Naval Network & Space Operations Command (NNSOC)
Dahlgren, VA

Christopher Ankeny
Lighting/Electrical
Final Report
Spring 2007
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Naval Network & Space Operations Command (NNSOC)

Naval Surface Warfare Center Dahlgren Division
Dahlgren, VA

Project

Owner: United States Navy
A/E: Kling, Washington, D.C.
CM - Skanska Corp. - Design/Build Project
Two Story, 75,000 s.f.
$17 Million, Scheduled Opening Oct. 2006

Mechanical

- Three Air Handling Units to supply the 1st and 2nd floor, and theater space
- Three Electric Steam humidifiers for the 1st and 2nd floor, and theater space
- Two expansion tanks for hot/chilled water
- A 1991 MBH Oil-fired Boiler and a 110 ton water-cooled chiller
- 330 GPM Cooling Tower

Architecture

- Two story mixed-use business with some A-3 Assembly use (training theater)
- The building serves as the final element in the ensemble with two other buildings
- The entrance lobby is the main focal point of the design bridging the new building with the existing one

Electrical

- 13.8 KV 3 phase parallel service entrance to existing exterior switchgear
- Power is connected from the existing exterior switchgear to the double-ended Main Switchboard (1600A)
- Two existing 1250 kW diesel-fired engine generators will provide standby power
- Life safety loads will be provided with battery backup from the Standby Power System (SPS)

Structural

- Superstructure will be framed with structural steel
- Second floor will be a composite metal floor deck and wide flange beams and girders
- Roof will utilize steel joists and a metal roof deck.
- Exterior is 8" reinforced CMU with punched windows
- Slab-on-grade foundation with footers under all columns and exterior walls

Lighting

- Site lighting is pole mounted fixtures with bollards along some walkways
- Daylighting the indoor space was maximized using two "L" shaped wings that provide a break in the exterior wall allowing daylight to enter
- Indirect fixtures in the office areas, direct fixtures in most other spaces, specialty lighting in the Auditorium and Lobby

Christopher Ankeny

Lighting/Electrical

http://www.arche.psu.edu/thesis/eportfolio/2007/portfolios/CSA130/

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Executive Summary

The Naval Network Space & Operations Command is a very interesting building to study. The architecture seems very straight forward without any obvious aesthetic designs besides the glass curtain wall lobby. The rest of the building is CMU with punched out windows and all interior spaces are very functional. The challenge of my redesign is to try and enhance the architecture some while maintaining the feel of a Naval Office Building.

The lighting depth is an integration of a new daylight system into the open office area of the building while using controls to limit the amount of electric light needed. I am also redesigning the outdoor entrance area, lobby, and training theater to try and make them somewhat more interesting spaces. The content in the report for these spaces will include design concepts, reflected ceiling plans, section drawings, equipment selections, power densities and control schemes. My goal of the lighting design was to keep it simple following the architecture while giving some aesthetics to certain features of the building such as the training theater and outdoor/lobby spaces. I referenced the IESNA Handbook and ASHRAE 90.1 for lighting design considerations and code requirements.

The electrical depth will be a redesign of the emergency UPS (Uninterruptible Power System) system of the building. The goal of the redesign is to save space in the building by removing the battery bank room, have easier and safer maintenance, and save money over the cost of the entire system. The report will include equipment selections and a 10-year cost analysis between a 7-minute battery bank static UPS system and a rotary UPS system with no battery bank.

The other electrical depth is to see whether Photovoltaic panels would be a beneficial source of power to the building. The analysis will consider the cost of the installation with the expected payback period of the system. Any incentives or credits available by the state or federal government will also be taken into account. The report will have equipment selections, a proposed layout for the system, and the payback analysis.

For my two breadth topics I will be analyzing the affects of adding in the glazing for daylight integration with the HVAC equipment. I will also be doing a Construction Management Coordination of systems with the new daylight design to see what affects the skylights would have on the structural and MEP locations of equipment and systems.

Background

The Naval Network Space & Operations Command is an office facility of the U.S. Navy. It is part of the Naval Surface Warfare Center Dahlgren Division in Dahlgren, VA. This two-story, 75,000 square feet new construction is connected to an existing building via a new lobby. The building is almost square (199'x188') and used mainly as an open office plan with an assembly training theater located near the center of the 1st floor. The lobby is the main entrance to both the new building and the existing building using two entrances, one for the back parking lot and one for the main front parking area.

Building Overview

General Building Data

Building Name:	Naval Network & Space Operations Command (NNSOC)
Location/Site:	Naval Surface Warfare Center, Dahlgren, VA
Occupant Name:	Navy
Occupancy:	Mixed use - business with some A-3 Assembly use (Training Theater)
Size:	75,000 square feet
# of stories:	no below grade floors and 2 stories above grade
Project Team:	Architecture and Engineering – Kling www.kling.us Construction Management – Skanska Corp. www.usacivil.skanska.com
Dates of Construction:	Construction Documents Issued 12/05. Construction Expected Complete 3/07.
Cost Information:	$17 million Total Cost
Delivery Method:	Design-Build

Lighting Depth

Outdoor Area

Spatial Overview

Outside the building left of the main entrance is a building sign, flagpole and anchor surrounding the walkway into the building. There is also a parking lot here with sidewalks leading to the entrance area. I am keeping the existing lighting design for the parking lot area and changing the lighting outside the entrance. Security bollards are placed every 5' surrounding the lobby and entrance area. The building façade is all CMU except for the punched windows and the glass lobby. The lighting area I am redesigning covers around 2500s.f. of surface space right outside of the entrance.

Performance Considerations

The main performance of the outdoor lighting is to provide enough egress light to walk to and from the building. The outdoor lighting needs to be controlled by either a timer system or photocell for proper ON/OFF during the day and night as required by ASHRAE 90.1. The lighting design also needs to stay under proper power densities for an outdoor egress area.

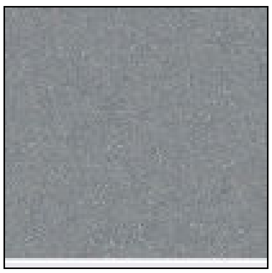
Design Concept

My design concept for the outdoor area is to provide a visually appealing space that commends our Navy and Nation. The flagpole, building sign, and anchor are the three main attractions leading into the building and need to stand out from the rest of the area. The outdoor space also needs to complement the lighting design of the lobby.

The building sign is uplighted from the ground with a small T5 fixture. A narrow beam spotlight is located on the top canopy aimed at the anchor and the same fixture on top of the lower canopy aimed at the flag. Four security bollards are being replaced by lighting bollards along the pathway to reach the required illuminance value for walkway egress. The entrance is lighted by four downlights recessed into the exterior canopy.

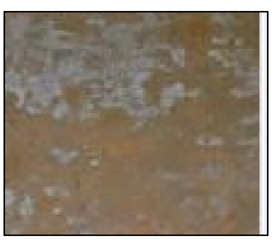
Finishes

Concrete - reflectance - 0.15 (Assumed)



Asphalt – reflectance – 0.05 (Assumed)

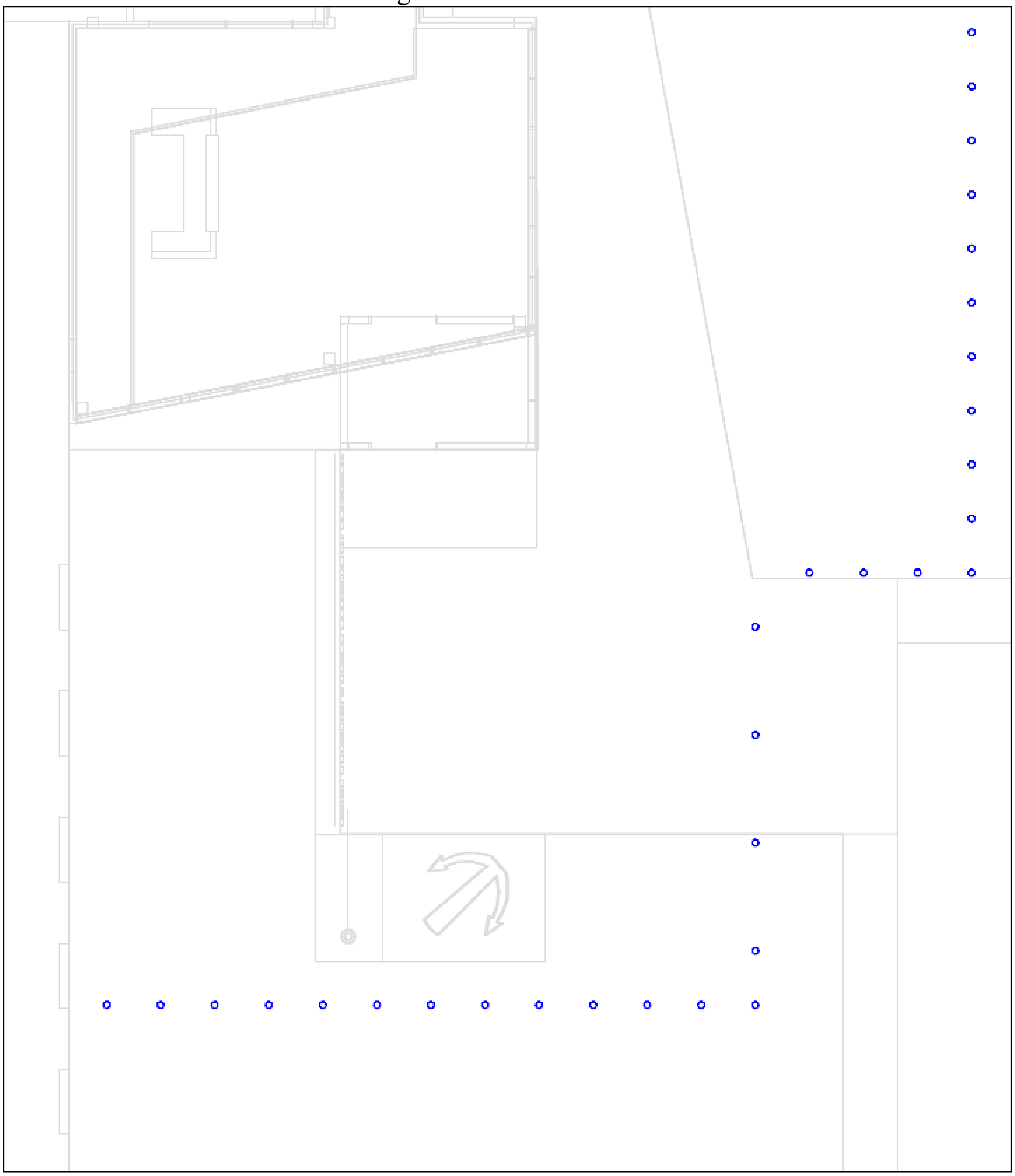
Grass – reflectance – 0.18 (Assumed)



Anchor – reflectance – 0.50 Assumed)

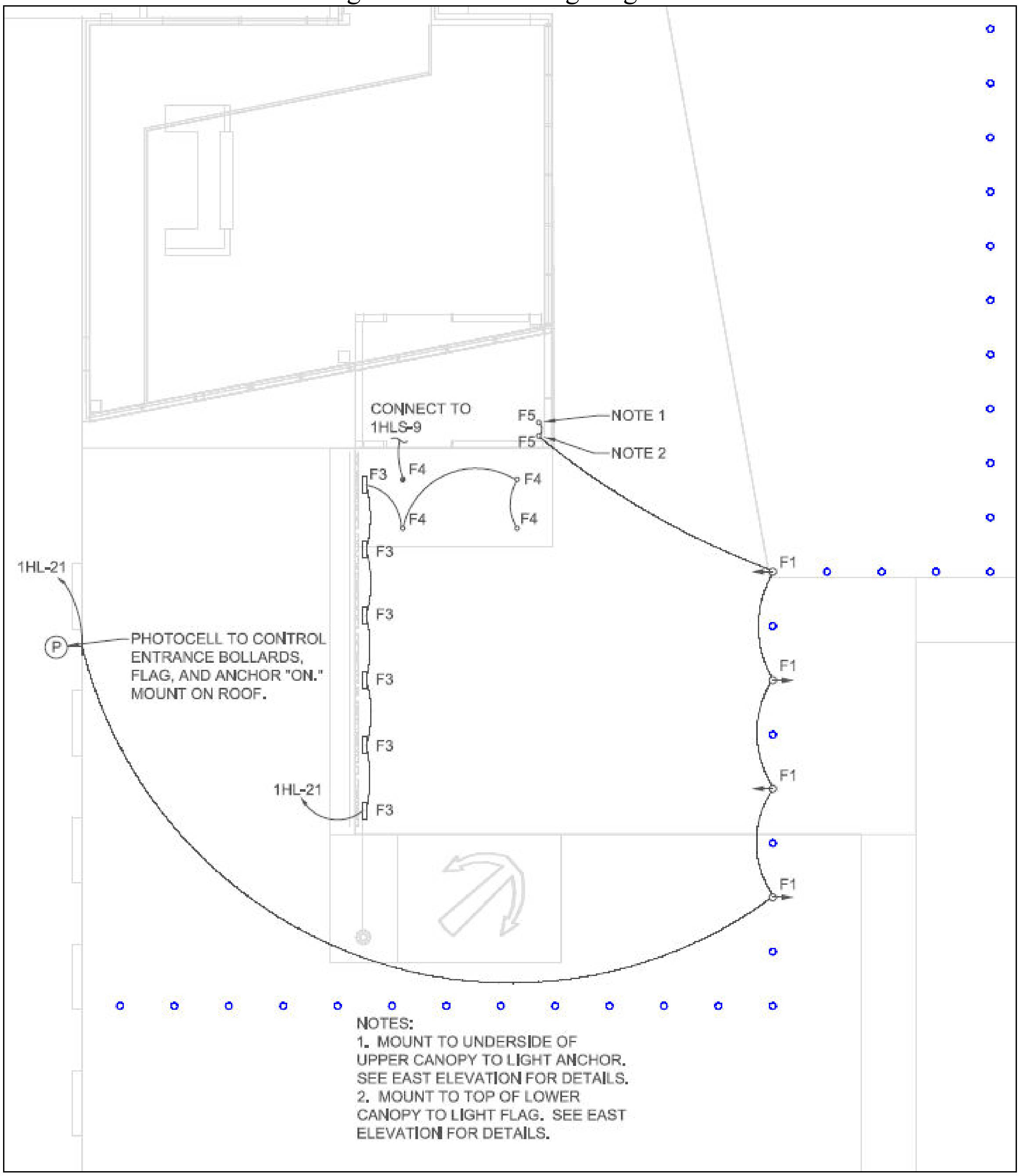
Original Plan

Figure 1: Outdoor Plan



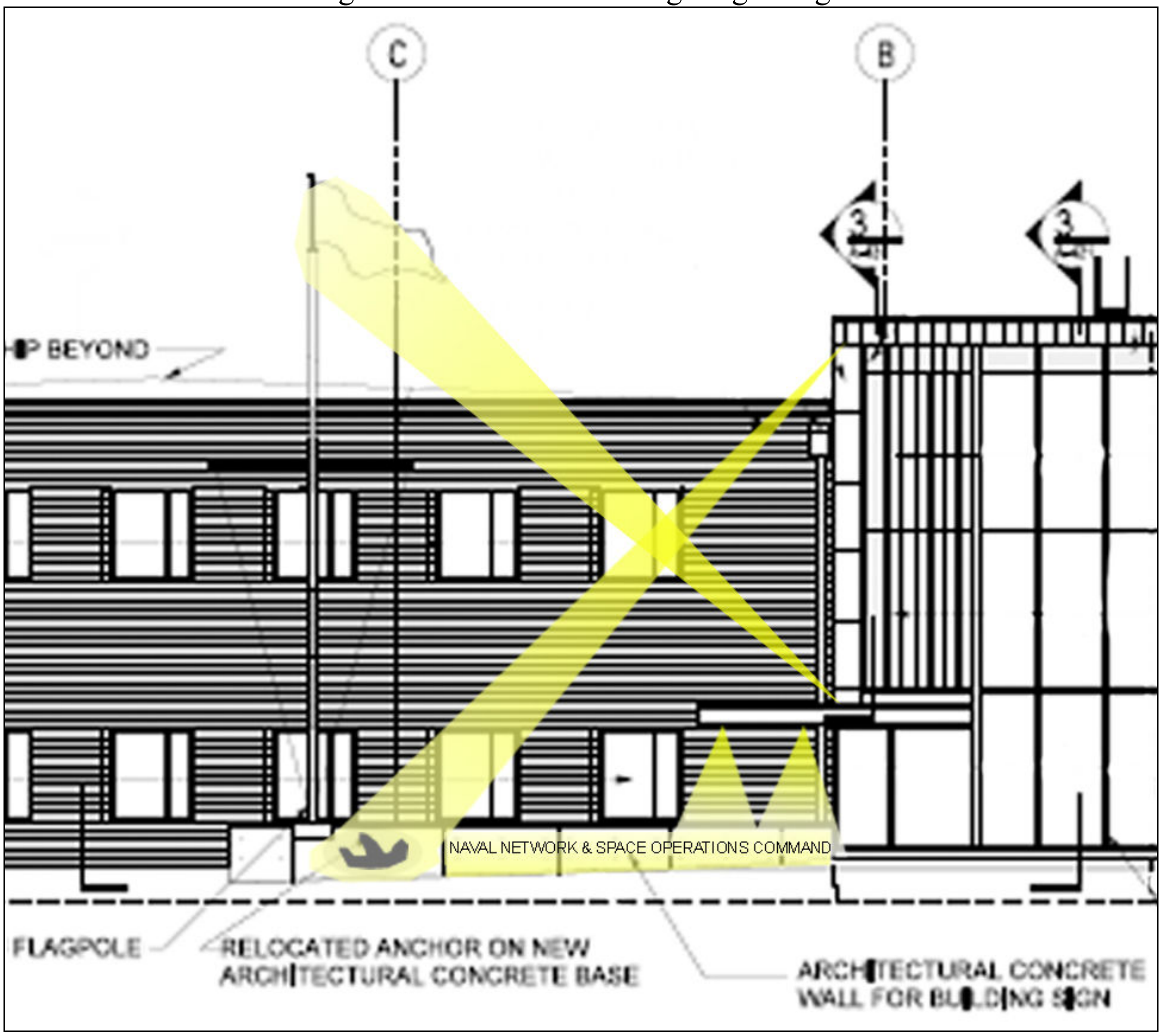
New Lighting Plan

Figure 2: Outdoor Lighting Plan



East Elevation Design Intent

Figure 3: East Elevation Lighting Design



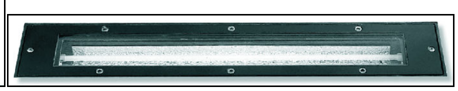
Luminaires

Table 1

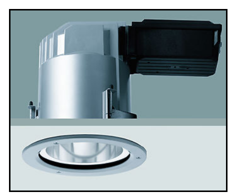
LUMINAIRE SCHEDULE			
Type	**Description**	**Lamping**	**CCT**
F1	EXTRUDED ALUMINUM BOLLARD LUMINAIRE WITH TYPE V, 360 DEGREE LATERAL LIGHT DISTRIBUTION. NOMINAL 42" HIGH x 8.5" DIAMETER. FINISH IS TO MATCH SECURITY BOLLARDS.	(1) CMH70/TD/942RX7S	4200
F3	RECESSED PROJECTOR, TYPE VI, FIXED REFLECTOR LUMINAIRE, NOMINAL 19" x 3.6". DRIVE OVER RATED, WATERPROOF.	(1) FM 11W/760 W4,3 UNV1	6000
F4	CAST ALUMINUM, SILVER POWDER-COATED TYPE V DOWNLIGHT, NOMINAL 8" DIAMETER x 9" DEPTH. CUT-OFF ANGLE 30 DEGREES. WATER-JET PROOF.	(1) F18TBX/SPX41/A/4	4100
F5	CORROSION-RESISTANT CAST ALUMINUM TYPE V BEAMER II PROJECTOR, NOMINAL 12" HIGH x 6.25" DIAMETER. 130 DEGREE TILT, MOUNTING PLATE FOR METAL HALIDE LAMPS. CUT-OFF ANGLE 50 DEGREES. WATER-JET PROOF.	(1) CMH35/T/UVC/U/830/G12	3000

*Full Luminaire, Ballast, LLF schedule and cutsheets attached in Appendix A.

F1



F3



F4

F5

LLF's

Table 2

TYPE	BF	CLEANING	MAINTENANCE	LLD	LDD	RSDD	LLF
F1	1.00	12 Month	V	0.77	0.87	-	0.67
F3	1.00	12 Month	VI	0.92	0.85	-	0.78
F4	1.05	12 Month	V	0.85	0.87	-	0.78
F5	1.00	12 Month	V	0.80	0.87	-	0.70

Power Density

Table 3

TYPE	# LUMINAIRES	# LAMPS/LUMINAIRE	WATTAGE/LAMP	WATTAGE
F1	4	1	77	308
F3	6	1	11	66
F4	4	1	39-(2) LAMPS	78
F5	2	1	35	70

Wattage on Walkways 10' or greater (F1, (4) F3, F5) = 422W
Wattage under Canopy (F4, (2) F3) = 100W

Power Density on Walkways: 422/2500 = 0.17 W/sq ft.
Power Density under Canopy: 100/180 = 0.56 W/sq ft.

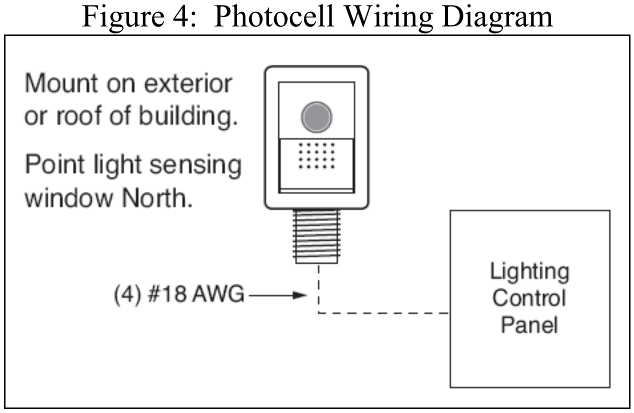
Using the Space-by-Space Method in ASHRAE 90.1
Walkways 10' wide or greater = 0.2 W/sq ft.
Canopy = 1.25 W/sq ft.

All the requirements are met for ASHRAE 90.1 for the outdoor power density.

Controls

The entire Naval Base is controlled by the Base Public Works Department (PWD) using a central SCADA (Supervisory Control and Data Acquisition) system. This system controls all of the lighting on the base and keeps all internal clocks synchronized within the system. They control when interior and exterior lights are turned on/off by a predetermined time setting. To provide the PWD with more flexibility, I am providing a photocell interface on the roof to be able to control the bollard, parking and signage lighting (Circuit 1HL-21). The existing diagram of the Naval Base's SCADA system is in Appendix A.

Figure 4: Photocell Wiring Diagram



Renderings and Calculation Results

Figure 5: Outdoor Rendering

Figure 6: Outdoor Rendering

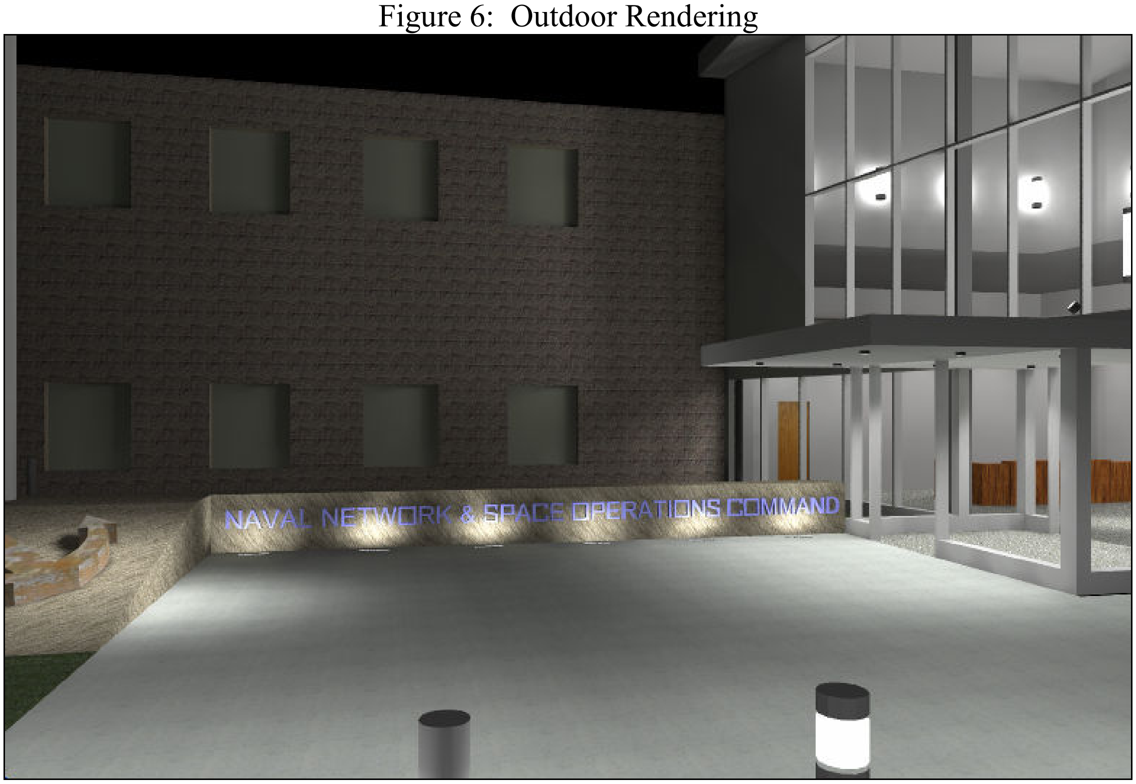


Figure 7: Outdoor Rendering

Figure 8: Outdoor Rendering

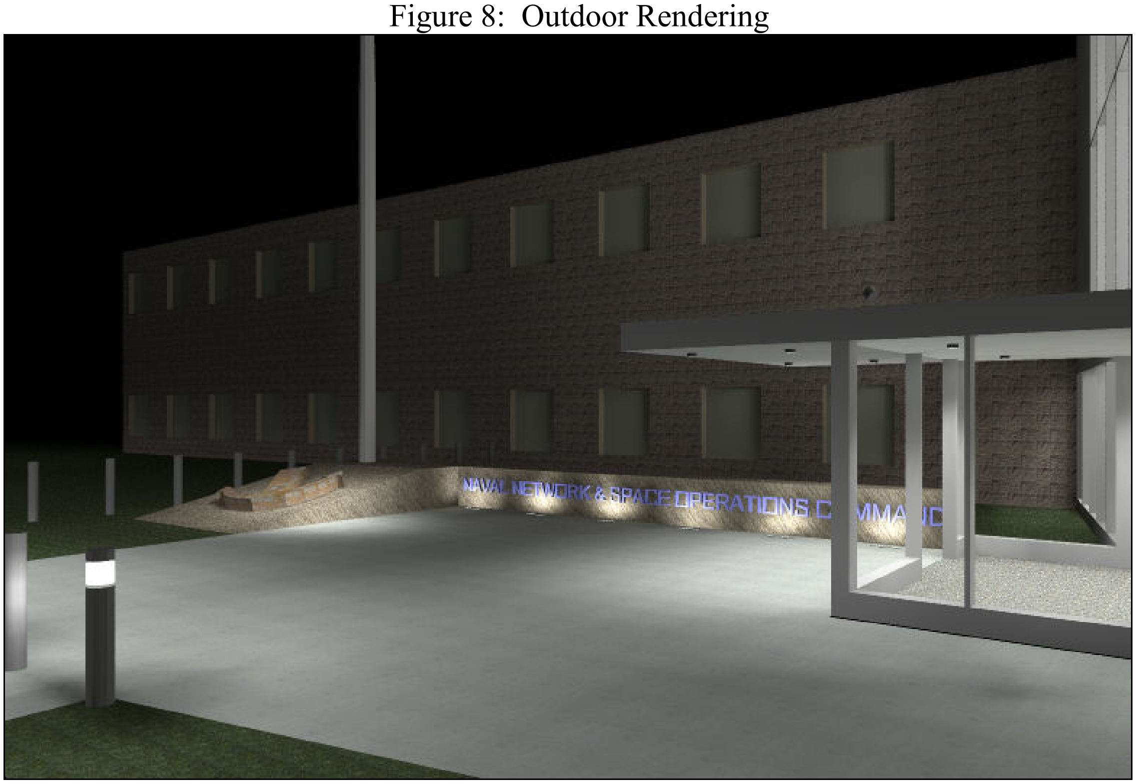


Figure 9: Outdoor Pseudo Rendering

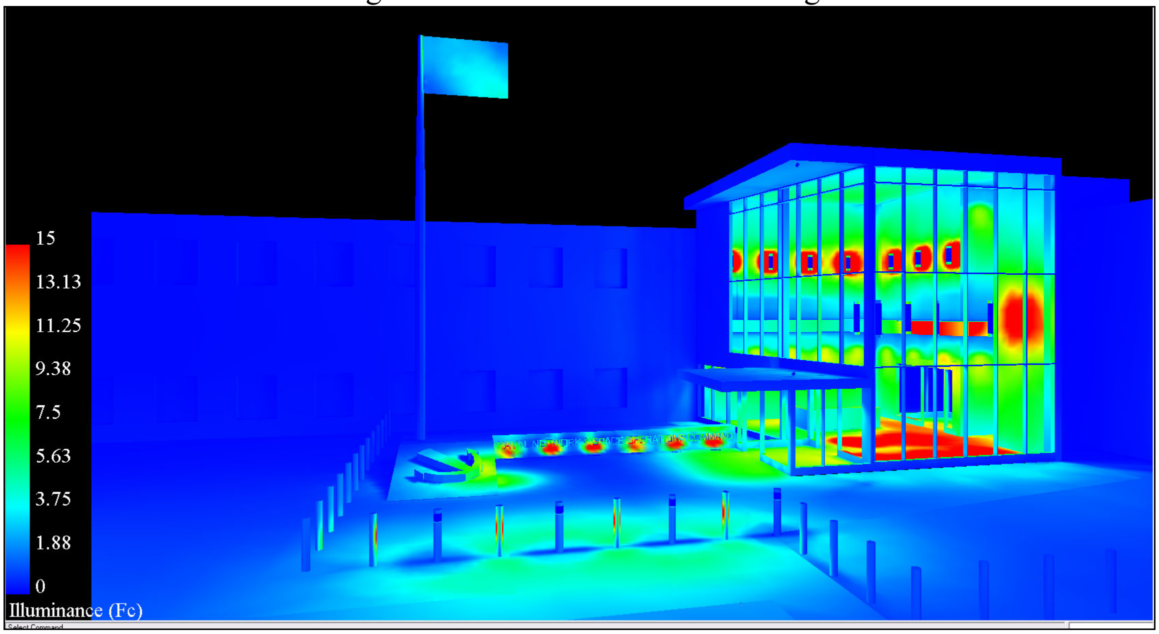
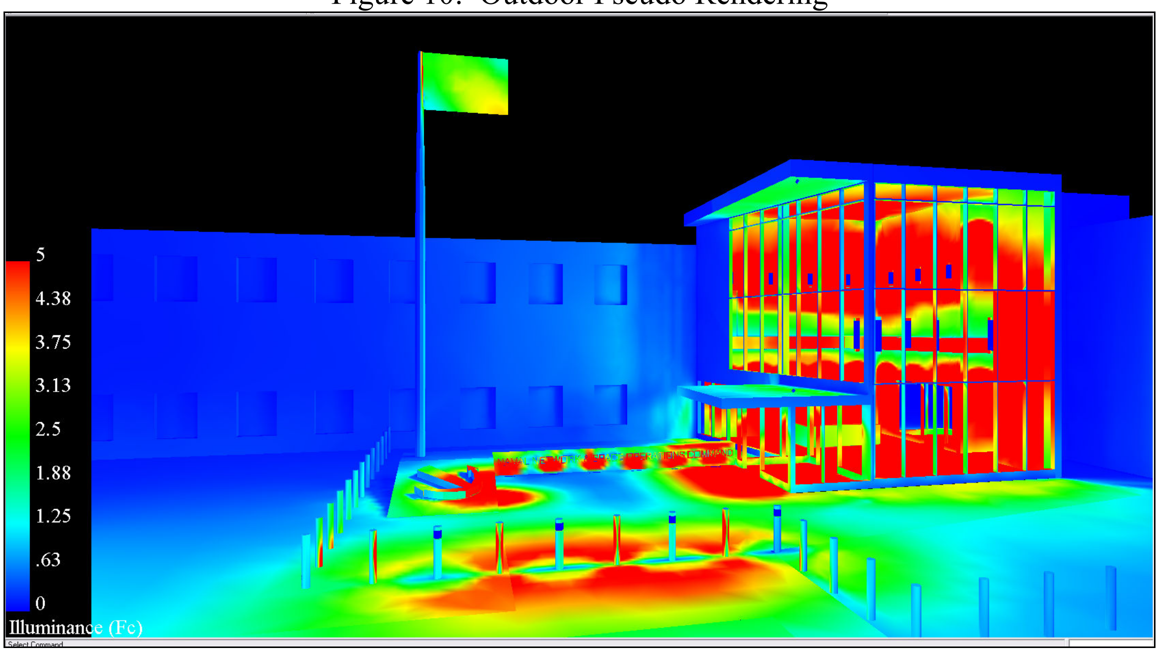


Figure 10: Outdoor Pseudo Rendering



Conclusion

All the locations that I felt were important have a nice contrast between their lighted surface and the surrounding space. Overall I think the design highlights the areas that I feel are the most important to the space. The flag is only receiving 1-2 fc but I feel is this acceptable since the surround is dark sky. The anchor and sign seem to have the most light and should draw a person's attention to each of these items along with the entrance to the lobby.

Lobby Space

Spatial Overview

The lobby area is the main feature of the building. It connects the existing building with the new building (NNSOC) and acts as a bridge between the two. This two story space is mostly a glass curtain wall and serves as a welcome area to the occupants. The space is 35' floor to ceiling and is the only public entrance to these facilities. There are two entrances into the lobby, one from the back parking lot and another from the front lot. The lobby has a bridge on the 2nd floor, 17'4" from the ground that extends about 6' from the NNSOC wall and connects to the existing building on the 2nd floor. There are no pictures or artwork hanging on the walls and the only furniture in the space is a security desk and an X-RAY machine.

Performance Considerations

The lobby is a circulation area with many people passing through it all day. Tasks such as reading and writing do not apply in here, except possibly for an information directory or directional sign. The security desk will need extra vertical and horizontal illuminance for facial appearance and writing tasks. The best way to achieve this is with task lighting on the desk surface. This will keep the direct glare out of the security guard's eyes while providing the needed levels to prevent fatigue by straining the eyes.

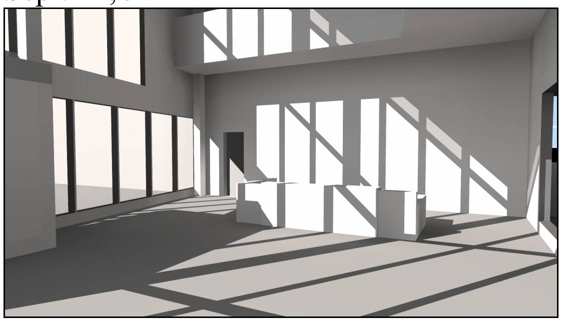
Another important issue in a lobby design is the transition from outside to inside and vise-versa. The light levels need to help adjust the eyes to the upcoming environment so people do not have to pause or squint when entering. This can be hard to do, but implementing a daylight photocell can be a good method to keep a constant lighting ratio between outside and inside the lobby space.

