
(31*20) = 620A * 0.7 = 434 A

434 A + (New Design Load: 4 A) = 438 A

Feeder Size:
700 MCM THW Copper in 3.5" Conduit (460A Capacity)

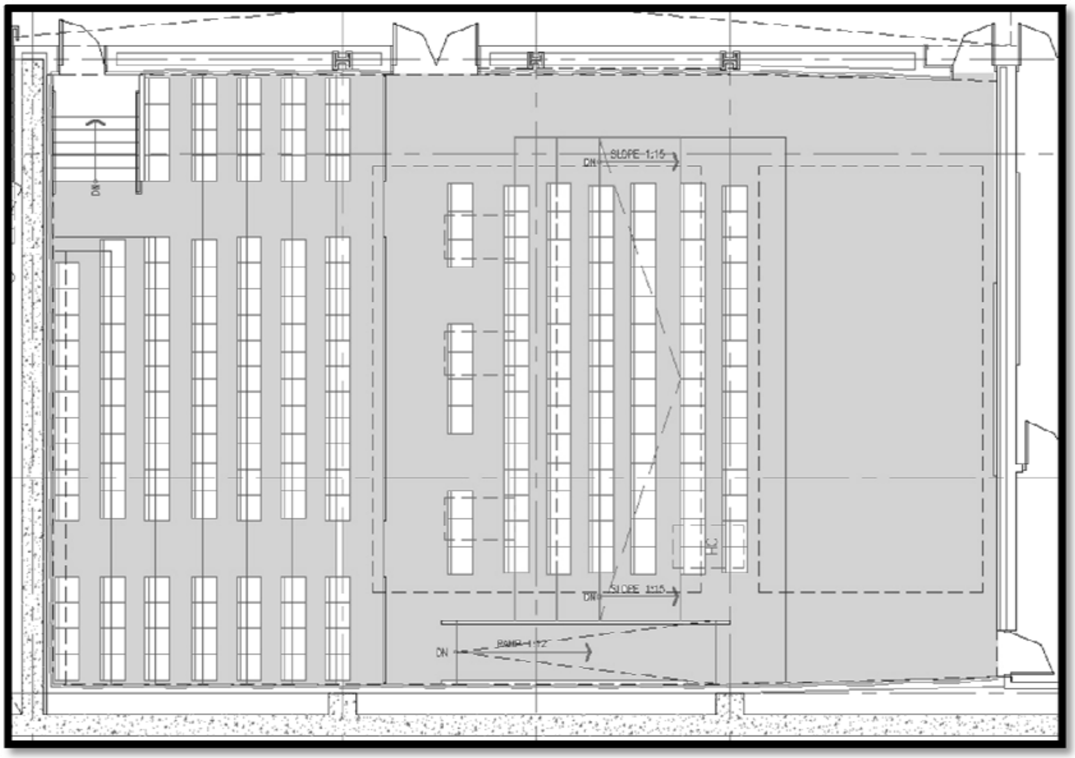
Lighting Depth Study- Meeting Room

Meeting Room: Summary of Space

The large meeting room can accommodate up to 230 guests in auditorium seats. This portion of the library's renovation has greatly expanded its program for the public. The auditorium is split into three sections; the first consists of a wooden stage, and the remaining sections include rows of seating. The first group of seats is located on a 1:15 carpeted slope in the front of the room between two perimeter walkway aisles. Four of these seats are removable for wheelchair space and additional wheelchair space is located in the last row. To the right of the seating section is a ramp with a 1:12 slope. A stainless steel railing splits the third portion of the room from the first by means of a stainless steel railing, which guards an aisle walkway. Two aisles divide this third group of seating and each row climbs in elevation. Located on the front wall of the room is a large motorized projector screen. The projector is recessed into a wooden panel at the rear of the space. Two angled lecterns are located on both sides of the projection screen. These lecterns sit on a 4 1/2" elevated wooden stage platform. In addition to the level changing floor, the room is unique due to its undulating wood wall panels and sloped maple veneer ceiling.

As the space consists of auditorium seating, the room is for presentations and guest speakers. Speakers may choose to give presentations that require the lecterns or visual assistance of a projection screen. Supplementary to projection presentation viewing, the task will mostly consist of speaking, reading, and writing. The room may also occasionally be for film viewing.

Location	Material/Tag	Description/Color	Reflectance
Flooring	Concrete	Light Gray Color	0.33
Furniture	Auditorium Chairs	Maroon Fabric	0.12
Doors	Maple Wood	Maple Wood	0.22
Wall Panels	Chevron Wall Panels (06200)	Maple Wood	0.22
Hung Ceiling Panels	½" Maple Veneered Ceiling Panels (06200)	Maple Veneered Wood	0.22
Curved Wall Panels	PTD GWB Gypsum Wall Board (09522)	White Painted- Gypsum Wall Board	0.76



Meeting Room: Design Criteria

<u>IESNA Design Criteria</u>

Auditorium (Social Activity- Normal gathering (without projection))

Very Important Criteria:
- System control and Flexibility
- **Horizontal Illuminance- Category D- 30 fc**

Important Criteria:
- Color Appearance (and color contrast)
- Daylighting Integration and Contrast
- Modeling of Faces or Objects

Somewhat Important Criteria:
- Appearance of Space and Luminaires
- Direct Glare
- Flicker (and Strobe)
- Luminance of Room Surfaces

Appropriate Design Considerations

- **<u>Aesthetic Criteria:</u>**
  Because the space is for meetings, speeches and presentations by the public, the **appearance of space and luminaires** is important. The auditorium seating should have diffuse, uniform, comfortable illumination. The luminaires style should match the sophisticated feel of architecture within the room.

- **Psychological Aspects:**
  Since the meeting room is a multipurpose space with numerous visual tasks the most essential impression is **visual clarity. High uniform light levels**, which are particularly beneficial for discussions, can enhance the impression of visual clarity. The lighting should be mostly **overhead (direct) lighting** with some **peripheral emphasis**. Emphasis of the **architectural details** can create visual interest**.** In particular, grazing the distinctive undulating perimeter with light to highlight their distinctive shape can facilitate visual stimulation.

- **Illuminance Criteria:**
  There should be a **minimum horizontal illuminance of between 10-20 fc** for the auditorium seating and a higher **horizontal illuminance value** of around **30 fc** for **visual tasks** such as reading and writing.
  Speakers located at the podiums should have a **vertical illuminance** of at least **20 fc.** The podium lighting should be on a different control setting for stage usage. Architectural presets can allow for the seating area to be dimmed and the stage to be highlighted during non-active discussions and monologues.

- **Control Criteria:**
  Due to the multi-functionality of the room, there must be **multiple scene settings** for the controls. The room should have a **dimmer control** to transition between speaking and video projection. Controls should include **easy switching** which librarians or patrons can utilize. This space should have **occupancy sensors** to shut down lights when the room is vacant to conserve energy.

- **Appearance Criteria:**
  Chandeliers / suspended luminaires must be placed in locations that do not interfere with the rear projection. During a projection, the **vertical illuminance** on the screen should not exceed **5 fc. Downlighting** is one of the most effective methods for this purpose.

- **Light Quality and Color Appearance:**
  IESNA lists color appearance as important. As most of the interior consists of a dark wood, the lamps should render a **warmer CRI and CCT.** Lamps should have a CCT of around 3000K and a **high CRI (close to 100).**

- **Maintenance Issues:**
  The selection of dimmable lamps for the multiple lighting modes in the space is mandatory. Lamps must also be **distinguishable** for the ease of replacement (no lamps of the same size and shape should share two different wattages etc.). Luminaires out of reach of ladder assistance must maintain a higher life expectancy.

- **Power Density:**
  The **power density** for a Conference/Meeting Space is **1.3 W/ft^2.**

Stacks & Seating Area: Lighting Design Concept

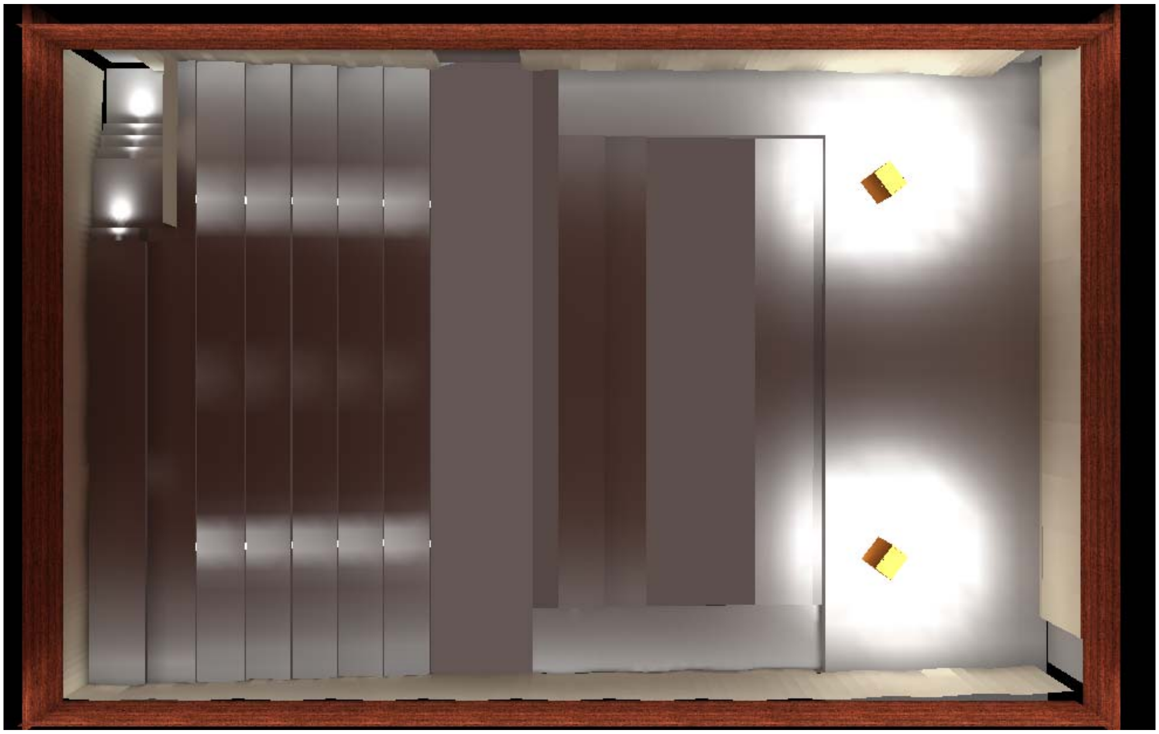
The special purpose room with 230 seats has multiple functions. Therefore, for each of its functions, there should be different lighting schemes. Layers of light should be created that can be turned on or off, or dimmed. Lighting should be comfortable to view speakers and video projects. There should also be adequate horizontal illumination for writing and reading tasks. Architectural details, such as the undulating walls, should also be highlighted. To provide different architectural preset settings for the space the Lutron Grafik Eye 4000 Series with 4 preset lighting scenes which are accessible for occupants from the control unit panel.

To provide ambient light in the space Focal Point's recessed linear fluorescent fixture with adjustable MR-16 downlights slant along the wooden ceiling panels. The walls are washed with uniform light with Elliptipar's pendant mounted fluorescent wall washer. As light cascades down the wall, highlights and shadows are created on the undulating lower wall panels. The overhead and peripheral wall emphasis, created with these two fixtures alone, creates the impression of visual clarity. Additional adjustable accent lights are used to highlight the two podiums on the stage. During presentations the occupants in the space can safely exit and enter the room due to Cole Lighting's LED step light. All of these luminaires are dimmable with the exception of the LED step light and can be utilized in preset scenes.

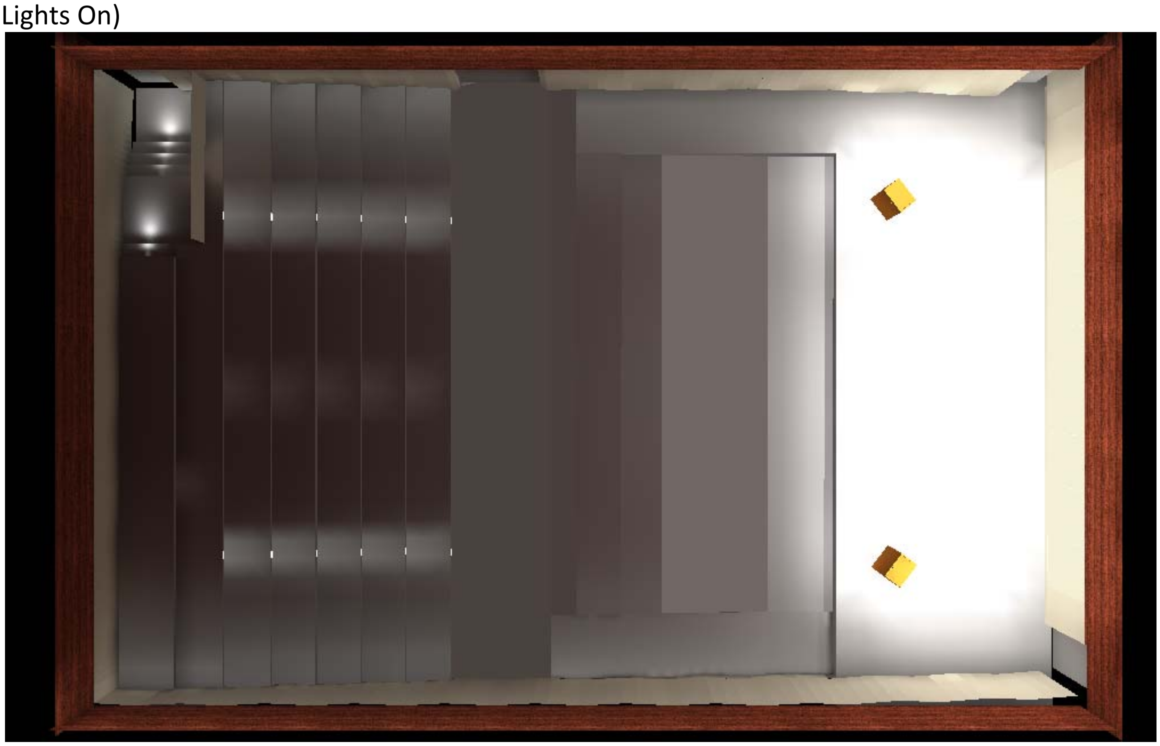
Please refer to appendix B for lighting plans.

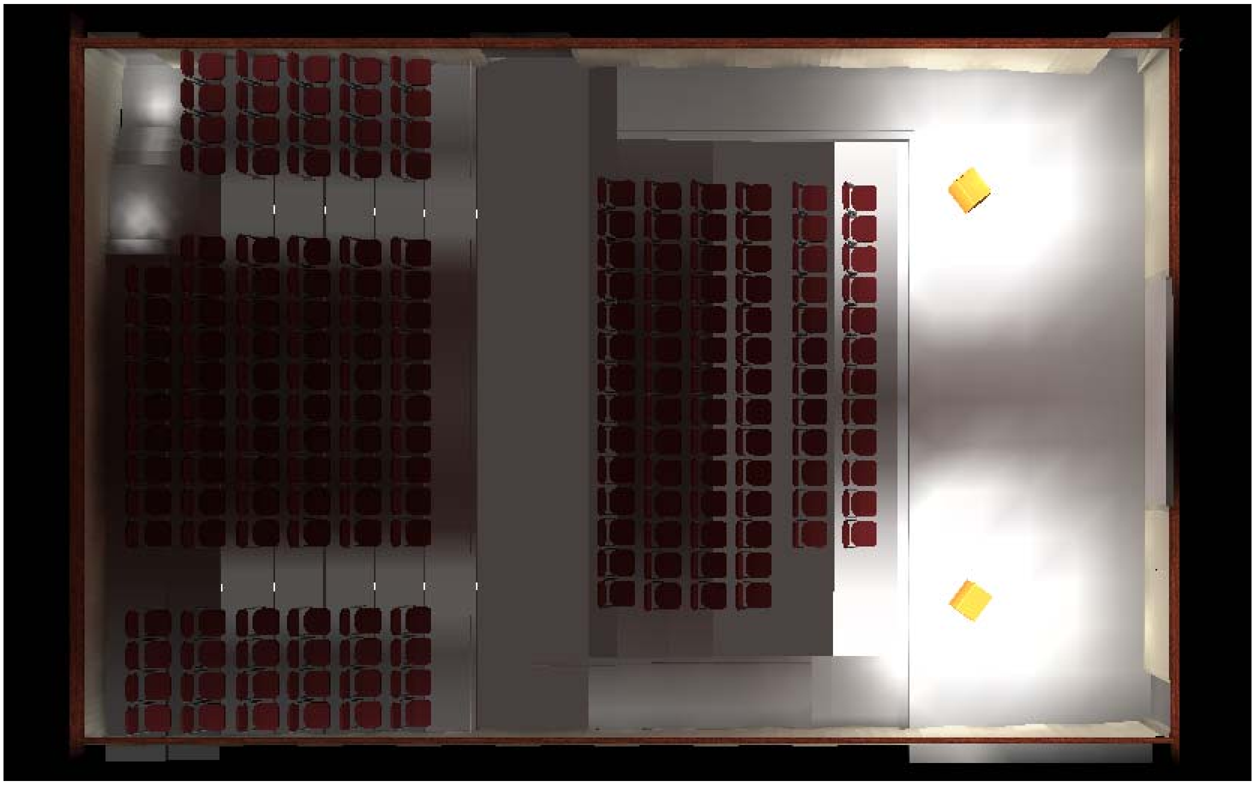
Meeting Room: Renderings

Above: Rendering looking at seating from stage view
(Podium Speaker/Projection Scene –Overhead Lights Off, WallWashers 25%, step lights On, Accent lights on podiums only)

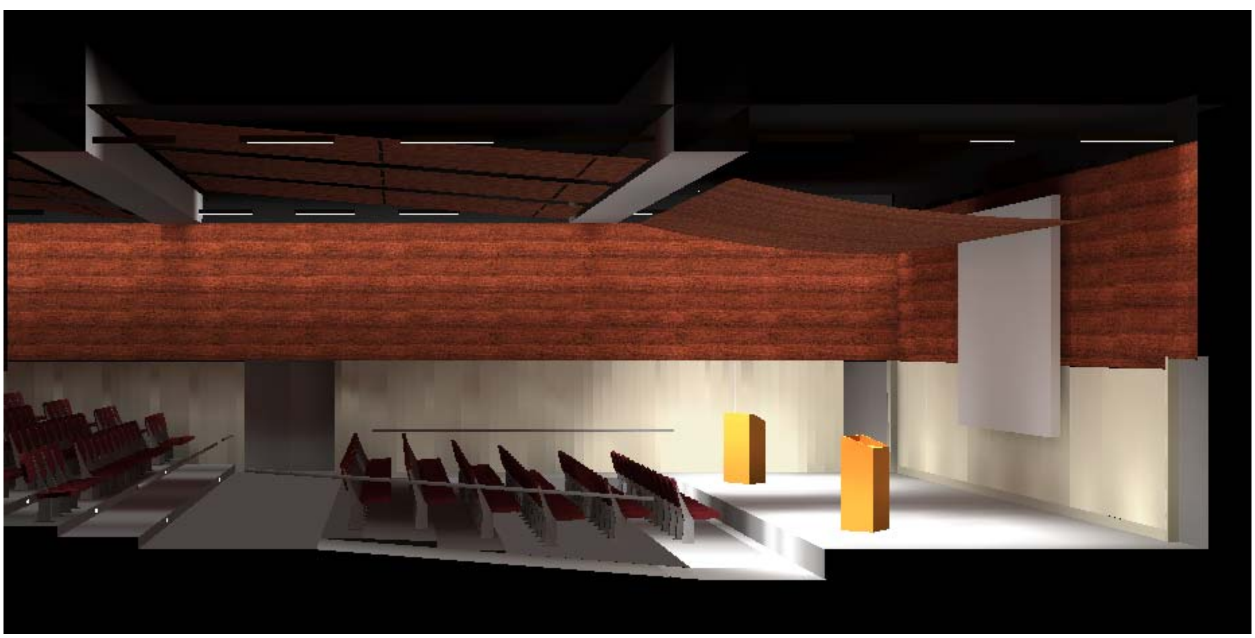


Above: Rendering overhead view of meeting room
(Podium Speaker/Projection Scene –Overhead Lights Off, WallWashers 25%, step lights On, Accent Lights On Podiums)
Below: Rendering overhead view of meeting room
(Podium Speaker –Overhead Auditorium Lights Off, WallWashers 25%, step lights On, Overhead Stage Lights On)

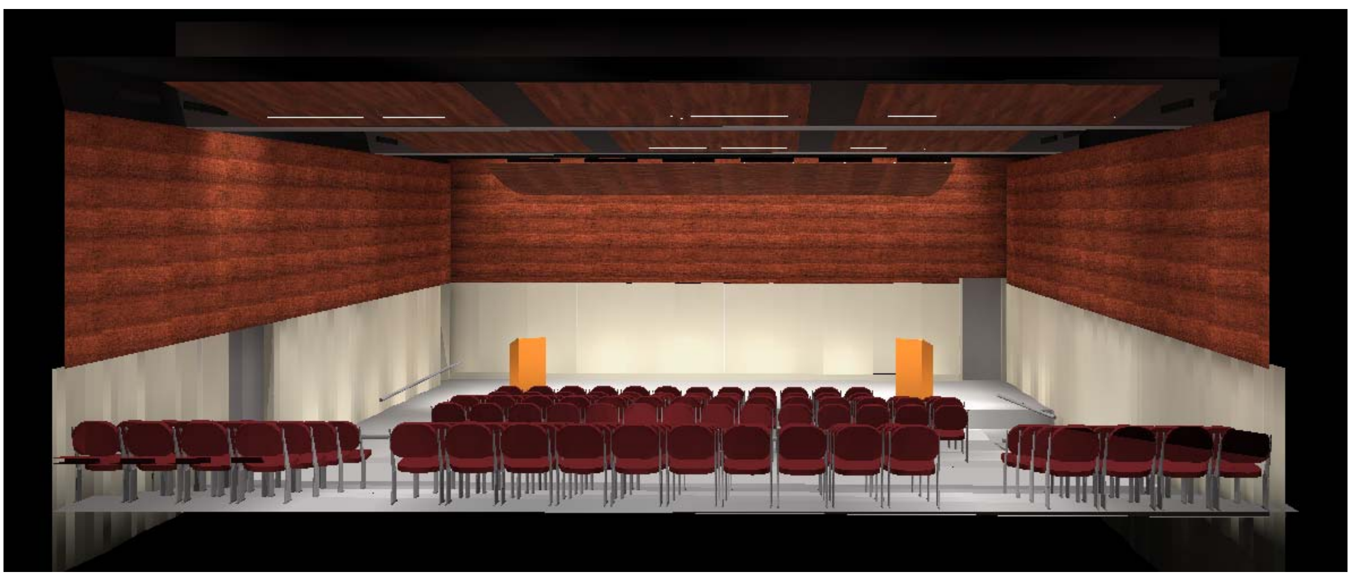


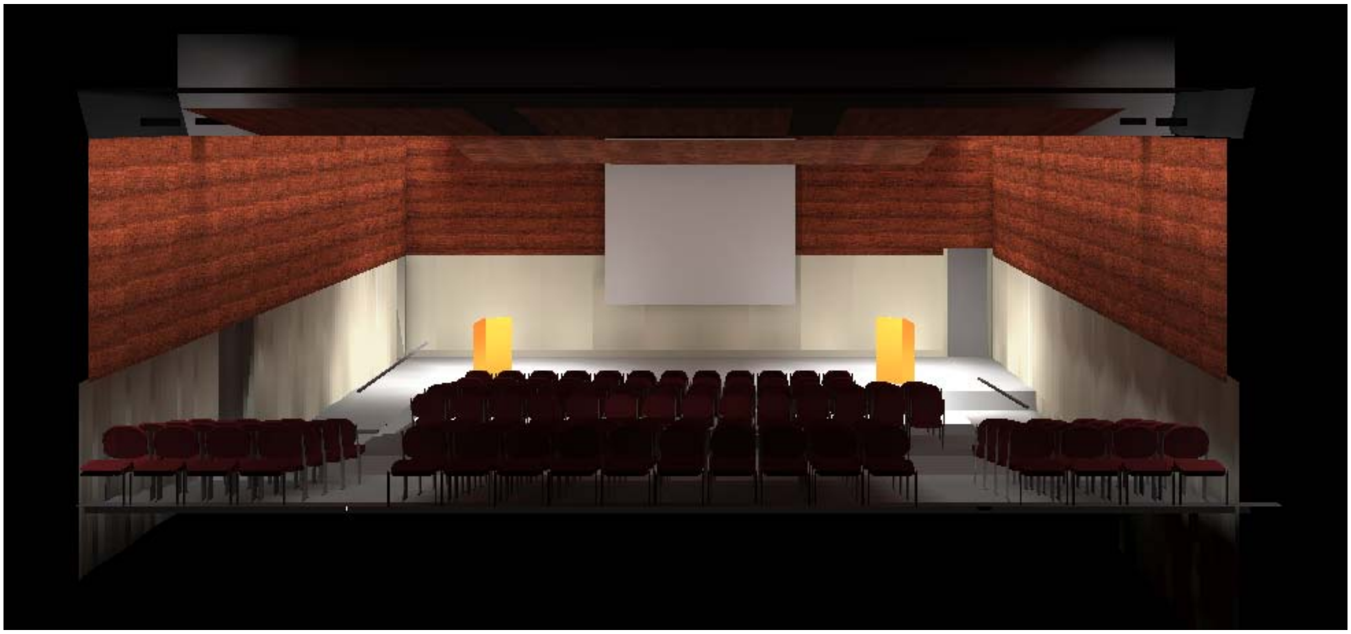


Above: Rendering overhead view of meeting room
(Podium Speaker/Projection Scene –Overhead Lights Off, WallWashers 25%, step lights On, Accent Lights On Podiums)
Below: Rendering section view of meeting room stage
(Podium Speaker/Projection Scene –Overhead Lights Off, WallWashers 25%, step lights On, Accent Lights On Podiums)



Above: Rendering section view of meeting room
(Classroom Scene- All Overhead Lights full output, Wallwashers full output, Stage lights full output)
Below: Rendering looking at stage
(Classroom Scene- All Overhead Lights full output, Wallwashers full output, Stage Lights full output)

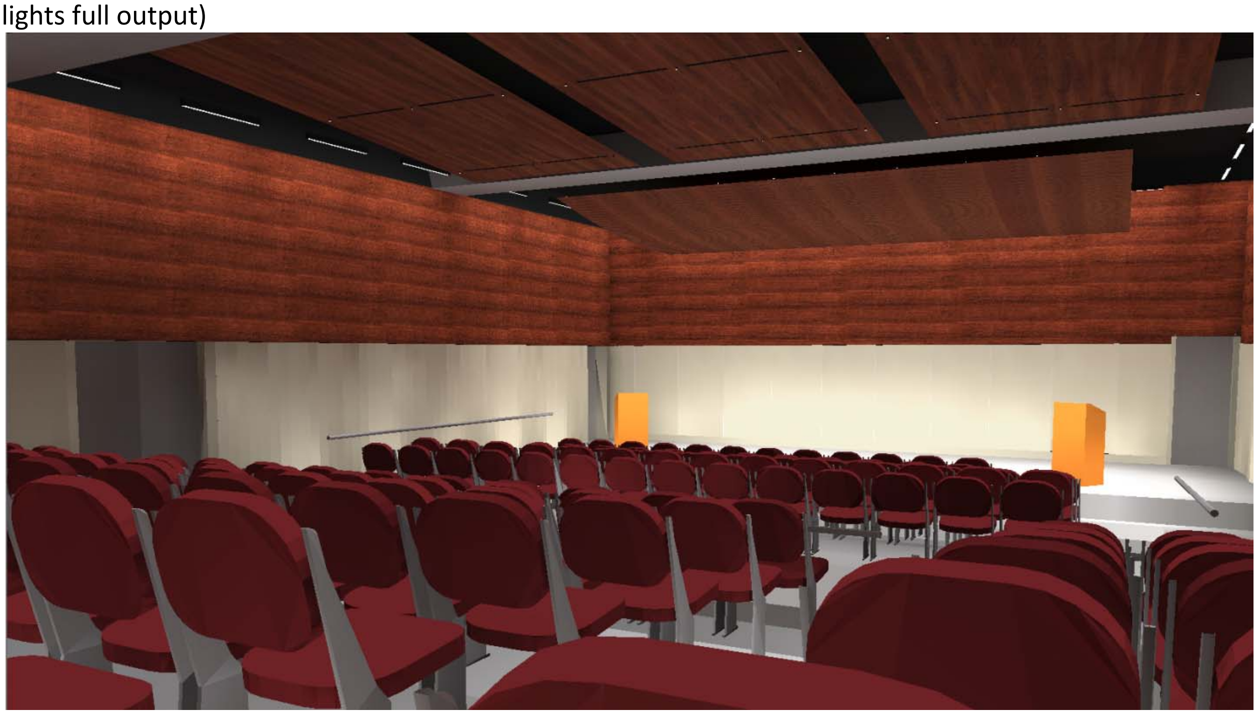




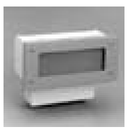
Above: Rendering looking at stage
(Podium Speaker/Projection Scene –Overhead Lights Off, WallWashers 25%, step lights On, Accent lights on podiums only)
Below: Rendering section view of meeting room
(Podium Speaker –Overhead Auditorium Lights Off, WallWashers 25%, step lights On, Accent lights on podiums only)

Above: Rendering perspective view of seating from stage
(meeting scene –Overhead Lights with only MR-16 on, WallWashers full-output, step lights On, Stage lights full output)

Below: Rendering perspective view of stage from seating
(meeting scene –Overhead Lights with only MR-16 on, WallWashers full-output, step lights On, Stage lights full output)



Meeting Room: Fixture Schedule

Type		Mfr/Catalog #	Lamping	Notes
F11		Focal Point FAVB-FLM-1T5-2C-120-D-G1-2EG-SFL-TS-5'+MR16 Description: 2" recessed fluorescent downlight with 1-F28T5 (48in) lamp (in cross-section). Optics: acrylic diffuse white lens , steel die-formed reflector. Ballast: Lutron EC5-T528-J-UNV-1 Voltage:120V	1 - Osram Slyvania FP28/830PM/ECO F28T5 (48in) lamp (in cross-section), 20MR16/IR/WFL60/C	Location: Meeting Room
F12		**Zumtobel 902-4-BK** Description: 3" track-mounted halogen accent light with 1-PAR20 50W max lamp. Optics: glass lens. Voltage: 120V	1 - Osram Slyvania 50PAR20/HAL/NFL30 PAR20 50W max lamp	Location: Meeting Room Onsite aiming
F13		**Cole Lighting LW158** Description: Recessed LED step light. Optics: straight louver , frosted glass diffuser , anodized aluminum die-formed reflector.	1 - LED	Location: Meeting Room Mount: 2" AFF, centered in each step. See lighting plan for details.
F14		**Elliptipar F115-T1-28-X-81-1-00-0-*-08-*-0-0** Description: Pendant mounted linear wall washer with 1-28T5 lamp. Ballast:Lutron EC5-T528-J-UNV-1 Voltage:120V	1 - Osram Slyvania FP28/830PM/ECO 1-28W-T5	Location: Meeting Room Housing must be matte black. Mount: 17'-0" A.F.F