Daylight

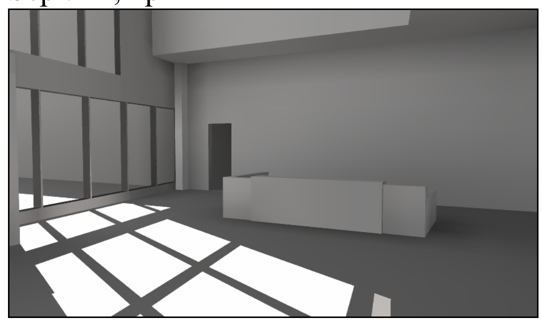
Daylight analysis of this space is very important due to the lobby's orientation and massive glass surfaces. The glass curtain wall is just slightly off from being directly east facing, and the main entrance doors are facing south. After running daylight studies on in the space, for clear days on June 21, Sept. 21, and Dec. 21, at 9am and 1pm, my results suggest there needs to be daylight integration incorporated into the lighting design of the lobby.

The lobby sees some direct sun until well after 1pm on every day of the year so adding photocells to the lobby can help regulate the amount of time that the luminaires need to be on any given day. This can cut down on electricity by a fair amount and enable the constant ratio between the outside and inside lighting. Another issue direct sunlight causes is radiation, or heating of the space. To prevent the direct sunlight from penetrating the lobby, low solar heat gain windows would be advisable. Shading devices could be impletement but for a lobby space this seems unnessary due to the constant traveling through the space. The results of my study are below, each showing the direct daylight penatration in a rendered image.

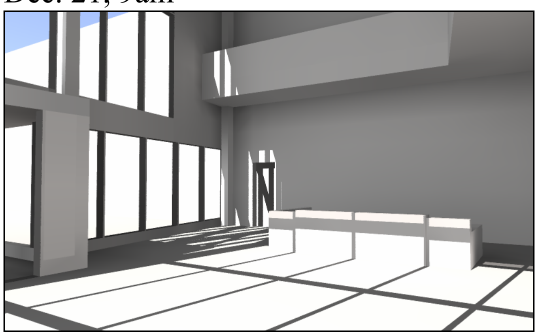
Sept. 21, 9am



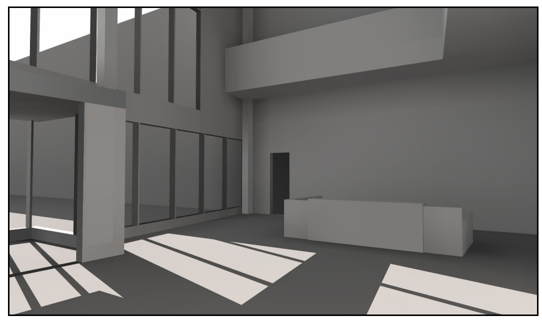
Sept. 21, 1pm



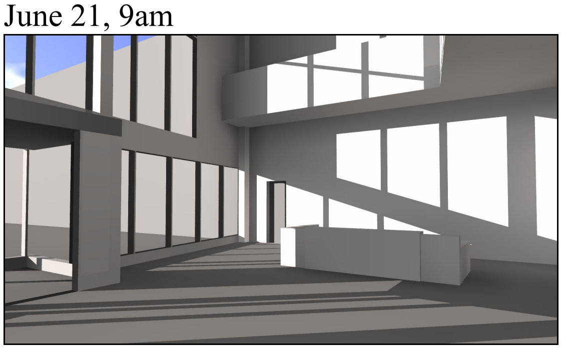
Dec. 21, 9am



Dec. 21, 1pm



June 21, 9am



June 21, 1pm

Design Concept

The idea behind this design is to provide an overall appealing look to the building. Since the lobby is the only area that a passerby can see into, and the architecture is very plain here, the lighting design has to make it look interesting. My idea was to provide some type of pendant fixture hanging from the ceiling and then have sconces on the walls to further add to the space. Having different fixtures for the pendants and sconces seem to be fighting each other visually, so I decided to use the same type of fixture for both, just different sizes. I was having trouble trying to find something that looked nautical for the space so I went with a simple circular fluorescent fixture. Downlights were added to the underside of the 2nd floor bridge for proper lighting around the security desk and X-RAY machine. There was task lighting added to the desk for the security guards.

Finishes

Glass curtain wall has a visible transmittance of 72%

Floor – Broadloom Carpet – Reflectance 20%

Walls – Painted – Reflectance 50%

Ceiling – Gypsum Wall Board/Painted – Reflectance 70%

Original Plan

Figure 11: 1st Floor Plan

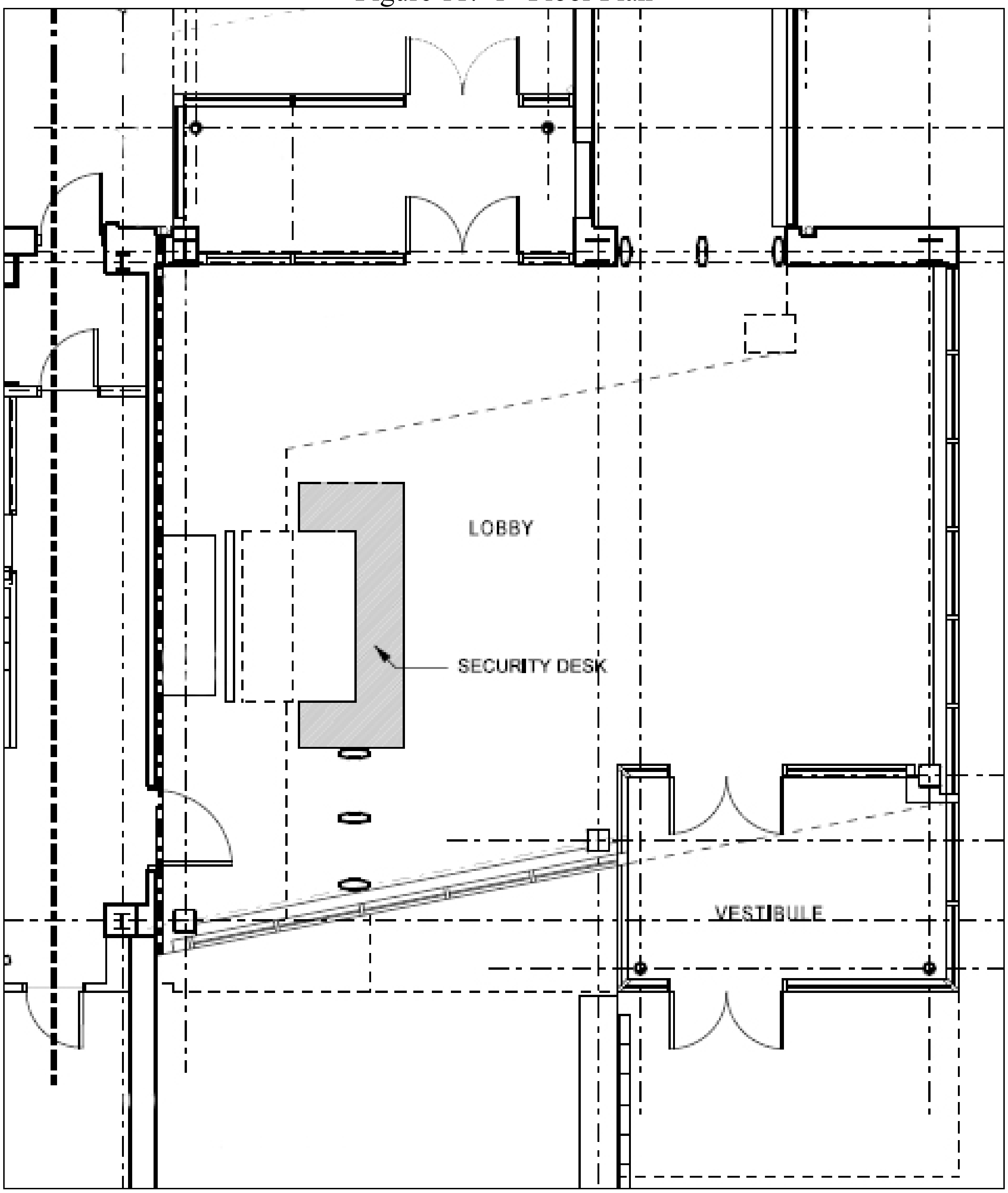
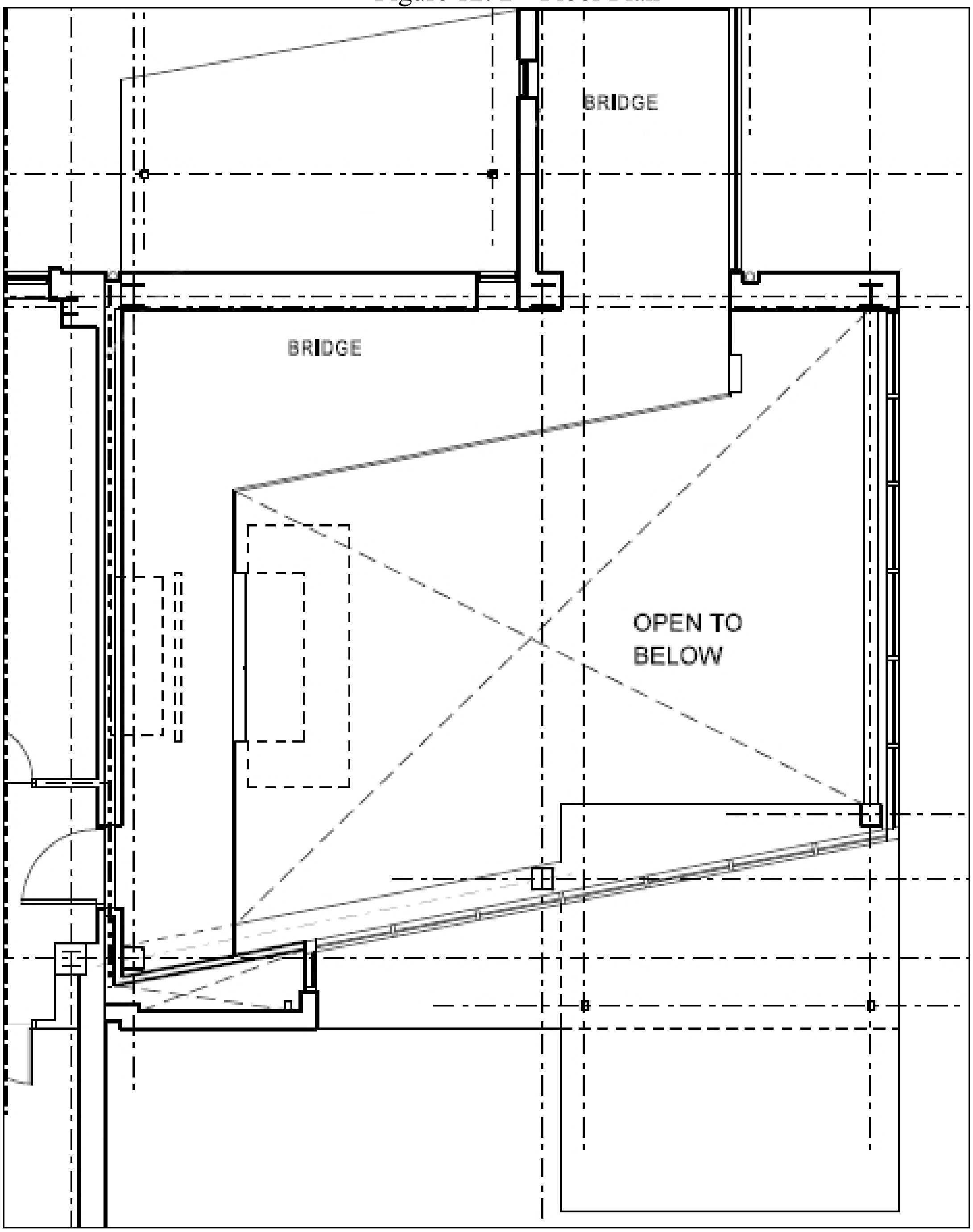


Figure 12: 2nd Floor Plan



Lighting Plan

Figure 13: 1st Floor Lighting Plan

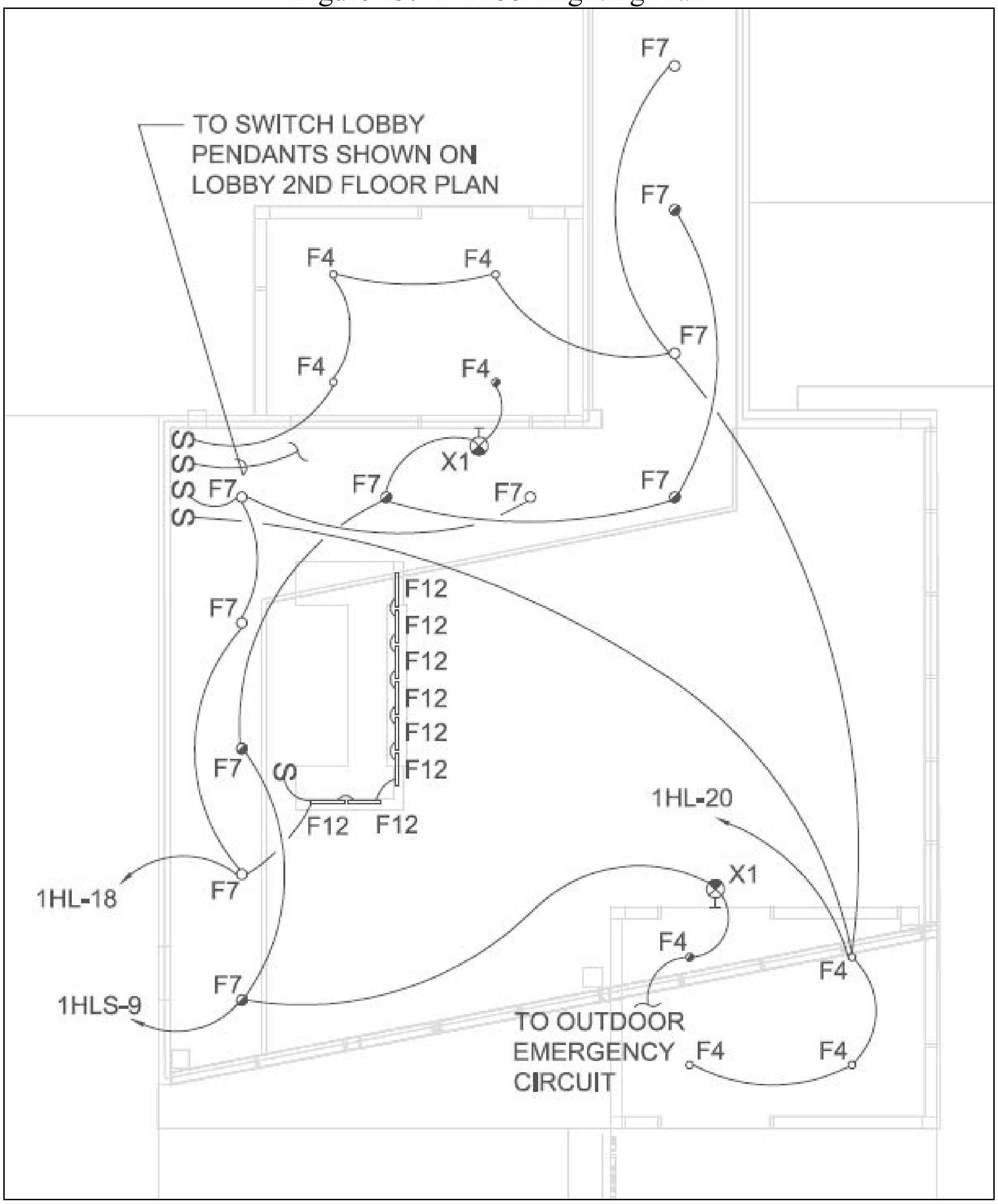
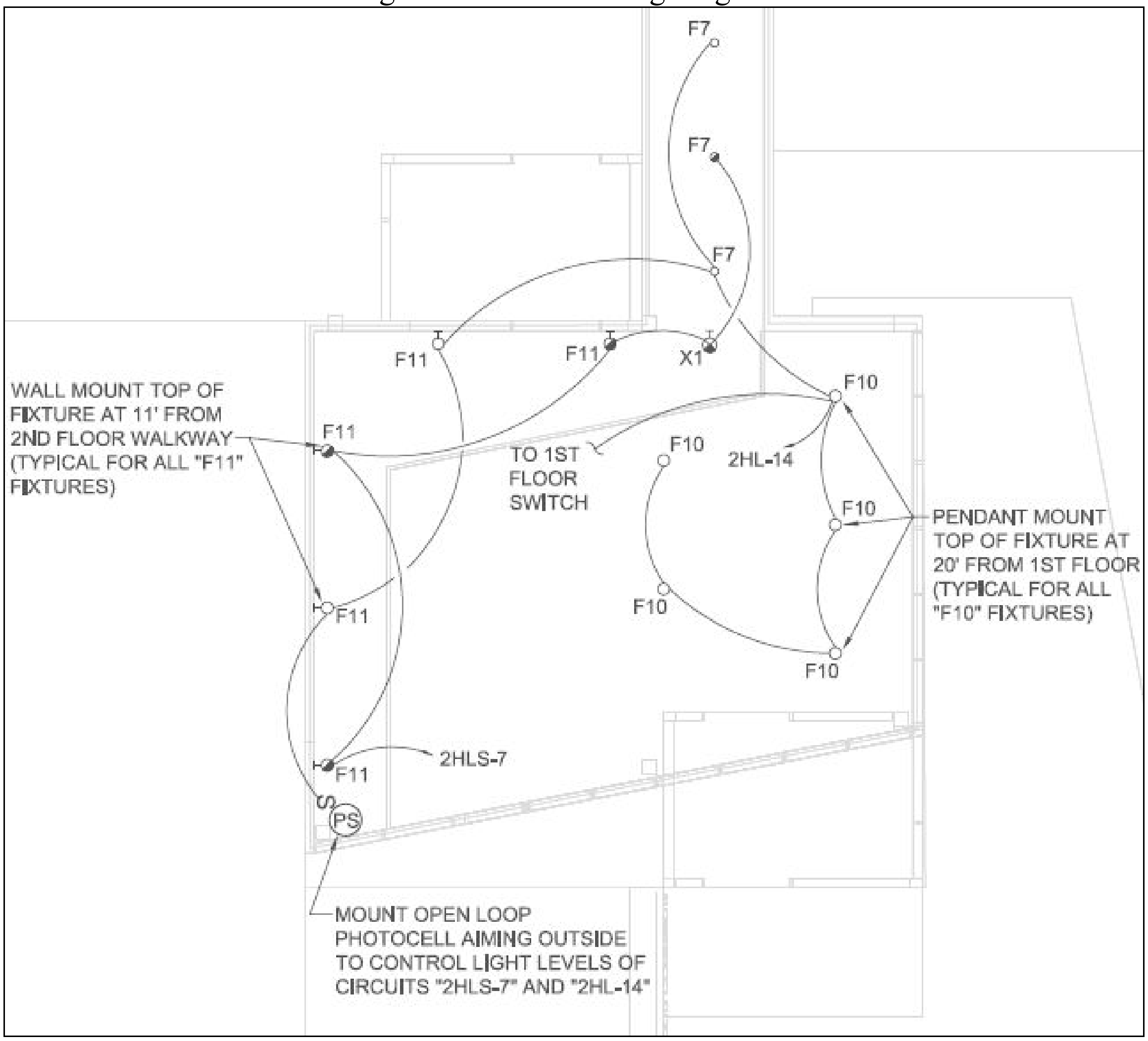
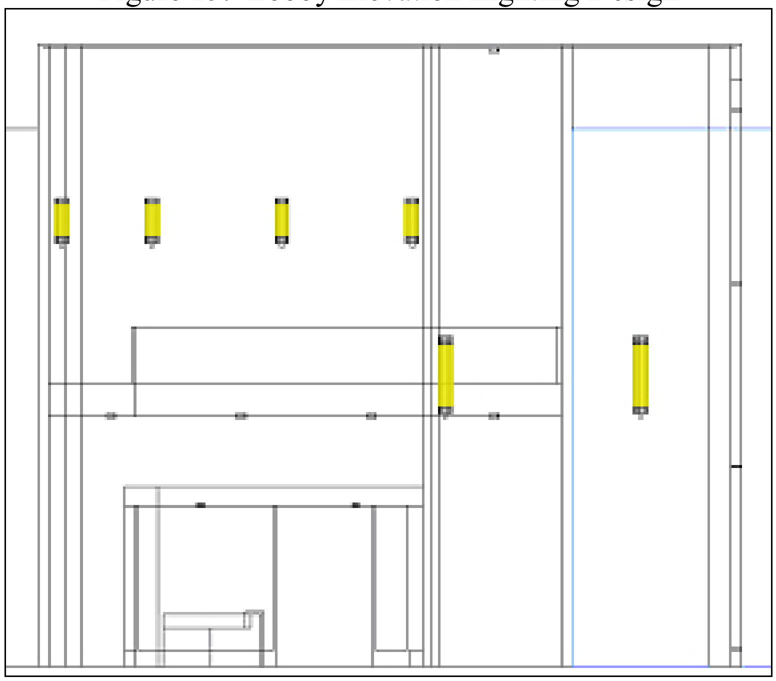


Figure 14: 2nd Floor Lighting Plan



Lobby Elevation

Figure 15: Lobby Elevation Lighting Design

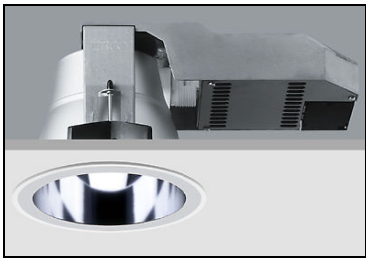


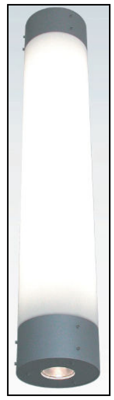
Luminaires

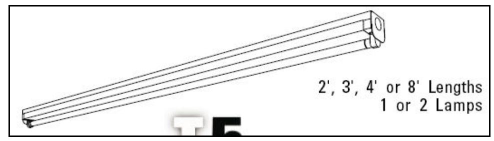
Table 4

LUMINAIRE SCHEDULE			
Type	**Description**	**Lamping**	**CCT**
F7	CAST ALUMINUM DOWNLIGHT, WHITE POWDER COATED TYPE V SYMMETRIC DISTRIBUTION. NOMINAL 8" DIAMETER x 7" DEPTH	(1) F32TBX/830/A/ECO	4100
F10	KONE PENDANT CYLINDER WITH DOWNLIGHT COMPONENT, EXTRUDED ALUMINUM CENTER TUBE IS LAMP HOLDER AND ELECTRONIC BALLAST. TYPE V SYMMETRIC DISTRIBUTION, TOP AND BOTTOM CYLINDER IS 1/4" THICK WITH ALUMINUM COVER PLATES WITH SILVER POWDER COAT FINISH.	(3) F32T8SP30ISWMECO (1) CMH39UPAR20FL25	4100 3000
F11	KONE PENDANT CYLINDER, EXTRUDED ALUMINUM CENTER TUBE IS LAMP HOLDER AND ELECTRONIC BALLAST. TYPE V SYMMETRIC DISTRIBUTION, TOP AND BOTTOM CYLINDER IS 1/4" THICK WITH ALUMINUM COVER PLATES WITH SILVER POWDER COAT FINISH.	(3) F17T8XL/SPX41ECO	4100
F12	LINEAR DIRECT FLUORESCENT LOW-PROFILE FIXTURE. NOMINAL 2"x2"x22.5". HIGH GLOSS, BAKED WHITE ENAMEL FINISH. TYPE IV SYMMETRIC DISTRIBUTION.	(1) F21W/T5/841/ECO	4100

*Full Luminaire, Ballast, LLF schedule and cutsheets attached in Appendix A.







F7 F10, F11 F12

LLF's

Table 5

TYPE	BF	CLEANING	MAINTENANCE	LLD	LDD	RSDD	LLF
F4	1.05	12 Month	V	0.85	0.87	0.97	0.75
F7	0.05/1.00	12 Month	V	0.84	0.87	0.97	0.71
F10	0.05/1.00	12 Month	V	0.9	0.87	0.92	0.71
F10	0.99	12 Month	V	0.9	0.87	0.92	0.71
F11	0.03/1.00	12 Month	V	0.95	0.87	0.92	0.76
F12	1.03	12 Month	II	0.92	0.94	0.97	0.86

*Assuming a clean environment.

Power Density

Table 6

TYPE	# LUMINAIRES	# LAMPS/LUMINAIRE	WATTAGE/LAMP	WATTAGE
F4	8	1	39-(2) LAMPS	156
F7	14	1	75-(2) LAMPS	525
F10	5	4	155-(4) LAMPS	775
F11	5	3	54-(3) LAMPS	270
F12	4	1	26	104

Total Wattage = 1830
Total Square Ft. = 1900s.f.
Power Density = 0.96 W/sq ft.

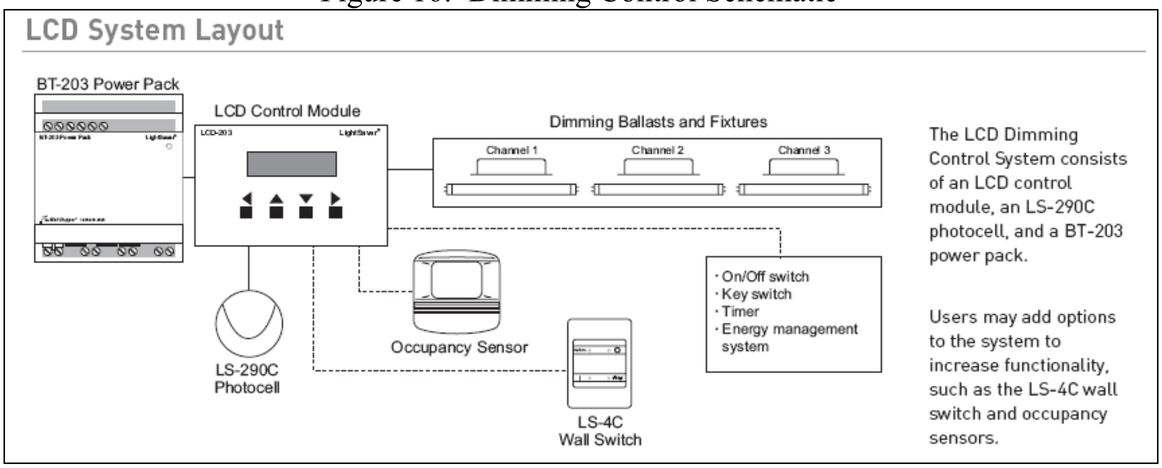
Using the Space-by-Space Method in ASHRAE 90.1
Lobby: 1.3 W/sq ft.

All the requirements are met for ASHRAE 90.1 for the lobby power density.

Controls

There will be a photocell controlled system for the lobby space due the massive amount of daylight coming from the glass façade. The photocell will control circuits "2HLS-7" and "2HL-14." These circuits control the majority of the light in the space and dimming them should provide good energy savings. I am leaving the 1st floor lighting (F7 fixtures) on at full output under the bridge so the security guards will always have plenty of light.

Figure 16: Dimming Control Schematic



Renderings and Calculation Results

Figure 17: Lobby Rendering

Figure 18: Lobby Rendering

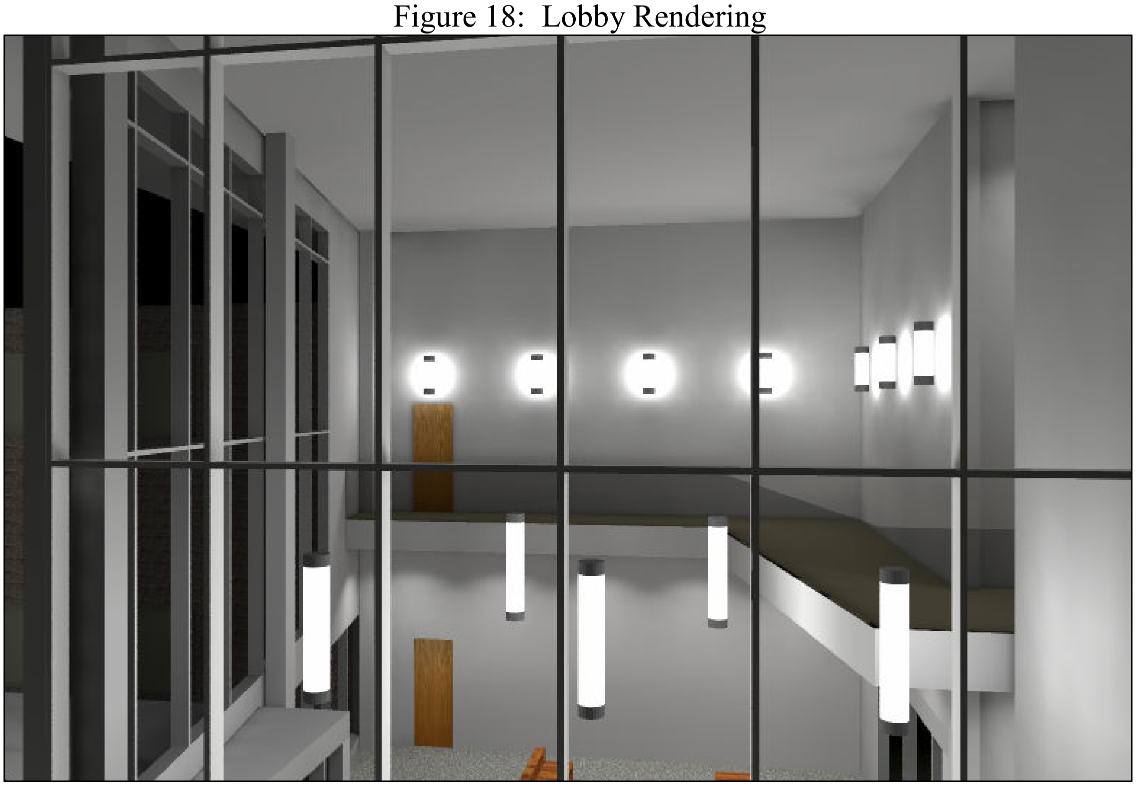


Figure 19: Lobby Rendering

Figure 20: Lobby Rendering

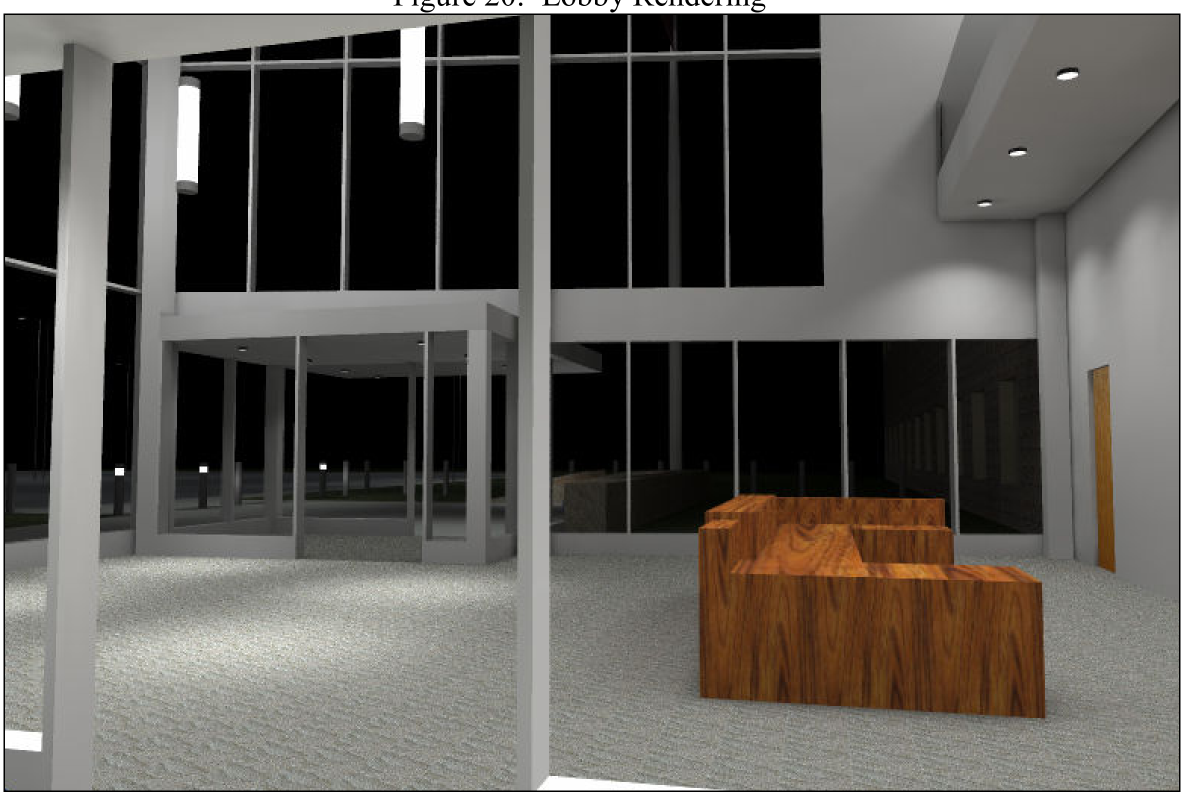


Figure 21: Lobby Pseudo Rendering

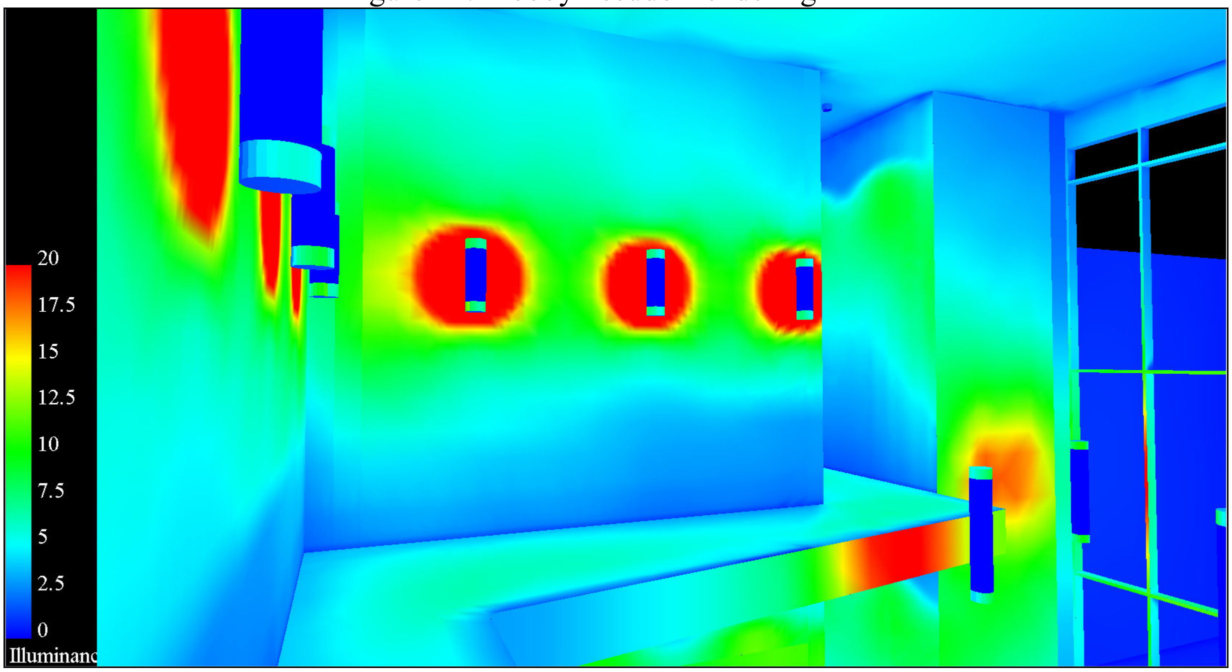


Figure 22: Lobby Pseudo Rendering

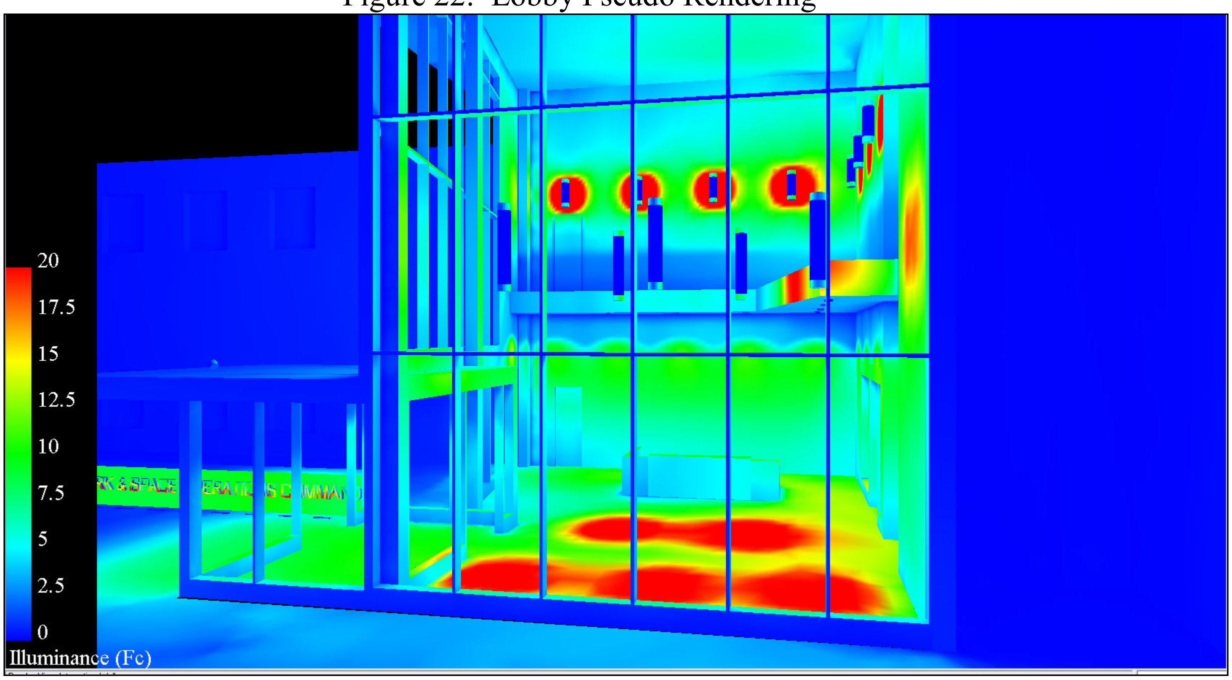
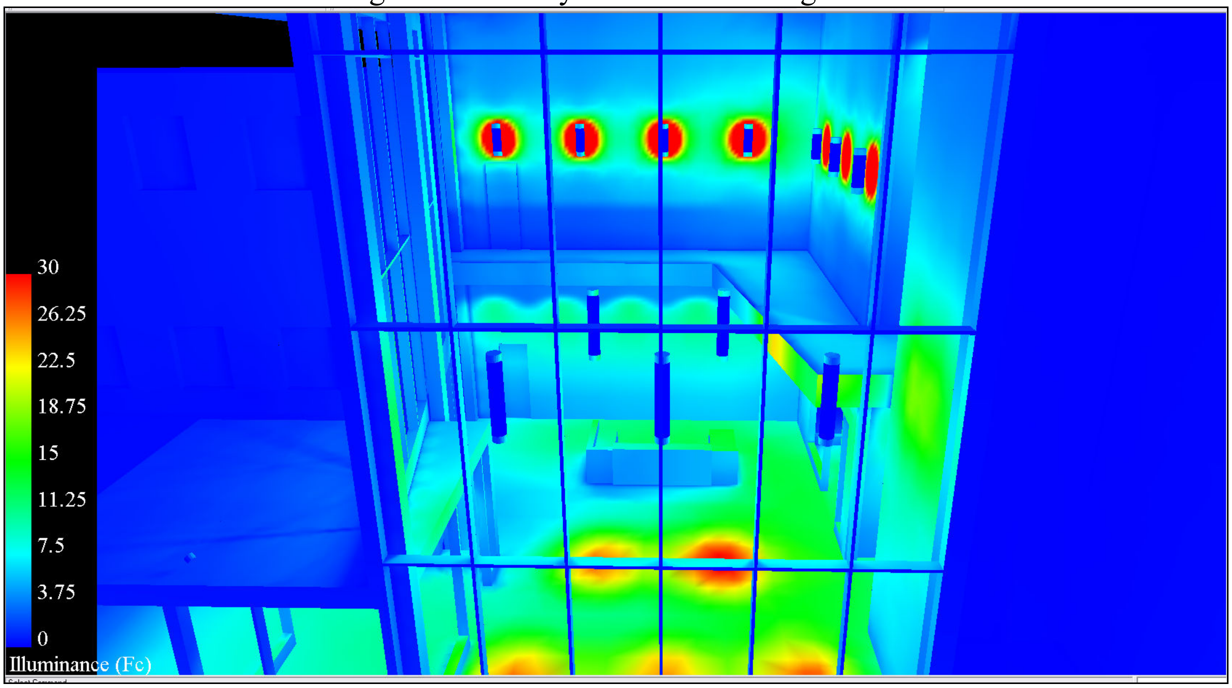


Figure 23: Lobby Pseudo Rendering



Conclusion

The same fixture for the pendants and sconces really helps to balance out the space out well. The larger pendant fixtures coupled with the smaller sconces give a nice visual look from the exterior of the building. Dimming the pendant and sconces should help to keep an even ratio of light between the exterior and interior giving an easier transition between the two areas. Overall I think the space is visually pleasing yet simple enough for a Naval Command Center.

Training Theater

Spatial Overview

The training theater is used as a training assembly for the occupants. The theater is tiered following the existing site grading down to the front of the room. One ramp is available along the north side of the auditorium for handicap access and the seating is arranged in a gentle arc, focusing attention toward the presenter and projection screen. There are three aisles that lead down the rows to the front of the room, one in the middle and two on each end. The main purpose of the space is to attend lectures and view presentations. Structural columns were carefully placed in areas where there would be no site line obstructions to the front wall.

Performance Considerations

A space like a training theater has a few different scenarios in which lighting design must be taken into account. Sitting in one of the seats a person will typically have two or three different areas to look at. One is at the projection screen, another would be toward a presenter/speaker and the third would be reading/writing sitting in a seat. For most cases, the eyes will be switching back and forth between two of them. Care has to be taken in the lighting design to make sure the ratios of the speaker and the screen are relatively similar, within 3:1. This ratio should be the same for these tasks to the background wall as well, with the background being darker.

Reflectances can be a huge issue when they are discussed with VDT and projection screens. First thing is to realize that having a high reflectance floor is not suitable. Carpet is the best choice because it has a matte surface which is able to diffuse the light in a non-glaring manner. Choice of light fixtures is also a daunting task. Direct glare, multiple light levels, and a comfortable feeling all need to be evaluated for an auditorium space. A designer needs to make sure that the fixtures won't cause glare to the audience, as well as on the projection screen. Recessed fixtures are usually a good choice for a space like this, especially when multiple lamps can be placed in the fixtures and switched on for different lighting levels. The walls should be fairly bland and not draw attention by having pictures or artwork hanging anywhere. This will keep the eyes from wandering around and help keep attention on the presentation, instead of somewhere else.

Controlling a space like an auditorium is a must for today's technologies. With all the different events that a space this flexible can hold, it is imperative to be able to control multiple lighting fixtures, with multiple settings such as dimming and switching of different lamps within a single fixture. Adding more fixtures to the space can also add flexibility. Placing step lights in the aisles can allow all the overhead fixtures to be turned off, providing the brightest screen possible for the projector. Once again, having control over the lighting system to meet each individual presenters needs is probably the best possible solution. Being able to control the lighting environment completely, allows the greatest flexibility without sacrificing quality.

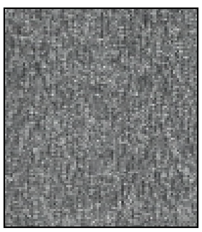
Design Concept

The design concept for the theater is to provide a flexible lighting system that minimizes glare and has a comfortable look. My design attempt is to draw away from the acoustical ceiling tile with typical 2'x2' fluorescent troffers, and replace them with a gypsum wallboard cove system. The cove system follows the form and dimensions of the tiered floor system which gives a nice balance to the space. The lighting controls are all dimmable and separated into different zones, giving the user optimal control over the entire space.

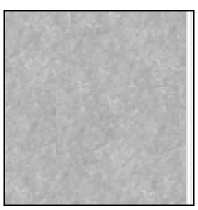
Finishes

The materials used in this space were chosen to provide good acoustics and to minimize future maintenance needs.

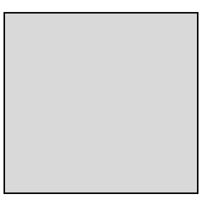
Finishes



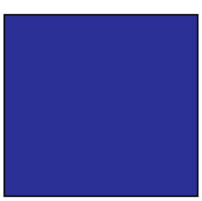
Floor – Broadloom Carpet – Reflectance 20%



Walls – Acoustical Wall Covering – Reflectance 30%



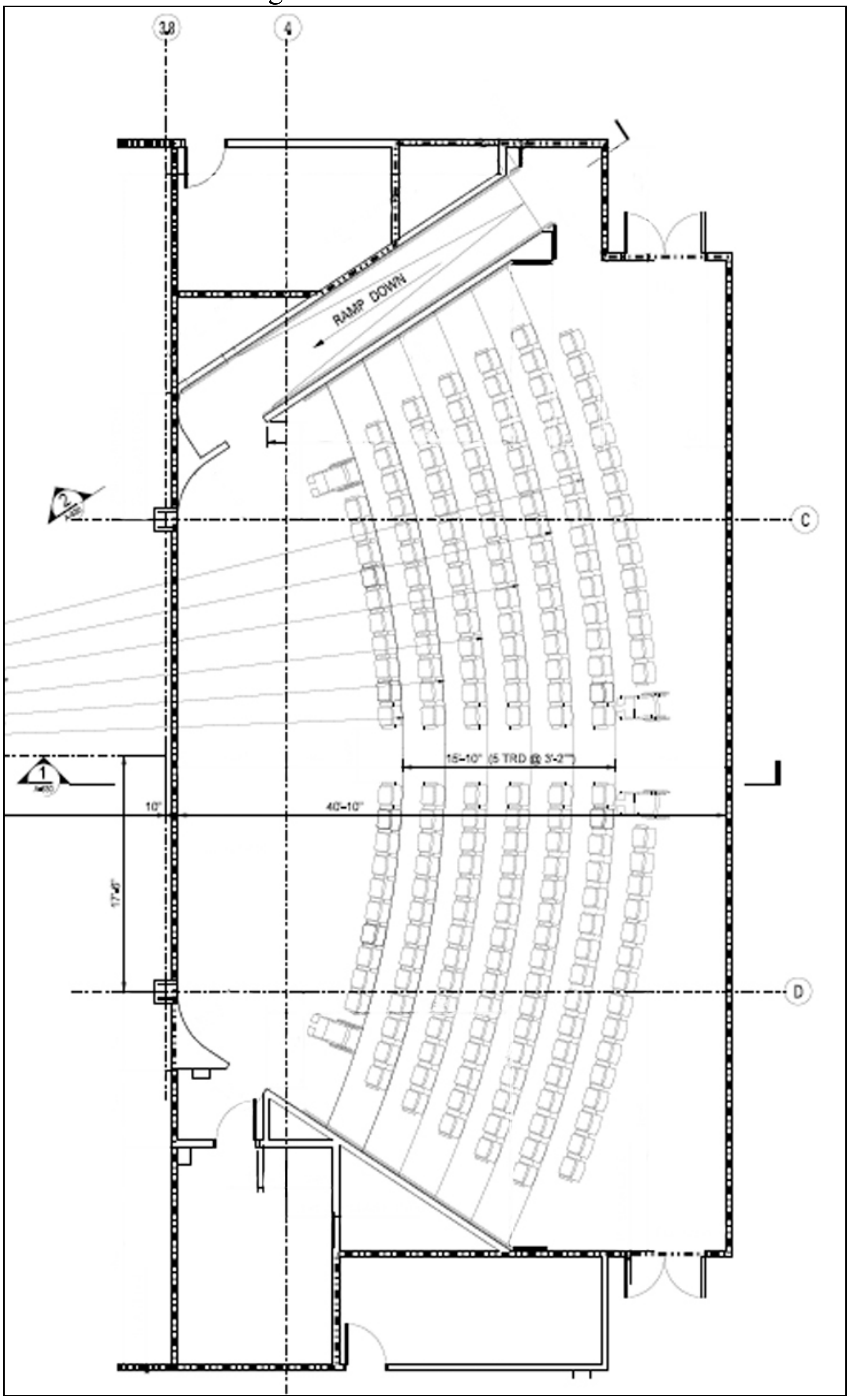
Ceiling – White Painted Gypsum Wallboard – Reflectance 85%



Seating – Blue Seat Coverings – Reflectance 21%

Original Plan

Figure 24: Theater Floor Plan



Section Drawings

Figure 25: Original Section of Training Theater

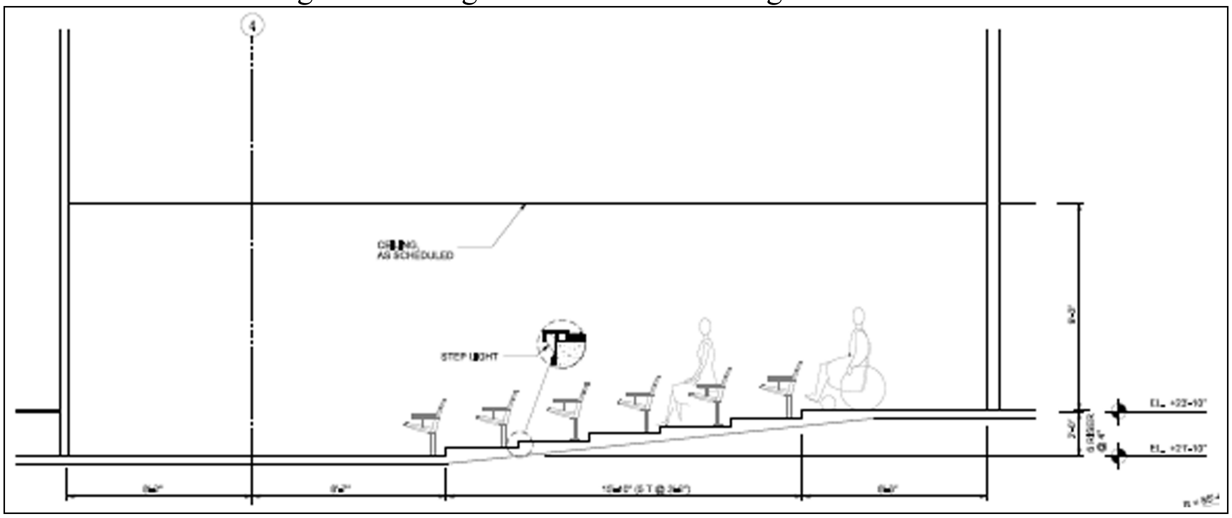
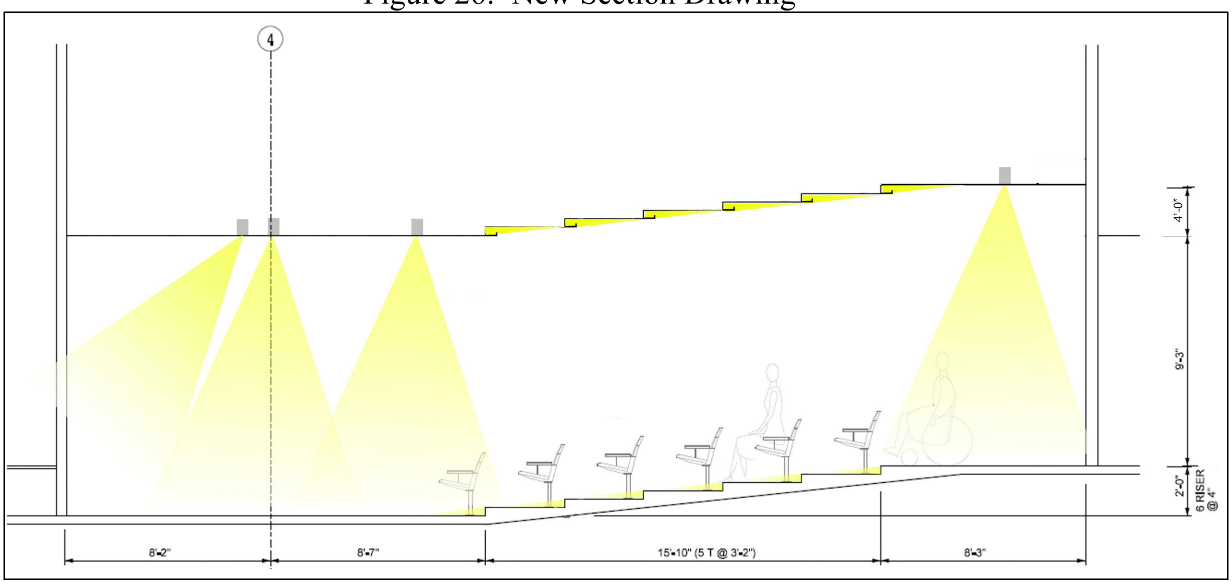
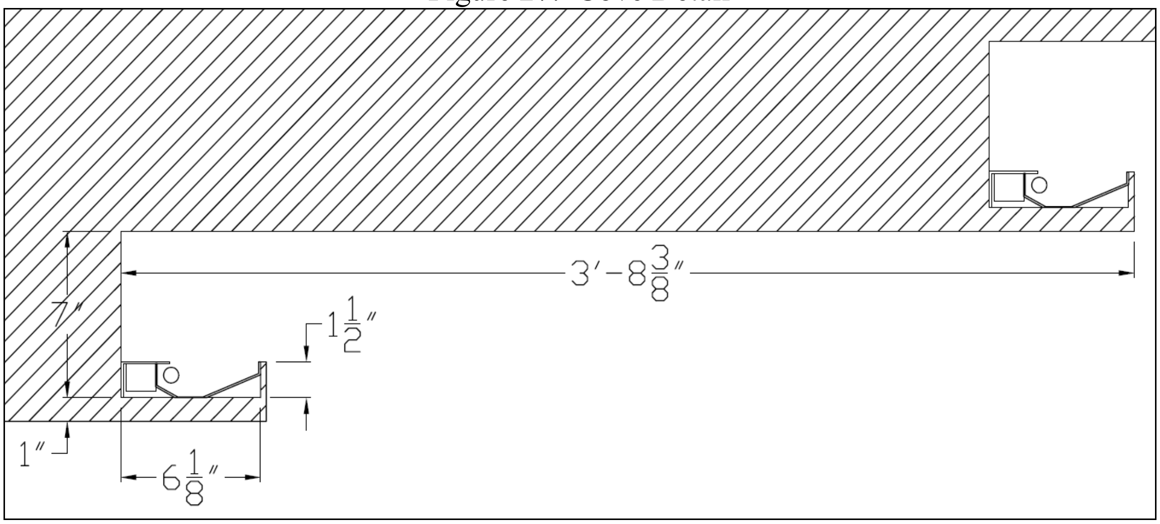


Figure 26: New Section Drawing



Cove Lighting Detail

Figure 27: Cove Detail



Lighting Plan

Figure 28: General Lighting Plan

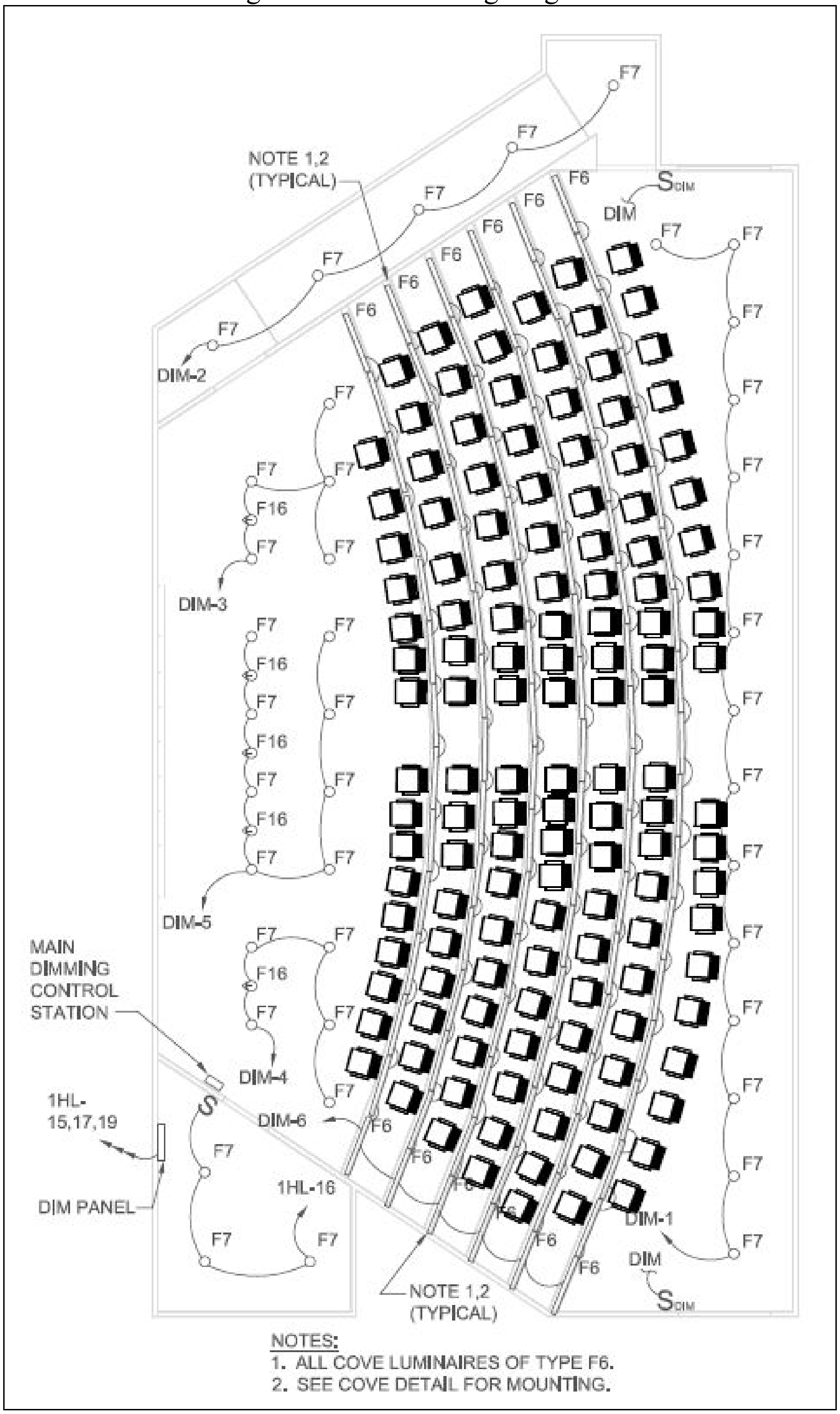
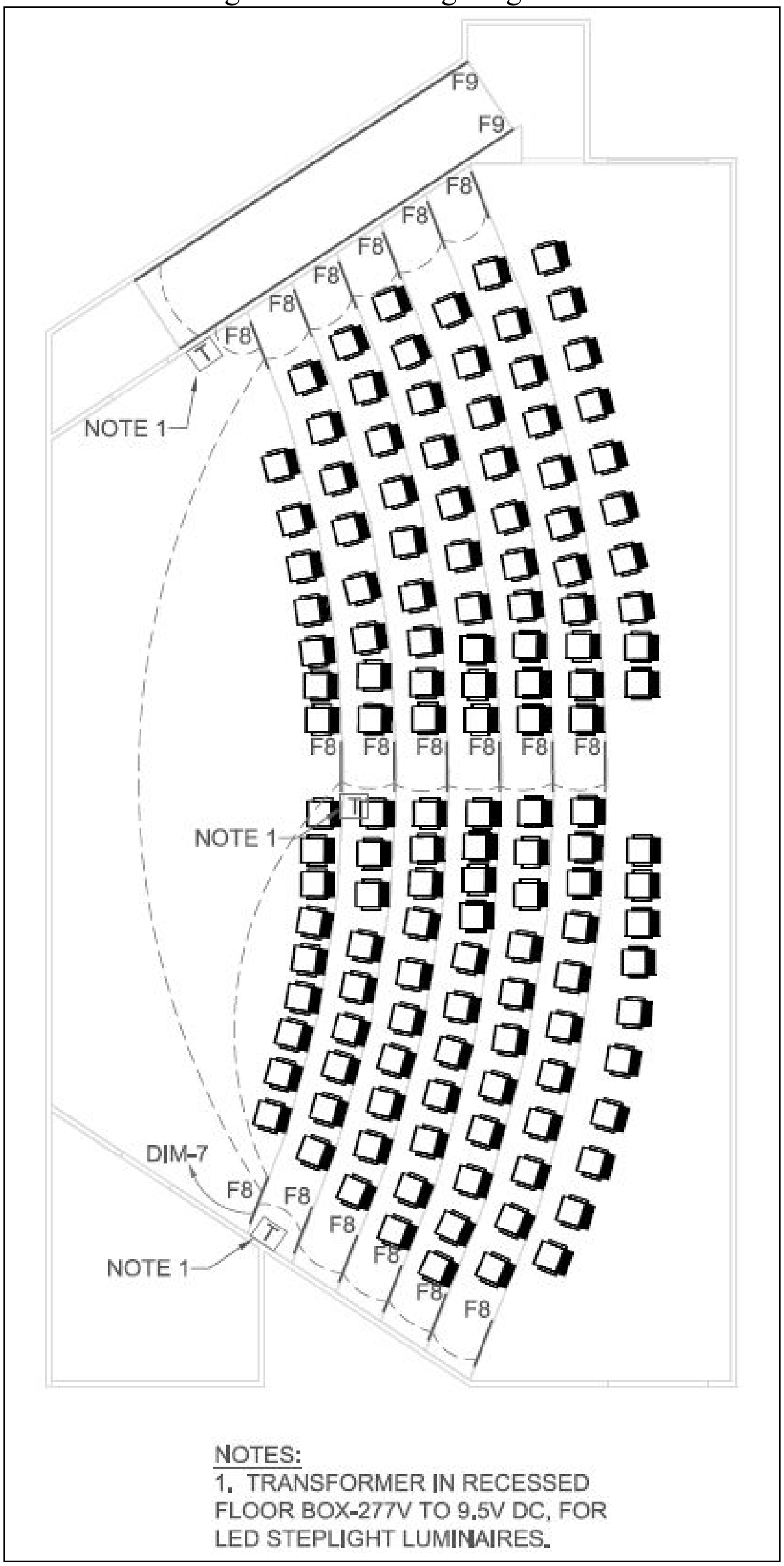


Figure 29: LED Lighting Plan

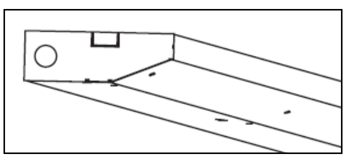


Luminaires

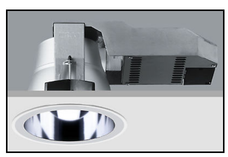
Table 7

LUMINAIRE SCHEDULE			
Type	**Description**	**Lamping**	**CCT**
F6	DIE-FORMED 24 GAUGE METAL PAINTED WHITE COVE LUMINAIRE. NOMINAL 6" x 48" x 1.5" DEPTH, TYPE VI ASYMMETRIC DISTRIBUTION.	(1) F32T8SP30ISWMECO	4100
F7	CAST ALUMINUM DOWNLIGHT, WHITE POWDER COATED TYPE V SYMMETRIC DISTRIBUTION. NOMINAL 8" DIAMETER x 7" DEPTH	(1) F32TBX/830/A/ECO	4100
F8	DELINEATED STAIRNOSE LED LUMINAIRE, LOW VOLTAGE, COMPLIES WITH NFPA'S LIFE SAFETY CODE (0.2 FC) WHEN INSTALLED AS RECOMMENDED.	INCLUDED IN LUMINAIRE	4100
F9	CARPET TO WALL PATH LIGHT LED LUMINAIRE, LOW VOLTAGE, COMPLIES WITH NFPA'S LIFE SAFETY CODE(0.2FC) WHEN INSTALLED AS RECOMMENDED.	INCLUDED IN LUMINAIRE	4100
F16	LOW VOLTAGE, RECESSED DIRECTIONAL SPOTLIGHT. BLACK POWDER-COATED, 0-40 DEGREE TILT. NOMINAL 7" DIAMETER x 6" DEPTH, TYPE V SYMMETRIC DISTRIBUTION.	(1) Q100T3/12V/CL	3000

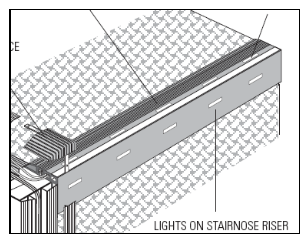
*Full Luminaire, Ballast, LLF schedule and cutsheets attached in Appendix A.



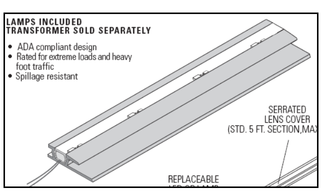
F6



F7



F8



F9

F16

LLF's

Table 8

TYPE	BF	CLEANING	MAINTENANCE	LLD	LDD	RSDD	LLF
F6	0.05/0.88	12 Month	VI	0.94	0.85	0.85	0.6
F7	0.05/1.00	12 Month	V	0.84	0.87	0.97	0.71
F8	1	12 Month	V	0.9	0.87	0.94	0.74
F9	1	12 Month	V	0.9	0.87	0.94	0.74
F16	1	12 Month	V	0.85	0.87	0.97	0.72

*Assuming a clean environment.

Power Density

Table 9

TYPE	# LUMINAIRES	# LAMPS/LUMINAIRE	WATTAGE/LAMP	WATTAGE
F6	99	1	116-(4) LAMPS	2871
F7	41	1	75-(2) LAMPS	1537.5
F8	18	6	0.2	21.6
F9	2	25	0.2	10
F16	5	1	100	500

Total Wattage = 4940.1 W
Total Square Ft. = 3000s.f.
Power Density = 1.65 W/sq ft.

Using the Space-by-Space Method in ASHRAE 90.1
Classroom/Lecture/Training: 1.4 W/sq ft.

This lighting design is slightly higher than the power density allowed for this space, but I plan to make up the difference in the other spaces.

Controls

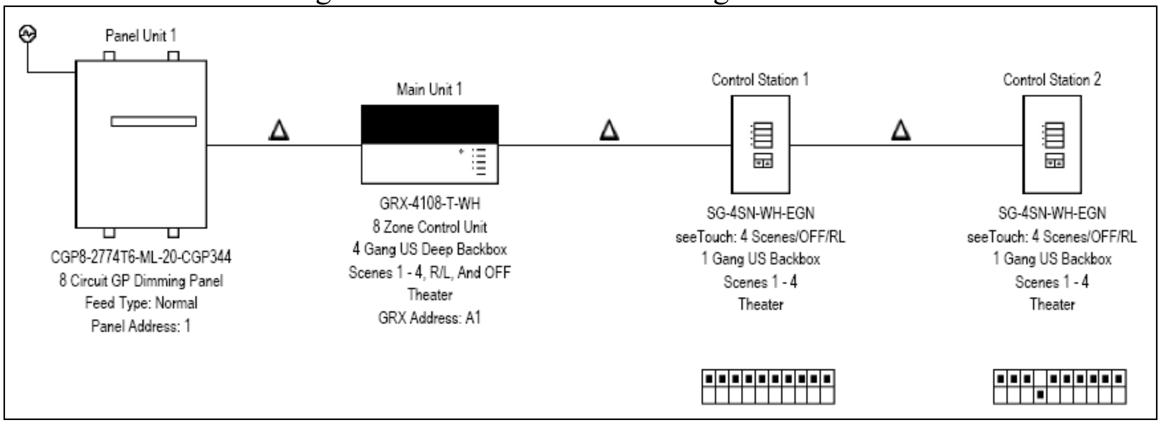
Automated lighting control panel is provided to enable remote monitoring and control of the building's non-emergency interior and exterior lighting from the Base's MODBUS SCADA System. The training theater has an automatic programmable remote control. There are 7 dimmable zones in the theater; the following chart describes each zone:

Table 10

Training Theater Summary Load Schedule					
Lutron Zone	DIM Zone	Zone/Circuit Description	Voltage	Load Type	Wattage
DIM 1	1	Back Downlights	277	Mark 7 0-10V	563
DIM 2	2	Ramp Downlights	277	Mark 7 0-10V	188
DIM 3	3	Left Front Downlights	277	Mark 7 0-10V	288
DIM 4	4	Right Front Downlights	277	Mark 7 0-10V	288
DIM 5	5	Middle Front Downlights	277	Mark 7 0-10V	600
DIM 6	6	Cove Lighting	277	Mark 7 0-10V	2871
DIM 7	7	Steplights	277	Magnetic LV	31.6

This Lutron system has one control box at each entrance to control Dim Zones 1-4, and a Master Control Station in the front left corner that has control over the entire system. This control solution for the theater provides many different options regarding which lights are on and at what levels are wanted for each specific configuration.