Meeting Room: Light Loss Factors

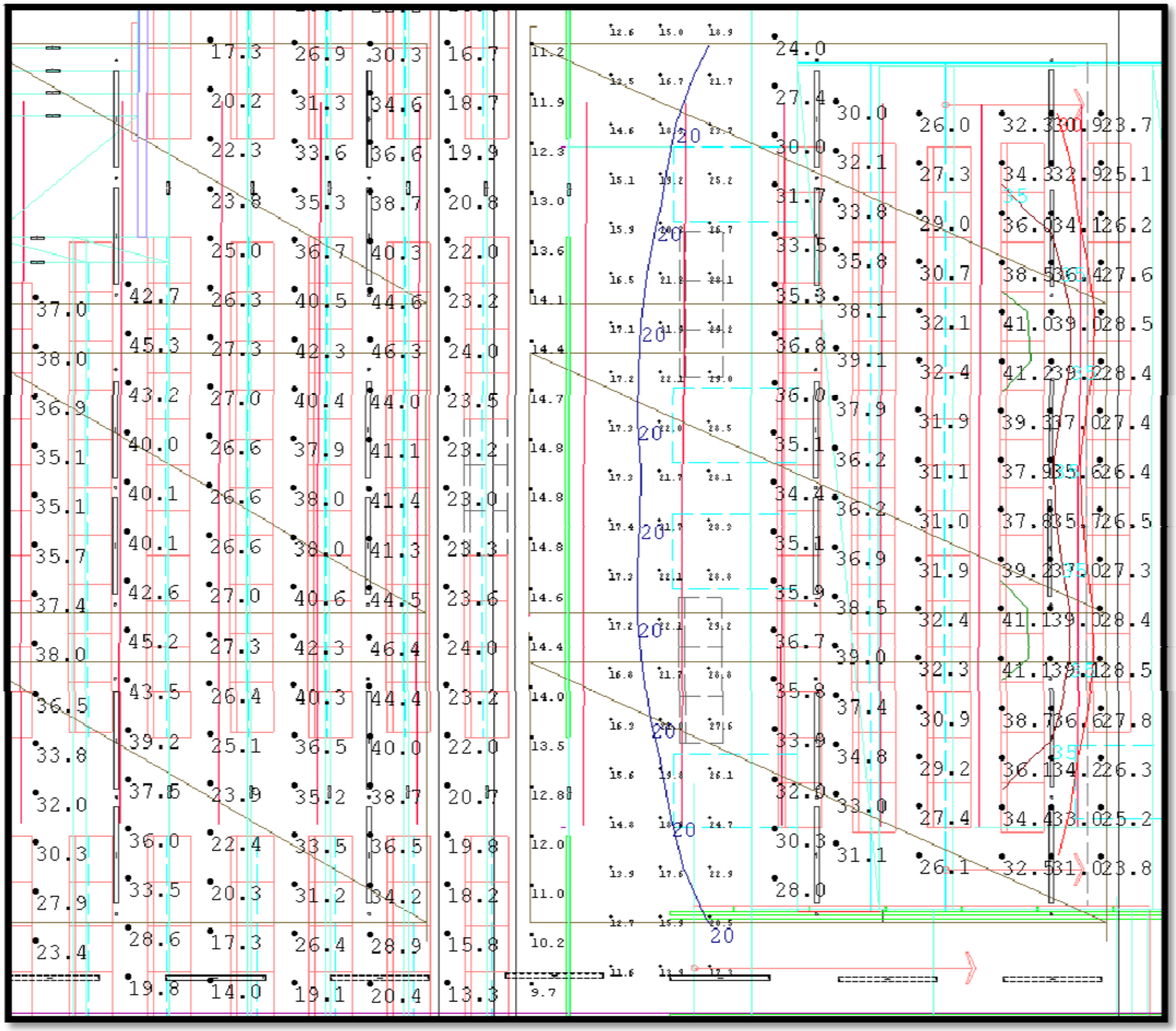
Assumptions:

Degree of Dirt Conditions: Very Clean
Months: 12

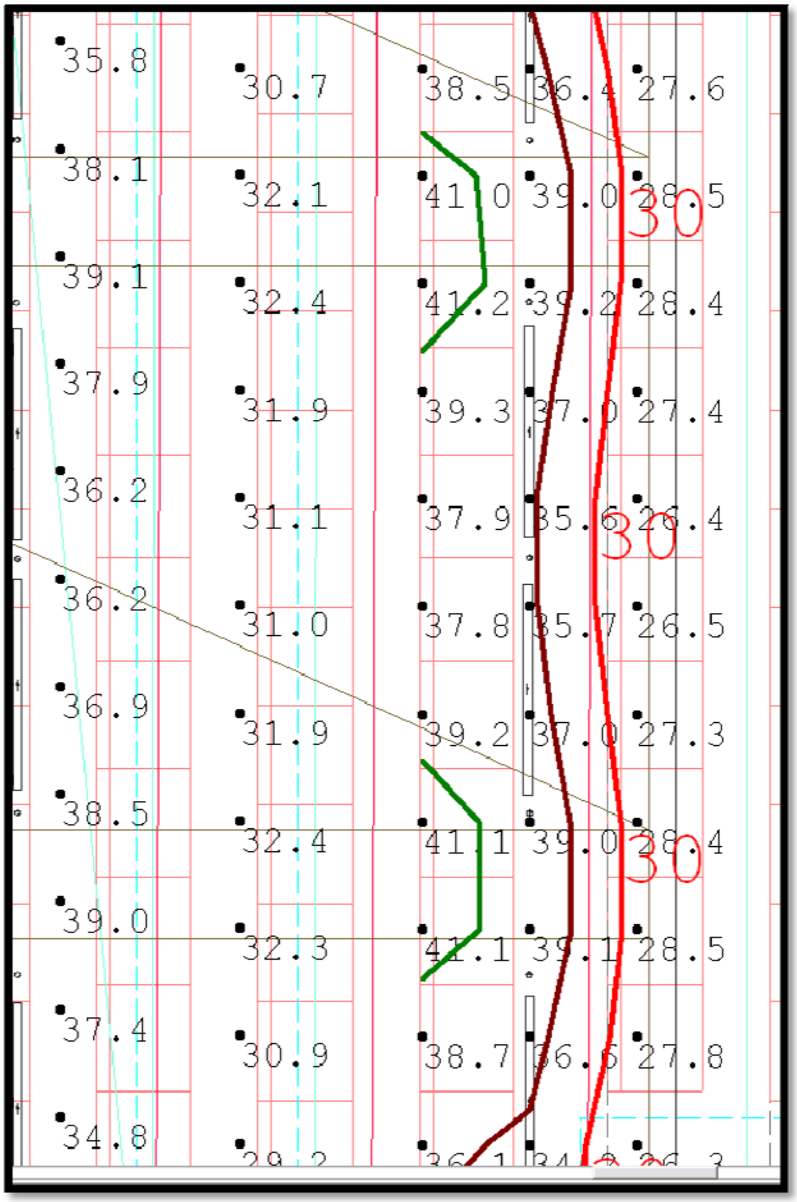
Label	Maintenance Category	Distribution	LDD	LLD Mean/Initial	BF	Total LLF
F11-Downlight	V	Direct	0.93	0.9	1.0	0.84
F12-Accent Light	V	Direct	0.93	0.9	1.0	0.84
F13-Step Light	V	Direct-Indirect	0.93	1.0	1.0	0.93
F14-Wall Washer	IV	Direct	0.94	0.9	1.0	0.85

Meeting Room: Illuminance Calculations

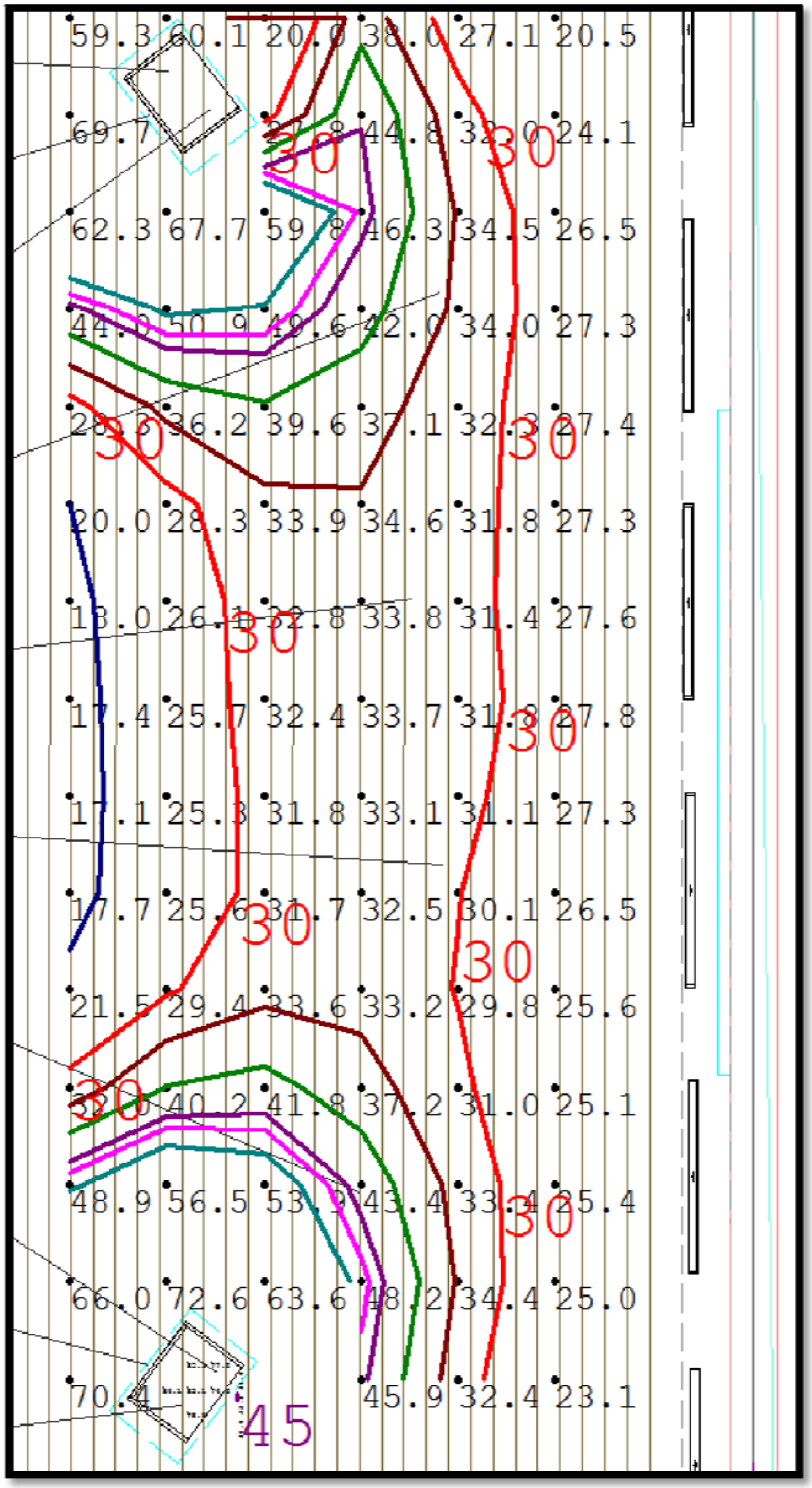
Description	Location	Orientation	Units	Average	Max	Min	Avg/min	Max/Min
Floor Calc1- Full Output	2'-5" AFF	Horizontal	FC	19.99	29.2	11.6	1.72	2.52
Floor Calc2- Full Output	2'-5" AFF	Horizontal	FC	32.19	36.8	19.7	1.63	1.87
Floor Calc3- Full Output	2'-5" AFF	Horizontal	FC	37.88	46.4	20.4	1.86	2.27
Floor Calc4- Full Output	2'-5" AFF	Horizontal	FC	34.57	42.3	19.1	1.81	2.21
Full Calc5- Output	2'-5" AFF	Horizontal	FC	23.18	27.3	14.0	1.66	1.95
Floor Calc6- Full Output	2'-5" AFF	Horizontal	FC	38.49	45.3	19.8	1.94	2.29
Floor Calc7- Full Output	2'-5" AFF	Horizontal	FC	34.08	38.0	23.4	1.46	1.62
Floor Calc8- Full Output	2'-5" AFF	Horizontal	FC	30.11	32.4	26.0	1.16	1.25
Floor Calc9- Full Output	2'-5" AFF	Horizontal	FC	35.62	39.1	30.0	1.19	1.30
Aisle- Full Output	2'-5" AFF	Horizontal	FC	13.08	14.8	9.7	1.35	1.53
Floor Calc11- Full Output	v	Horizontal	FC	47	54	30	1.61	1.87
Podium	3'-5" AFF	Horizontal	FC	80.6	85.3	74.6	1.08	1.14
Podium	5'-6" AFF	Vertical	FC	43.12	46.0	40.1	1.08	1.15
Stage-All On	0'-0" AFF	Horizontal	FC	36.06	72.6	17.1	2.11	4.25
Stage- Accent Lights and 25% Wallwashers Only)	0'-0" AFF	Horizontal	FC	8.11	43.6	0.2	40.55	218
Projector Screen- (Accent Lights and 25% Wallwashers Only)	2'-10' AFF	Vertical	FC	0.97	1.4	0.7	1.39	2.0
Projector Screen- (Step Lights Only)	2'-10' AFF	Vertical	FC	0.1	0.3	0.0	NA	NA



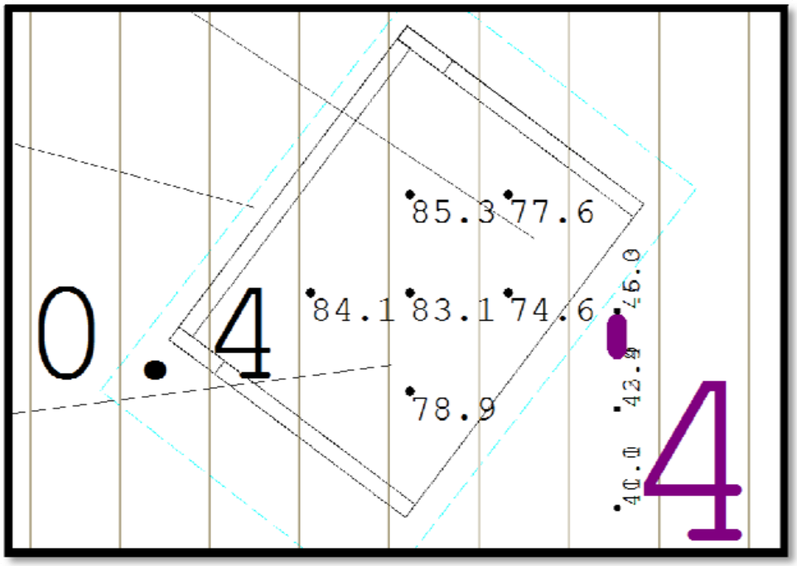
Above: Overhead view of meeting room, horizontal illuminance calculation
(Classroom/Meeting Scene Setting- All overhead lights on at full output, wallwashers on full output)



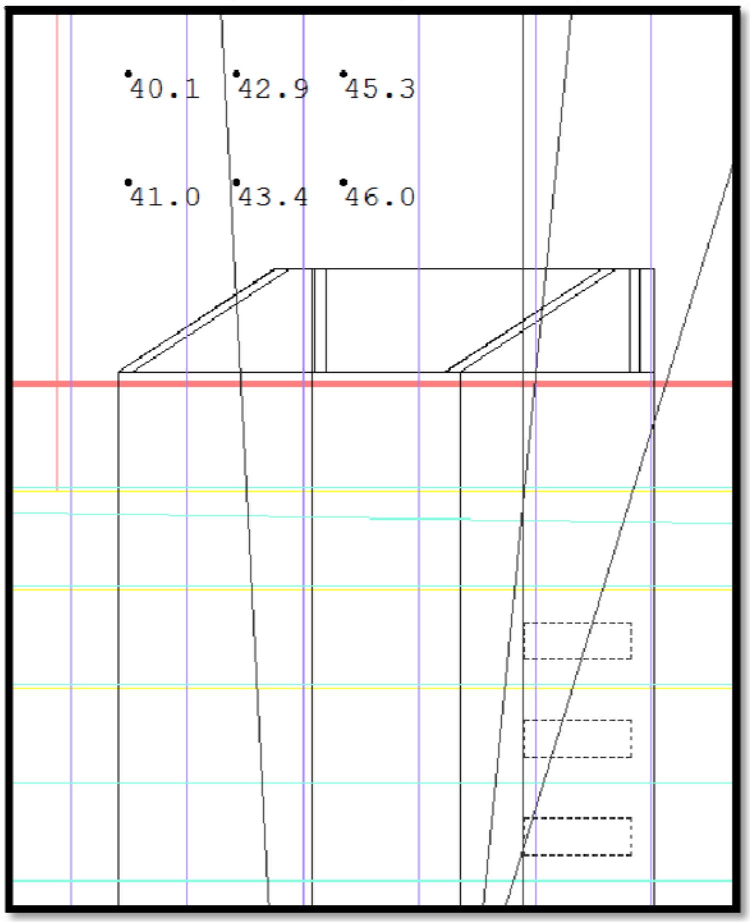
Above: Closer view of auditorium seating, horizontal illuminance calculation
(Classroom/Meeting Scene Setting- All overhead lights on at full output, wallwashers on full output)

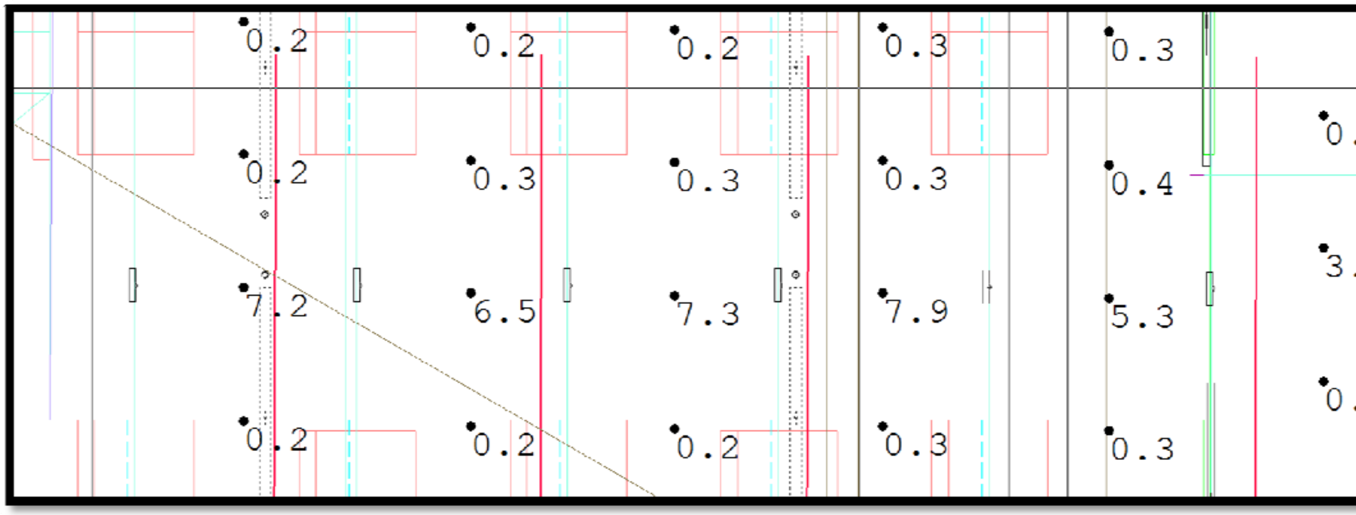


Above: View of stage, horizontal illuminance calculation
(Classroom/Meeting Scene Setting –Overhead Lights Full Output)

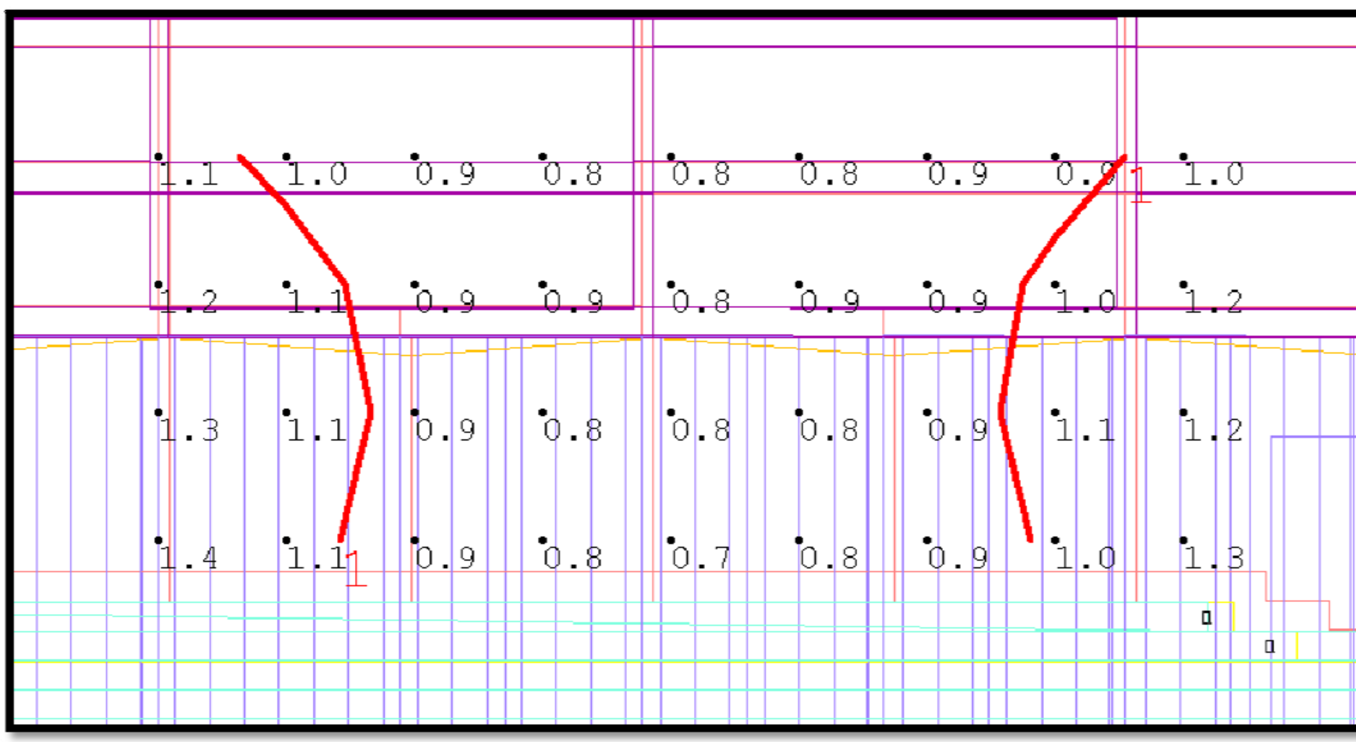


Above: View of stage podium, horizontal illuminance calculation
(Classroom/Meeting Scene Setting –Overhead Lights Full Output)
Below: View of stage podium, vertical illuminance calculation
(Classroom/Meeting Scene Setting –Overhead Lights Full Output

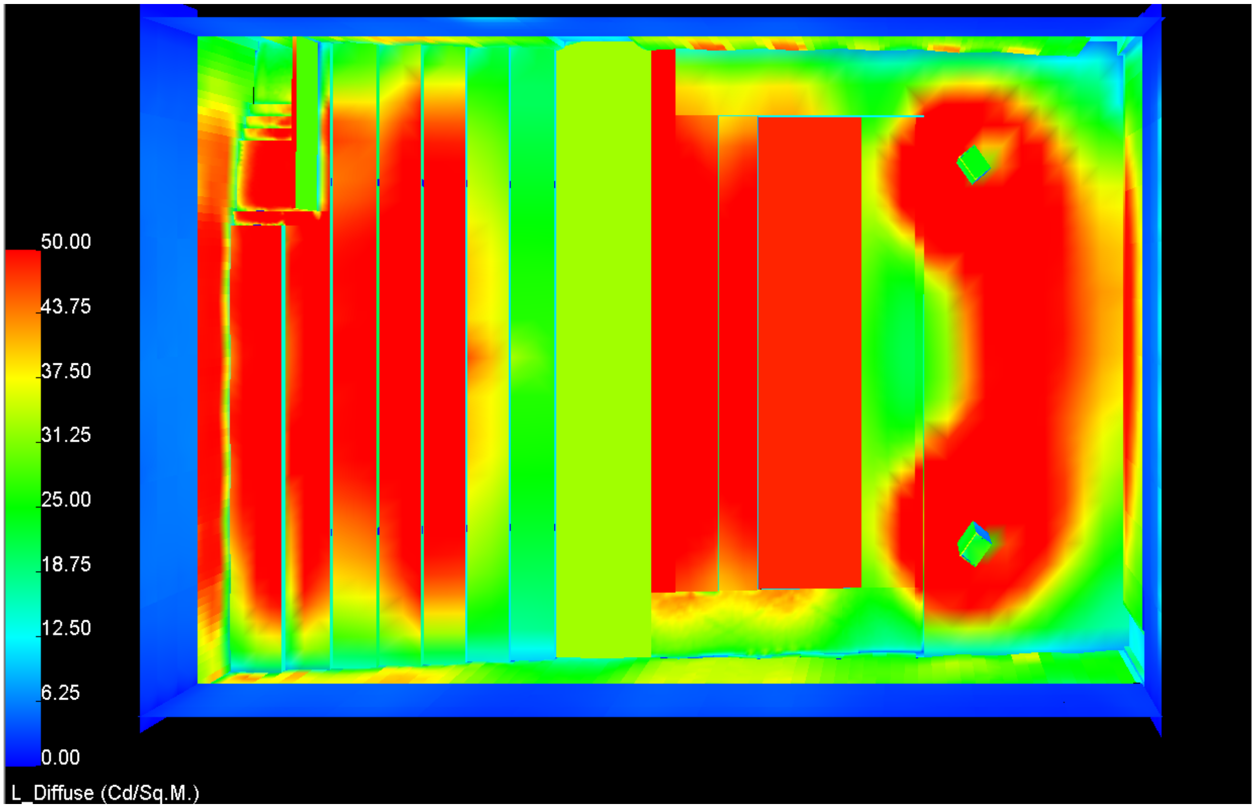




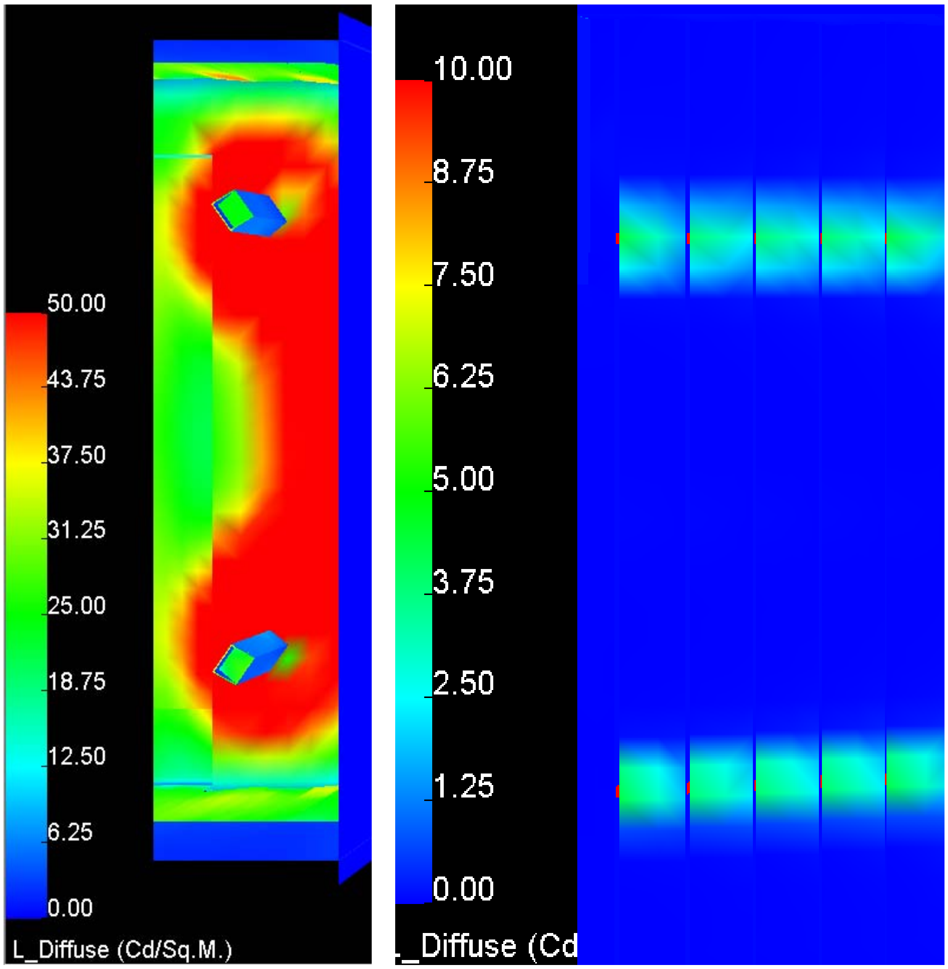
Above: View of auditorium seating steps, horizontal illuminance calculation
(Projection Scene –Overhead Lights Off, WallWashers 25% Output)
Below: View of projection screen, vertical illuminance calculation
(Projection Scene/Podium Speaker –Overhead Lights Off, Accent Lights On, WallWashers 25% Output)



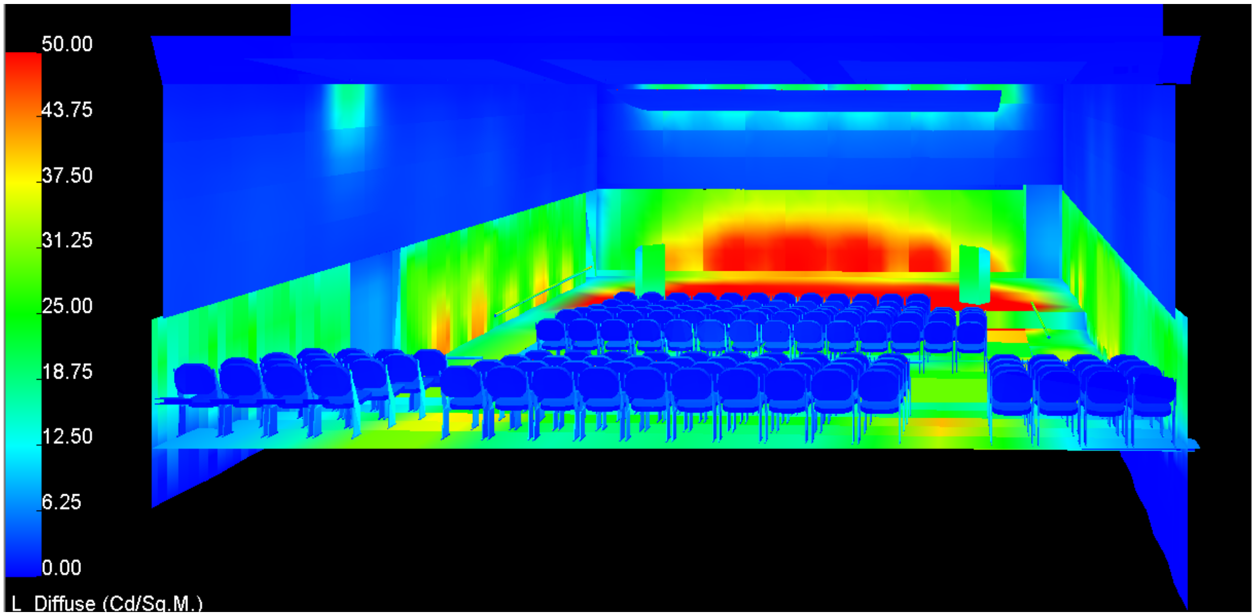
Meeting Room: Pseudo Color Renderings



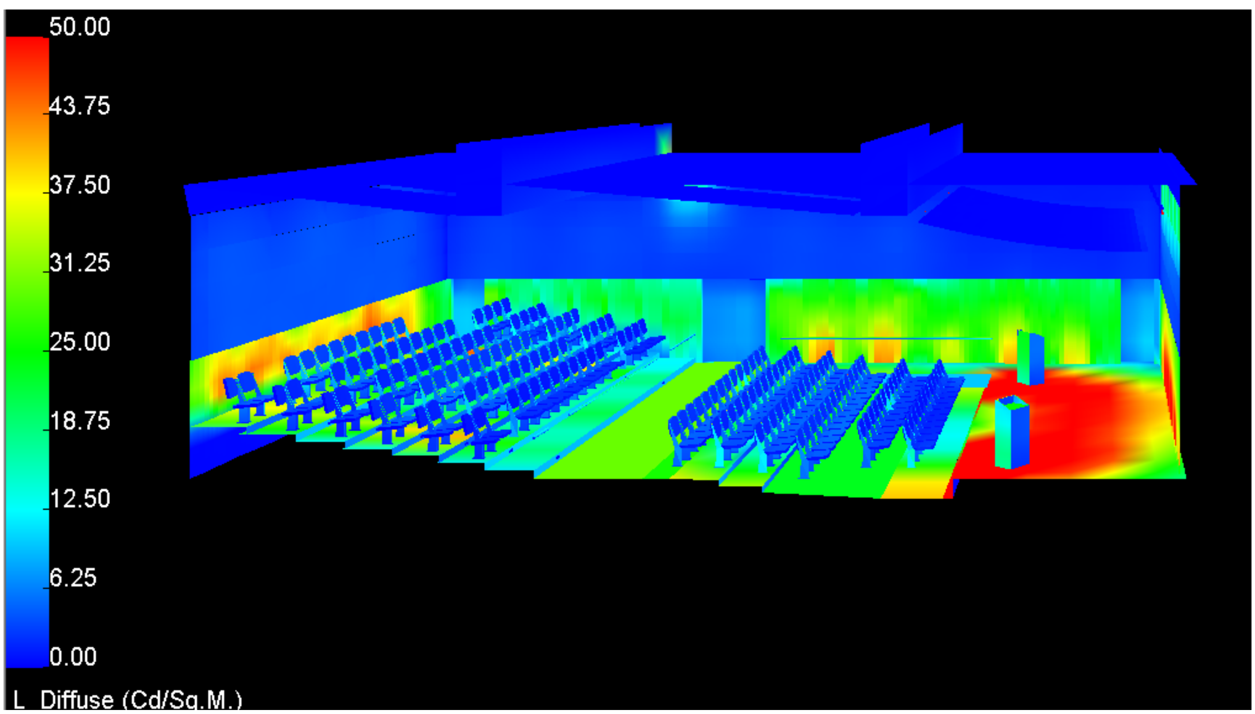
Above: View over meeting room, luminance pseudo color rendering
(Classroom/Meeting Scene –Overhead Lights Full Output, WallWashers Full Output)