Figure 30: Lutron Control Wiring Schematic



Renderings and Calculation Results

Figure 31: Theater Rendering

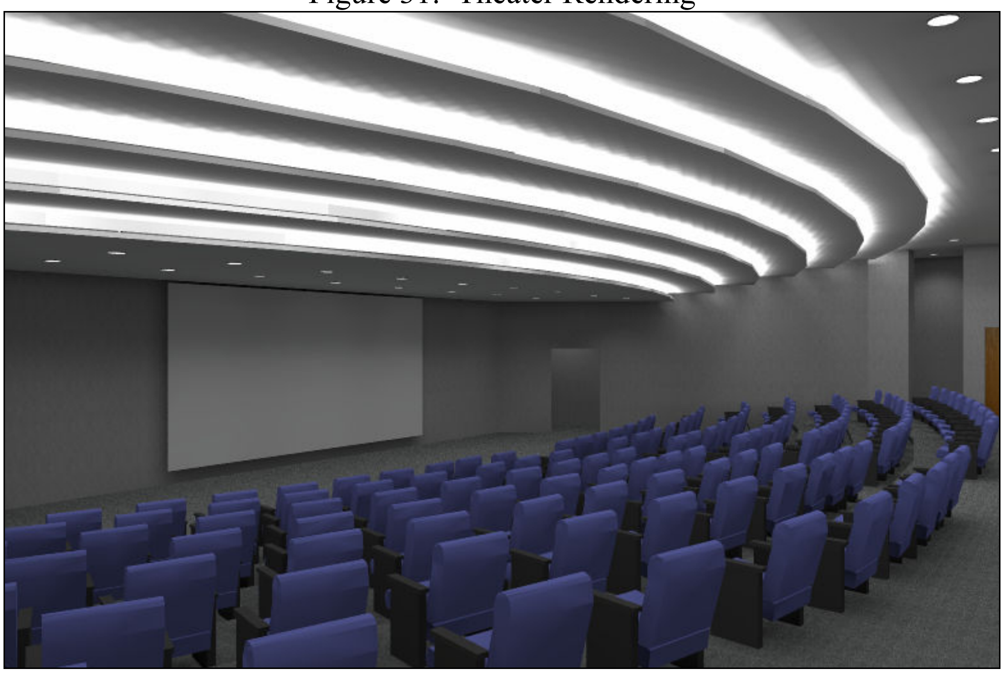


Figure 32: Theater Rendering

Figure 33: Theater Rendering

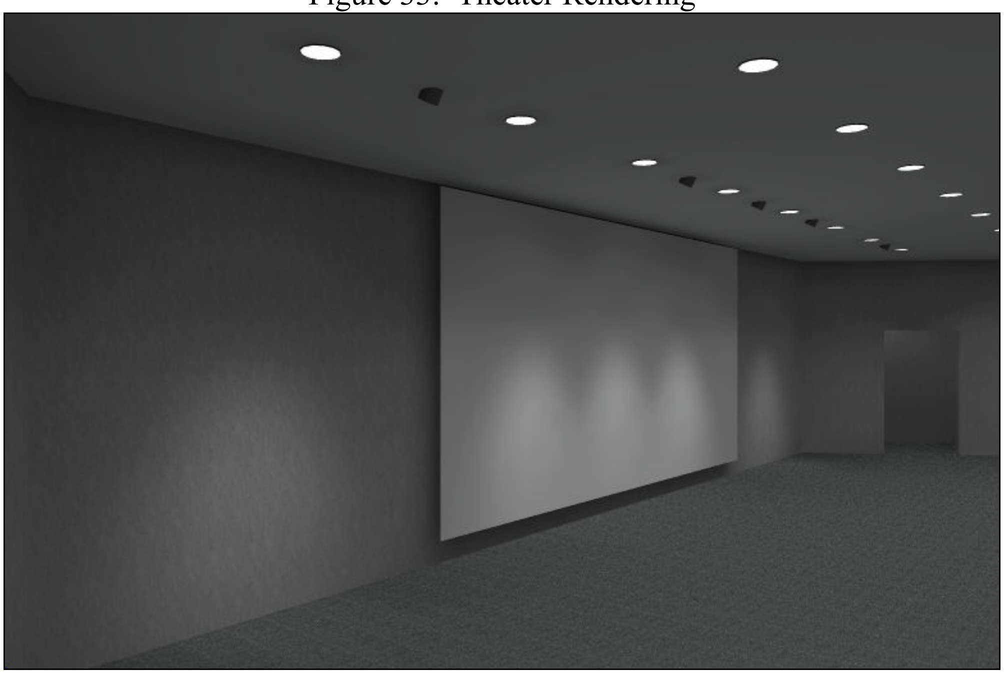


Figure 34: Theater Pseudo Rendering

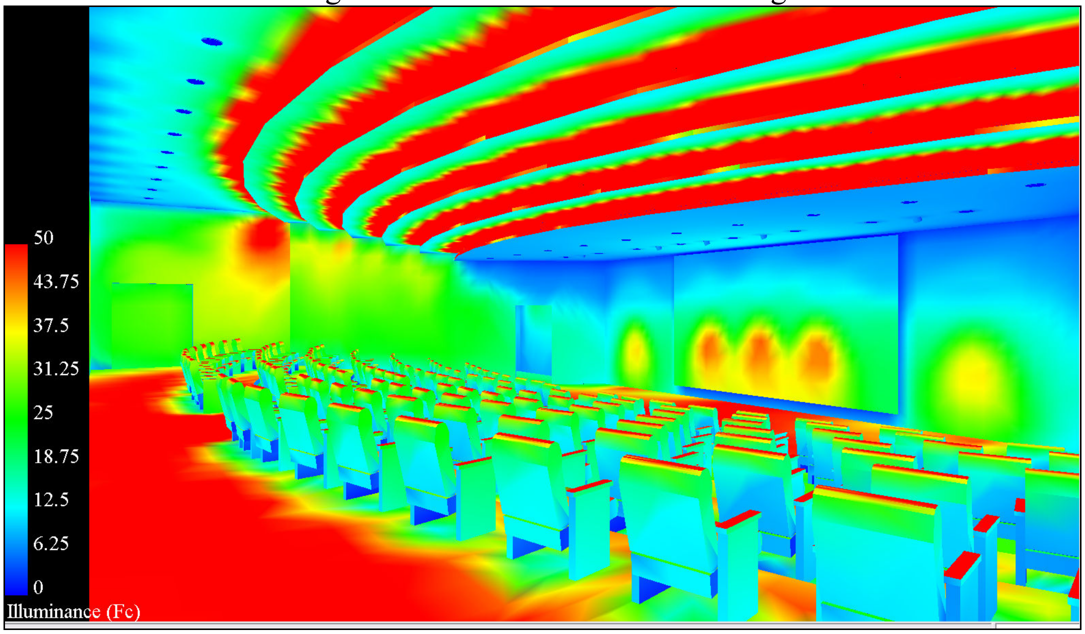


Figure 35: Theater Pseudo Rendering

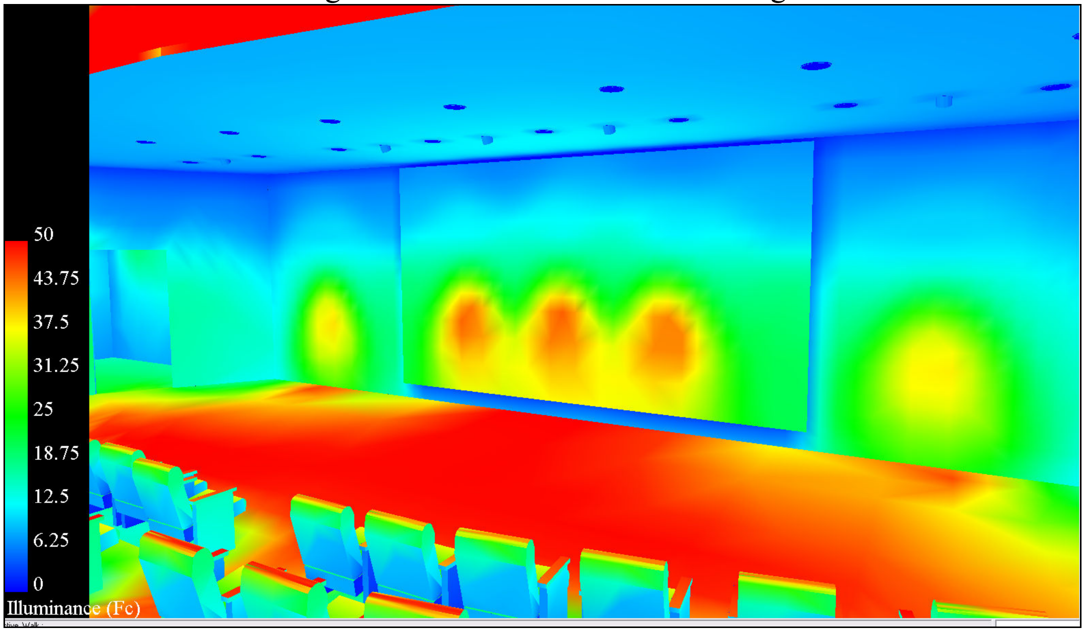
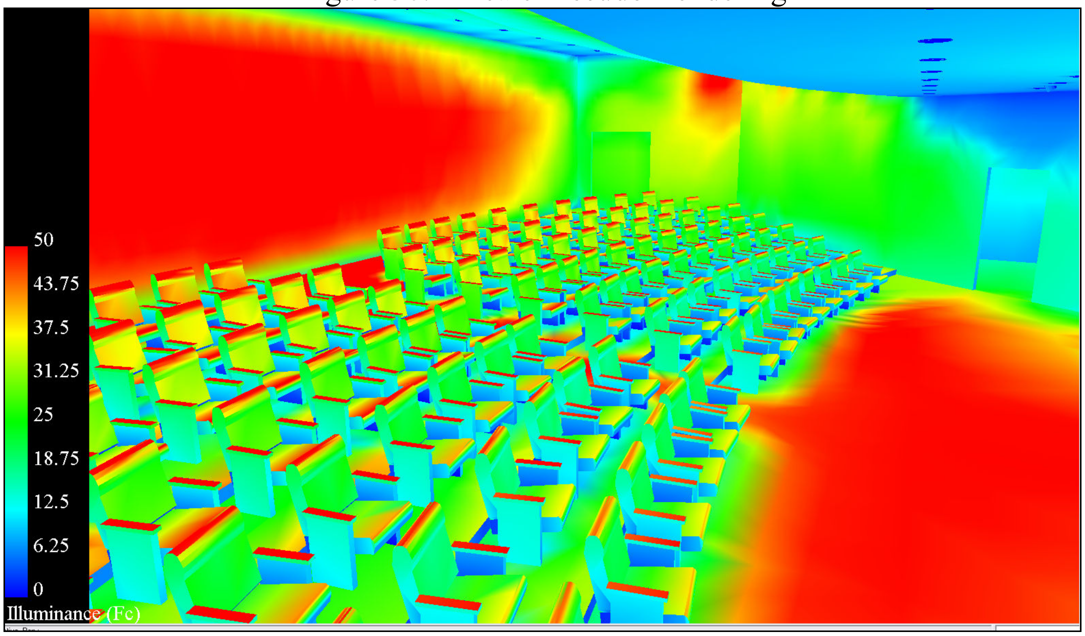


Figure 36: Theater Pseudo Rendering



Conclusion

I feel these renderings show really well how this space would perform with the exception of the omitted step lighting. The cove lighting in the first rendering seems really bright, and a high contrast surface compared to the rest of the space, but that is at full output. Dimming down the cove lighting would provide a much more comfortable sitting area for listening to lectures while still being able to take notes.

In these pseudo images, the front of the room is dark on the ceiling which I consider good since the projection screen will normally be on and a dark front area will have a clearer image on the screen for the viewer. Having the front lights separated into 3 zones will also help control where the light is going and which of the three areas a user wants turned on or be dimmed. On each chair arm is an illuminance of 50fc so at full output there is enough light to take notes. The back wall has more light on it than I would like, but I believe this is from the coves bouncing light from the ceiling to the back wall. If a lower surface reflectance is used on the back wall then I believe this space would become more comfortable when all the lights are on at full output.

Open Office

Spatial Overview

The office space I am redesigning is oriented along the west façade of the building on the 2nd floor. The desk layout is set up in four cubicle groups, placed along the walls of the office. The cubicle heights are not given but the window height is 4' so I will be assuming 4' for the cubicle height in the analysis. Windows are 6'wide by 6' high are spaced evenly along the south, west, and north walls. These provide some daylight but become a problem in the afternoon with direct glare into the cubicles along the west wall. Each cubicle has a computer station so care has been taken to provide the least amount of glare possible on each computer screen.

Performance Considerations

Performance in an open office space has everything to do with comfort, and how well the surroundings interact with each individual's personal preference. Although it is just about impossible to please everyone in an office, a few basic strategies can help to get the most production out of the staff. Performance criteria in an office include glare, veiling reflections, light distribution and daylight integration.

Glare is a major issue that needs to be dealt with anytime computer work is involved. Glare can come from the ceiling to the computer screen, directly from the luminaires and from windows or skylights. Using VDT luminaires works well for reducing glare, but seems to bring a more depressing mood to the office. Adding in wall washers can help make the space more comfortable again. Another issue that VDT luminaires have is that they can create shadows.

Light distribution in an office needs to be fairly uniform if possible. This is so the ratios of tasks to background stay within the 3:1 acceptable levels. Another reason is that open office plans tend to change and move cubicles here and there, and a uniform distribution over the whole space will alleviate any problems with illumination on any workplane.

Design Concept

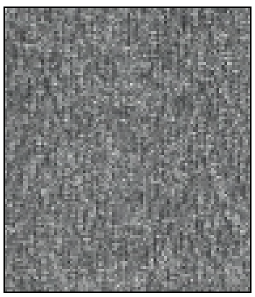
The lighting design of the office will incorporate a skylight system for a more comfortable feel while working. The skylights have splayed wells and are diffuse 16mm polygal glazing. The polygal glazing helps to thermally insulate the glass surface while providing good diffuse light into the space. To reduce glare from the south and west windows I am proposing manual shades for these windows. The lighting system is broken into an ambient system and a task system.

The ambient system will be suspended indirect/direct fixtures in groups of four, mounted 2' from the ceiling, over each cubicle section along the perimeter of the office area. These will provide general illuminance levels around 20-30fc on the workplane, while brightening up the ceiling to complement the diffuse skylight additions running through the center walkway of the office. Lighting the ceiling helps reduce glare coming

through the skylights by lower the contrast ratio between the skylights and the ceiling. These luminaires will be controlled with a ceiling mounted photosensor and occupancy sensor. The zones and controls are shown on Figure 44 and Figure 45.

The task lighting system is a movable plug-in cord luminaire that attaches to each cubicle. The system provides a bright, even distribution over the desk while keeping the wattage fairly low for 50+ fc of illuminance.

Finishes



Floor – Broadloom Carpet – Reflectance 20%

Walls – Painted – Reflectance 60%

Ceiling – Acoustical Ceiling Tile – Reflectance 85%

Original Plan

Figure 37: North Office Plan

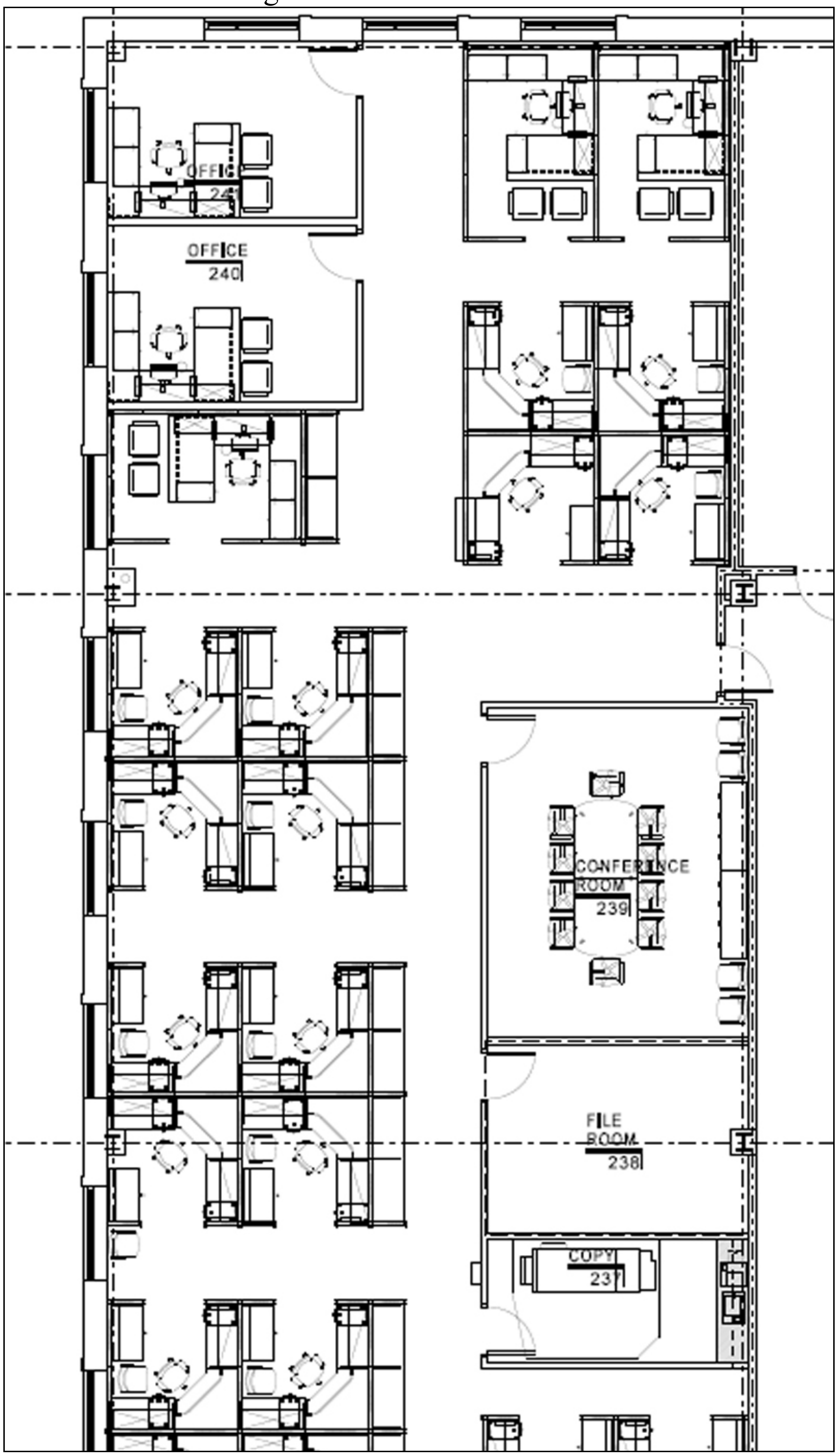
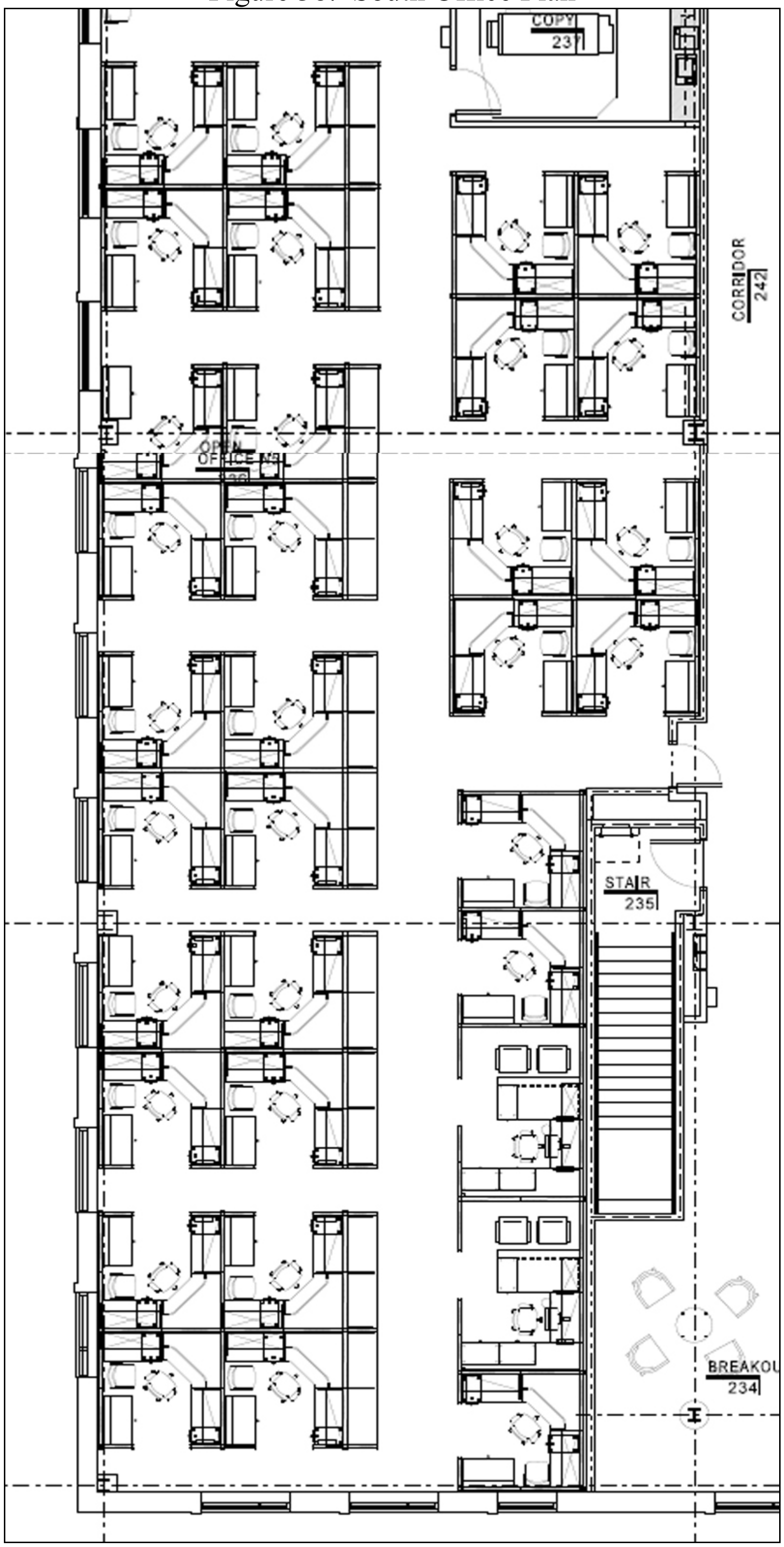


Figure 38: South Office Plan



Skylight Design

The skylight design is used to provide a better overall daylight integration within the open office area. Each skylight is a nominal 4.5’ x 4.5’ wide square opening. From the top of the skylight until it splays out is 4.5’. The splay is at a 45 degree angle and extends the opening at the bottom to 8.5’ x 8.5’ square. The reason for the splay is to allow some more spread of daylight throughout the office without adding more or larger skylights. The overall height of the skylight system comes to 6.5’. I chose these results using the program Skycalc, which provides an estimation of the energy balance between lighting savings and HVAC losses with the addition of skylights.

Skycalc is an excel program that works by percent area of the roof that is skylights compared to the floor area. Adjusting the location, reflectance values of surfaces, type of space, partition heights, lighting type and controls, skylight properties, and cost of electricity and heating gives a good estimate of the size and number of skylights that would be optimal in the space. I do not have costs of electricity or fuel for my building because they would not release the information to me, so I assumed $0.10 kWh for electricity and $0.50/Therm for oil costs. The program does not take into account exterior window openings so this is just estimation. Results are as follows with rest of the analysis in Appendix A:

Figure 39: Skycalc Output Results

SkyCalc: Skylight Design Assistant - Tabular Results

Company Name: NNSOC
Project Description: OFFICE DESIGN

Electric Lighting Usage	kWh/yr		
Ltg. Energy without Skylights	17,309	Lighting Fraction Saved	41%
Lighting Energy w/ Skylights	10,279	Full daylighting (h/yr)	1,941

Savings from Design Skylighting System

Savings		Annual Energy Savings (kWh/yr)	Annual Cost Savings ($/yr)
Lighting		7,030	$703
Cooling		-904	-$90
Heating		239	$4
Total		**6,365**	**$617**

Skylighting System Description

Skylight unit size (ft^2)	20.3
Number of Skylights	8
Total Skylight Area (ft^2)	162
Skylight to Floor Ratio (SFR)	2.7%
Effective Aperture	1.1%
Floor Area per Skylight	750
Skylight U-value	0.410
Skylight SHGC	68%
Skylight T_{vis}	72%
Well Efficiency (WF)	79%
Dirt and Screen Factor	70%
Overall Skylight System Tvis	40%
Skylight CU	80%

Site Description

Climate Location	Fredericksburg.wea3	
Climate Zone	CZ4 (mixed, 3,600 < HDD65°F <= 5,400)	
Building Type	Office	
Building Area	6,000	(ft^2)

Elecric Lighting System Description

Lighting Type	Direct/Indirect fluorescent	
Lighting Control	Dimming min 10% light	
Light Level Setpoint	30	fc
Lighting Density	0.81	W/ft^2
Connected Load	4.9	kW
Fraction Controlled	90%	

As compared to the design with 8 skylights but no photocontrols

Savings from Functioning Photocontrol System

Savings		Annual Energy Savings (kWh/yr)	Annual Cost Savings ($/yr)
Lighting		7,030	$703
Cooling		1,974	$197
Heating		-56	-$1
Total		**8,947**	**$899**

Skylight Plan

Figure 40: North Skylight Office Plan

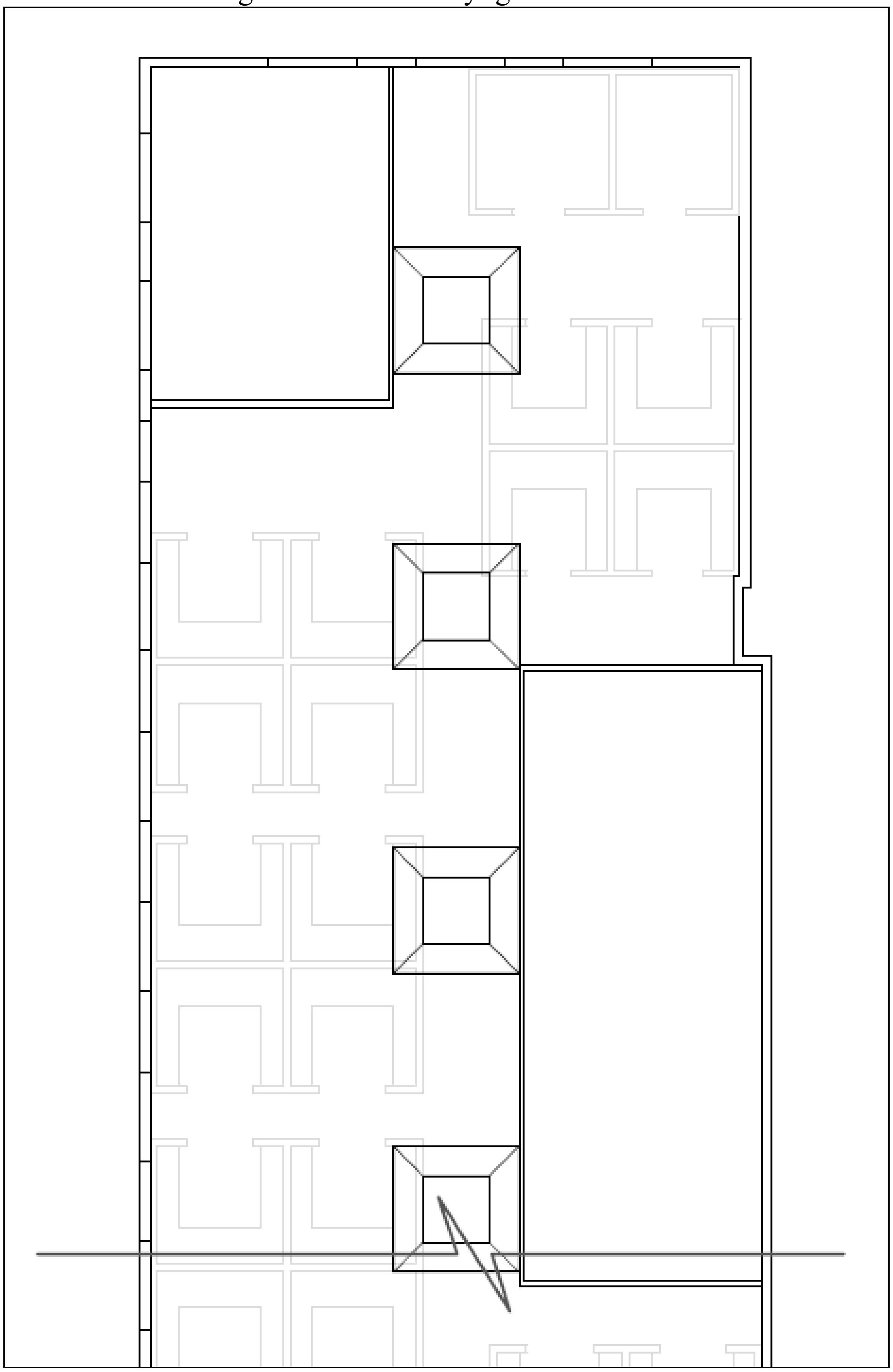
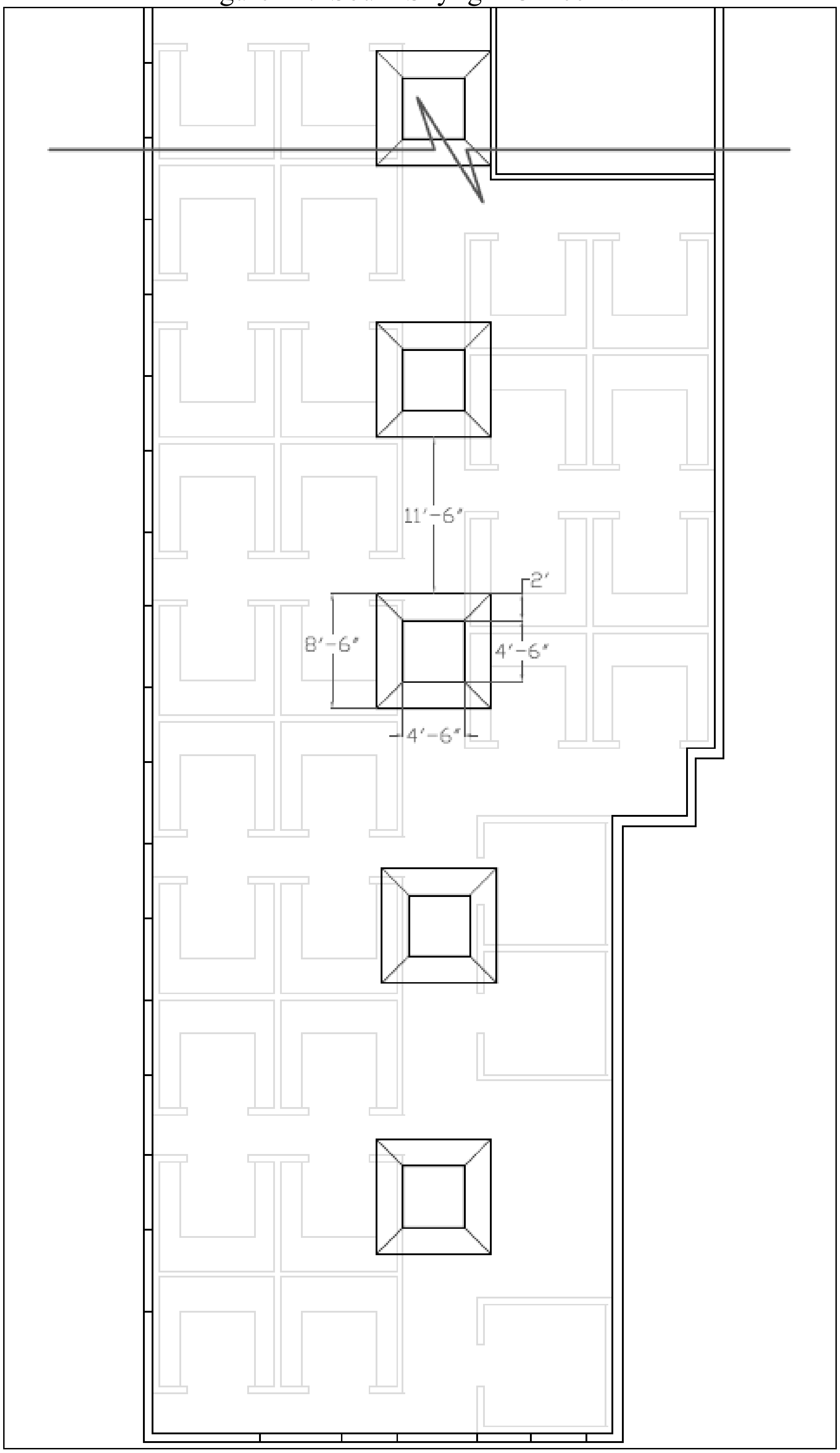
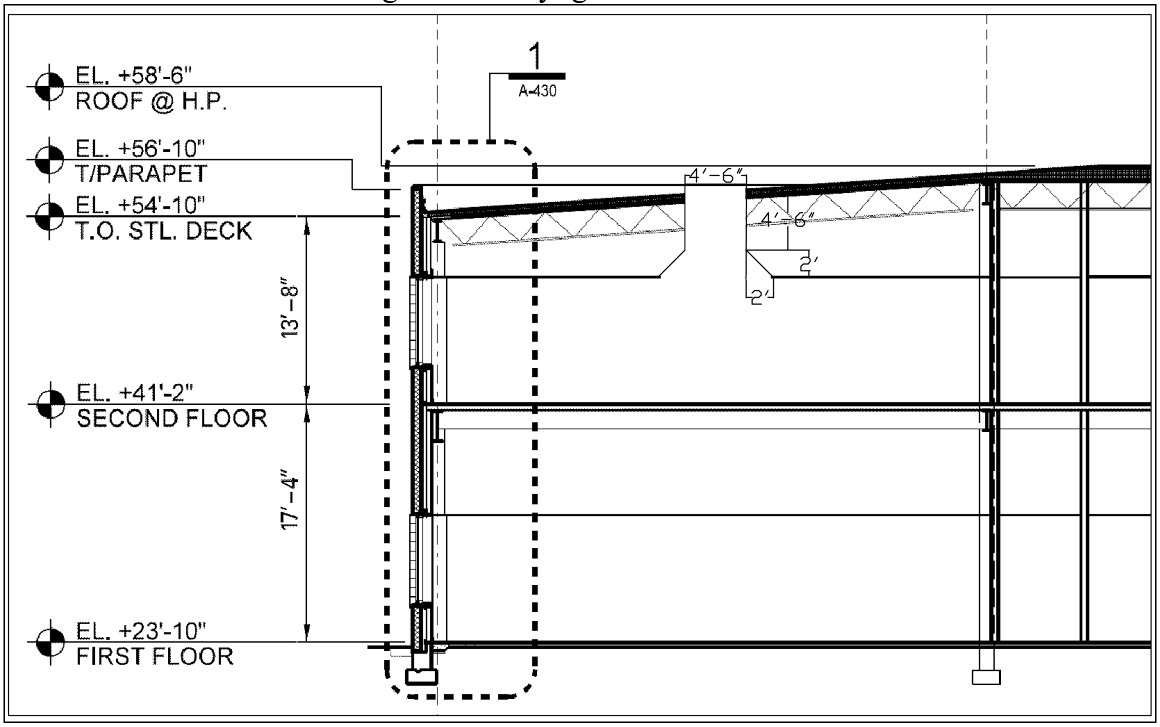


Figure 41: South Skylight Office Plan



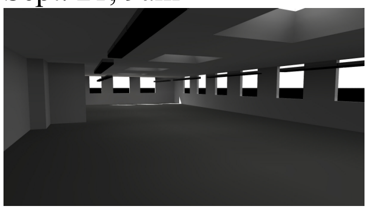
Skylight Section

Figure 42: Skylight Section Detail

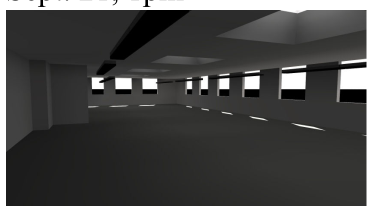


Daylight

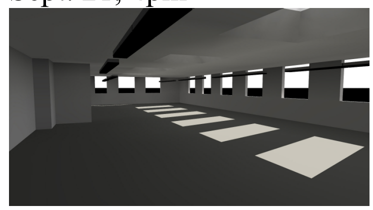
Sept. 21, 9am



Sept. 21, 1pm

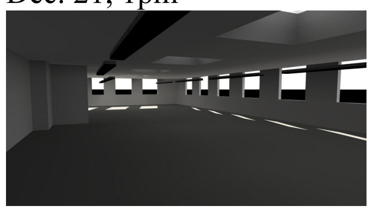


Sept. 21, 4pm

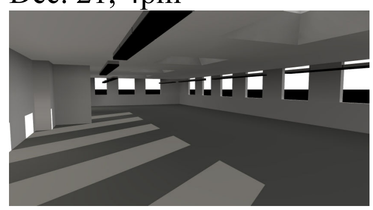


Dec. 21, 9am

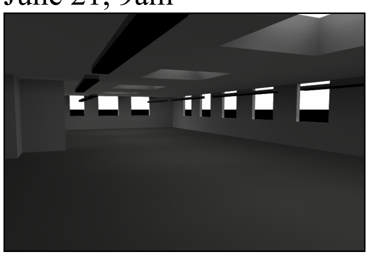
Dec. 21, 1pm



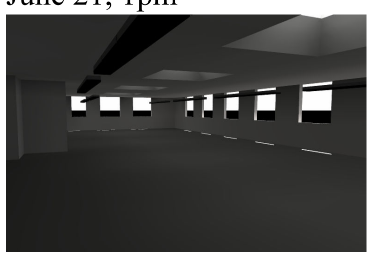
Dec. 21, 4pm



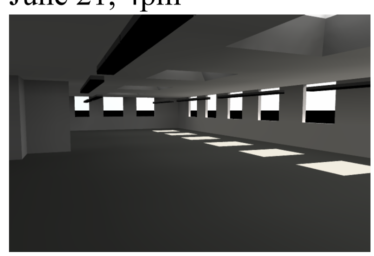
June 21, 9am



June 21, 1pm



June 21, 4pm



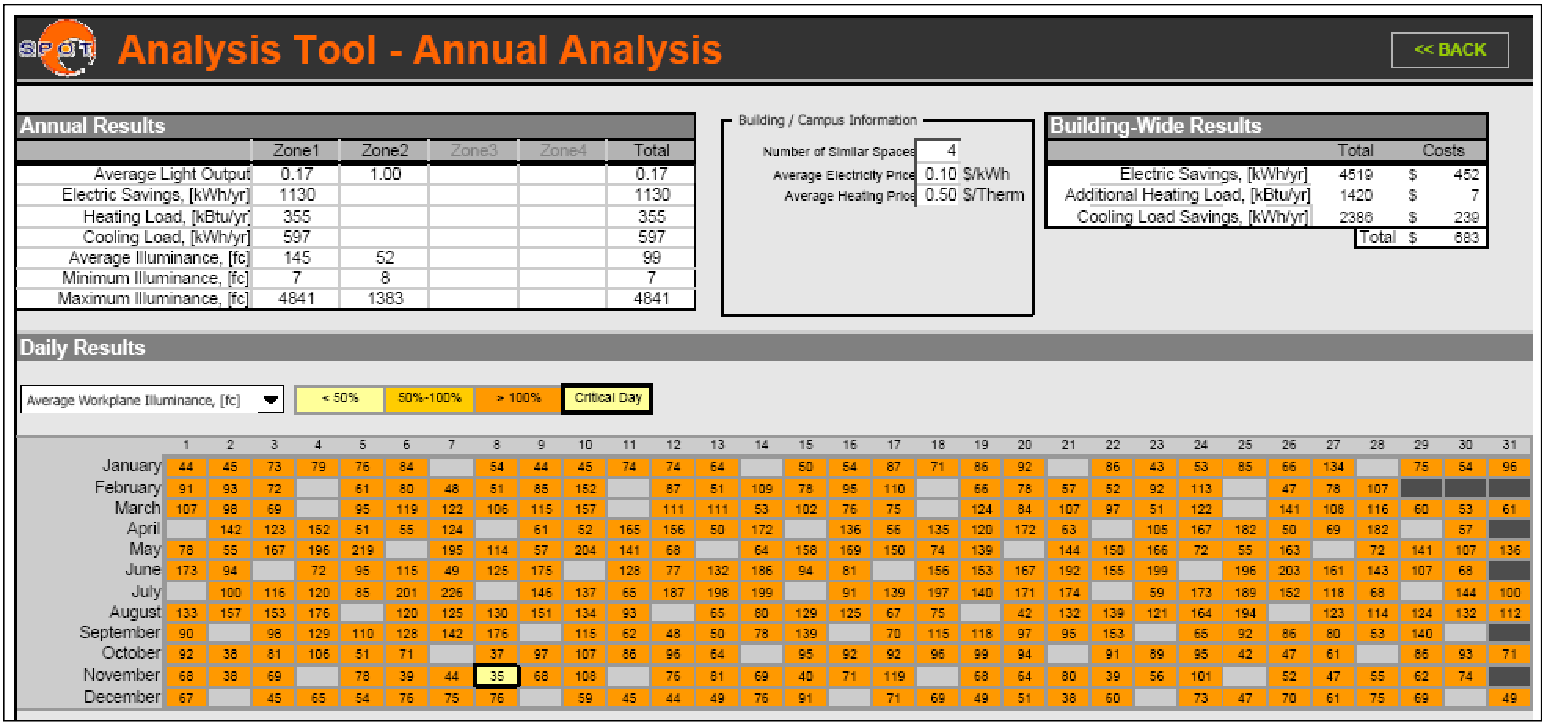
Daylight Integration

To use the added daylight properly, I had to incorporate a dimmed electrical lighting system into the space. In order to find out how much money would be saved each year using the daylight integration, I used the SPOT (Sensor Placement + Optimization Tool) to determine when and for how long the lights could be dimmed. I chose to use a quarter of the office space to do the analysis. The space was in the middle where no light was contributing from the south or north wall windows. Two skylights and four windows were included in the study. For the skylight design, the program could not do the splayed well I have designed so I went with the most conservative and had a square 4.5’x4.5’ skylight opening. The depth of the skylight to the ceiling was 5’ with a reflectance of 85% in the skylight well. The luminaire used was the same one in my lighting design, mounted at the same height of 2’ from the ceiling.