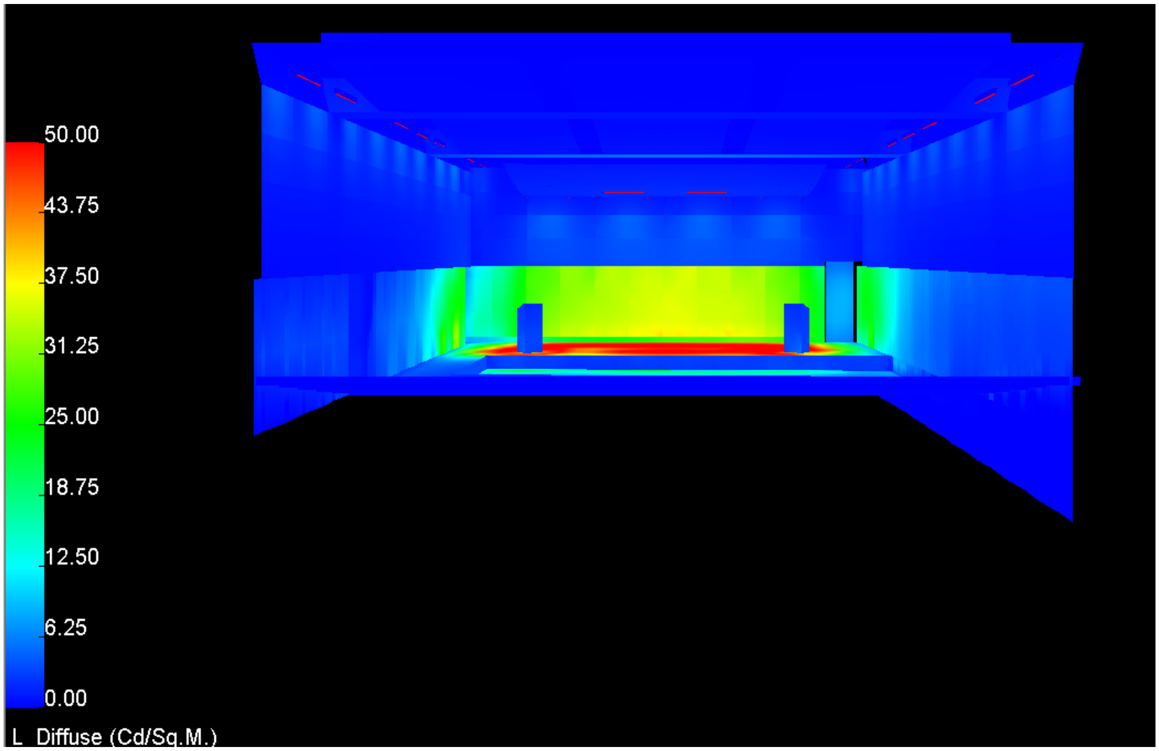


Left: View over stage, luminance pseudo color rendering
(Podium Speakers –Overhead Stage Lights Full Output, WallWashers 25%)
Right: View over steps, luminance pseudo color rendering
(Podium Speakers –Overhead Lights Off, WallWashers 25%, Step lights On)

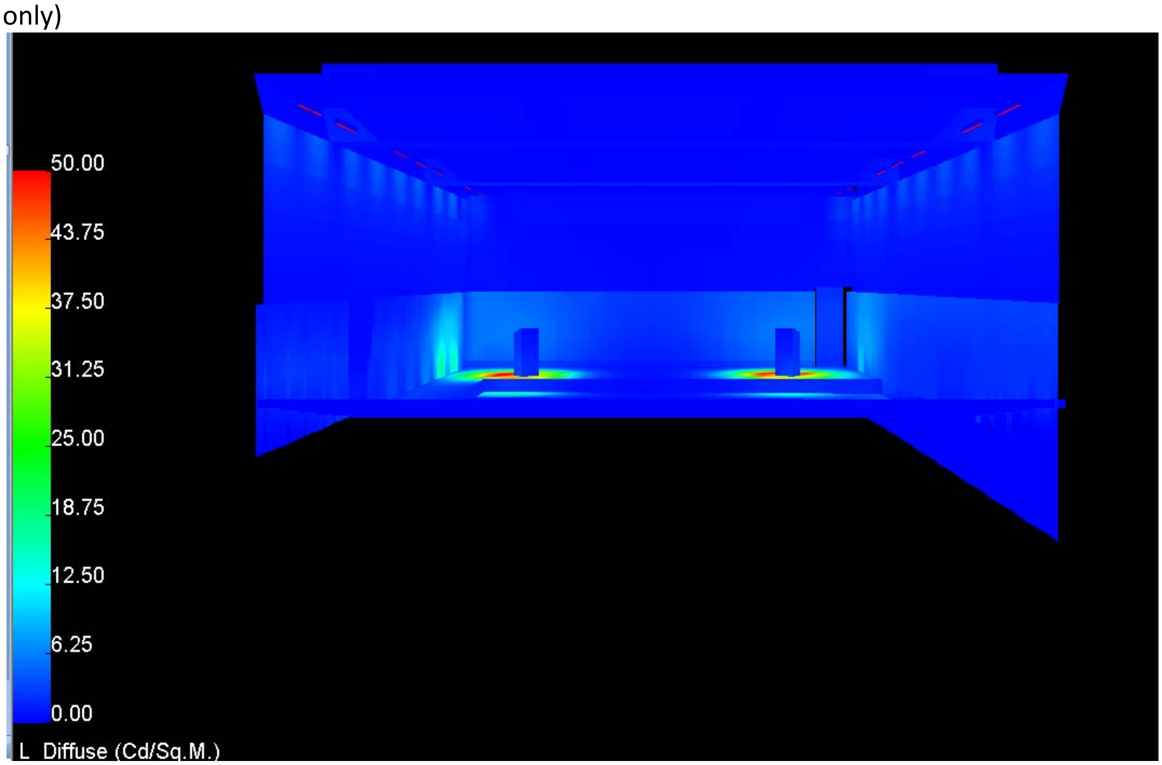


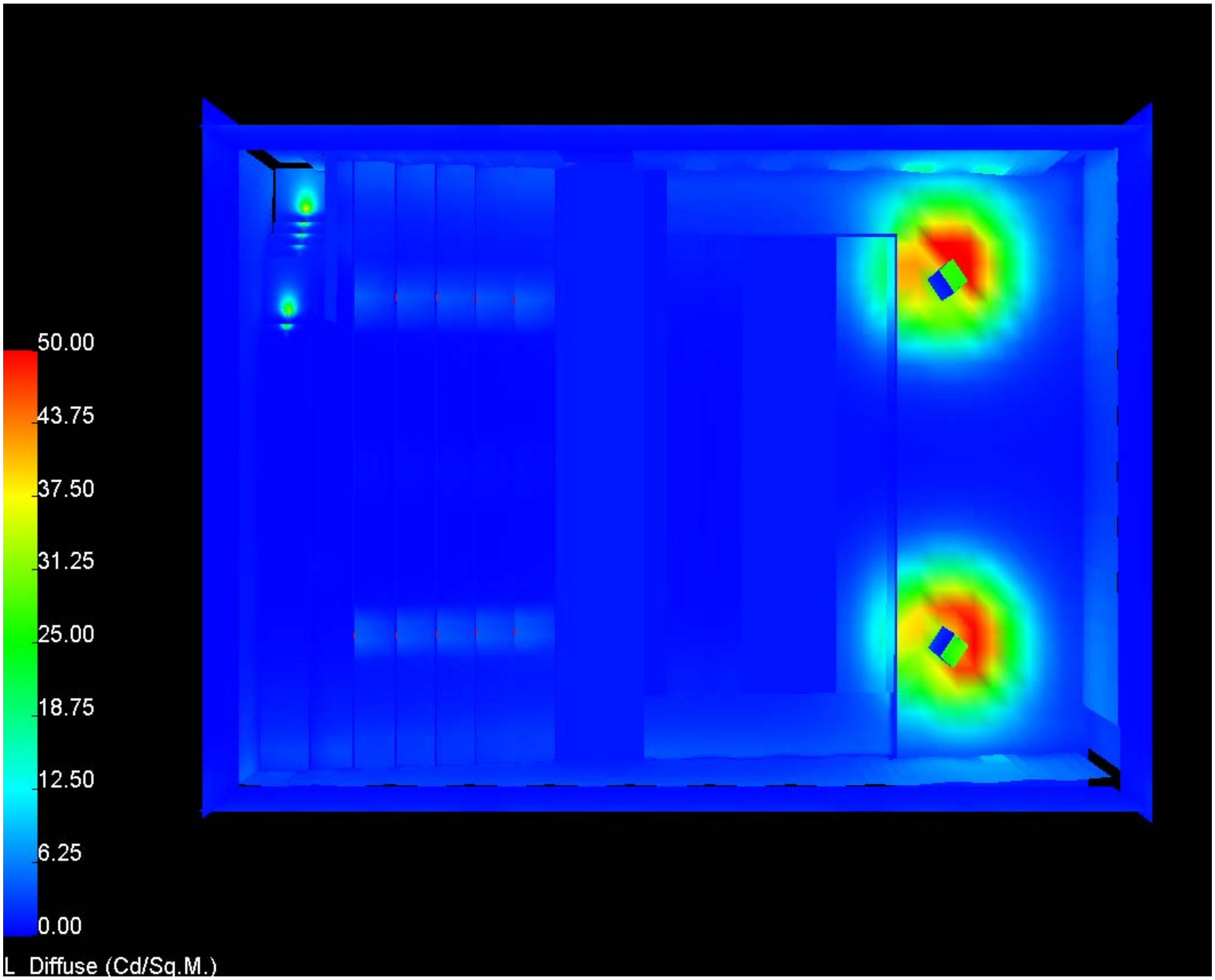
Above: View looking towards stage, luminance pseudo color rendering
(Podium Speakers –Overhead Stage Lights Full Output, Overhead Audience Off, WallWashers 25%)
Below: View of meeting room section, luminance pseudo color rendering
(Podium Speakers –Overhead Stage Lights Full Output, Overhead Audience Off, WallWashers 25%))



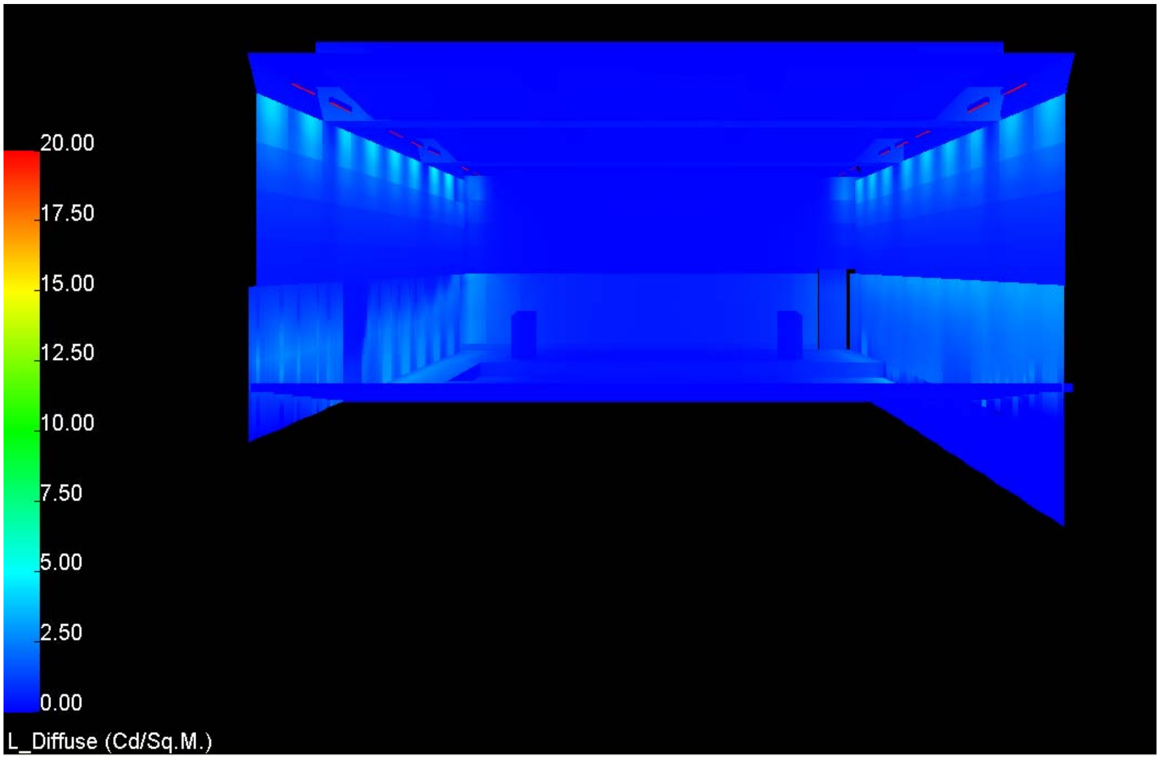


Above: View looking towards stage, luminance pseudo color rendering
(Podium Speakers –Overhead Stage Lights Full Output, Overhead Audience Off, WallWashers 25%)
Below: View looking towards stage, luminance pseudo color rendering
(Podium Speakers with Projection Scene –Overhead Lights Off, WallWashers 25%, Accent Lights on stage only)

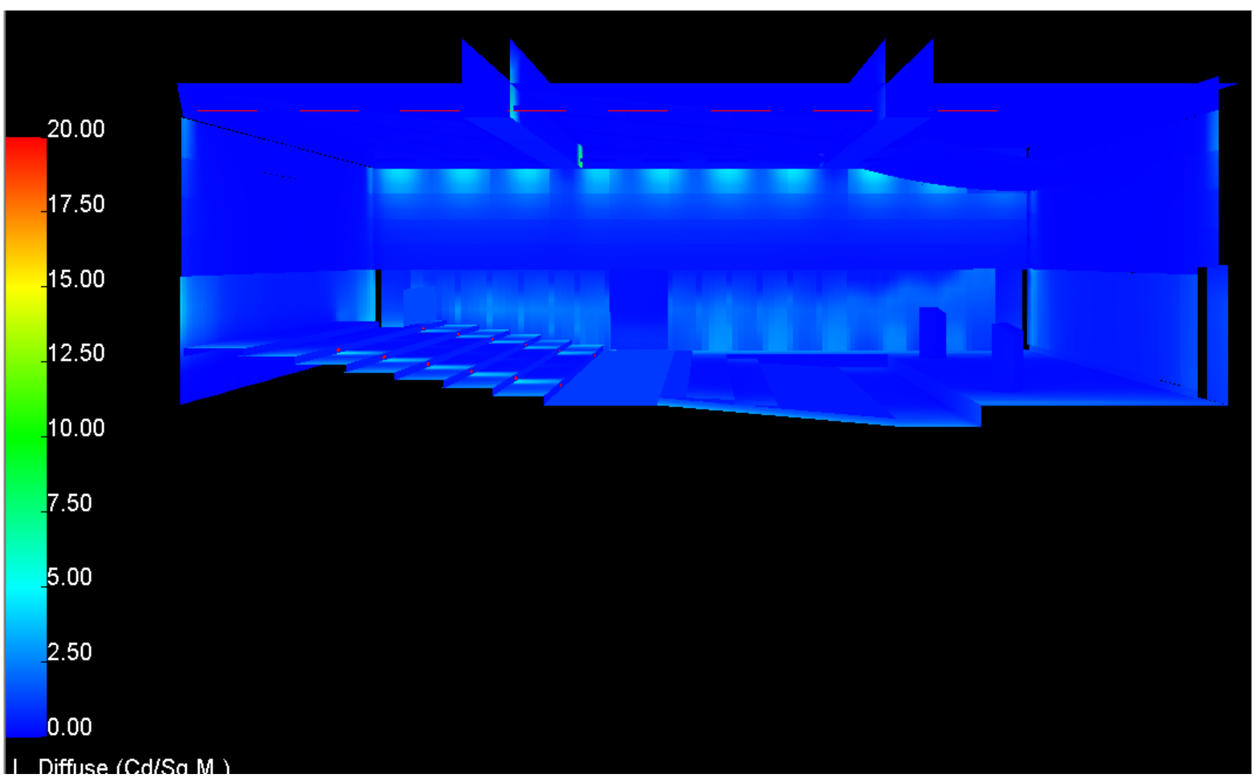




Above: View over meeting room, luminance pseudo color rendering
(Podium Speakers with Projection Scene –
Overhead Lights Off, WallWashers 25%, Accent Lights on podiums only, step lights on)



Above: View looking towards the stage, luminance pseudo color rendering
(Projection Scene –Overhead Lights Off, WallWashers 25%, step lights On)
Below: View of meeting room section, luminance pseudo color rendering
(Projection Scene –Overhead Lights Off, WallWashers 25%, step lights On)



Meeting Room: Power Density

Fixture	Ballast Watts	Quantity (lamps)	BF	Total Watts
F11	73	24	1.0	1752
F12	50	10	1.0	500
F13	2	18	1.0	36
F14	32.6	26	1.0	847.6
Space Type ASHRAE 90.1			Conference/ Meeting Space	
Area (ft^2)			2970 Total	
Allowable LPD (W/ft^2)			1.3	
Allowable Watts			3861	
Actual LPD (W/ft^2)			1.05	
Actual Watts			3136	

Analysis was done using the space-by-space method

Meeting Room: Performance Summary

Multiple scene settings sufficiently adapt the lighting for the variety of activities in the meeting room. All lights, with exclusion of the track light, are recessed due to the rear projection. The track lights are tucked up between the ceiling panels. Visual clarity is achieved with the overhead lighting and some peripheral wall emphasis. Architectural details, like the undulating wall appear to have depth with the peripheral lighting. During meetings when reading and writing may occur in the audience seating, an average horizontal illuminance of around 30 fc is met. The speakers standing at the podiums have a vertical illuminance of 43 fc, exceeding the required level. The increased luminance ratio on the stage podiums make them stand out and very visible to the audience. With the usage of cinema scene lighting, vertical illuminance is limited on the projector screen averaging about 1 fc which is well below the required minimum. The Lutron Grafix Eye allows for the client to choose which scenes are desirable for the space. Almost all the lamps are dimmable with the exclusion of the LED step lights. Warmer CRI and CCT in lamps such as the halogen lamps render the warm colors and wood tones well in the space, making it appear inviting. Overall, the room achieves multi-functionality with light and is below the power density with 1.05 W/ft^2.

Meeting Room: Controls

The Lutron Grafik Eye allows for multiple preset lighting scenes which could include a meeting scene (filling the room with ambient light) for note-taking and presentations, a video projection scene (minimal amounts of light), and combinations of scenes between these two extremes, which include video projections during speaker presentations. Massachusetts Public Library librarians can choose the 4 commonly used scenes and store an additional 12 scenes within the control unit; this would allow for more flexibility of the space and energy savings because all the lamps in the space are dimmable with the exclusion of the LED step light. Light levels fade smoothly between scenes within the grafik eye settings. The control box is located at the front of the auditorium on the stage area. The room is also controlled by an occupancy sensor so that lights automatically shut off if the room is unoccupied. To view more about the zone controls please see the electrical portion of the report.
Dimming Lights further in multiple architectural preset scenes. The few three basic scenes calculated reach required footcandle levels, however clients may desire more scenes with dimmed light. The focal point fixture can be circuited so that the MR-16 lights and fluorescent lights can be operated separately and dimmed accordingly.

Meeting Room: Electrical Characteristics

Panelboard DC4NBA serves the branch circuits in the meeting room. Emergency fixtures are on panelboard DC4LSB which is located beside DC4NBA in B110, the electrical room in the basement. The new lighting design is placed on the same circuits as the existing lighting design. The remainder of the panelboard is unknown so some assumptions were made to complete the electrical calculations.

Please refer to the appendix to view the lighting plans

Load Calculations

Label	Location	W	VA	A	PF	QTY	∑VA	∑A	Circuit
F11	Ceiling Panel	125.2	125.2	1.04	1	12	1502.4	12.52	DC4NBA-13,14,11,12
F12	Track	50	50	0.42	1	10	500	4.17	DC4NBA-8,9,10
F13	Steps	2	2	0.02	1	18	36	0.30	DC4NBA-19
F14	Walls	32.6	32.6	0.27	1	24	782.4	6.52	DC4NBA-15,16,17,18

LUTRON LIGHTING DIMMING PANEL-DC4NBA					LOCATION: Meeting Room	
ZONE	FIXTURE TYPE	VOLTAGE	SOURCE	CIRCUIT NO.	LOAD VA	CONTROL
1	F11	120	NORMAL	13	194.4	GRAFIK EYE
2	F11	120	NORMAL	14	360	GRAFIK EYE
3	F11	120	NORMAL	11	194.4	GRAFIK EYE
4	F11	120	NORMAL	12	360	GRAFIK EYE
5	F12	120	NORMAL	8	150	GRAFIK EYE
6	F12	120	NORMAL	9	200	GRAFIK EYE
7	F12	120	NORMAL	10	150	GRAFIK EYE
8	F14	120	NORMAL	15	194.4	GRAFIK EYE
9	F14	120	NORMAL	16	259.2	GRAFIK EYE
10	F14	120	NORMAL	17	194.4	GRAFIK EYE
11	F14	120	NORMAL	18	129.6	GRAFIK EYE
12	F13	120	NORMAL	19	36	GRAFIK EYE

ARCHITECTURAL PRESETS			
SET	DESCRIPTION	FIXTURE -PERCENT	ZONE
1	MEETING	100%	1,2,3,4,5,6,7,8,9,10,11
2	2 SPEAKERS	100%	5,7,11,12
		25%	8,9,10
3	1 SPEAKER	100%	7,11,12
		25%	8,9,10
4	PROJECTION ONLY	100%	12
		25%	8,9,10

PANELBOARD SIZING WORKSHEET

Panel Tag-------------------------->					DC4NBA	Panel Location:			Elec. Closet B110		
Nominal Phase to Neutral Voltage------->					120	Phase:			3		
Nominal Phase to Phase Voltage-------->					208	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A				0	w	1.00	0	0		
2	A				0	w	1.00	0	0		
3	B				0	w	1.00	0	0		
4	B				0	w	1.00	0	0		
5	C				0	w	1.00	0	0		
6	C				0	w	1.00	0	0		
7	A				0	w	1.00	0	0		
8	A	Track Light	5	Basement	150	w	1.00	150	150		
9	B	Track Light	5	Basement	200	w	1.00	200	200		
10	B	Track Light	5	Basement	150	w	1.00	150	150		
11	C	Down Light	3	Basement	194.4	w	1.00	194	194		
12	C	Down Light	5	Basement	360	w	1.00	360	360		
13	A	Down Light	3	Basement	194.4	w	1.00	194	194		
14	A	Down Light	5	Basement	360	w	1.00	360	360		
15	B	Wall Washer	3	Basement	194.4	w	1.00	194	194		
16	B	Wall Washer	3	Basement	259.2	w	1.00	259	259		
17	C	Wall Washer	3	Basement	194.4	w	1.00	194	194		
18	C	Wall Washer	3	Basement	129.6	w	1.00	130	130		
19	A	Step Light	9	Basement	36	w	1.00	36	36		
20	A				0	w		0	0		
21	B				0	w		0	0		
22	B				0	w		0	0		
23	C				0	w		0	0		
24	C				0	w		0	0		
25	A				0	w		0	0		
26	A				0	w		0	0		
27	B				0	w		0	0		
28	B				0	w		0	0		
29	C				0	w		0	0		
30	C				0	w		0	0		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								2.4	2.4	Amps=	6.7
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					0.7	0.7	31%	6.2
PHASE TOTAL			B					0.8	0.8	33%	6.7
PHASE TOTAL			C					0.9	0.9	36%	7.3
LOAD CATAGORIES				Connected			Demand				Ver. 1.03
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0		0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			1.2	1.2		1.2	1.2	1.00		
4	HID lighting			0.0	0.0		0.0	0.0			
5	incandescent lighting			1.2	1.2		1.2	1.2	1.00		
6	HVAC fans			0.0	0.0		0.0	0.0			
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			0.0	0.0		0.0	0.0	1.00		
Total Demand Loads							2.4	2.4			
Spare Capacity				20%			0.5	0.5			
Total Design Loads							2.9	2.9	1.00	Amps=	8.1

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W	PANEL TAG: DC4NBA	MIN. C/B AIC: 10K
SIZE/TYPE BUS: 100A	PANEL LOCATION: Elec. Closet B110	OPTIONS: PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN: 100A/3P C/B	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
0	0	0	20A/1P	1	*			2	20A/1P	0	0	0
0	0	0	20A/1P	3		*		4	20A/1P	0	0	0
0	0	0	20A/1P	5			*	6	20A/1P	0	0	0
	0	0	20A/1P	7	*			8	20A/1P	150	Basement	Track Light
Track Light	Basement	200	20A/1P	9		*		10	20A/1P	150	Basement	Track Light
Down Light	Basement	194	20A/1P	11			*	12	20A/1P	360	Basement	Down Light
Down Light	Basement	194	20A/1P	13	*			14	20A/1P	360	Basement	Down Light
Wall Washer	Basement	194	20A/1P	15		*		16	20A/1P	259	Basement	Wall Washer
Wall Washer	Basement	194	20A/1P	17			*	18	20A/1P	130	Basement	Wall Washer
Step Light	Basement	36	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	0.74	TOTAL DESIGN LOAD (KW)	2.91
CONNECTED LOAD (KW) - B	0.80	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C	0.88	TOTAL DESIGN LOAD (AMPS)	8

The remainder of the panelboard is unknown so some assumptions were made to complete these electrical calculations. The new electrical circuits are not highlighted because all of the information provided includes the new lighting loads.

Assumed Total Load:
42 * 20A * 480V * 0.7 = 282.24 kVA

42- 20A/1P - 12-20A/1P = 30-20A/1P Existing
(30*20) = 600A * 0.7 = 420 A

420 A + (New Design Load: 4 A) = 424 A

Feeder Size:

700 MCM THW Copper in 3.5" Conduit (460A Capacity)

Acoustics Breadth Study-Meeting Room

If architectural details are changed due to the lighting scheme it will impact the dynamics of the room and the acoustics of the space. Originally, the architect stated that the floor in the auditorium may either be a gray carpet or a bare finished concrete; the latter of the two would be a more sustainable option. Initially, the entire room was meant to be covered in wood acoustical panels however, the bottom portions of the walls were changed to a lighter color in order to reflect light to make the curved walls appear to have more depth. These changes have a huge impact on the reverberation time in the space.

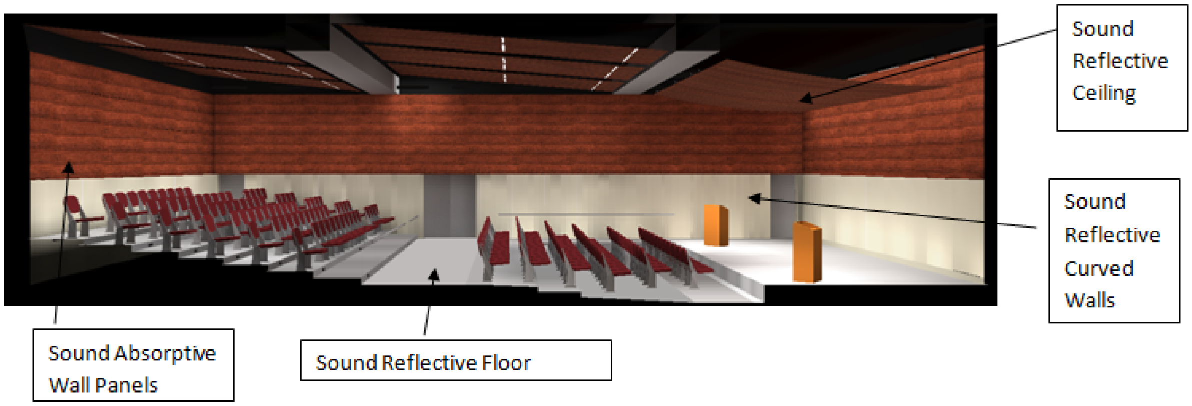
Due to the usage of the space the optimum reverberation time should be that of a lecture room or cinema, which is approximately 1.0 second.

Reverberation time is calculated by the equation: ET(sec) = (0.05V)∑A (Sabians)

The reverberation time of a room depends on the surface area and absorption coefficient (measured in sabians) of each material in the space. Sound-absorbing materials can be used to control reverberation so speech will not be garbled. When correctly used, sound-absorbing materials can be effective in controlling noise buildup within a room and can also be used to control echoes

In spaces such as the meeting room, unobstructed sight lines from all seats to the front of the forestage allow for full view of speakers and unobstructed propagation of the direct sound. In the ceiling, the flat, hard-surfaced, wood elements, oriented properly, can effectively distribute reflected sound.

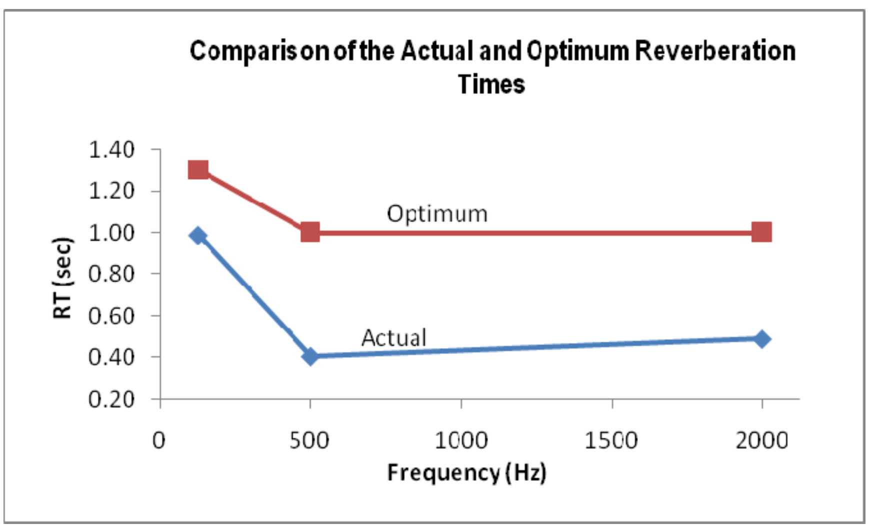
Therefore, the new design of the space includes wood wall sound-absorbing panels on the upper portions of the walls, and sound reflective curved gypsum wallboard on the lower portions of the walls. The tilted ceiling panels are made of a hard sound-reflective wood unlike the wall panels to project sound further back in the space.



Although the concrete floor being sound reflective may be concerning at first due to echo, the sound absorption created by the seating and occupants eliminates this problem. After all of these changes within the space, the reverberation time is improved from approximately 0.41 seconds for a frequency of 500 Hz to 1.06 seconds at 500 Hz which is much closer to the optimum reverberation time for the space. The following tables include the material properties for the different elements and the calculations for reverberation time. A graph displays the actual reverberation time in comparison to the optimum.