One photocell was used in the space only controlling the two sets of lighting closest to the windows. I am assuming that the lighting on the east side will always be on full output. The photocell has a cosine distribution and sliding setpoint value. The location is on the ceiling between the set of luminaires closest to the window and aimed toward the floor to receive light from the windows and skylights. The target illuminance

value for the space was 30fc on the workplane. The extra levels needed for reading and writing will be supplied by the task luminaires on each cubicle. The results are below, with the rest of the analysis in Appendix A:

Figure 43: SPOT Analysis Final Results



Analysis Tool - Annual Analysis << BACK

Annual Results

	Zone1	Zone2	Zone3	Zone4	Total
Average Light Output	0.17	1.00			0.17
Electric Savings, [kWh/yr]	1130				1130
Heating Load, [kBtu/yr]	355				355
Cooling Load, [kWh/yr]	597				597
Average Illuminance, [fc]	145	52			99
Minimum Illuminance, [fc]	7	8			7
Maximum Illuminance, [fc]	4841	1383			4841

Building / Campus Information

Number of Similar Spaces	4	
Average Electricity Price	0.10	$/kWh
Average Heating Price	0.50	$/Therm

Building-Wide Results

	Total	Costs	
Electric Savings, [kWh/yr]	4519	$	452
Additional Heating Load, [kBtu/yr]	1420	$	7
Cooling Load Savings, [kWh/yr]	2386	$	239
	Total	$	683

Daily Results

Average Workplane Illuminance, [fc] < 50% 50%-100% > 100% Critical Day

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
January	44	45	73	79	76	84		54	44	45	74	74	64		50	54
February	91	93	72		61	80	48	51	85	152		87	51	109	78	95
March	107	98	69		95	119	122	106	115	157		111	111	53	102	76
April		142	123	152	51	55	124		61	52	165	156	50	172		136
May	78	55	167	196	219		195	114	57	204	141	68		64	158	169
June	173	94		72	95	115	49	125	175		128	77	132	186	94	81
July		100	116	120	85	201	226		146	137	65	187	198	199		91
August	133	157	153	176		120	125	130	151	134	93		65	80	129	125
September	90		98	129	110	128	142	176		115	62	48	50	78	139	
October	92	38	81	106	51	71		37	97	107	86	96	64		95	92
November	68	38	69		78	39	44	35	68	108		76	81	69	40	71
December	67		45	65	54	76	75	76		59	45	44	49	76	91	

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
January	87	71	86	92		86	43	53	85	66	134		75	54	96
February	110		66	78	57	52	92	113		47	78	107			
March	75		124	84	107	97	51	122		141	108	116	60	53	61
April	56	135	120	172	63		105	167	182	50	69	182		57	
May	150	74	139		144	150	166	72	55	163		72	141	107	136
June		156	153	167	192	155	199		196	203	161	143	107	68	
July	139	197	140	171	174		59	173	189	152	118	68		144	100
August	67	75		42	132	139	121	164	194		123	114	124	132	112
September	70	115	118	97	95	153		65	92	86	80	53	140		
October	92	96	99	94		91	89	95	42	47	61		86	93	71
November	119		68	64	80	39	56	101		52	47	55	62	74	
December	71	69	49	51	38	60		73	47	70	61	75	69		49

Lighting Plan

Figure 44: North Office Lighting Plan

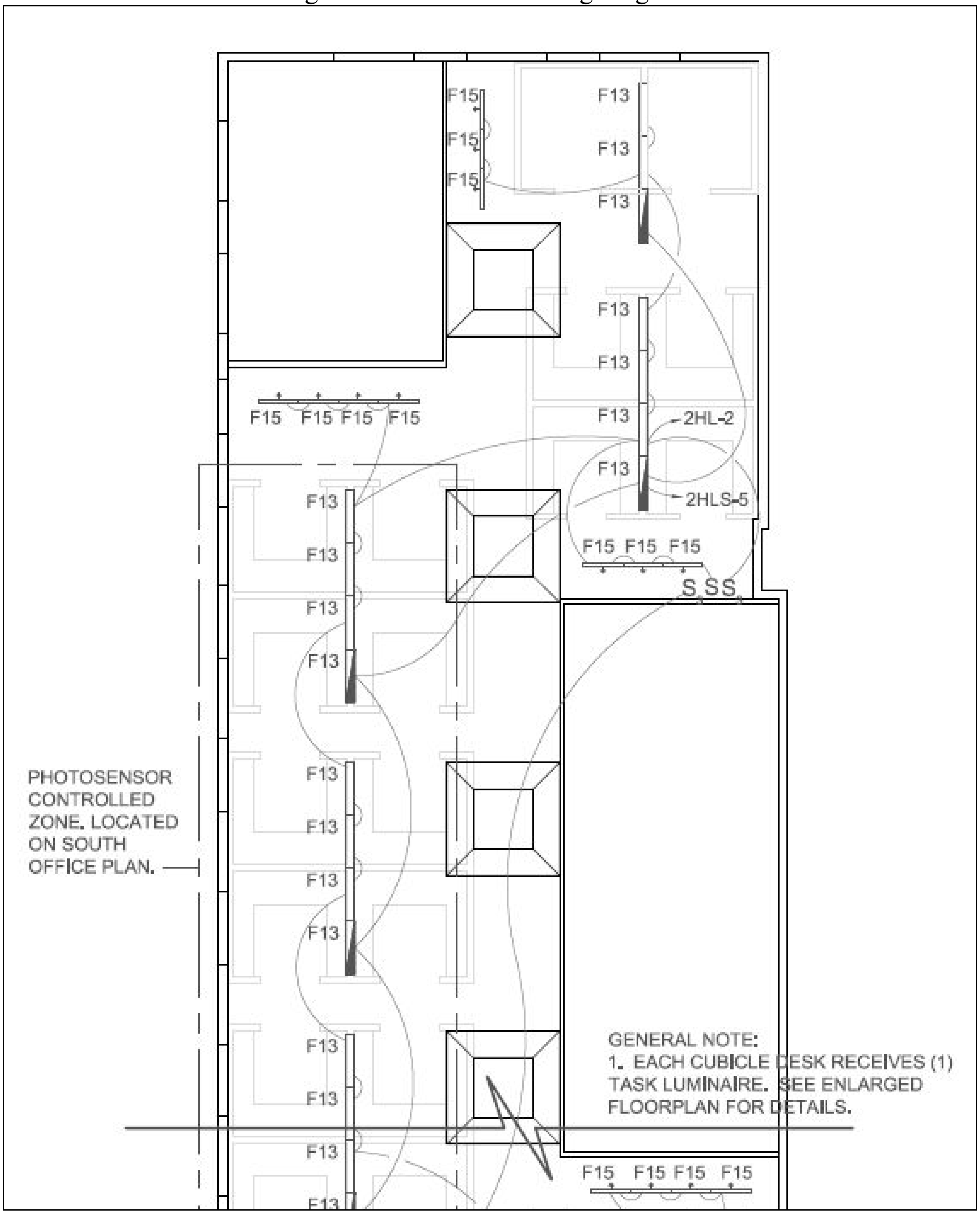


Figure 45: South Office Lighting Plan

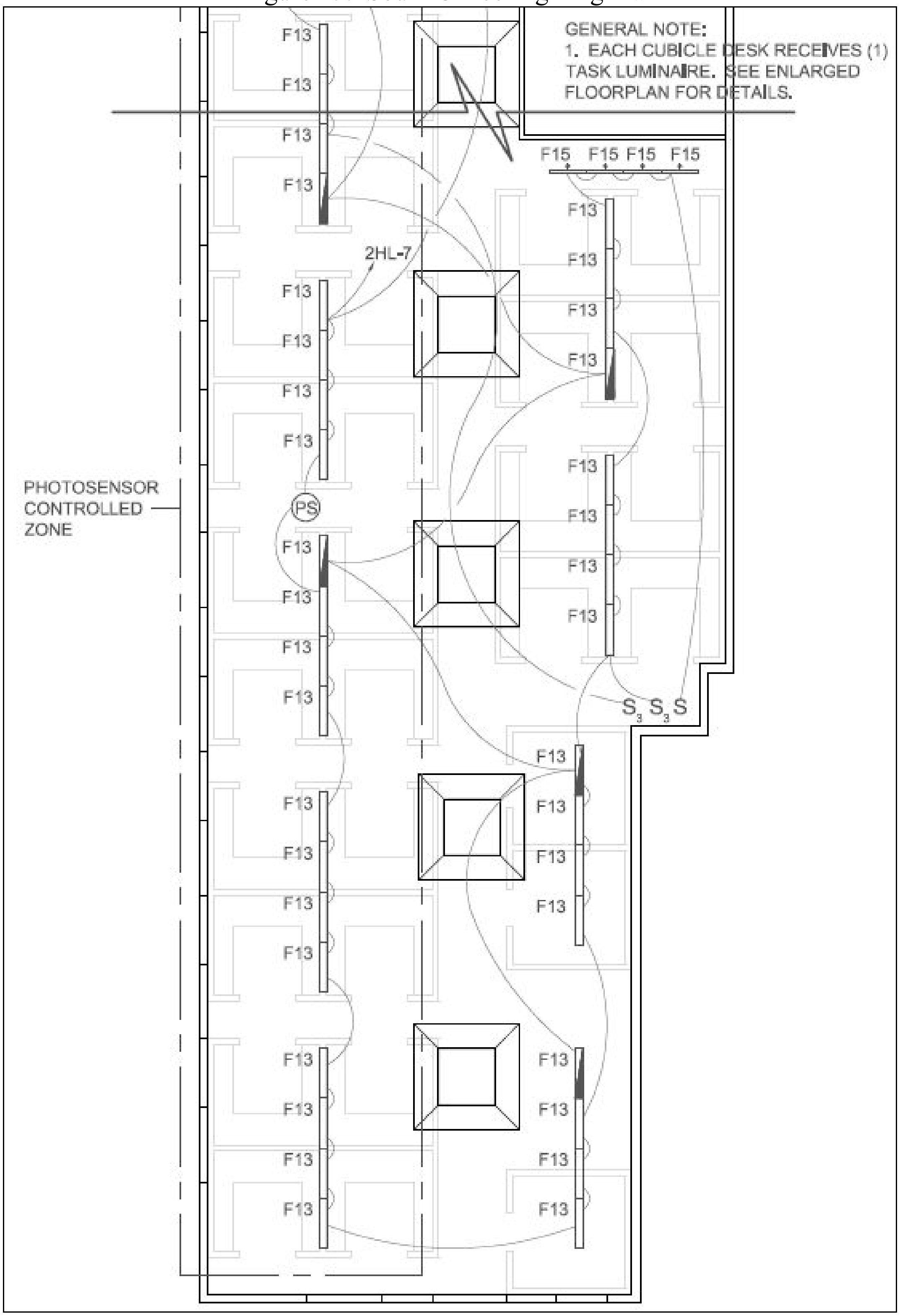


Figure 46: North Office Cubicle Lighting Plan

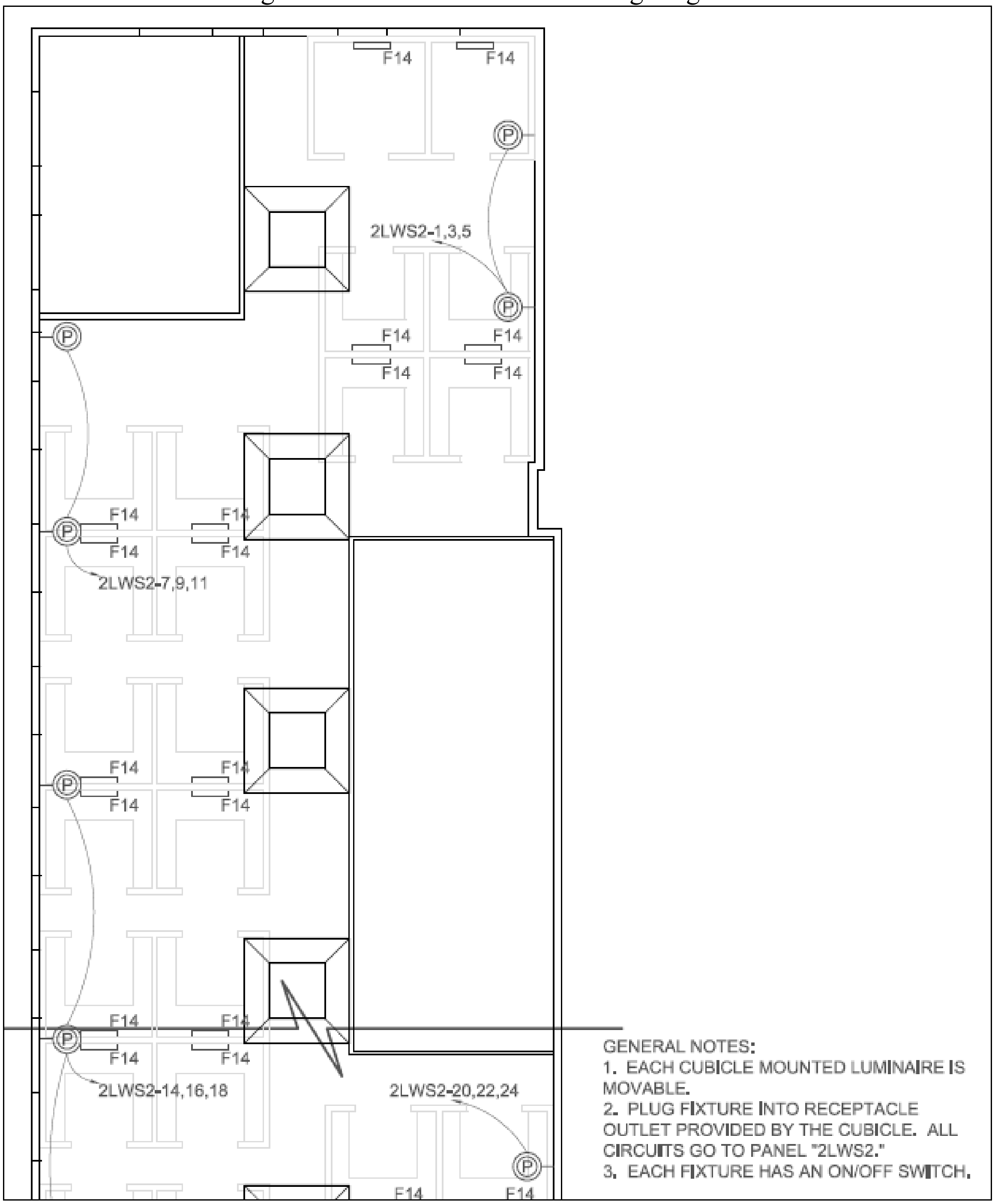
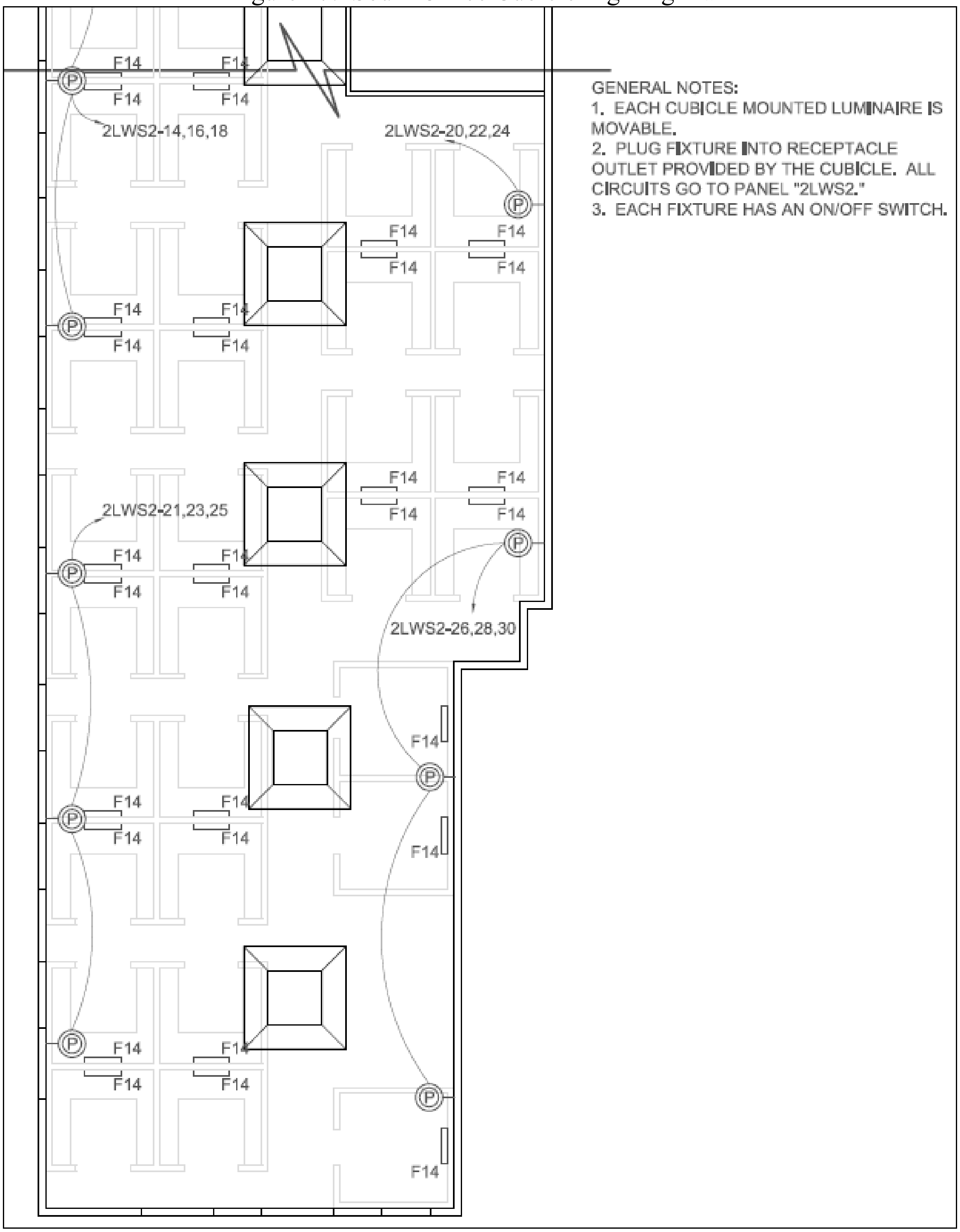


Figure 47: South Office Cubicle Lighting Plan

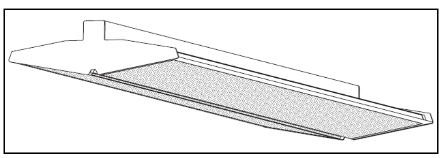


Luminaires

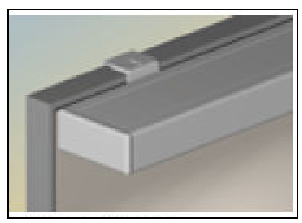
Table 11

LUMINAIRE SCHEDULE			
Type	**Description**	**Lamping**	**CCT**
F13	INDIRECT SUSPENDED LINEAR FLUORESCENT, DOUBLE DIFFUSER OPTICAL DESIGN, 96% REFLECTIVE WHITE PAINT. NOMINAL 3.5"x12"x48". CAN BE CONNECTED IN SECTIONS. TYPE 6 SYMMETRICAL DISTRIBUTION.	(1) F54W/T5/841/ECO	4100
F14	WORKSTATION LUMINAIRE FOR INSTALLATION ON OPEN OFFICE FURNITURE PANELS. DESIGNED TO PROVIDE LOW-GLARE TASK LIGHTING FOR HORIZONTAL SURFACES. NOMINAL 6"x2.5"x36". TYPE IV ASYMMETRICAL DISTRIBUTION. PLUG IN CONNECTION TO RECEPTACLE OUTLET.	(1) F21W/T5/841/ECO	4100
F15	SURFACE MOUNTED WALLWASH, ASYMMETRICAL DISTRIBUTION, TYPE IV FIXTURE. NOMINAL 5"x2.5"x36". MATTE WHITE FINISH WITH DECORATIVE ENDPLATES. CAN BE CONNECTED IN SECTIONS.	(1) F21W/T5/841/ECO	4100

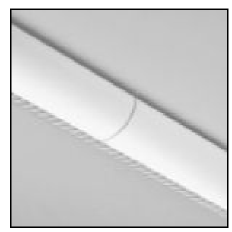
*Full Luminaire, Ballast, LLF schedule and cutsheets attached in Appendix A.



F13



F14



F15

LLF's

Table 12

TYPE	BF	CLEANING	MAINTENANCE	LLD	LDD	RSDD	LLF
F13	0.03/1.00	12 Month	VI	0.92	0.85	0.93	0.73
F14	1	12 Month	III	0.92	0.9	0.97	0.8
F15	1.03	12 Month	III	0.92	0.9	0.97	0.83

*Assuming a clean environment.

Power Density and Illuminance Levels

Table 13

TYPE	# LUMINAIRES	# LAMPS/LUMINAIRE	WATTAGE/LAMP	WATTAGE
F13	51	1	125-(2) LAMPS	3187.5
F14	45	1	27	1215
F15	14	1	26	364

Total Wattage = 4766.5 W
Total Square Ft. = 5900s.f.
Power Density = 0.81 W/sq ft.

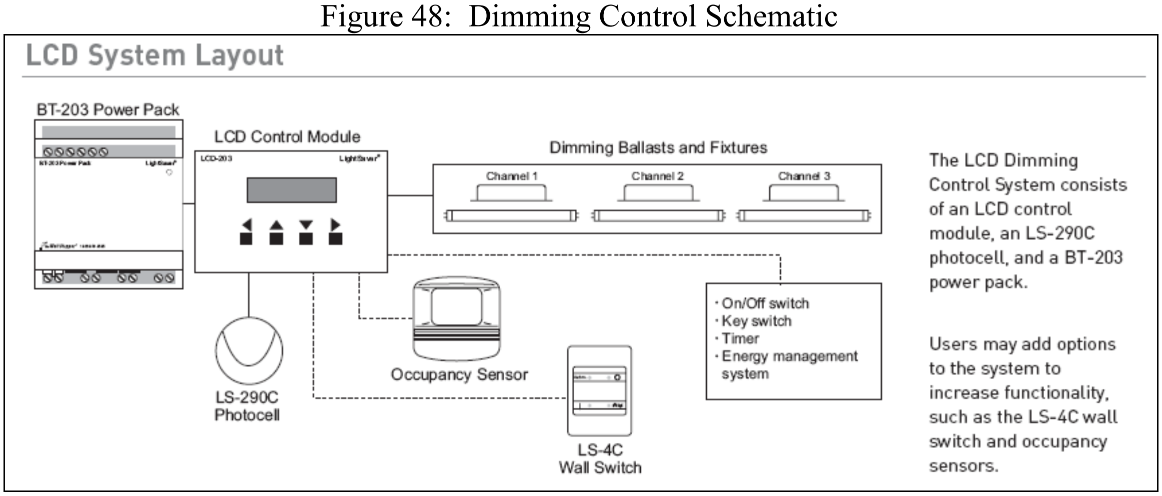
Using the Space-by-Space Method in ASHRAE 90.1
Open Office: 1.1 W/sq ft.

This lighting design meets ASHRAE 90.1 for power density for an open office space.

Controls

The office area will be controlled by a photocell and the Base SCADA system. There will be switches on the walls for override control as well. The photocells will control the fixtures along the exterior wall only, circuits “2HL-2” and “2HL-7,” shown on the office lighting plan within the boxed out region. The following shows the schematic diagram of the system. It is a Wattstopper system with Photocell, Dimming Module, Power Pack, and wall switches. Occupancy sensors will not be used in this design due to the SCADA system and the open office layout. The cutsheets are available in Appendix A.

Figure 48: Dimming Control Schematic



Renderings and Calculation Results

Figure 49: Office Rendering

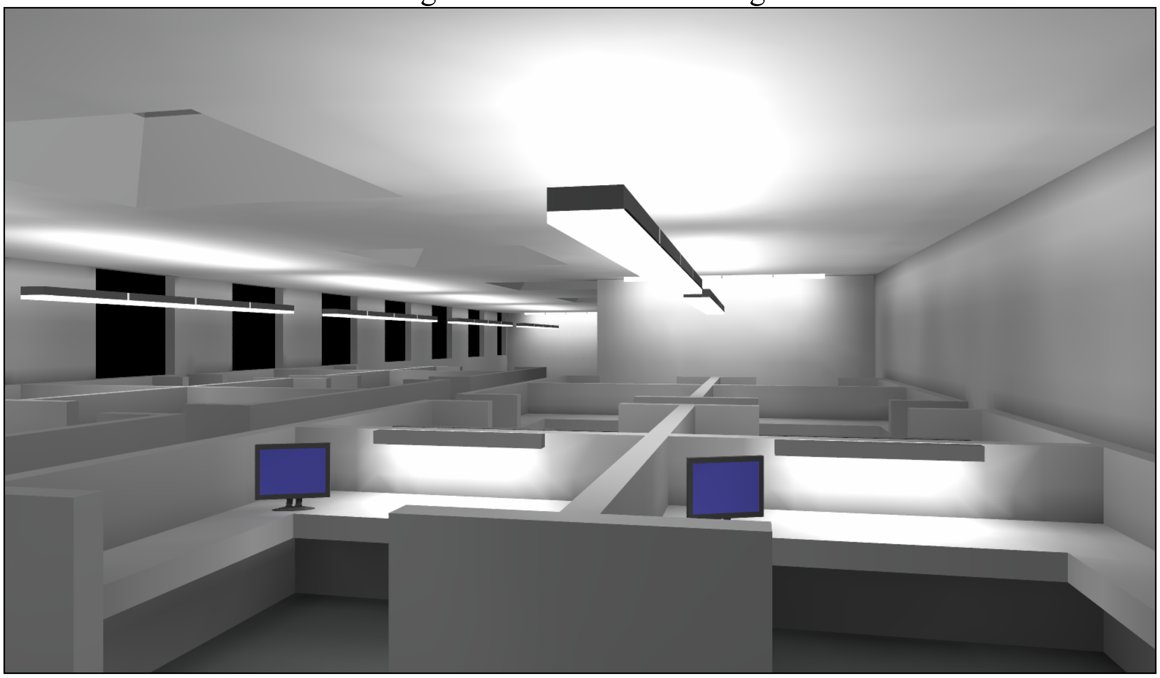


Figure 50: Office Rendering

Figure 51: Office Pseudo Rendering

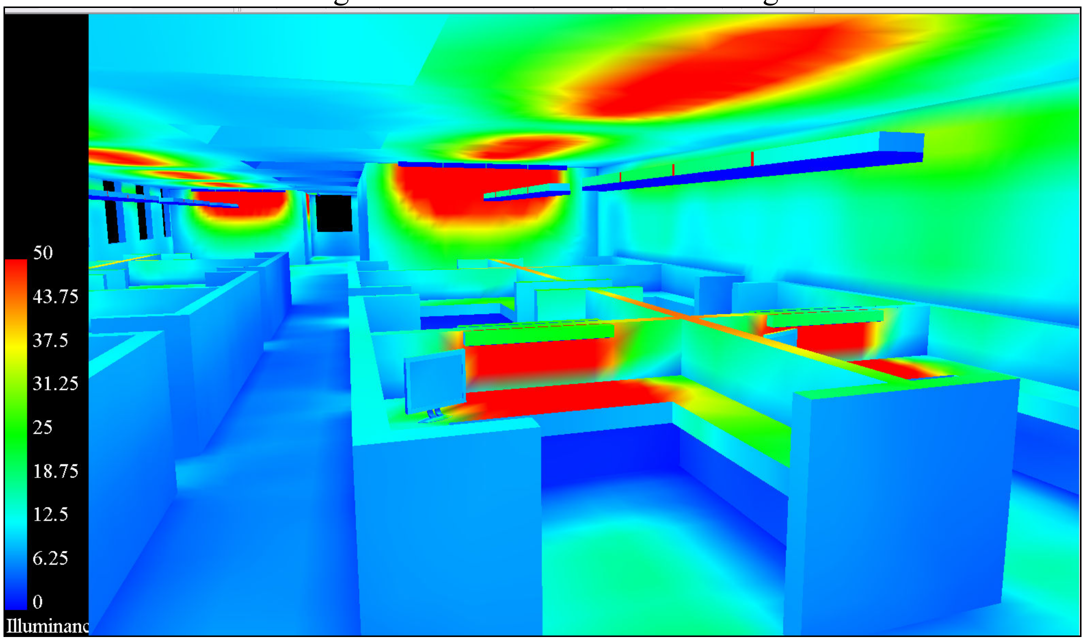
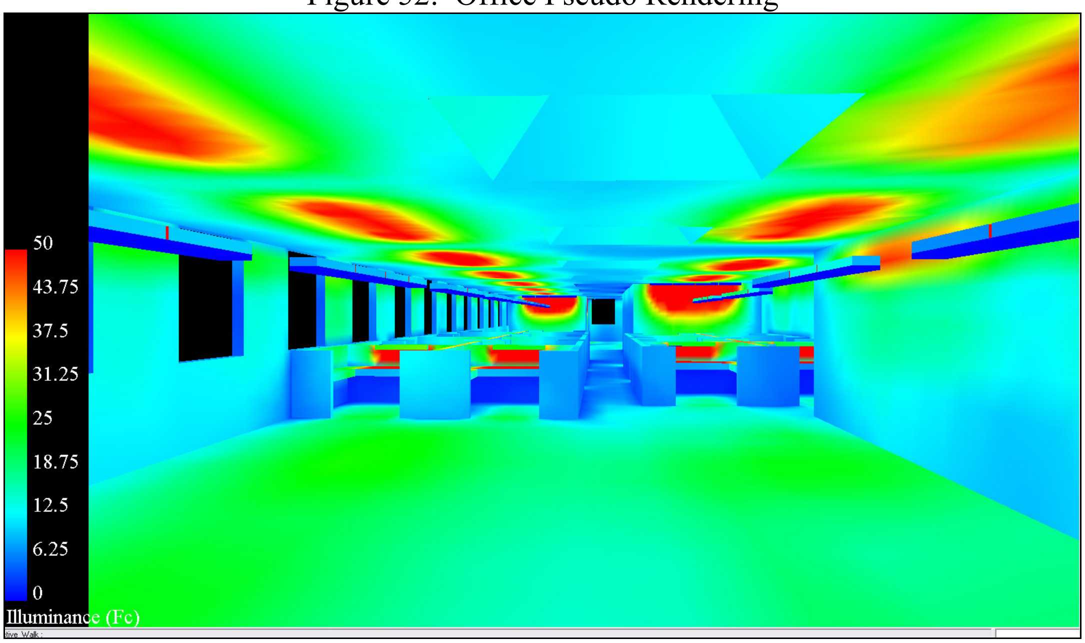


Figure 52: Office Pseudo Rendering



Electrical Depth

Background

The electrical system in the Naval Network & Space Operations Command is powered from an existing switchgear unit located outside the adjacent building. The utility service ends at two existing exterior 1750kVA transformers before entering the existing switchgear. This utility comes in parallel to these transformers that step-down the voltage from 13.8KV to 480V. These 480Y/277V feeders enter the existing double-ended switchgear that powers the adjacent building. Two secondary feeders are routed from here to the new building, where they enter double-ended 1600A switchgear located in the first floor electrical room. Each feeder and switchgear panel is designed to carry the entire load of the building. The switchgear's main tie breaker will automatically transfer on the loss of a power to a single feeder in order to keep the entire building powered.