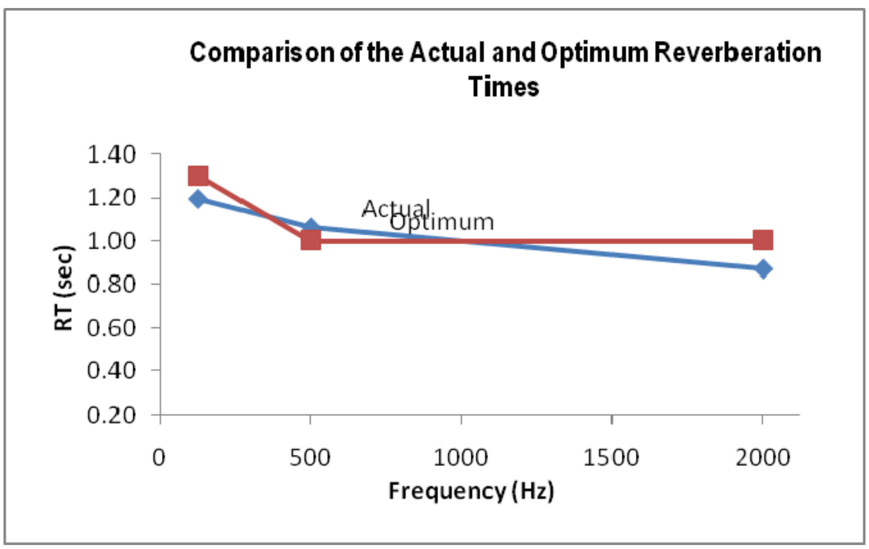
Calculations-Original Design

Original Design Reverberation Time (with all wood panels and carpet floor)				
Element	Units	Frequency (Hz)		
		125	500	2000
1. Wood Wall Panels	α	0.40	0.80	0.30
4507	Sα (sabins)	1802.80	3605.60	1352.10
Area ft2				
2. Wood Stage Floor	α	0.15	0.10	0.07
792	Sα (sabins)	118.80	79.20	55.44
Area ft2				
3. Wood Ceiling Panels	α	0.21	1.15	0.79
2251	Sα (sabins)	472.71	2588.65	1778.29
Area ft2				
5. Carpet Floor	α	0.02	0.14	0.65
2022	Sα (sabins)	40.44	283.08	1314.30
Area ft2				
6. Gypsum Ceiling	α	0.29	0.05	0.09
563	Sα (sabins)	163.27	28.15	50.67
Area ft2				
9. Seats (Fully Occupied)	α	0.39	0.80	0.87
1720	Sα (sabins)	670.80	1376.00	1496.40
Area ft2				
10. Air	m	0.00	0.00	0.01
64659	mV (sabians)	0.00	0.00	581.93
Volume ft3				
Total absorption, ΣA (sabins) fully occupied room		**3268.8**	**7960.7**	**6629.1**
RT (sec) = (0.05V)/ΣA		**0.99**	**0.41**	**0.49**
Optimum RT_{500} = 1.0 RT_{125} = 1.3(1.0) = 0.91		1.3	1	1



Calculations-New Design

New Design Reverberation Time (with new walls and concrete floor)				
Element	Units	Frequency (Hz)		
		125	500	2000
1. Wood Wall Panels	α	0.29	0.55	0.53
2180	Sα (sabins)	632.20	1199.00	1155.40
Area ft2				
2. Wood Stage Floor	α	0.15	0.10	0.07
792	Sα (sabins)	118.80	79.20	55.44
Area ft2				
3. Wood Ceiling Panels	α	0.19	0.09	0.05
2251	Sα (sabins)	427.69	202.59	112.55
Area ft2				
4.Gypsum Wall	α	0.29	0.05	0.09
2327	Sα (sabins)	674.83	116.35	209.43
Area ft2				
5. Concrete Floor	α	0.01	0.02	0.02
2022	Sα (sabins)	20.22	40.44	40.44
Area ft2				
6. Gypsum Ceiling	α	0.29	0.05	0.09
563	Sα (sabins)	163.27	28.15	50.67
Area ft2				
9. Seats (Fully Occupied)	α	0.39	0.80	0.87
1720	Sα (sabins)	670.80	1376.00	1496.40
Area ft2				
10. Air	m	0.00	0.00	0.01
64659	mV (sabians)	0.00	0.00	581.93
Volume ft3				
Total absorption, ΣA (sabins) fully occupied room		**2707.8**	**3041.7**	**3702.3**
RT (sec) = (0.05V)/ΣA		**1.19**	**1.06**	**0.87**
Optimum RT_{500} = 1.0 RT_{125} = 1.3(1.0) = 0.91		1.3	1	1



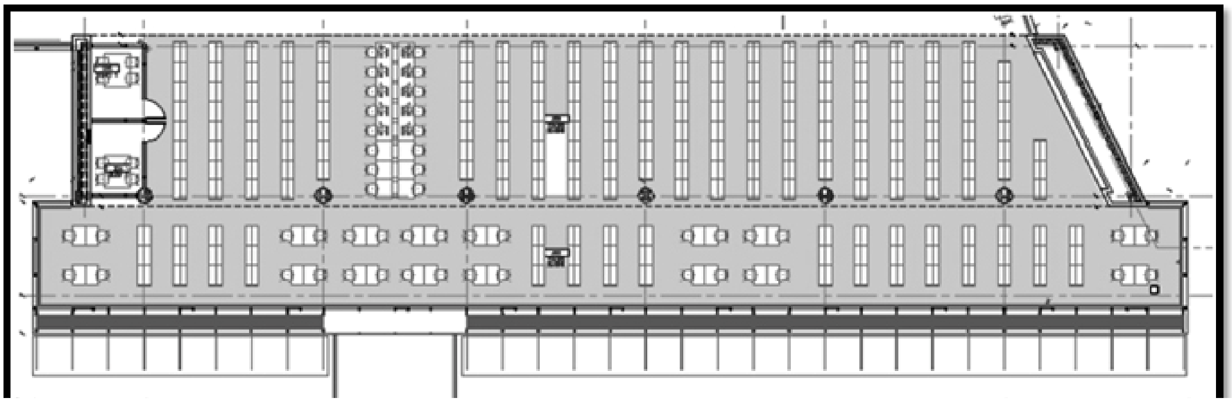
Lighting Depth Study- Stacks & Seating Area

Stacks & Seating Area: Summary of Space

As an occupant climbs to the second floor they are welcomed by a warm flood of daylight and a large open floor plan. Past a circulation area, similar to that of the first floor, is a very sizeable stacks area in combination with a seating zone. After selecting a book in the stacks a patron can find seating neighboring an extensive state-of-the-art curtain wall facade. This facade has operable concealed vent-type factory-glazed awning windows and cantilevered glass sun-shading visors, which provide the library with an abundance of daylight year round. Because of this people may admire optimal views of the library's park. The ceiling in this seating region reflects light into the stacks due to the perforated acoustical aluminum specular ceiling panels. All furniture, including the stacks, are evenly spaced throughout, and run perpendicular to the windows. The 12’-6” ceiling over the seating area is reduced by a foot over the stacks and the ceiling alters to acoustical wood ceiling panels. The very few walls of the space are gypsum wall board and painted white. In addition to seating for reading, there is a cluster of desks sandwiched between the stacks which include 16 computers. The room is 175’-0” in length and 41’-0” in width.

All typical libraries maintain this type of space in which patrons can acquire books in the stacks and read in the seating area. The large work space will mainly be utilized for occupants to do research on the computers or study at desks.

Location	Material/Tag	Description/Color	Reflectance
Flooring	CPT 1- Carpet 1 Flooring	Light Gray Color	0.33
Furniture	Book Shelves, Chairs and Desks	Maple Wood (Tan/Brown Color with Reddish Tint)	0.22
Window Facade	Structural Insulated Glass System (08920 ENG.SYS. 1)	Low-E, Low-Iron glass	Transmittance- 0.7
Ceiling over stacks	Wood Ceiling Panels (09515)	Maple Wood	0.22
Ceiling over seating	Aluminum Ceiling Panels COLOR 2 (09515)	Perforated Acoustical Aluminum Ceiling Panels with White Powdercoated finish	0.74
Walls	PTD GWB Gypsum Wall Board (09522)	White Painted- Gypsum Wall Board	0.76



Stacks & Seating Area: Design Criteria

<u>IESNA Design Criteria</u>

Libraries (Reading Stacks- Seating near stack area)

Very Important Criteria:
Direct Glare
Source, Task, Eye Geometry
Horizontal Illuminance- Category D- 30 fc
Important Criteria:
Appearance of Spaces and Luminaires
Color Appearance (and color contrast)
Light Distribution on Surfaces
Light Distribution on Task Plane (uniformity)
Somewhat Important Criteria:
Modeling of Faces of Objects

Libraries (Book stacks)

Very Important Criteria:
Vertical Illuminance- Category D- 30 fc
Important Criteria:
Color Appearance and color contrast)
Direct Glare
Somewhat Important Criteria:
Appearance of Space and Luminaires
Light Distribution on Surfaces
Light Distribution on Task Plane (uniformity)

Appropriate Design Considerations

- <u>Aesthetic Criteria:</u>

Because the space is for the public, the **appearance of space and luminaires** is important. The space maintains a very linear and **uniform** architectural pattern. The furniture is **rectangular, linear** and **evenly spaced** in layout; the luminaires should mimic the same type of geometry and spacing.

- Appearance Criteria:
  The architectural plan of the entire building is very **open** and connected to the outdoors. The lighting in the stacks/seating should sustain this feeling and illuminate the space with **ambient light.** Each room appears to flow to the next area and the lighting **should not segregate spaces** harshly. The luminaires should run **continuously** complimentary to the architectural flow.

- Light Quality and Color Appearance:
  Also listed in IESNA, was the importance of **color appearance.** The color of the seating area and book shelves should appear warm and inviting. As most of the interior is wood, the lamps should render a **warmer CRI and CCT**. The lamps should be around **3000 K** CCT with a **high CRI (close to 100).** The CCT of daylight is much higher than this CCT, however the human eye can more easily adapt to daylighting than electric lighting.

- Controls Criteria:
  Since the curtain wall facade provides the library with an abundance of daylight year round, **daylighting sensors** should be installed. It is important to integrate natural light and create a balance of electric lighting. Also, because public libraries are typically open no later than 8 pm, **time clocks** must be utilized within this facility. It is very important to have lights turned off in all vacant spaces. Controls should be located in an area librarians can easily access, and the public cannot tamper with.

- Glare Criteria:
  IESNA lists **direct glare** as a very important issue with work tasks such as reading and writing. Glare occurs when one part of the visual scene is much brighter than the remainder. It can impair vision, cause discomfort and reduce task performance. Therefore, **source, task, eye geometry** must be considered for both horizontal desk tasks and vertical computer tasks, due to direct glare and **veiling reflection.**

- Illuminance/Luminance Criteria:
  For tasks such as reading and writing, the **average maintained illuminance levels** should not exceed **50 fc** on the **horizontal work plane.** As IESNA stated, the horizontal illuminance should be around **30 fc** and **uniformly** light the work plane. The **luminance ratio** between a task and the adjacent surround should be no greater than **3:1**.

- Quality of Lighting:
  The wooden furniture and flooring in the space should have a matte property to reduce the **reflected glare.** Luminaires should be positioned to reduce **human shadows** over the work plane. More importantly, luminaires must be strategically placed over the **bookshelves** to **minimize shadows.** Placing multiple sources over the work plane, to create an abundance of ambient light will reduce shadowing over the desk. Similarly, creating **adequate ambient lighting** in the stacks area will diminish shelving shadows. Positioning luminaires parallel to shelving, in aisles, can assist with this. Also, situating shelving perpendicular to the windows will reduce shadows created by daylighting. **Vertical illuminance** on book shelves is very critical in the space. The library will be

explored by all age ranges, and it is important for titles and code numbers to be easily read. Not only is vertical illuminance important, but maintaining **uniform luminance** on the books is crucial. A uniform vertical luminance can be maintained through highlighting shelves with the assistance of ample ambient light.

- Aesthetic Night Light:
  To create an appealing view at night, the building facade should "glow" from within. Because the geometry of the facade is very linear and uniform, the glow should accentuate the buildings' linear lines. The glow can be created by illuminating structure of the facade from within. Washing the interior visible vertical surfaces such as the shelves or interior walls create an exterior night glow.

- Maintenance Issues:
  Lamps for this room must maintain a good CRI and CCT. Lamps which are dimmable must be considered for daylighting integration. Lamps must be **distinguishable** for the ease of replacement (no lamps of the same size and shape should share two different wattages etc.). Luminaires out of reach of ladder assistance must maintain a higher life expectancy.

- Power Density:
  According to ASHRAE 90.1, the power density for the library stacks area is **1.7 W/ft^2**.

Stacks & Seating Area: Lighting Design Concept

The stacks and seating area, located on the second floor, is flooded with daylight through the state-of-the-art curtain glass façade wall. Due to the curtain wall, daylight sensors are utilized for this area. Because of the tasks involved in this space, the main impression of the room is visual clarity. Similar to the other rooms, the lighting for the stacks and seating area enhances the flow of open space. The overall theme of the library is the idea that the community of a library is guided with "words of light". The lighting design in this space maintains a visual hierarchy of light; focusing light on the stacks and seating area. Small details throughout the design, such as the Louis Poulsen pendants over the seating area, relate to the abstract idea of an open book.

To provide light on the stack area, Elliptipar's stack-light floats between stack aisles. Integrated into the shorter stacks are the Elextrix surface-mounted cove lights. These surface-mounted lights create a clean linear edge of light that grazes the books. To provide more ambient light and establish the feeling of an open space, indirect Electrix cove lights are incorporated into the architecture. The exterior view at night appears to “glow” from within. The very linear geometry of the architecture is well accentuated with the linear lighting design.

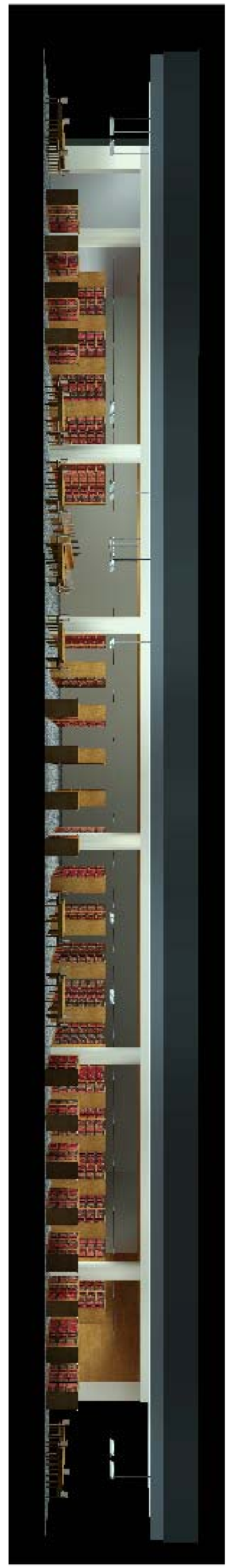
Please refer to appendix to view lighting plan

Stacks & Seating Area: Renderings

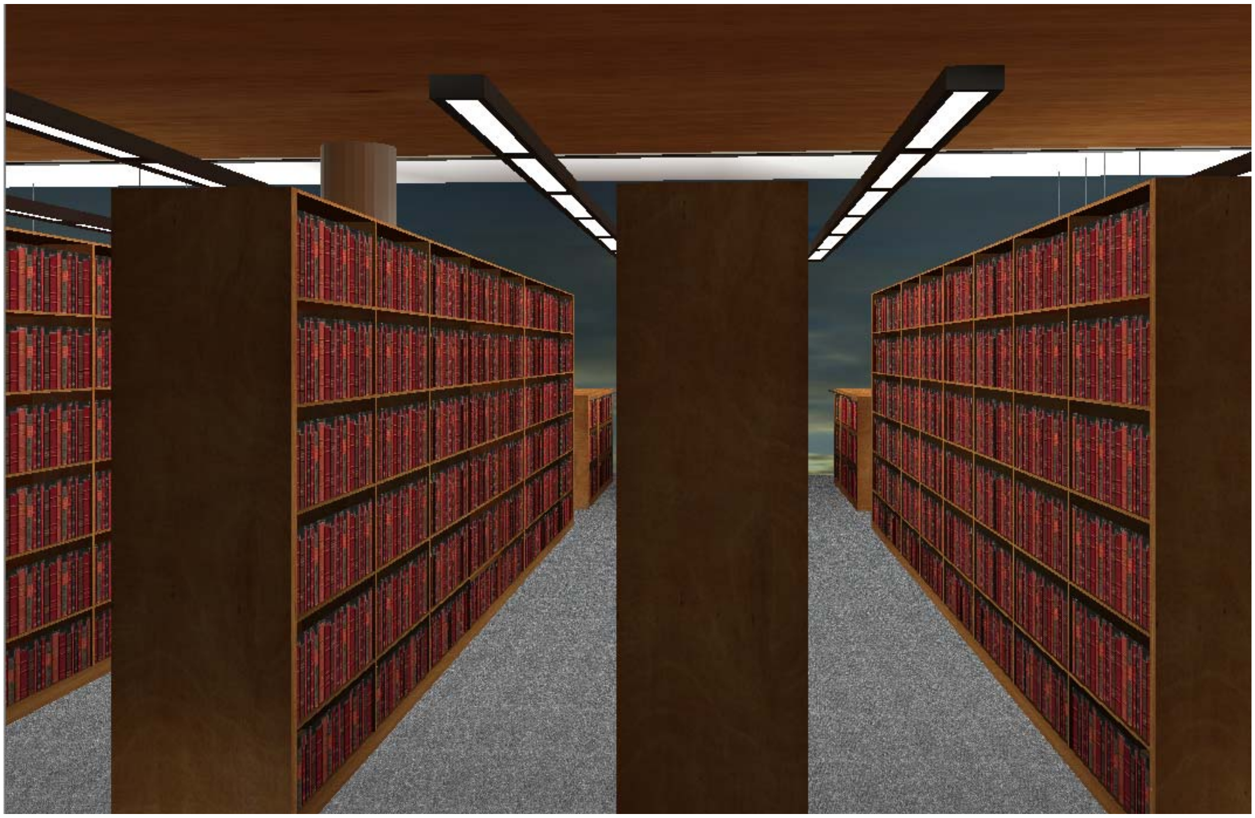
Above: Rendering of computer area

Above: Rendering of right perspective, view through exterior glass

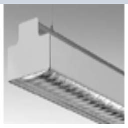
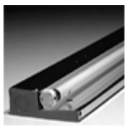
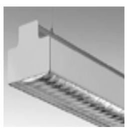
To the right: Rendering of entire floor from street view



Above: Rendering of library stacks, view from hallway
Below: Rendering of left perspective, view from exterior


Above: Rendering of stacks, view from hallway

Stacks & Seating Area: Fixture Schedule

Type		Mfr/Catalog #	Lamping	Notes
F1		**Elliptipar 3036-T128-X-01-2-EK-0-VE-S-99-48-0** Description: Suspended pendant 28W T5 linear fluorescent stack light. Cable mounted from ceiling. Optics are asymmetric with 6% uplight. Ballast:Advance ICN-2S28@ 277. Voltage: 277	1 - Osram Slyvania FP28/830PM/ECO F28T5 (48in) lamps	Location: 2nd Floor- Between Tall Stacks Suspended 8' AFF
F2		**Electrix illumination EX-28-S1-2-E-46-SD** Description: Low profile cove luminaire with 1-28WT5 lamp. Ballast: ADVANCE ICN-2S28@277-F28T5 Voltage: 277V	1 - Osram Slyvania FP28/830PM/ECO 1-28WT5	Location: 1st Floor- Entry Lobby, 2nd Floor-Cove Light Mount: Cove mounted in entry desk overhang. See Details.
F3		**Elliptipar 3036-T128-X-01-2-EK-0-ARS30480-VE-S-99-48-0** Description: Suspended pendant 28W T5 linear fluorescent stack light with roomside shield. Cable mounted from ceiling. Optics are asymmetric with 6% uplight. Ballast:Advance ICN-2S28@ 277.Voltage: 277	1 - Osram Slyvania FP28/830PM/ECO F28T5 (48in) lamps	Location: 2nd Floor- Between Tall Stacks Suspended 8' AFF. Same as F1 with roomside shield for asymmetric illumination.
F4		**Louis Poulsen X-DIR/IND-51.2-2/28W/T-5-SBL.GLASS** Description: Suspended fluorescent up/downlight with 2-F28T5 (48in) lamps. Optics: glare shield , frosted glass diffuse white lens. Ballast:Lutron EC5-T528-J-UNV-2. Voltage: 277	2 - Osram Slyvania FP28/830PM/ECO F28T5 (48in) lamps	Location: 2nd Floor- Over Desks Suspended 8' AFF
F5		**Electrix GTP-7-28-2-E-CUSTOM MOUNT** Description: 28W T5 adjustable linear fuorescent surface mount. Small profile is concealed easily within bookshelf. Reflectors lock with set screw and link to adjacent unit for symmetrical distribution.Ballast: Advance ICN-2S28@277 Voltage: 277	1 - Osram Slyvania FP28/830PM/ECO F28T5 (48in) lamps	Location: 2nd Floor- Small Book Shelf Custom adjustable 28W T5 linear fluorescent concealed in bookshelf. Covelight is adjusted to suit the needs of asymmetric surface mount. See Details.

Stacks & Seating Area: Light Loss Factors

Assumptions:

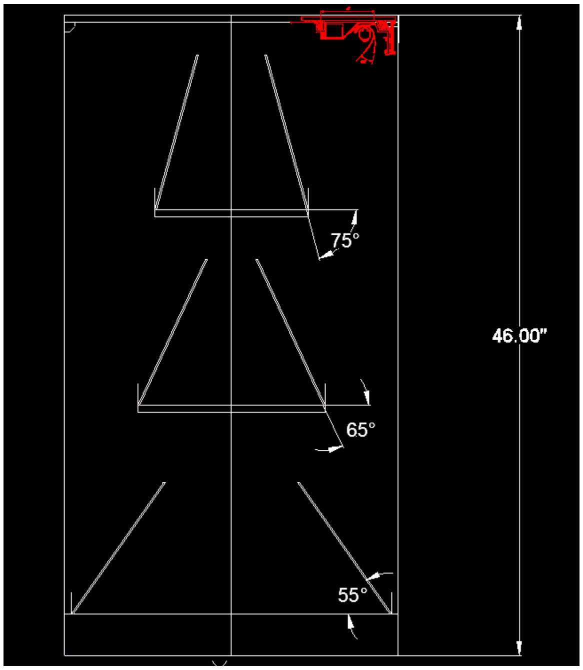
Degree of Dirt Conditions: Very Clean
Months: 12

Label	Maintenance Category	Distribution	LLD	LDD Mean/Initial	BF	Total LLF
F1- Stack Light	III	Direct-Indirect	0.93	0.9	1.04	0.84
F2- Cove Light	VI	Indirect	0.93	0.9	1.0	0.84
F3- Stack Light Ends	III	Direct-Indirect	0.93	0.9	1.04	0.84
F4- Decorative Pendant	V	Direct-Indirect	0.93	0.9	1.0	0.84
F5- Stack Light	VI	Indirect	0.94	0.9	1.04	0.94

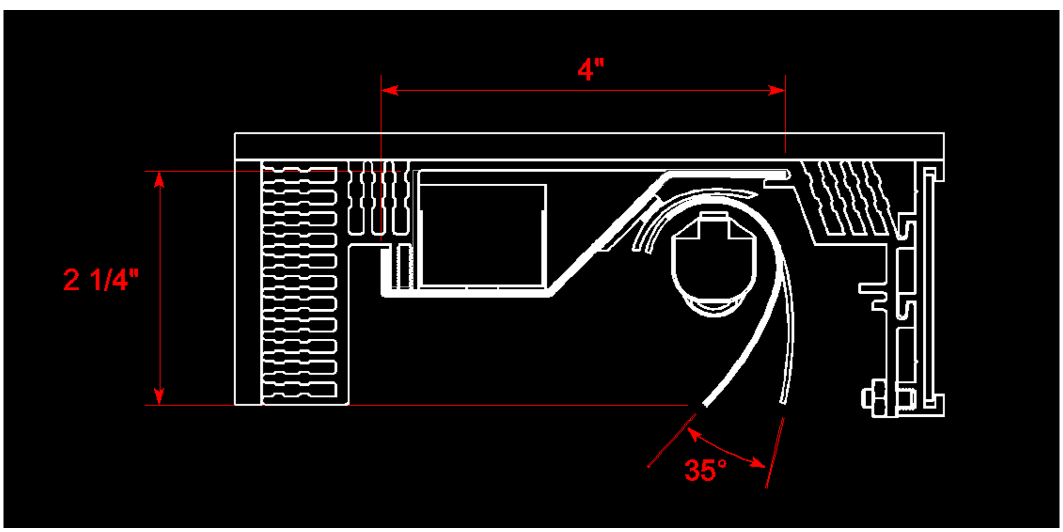
Stacks & Seating Area: Illuminance Calculations

Description	Location	Orientation	Units	Average	Max	Min	Avg/min	Max/Min
Stack Left	0’-7’ AFF	Vertical	FC	21.87	32.1	9.9	2.21	3.24
Stack Right	0’-7’ AFF	Vertical	FC	22.82	32.7	11.8	1.93	2.77
Computer Desk	2.5’-0” AFF	Horizontal	FC	27.04	33.6	18.1	1.49	1.86
Study Desk Left	2.5’-0” AFF	Horizontal	FC	29.64	34.1	25.7	1.15	1.33
Study Desk Right	2.5’-0” AFF	Horizontal	FC	28.80	33.4	24.9	1.16	1.34
Floor -tall stacks	0’-0” AFF	Horizontal	FC	27.27	50.1	NA	NA	NA
Floor-short stacks	0'-0" AFF	Horizontal	FC	42.8	50.4	NA	NA	NA

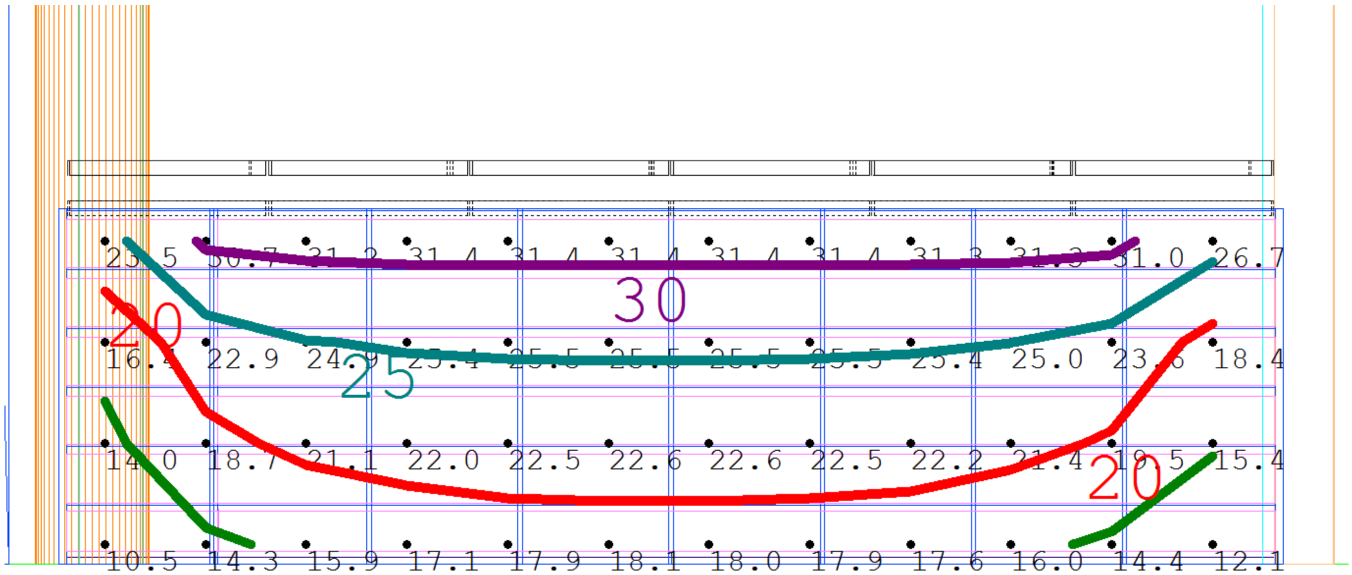
Stacks & Seating Area: Luminaire Details



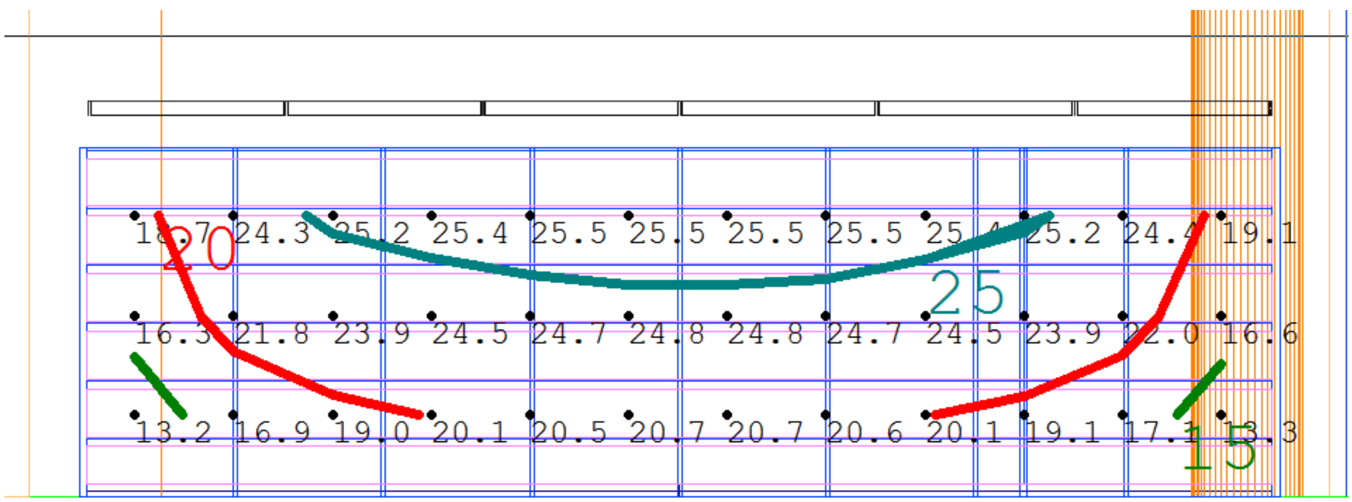
Above: Section of short stack with fixture F5
Below: Section of fixture F5

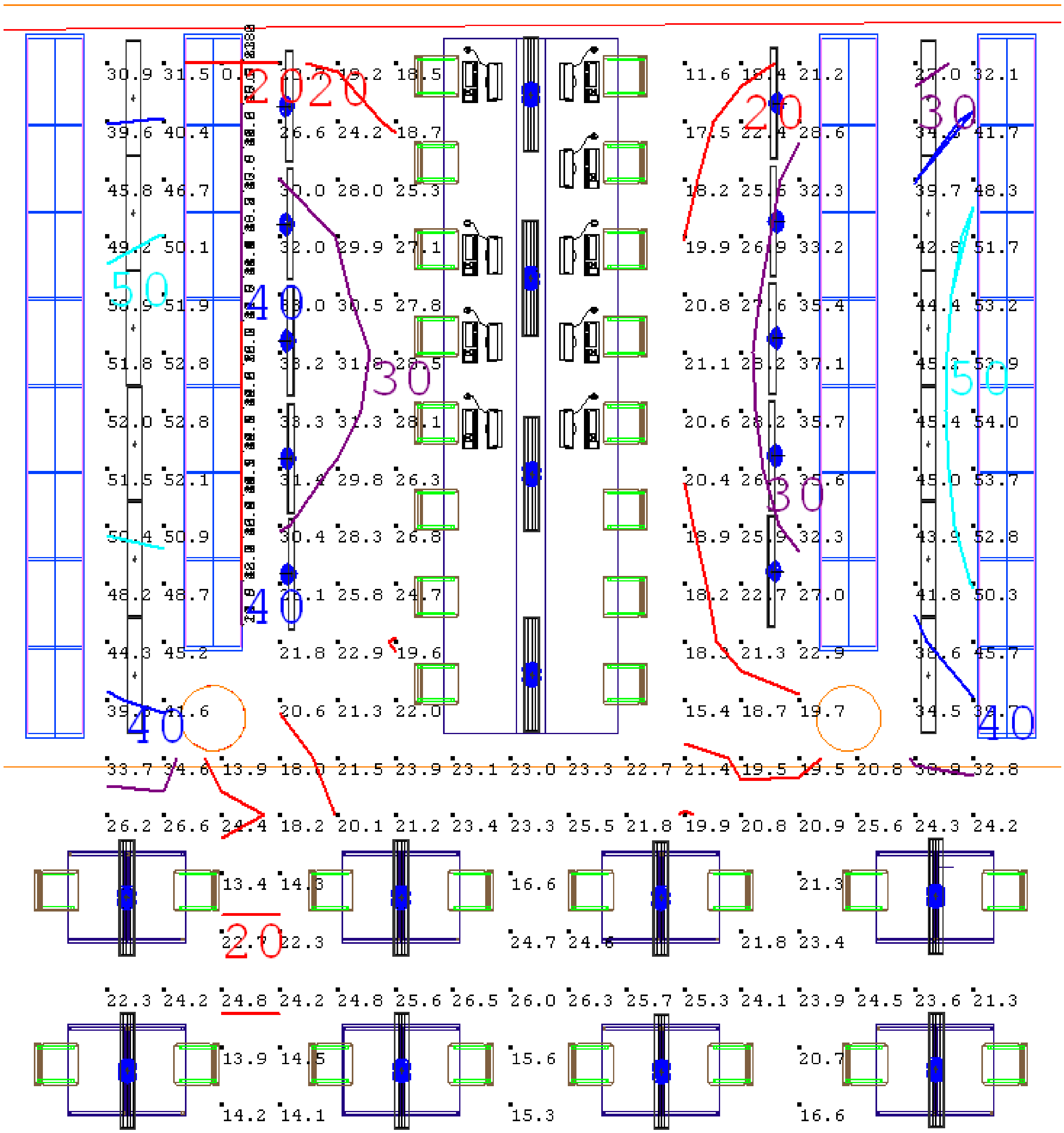


Stacks & Seating Area: Lighting Design Illuminance Calculations

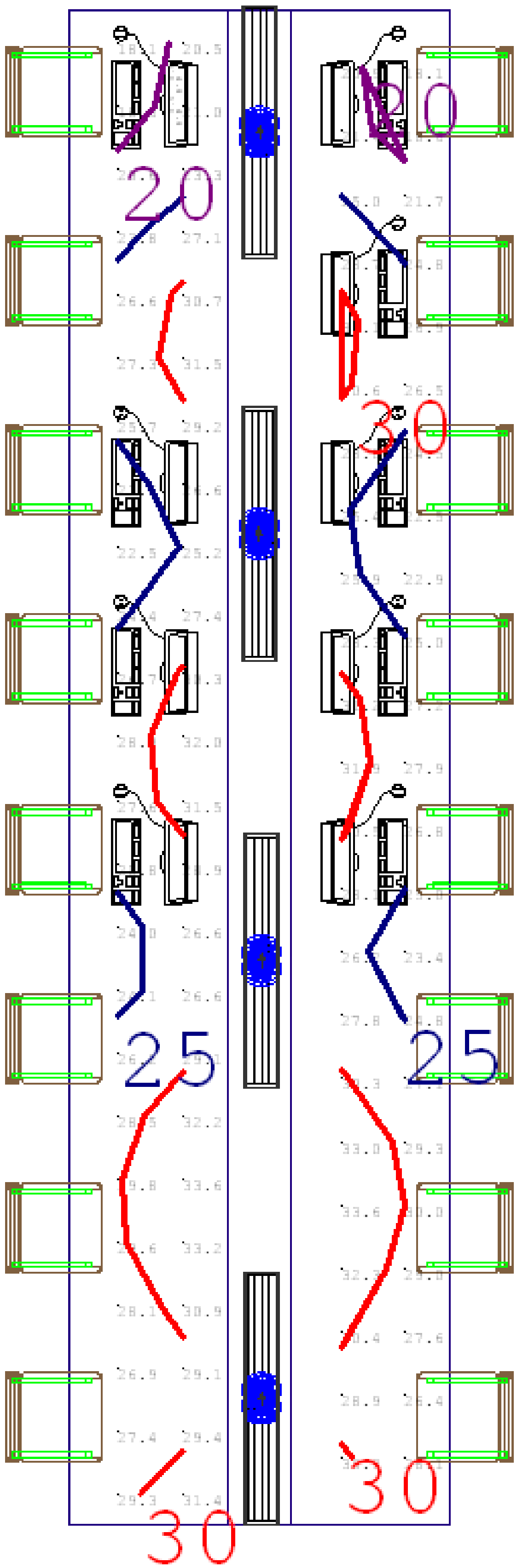


Above: View of stack to the left, vertical illuminance calculation
Below: View of stack to the right, vertical illuminance calculation



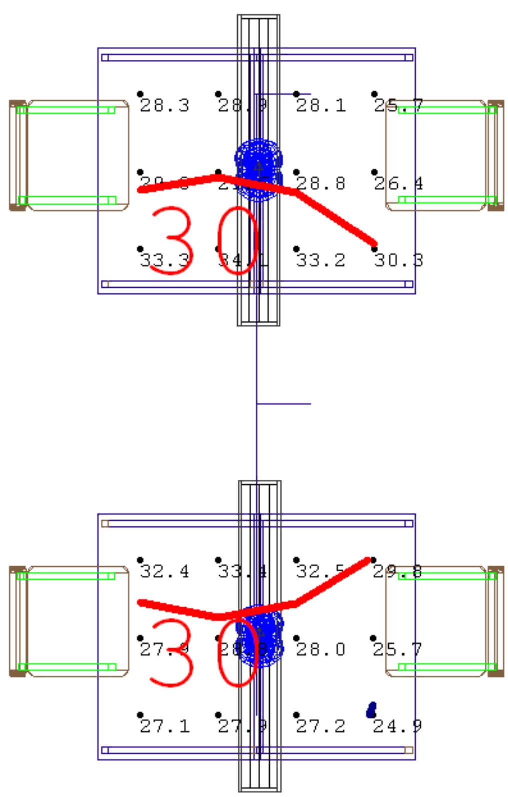


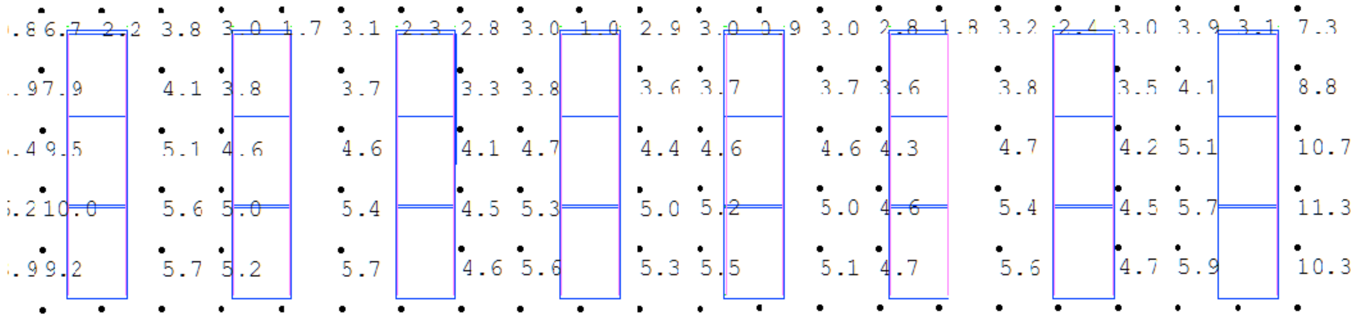
Above: Ground plane illuminance calculation



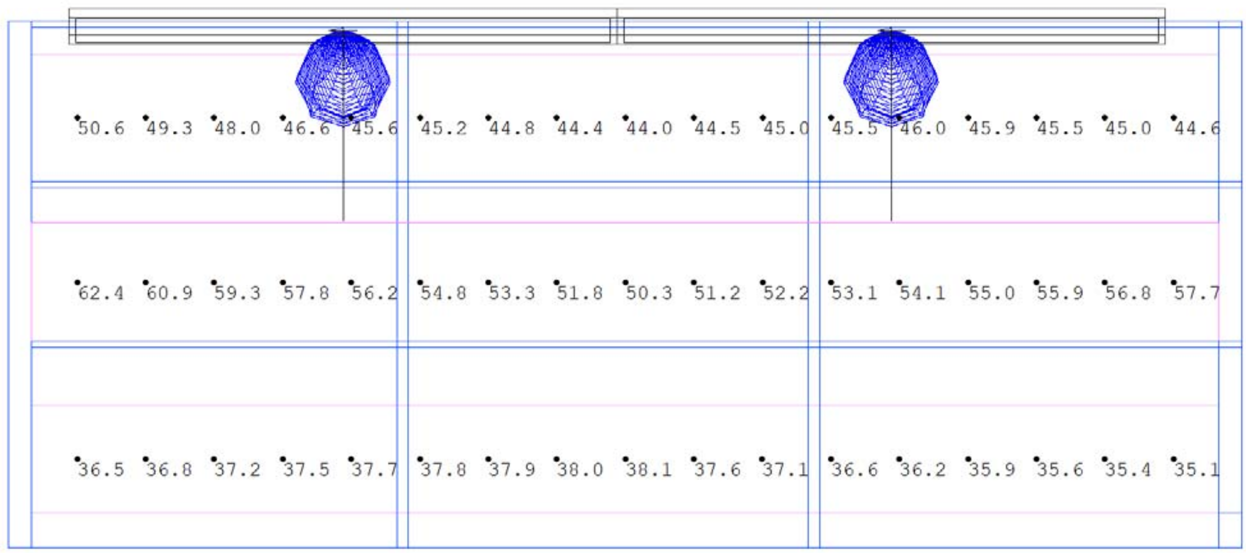
Left: Computer Horizontal Illuminance calculation

Right: Seating Area Horizontal Illuminance calculation

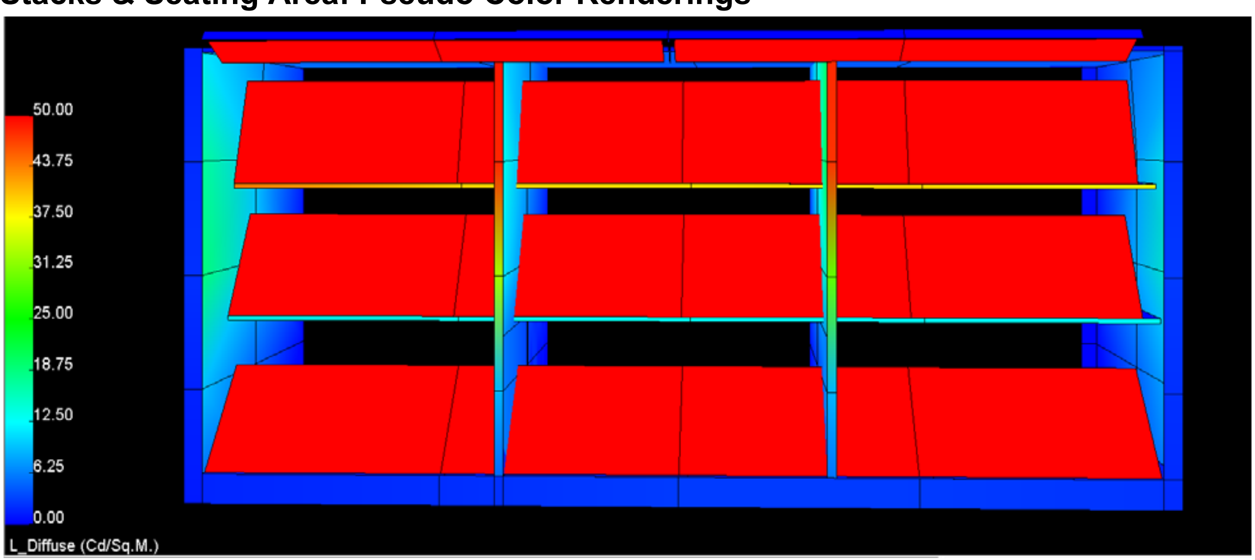




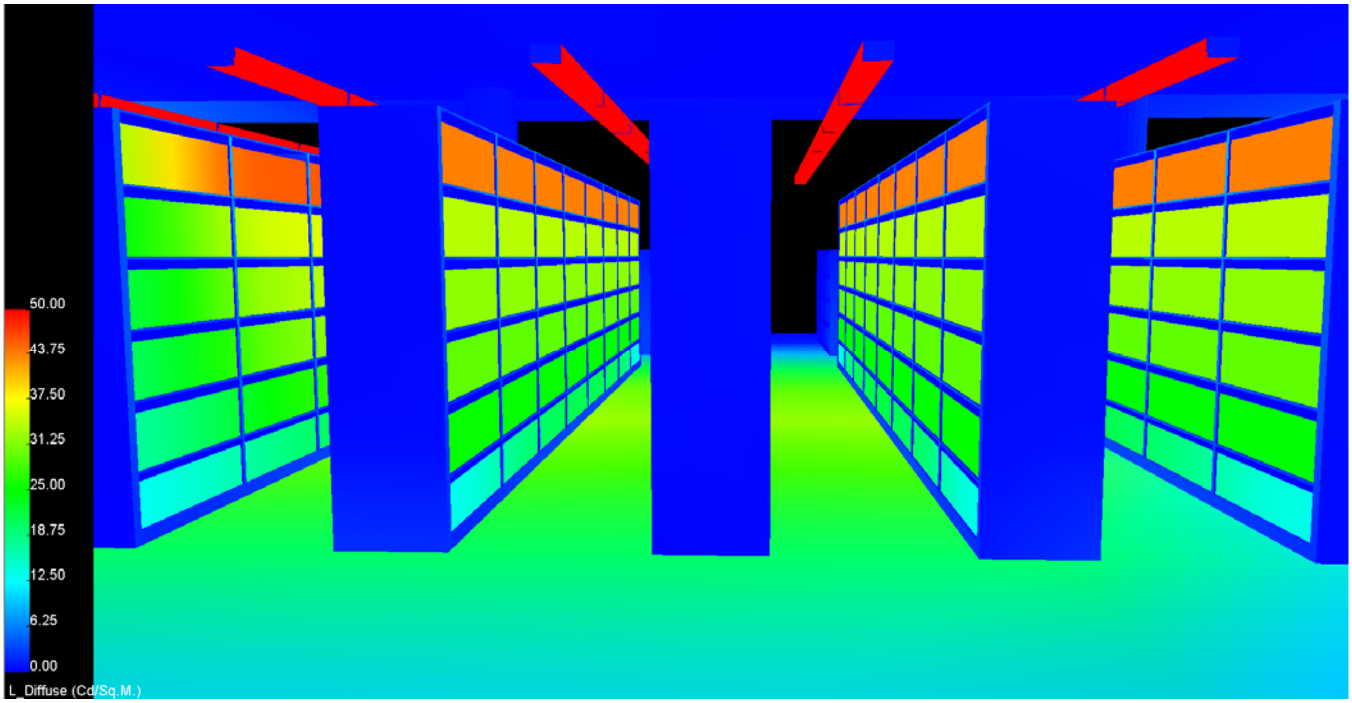
Above: Horizontal floor between shorter stacks, illuminance calculation
Below: Shorter magazine stack, illuminance calculation



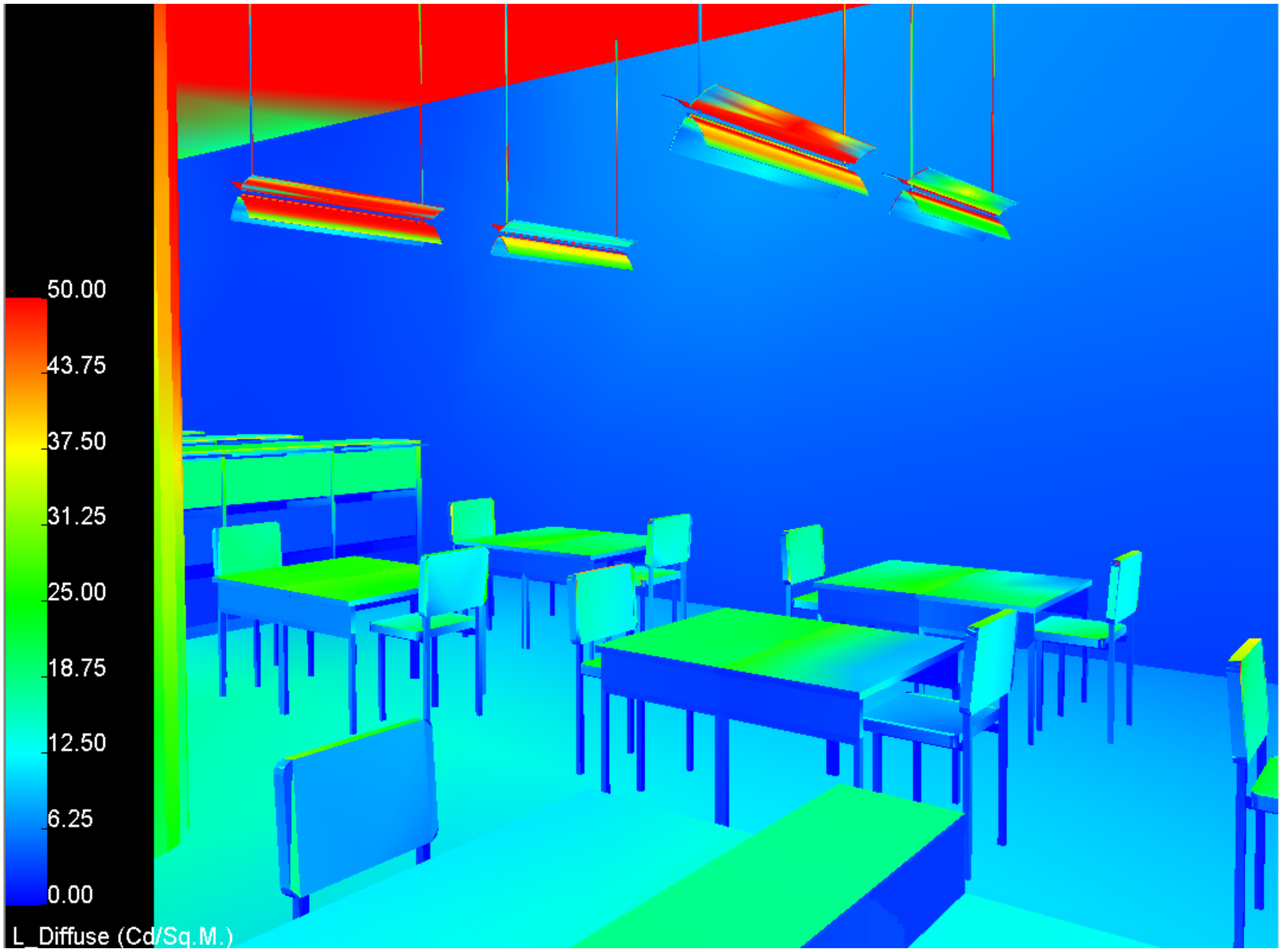
Stacks & Seating Area: Pseudo Color Renderings



Above: Shorter stack, Pseudo Color Rendering Luminance



Above: View from hallway, Stacks Pseudo Color Rendering Luminance
Below: View from stacks, Seating Area Pseudo Color Rendering Luminance



Stacks & Seating Area: Power Density

Fixture	Ballast Watts	Quantity (lamps)	BF	Total Watts
F1	33	121	1.04	4152.7
F2	32.6	23	1.0	749.8
F3	33	16	1.04	549
F4	64.5	20	1.0	1290
F5	32.6	64	1.0	2086.4
Space Type ASHRAE 90.1			Library stacks	
Area (ft^2)			6344 Total	
Allowable LPD (W/ft^2)			1.7-stacks	
Allowable Watts			10784.8	
Actual LPD (W/ft^2)			1.4	
Actual Watts			8827.9	

Analysis was done using the space-by-space method

Stacks & Seating Area: Performance evaluation

The lighting design in this space maintains a visual hierarchy of light; focusing light on the stacks and seating area. Vertical illuminance is critical in this area and is achieved with a vertical illuminance average of 22 fc. To prevent any unwanted glare from the end stack unit lights, a shield is added to cut off all spill light. The smaller magazine stacks have a slightly higher vertical illuminance of 42.8 fc. During most hours of the day, the photosensors in the space shut off this light. The horizontal illuminance on the desks is also sufficient with an average of 29 fc. These luminaires are also dimmed with daylight controls. During the day the space is beautifully flood with light, and at night a cove light mimics this affect with reflected light from the white ceiling. The warmer CRI and CCT of the lamps in this space, similar to the previous spaces, renders the warmer colors and wood tones of the stacks area nicely. The appearance of the space and luminaires remains linear and uniform in pattern. The abstract "open book" luminaire is hung over the desks tying in the stacks area to the overall lighting theme of the library. The room is below the allowable power density with a power density of 1.4 W/ft^2.

Stacks & Seating Area: Controls

All luminaires in the space are controlled by relays according to an astronomical time clock. Fluorescent fixture F5 is controlled by an on-off Wattstopper LightSaver LS-101 daylighting controller that turns lighting off automatically when sufficient natural daylight is present. The LS-101 features adjustable settings for ON setpoint, OFF setpoint to a predetermined deadband setting. The deadband can be adjusted to a value of 25%, 50%, 75% or 100% above the ON setpoint.

The Fluorescent cove lights F2 and pendants F5 are controlled by a second control system for dimming. The Wattstopper LightSaver LCD-203 Dimming Controller provides automatic dimming control from up to three individual zones of lighting from a single photocell. In addition, manual light level adjustments and overrides may be made with the LS-4C wall switch. Please refer to the appendix to view more information about the Wattstopper systems.

Stacks & Seating Area: Electrical Characteristics

Panelboard L4N2A serves the branch circuits in the stack area. This panel is located on the 2nd floor in the electric closet, room 234. Emergency fixtures are on panelboard L4LS2A located on the 2nd floor in the emergency electric closet. The new lighting design is placed on the same circuits as the existing lighting design. The remainder of the panelboard is unknown so some assumptions were made to complete the electrical calculations.

Please refer to the appendix to view the lighting plans.

Load Calculations

Label	Location	W	VA	A	PF	QTY	∑VA	∑A	Circuit
F1	Stacks	33	33.24	0.12	1.04	121	4022.04	14.52	L4N2A-2,4,6,10
F2	Cove Lights	32.6	33.24	0.12	1	23	764.52	2.76	L4N2A-17
F3	Stacks	33	33.24	0.12	1.04	16	531.84	1.92	L4N2A-2,4,
F4	Seating Area	64.5	63.71	0.23	1	20	1274.2	4.6	L4N2A-17, 3
F5	Small Stacks	32.6	32.6	0.4	1	64	2086.4	23.10469	L4N2A-1

PANELBOARD SIZING WORKSHEET

Panel Tag------------------------->	L4N2A	Panel Location:	Elec. Closet 234
Nominal Phase to Neutral Voltage------->	277	Phase:	3
Nominal Phase to Phase Voltage-------->	480	Wires:	4

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	Short Stack	3	200	2086	w	0.98	2086	2129		
2	A	Stack Lights	3	206	1141	w	0.98	1141	1164		
3	B	Seating Area	3	206	258	w	1.00	258	258		
4	B	Stack Lights	3	206	1141	w	0.98	1141	1164		
5	C					w	1.00	0	0		
6	C	Stack Lights	3	206	978	w	0.98	978	998		
7	A				0	w		0	0		
8	A				0	w		0	0		
9	B				0	w		0	0		
10	B	Stack Lights	3	206	1206.2	w	1.00	1206	1206		
11	C				0	w		0	0		
12	C				0	w		0	0		
13	A				0	w		0	0		
14	A				0	w		0	0		
15	B				0	w		0	0		
16	B				0	w		0	0		
17	C	Cove Lights	3	200	1781.8	w	1.00	1782	1782		
18	C				0	w		0	0		
19	A				0	w		0	0		
20	A				0	w		0	0		
21	B				0	w		0	0		
22	B				0	w		0	0		
23	C				0	w		0	0		
24	C				0	w		0	0		
25	A				0	w		0	0		
26	A				0	w		0	0		
27	B				0	w		0	0		
28	B				0	w		0	0		
29	C				0	w		0	0		
30	C				0	w		0	0		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								8.6	8.7	Amps=	10.5
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					3.2	3.3	38%	11.9
PHASE TOTAL			B					2.6	2.6	30%	9.5
PHASE TOTAL			C					2.8	2.8	32%	10.0
LOAD CATAGORIES				Connected			Demand				Ver. 1.03
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0		0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			8.6	8.7		8.6	8.7	0.99		
4	HID lighting			0.0	0.0		0.0	0.0			
5	incandescent lighting			0.0	0.0		0.0	0.0			
6	HVAC fans			0.0	0.0		0.0	0.0			
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			0.0	0.0		0.0	0.0			
Total Demand Loads							8.6	8.7			
Spare Capacity				20%			1.7	1.7			
Total Design Loads							10.3	10.4	0.99	Amps=	12.6

Default Power Factor = 0.80
Default Demand Factor = 1.00

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W	PANEL TAG: L4N2A	MIN. C/B AIC: 35K
SIZE/TYPE BUS: 225A	PANEL LOCATION: Elec. Closet 234	OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B
SIZE/TYPE MAIN: 225A/3P C/B	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Short Stack	200	2086	20A/1P	1	*			2	20A/1P	1141	206	Stack Lights
Seating Area	206	258	20A/1P	3		*		4	20A/1P	1141	206	Stack Lights
0	0	0	20A/1P	5			*	6	20A/1P	978	206	Stack Lights
	0	0	20A/1P	7	*			8	20A/1P	0	0	
	0	0	20A/1P	9		*		10	20A/1P	1206	206	Stack Lights
		0	20A/1P	11			*	12	20A/1P	0		
		0	20A/1P	13	*			14	20A/1P	0		
		0	20A/1P	15		*		16	20A/1P	0		
Cove Lights	200	1782	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	3.23		TOTAL DESIGN LOAD (KW)	10.31
CONNECTED LOAD (KW) - B	2.61		POWER FACTOR	0.99
CONNECTED LOAD (KW) - C	2.76		TOTAL DESIGN LOAD (AMPS)	13

The remainder of the panelboard is unknown so some assumptions were made to complete these electrical calculations. The new electrical circuits are not highlighted because all of the information provided includes the new lighting loads.

Electrical Data:
Main Lugs: 125A
Bottom feed
35K AIC
Incoming conductor(s) per phase:
(1) #6- 250 kcmil

Existing Panelboard Branch Summation
40-20A/1P

Assumed Total Load:
40 * 20A * 120V * 0.7 = 67.2 kVA

40- 20A/1P - 7-20A/1P = 33-20A/1P Existing
(33*20) = 660A * 0.7 = 462 A

462 A + (New Design Load: 13 A) = 475 A

Feeder Size:

750 MCM THW Copper 3.5" Conduit (475A Capacity)

Daylighting

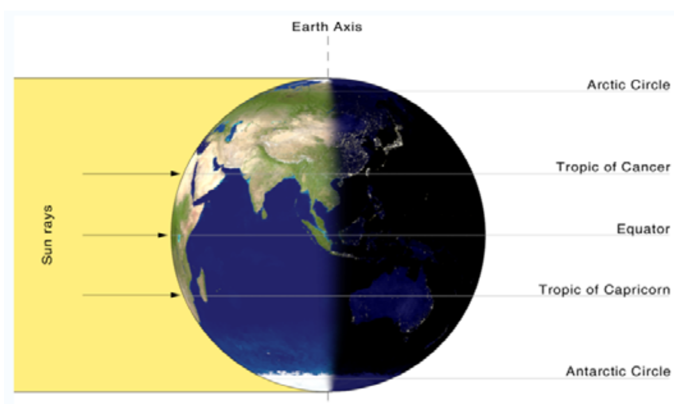
Due to the abundance of daylight in the space, fixtures can be switched off or dimmed anytime throughout the day. There are two different systems which have been installed to control the luminaires. A daylight open-loop photosensor switches the shorter stack luminaires on and off and a different photosensor dims the pendant over the desks as well as the lights in the coves. Because the desks are utilized for reading and writing it is important for the luminaires to be dimmed rather than switched on and off.

To determine the energy savings obtained, first parameters were set to analyze the daylighting. March June and December, the equinox and solstice were chosen as the three months to observe. Clearsky and overcast conditions are analyzed as well at multiple times throughout the day, 9 am, noon and 4 pm.

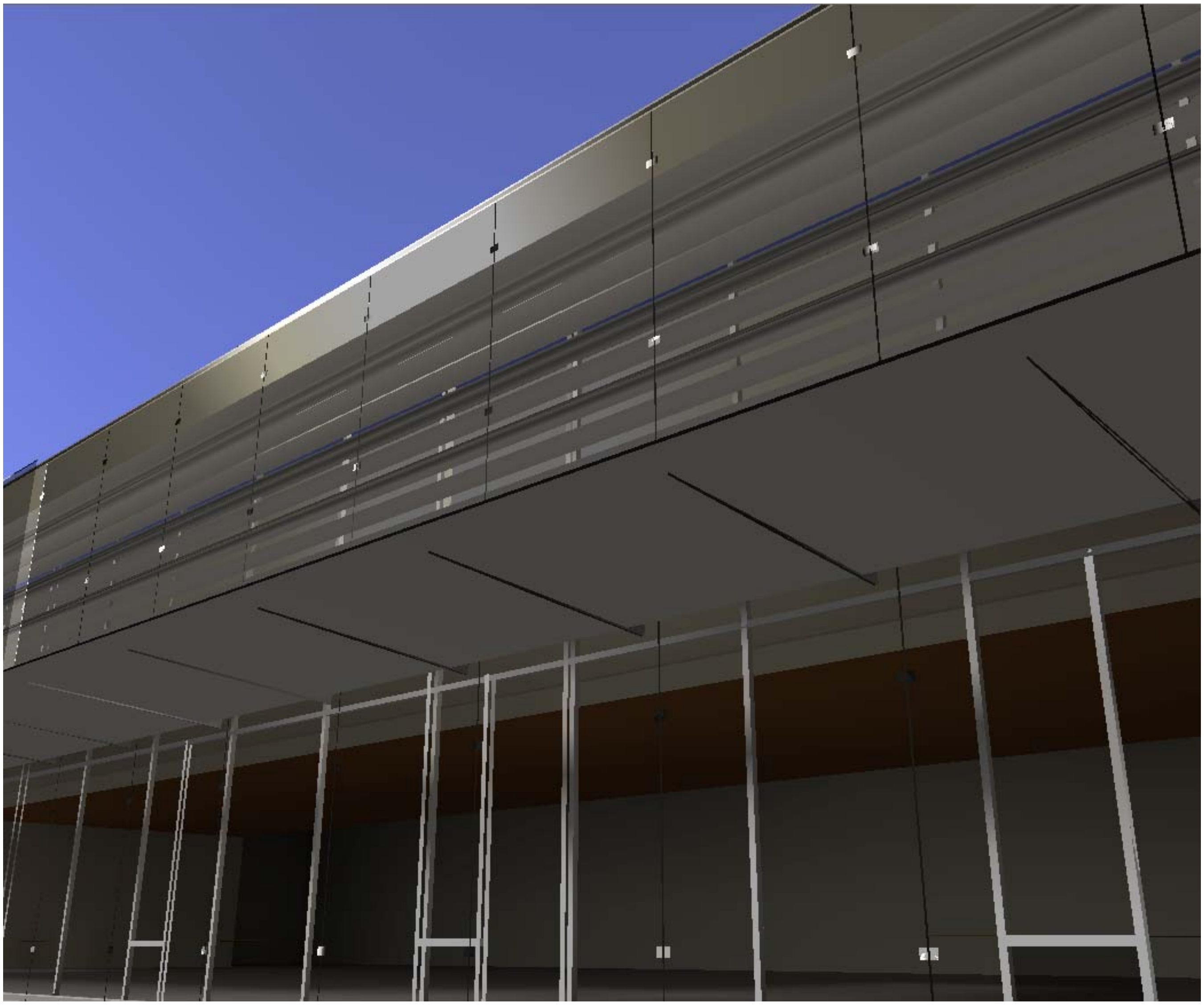
Daylighting: Parameters

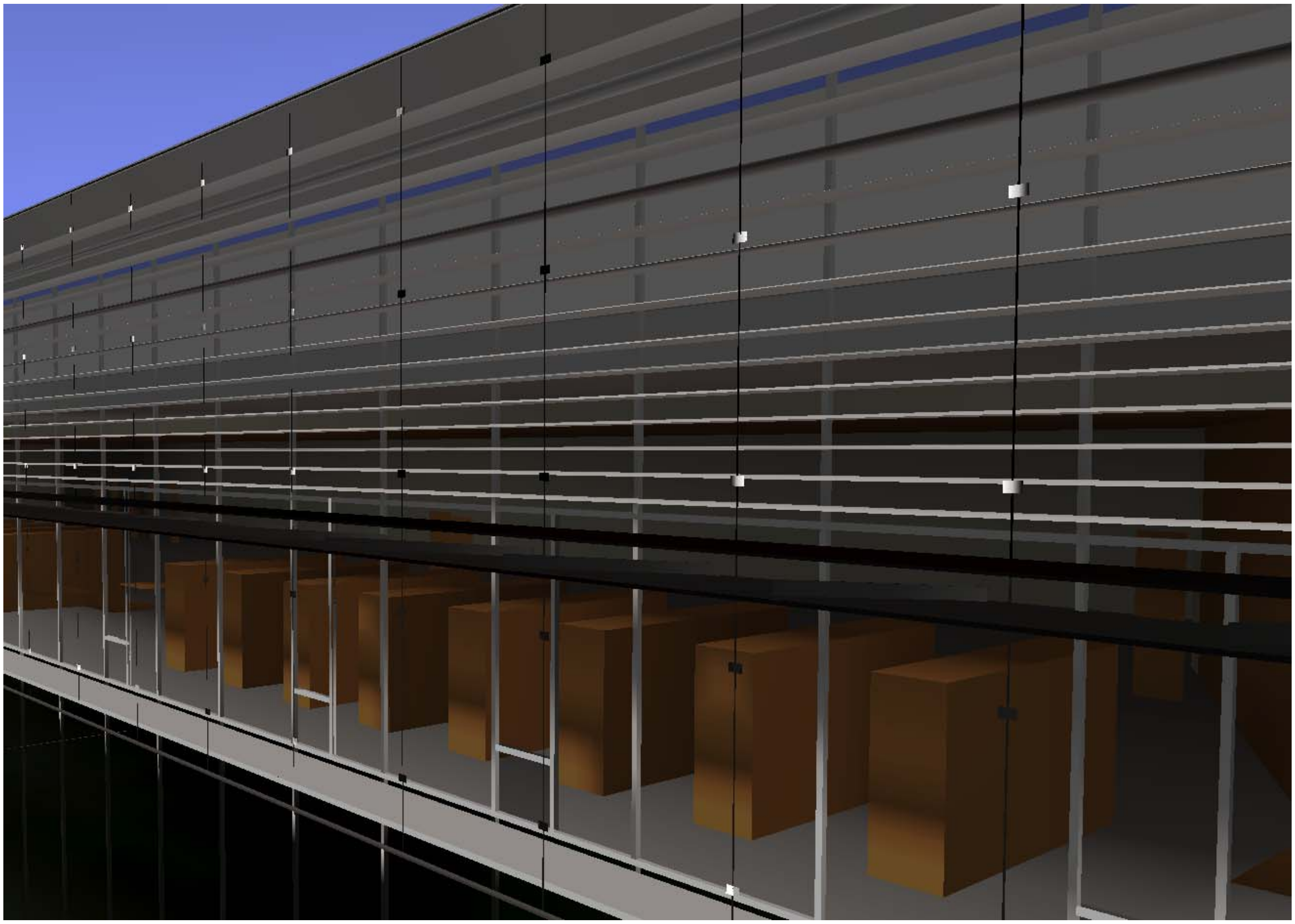
UTC date and time of solstices and equinoxes[1]

year	Equinox Mar		Solstice June		Equinox Sept		Solstice Dec	
	day	time	day	time	day	time	day	time
2004	20	06:49	21	00:57	22	16:30	21	12:42
2005	20	12:33	21	06:46	22	22:23	21	18:35
2006	20	18:26	21	12:26	23	04:03	22	00:22
2007	21	00:07	21	18:06	23	09:51	22	06:08
2008	20	05:48	20	23:59	22	15:44	21	12:04
2009	20	11:44	21	05:45	22	21:18	21	17:47
2010	20	17:32	21	11:28	23	03:09	21	23:38
2011	20	23:21	21	17:16	23	09:04	22	05:30
2012	20	05:14	20	23:09	22	14:49	21	11:11
2013	20	11:02	21	05:04	22	20:44	21	17:11
2014	20	16:57	21	10:51	23	02:29	21	23:03
2015	20	22:45	21	16:38	23	08:20	22	04:48
2016	20	04:30	20	22:34	22	14:21	21	10:44
2017	20	10:28	21	04:24	22	20:02	21	16:28