Interior building power will be distributed at 480Y/277V, using a 3-phase and 4-wire system. Feeders from the switchgear go to distribution panels for lighting, receptacles and power panels, along with the UPS system and all other loads throughout the building. Step-down transformers are provided for those loads that run off of 208Y/120V service. Panels are located primarily in the first floor and second floor electrical rooms. Exceptions to this are the critical systems and workstation receptacle panels which are located in each specific office area.

Two existing 1250kVA generators are outside and provide redundant standby power if the system goes down. These generators activate upon loss of normal power, and sense the maximum load to the double-ended switchboard (Panel MSBA and MSBB). If the building load is below maximum for the generators, the tie breaker in the generator switchgear stays open and does not activate any shunt trip breakers. If the maximum load is exceeded then the tie breaker stays open and shunt trips are activated on appropriate non-essential loads to maintain facility load. If one generator fails to start the tie breaker in the generator switchgear closes and the appropriate shunt trip breakers are activated to shed non-essential loads across the entire system. The generators are not rated to serve life safety loads so these are served by the standby power system (SPS).

The SPS system provides power for emergency egress lighting, non-egress lighting to maintain essential operations, and essential equipment. The egress lighting also has a 90-minute battery backup via an automatic transfer switch to ensure the emergency lights will stay on. Fire alarm and security systems, along with the UPS system are also run from this SPS.

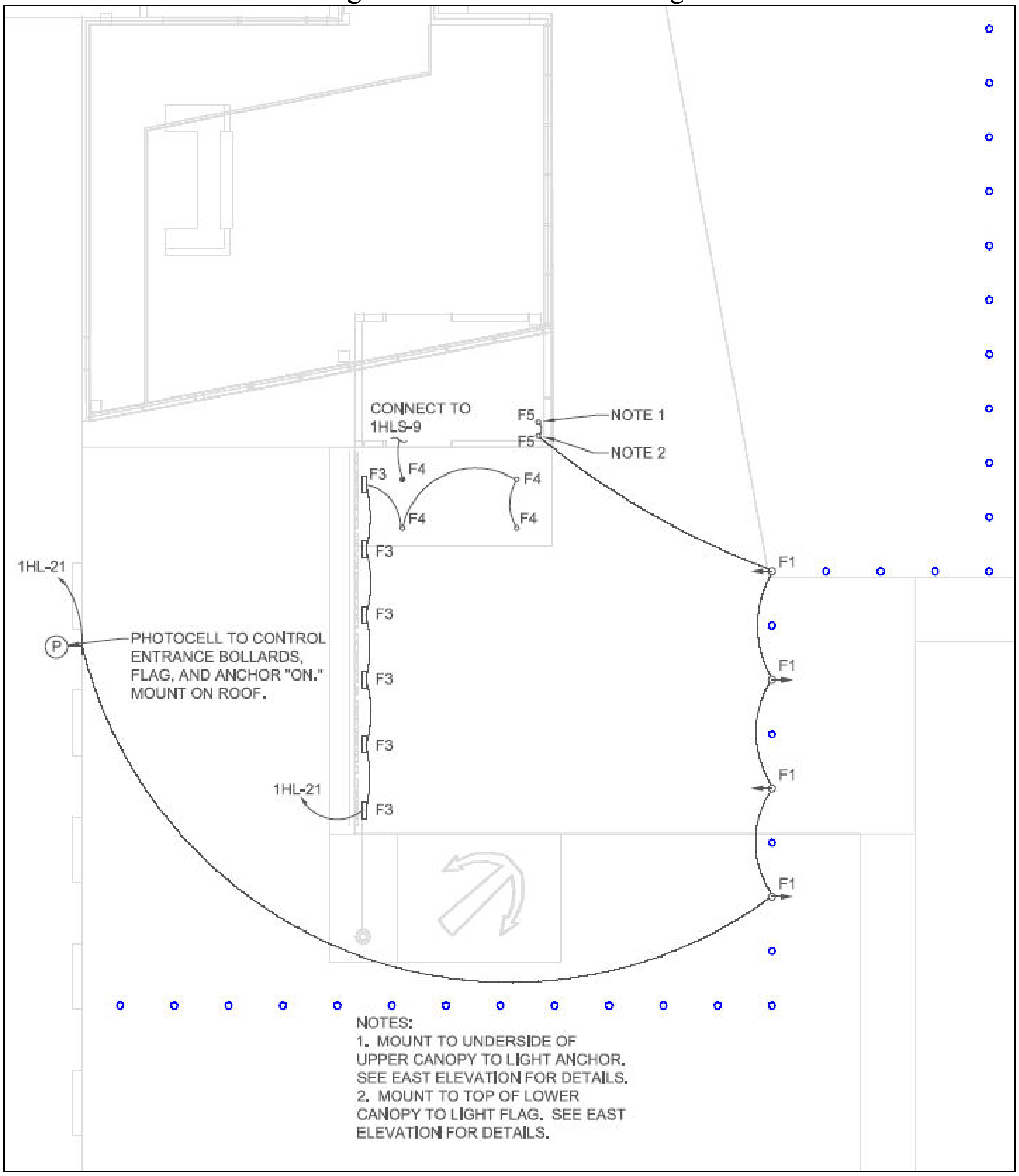
The UPS system services critical loads in both facilities and has two 625kVA modules to provide N+1 reliability. Each system has a 30-minute battery plant to provide the necessary power to service the present critical loads and 25% spare capacity for future expansion. The UPS system is set up so if one system goes down, critical loads can be transferred to the other UPS module by closing the static transfer switch located between the UPS switchboards and UPS distribution panels.

Panelboards and Circuiting

All four lighting spaces are circuited as shown in the following drawings. Following the plans are the panelboards as they originally were designed with the circuits that changed highlighted. Below each original panelboard is the updated panelboard with the new circuits.

Outdoor Area

Figure 53: Outdoor Circuiting Plan



Lobby

Figure 54: 1st Floor Lobby Circuiting Plan

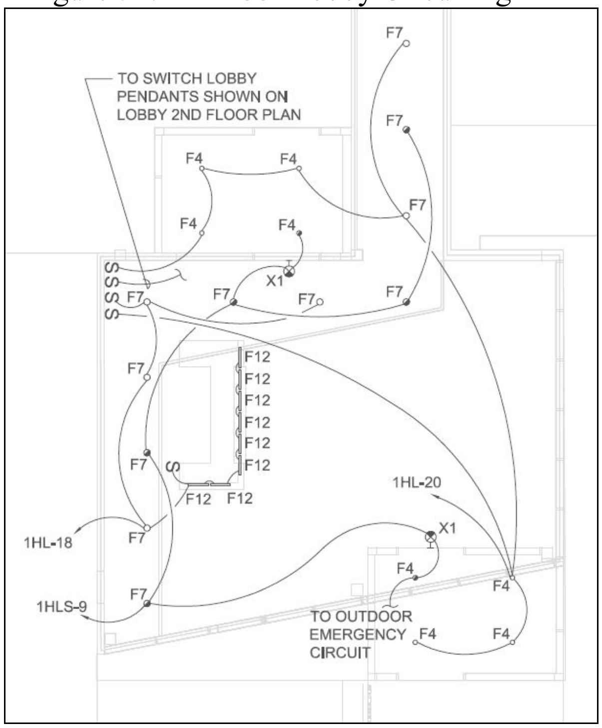
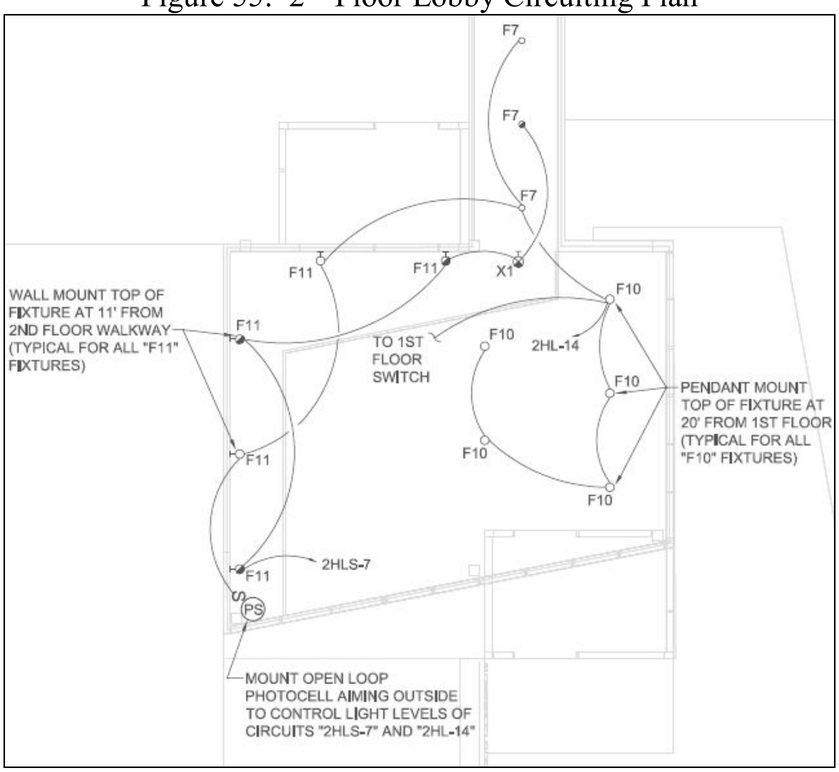


Figure 55: 2nd Floor Lobby Circuiting Plan



Training Theater

Figure 56: Theater Circuiting Plan

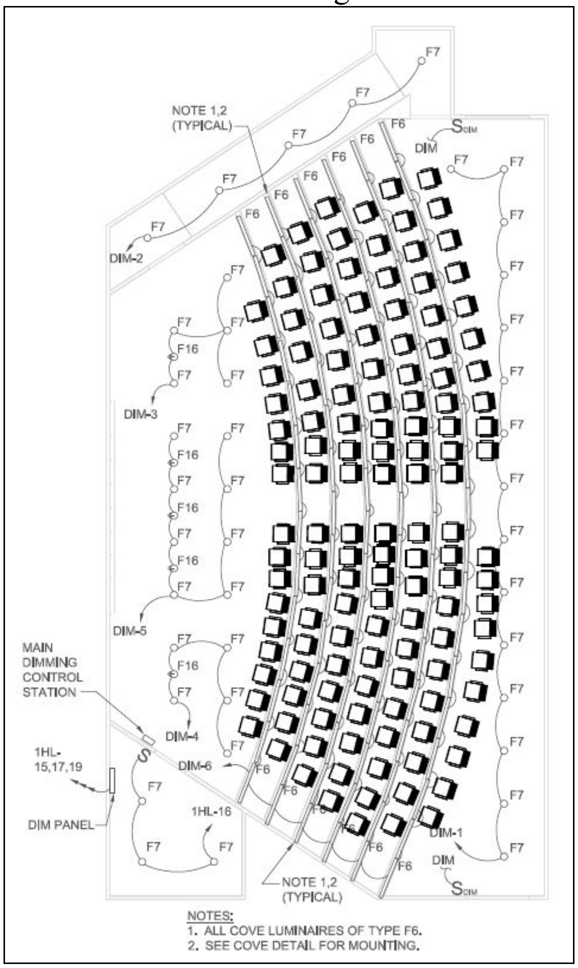
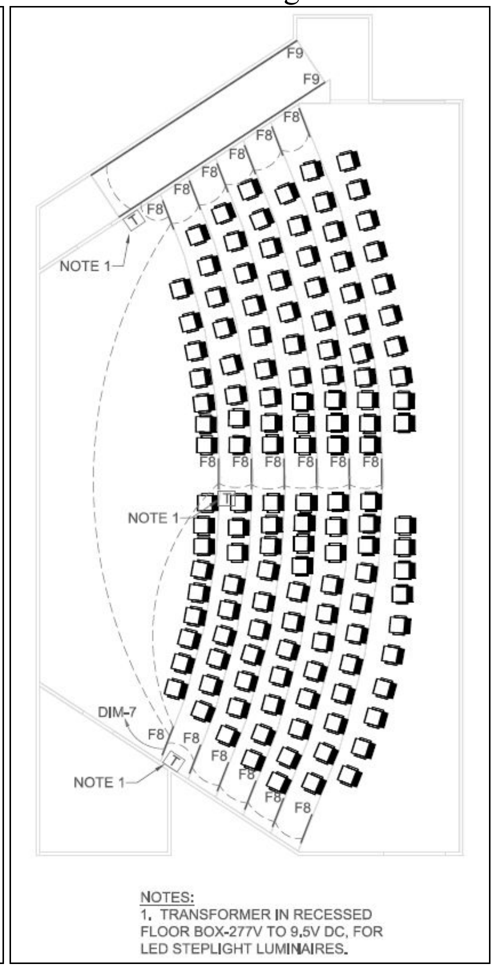


Figure 57: Theater LED Circuiting Plan



Office

Figure 58: Office Circuiting Plan

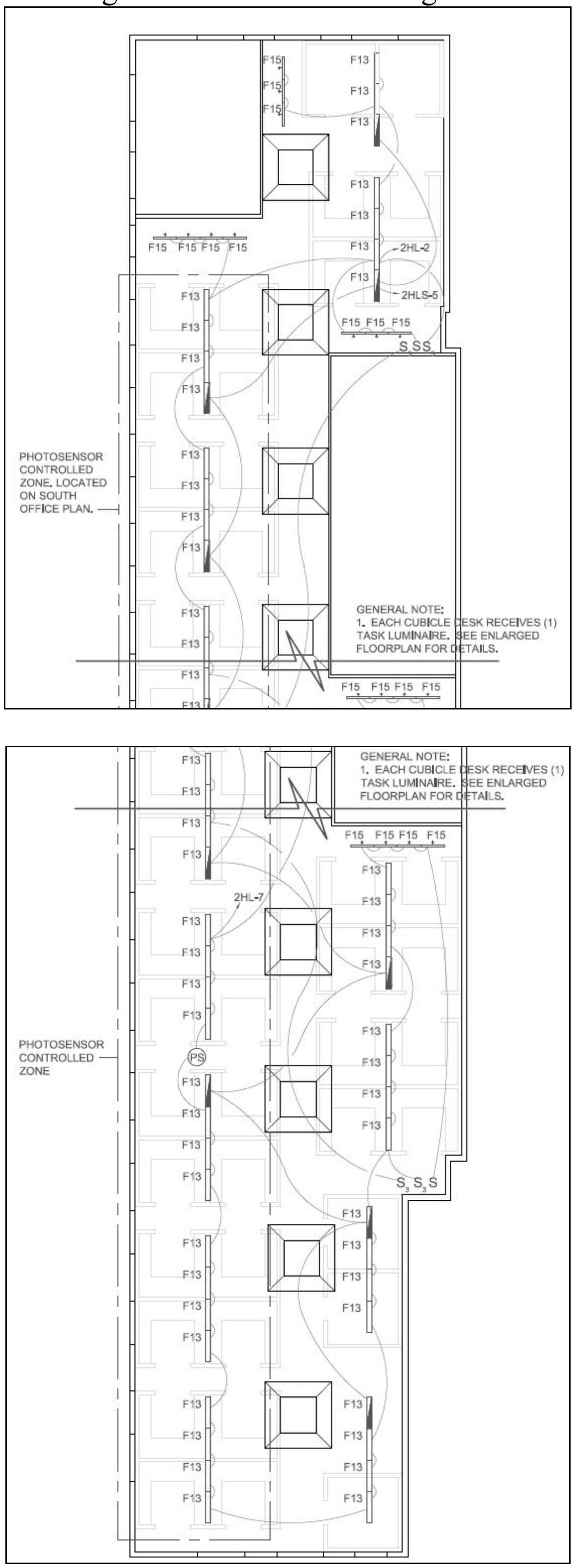
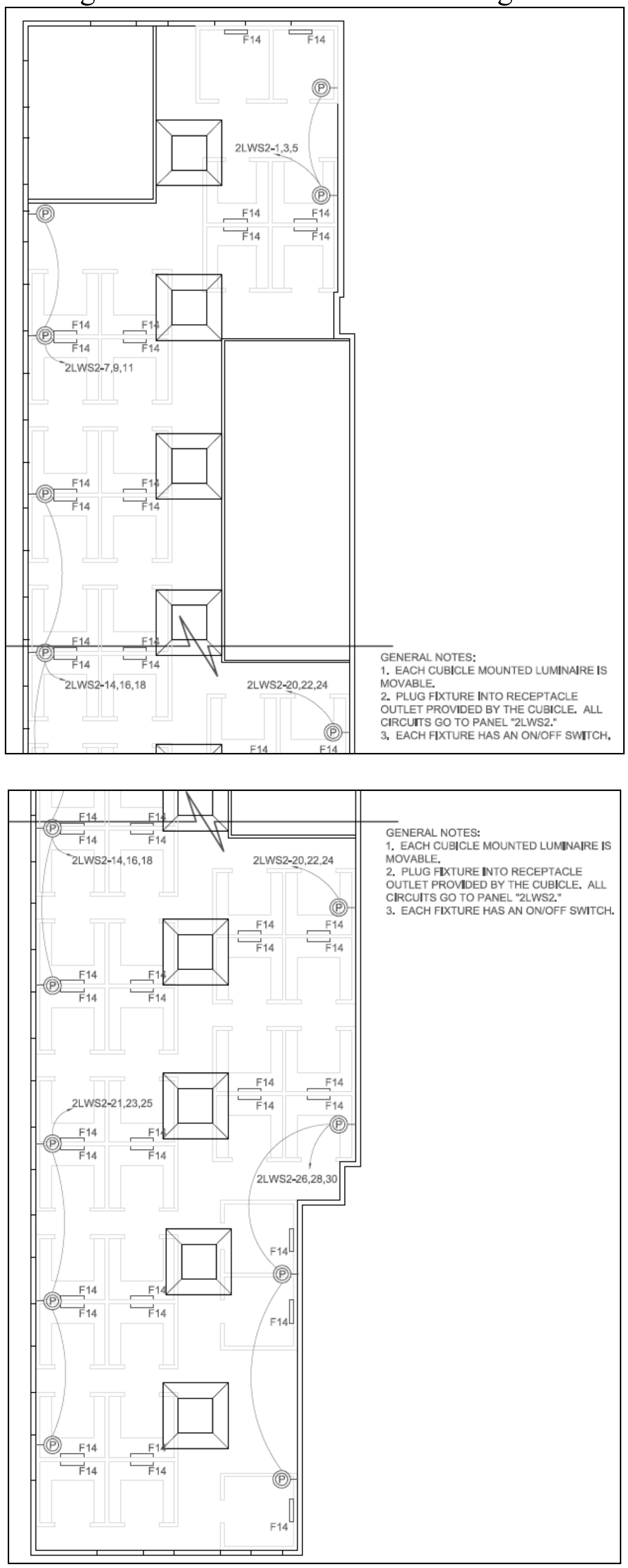


Figure 59: Office Cubicle Circuiting Plan



Original

Table 14: Panel "1HL" Old

PANEL "1HL" (AUTOMATED LIGHTING PANEL)		NEUTRAL BUS: 100%	GROUND BUS: YES	ISOLATED GROUND BUS: NO	MOUNTING: SURFACE	VOLTAGE: 480Y/277V, 3PH, 4W + GND; MAINS: 125A	MAIN CIR. BKR.: 100A/3P; AIC RATING: 14,000
CIR. NO.	DESCRIPTION	VA LOAD	BREAKER amps / poles	BREAKER amps / poles	VA LOAD	DESCRIPTION	CIR. NO.
1	LIGHTS - 156, 139, 154, 127, 118, 106, 125, 126	3,240	20/1	20/1	1,560	LIGHTS - 120, 121, 222, 123	2
3	LIGHTS - 165 (WEST)	1,500	20/1	20/1	3,060	LIGHTS - 110, 111, 113, 112, 114, 117,118	4
5	LIGHTS - 165 (CENTER)	1,440	20/1	20/1	1,620	LIGHTS - PERIMETER 112, WITH PHOTOCELL	6
7	LIGHTS - 165 (EAST)	1,500	20/1	20/1	2,980	LIGHTS - 129 (SOUTH), 130, 131, 132, 133	8
9	LIGHTS - 140, 141, 144, 146	3,080	20/1	20/1	3,000	LIGHTS - 129 (NORTH), 134, 135, 136, 137	10
11	EXTERIOR LIGHTS (NORTH & WEST)	2,250	20/1	20/1	2,700	LIGHTS - 103, 103A, 104, 105, 107, 108, 109	12
13	EXTERIOR LIGHTS (SOUTH & EAST)	2,250	20/1	20/1	2,730	LIGHTS - 102, 149, 150, 100	14
15	AUDITORIUM DIMMING PANEL	5,000	60/3	20/1	350	LIGHTS - 163	16
17	-	5,000	-	20/1	1,800	LIGHTS - LOBBY SCONCE	18
19	-	5,000	-	20/1	256	LIGHTS - 100A, 100B, 101	20
21	LIGHTS - MAIN ENTRY BOLLARDS, FLAG POLE	500	20/1	20/1	481	LIGHTS - FLAG POLE, BLDG. SIGN, OVER HANG	22
23	SPARE	-	20/1	20/1	3,120	LIGHTS - PARKING LOT (WEST)	24
25	SPARE	-	20/1	20/1	1,695	LIGHTS - SIDEWALK, ROADWAY (NORTH)	26
27	SPARE	-	20/1	20/1	2,550	LIGHTS - PARK.,SIDEWALK (NORTH & WEST)	28
29	SPARE	-	20/1	20/1	-	SPARE	30
31	SPARE	-	20/1	20/1	-	SPARE	32
33	SPACE	-	-	20/1	-	SPARE	34
35	SPACE	-	-	20/1	-	SPARE	36
37	SPACE	-	-	40/3	-	SCADA UNIT	38
39	SPACE	-	-	-	-	-	40
41	SPACE	-	-	-	-	-	42
	SUB TOTAL	30,760			27,902	SUB TOTAL	
LEGEND: ** 6mA GROUND FAULT CIRCUIT BREAKER; * 30mA GROUND FAULT CIRCUIT BREAKER; • LOCK-ON CIRCUIT BREAKER HANDLE			CONNECTED LOAD: 58.7 KVA; 70.6 3 PH. AMPS		REMARKS:		

Redone

Table 15: Panel "1HL" New

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W+GND	PANEL TAG: 1HL	MIN. C/B AIC: 14K
SIZE/TYPE BUS: 125A	PANEL LOCATION: Main Electrical Rm 141	OPTIONS: None
SIZE/TYPE MAIN: 100A/3P C/B	PANEL MOUNTING: SURFACE	None

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	156139	3522	20A/1P	1	*			2	20A/1P	1696	120121	Lighting
Lighting	165west	1630	20A/1P	3		*		4	20A/1P	3326	110111	Lighting
Lighting	165center	1565	20A/1P	5			*	6	20A/1P	1761	112	Lighting
Lighting	165east	1630	20A/1P	7	*			8	20A/1P	3239	129	Lighting
Lighting	140141	3348	20A/1P	9		*		10	20A/1P	3261	129	Lighting
Lighting	Ext. North	2446	20A/1P	11			*	12	20A/1P	2935	103	Lighting
Lighting	Ext. South	2446	20A/1P	13	*			14	20A/1P	2967	102	Lighting
Theater DIM Pnl	Theater	2118	20A/1P	15		*		16	20A/1P	511	163	Lighting
Theater DIM Pnl	Theater	2118	20A/1P	17			*	18	20A/1P	259	Lobby	Lighting
Theater DIM Pnl	Theater	2118	20A/1P	19	*			20	20A/1P	200	Lobby	Lighting
Lighting	Outdoor	519	20A/1P	21		*		22	20A/1P	0	-	Spare
Spare	-	0	20A/1P	23			*	24	20A/1P	3391	Parking	Lighting
Spare	-	0	20A/1P	25	*			26	20A/1P	1842	Roadway	Lighting
Spare	-	0	20A/1P	27		*		28	20A/1P	2772	Parking	Lighting
Spare	-	0	20A/1P	29			*	30	20A/1P	0	-	Spare
Spare	-	0	20A/1P	31	*			32	20A/1P	0	-	Spare
Spare	-	0	20A/1P	33		*		34	20A/1P	0	-	Spare
Spare	-	0	20A/1P	35			*	36	20A/1P	0	-	Spare
Spare	-	0	20A/1P	37	*			38	40A/3P	0	-	Scada Unit
Spare	-	0	20A/1P	39		*		40		0	-	Scada Unit
Spare	-	0	20A/1P	41			*	42		0	-	Scada Unit

CONNECTED LOAD (KW) - A	19.66	TOTAL DESIGN LOAD (KW)	43.36
CONNECTED LOAD (KW) - B	17.48	POWER FACTOR	0.92
CONNECTED LOAD (KW) - C	14.47	TOTAL DESIGN LOAD (AMPS)	56

Original

Table 16: Panel "1HLS" Old

PANEL "1HLS"				NEUTRAL BUS: 100%		VOLTAGE: 480Y/277V, 3PH, 4W + GND	
				GROUND BUS: YES		MAINS: 125A	
				ISOLATED GROUND BUS: NO		MAIN CIR. BKR.: 30A/3P	
				MOUNTING: SURFACE		AIC RATING: 14,000	
CIR. NO.	DESCRIPTION	VA LOAD	BREAKER amps / poles	BREAKER amps / poles	VA LOAD	DESCRIPTION	CIR. NO.
1	EMG LIGHTS - 140 THRU 146	3,000	20/1	20/1	520	EMG LIGHTS - 110 THRU 117	2
3	EMG LIGHTS - C102, C103, C106, 108, C139	2,050	20/1	20/1	130	EMG LIGHTS - 120 THRU 124	4
5	EMG LIGHTS - 118, 126, 127, C138	710	20/1	20/1	440	EMG LIGHTS - OPS	6
7	EMG LIGHTS - AUDITORIUM	680	20/1	20/1	64	EMG LIGHTS - ELEVATOR MACHINE ROOM	8
9	EMG LIGHTS - LOBYY 100, CORR 101	1,058	20/1	20/1	-	SPARE	10
11	SPARE	-	20/1	20/1	-	SPARE	12
13	SPARE	-	20/1	20/1	-	SPARE	14
15	SPARE	-	20/1	20/1	-	SPARE	16
17	SPARE	-	20/1	20/1	-	SPARE	18
19	SPARE	-	20/1	20/1	-	SPARE	20
21	SPARE	-	20/1	20/1	-	SPARE	22
23	SPARE	-	20/1	20/1	-	SPARE	24
25	SPARE	-	20/1	20/1	-	SPARE	26
27	SPARE	-	20/1	20/1	-	SPARE	28
29	SPARE	-	20/1	20/1	-	SPARE	30
31	SPACE	-	-	-	-	SPACE	32
33	SPACE	-	-	-	-	SPACE	34
35	SPACE	-	-	-	-	SPACE	36
37	SPACE	-	-	40/3	-	TVSS UNIT	38
39	SPACE	-	-	-	-	-	40
41	SPACE	-	-	-	-	-	42
	SUB TOTAL	7,498			1,154	SUB TOTAL	
LEGEND: ** 6mA GROUND FAULT CIRCUIT BREAKER			CONNECTED LOAD		REMARKS:		
* 30mA GROUND FAULT CIRCUIT BREAKER			8.7 KVA				
• LOCK-ON CIRCUIT BREAKER HANDLE			10.4 3 PH. AMPS				

Redone

Table 17: Panel "1HLS" New

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W+GND	PANEL TAG: 1HLS	MIN. C/B AIC: 14K
SIZE/TYPE BUS: 125A	PANEL LOCATION: Main Electrical Rm 141	OPTIONS: None
SIZE/TYPE MAIN: 30A/3P C/B	PANEL MOUNTING: SURFACE	None

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Emg Lighting	140-146	3261	20A/1P	1	*			2	20A/1P	565	110-117	Emg Lighting
Emg Lighting	C102,C103	2228	20A/1P	3		*		4	20A/1P	141	120-124	Emg Lighting
Emg Lighting	118126	772	20A/1P	5			*	6	20A/1P	478	OPS	Emg Lighting
Emg Lighting	Theater	739	20A/1P	7	*			8	20A/1P	70	Elev. Mach	Emg Lighting
Emg Lighting	Lobby	251	20A/1P	9		*		10	20A/1P	0	-	Spare
Spare	-	0	20A/1P	11			*	12	20A/1P	0	-	Spare
Spare	-	0	20A/1P	13	*			14	20A/1P	0	-	Spare
Spare	-	0	20A/1P	15		*		16	20A/1P	0	-	Spare
Spare	-	0	20A/1P	17			*	18	20A/1P	0	-	Spare
Spare	-	0	20A/1P	19	*			20	20A/1P	0	-	Spare
Spare	-	0	20A/1P	21		*		22	20A/1P	0	-	Spare
Spare	-	0	20A/1P	23			*	24	20A/1P	0	-	Spare
Spare	-	0	20A/1P	25	*			26	20A/1P	0	-	Spare
Spare	-	0	20A/1P	27		*		28	20A/1P	0	-	Spare
Spare	-	0	20A/1P	29			*	30	20A/1P	0	-	Spare
Spare	-	0	20A/1P	31	*			32	20A/1P	0	-	Spare
Spare	-	0	20A/1P	33		*		34	20A/1P	0	-	Spare
Spare	-	0	20A/1P	35			*	36	20A/1P	0	-	Spare
Spare	-	0	20A/1P	37	*			38	30A/3P	0	-	TVSS Unit
Spare	-	0	20A/1P	39		*		40		0	-	TVSS Unit
Spare	-	0	20A/1P	41			*	42		0	-	TVSS Unit

CONNECTED LOAD (KW) - A	4.63	TOTAL DESIGN LOAD (KW)	10.21
CONNECTED LOAD (KW) - B	2.62	POWER FACTOR	0.92
CONNECTED LOAD (KW) - C	1.25	TOTAL DESIGN LOAD (AMPS)	13

Original

Table 18: Panel "DIM" Old

AUDITORIUM SUMMARY LOAD SCHEDULE					
LUTRON ZONE	DIM ZONE	ZONE / CIRCUIT DESCRITION	VOLTAGE	LOAD TYPE	ACTUAL LOAD(VA)
A1-1	1	BACK 2 x 2's	277V	FL - HILUME / ECO 10	2720
A1-2	2	MID 2 x 2's	277V	FL - HILUME / ECO 10	640
A1-3	3	FRONT 2 x 2's	277V	FL - HILUME / ECO 10	960
A1-4	4	SPEAKER ACCENTS	277V	MAGNETIC LV	480
A1-5	5	RAMP DNLT WW	277V	FL - NON-DIM	340
A1-6	6	RAMP STEP	277V	FL - NON-DIM	188
A1-7	7	BULL NOSE STEP	277V	MAGNETIC LV	900

Redone

Table 19: Panel "DIM" New

Training Theater Summary Load Schedule					
Lutron Zone	DIM Zone	Zone/Circuit Description	Voltage	Load Type	Wattage
DIM 1	1	Back Downlights	277	Mark 7 0-10V	563
DIM 2	2	Ramp Downlights	277	Mark 7 0-10V	188
DIM 3	3	Left Front Downlights	277	Mark 7 0-10V	288
DIM 4	4	Right Front Downlights	277	Mark 7 0-10V	288
DIM 5	5	Middle Front Downlights	277	Mark 7 0-10V	600
DIM 6	6	Cove Lighting	277	Mark 7 0-10V	2871
DIM 7	7	Steplights	277	Magnetic LV	31.6

Original

Table 20: Panel "2HL" Old

PANEL "2HL" (AUTOMATED LIGHTING PANEL)							
	NEUTRAL BUS: 100%			VOLTAGE: 480Y/277V, 3PH, 4W + GND			
	GROUND BUS: YES			MAINS: 125A			
	ISOLATED GROUND BUS: NO			MAIN CIR. BKR.: 100A/3P			
	MOUNTING: SURFACE			AIC RATING: 14,000			
CIR. NO.	DESCRIPTION	VA LOAD	BREAKER amps / poles	BREAKER amps / poles	VA LOAD	DESCRIPTION	CIR. NO.
1	LIGHTS - 202, 204, 250, 254	3,324	20/1	20/1	2,200	LIGHTS - 236 (PERIMETER), 240, 241	2
3	LIGHTS - 232, 242	1,446	20/1	20/1	2,500	LIGHTS - 236, 237, 238, 239	4
5	LIGHTS - 274, 275, 270, 271, 268, 269	2,711	20/1	20/1	2,310	LIGHTS - 253, 249, 248	6
7	LIGHTS - 235, 234	2,326	20/1	20/1	815	LIGHTS - 244	8
9	LIGHTS - 208, 209, 210, 211, 212, 213	2,683	20/1	20/1	3,058	LIGHTS - 214, 220, 222, 224, 226, 228	10
11	LIGHTS - 203, 206, 207	1,460	20/1	20/1	2,079	LTS-215-17, 219, 221, 223, 225, 227, 229-31	12
13	LIGHTS - 256, 257, 258, 259, 260, 261	2,336	20/1	20/1	2,100	LIGHTS - BRIDGE 200, SCONCES	14
15	LIGHTS - 255, 263, 264, 266, 267	3,114	20/1	20/1	256	LIGHTS - BRIDGE 201, LOBBY	16
17	SPARE	-	20/1	20/1	-	SPARE	18
19	SPARE	-	20/1	20/1	-	SPARE	20
21	SPARE	-	20/1	20/1	-	SPARE	22
23	SPARE	-	20/1	20/1	-	SPARE	24
25	SPARE	-	20/1	20/1	-	SPARE	26
27	SPARE	-	20/1	20/1	-	SPARE	28
29	SPARE	-	20/1	20/1	-	SPARE	30
31	SPACE	-	-	-	-	SPACE	32
33	SPACE	-	-	-	-	SPACE	34
35	SPACE	-	-	-	-	SPACE	36
37	SPACE	-	-	40/3	-	SCADA UNIT	38
39	SPACE	-	-	-	-	-	40
41	SPACE	-	-	-	-	-	42
	SUB TOTAL	19,400			15,318	SUB TOTAL	
	LEGEND: ** 6mA GROUND FAULT CIRCUIT BREAKER; * 30mA GROUND FAULT CIRCUIT BREAKER; • LOCK-ON CIRCUIT BREAKER HANDLE		CONNECTED LOAD: 34.7 KVA; 41.8 3 PH. AMPS		REMARKS:		

Redone

Table 21: Panel "2HL" New

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W+GND	PANEL TAG: 2HL	MIN. C/B AIC: 14K
SIZE/TYPE BUS: 125A	PANEL LOCATION: Electrical Rm 247	OPTIONS: None
SIZE/TYPE MAIN: 100A/3P C/B	PANEL MOUNTING: SURFACE	None

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	202+	3613	20A/1P	1	*			2	20A/1P	1170	234	Lighting
Lighting	232242	1572	20A/1P	3		*		4	20A/1P	2717	236+	Lighting
Lighting	274+	2947	20A/1P	5			*	6	20A/1P	2511	253+	Lighting
Lighting	234	1911	20A/1P	7	*			8	20A/1P	886	244	Lighting
Lighting	208+	2916	20A/1P	9		*		10	20A/1P	3324	214+	Lighting
Lighting	203+	1587	20A/1P	11			*	12	20A/1P	2260	215+	Lighting
Lighting	256+	2539	20A/1P	13	*			14	20A/1P	988	Bridge Lobby	Lighting
Lighting	255+	3385	20A/1P	15		*		16	20A/1P	0	-	Spare
Spare	-	0	20A/1P	17			*	18	20A/1P	0	-	Spare
Spare	-	0	20A/1P	19	*			20	20A/1P	0	-	Spare
Spare	-	0	20A/1P	21		*		22	20A/1P	0	-	Spare
Spare	-	0	20A/1P	23			*	24	20A/1P	0	-	Spare
Spare	-	0	20A/1P	25	*			26	20A/1P	0	-	Spare
Spare	-	0	20A/1P	27		*		28	20A/1P	0	-	Spare
Spare	-	0	20A/1P	29			*	30	20A/1P	0	-	Spare
Spare	-	0	20A/1P	31	*			32	20A/1P	0	-	Spare
Spare	-	0	20A/1P	33		*		34	20A/1P	0	-	Spare
Spare	-	0	20A/1P	35			*	36	20A/1P	0	-	Spare
Spare	-	0	20A/1P	37	*			38	40A/3P	0	-	Scada Unit
Spare	-	0	20A/1P	39		*		40		0	-	Scada Unit
Spare	-	0	20A/1P	41			*	42		0	-	Scada Unit