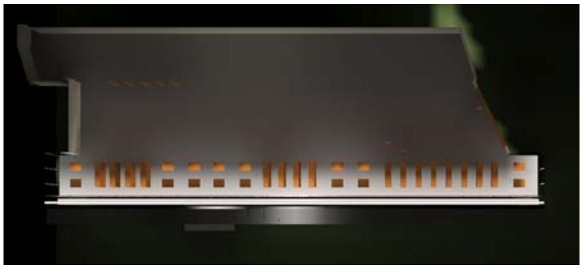


Daylighting: Exterior Renderings

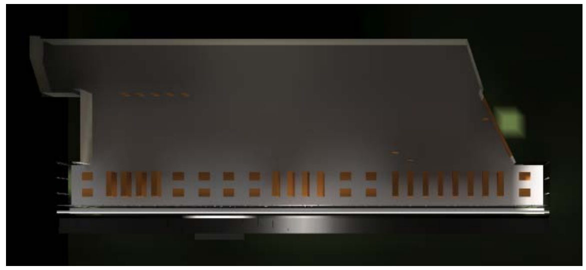




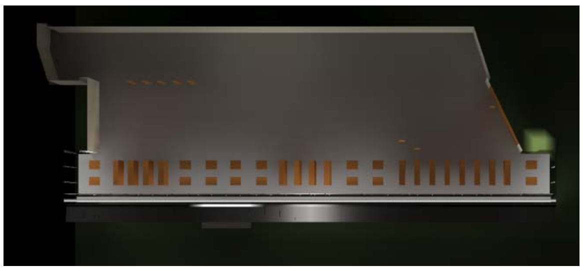
Daylighting: Noon Renderings



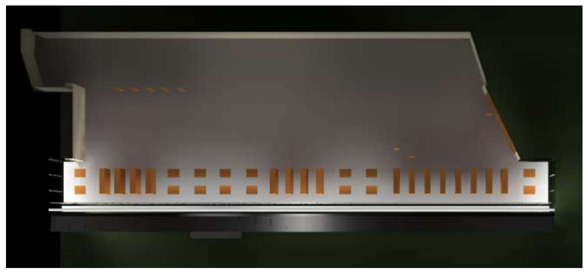
Clearsky- Dec. Noon



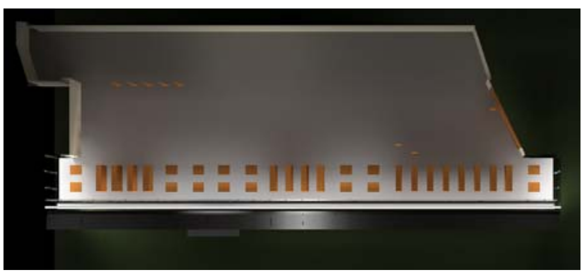
Clearsky- March Noon



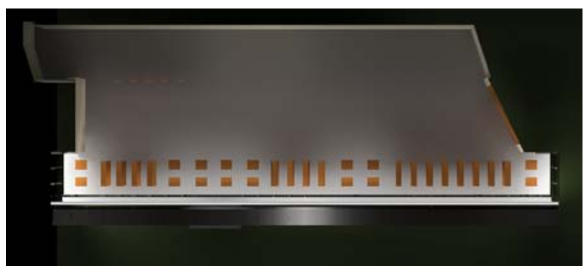
Clearsky- June Noon



Overcast- June Noon

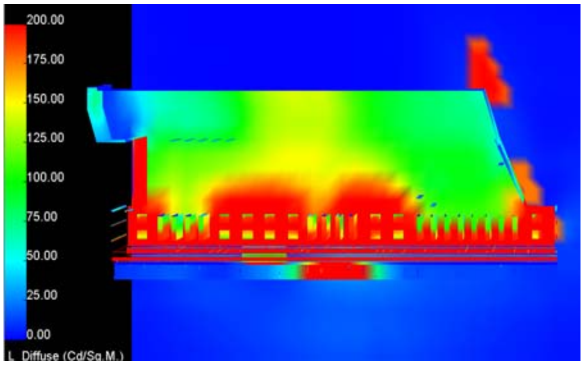


Overcast- Dec. Noon

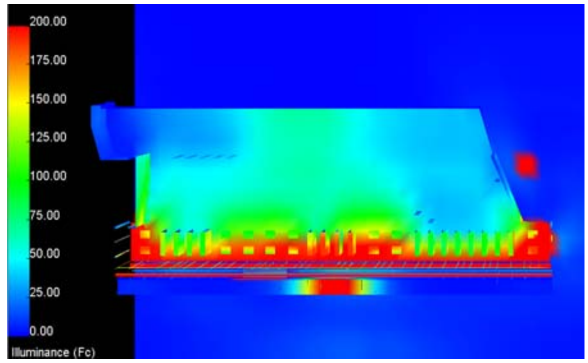


Overcast- March Noon

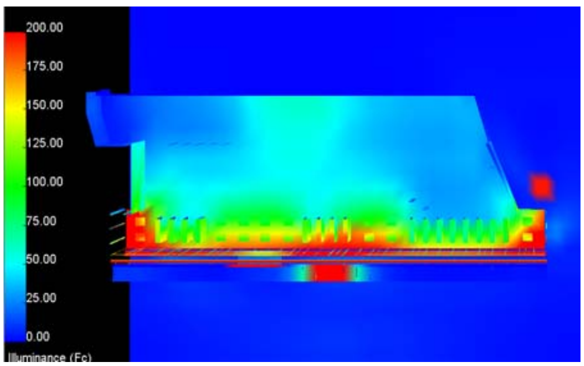
Daylighting: Noon Pseudo Color Renderings



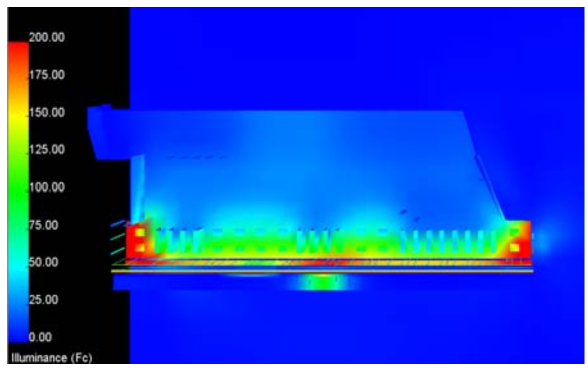
Clearsky- Dec. Noon



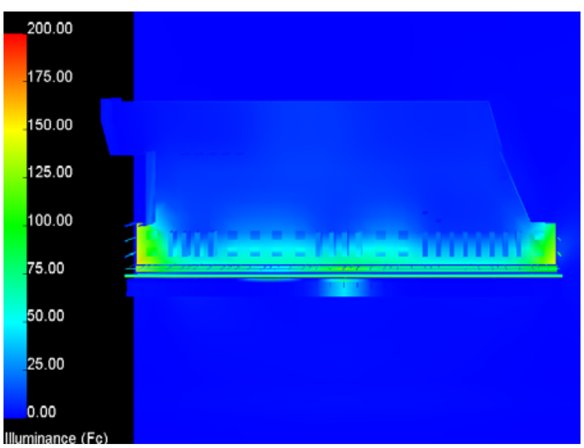
Clearsky- March Noon



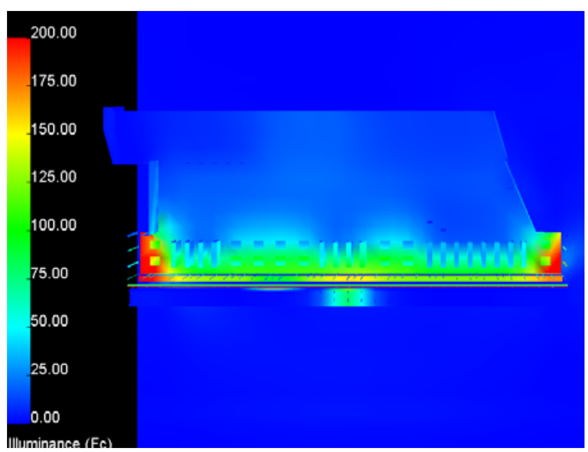
Clearsky- June Noon



Overcast-June Noon

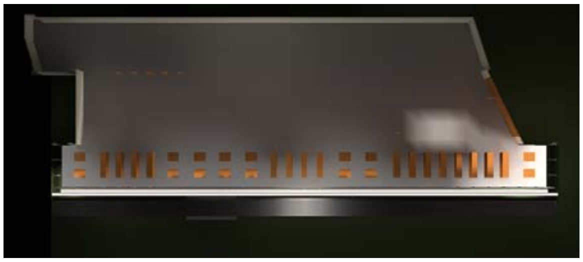


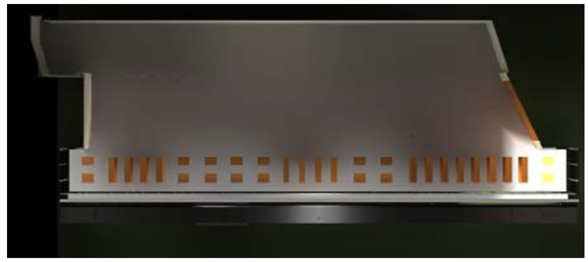
Overcast- Dec Noon

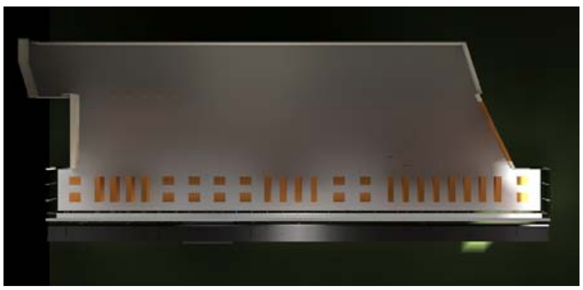


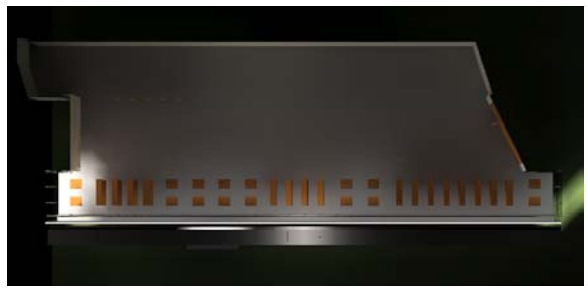
Overcast-March Noon

Daylighting: Morning and Afternoon Renderings


Clearsky- Dec. 9am


Clearsky- March 9am

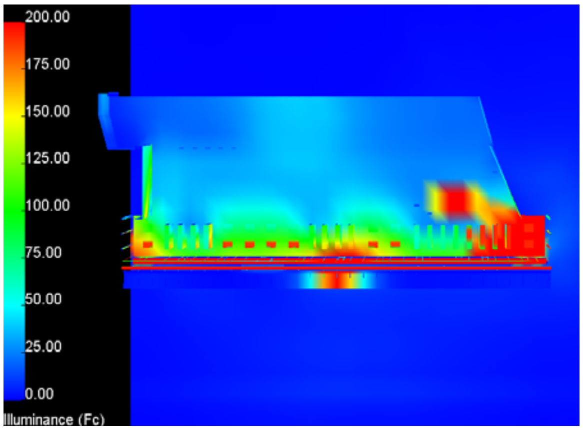

Clearsky- July 9am


Clearsky- July 4pm

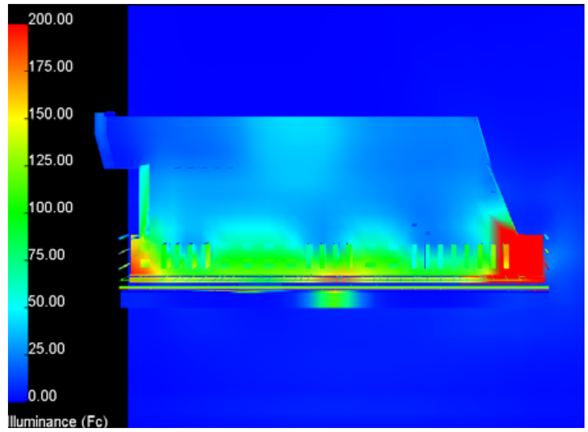

Clearsky- Dec. 4pm


Clearsky- March 4pm

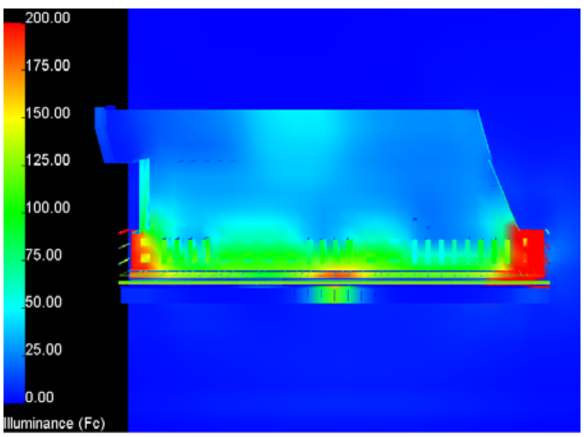
Daylighting: Morning and Afternoon Pseudo Color Renderings



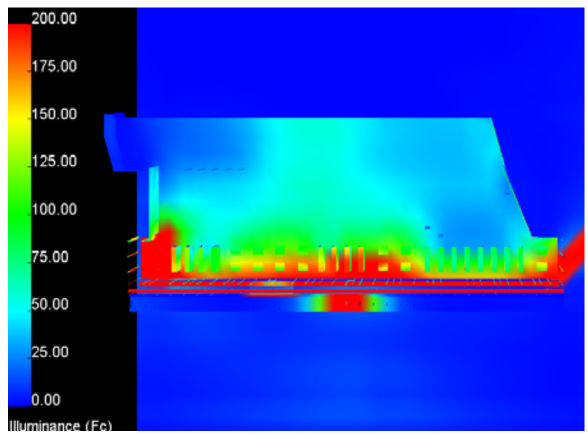
Clearsky- Dec. 9am



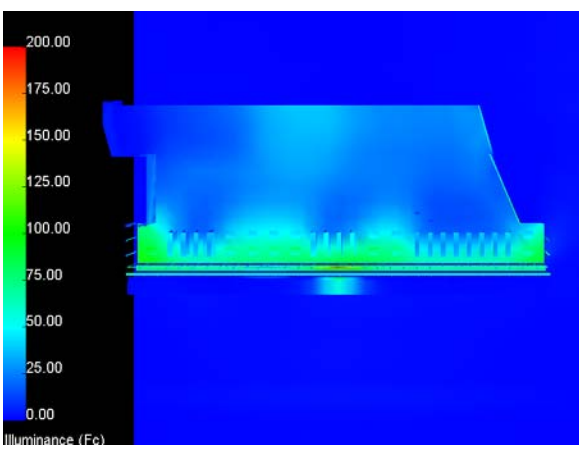
Clearsky- March 9am



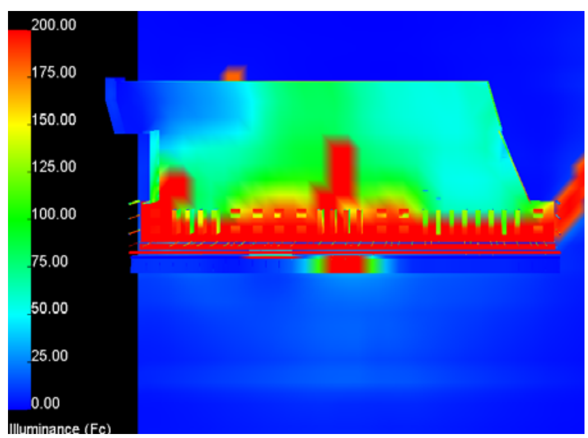
Clearsky- July 9am



Clearsky- July 4pm



Clearsky- Dec. 4pm



Clearsky- March 4pm

Based on these calculations the critical point is determined for two different calculation grids. There is a grid for only horizontal calculations over the study desks and a separate grid for only vertical calculations; the vertical calculation grid is used for the shorter stacks. A critical point is chosen to be furthest from the curtain wall and centered between the east and west windows. The target illuminance is between 150% to 200% of the desired illuminance level do the deadband and sensitivity of the photosensors. Therefore, a target illuminance of 45-50 footcandles is used to calculate the dimming levels. At noon, majority of the calculations showed that lights would be shut off due to the abundance of daylight. The calculations for 4 pm and 9am displayed a wider range of dimming levels. The following sample of tables display the dimmed levels calculated for 9am for clearsky and overcast conditions during March, December, and June.

Horizontal Desk Dimmed Level Calculations

Horizontal Dimmed Level- Clearsky 9 am March										
-21.95	0.22	0.36	0.19	0.26	0.16	0.24	0.17	0.22	0.19	-0.66
-16.50	0.23	0.35	0.20	0.32	0.17	0.27	0.17	0.22	0.20	-0.65
-24.74	0.37	0.57	0.39	0.62	0.36	0.55	0.38	0.47	0.40	-1.08

Horizontal Dimmed Level- Clearsky 9 am December										
-7.44	-0.06	-0.07	-0.12	-0.33	-0.07	-0.02	0.03	0.07	0.07	-0.31
-5.71	-0.01	0.02	-0.03	-0.08	0.01	0.07	0.06	0.11	0.12	-0.29
-8.93	0.12	0.23	0.14	0.26	0.20	0.35	0.26	0.35	0.33	-0.59

Horizontal Dimmed Level- Clearsky 9 am June										
-2.92	0.23	0.36	0.18	0.18	0.11	0.16	0.12	0.15	0.13	-1.08
-2.84	0.24	0.35	0.18	0.24	0.12	0.19	0.12	0.14	0.12	-1.06
-5.73	0.38	0.57	0.38	0.54	0.30	0.45	0.32	0.39	0.32	-1.62

Horizontal Dimmed Level-Overcast 9 am March										
-0.26	0.47	0.73	0.43	0.54	0.40	0.44	0.38	0.49	0.43	-0.07
-0.58	0.45	0.66	0.39	0.54	0.37	0.58	0.38	0.47	0.42	-0.07
-2.46	0.59	0.86	0.60	0.71	0.57	0.63	0.57	0.72	0.64	-0.07

Horizontal Dimmed Level-Overcast 9 am June										
-0.93	0.26	0.41	0.21	0.21	0.17	0.19	0.19	0.24	0.23	-0.57
-1.22	0.32	0.46	0.26	0.32	0.22	0.35	0.24	0.31	0.28	-0.45
-4.11	0.45	0.65	0.44	0.49	0.40	0.45	0.42	0.53	0.47	-0.58

Horizontal Dimmed Level- Overcast 9 am December										
0.54	0.72	1.11	0.69	0.94	0.68	0.75	0.62	0.80	0.67	0.52
0.20	0.61	0.89	0.56	0.81	0.55	0.85	0.54	0.68	0.59	0.38
-0.47	0.76	1.13	0.79	0.97	0.78	0.85	0.75	0.95	0.84	0.54

Vertical Stacks Dimmed Level Calculations

Vertical Dimmed Level- Clearsky 9am December													
-2.01	-0.32	-2.56	-0.29	-0.48	-1.76	-2.70	-0.05	-2.11	-0.91	-3.30	-2.53	-4.11	-5.54
-0.17	0.24	-0.53	-0.14	0.18	-0.36	-0.94	0.42	-0.10	0.16	-0.40	-0.32	-1.04	-4.41

Vertical Dimmed Level- Clearsky 9am March													
-0.04	0.20	0.01	0.19	0.29	0.23	0.04	0.53	0.15	0.24	-0.16	-0.58	-3.54	-11.46
0.41	0.59	0.52	0.39	0.69	0.68	0.52	0.80	0.68	0.62	0.33	-0.23	-2.97	-13.87

Vertical Dimmed Level- Clearsky 9am March													
-0.16	0.12	-0.07	0.10	0.23	0.16	-0.02	0.47	0.12	0.22	-0.03	-0.15	-0.77	-5.18
0.35	0.54	0.46	0.31	0.66	0.64	0.47	0.78	0.67	0.64	0.50	0.24	-0.45	-7.52

Vertical Dimmed Level- Overcast 9am June													
0.06	0.33	0.13	0.32	0.38	0.37	0.19	0.65	0.22	0.40	0.23	0.31	0.04	-1.55
0.49	0.68	0.63	0.55	0.74	0.76	0.62	0.85	0.74	0.77	0.71	0.68	0.45	-2.00

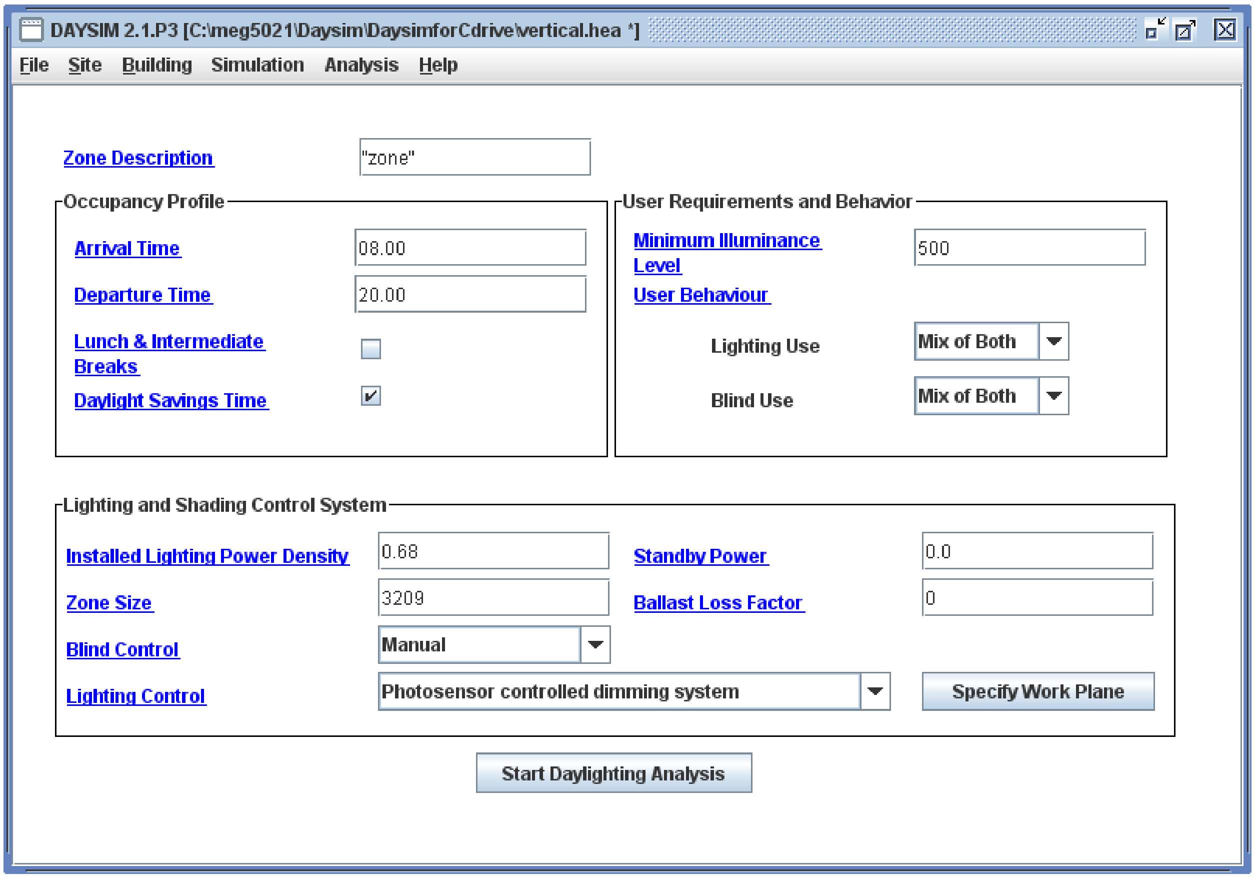
Vertical Dimmed Level- Overcast 9am December													
0.44	0.53	0.49	0.53	0.58	0.71	0.56	0.90	0.53	0.66	0.66	0.71	0.61	-0.27
0.65	0.81	0.82	0.77	0.87	0.94	0.83	0.96	0.88	0.90	0.89	0.90	0.82	-0.39

Vertical Dimmed Level- Overcast 9am March													
0.21	0.41	0.27	0.40	0.46	0.50	0.34	0.75	0.35	0.50	0.40	0.47	0.27	-1.04
0.55	0.73	0.70	0.63	0.79	0.83	0.70	0.89	0.80	0.82	0.78	0.77	0.60	-1.37

Daysim Calculations

After the critical points are determined and work plan is established Daysim can be used to calculate the energy savings due to dimming and on/off switching. Daysim is a radiance-based daylighting analysis software to predict the annual daylight availability and electric lighting used in arbitrary buildings for manual and automated lighting and blind controls. For the stacks area, where on/off switching is preferred, the power density is 0.68 W/ft^2. For the seating area, where dimming is preferred due to tasks such as reading and writing, the power density is 0.55 W/ft^2. Unlike the switching calculations in which the ballast will either be on or off, the desk areas Daysim calculation requires the input of a ballast loss factor.

Daylighting: Daysim On-Off Calculations

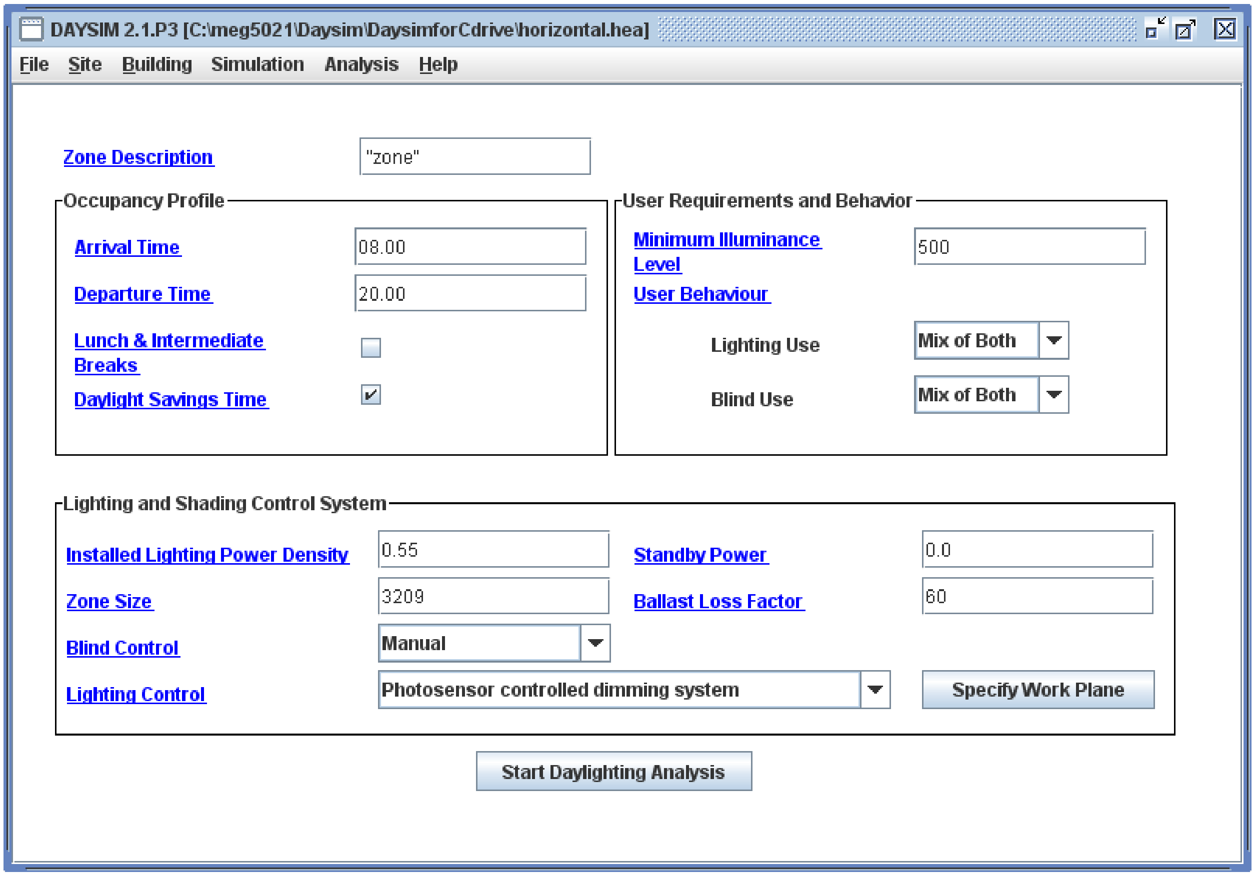


Results

The simulation report stated that the daylight autonomy for the core workplane sensor is 52%. The total annual hours of occupancy at the library are 3131.3. The electric lighting is activated 3251.2 hours per year. Therefore, 1690.6 hours per year the light for the stacks can be switched off.

The stack lights are a total load of 2086 W, which means if the lights are on 3251.2 hours at 2086 W that is 6782 kWh for lighting. If the lights are off 1690.6 hours per year, then the lights save 3526.6 kWh. The distribution energy rate is $0.1099 per kWh. Therefore there is a savings of $388 a year due to the lights turned off in this space alone. Similar spaces to the stacks area are located throughout other portions of the building, contributing to greater overall energy and cost savings

Daylighting: Daysim Dimming Calculations



Results

The simulation report stated that the daylight the annual electric lighting energy use in the investigated lighting zone is : 0.8 kWh/unit area. Assuming that a lighting zone size of 3209 (unit area), this corresponds to a total annual lighting energy use of 2630.5 kWh. The total annual hours of occupancy at the work place are 3131.3. The electric lighting is activated 3263.2 hours per year.

3263.2 hours multiplied by the power load of 1784 W at a distribution energy rate of $0.1099 per kWh is $639.80 per year. If the annual lighting energy use is 2630.5 kWh with dimming, then cost is $289.00 per year. Meaning, there is an energy cost savings of $350.80 a year for this space alone. Similar spaces to the seating area are located throughout other portions of the building, contributing to greater overall energy and cost savings.

Mechanical Breadth- Curtain Wall Facade

Massachusetts Public Library features a state-of-the-art glass curtain wall façade. The glass envelops the building on all sides. In addition to light penetration, the wall will also create solar heat gains and heat loses due to poor insulation. Because the southern facing facade effects the building the most, I will be focusing my daylighting studies, as well as the mechanical studies, on this facade wall side. The façade system will be studied to determine if changing the glass, due to preferences related to daylighting transmittance values, has any effect on the total cooling load from fenestration. The total cooling load, due to fenestration, is the sum of the conductive and radiant components qcond and qrad.

For conduction heat gain, the overall heat transfer coefficient accounts for the heat transfer processes of 1) convection and long-wave radiation exchange outside and inside the conditioned space, and 2) conduction through the fenestration material. To calculate cooling load for this component, the conduction heat gain is treated in a manner similar to that through walls and roofs. The cooling load from conduction and convection heat gain is calculated with the equation:

qcond = UA(CLTD)

qcond= cooling load caused by solar conduction, W
U= coefficient of heat trasfer, W/($(m)^2$K)
A=area of surface, $(m)^2$
CLTD = cooling load temperature difference

The basic principles of evaluating heat gain from transmitted and absorbed solar energy through fenestration, including the primary terms shading coefficient (SC), are the same for the cooling load temperature difference (CLTD) procedure as previously described. Solar cooling load (SCL), is introduced to more closely approximate cooling loads due to solar radiation transmitted through fenestration. Cooling load caused by solar radiation through fenestration is calculated by:

qrad = A(SC)(SCL)

qrad= cooling load caused by solar radiation, W
A=area of surface, $(m)^2$
SC = cooling load temperature difference
SCL = solar cooling load, W/$(m)^2$

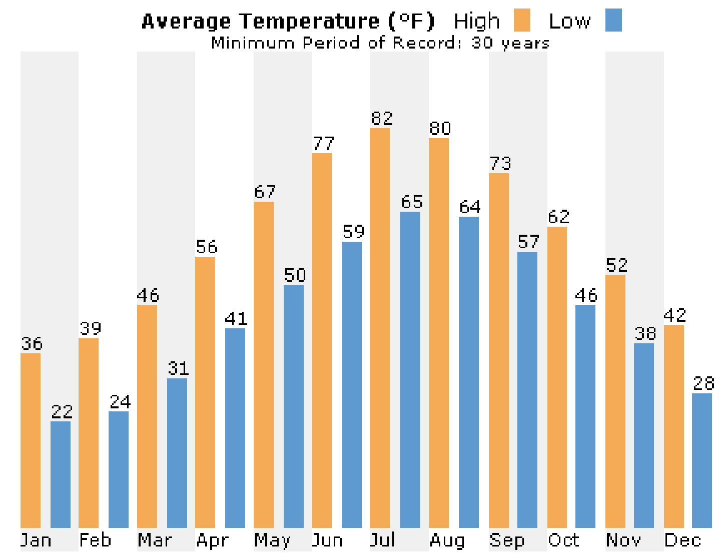
The maximum cooling load for the building as a whole can be expected to occur in one of the summer months- June, July or August. The f table located to the right includes yearly temperature data for the Massachusetts area. The peak load hour are established with data from this chart.
Correction factors are determined with the average temperatures for the month of July. The average high and average low for the month are converted to Celsius and then used within the indoor design temperature correction equation as well as the daily average temperature correction equation.