CONNECTED LOAD (KW) - A	11.11	TOTAL DESIGN LOAD (KW)	28.83
CONNECTED LOAD (KW) - B	13.91	POWER FACTOR	0.93
CONNECTED LOAD (KW) - C	9.30	TOTAL DESIGN LOAD (AMPS)	37

Original

Table 22: Panel “2HLS” Old

PANEL "2HLS"

NEUTRAL BUS: 100% VOLTAGE: 480Y/277V, 3PH, 4W + 2GND
GROUND BUS: YES MAINS: 125A
ISOLATED GROUND BUS: NO MAIN CIR. BKR.: 30A/3P
MOUNTING: SURFACE AIC RATING: 14,000

CIR. NO.	DESCRIPTION	VA LOAD	BREAKER amps / poles	BREAKER amps / poles	VA LOAD	DESCRIPTION	CIR. NO.
1	EMG LTS-202,204,206,207,242,243,232,234	2,170	20/1	20/1	295	EMG LTS-270, 271, 272A, 268, 273, 274, 275	2
3	EMG LIGHTS - 244, 245, 246, 247, 248, 249	2,160	20/1	20/1	515	EMG LIGHTS - 255, 258, 263	4
5	EMG LIGHTS - 236	425	20/1	20/1	360	EMG LIGHTS - 214, 220	6
7	EMG LIGHTS - BRIDGE 200	406	20/1	20/1	205	EMG LIGHTS - 208	8
9	SPARE	-	20/1	20/1	-	SPARE	10
11	SPARE	-	20/1	20/1	-	SPARE	12
13	SPARE	-	20/1	20/1	-	SPARE	14
15	SPARE	-	20/1	20/1	-	SPARE	16
17	SPARE	-	20/1	20/1	-	SPARE	18
19	SPARE	-	20/1	20/1	-	SPARE	20
21	SPARE	-	20/1	20/1	-	SPARE	22
23	SPARE	-	20/1	20/1	-	SPARE	24
25	SPARE	-	20/1	20/1	-	SPARE	26
27	SPARE	-	20/1	20/1	-	SPARE	28
29	SPARE	-	20/1	20/1	-	SPARE	30
31	SPACE	-	-	-	-	SPACE	32
33	SPACE	-	-	-	-	SPACE	34
35	SPACE	-	-	-	-	SPACE	36
37	SPACE	-	-	40/3	-	TVSS UNIT	38
39	SPACE	-	-	-	-	-	40
41	SPACE	-	-	-	-	-	42
	SUB TOTAL	5,161			1,375	SUB TOTAL	

LEGEND: ** 6mA GROUND FAULT CIRCUIT BREAKER
* 30mA GROUND FAULT CIRCUIT BREAKER
■ LOCK-ON CIRCUIT BREAKER HANDLE

CONNECTED LOAD	
6.5	KVA
7.9	3 PH. AMPS

REMARKS:

Redone

Table 23: Panel “2HL” New

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W+2GND
SIZE/TYPE BUS: 125A
SIZE/TYPE MAIN: 30A/3P C/B

PANEL TAG: 2HLS
PANEL LOCATION: Electrical Rm 247
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 14K
OPTIONS: None
None

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Emg Lighting	202+	2284	20A/1P	1	*			2	20A/1P	311	270+	Emg Lighting
Emg Lighting	244+	2274	20A/1P	3		*		4	20A/1P	542	255+	Emg Lighting
Emg Lighting	236	593	20A/1P	5			*	6	20A/1P	379	214220	Emg Lighting
Emg Lighting	Bridge Lobby	204	20A/1P	7	*			8	20A/1P	209	208	Emg Lighting
Spare	-	0	20A/1P	9		*		10	20A/1P	0	-	Spare
Spare	-	0	20A/1P	11			*	12	20A/1P	0	-	Spare
Spare	-	0	20A/1P	13	*			14	20A/1P	0	-	Spare
Spare	-	0	20A/1P	15		*		16	20A/1P	0	-	Spare
Spare	-	0	20A/1P	17			*	18	20A/1P	0	-	Spare
Spare	-	0	20A/1P	19	*			20	20A/1P	0	-	Spare
Spare	-	0	20A/1P	21		*		22	20A/1P	0	-	Spare
Spare	-	0	20A/1P	23			*	24	20A/1P	0	-	Spare
Spare	-	0	20A/1P	25	*			26	20A/1P	0	-	Spare
Spare	-	0	20A/1P	27		*		28	20A/1P	0	-	Spare
Spare	-	0	20A/1P	29			*	30	20A/1P	0	-	Spare
Spare	-	0	20A/1P	31	*			32	20A/1P	0	-	Spare
Spare	-	0	20A/1P	33		*		34	20A/1P	0	-	Spare
Spare	-	0	20A/1P	35			*	36	20A/1P	0	-	Spare
Spare	-	0	20A/1P	37	*			38	40A/3P	0	-	TVSS Unit
Spare	-	0	20A/1P	39		*		40		0	-	TVSS Unit
Spare	-	0	20A/1P	41			*	42		0	-	TVSS Unit

CONNECTED LOAD (KW) - A	3.01	TOTAL DESIGN LOAD (KW)	8.15
CONNECTED LOAD (KW) - B	2.82	POWER FACTOR	0.95
CONNECTED LOAD (KW) - C	0.97	TOTAL DESIGN LOAD (AMPS)	10

Original

Table 24: Panel "2LWS2" Old

PANEL "2LWS2"

NEUTRAL BUS: 200% | VOLTAGE: 208Y/120V, 3PH, 5W + 2GND
GROUND BUS: YES | MAINS: 225A
ISOLATED GROUND BUS: YES | MAIN CIR. BKR.: 150A/3P
MOUNTING: FLUSH | AIC RATING: 10,000

CIR. NO.	DESCRIPTION	VA LOAD	BREAKER amps / poles	BREAKER amps / poles	VA LOAD	DESCRIPTION	CIR. NO.
1	SYSTEM FURN., OPEN OFFICE N5 RM 23603	720	20/1	20/1	1,080	OFFICE RECEPTACLES, RM 24001, 24101	2
3	SYSTEM FURN., OPEN OFFICE N5 RM 23603	720	20/1	20/1	1,080	CONFERENCE RM RECEPTS, RM 239A1	4
5	SYSTEM FURN., OPEN OFFICE N5 RM 23603	720	20/1	20/1	1,080	OFFICE RECEPTS, RM 24001, 23603, 238A1	6
7	SYSTEM FURN., OPEN OFFICE N5 RM 23603	720	20/1	20/1	300	CONFERENCE RM CATV RECEPT., RM 239A1	8
9	SYSTEM FURN., OPEN OFFICE N5 RM 23603	720	20/1	20/1	240	CONFERENCE RM RECEPT., RM 239A1	10
11	SYSTEM FURN., OPEN OFFICE N5 RM 23603	360	20/1	20/1	240	CONFERENCE RM RECEPT., RM 239A1	12
13	COPIER, RM 23704	1,200	20/1	20/1	1,440	SYSTEM FURN., OPEN OFFICE N5 RM 23603	14
15	PRINTER, RM 23704	940	20/1	20/1	1,440	SYSTEM FURN., OPEN OFFICE N5 RM 23603	16
17	FAX MACHINE, RM 23704	940	20/1	20/1	1,440	SYSTEM FURN., OPEN OFFICE N5 RM 23603	18
19	RECEPTS, OPEN OFFICE N5 RM 23603, 23704	1,260	20/1	20/1	720	SYSTEM FURN., OPEN OFFICE N5 RM 23603	20
21	SYSTEM FURN., OPEN OFFICE N5 RM 23603	1,440	20/1	20/1	720	SYSTEM FURN., OPEN OFFICE N5 RM 23603	22
23	SYSTEM FURN., OPEN OFFICE N5 RM 23603	1,440	20/1	20/1	-	SYS. FURN., OPEN OFF. N5 RM 23603(SPARE)	24
25	SYSTEM FURN., OPEN OFFICE N5 RM 23603	1,440	20/1	20/1	1,440	SYSTEM FURN., OPEN OFFICE N5 RM 23603	26
27	SPARE	-	20/1	20/1	1,080	SYSTEM FURN., OPEN OFFICE N5 RM 23603	28
29	SPARE	-	20/1	20/1	720	SYSTEM FURN., OPEN OFFICE N5 RM 23603	30
31	SPARE	-	20/1	20/1	100	SOUND GENERATOR 237	32
33	SPARE	-	20/1	20/1	-	SPARE	34
35	SPARE	-	20/1	20/1	-	SPARE	36
37	SPARE	-	20/1	40/3		TVSS UNIT	38
39	SPARE	-	20/1	-		-	40
41	SPARE	-	20/1	-		-	42
	SUB TOTAL	12,620			13,120	SUB TOTAL	

LEGEND: ** 6mA GROUND FAULT CIRCUIT BREAKER
* 30mA GROUND FAULT CIRCUIT BREAKER
• LOCK-ON CIRCUIT BREAKER HANDLE

CONNECTED LOAD	
25.74	KVA
71.50	3 PH. AMPS

REMARKS: FEED-THRU LUGS

Redone

Table 25: Panel "2LWS2" New

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,5W+2GND
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 150A/3P C/B

PANEL TAG: 2LWS2
PANEL LOCATION: Open Office 236
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: None
None

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Systems Furniture	Open Office	858	20A/1P	1	*			2	20A/1P	1200	Open Office	Systems Furniture
Systems Furniture	Open Office	858	20A/1P	3		*		4	20A/1P	1200	Open Office	Systems Furniture
Systems Furniture	Open Office	858	20A/1P	5			*	6	20A/1P	1200	Open Office	Systems Furniture
Systems Furniture	Open Office	858	20A/1P	7	*			8	20A/1P	333	Open Office	Systems Furniture
Systems Furniture	Open Office	858	20A/1P	9		*		10	20A/1P	267	Open Office	Systems Furniture
Systems Furniture	Open Office	487	20A/1P	11			*	12	20A/1P	267	Open Office	Systems Furniture
Systems Furniture	Open Office	1333	20A/1P	13	*			14	20A/1P	1658	Open Office	Systems Furniture
Systems Furniture	Open Office	1044	20A/1P	15		*		16	20A/1P	1687	Open Office	Systems Furniture
Systems Furniture	Open Office	1044	20A/1P	17			*	18	20A/1P	1687	Open Office	Systems Furniture
Systems Furniture	Open Office	1400	20A/1P	19	*			20	20A/1P	916	Open Office	Systems Furniture
Systems Furniture	Open Office	1716	20A/1P	21		*		22	20A/1P	916	Open Office	Systems Furniture
Systems Furniture	Open Office	1716	20A/1P	23			*	24	20A/1P	0	Open Office	Spare
Systems Furniture	Open Office	1716	20A/1P	25	*			26	20A/1P	1600	Open Office	Systems Furniture
Systems Furniture	-	0	20A/1P	27		*		28	20A/1P	1316	Open Office	Systems Furniture
Systems Furniture	-	0	20A/1P	29			*	30	20A/1P	916	Open Office	Systems Furniture
Spare	-	0	20A/1P	31	*			32	20A/1P	111	237	Sound Generator
Spare	-	0	20A/1P	33		*		34	20A/1P	0	-	Spare
Spare	-	0	20A/1P	35			*	36	20A/1P	0	-	Spare
Spare	-	0	20A/1P	37	*			38	40A/3P	0	-	TVSS Unit
Spare	-	0	20A/1P	39		*		40		0	-	TVSS Unit
Spare	-	0	20A/1P	41			*	42		0	-	TVSS Unit

CONNECTED LOAD (KW) - A	11.98	TOTAL DESIGN LOAD (KW)	25.21
CONNECTED LOAD (KW) - B	9.86	POWER FACTOR	0.90
CONNECTED LOAD (KW) - C	8.17	TOTAL DESIGN LOAD (AMPS)	78

Feeder and Overcurrent Protection

The panelboard layouts were all standardized for the type of load that was placed on them. All the lighting loads were circuited by the two lighting panels or the two emergency lighting panels. Each receptacle panelboard was sized the same regardless if the panel was oversized for its load. Because of this I did the feeder sizing and overcurrent protection but left the panels the same as the existing because the loads hardly changed with my additions and I wanted to keep them uniform with the rest of the building. There were no loads that I added to any panel that required me to size up the feeder or circuit breaker.

Figure 60: Single Line Diagram of Redone Panels

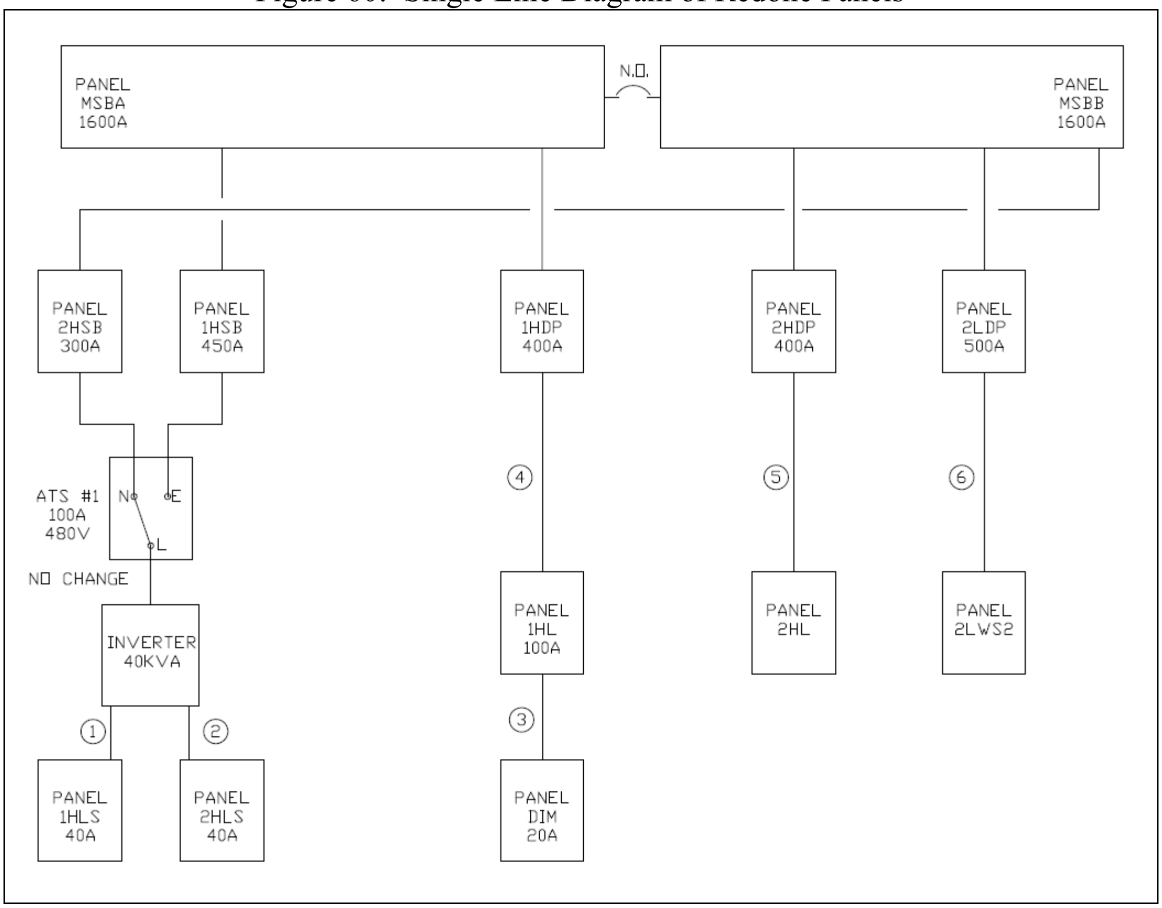


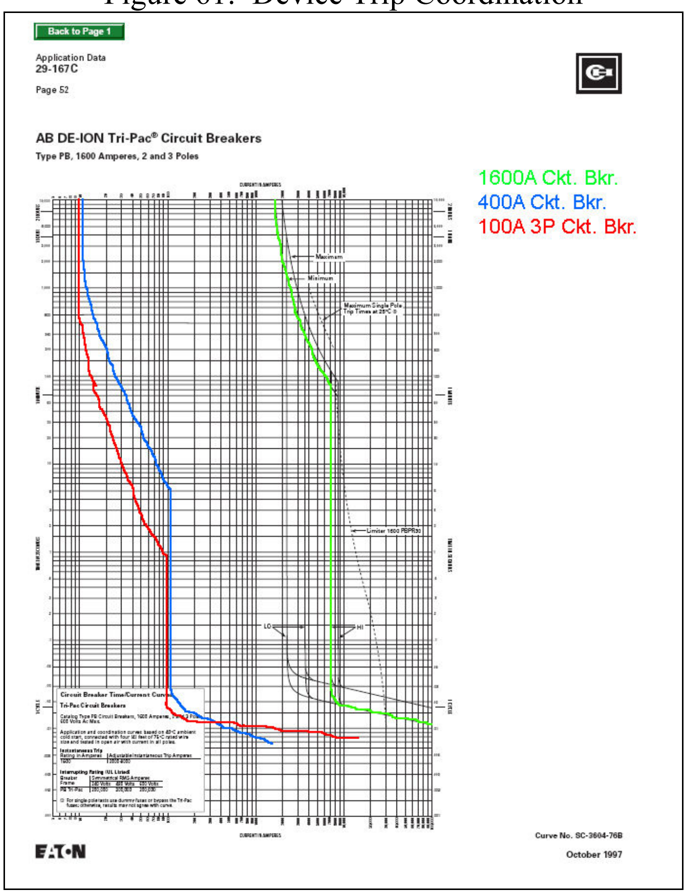
Table 26: Feeder Schedule

FEEDER SCHEDULE																	
			NO. OF	CONDUIT (PER SET)		CONDUCTORS (PER SET)									SIZE OF	FRAME OR
						PHASE CONDUCTORS			NEUTRAL CONDUCTORS			GROUND CONDUCTORS			OVERCURRENT	SWITCH
TAG	FROM	TO	SETS	SIZE	TYPE	No.	SIZE	TYPE	No.	SIZE	TYPE	No.	SIZE	TYPE	PROTECTION	SIZE
1	1HLS	ATS-1	1	3/4"	EMT	3	8AWG	CU THWN	1	8AWG	CU THWN	1	10AWG	CU THWN	30	40A/3P
2	2HLS	ATS-1	1	3/4"	EMT	3	8AWG	CU THWN	1	8AWG	CU THWN	1	10AWG	CU THWN	30	40A/3P
3	DIM	1HLS	1	1/2"	EMT	3	12AWG	CU THWN	1	12AWG	CU THWN				20	20A/3P
4	1HLS	1HDP	1	1 3/4"	EMT	3	3AWG	CU THWN	1	3AWG	CU THWN	1	8AWG	CU THWN	100	125A/3P
5	2HL	2HDP	1	1 3/4"	EMT	3	3AWG	CU THWN	1	3AWG	CU THWN	1	8AWG	CU THWN	100	125A/3P
6	2LWS2	2LDP	1	2"	EMT	3	1/0AWG	CU THWN	1	1/0AWG	CU THWN	2	6AWG	CU THWN	150	225A/3P

Full Feeder table and trip devices are in Appendix B. Below are the electrical device coordination trip breakers for a 100A, 400A, and 1600A panelboard. These devices are coordinated properly.

I could not do the short circuit calculation because the available incoming short-circuit rating was not given to me. My building is powered from existing switchgear which is rated at 30,000AIC. The main double-ended switchboard is rated at 30,000AIC.

Figure 61: Device Trip Coordination



Rotary UPS-vs.-Static UPS

Background

Currently the UPS system services critical loads in both facilities and has two 625kVA modules to provide N+1 reliability. Each system has a 30-minute battery plant to provide the necessary power to service the present critical loads and 25% spare capacity for future expansion. The UPS system is set up so if one system goes down, critical loads can be transferred to the other UPS module by closing the static transfer switch located between the UPS switchboards and UPS distribution panels. These transfer switches allow power to be delivered to either UPS distribution panel which in turn delivers power to the end panels and loads. Once the two 1000KW generators start, they will power the loads until the main electrical system is up and running again. The main advantage of the Static system is that the 30 minutes of available power allow for all systems to properly shut down if the generators fail to start.

Analysis

The current design of the uninterruptible power system is first cost efficient, but appears to require a lot of space inside the building due to the need for a battery room and the Static UPS system. The battery room takes up an area of roughly 1300 square feet while the Static UPS equipment requires an area of 180 square feet.

Replacing the Static UPS system with a Rotary UPS system will create more space in the building by removing the batteries and additional HVAC equipment required for them. The rotary system does not need to be conditioned and works in temperatures up to 104 degrees. Batteries have specific operating temperatures and degrade faster when not properly conditioned. Removing the batteries also takes away the environmental and safety issues that need to be accounted for in battery installations. The Rotary UPS system generally has a higher first cost, but can be better in the long run with longer life and simpler maintenance. The space for the system requires the same footprint as the Static UPS system without the battery bank room, so about 1300 square feet of space will be freed up in this building. The cost of the building was $17,000,000 and the square footage was 75,000s.f. That ends up being 17,000,000 / 75000 = $227/s.f. So putting in the rotary system would save 1300s.f.* $227/s.f. = $295,100 of the building cost. Figure 2.8 and Figure 2.9 show the comparison between both system layouts in the electrical room.

Figure 62: Static UPS Electrical Room Layout

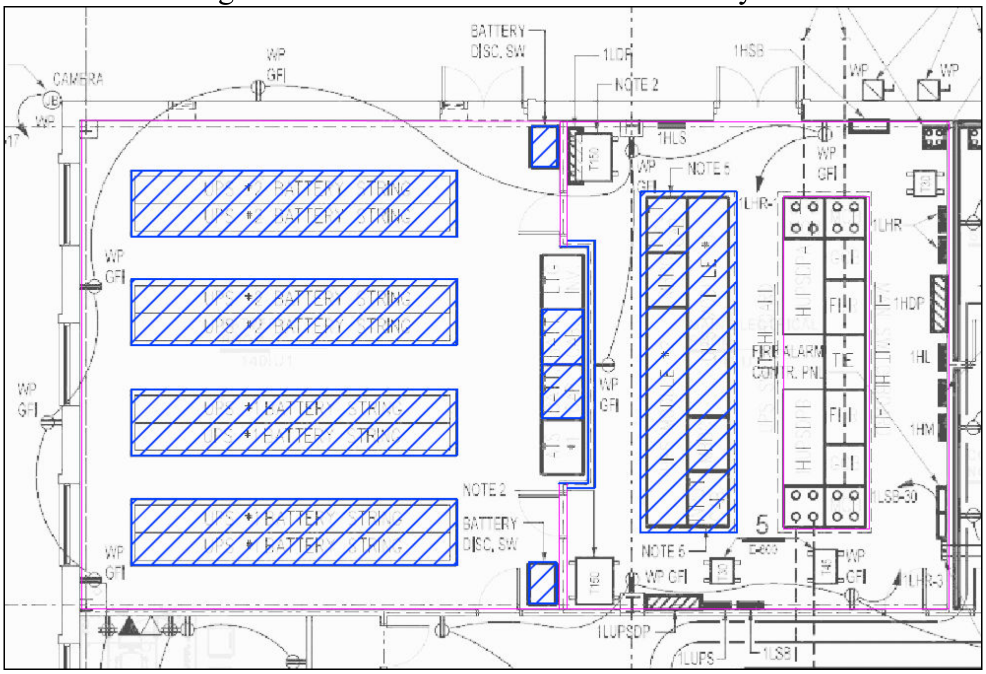
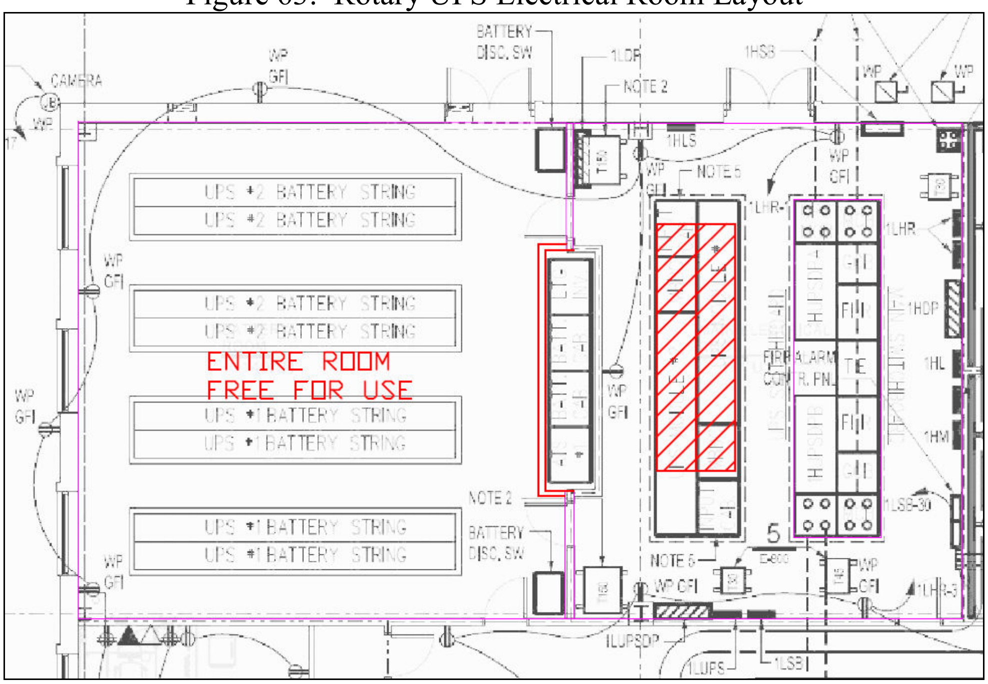
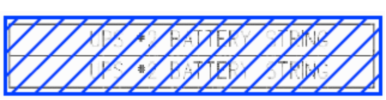
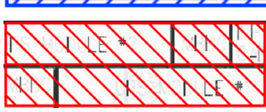


Figure 63: Rotary UPS Electrical Room Layout




Static UPS System Components


Rotary UPS System Components

The downside of using a Rotary UPS system is the fact that it only works for seconds whereas the Static UPS with battery system can last for minutes. This building is set up for 30 minutes of backup battery reliability once the system starts. The Caterpillar UPS 300 Series Multi Module System that I have chosen to use will only provide 13 seconds of power at 100% capacity. This level of time is sufficient since the majority of power disruptions last less than 5 seconds, and the standby generators are rated to start in 10 seconds or less. If the standby generators fail to start and the electrical outage lasts, then the critical equipment in the building will not shut down properly and information may be lost. This is the major concern of using rotary technology.

Rotary UPS can be coupled with battery backup but I am not using this approach in my design. The advantage of that system is to allow longer life on the batteries by letting the rotary unit handle the 5 second outages and allow the batteries to be used in the longer outages. Batteries degrade when used, so only using them for longer outages will increase their lifespan. The batteries also allow the critical system loads to shut down properly if both generators fail to come online. I am not using this system because each standby generator for my building has the capacity to power the entire UPS load on just one generator. With all of the redundancy (two utilities, two parallel switchboards, two parallel UPS systems, two parallel standby generators) in the electrical system, I am willing to live with the slim chance of both generators failing to start when a power outage occurs.

System Comparison

For my life cycle cost comparison, I will be using the Caterpillar UPS 300 600kVA and 900kVA Series Multi Module Systems against the MGE UPS EPS 8000 750kVA Static System. Sadly, the rotary system only comes in 600kVA or 900kVA while the cost information I have for the static system is for a 750kVA unit, so the comparisons will not be same size unit to same size unit. Instead of comparing the rotary system to 30 minutes of battery backup, I will be comparing them with 7 minutes of battery backup. Seven minutes of battery power would require the generator startup immediately just as the rotary system does, which would give a better overall comparison of the two systems. With the 30 minutes of battery backup the generators would not need to carry the full UPS load on startup and therefore be an unfair comparison of the systems(due to the increased cost of 30 minutes of battery backup). The cost of displaced space is only relevant to the two systems being compared, not the space required by the 30 minutes of batteries in the actual building.

Assumptions

- I am not comparing the air conditioning cost savings in this analysis because the gained area from the rotary system can be usable space which requires conditioning as well.
- Cost of space = $17,000,000 for building / 75,000 square feet of building floor area: $227/s.f.
- Life cycle duration analysis of 10 years.

- Interest rate of 6% a year for the life cycle cost analysis.
- Cost of electricity of \$0.10/kwh.
- Total load on system of 500kw. Full load efficiency on all equipment
- Energy losses = System output*(1-efficiency)/efficiency
- Energy Cost = Energy losses (kw)* 24 (hrs)* 365 (days)* \$0.10/kwh
- Present Worth = Annual cost $((1 + i)^n - 1)/ (i(1+i)^n)$
- Present Value = Cost* $((1+i)^{-n})$

Rotary UPS Cost, one system

The budgetary figure for the 600kVA system is \$230,000.00.
The budgetary figure for the 900kVA system is \$340,000.00.

- Cost includes equipment, freight to site, startup and commissioning and owner's instructions.

An estimated installation cost of 25% of the equipment cost was the number given to me, so \$57,500 for the 600kVA unit and \$85,000 for the 900kVA unit.

The only wear items in the system are two flywheel bearings which are constantly monitored by the unit over time. The monitoring equipment determines when the bearings need to be replaced, typical every 3-5 years. The replacement cost and two days of technician time are about \$6,000 for the 600kVA unit and \$9000 for the 900kVA unit.

- Assuming Present Value replacement in the 5^{th} year:
  \$6000* $((1+0.06)^{-5})$ = \$4,483.55 (600kVA unit)
  \$9000* $((1+0.06)^{-5})$ = \$6,725.32 (900kVA unit)
- Assuming Present Value replacement in the 10^{th} year:
  \$6000* $((1+0.06)^{-10})$ = \$3,350.37 (600kVA unit)
  \$9000* $((1+0.06)^{-10})$ = \$5,025.55 (900kVA unit)

Each year the oil for a vacuum pump needs to be changed in the system. The oil used is vegetable oil and can be changed by the owner or contractor will do it for \$600/year for the 600kVA unit and \$900/year for the 900kVA unit. There is no yearly maintenance contract for this system.

- Assuming Present Worth:
  \$600* $((1 + 0.06)^{10}-1)/ (0.06(1+0.06)^{10})$ = \$4,416.05 (600kVA unit)
  \$900* $((1 + 0.06)^{10}-1)/ (0.06(1+0.06)^{10})$ = \$6,624.08 (900kVA unit)

Energy Cost:
Efficiency of system is 97% at full output, with assumed load of 500kw
Energy losses = 500*(1-0.97)/0.97 = 15.46kw
Energy Cost = 15.46kw*24hrs*365days*\$0.10/kwh = \$13,542.96/yr

- Assuming Present Worth:
  \$13,542.96* $((1 + 0.06)^{10}-1)/ (0.06(1+0.06)^{10})$ = \$99,677.36

Dimensions:
The 600kVA unit is 34” deep, 170” wide, and 96” high. 40 square feet
The 900kVA unit is 34” deep, 213” wide, and 96” high. 50 square feet

Cost of Space:
600kVA unit: 40s.f.*$227/s.f. = $9,080
900kVA unit: 50s.f.*$227/s.f. = $11,350

- Assuming Present Worth:
  $\$9{,}080*((1 + 0.06)^{10}-1)/ (0.06(1+0.06)^{10}) = \$66{,}829.59$ (600kVA unit)
  $\$11{,}350*((1 + 0.06)^{10}-1)/ (0.06(1+0.06)^{10}) = \$83{,}536.99$ (900kVA unit)

Static UPS Cost, one system

The budgetary figure for the 750kVA system is $200,000.00.

- Cost includes equipment, battery cabinets, Factory startup and training, load bank testing at site, and one year warranty parts and labor.

An estimated installation cost of $60,000 for the unit and batteries.

A maintenance contract which includes 24/7 coverage, parts, labor and two preventative maintenances on the UPS and batteries has a budget cost of $25,000 per year.

- Assuming Present Worth:
  $\$25{,}000*((1 + 0.06)^{10}-1)/(0.06(1+0.06)^{10}) = \$184{,}002.18$

Every five years is the recommended time to change the battery system. The total cost of batteries, installation, and removal of old batteries is $60,000.

- Assuming Present Value replacement in the 5th year:
  $\$60{,}000* ((1+0.06)^{-5}) = \$44{,}835.49$
- Assuming Present Value replacement in the 10th year:
  $\$60{,}000* ((1+0.06)^{-10}) = \$33{,}503.69$

Energy Cost:
Efficiency of system is 93% at full output, with assumed load of 500kw
Energy losses = 500*(1-0.93)/0.93 = 37.63kw
Energy Cost = 37.63kw*24hrs*365days*$0.10/kwh = $32,963.88/year

- Assuming Present Worth:
  $\$32{,}963.88*((1 + 0.06)^{10}-1)/ (0.06(1+0.06)^{10}) = \$242{,}617.03$

Dimensions:
The 750kVA unit is 39” deep, 122” wide, and 82” high.
The Maintenance Bypass Cabinet is 39’ deep, 23” wide, and 82” high.
The 4 Battery Cabinets are 33” deep, 50” wide, and 75” high each.
85 total square feet

Cost of Space:
85s.f.*$227/s.f. = $19,295

- Assuming Present Worth:
  $\$19,295*((1 + 0.06)^{10}-1)/ (0.06(1+0.06)^{10}) = \$142,012.88$

Comparison

Table 27: Total Life Cycle Costs

Present Worth Costs ($) Over 10 Year Span			
	600kVA Rotary UPS	**900kVA Rotary UPS**	**750kVA Static UPS**
First Cost Equipment	$230,000	$340,000	$200,000
Installation	$57,500	$85,000	$60,000
Total First Costs	**$287,500**	**$425,000**	**$260,000**
Total Savings of each Rotary system compared to the Static System. First Costs, Single System.	**-$27,500**	**-$165,000**	**$0**
Maintenance	$4,416	$6,624	$184,002
Replace Equipment (5,10th year)	$7,834	$11,751	$78,339
Energy Cost	$99,677	$99,677	$242,617
Cost of Space	$66,830	$83,537	$142,013
Present Worth Total 10 Year Cost	**$466,257**	**$626,589**	**$906,971**
Total cost of all Equipment (2 systems)	**$932,514**	**$1,253,178**	**$1,813,943**
Total Savings of each Rotary system compared to the Static System. 10 Year.	**$881,429**	**$560,765**	**$0**

Conclusion

I am very pleased with the results of the analysis. The few values that I am unsure of are the energy costs due to the fact that the sizes of the systems are different and I assumed the full load efficiency of each system. The units would not be running at full load at the 500kw assumed load but I had no other values to use. Also, manufacturers sometimes make most of their money with yearly maintenance contracts with owners, which might explain the $25,000/year contract with the static system, but there was no maintenance contract on the rotary system. Then again, the batteries are more dangerous and require more maintenance so perhaps this is a fairly accurate representation. First cost is a big deal but the values are not that different. It costs only $55,000 more for (2) 600kVA rotary systems and $330,000 more for (2) 900kVA rotary systems, compared to (2) 750kVA static systems. In the long term both rotary systems use less money than the static system, are safer with the respect to batteries and environment, and easier to maintain over time. I would recommend using either rotary system over the static system for this building.

Photovoltaic Array Analysis

Introduction

The following photovoltaic analysis is used to determine whether it is viable to install a PV array on the roof of the NNSOC. I will be using the RETScreen photovoltaic analysis tool to determine energy production and the payback period of a PV array. The energy usage of my building is much higher than anything a PV array can produce within the area of the roof. Since I plan on using all the energy produced, the system will be on-grid with the utility and no battery storage system. If by chance the PV array is producing more energy than the building is using, then it will send this energy back to the utility.