Indoor Design temperature correction (C1)

(25.5 - Ti) = 25.5 - 22.2 = 3.3 = C1

Daily average temperature correction (C2)

(27.8 + 18.3) / 2 - 29.4 = 23.1 - 29.4 = -6.3



Month	Avg. High	Avg. Low	Mean	Avg. Precip.	Record High	Record Low
Jan	36°F	22°F	29°F	3.92 in.	72°F (1950)	-30°F (1946)
Feb	39°F	24°F	32°F	3.30 in.	70°F (1985)	-18°F (1934)
Mar	46°F	31°F	39°F	3.85 in.	89°F (1998)	-8°F (1872)
Apr	56°F	41°F	48°F	3.60 in.	94°F (1976)	11°F (1874)
May	67°F	50°F	59°F	3.24 in.	97°F (1880)	31°F (1882)
Jun	77°F	59°F	68°F	3.22 in.	100°F (1952)	41°F (1945)
Jul	82°F	65°F	74°F	3.06 in.	104°F (1911)	50°F (1988)
Aug	80°F	64°F	72°F	3.37 in.	102°F (1975)	46°F (1940)
Sep	73°F	57°F	65°F	3.47 in.	102°F (1881)	34°F (1914)
Oct	62°F	46°F	54°F	3.79 in.	90°F (1963)	25°F (1936)
Nov	52°F	38°F	45°F	3.98 in.	83°F (1950)	-2°F (1875)
Dec	42°F	28°F	35°F	3.73 in.	76°F (1998)	-17°F (1933)

Solar cooling loads are calculated by specific zone parameters. Because the interior space of the stacks/seating area has carpet and primarily gypsum walls with no inside shading, the zone type for the glass is considered to be zone type A. Due to the overhangs and louvers on the exterior of the building the glass for this calculation is considered to be "north facing" rather than south due to limited direct sun penetration. Based on these parameters, the SCL values for different solar times are obtained from the 1997 ASHRAE Fundamentals Handbook (SI) table 36 July Solar Cooling Load for Sunlit Glass 40 degrees North Latitude. These values are included in the following table to determine the cooling load caused by solar radiation.
An assumption was made for the shading coefficient based on the given shading coefficient of the glass and shading coefficients for louvers.

The following tables include these correction factors and determine the cooling load caused by solar conduction for several different U-Values of glass. Each glass with a different transmission value maintains a different U-Value and different shading coefficient.

Spectrally Selective Tinted Glass Products- PPG Azuria glass

Type: Solar Control Low-E Tinted Insulating Glass
"Azuria™" + "Solarban®" z50 (3) "Optiblue®" by PPG Industries, Inc.
Outdoor Lite: ***"Azuria"*** Glass by PPG Industries, Inc.
Indoor Lite: ***" Solarban z50 (3) Optiblue"*** Glass by PPG Industries, Inc., Sputter Coated on third surface (3)
Low-E Coating: ***"Solarban"*** z50 Solar Control (Sputtered) by PPG Industries, Inc.
Location: Third Surface (3)

Performance Values

Visible Light Transmission	U-Value Winter	U-Value Summer	SHGC	Shading Coefficient	Outdoor Visible Light Reflectance
39%	0.29	0.27	0.30	0.35	8%

Type: Pytolytic Low-E Tinted Insulating Glass
"Azuria™" + "Sungate®" 500 (3) Clear by PPG Industries, Inc.
Outdoor Lite: ***"Azuria"*** Glass by PPG Industries, Inc.
Indoor Lite: Clear Float Glass, Pyrolytic Coated on third surface (3)
Low-E Coating: ***"Sungate"*** 500 (Pyrolytic) by PPG Industries, Inc.
Location: Third Surface (3)

Performance Values

Visible Light Transmission	U-Value Winter	U-Value Summer	SHGC	Shading Coefficient	Outdoor Visible Light Reflectance
57%	0.35	0.35	0.34	0.40	12%

Type: Uncoated Tinted Insulating Glass
"Azuria™" + Clear by PPG Industries, Inc.
Outdoor Lite: ***"Azuria"*** (transparent) Float Glass by PPG Industries, Inc.
Indoor Lite: Clear (transparent) Float Glass
Tint Color: ***"Azuria"*** by PPG Industries, Inc.

Performance Values

Visible Light Transmission	U-Value Winter	U-Value Summer	SHGC	Shading Coefficient	Outdoor Visible Light Reflectance
61%	0.47	0.50	0.39	0.45	11%

Type: Solar Control Low-E Tinted Insulating Glass U= 0.27, Glass SC= 0.35
"Azuria™" + "Solarban®" z50 (3) "Optiblue®" by PPG Industries, Inc.

Cooling load caused by solar conduction, W

SOLAR TIME, h	CLTD, C	C1	C2	Corr.CLTD	Area (m²)	U- W/m²K	qcond (W)
100	1	3.3	-6.3	-2	1.533	1.53313101	-4.700579677
200	0	3.3	-6.3	-3	1.533	1.53313101	-7.050869515
300	-1	3.3	-6.3	-4	1.533	1.53313101	-9.401159353
400	-1	3.3	-6.3	-4	1.533	1.53313101	-9.401159353
500	-1	3.3	-6.3	-4	1.533	1.53313101	-9.401159353
600	-1	3.3	-6.3	-4	1.533	1.53313101	-9.401159353
700	-1	3.3	-6.3	-4	1.533	1.53313101	-9.401159353
800	0	3.3	-6.3	-3	1.533	1.53313101	-7.050869515
900	1	3.3	-6.3	-2	1.533	1.53313101	-4.700579677
1000	2	3.3	-6.3	-1	1.533	1.53313101	-2.350289838
1100	4	3.3	-6.3	1	1.533	1.53313101	2.350289838
1200	5	3.3	-6.3	2	1.533	1.53313101	4.700579677
1300	7	3.3	-6.3	4	1.533	1.53313101	9.401159353
1400	7	3.3	-6.3	4	1.533	1.53313101	9.401159353
1500	8	3.3	-6.3	5	1.533	1.53313101	11.75144919
1600	8	3.3	-6.3	5	1.533	1.53313101	11.75144919
1700	7	3.3	-6.3	4	1.533	1.53313101	9.401159353
1800	7	3.3	-6.3	4	1.533	1.53313101	9.401159353
1900	6	3.3	-6.3	3	1.533	1.53313101	7.050869515
2000	4	3.3	-6.3	1	1.533	1.53313101	2.350289838
2100	3	3.3	-6.3	0	1.533	1.53313101	0
2200	2	3.3	-6.3	-1	1.533	1.53313101	-2.350289838
2300	2	3.3	-6.3	-1	1.533	1.53313101	-2.350289838
2400	1	3.3	-6.3	-2	1.533	1.53313101	-4.700579677

Type: Pytolytic Low-E Tinted Insulating Glass U= 0.35, Glass SC = 0.4
***"Azuria™" + "Sungate®"* 500 (3) Clear** by PPG Industries, Inc.

Cooling load caused by solar conduction, W

SOLAR TIME, h	CLTD, C	C1	C2	Corr.CLTD	Area (m^2)	U- W/m^2K	qcond (W)
100	1	3.3	-6.3	-2	1.533	1.98739205	-6.093344025
200	0	3.3	-6.3	-3	1.533	1.98739205	-9.140016038
300	-1	3.3	-6.3	-4	1.533	1.98739205	-12.18668805
400	-1	3.3	-6.3	-4	1.533	1.98739205	-12.18668805
500	-1	3.3	-6.3	-4	1.533	1.98739205	-12.18668805
600	-1	3.3	-6.3	-4	1.533	1.98739205	-12.18668805
700	-1	3.3	-6.3	-4	1.533	1.98739205	-12.18668805
800	0	3.3	-6.3	-3	1.533	1.98739205	-9.140016038
900	1	3.3	-6.3	-2	1.533	1.98739205	-6.093344025
1000	2	3.3	-6.3	-1	1.533	1.98739205	-3.046672013
1100	4	3.3	-6.3	1	1.533	1.98739205	3.046672013
1200	5	3.3	-6.3	2	1.533	1.98739205	6.093344025
1300	7	3.3	-6.3	4	1.533	1.98739205	12.18668805
1400	7	3.3	-6.3	4	1.533	1.98739205	12.18668805
1500	8	3.3	-6.3	5	1.533	1.98739205	15.23336006
1600	8	3.3	-6.3	5	1.533	1.98739205	15.23336006
1700	7	3.3	-6.3	4	1.533	1.98739205	12.18668805
1800	7	3.3	-6.3	4	1.533	1.98739205	12.18668805
1900	6	3.3	-6.3	3	1.533	1.98739205	9.140016038
2000	4	3.3	-6.3	1	1.533	1.98739205	3.046672013
2100	3	3.3	-6.3	0	1.533	1.98739205	0
2200	2	3.3	-6.3	-1	1.533	1.98739205	-3.046672013
2300	2	3.3	-6.3	-1	1.533	1.98739205	-3.046672013
2400	1	3.3	-6.3	-2	1.533	1.98739205	-6.093344025

Type: Uncoated Tinted Insulating Glass U= 0.50, Glass SC= 0.45
***"Azuria™"* + Clear** by PPG Industries, Inc.

Cooling load caused by solar conduction, W

SOLAR TIME, h	CLTD, C	C1	C2	Corr.CLTD	Area (m^2)	U- W/m^2K	qcond (W)
100	1	3.3	-6.3	-2	1.533	2.8391315	-8.704777179
200	0	3.3	-6.3	-3	1.533	2.8391315	-13.05716577
300	-1	3.3	-6.3	-4	1.533	2.8391315	-17.40955436
400	-1	3.3	-6.3	-4	1.533	2.8391315	-17.40955436
500	-1	3.3	-6.3	-4	1.533	2.8391315	-17.40955436
600	-1	3.3	-6.3	-4	1.533	2.8391315	-17.40955436
700	-1	3.3	-6.3	-4	1.533	2.8391315	-17.40955436
800	0	3.3	-6.3	-3	1.533	2.8391315	-13.05716577
900	1	3.3	-6.3	-2	1.533	2.8391315	-8.704777179
1000	2	3.3	-6.3	-1	1.533	2.8391315	-4.35238859
1100	4	3.3	-6.3	1	1.533	2.8391315	4.35238859
1200	5	3.3	-6.3	2	1.533	2.8391315	8.704777179
1300	7	3.3	-6.3	4	1.533	2.8391315	17.40955436
1400	7	3.3	-6.3	4	1.533	2.8391315	17.40955436
1500	8	3.3	-6.3	5	1.533	2.8391315	21.76194295
1600	8	3.3	-6.3	5	1.533	2.8391315	21.76194295
1700	7	3.3	-6.3	4	1.533	2.8391315	17.40955436
1800	7	3.3	-6.3	4	1.533	2.8391315	17.40955436
1900	6	3.3	-6.3	3	1.533	2.8391315	13.05716577
2000	4	3.3	-6.3	1	1.533	2.8391315	4.35238859
2100	3	3.3	-6.3	0	1.533	2.8391315	0
2200	2	3.3	-6.3	-1	1.533	2.8391315	-4.35238859
2300	2	3.3	-6.3	-1	1.533	2.8391315	-4.35238859
2400	1	3.3	-6.3	-2	1.533	2.8391315	-8.704777179

Shading coefficients

Table 24 Shading Coefficients for Louvered Sun Screens

Profile Angle	Group 1		Group 2		Group 3		Group 4		Group 5		Group 6	
	Transmittance	SC	Transmittance	SC	Transmittance	SC	Transmittance	SC	Transmittance	SC	Transmittance	SC
10°	0.23	0.35	0.25	0.33	0.40	0.51	0.48	0.59	0.15	0.27	0.26	0.45
20°	0.06	0.17	0.14	0.23	0.32	0.42	0.39	0.50	0.04	0.11	0.20	0.35
30°	0.04	0.15	0.12	0.21	0.21	0.31	0.28	0.38	0.03	0.10	0.13	0.26
≥ 40°	0.04	0.15	0.11	0.20	0.07	0.18	0.20	0.30	0.03	0.10	0.04	0.13

Group 1. Black, width over spacing ratio 1.15/1; 1.1 mm between louvers. Group 2. Light color; high reflectance, otherwise same as Group 1. Group 3. Black or dark color; w/s ratio 0.85/1; 1.5 mm between louvers. Group 4. Light color or unpainted aluminum; high reflectance; otherwise same as Group 3. Group 5. Same as Group 1, except two lights of 6 mm clear glass with 13 mm air space. Group 6. Same as Group 3, except two lights of 6 mm clear glass with 13 mm air space. $U = 4.83\ W/(m^2 \cdot K)$ for all groups when used with single glazing.

Shading coefficients for louvered sun screens are calculated using this table from the ASHRAE Handbook, however this table assumes straight louvers not curved. Therefore, it was assumed based on this data that for the curved louvers on Massachusetts Public Library, the profile angle is about 20 degrees for a light colored louver with a ratio of w/s ratio 0.85/1; 1.5 mm between louvers and a shading coefficient of 0.50. This shading coefficient is then multiplied by the shading coefficient of the glass.

Type: Solar Control Low-E Tinted Insulating Glass U= 0.27, Glass SC= 0.35
"Azuria™" + "Solarban®" z50 (3) "Optiblue®" by PPG Industries, Inc.

Cooling load caused by solar radiation, W

SOLAR TIME, h	Area (m²)	SC	SCL (W/m²)	qrad (W)
100	1.533	0.175	0	0
200	1.533	0.175	0	0
300	1.533	0.175	0	0
400	1.533	0.175	0	0
500	1.533	0.175	3	0.804825
600	1.533	0.175	79	21.193725
700	1.533	0.175	85	22.803375
800	1.533	0.175	88	23.6082
900	1.533	0.175	101	27.095775
1000	1.533	0.175	110	29.51025
1100	1.533	0.175	120	32.193
1200	1.533	0.175	126	33.80265
1300	1.533	0.175	126	33.80265
1400	1.533	0.175	123	32.997825
1500	1.533	0.175	113	30.315075
1600	1.533	0.175	98	26.29095
1700	1.533	0.175	98	26.29095
1800	1.533	0.175	113	30.315075
1900	1.533	0.175	38	10.19445
2000	1.533	0.175	19	5.097225
2100	1.533	0.175	9	2.414475
2200	1.533	0.175	3	0.804825
2300	1.533	0.175	3	0.804825
2400	1.533	0.175	0	0

Type: Pytolytic Low-E Tinted Insulating Glass U= 0.35, Glass SC = 0.4
***"Azuria™"* + *"Sungate®"* 500 (3) Clear** by PPG Industries, Inc

Cooling load caused by solar radiation, W

SOLAR TIME, h	Area (m²)	SC	SCL (W/m²)	qrad (W)
100	1.533	0.2	0	0
200	1.533	0.2	0	0
300	1.533	0.2	0	0
400	1.533	0.2	0	0
500	1.533	0.2	3	0.9198
600	1.533	0.2	79	24.2214
700	1.533	0.2	85	26.061
800	1.533	0.2	88	26.9808
900	1.533	0.2	101	30.9666
1000	1.533	0.2	110	33.726
1100	1.533	0.2	120	36.792
1200	1.533	0.2	126	38.6316
1300	1.533	0.2	126	38.6316
1400	1.533	0.2	123	37.7118
1500	1.533	0.2	113	34.6458
1600	1.533	0.2	98	30.0468
1700	1.533	0.2	98	30.0468
1800	1.533	0.2	113	34.6458
1900	1.533	0.2	38	11.6508
2000	1.533	0.2	19	5.8254
2100	1.533	0.2	9	2.7594
2200	1.533	0.2	3	0.9198
2300	1.533	0.2	3	0.9198
2400	1.533	0.2	0	0

Type: Uncoated Tinted Insulating Glass U= 0.50, Glass SC= 0.45
***"Azuria™"* + Clear** by PPG Industries, Inc.

Cooling load caused by solar radiation, W

SOLAR TIME, h	Area (m^2)	SC	SCL (W/m^2)	qrad (W)
100	1.533	0.225	0	0
200	1.533	0.225	0	0
300	1.533	0.225	0	0
400	1.533	0.225	0	0
500	1.533	0.225	3	1.034775
600	1.533	0.225	79	27.249075
700	1.533	0.225	85	29.318625
800	1.533	0.225	88	30.3534
900	1.533	0.225	101	34.837425
1000	1.533	0.225	110	37.94175
1100	1.533	0.225	120	41.391
1200	1.533	0.225	126	43.46055
1300	1.533	0.225	126	43.46055
1400	1.533	0.225	123	42.425775
1500	1.533	0.225	113	38.976525
1600	1.533	0.225	98	33.80265
1700	1.533	0.225	98	33.80265
1800	1.533	0.225	113	38.976525
1900	1.533	0.225	38	13.10715
2000	1.533	0.225	19	6.553575
2100	1.533	0.225	9	3.104325
2200	1.533	0.225	3	1.034775
2300	1.533	0.225	3	1.034775
2400	1.533	0.225	0	0

Type: Solar Control Low-E Tinted Insulating Glass U= 0.27, Glass SC= 0.35 ***"Azuria™" + "Solarban®" z50*** **(3)** ***"Optiblue®"*** by PPG Industries, Inc.	**Type: Pytolytic Low-E Tinted Insulating Glass U= 0.35, Glass SC = 0.4** ***"Azuria™" + "Sungate®" 500*** **(3) Clear** by PPG Industries, Inc	**Type: Uncoated Tinted Insulating Glass U= 0.50, Glass SC= 0.45** ***"Azuria™"*** **+ Clear** by PPG Industries, Inc.

qrad (W)	qcond (W)	Total Cooling	qrad (W)	qcond (W)	Total Cooling	qrad (W)	qcond (W)	Total Cooling
0.00	-4.70	-4.70	0.00	-6.09	-6.09	0.00	-8.70	-8.70
0.00	-7.05	-7.05	0.00	-9.14	-9.14	0.00	-13.06	-13.06
0.00	-9.40	-9.40	0.00	-12.19	-12.19	0.00	-17.41	-17.41
0.00	-9.40	-9.40	0.00	-12.19	-12.19	0.00	-17.41	-17.41
1.06	-9.40	-8.34	0.92	-12.19	-11.27	1.03	-17.41	-16.37
27.85	-9.40	18.45	24.22	-12.19	12.03	27.25	-17.41	9.84
29.97	-9.40	20.57	26.06	-12.19	13.87	29.32	-17.41	11.91
31.03	-7.05	23.98	26.98	-9.14	17.84	30.35	-13.06	17.30
35.61	-4.70	30.91	30.97	-6.09	24.87	34.84	-8.70	26.13
38.78	-2.35	36.43	33.73	-3.05	30.68	37.94	-4.35	33.59
42.31	2.35	44.66	36.79	3.05	39.84	41.39	4.35	45.74
44.43	4.70	49.13	38.63	6.09	44.72	43.46	8.70	52.17
44.43	9.40	53.83	38.63	12.19	50.82	43.46	17.41	60.87
43.37	9.40	52.77	37.71	12.19	49.90	42.43	17.41	59.84
39.84	11.75	51.59	34.65	15.23	49.88	38.98	21.76	60.74
34.55	11.75	46.31	30.05	15.23	45.28	33.80	21.76	55.56
34.55	9.40	43.95	30.05	12.19	42.23	33.80	17.41	51.21
39.84	9.40	49.24	34.65	12.19	46.83	38.98	17.41	56.39
13.40	7.05	20.45	11.65	9.14	20.79	13.11	13.06	26.16
6.70	2.35	9.05	5.83	3.05	8.87	6.55	4.35	10.91
3.17	0.00	3.17	2.76	0.00	2.76	3.10	0.00	3.10
1.06	-2.35	-1.29	0.92	-3.05	-2.13	1.03	-4.35	-3.32
1.06	-2.35	-1.29	0.92	-3.05	-2.13	1.03	-4.35	-3.32
0.00	-4.70	-4.70	0.00	-6.09	-6.09	0.00	-8.70	-8.70
		508.32			440.01			493.16

In conclusion, changing the type of glass used throughout the curtain wall facade will have an impact on the cooling loads for the mechanical system. The U-Value is not the only important variable which much be considered, the shading coefficient of the curtain-wall has a very large effect on cooling loads as well. According to this study the lowest total cooling load is the Pytolytic Low-E tinted insulating glass with a visible transmission of 57%. With more visibility and daylight in the space, greater savings can be achieved due to the lighting load reduction. For approximately half the year, any reduction in electric lighting loads due to daylighting will directly impact the savings of the cooling load in the building.

Electrical Depth

The Massachusetts Public Library has made conscious to provide a sustainable building design. The library is attempting to receive LEED certification after it is completed in 2009. The Massachusetts Public Library tries to use energy efficient lighting equipment in the controls system. In many of the rooms, in both the existing and new building there are dimming controls. As documented in this report, efforts are taken to reduce electric lighting loads with the use of natural daylight. Many rooms also have occupancy sensors to shut off lights when the building is unoccupied.

Because majority of the electrical equipment was provided by NSTAR, it is considered to be energy efficient according to their standards. A transformer comparison study is conducted to determine if the Powersmith energy efficient transformer is more beneficial than the industry standard NSTAR currently specified. Many factors are considered in this comparison study including cost savings and environmental impacts.

Another electrical study is done to compare the cost of aluminum feeders to copper feeders. All materials installed in a LEED certificated building are typically analyzed for not by their cost and environmental effects, but life expectancy as well. Copper is one material that is always being substituted for, or being used as a substitute in many buildings fabricated today.

Copper vs. Aluminum: Electrical Depth Study

All of the existing feeders throughout the building are copper. To determine whether it would be advantageous for the building to use aluminum feeders instead of copper, a cost analysis was completed. The distance of each feeder run was calculated and then multiplied by the current RSMeans values for copper and aluminum. This cost was then also adjusted for the location of the building (Massachusetts).

The first table on the following pages lists the feeders throughout the building. The second table includes the length and price of copper feeders. The third table includes the price of aluminum feeders.

Summary of tables:

Copper Feeders-

Total Cost CU	138004.2
Total w/ MA multiplier	160360.8

Aluminum Feeders-

Total Cost Al	82692.49
Total w/ MA multiplier	96088.67

In conclusion, the aluminum feeders is $64,272 cheaper than the copper feeders. Based on this calculation alone the recommendation would be to use aluminum feeders in the Massachusetts Public Library. However, copper is an industry standard and it has been known to have a longer life span, and easier to install.

According to the Copper Development Association, aluminum's light weight is its one advantage in current-carrying applications and it is used almost exclusively in overhead transmission and distribution cable. The mini-materials battle between copper and aluminum for the best such material for current-technology superconductors such as niobium-titanium has been won by copper. Superconductivity could be an important new market for copper, particularly in transmission lines, energy storage devices, and other applications not yet contemplated.

Tag	From	To	No. of Sets	Conduit	Phase Conductors			Neutral Conductor			Ground Conductors			TRIP	Distance (feet)
				Size	No.	Size	Type	No.	Size	Type	No.	Size	Type		
1	D4NBA	L4NMA	1	1”	3	6 AWG	CU-THWN	1	6 AWG	CU-THWN	1	10 AWG	CU-THWN	60	108
2	D4NBA	L4N2A	1	1 ¼”	3	4 AWG	CU-THWN	1	4 AWG	CU-THWN	1	8 AWG	CU-THWN	70	89
3	MAIN SWITCHBOARD SS4NB (5)	100AS	1	1 ¼”	3	4 AWG	CU-THWN	0	0	CU-THWN	1	8 AWG	CU-THWN	100	328
4	M4NBB	M4N2B	1	1 1/2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	8 AWG	CU-THWN	100	143
5	MAIN SWITCHBOARD SS4NB	SWRTCP	1	1 1/2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	8 AWG	CU-THWN	100	8
6	TRANSFORMER	MAIN SWITCHBOARD SS4NB	1	1 1/2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	8 AWG	CU-THWN	100	27
7	D2NBC	R2N2C	1	1 1/2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	8 AWG	CU-THWN	100	274.5
8	D4LSB	L4LSBA	1	1 1/2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	8 AWG	CU-THWN	100	17
9	MAIN SWITCHBOARD SS4NB (4)	M4NBB	1	2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	6 AWG	CU-THWN	125	289
10	D2NBC	R2N1A	1	2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	6 AWG	CU-THWN	125	283.5
11	MAIN SWITCHBOARD SS4NB (1)	L4NGB	1	2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	6 AWG	CU-THWN	125	9
12	D4LRB	M4LR2	1	2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	6 AWG	CU-THWN	125	95
13	M4NBA	M4N2A	1	2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	6 AWG	CU-THWN	125	89
14	D2NBA	R2NMA	1	2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	6 AWG	CU-THWN	125	108
15	D2NBA	R2NMB	1	2"	3	1 AWG	CU-THWN	1	1 AWG	CU-THWN	1	6 AWG	CU-THWN	125	108
16	D2NBC	R2NBB	1	2"	3	1/0 AWG	CU-THWN	1	1/0 AWG	CU-THWN	1	6 AWG	CU-THWN	150	186
17	MAIN SWITCHBOARD SS4NB (11)	D4NBA	1	2"	3	1/0 AWG	CU-THWN	1	1/0 AWG	CU-THWN	1	6 AWG	CU-THWN	150	187.5
18	MAIN SWITCHBOARD SS4NB (7)	D4LRB	1	2"	3	2/0 AWG	CU-THWN	1	2/0 AWG	CU-THWN	1	6 AWG	CU-THWN	175	178
19	MAIN SWITCHBOARD SS4NB (8)	DIESEL GENERATOR	1	2"	3	2/0 AWG	CU-THWN	1	2/0 AWG	CU-THWN	1	6 AWG	CU-THWN	175	172
20	MAIN SWITCHBOARD SS4NB (7)	DIESEL GENERATOR	1	2"	3	2/0 AWG	CU-THWN	1	2/0 AWG	CU-THWN	1	6 AWG	CU-THWN	175	172
21	MAIN SWITCHBOARD SS4NB (7)	FIRE PUMP CONTROLLER	1	2"	3	2/0 AWG	CU-THWN	0	0	CU-THWN	1	2/0 AWG	CU-THWN	175	140.5

Tag	From	To	No. of Sets	Conduit	Phase Conductors			Neutral Conductor			Ground Conductors			TRIP	Distance (feet)
				Size	No.	Size	Type	No.	Size	Type	No.	Size	Type		
22	D2NBA	R2NBA	1	2"	3	2/0 AWG	CU-THWN	0	0	CU-THWN	1	2/0 AWG	CU-THWN	175	2
23	MAIN SWITCHB OARD SS4NB	D4NGB	1	2"	3	3/0 AWG	CU-THWN	1	3/0 AWG	CU-THWN	1	6 AWG	CU-THWN	200	3
24	MAIN SWITCHB OARD SS4NB (6)	D4LSB	1	2 1/2"	3	4/0 AWG	CU-THWN	1	4/0 AWG	CU-THWN	1	4 AWG	CU-THWN	225	24.5
25	MAIN SWITCHB OARD SS4NB (6)	DIESEL GENERAT OR	1	2 1/2"	3	4/0 AWG	CU-THWN	1	4/0 AWG	CU-THWN	1	4 AWG	CU-THWN	225	172
26	MAIN SWITCHB OARD SS4NB (9)	M4NBA	1	4"	3	600 KCMIL	CU-THWN	1	600 KCMIL	CU-THWN	1	3 AWG	CU-THWN	400	187.5
27	MAIN SWITCHB OARD SS4NB (12)	M4NS	2	3 1/2"	3	350 KCMIL	CU-THWN	1	350 KCMIL	CU-THWN	2	2 AWG	CU-THWN	600	187.5
28	TRANSFO RMER	MAIN SWITCHB OARD SS4NB	2	3 1/2"	3	600 KCMIL	CU-THWN	0	0	CU-THWN	2	1/0 AWG	CU-THWN	800	27
29	TRANSFO RMER	MAIN SWITCHB OARD SS4NB	5	3 1/2"	3	600 KCMIL	CU-THWN	1	600 KCMIL	CU-THWN	5	250 KCMIL	CU-THWN	2000	27
30	D4LSB	L4LS2B	1		3	8 AWG	MI	1	8 AWG	MI				70	
31	D4LSB	L4LS2A	1		3	8 AWG	MI	1	8 AWG	MI				70	89
32	D4LSB	L4LSBB	1		3	8 AWG	#7/8-710 MI	0	0					30	64
33	D4NBA	L4NBA	1	1"	3	8 AWG	CU-THWN	1	8 AWG	CU-THWN	1	10 AWG	CU-THWN	40	9
34	L4NBB	L4N2B	1	3/4"	3	10 AWG	CU-THWN	1	10 AWG	CU-THWN	1	10 AWG	CU-THWN	40	95
35	MAIN SWITCHB OARD SS4NB (13)	CHILLER NO.1	1	1/2"	3	250 KCMIL	CU-THWN	2	250 KCMIL	CU-THWN	2	2 AWG	CU-THWN	500	187.5
36	MAIN SWITCHB OARD SS4NB (14)	CHILLER NO.2	1	1/2"	3	250 KCMIL	CU-THWN	2	250 KCMIL	CU-THWN	2	2 AWG	CU-THWN	500	187.5
37	L4NGB	TA	3	1/2"	3	12 AWG	CU-THWN	1	12 AWG	CU-THWN	1	12 AWG	CU-THWN	15	7.5
38	L4NGB	T4	3	1- 1/4"	3	3 AWG	CU-THWN	1	3 AWG	CU-THWN	1	8 AWG	CU-THWN	90	3.5
39	TA	R2NGB	4	3/4"	3	12 AWG	CU-THWN	1	12 AWG	CU-THWN	1	12 AWG	CU-THWN	40	1
40	T4	R2NGA	4	2"	3	1/0 AWG	CU-THWN	1	1/0 AWG	CU-THWN	1	4 AWG	CU-THWN	150	1

Tag	From	To	No. of Sets	Conduit	Phase Conductors			Neutral Conductor			Ground Conductors			TRIP	Distance (feet)
				Size	No.	Size	Type	No.	Size	Type	No.	Size	Type		
41	MAIN SWITCHBOARD SS4NB (14)	T6	3	2"	3	3/0 AWG	CU-THWN	1	3/0 AWG	CU-THWN	1	6 AWG	CU-THWN	200	18
42	T6	D2NBC	4	3.5"	3	500kcmil	CU-THWN	1	500kcmil	CU-THWN	1	3 AWG	CU-THWN	400	4
43	MAIN SWITCHBOARD SS4NB (14)	T6	3	2"	3	3/0 AWG	CU-THWN	1	3/0 AWG	CU-THWN	1	6 AWG	CU-THWN	200	187.5
44	T6	D2NBA	4	3.5"	3	500kcmil	CU-THWN	1	500kcmil	CU-THWN	1	3 AWG	CU-THWN	400	8
45	M4NS	T3	3	3/4"	3	6 AWG	CU-THWN	1	6 AWG	CU-THWN	1	10 AWG	CU-THWN	60	17.5
46	T3	R2NS	4	1- 1/4"	3	3 AWG	CU-THWN	1	3 AWG	CU-THWN	1	8 AWG	CU-THWN	100	3
47	M4NBA	T1	3	3/4"	3	12 AWG	CU-THWN	1	12 AWG	CU-THWN	1	12 AWG	CU-THWN	20	13
48	T1	M2NB	4	3/4"	3	8 AWG	CU-THWN	1	8 AWG	CU-THWN	1	10 AWG	CU-THWN	40	2
49	D4LRB	T3	3	3/4"	3	6 AWG	CU-THWN	1	6 AWG	CU-THWN	1	10 AWG	CU-THWN	60	12
50	T3	M2LRB	4	1- 1/4"	3	3 AWG	CU-THWN	1	3 AWG	CU-THWN	1	8 AWG	CU-THWN	100	1
51	MAIN SWITCHBOARD SS4NB (14)	M40SB	1	1”	3	6 AWG	CU-THWN	1	6 AWG	CU-THWN	1	10 AWG	CU-THWN	60	187.5
52	M40SB	T2	3	3/4"	3	10 AWG	CU-THWN	1	10 AWG	CU-THWN	1	10 AWG	CU-THWN	30	2
53	T2	M20SBA	4	1"	3	6 AWG	CU-THWN	1	6 AWG	CU-THWN	1	10 AWG	CU-THWN	50	2
54	100 AS	T4	3	1 1/4"	3	3 AWG	CU-THWN	1	3 AWG	CU-THWN	1	8 AWG	CU-THWN	90	2
55	T4	R2N2A-R2N2B	4	2"	3	1/o	CU-THWN	1	1/o	CU-THWN	1	6 AWG	CU-THWN	150	2
56	L4LSBA	TB	3	1/2"	3	12 AWG	CU-THWN	1	12 AWG	CU-THWN	1	12 AWG	CU-THWN	15	2
57	TB	R2LSB	4	3/4"	3	12 AWG	CU-THWN	1	12 AWG	CU-THWN	1	12 AWG	CU-THWN	40	2
58	L4LSBB	D4LSB	1	7/8"	3	8 AWG	CU-THWN	1	8 AWG	CU-THWN	1	10 AWG	CU-THWN		30
59	MAIN SWITCHBOARD SS4NB (14)	L4NBB	4	1"	3	6 AWG	CU-THWN	1	6 AWG	CU-THWN	1	10 AWG	CU-THWN		201

Tag	Cost-Phase CU THWN	No.	x Distance	Total Cost Phase CU	Cost-Neutral CU THWN	No.	x Distance	Total Cost Neutral CU	Cost-Ground CU THWN	No.	x Distance	Total Cost Ground CU	Total
1	125.5	3	108	406.62	125.5	1	108	135.54	62.5	1	108	67.5	609.66
2	177	3	89	472.59	177	1	89	157.53	90.5	1	89	80.545	710.665
3	177	3	328	1741.68	177	0	328	0	90.5	1	328	296.84	2038.52
4	307	3	143	1317.03	307	1	143	439.01	90.5	1	143	129.415	1885.455
5	307	3	8	73.68	307	1	8	24.56	90.5	1	8	7.24	105.48
6	307	3	27	248.67	307	1	27	82.89	90.5	1	27	24.435	355.995
7	307	3	274.5	2528.145	307	1	274.5	842.715	90.5	1	274.5	248.4225	3619.283
8	307	3	17	156.57	307	1	17	52.19	90.5	1	17	15.385	224.145
9	307	3	289	2661.69	307	1	289	887.23	125.5	1	289	362.695	3911.615
10	307	3	283.5	2611.035	307	1	283.5	870.345	125.5	1	283.5	355.7925	3837.173
11	307	3	9	82.89	307	1	9	27.63	125.5	1	9	11.295	121.815
12	307	3	95	874.95	307	1	95	291.65	125.5	1	95	119.225	1285.825
13	307	3	89	819.69	307	1	89	273.23	125.5	1	89	111.695	1204.615
14	307	3	108	994.68	307	1	108	331.56	125.5	1	108	135.54	1461.78
15	307	3	108	994.68	307	1	108	331.56	125.5	1	108	135.54	1461.78
16	373	3	186	2081.34	373	1	186	693.78	125.5	1	186	233.43	3008.55
17	373	3	187.5	2098.125	373	1	187.5	699.375	125.5	1	187.5	235.3125	3032.813
18	455	3	178	2429.7	455	1	178	809.9	125.5	1	178	223.39	3462.99
19	455	3	172	2347.8	455	1	172	782.6	125.5	1	172	215.86	3346.26
20	455	3	172	2347.8	455	1	172	782.6	125.5	1	172	215.86	3346.26
21	455	3	140.5	1917.825	455	0	140.5	0	455	1	140.5	639.275	2557.1

Tag	Cost-Phase CU THWN	No.	x Distance	Total Cost Phase CU	Cost-Neutral CU THWN	No.	x Distance	Total Cost Neutral CU	Cost-Ground CU THWN	No.	x Distance	Total Cost Ground CU	Total
22	455	3	2	27.3	455	0	2	0	455	1	2	9.1	36.4
23	560	3	3	50.4	560	1	3	16.8	125.5	1	3	3.765	70.965
24	686	3	24.5	504.21	686	1	24.5	168.07	177	1	24.5	43.365	715.645
25	686	3	172	3539.76	686	1	172	1179.92	177	1	172	304.44	5024.12
26	1689	3	187.5	9500.625	1689	1	187.5	3166.875	209	1	187.5	391.875	13059.38
27	1059	6	187.5	11913.75	1059	2	187.5	3971.25	251.5	4	187.5	1886.25	17771.25
28	1689	6	27	2736.18	1689	0	27	0	373	4	27	402.84	3139.02
29	1689	15	27	6840.45	1689	5	27	2280.15	798	25	27	5386.5	14507.1
30	90.5	3	0	0	90.5	1	0	0		0	0	0	0
31	90.5	3	89	241.635	90.5	1	89	80.545		0	89	0	322.18
32	90.5	3	64	173.76	90.5	0	64	0		0	64	0	173.76
33	90.5	3	9	24.435	90.5	1	9	8.145	62.5	1	9	5.625	38.205
34	62.5	3	95	178.125	62.5	1	95	59.375	62.5	1	95	59.375	296.875
35	798	3	187.5	4488.75	798	2	187.5	2992.5	251.5	2	187.5	943.125	8424.375
36	798	3	187.5	4488.75	798	2	187.5	2992.5	251.5	2	187.5	943.125	8424.375
37	50.25	9	7.5	33.91875	50.25	3	7.5	11.30625	90.5	3	7.5	20.3625	65.5875
38	209	9	3.5	65.835	209	3	3.5	21.945	90.5	3	3.5	9.5025	97.2825
39	50.25	12	1	6.03	50.25	4	1	2.01	90.5	4	1	3.62	11.66
40	373	12	1	44.76	373	4	1	14.92	177	4	1	7.08	66.76

Tag	Cost-Phase CU THWN	No.	x Distance	Total Cost Phase CU	Cost-Neutral CU THWN	No.	x Distance	Total Cost Neutral CU	Cost-Ground CU THWN	No.	x Distance	Total Cost Ground CU	Total
41	560	9	18	907.2	560	3	18	302.4	125.5	3	18	67.77	1277.37
42	1410	12	4	676.8	1410	4	4	225.6	209	4	4	33.44	935.84
43	560	9	187.5	9450	560	3	187.5	3150	125.5	3	187.5	705.9375	13305.94
44	1410	12	8	1353.6	1410	4	8	451.2	209	4	8	66.88	1871.68
45	125.5	9	17.5	197.6625	125.5	3	17.5	65.8875	62.5	3	17.5	32.8125	296.3625
46	209	12	3	75.24	209	4	3	25.08	90.5	4	3	10.86	111.18
47	50.25	9	13	58.7925	50.25	3	13	19.5975	50.25	3	13	19.5975	97.9875
48	90.5	12	2	21.72	90.5	4	2	7.24	62.5	4	2	5	33.96
49	125.5	9	12	135.54	125.5	3	12	45.18	62.5	3	12	22.5	203.22
50	209	12	1	25.08	209	4	1	8.36	90.5	4	1	3.62	37.06
51	125.5	3	187.5	705.9375	125.5	1	187.5	235.3125	62.5	1	187.5	117.1875	1058.438
52	62.5	9	2	11.25	62.5	3	2	3.75	62.5	3	2	3.75	18.75
53	125.5	12	2	30.12	125.5	4	2	10.04	62.5	4	2	5	45.16
54	209	9	2	37.62	209	3	2	12.54	90.5	3	2	5.43	55.59
55	373	12	2	89.52	373	4	2	29.84	125.5	4	2	10.04	129.4
56	39.4	9	2	7.092	39.4	3	2	2.364	39.4	3	2	2.364	11.82
57	39.4	12	2	9.456	39.4	4	2	3.152	39.4	4	2	3.152	15.76
58	90.5	3	30	81.45	90.5	1	30	27.15	62.5	1	30	18.75	127.35
59	125.5	12	201	3027.06	125.5	4	201	1009.02	62.5	4	201	502.5	4538.58
											Total Cost CU		138004.2
										Total w/ MA multiplier			160360.8

Tag	Size (AWG or kcmil)	Ground Size (AWG or	Cost-Phase AL THW	No.	x Distance	Total Cost Phase AL	Cost-Neutral AL THW	No.	x Distance	Total Cost Neutral CU	Cost-Ground AL THW	No.	x Distance	Total Cost Ground CU	Total
1	4	6	97.5	3	108	315.9	97.5	1	108	105.3	79	1	108	85.32	506.52
2	3	6	124.5	3	89	332.415	124.5	1	89	110.805	79	1	89	70.31	513.53
3	1	6	162	3	328	1594.08	162	0	328	0	79	1	328	259.12	1853.2
4	1	6	162	3	143	694.98	162	1	143	231.66	79	1	143	112.97	1039.61
5	1	6	162	3	8	38.88	162	1	8	12.96	79	1	8	6.32	58.16
6	1	6	162	3	27	131.22	162	1	27	43.74	79	1	27	21.33	196.29
7	1	6	162	3	274.5	1334.07	162	1	274.5	444.69	79	1	274.5	216.855	1995.615
8	1	6	162	3	17	82.62	162	1	17	27.54	79	1	17	13.43	123.59
9	2/o	4	216	3	289	1872.72	216	1	289	624.24	97.5	1	289	281.775	2778.735
10	2/o	4	216	3	283.5	1837.08	216	1	283.5	612.36	97.5	1	283.5	276.4125	2725.853
11	2/o	4	216	3	9	58.32	216	1	9	19.44	97.5	1	9	8.775	86.535
12	2/o	4	216	3	95	615.6	216	1	95	205.2	97.5	1	95	92.625	913.425
13	2/o	4	216	3	89	576.72	216	1	89	192.24	97.5	1	89	86.775	855.735
14	2/o	4	216	3	108	699.84	216	1	108	233.28	97.5	1	108	105.3	1038.42
15	2/o	4	216	3	108	699.84	216	1	108	233.28	97.5	1	108	105.3	1038.42
16	3/o	4	252	3	186	1406.16	252	1	186	468.72	97.5	1	186	181.35	2056.23
17	3/o	4	252	3	187.5	1417.5	252	1	187.5	472.5	97.5	1	187.5	182.8125	2072.813
18	4/o	4	275	3	178	1468.5	275	1	178	489.5	97.5	1	178	173.55	2131.55
19	4/o	4	275	3	172	1419	275	1	172	473	97.5	1	172	167.7	2059.7
20	4/o	4	275	3	172	1419	275	1	172	473	97.5	1	172	167.7	2059.7
21	4/o	4/o	275	3	140.5	1159.125	275	0	140.5	0	275	1	140.5	386.375	1545.5
22	4/o	4/o	275	3	2	16.5	275	0	2	0	275	1	2	5.5	22
23	250	4	318	3	3	28.62	318	1	3	9.54	97.5	1	3	2.925	41.085
24	300	2	398	3	24.5	292.53	398	1	24.5	97.51	125	1	24.5	30.625	420.665
25	300	2	398	3	172	2053.68	398	1	172	684.56	125	1	172	215	2953.24
26	1000	1	1065	3	187.5	5990.625	1065	1	187.5	1996.875	162	1	187.5	303.75	8291.25
27	500	1/o	528	6	187.5	5940	528	2	187.5	1980	188	4	187.5	1410	9330
28	1000	3/o	1065	6	27	1725.3	1065	0	27	0	252	4	27	272.16	1997.46
29	1000	350	1065	15	27	4313.25	1065	5	27	1437.75	414	25	27	2794.5	8545.5
30	6	0	79	3	0	0	79	1	0	0	0	0	0	0	0
31	6	0	79	3	89	210.93	79	1	89	70.31	0	0	89	0	281.24
32	6	0	79	3	64	151.68	79	0	64	0	0	0	64	0	151.68
33	6	6	79	3	9	21.33	79	1	9	7.11	79	1	9	7.11	35.55
34	6	6	79	3	95	225.15	79	1	95	75.05	79	1	95	75.05	375.25
35	300	1/o	318	3	187.5	1788.75	318	2	187.5	1192.5	188	2	187.5	705	3686.25
36	300	1/o	318	3	187.5	1788.75	318	2	187.5	1192.5	188	2	187.5	705	3686.25
37	6	6	79	9	7.5	53.325	79	3	7.5	17.775	79	3	7.5	17.775	88.875
38	2	6	124.5	9	3.5	39.2175	124.5	3	3.5	13.0725	79	3	3.5	8.295	60.585
39	6	6	79	12	1	9.48	79	4	1	3.16	79	4	1	3.16	15.8
40	3/o	2	252	12	1	30.24	252	4	1	10.08	124.5	4	1	4.98	45.3
41	250	4	318	9	18	515.16	318	3	18	171.72	97.5	3	18	52.65	739.53
42	750	1	709	12	4	340.32	709	4	4	113.44	162	4	4	25.92	479.68
43	250	4	318	9	187.5	5366.25	318	3	187.5	1788.75	97.5	3	187.5	548.4375	7703.438
44	750	1	709	12	8	680.64	709	4	8	226.88	162	4	8	51.84	959.36
45	4	6	97.5	9	17.5	153.5625	97.5	3	17.5	51.1875	79	3	17.5	41.475	246.225
46	1	6	162	12	3	58.32	162	4	3	19.44	79	4	3	9.48	87.24
47	6	6	79	9	13	92.43	79	3	13	30.81	79	3	13	30.81	154.05
48	6	6	79	12	2	18.96	79	4	2	6.32	79	4	2	6.32	31.6
49	4	6	97.5	9	12	105.3	97.5	3	12	35.1	79	3	12	28.44	168.84
50	1	6	162	12	1	19.44	162	4	1	6.48	79	4	1	3.16	29.08
51	4	6	97.5	3	187.5	548.4375	97.5	1	187.5	182.8125	79	1	187.5	148.125	879.375
52	6	6	79	9	2	14.22	79	3	2	4.74	79	3	2	4.74	23.7
53	6	6	79	12	2	18.96	79	4	2	6.32	79	4	2	6.32	31.6
54	1	6	162	9	2	29.16	162	3	2	9.72	79	3	2	4.74	43.62
55	3/o	4	252	12	2	60.48	252	4	2	20.16	97.5	4	2	7.8	88.44
56	6	6	79	9	2	14.22	79	3	2	4.74	79	3	2	4.74	23.7
57	6	6	79	12	2	18.96	79	4	2	6.32	79	4	2	6.32	31.6
58	6	6	79	3	30	71.1	79	1	30	23.7	79	1	30	23.7	118.5
59	6	6	79	12	201	1905.48	79	4	201	635.16	79	4	201	635.16	3175.8
												Total Cost Al			82692.49
												Total w/ MA multiplier			96088.67

Energy Efficient Transformers: Electrical Depth Study

Because the building is striving to be LEED certified, all electrical equipment should be made as energy efficient as possible. Therefore for the second electrical study involves the energy efficiency of the transformers. A cost-feasibility study was done using Powersmiths Energy Savings Payback Calculator, to determine if replacing the building's current transformers with their T1000-C3 series of energy efficient transformers is cost effective.

The building includes the following transformers with the costs included according to RSMeans.

TRANSFORMER SCHEDULE							
#REQ	**KVA**	**PHASE**	**PRIMARY**	**SECONDARY**	**CATALOG #**	**TEMP. RISE**	**Cost**
1	3	3	480V	208Y/120V	3T2F	115C	1525
1	6	3	480V	208Y/120V	6T2F	115C	2025
1	9	3	480V	208Y/120V	9T2F	115C	2300
2	112.5	3	480V	208Y/120V	EE112T3H	115C	7300
1	15	3	480V	208Y/120V	EE153H	115C	3025
2	30	3	480V	208Y/120V	EE30T3H	115C	3600
2	45	3	480V	208Y/120V	EE45T3H	115C	4225

Cost Total: $ 24,000 x 1.162 (MA multiplier) = $27,888

Powersmiths estimated cost total = $27,888 x 1.5 = $41,832

Delivery Service Charges

Customer (per month) $7.32	**Distribution Demand** First 10 kW (per kW) $3.76	**Distribution Demand** Over 10 kW (per kW) $7.01
Distribution Energy (per kWh) $0.1099	**Transition Demand** (per kW) $2.97	**Transition Energy** (credit per kWh) $0.00102
Transmission Demand (per kW) $2.42	**Energy Conservation** (per kWh) $0.00250	**Renewable Energy** (per kWh) $0.00050

The nameplate linear efficiency (normal operation) was stated to be 97%. Because the library is open from very early morning hours to late at night, it was estimated that the transformer would operate for approximately 14 hours a day for 365 days of the year. The load during normal operating hours is 35% and the load outside operating hours is 20%.

Although the initial cost of the Powersmith transformers is approximately 1.5 times the cost of the existing transformers, it is calculated that the energy efficient transformers will only have a payback of 2.37 years. This is due to the combination of the annual energy cost saving. The annual operating cost of the "status quo transformer" is almost quadruple that of the Powersmiths Transformers. Therefore, in 32 years, the difference in savings with Powersmiths would be about $485,000.

	Annual Operating Cost	Life Cycle Operating Cost & Savings 20 years	32 years
Status Quo Transformers	$8,143	$294,126	$670,966
Powersmiths Transformers	$2,249	$81,256	$185,362
Savings with Powersmiths	**$5,893**	**$212,870**	**$485,603**

Cost	**Cost**
Powersmiths Transformers	$41,832
Status Quo Transformers	**$27,888**

Payback on total cost	2.37	years	current kWh rate:
Cost of Energy Savings	$ 0.009	/kWh	**$0.110**
Cost - Benefit Ratio	12.4	times less to save a kWh than to buy a kWh	

Leasing Option	60 Month Term	48 Month Term	36 Month Term
Total Annual Leasing Payments	**$10,577**	**$12,901**	**$16,415**
Net Annual Cost with savings	$4,684	$7,008	$10,522

In addition to these cost savings, the Powersmith transformers have a significant reduction in Greenhouse Gases. The environmental benefits are listed within the following table:

Summary of Environmental Benefits

Annual Reduction in Greenhouse Gases (per EPA)		Equivalence	
36	tons of CO_2	7	Acres trees planted
117	tons of Coal	5	Car Emissions
283	kgs of SO_2	5	homes heated
122	kgs of NO_x		

Due to the environmental benefits as well as the savings on annual costs, it is recommended that the Massachusetts Public Library use Powersmiths transformers.

The following tables include the energy savings payback calculator:

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Energy Savings Payback Calculator

Project Description	**Massachusetts Public Library**
Date	**7-Apr-09**

Data Entry

Transformers on Project

QTY	kVA
1	15
2	30
2	45
	75
2	112.5
1	3
1	6
1	9
	500
	750
	1000
	1500
	2000
	7.5

		Calc Load kW	Calc Annual kWh
Available Full Load kW	**408**		
Average kVA (calc)	**41**		
equipment operating hrs/ day	**14**		
equipment operating days/yr	**365**		
Load during normal operating hours	**35%**	143	729,708
Load outside operating hours	**20%**	82	297,840
		Total Annual Load kWh:	**1,027,548**

Annual Cost to Operate Load Only

kWh rate	**$ 0.110**	Annual Consumption:	$ 113,030
demand rate ($/kW/mo) ex. $10.00	**$7.32**	Annual Demand:	$ 12,544
		Total Cost to run load	**$ 125,574**

Annual Cost of Status Quo Transformer Losses & Associated Air Conditioning (A/C) burden

Nameplate Linear efficiency (normal op hrs)	97.0%		% electronics or current THD	35.0%
Calculated operating efficiency	96.0%			
Transformer kW Losses (Normal Operation)	6.0	kW		
Status quo Efficiency (Outside op. hrs)	94.0%			
Transformer kW Losses (Outside op. hrs)	5.2	kW		
Annual addititional kWh from transformers	49,812	kWh		
Annual Cost of Transformer Losses	$ 6,009			
A/C System Performance (kW/ton)	1.25			
Additional Tons of Cooling (on peak)	1.71	tons		
Annual addititional kWh from A/C	17,689	kWh		
Annual Cost of Associated A/C	$ 2,134			

Summary with Status Quo Transformer

Annual Cost of feeding Building Load	$ 125,574
Annual Cost of Transformer Losses	$ 6,009
Annual Cost of Associated A/C	$ 2,134
Electrical Bill (Status Quo Transformer)	**$ 133,716**

Using Powersmiths instead of status quo transformers

Powersmiths Efficiency (Normal Operation)	98.8%	
Powersmiths kW Losses (Normal Operation)	1.7	kW
Powersmiths Efficiency (Outside op. hrs)	98.4%	
Transformer kW Losses (Outside op. hrs)	1.3	kW
Annual addititional kWh from transformers	13,706	kWh
Annual Cost of Powersmiths Losses	$ 1,660	
Additional Tons of Cooling (on peak)	0.49	tons
Annual addititional kWh from A/C	4,867	kWh
Annual Cost of Associated A/C	$ 589	

Comparing Status Quo & Powersmiths

	Status Quo	Powersmiths	Reduction
Annual Cost of feeding Building Load	$ 125,574	$ 125,574	
Annual Cost of Transformer Losses	$ 6,009	$ 1,660	
Annual Cost of Associated A/C	$ 2,134	$ 589	
Annual estimated Electrical Bill	$ 133,716	$ 127,823	**4%**

Peak kW reduction (normal op hours)	**5.8**	**kW**
Annual kWh reduction	**48,928**	**kWh**
Reduction in Air Conditioning Load (on peak)	**1.22**	**tons**

Cost Analysis (calc)

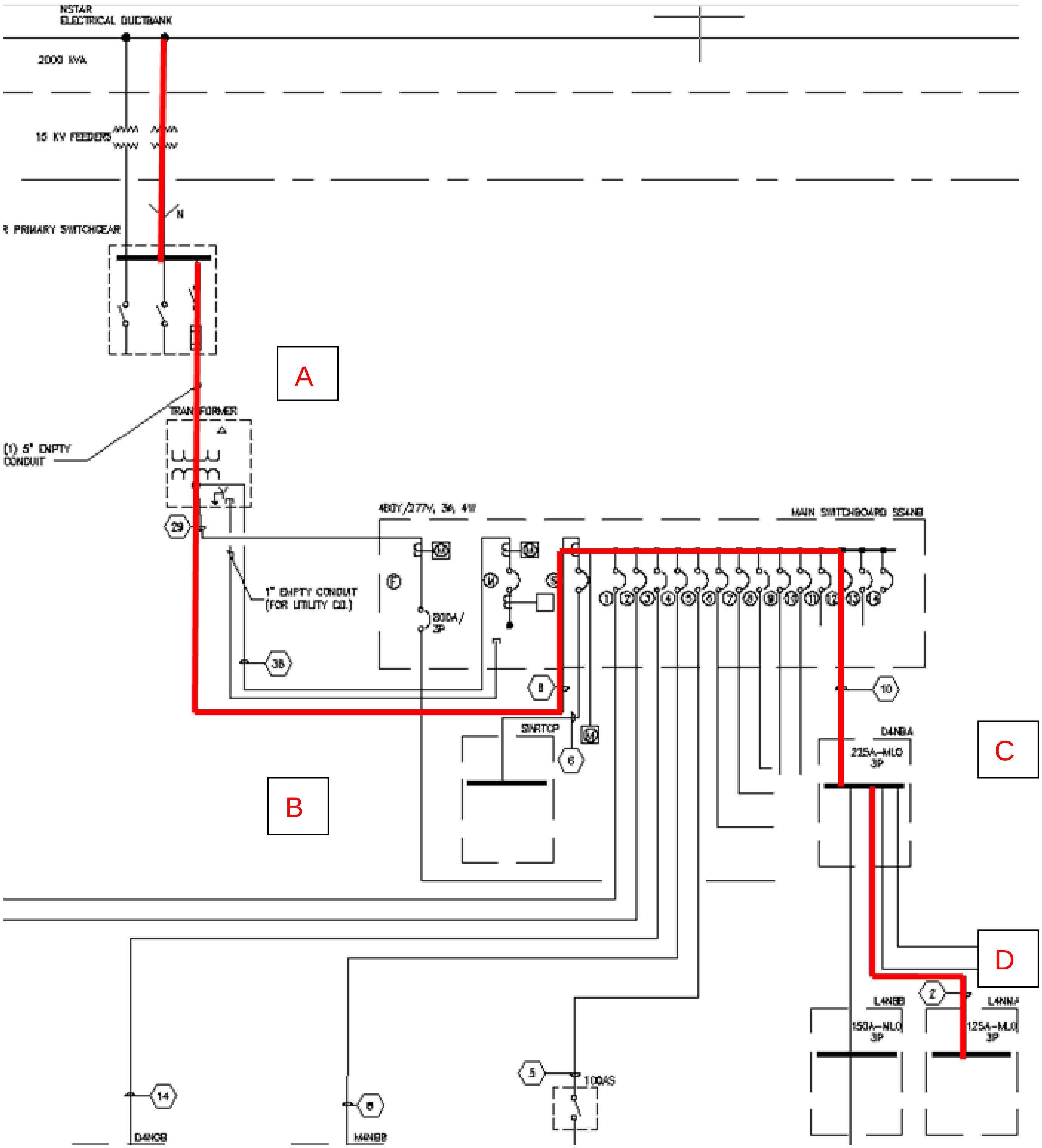
Energy Cost Escalation (above inflation)	3.0%
Annual Power Quality Benefit	$ -

Short Circuit Analysis and Protective Device Coordination Study: Electrical Depth Study

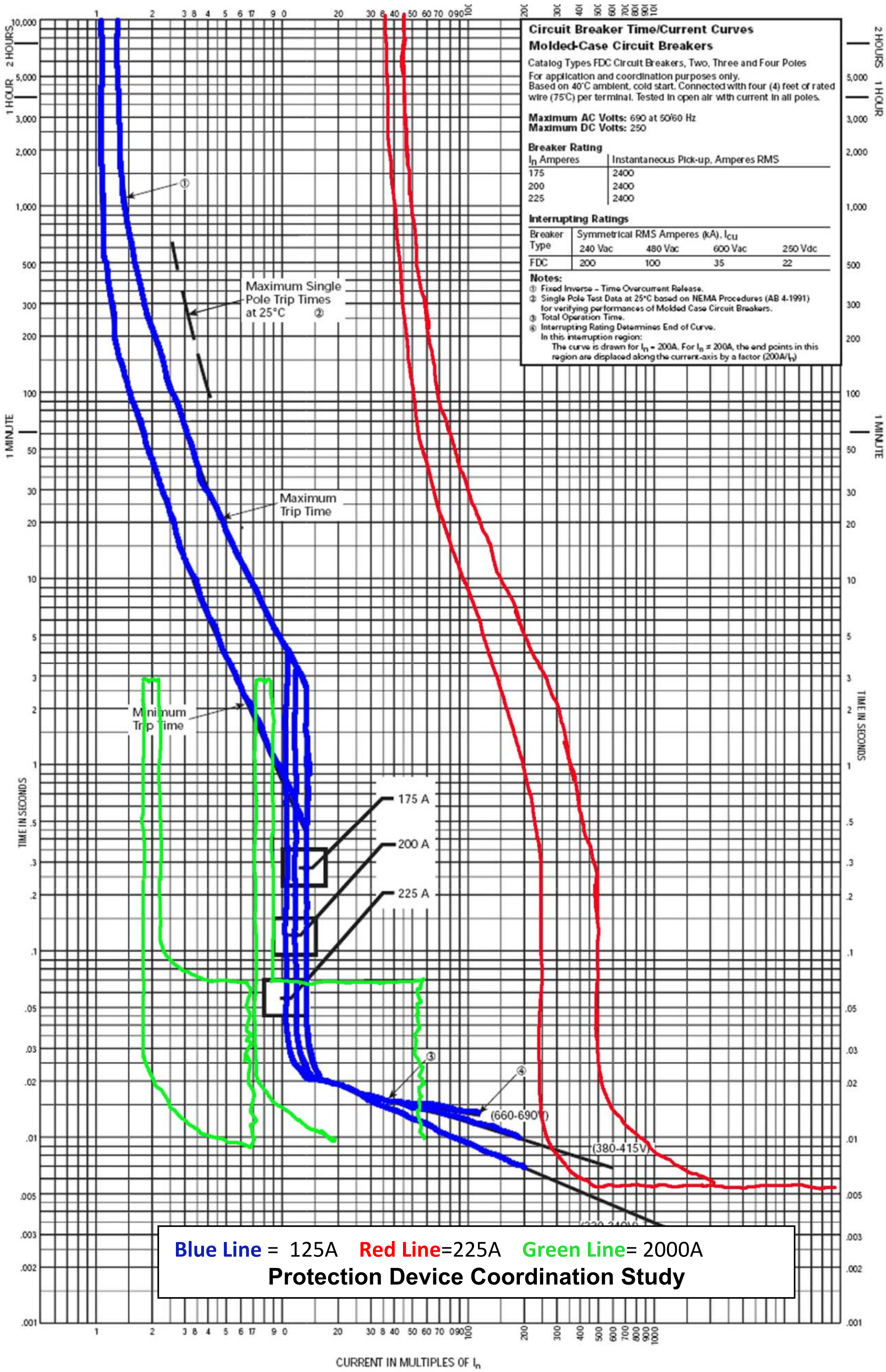
A protective device coordination study and a fault current analysis were performed for a selected path through the system (shown on the following pages). The calculations for the fault current analysis were done using a per unit method. The path begins at the utility transformer then goes to the main switchboard, continues to a distribution panel, and ends at an end-use panel.

The switchboard has an AIC rating of 65 K and the distribution panel has an AIC rating of 35 K which are both well above the calculated values of the short circuit analysis. All of the equipment analyzed meets the required hand calculations.

Per Unit Short Circuit Method			
Point	Location	Available Fault	Standard Breaking Rating
A	Utility Transformer Secondary Side	34366	35000
B	Main Switchboard SS4NB	32400	35000
C	Pandelboard D4NBA	6415	14000
D	Panelboard L4NMA	2845	14000


NSTAR
ELECTRICAL DUCTBANK
2000 KVA
15 KV FEEDERS
N
R PRIMARY SWITCHGEAR
A
TRANSFORMER
(1) 5" EMPTY CONDUIT
29
480Y/277V, 3A, 4W
MAIN SWITCHBOARD SS4NB
1" EMPTY CONDUIT (FOR UTILITY CO.)
800A/3P
38
8
10
SWRTCP
6
D4NBA
225A-MLO 3P
C
B
D
2
L4NEB
150A-MLO 3P
L4NNA
125A-MLO 3P
5
100AS
14
8
D4NCB
M4NBB

Per Unit Short Circuit Method			
Base kVA	10,000		
Available Utility Fault (kVA)	1,000,000		
System Voltage (kV)	0.48		
Utility Transformer Primary Side			
Utility Transformer Size (kVA)	2,000	**X (p.u.) = (Base kVA/Utility S.C. kVA)**	0.01
Utility Transformer Secondary Side			
Average % Z.	7	X (p.u.)= (%X * base kVA)/(100 *xfmr kVA)	0.34922481
Average X/R	15	R(p.u.) = (%R * base KVA)/(100 *xfrmr kVA)	0.02328165
R (%)	0.465633074		
X (%)	6.984496105	ΣX(p.u.)	0.35922481
		ΣR(p.u.)	0.02328165
		ΣZ(p.u.)	0.35
		Isc rms sym	34366.0875
Main Switchboard SS4NB			
# of sets	5	X(p.u.) =(X) x (baseKVA) / (1000) x(KV^2)	0.01085156
length	27	R(p.u.) =(R) x (baseKVA) / (1000) x(KV^2)	0.00602344
Wire Size	600 KCMIL		
XL	0.0463		
R	0.0257	ΣX(p.u.)	0.37007637
X = (length/1000)x(XL) x(1/(#sets)	0.00025002	ΣR(p.u.)	0.02930509
R= (length/1000)x(R) x(1/(#sets)	0.00013878	ΣZ(p.u.)	0.37123484
		Isc rms sym	32400.3281
Panelboard D4NBA			
# of sets	1	X(p.u.) =(X) x (baseKVA) / (1000) x(KV^2)	0.47607422
length	187.5	R(p.u.) =(R) x (baseKVA) / (1000) x(KV^2)	1.64388021
Wire Size	2		
XL	0.0585		
R	0.202	ΣX(p.u.)	0.84615059
X = (length/1000)x(XL) x(1/(#sets)	0.01096875	ΣR(p.u.)	1.6731853
R= (length/1000)x(R) x(1/(#sets)	0.037875	ΣZ(p.u.)	1.87497196
		Isc rms sym	6415.09892
Panelboard L4NMA			
# of sets	1	X(p.u.) =(X) x (baseKVA) / (1000) x(KV^2)	0.32109375
length	108	R(p.u.) =(R) x (baseKVA) / (1000) x(KV^2)	2.390625
Wire Size	#6		
XL	0.0685		
R	0.51	ΣX(p.u.)	1.16724434
X = (length/1000)x(XL) x(1/(#sets)	0.007398	ΣR(p.u.)	4.0638103
R= (length/1000)x(R) x(1/(#sets)	0.05508	ΣZ(p.u.)	4.22812175
		Isc rms sym	2844.79287


Circuit Breaker Time/Current Curves
Molded-Case Circuit Breakers
Catalog Types FDC Circuit Breakers, Two, Three and Four Poles
For application and coordination purposes only.
Based on 40°C ambient, cold start. Connected with four (4) feet of rated wire (75°C) per terminal. Tested in open air with current in all poles.
Maximum AC Volts: 690 at 50/60 Hz
Maximum DC Volts: 250
Breaker Rating
In Amperes | Instantaneous Pick-up, Amperes RMS
175 | 2400
200 | 2400
225 | 2400
Interrupting Ratings
Breaker Type | Symmetrical RMS Amperes (kA), Icu | 240 Vac | 480 Vac | 600 Vac | 250 Vdc
FDC | 200 | 100 | 35 | 22
Notes:
① Fixed Inverse – Time Overcurrent Release.
② Single Pole Test Data at 25°C based on NEMA Procedures (AB 4-1991) for verifying performances of Molded Case Circuit Breakers.
③ Total Operation Time.
④ Interrupting Rating Determines End of Curve.
Maximum Single Pole Trip Times at 25°C ②
Maximum Trip Time
Minimum Trip Time
175 A
200 A
225 A
(660-690V)
(380-415V)
TIME IN SECONDS
CURRENT IN MULTIPLES OF In
1 HOUR
2 HOURS
1 MINUTE
Blue Line = 125A Red Line=225A Green Line= 2000A
Protection Device Coordination Study