For a lot of states there are programs designed to help financially with the costs of a photovoltaic array for a home or business. However, currently in the state of Virginia, there are no tax incentives or credits for installation of PV systems. There is a federal tax credit of 30% for business installations that I will be using in my design.

Design Concept

I chose BP Solar's 3160 photovoltaic module for my base unit. Pricing data for the PV modules and inverter came from AdvancedEnergyOnline.com. The cost of the BP 3160 module is $800/module and the cost of a 225kW 480V inverter is $208,073. The inverter is rated at 480V so my PV modules should be connected to half of this voltage. Each module is 160 watts at 35.1 volts and 4.55 amps at full output. So connecting the modules in series to around 240 volts requires 7 modules, with the rest of the modules in parallel. The total roof area is 34,875s.f, but not all of this space is usable. Figure 2.11 shows the proposed layout for the system. With this layout and the proper wiring design, 1,456 modules fit the layout.

Figure 64: Schematic PV Wiring Diagram

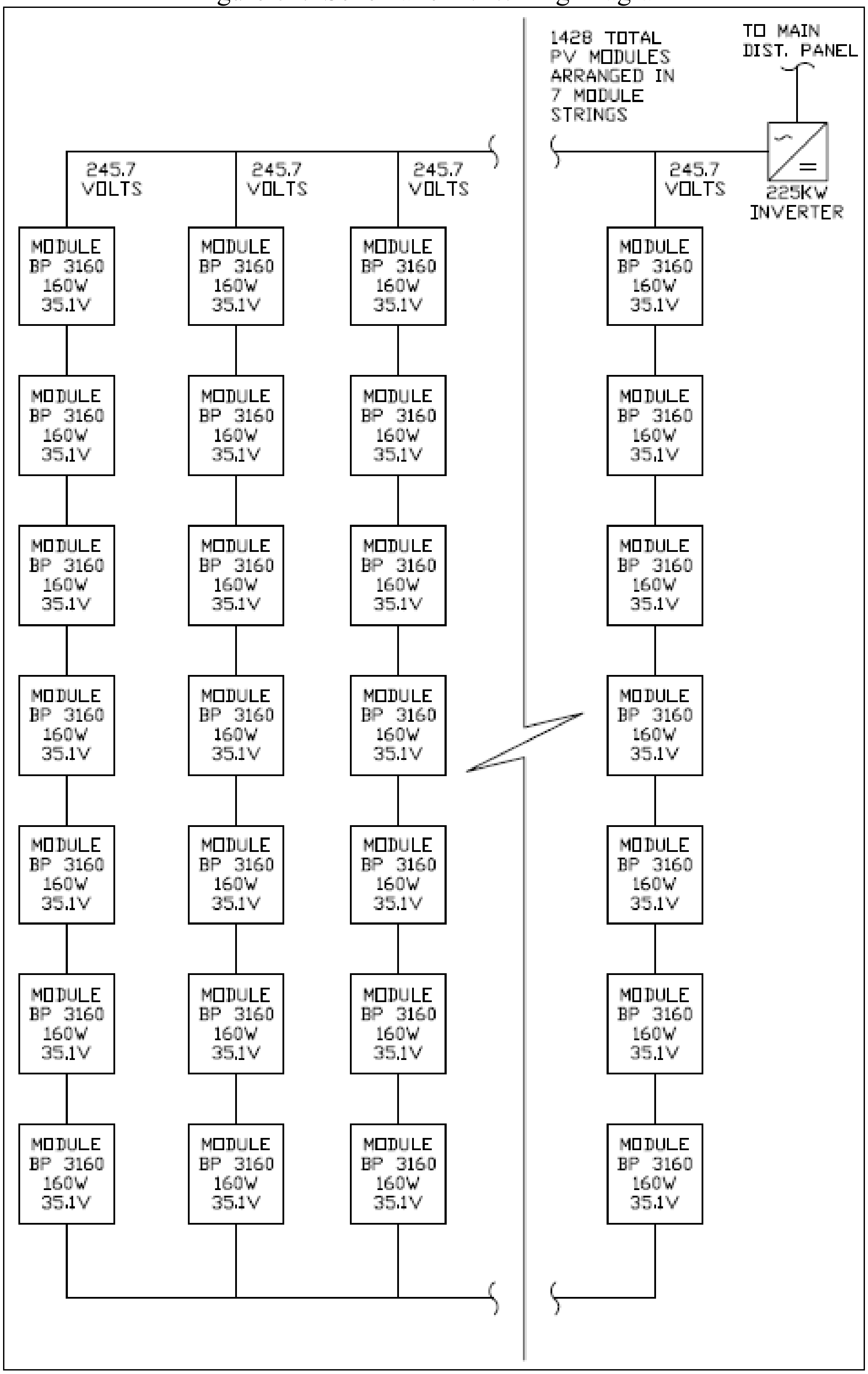
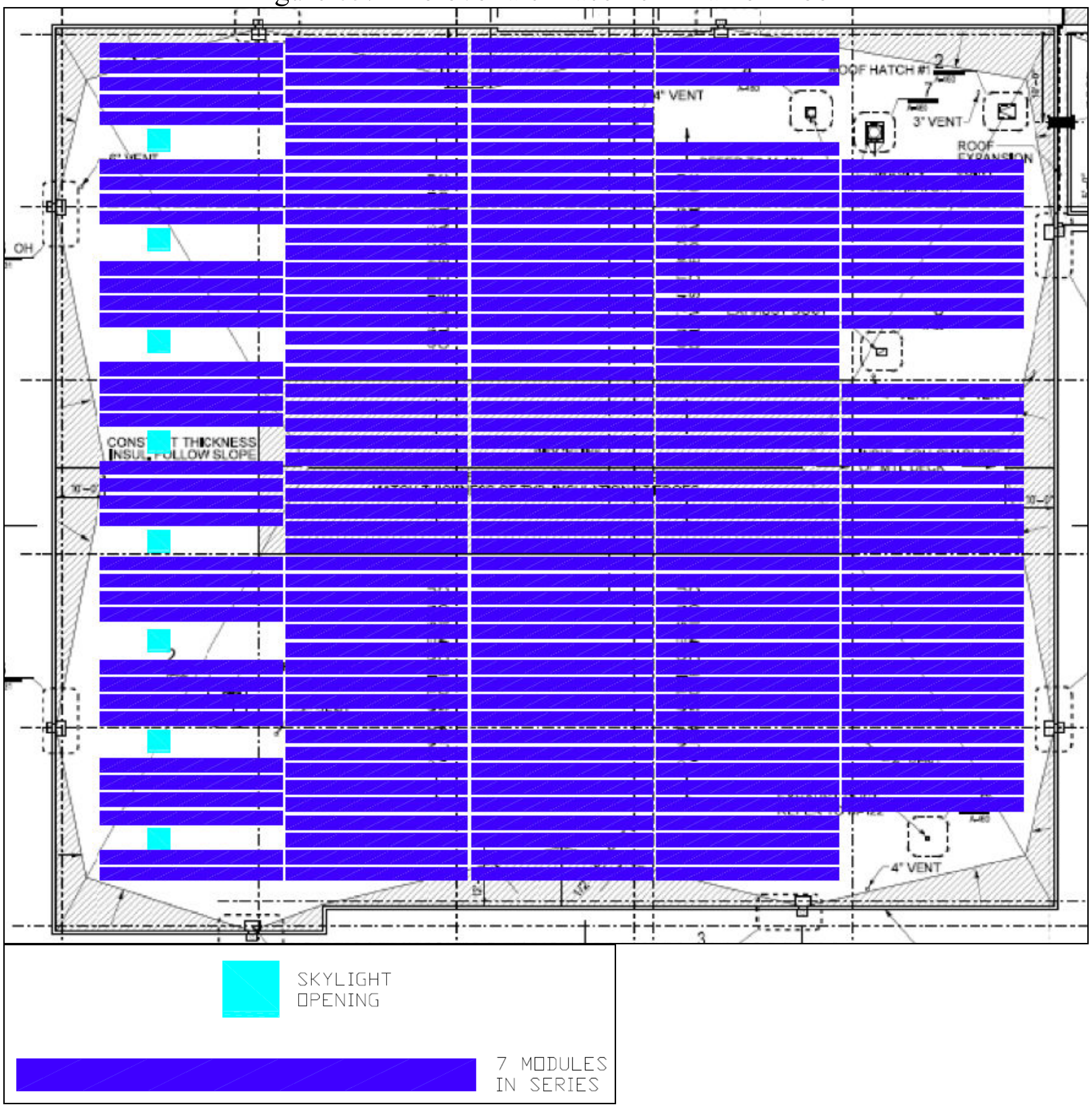


Figure 65: Photovoltaic Placement Plan on Roof



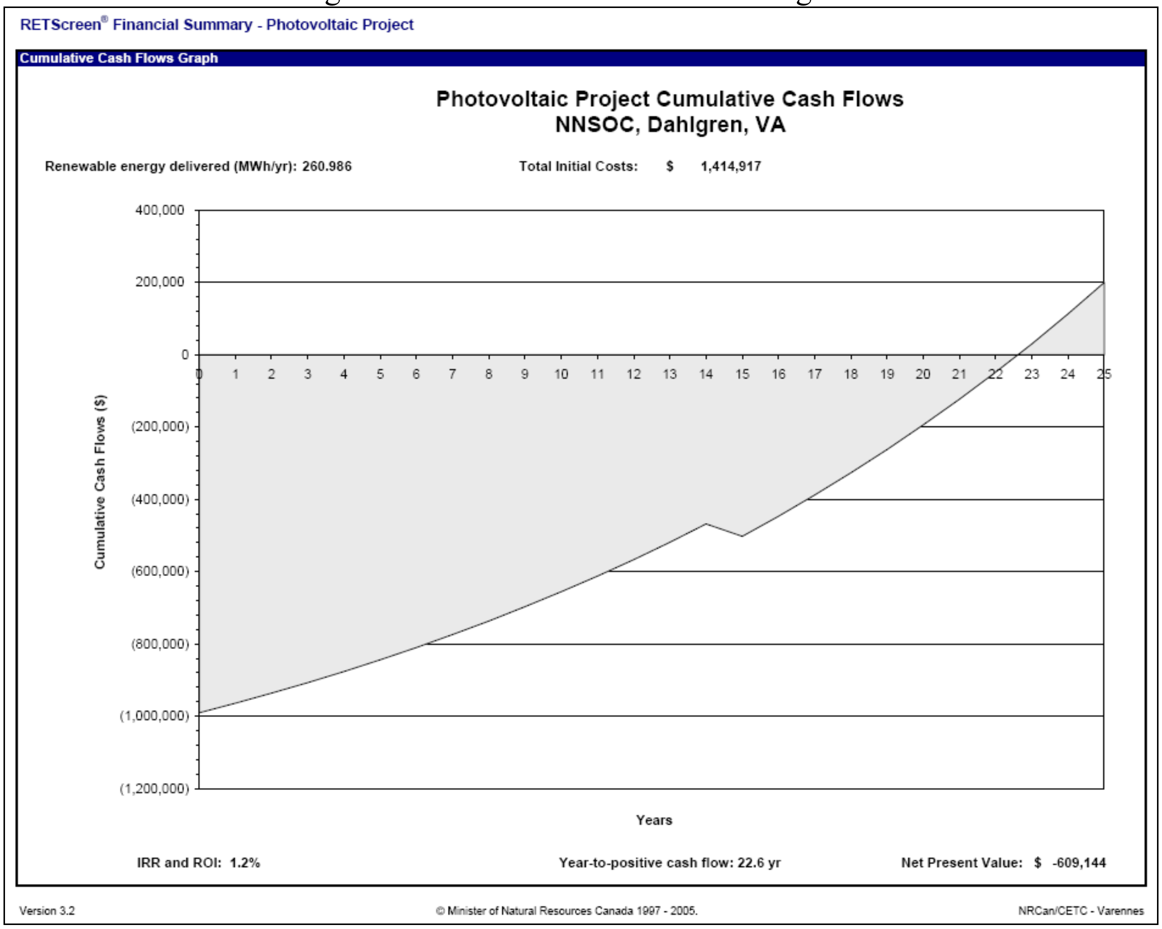
Assumptions

- Project life of 25 years
- Energy cost of $0.10/kWh with escalation rate at 5.0%
- 30% Federal tax credit for new installations
- Inverter repair every 15 years

Analysis

The RETScreen tool was used to determine the basic cost and payback of the system, along with the maximum energy it can produce. The results are below in Figure 65 with the rest of the analysis in Appendix B.

Figure 66: Cumulative Cash Flow Diagram



Conclusion

The net payback period on implementing a Photovoltaic array on the roof of the NNSOC does not seem to be worth while. It will take at least 22.5 years to reach the break even point. Unless the client would really want a PV system I would recommend against it at this point in time. If Virginia had some type of tax relief or credit program to help offset the costs of PV arrays then this analysis might have been possible. Also, in the next few years I expect PV arrays to become more popular due to our current energy situation and people wanting to be more environmental friendly. If PV panel manufacturers improve their production efficiency due to public demand then the price per panel should fall and become a better alternative energy source for consumers. This would be an option the building owners could look into for a future retrofit to help with energy costs.

Mechanical Breadth

HVAC affect on Skylight Design

Background

After my proposed daylight redesign for the office is complete, I will be analyzing the affects of the glazing area added on the roof with the HVAC design. The added glazing may affect ASHRAE Standard 90.1 as well as the designed heating and cooling loads of the space. I will compare the increase in HVAC loads to the original building using E-Quest 3-61 (Quick Energy Simulation Tool) for the analysis. Using E-Quest, I will run a base building HVAC load simulation with no skylights, and then run a simulation with the added skylights to determine the difference in the loads for each design. This value will be how much more HVAC load is needed for the building with the added skylights.

Assumptions

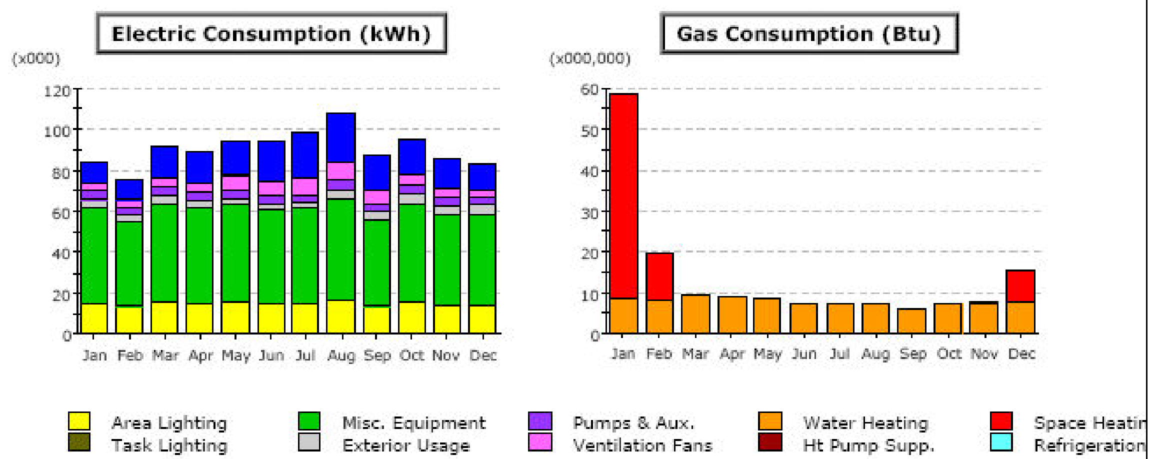
- E-Quest building model remains unchanged except for the skylights in each simulation
- Skylight glazing is Double Polycarbonate White Translucent
- Skylight to area of roof is 2.7% which is what the Skycalc tool showed to be the most efficient design
- Electricity cost is $0.10/kWh
- Thermal cost is $0.50/Therm

Analysis

I designed a generic model of my building in order to run this analysis. Placing in the mechanical loads from the schedules gave me the right size units for the building along with the efficiencies of each unit. The analysis was run twice with only the skylights changing in the design. Only changing the skylights should give me an accurate model of how much energy the extra skylights would use. The charts below show the monthly cost of energy for the electrical and thermal loads.

Figure 67: Base Building Model Results

Project/Run: NNSOC_no skylights - Fan Power Ctrl EEM   Run Date/Time: 04/05/07 @ 22:02



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	10.4	9.8	15.4	15.1	17.3	19.4	22.6	23.6	17.4	16.6	14.3	12.4	194.3
Heat Reject.	-	0.0	0.0	0.0	0.1	0.2	0.4	0.3	0.2	0.1	0.0	0.0	1.4
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	3.9	3.3	4.5	5.3	6.4	7.2	7.9	8.6	6.4	6.1	4.4	3.7	67.7
Pumps & Aux.	3.8	3.5	4.2	4.1	4.3	4.1	4.1	4.4	3.7	4.3	3.9	3.8	47.9
Ext. Usage	4.6	3.5	3.9	3.8	2.7	2.6	2.7	4.4	4.2	4.4	4.4	4.6	45.7
Misc. Equip.	46.6	42.1	48.5	46.4	48.5	46.4	46.6	50.5	42.5	48.5	44.5	44.6	555.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	14.7	13.3	15.3	14.6	15.3	14.6	14.7	16.0	13.3	15.3	14.0	14.0	175.2
Total	83.9	75.5	92.0	89.3	94.6	94.5	99.0	107.8	87.8	95.2	85.4	83.1	1,088.0

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	50.16	11.87	-	-	-	-	-	-	-	-	0.80	7.76	70.59
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	8.58	8.03	9.25	8.68	8.44	7.47	6.97	7.20	6.04	7.19	7.09	7.68	92.64
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	58.75	19.90	9.25	8.68	8.44	7.47	6.97	7.20	6.04	7.19	7.88	15.45	163.23

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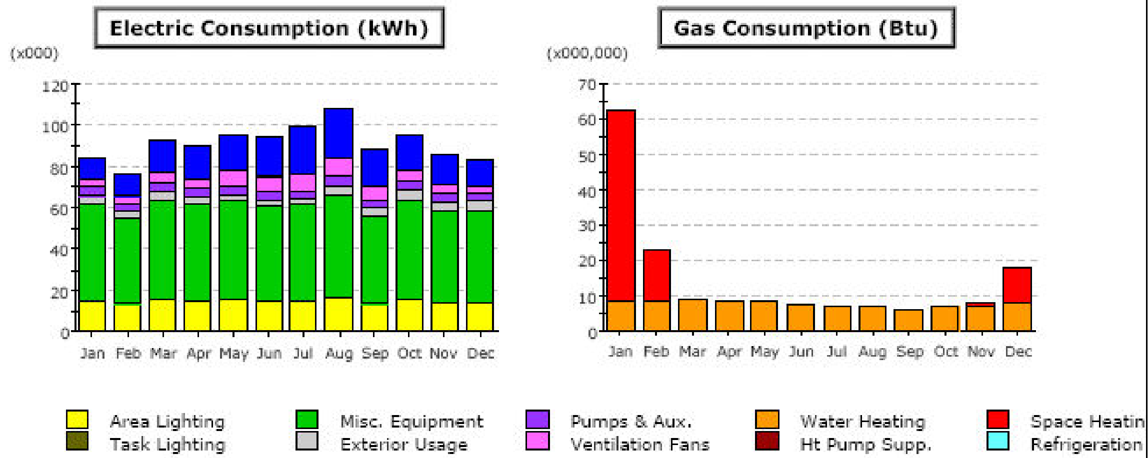
Figure 68: Skylight Addition Model Results

Project/Run: NNSOC_skylight_no dimming - Fan Power Ctrl EEM   Run Date/Time: 04/05/07 @ 21:57



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	10.7	10.1	15.7	15.4	17.6	19.7	22.9	23.9	17.6	16.8	14.6	12.6	197.7
Heat Reject.	-	0.0	0.0	0.0	0.1	0.2	0.4	0.3	0.2	0.1	0.0	0.0	1.4
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	4.0	3.4	4.6	5.3	6.5	7.3	8.1	8.7	6.5	6.1	4.3	3.8	68.3
Pumps & Aux.	3.9	3.5	4.3	4.1	4.3	4.1	4.1	4.5	3.7	4.3	3.9	3.8	48.5
Ext. Usage	4.6	3.5	3.9	3.8	2.7	2.6	2.7	4.4	4.2	4.4	4.4	4.6	45.7
Misc. Equip.	46.6	42.1	48.5	46.4	48.5	46.4	46.6	50.5	42.5	48.5	44.5	44.6	555.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	14.7	13.3	15.3	14.6	15.3	14.6	14.7	16.0	13.3	15.3	14.0	14.0	175.2
Total	84.3	75.9	92.3	89.7	95.0	94.9	99.4	108.3	88.1	95.5	85.7	83.5	1,092.6

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	54.03	15.05	-	-	-	-	-	-	-	-	0.89	9.89	79.86
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	8.58	8.03	9.25	8.68	8.45	7.47	6.97	7.20	6.04	7.19	7.09	7.69	92.65
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	62.62	23.08	9.25	8.68	8.45	7.47	6.97	7.20	6.04	7.19	7.98	17.58	172.51

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Comparison

Table 28

HVAC Load Comparison of Additional Skylights			
	HVAC Equipment Electrical Consumption/yr (kWh)	Lighting Equipment Electrical Consumption/yr (kWh)	Gas Consumption/yr (Btu)
Original Design	912,800	175,200	163,230,000
Skylight Addition	917,400	175,200	172,510,000
Difference	4,600	0	9,280,000
Btu to kWh Conversion	-	-	2,719.70
True Load in kWh	4,600.00	0.00	2,719.70
Cost at $0.10/kWh	**$460.00**	**$0.00**	**$271.97**

Conclusion

In the analysis it shows that adding in the 8 skylights will add an extra $731.97 a year to the energy cost of the building. Strictly on cost, the daylight integration with the skylights and dimmed lighting have a conservative energy savings of $680.00 but probably higher (See SPOT analysis Figure 43). The two costs are fairly similar for the most part, but having daylight integration within an office atmosphere has shown to enhance productivity among employees. Employee comfort should be a main priority and having daylight in a space helps to achieve that. Also, with the west wall oriented like it is, there is a good chance the manual blinds will be pulled down most afternoons so having the skylights in the middle of the space can still provide a good daylight solution. When the blinds are closed the lights still can be dimmed providing enough light is coming through the skylights. Even though it might be a larger upfront cost to install the skylights and dimming ballasts, the system almost balances itself out annually and employee comfort is enhanced so I would recommend using this skylight design and daylight integration within the open office space.

Construction Management Breadth

Skylight Integration with Building Systems

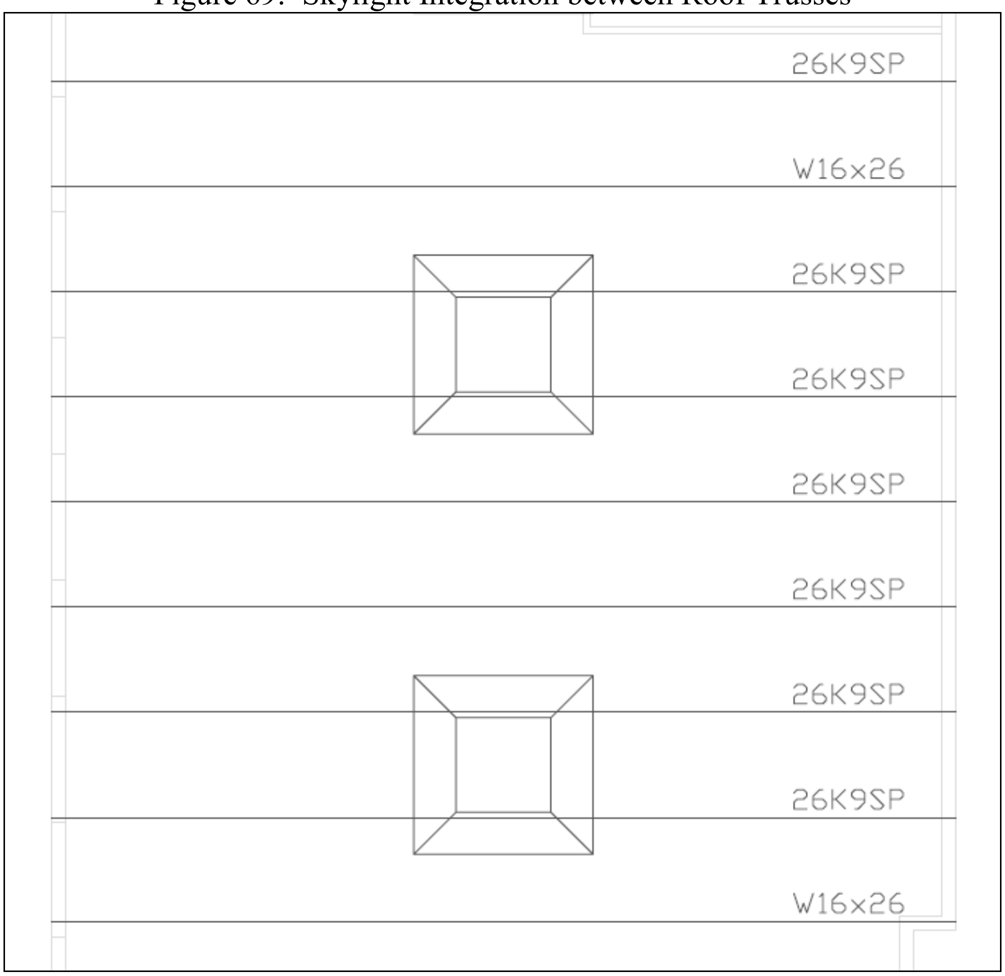
Background

The skylights that I have added into the open office area take up a lot of space in the ceiling grid. Coordination of the structural, architectural, and MEP systems needs to be coordinated together to make sure they do not conflict with each other.

Structural

The skylights need to be fit in-between the roof trusses and be framed in to properly install each skylight. The rough-in frame should extend to the ceiling grid which includes the splayed well too. Without having this area framed out, the chance of adding MEP equipment in these skylight spaces is higher.

Figure 69: Skylight Integration between Roof Trusses



Mechanical

Mechanical ducts pose a problem for the skylight design. The main branch duct was running right through the skylight design. I moved it 6' further into the office area so it wouldn't interfere with the skylights. The little amount that it moved should not affect the mechanical design at all. Below in Figure 69 is the new mechanical duct plan.

Figure 70: North Office Mechanical Duct Plan

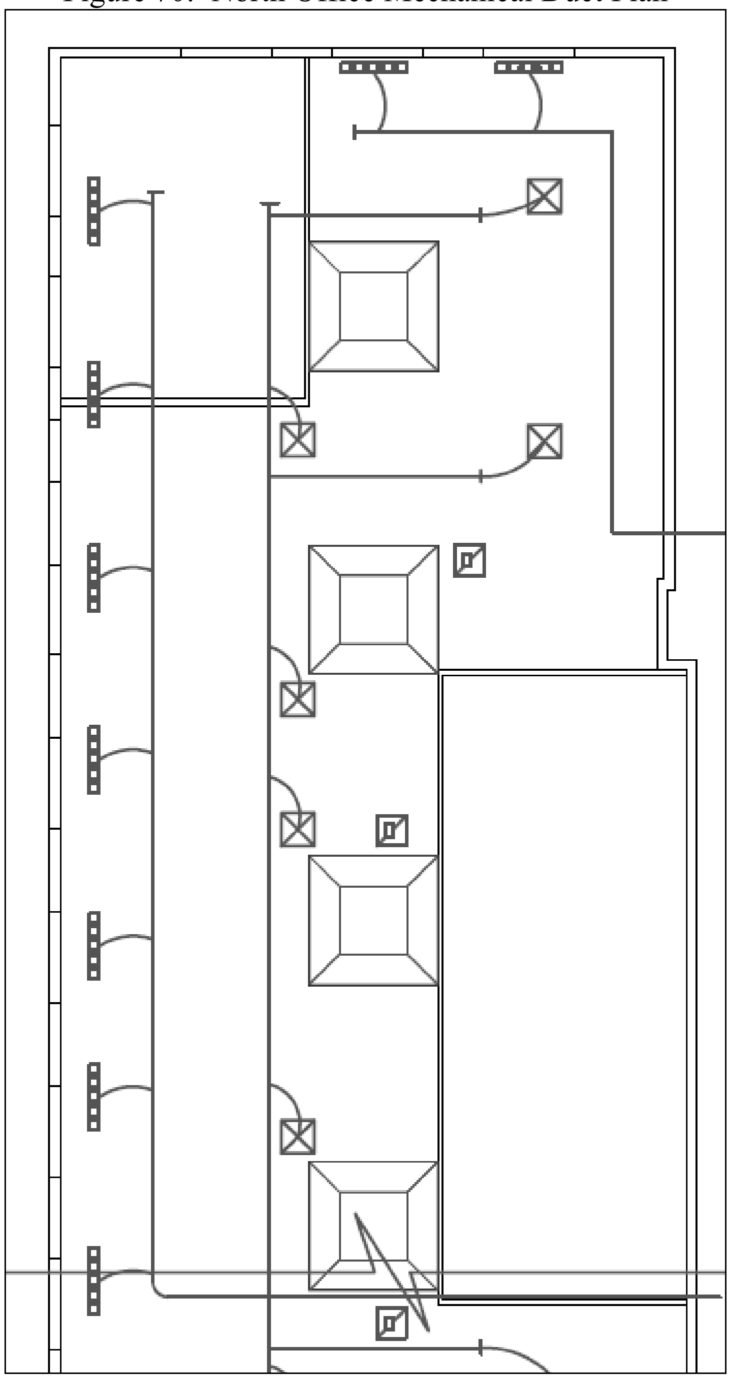
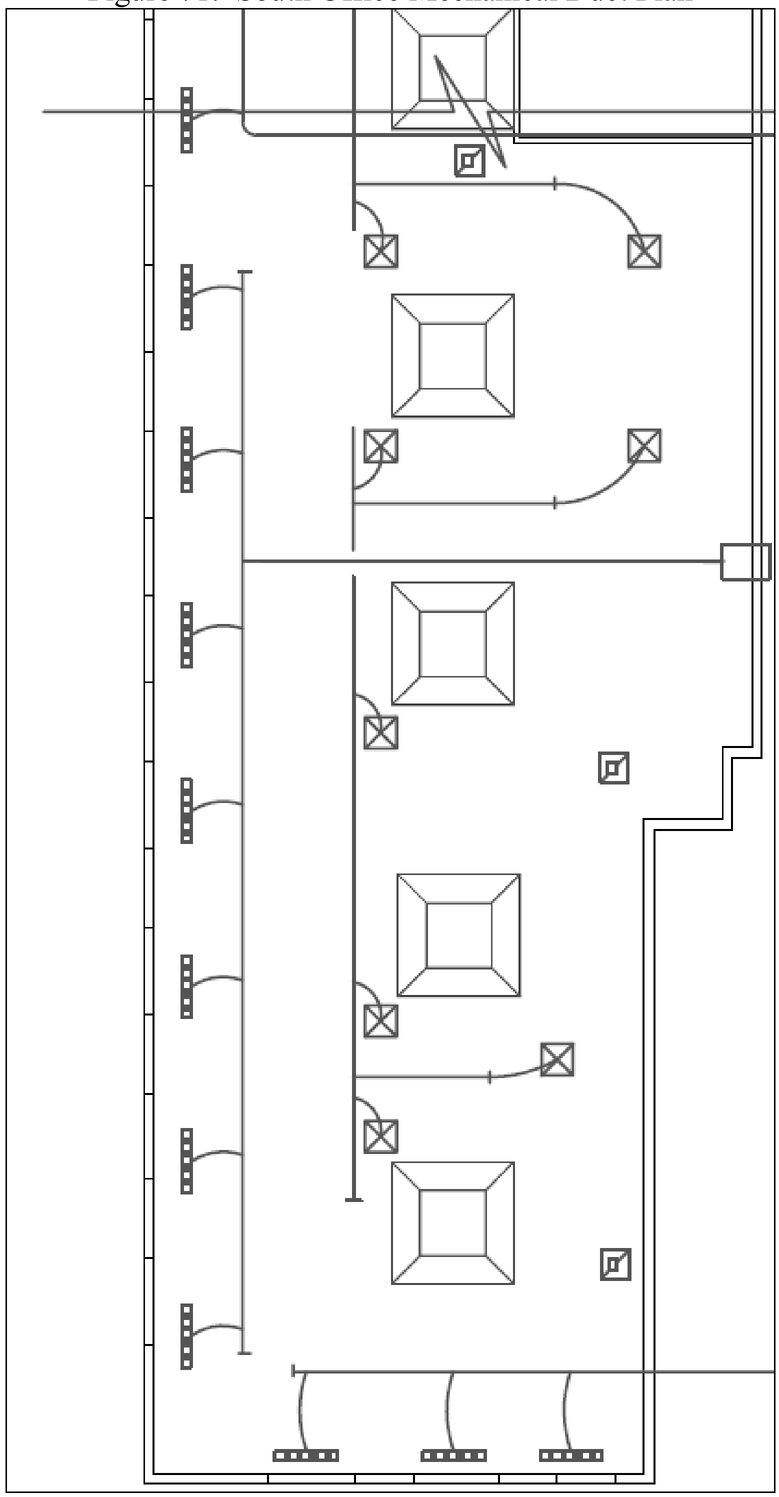


Figure 71: South Office Mechanical Duct Plan



Plumbing

The sprinkler system is only in select areas of the NNSOC. The open office area is a space that does not have fire suppression, just audio and visual alarms. Therefore no coordination needs to take place for plumbing.

Telecommunication

All telecommunication wiring goes through the cubicle furniture to the hallway where it is routed above the acoustical tile ceiling. No need for coordination with the skylights.

Conclusion

The addition of skylights to the office space has minimal effect on the other systems in the building. The mechanical coordination had the largest impact but could be changed rather quickly with a simple move of the main branch duct in the space. Designing the skylight to fit between trusses also simplified the structural design of the roof system allowing for a quick integration of the overall skylight system into the office area.

Conclusions

The Naval Network Space & Operations Command redesign was a success. The goals I set forth for the lighting and electrical redesign I feel were met. For lighting, the daylight integration seemed to make the office space more comfortable for the employees while limiting the increase in cost. All the lighting spaces seemed to fit within the architecture of a Naval Office, yet still be aesthetically pleasing and successful in lowering the power density in all redesigned spaces.

The NNSOC relies heavily on a reliable emergency power system for their critical loads that must have continuous power. The alternate design of the rotary UPS system instead of the static UPS system concluded that the rotary system would save more money in a 10 year life cycle analysis. The rotary system is also safer for the environment with the lack of lead acid batteries the need for air conditioning to them. From my results I would recommend using the rotary UPS system over a static UPS system.

The Photovoltaic analysis had shown that at this point in time adding a PV array to the building for solar power is not a viable solution for energy production. The good news is there is starting to be a push toward PV energy production from consumers and the price for a system like this may go down. State and federal incentives and tax credits are also developing to help with costs around the country so PV energy production may be worth while in the coming years. This analysis would provide a good start to a future installation of photovoltaic panels on this building.

In this thesis project, I was able to create an efficient lighting design while maintaining the look of a naval facility. The emergency power alternative solution was a success and can show a rotary system can be just as reliable as a static system, with cheaper cost and maintenance in the lifetime of the equipment. Overall, the entire project should provide some good ideas for future alternative designs of lighting and electrical systems for buildings.

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References

General

A/E firm Kling for providing the drawings, Specs, RFP report and Proposal

Advisor – Dr. Mistrick

Electrical Consultant – Mr. Ted Dannerth

Lighting

IESNA Handbook 9th Addition

ASHRAE 90.1

Electrical

National Electric Code 2005

Renmark – Renaissance Electrical Marketing, Inc.

Caterpillar

MGE UPS Systems

U.S. Department of Energy, Energy Efficiency and Renewable Energy
www.eere.energy.gov/femp/