Final Thesis Report

The Sterling and Francine Clark Art Institute

225 South Street, Williamstown, MA 01267-2878

4 April 2012

Executive Summary

The Sterling and Francine Clark Art Museum is located in Williamstown Massachusetts. Its multi-building campus is dedicated to the advancement of the arts through museum exhibits, conferences and educational resources. Although it is contending for LEED certification, it currently uses significantly more energy than is necessary with today's advancement in efficacious, high CRI LED sources. Additionally, the accessibility of artwork that The Clark is striving to present through programs and facility design are realized for the older patrons but not the younger guests.

This proposal includes lighting designs for four spaces, electrical power system designs, an architectural study, and a structural study.

The lighting and electrical redesigns are the focus of the report. The proposal for lighting and electrical systems focuses on the following four spaces: a woodshop, multi-use space, lobby, and terrace. The lighting designs complement the attention to detail that architect Tadao Ando has given to positioning and finishing his prominent vertical surfaces. Each space's electrical redesign accounts for the lighting redesign and adds additional loads on the spare circuits. Two electrical depth topics are explored: a rooftop photovoltaic system and cogeneration system. A feasibility study is performed for each. The structural considerations for adding a PV system to the roof are discussed in the structural breadth study. An additional architectural and media breadth study explores the use multimedia motion sensing technology to foster the interactive element of artwork that The Clark has been struggling to create for younger visitors.

The lighting, electrical, structural and architectural studies together form a proposal that will better reflect the sustainability goals and of the VECC as well as foster an interactive educational experience.

THE CLARK

info

Project Name: The Sterling and Francine Clark Art Institute
Project Phase II: Utility Plant & Visitors, Exhibition, and Conference Center Space
Address: 225 South Street, Williamstown, MA
Size: 78,000 sq.ft.
Levels: 2 | 1 above grade
Delivery Method: GMP

team

Design Architect: Tadao Ando Architects and Associates
Architect of Record: Gensler
MEP Engineer: Itieri Sebor Wieber, LLC
Structural Engineer: Buro Happold Consulting Engineers, PC
General Contractor: Turner

arch

The architecture for the Phase II addtions to The Clark are consistant with Tadao Ando's design themes. Minimalistic design, with light open spaces and straight clean lines characterize the architecture. A palette of architectural concrete, metal panels, hardwood, glazing, and clean white surfaces reinforce clarity of the space.

building systems

Structural

The primary structural systems in The Clark are composed of cast-in-place concrete. Spread footings are used in combination with strip footings around the perimeter of the building. The lateral support for the building is provided by a shear wall system.

Mechanical

Six AHU's are spaced out beteen the plant and the VECC. Four boilers used in the Clark have a combined capacity of 10,800 MBH, and the chillers have a capacity of 700 tons. The Clark's extensive water feature includes an large pumping system and an ozone generation system.

Electrical

The Clark's campus is supplied at 13.8kV and transformed down to the 480Y/277V service voltage at the plant entrance using a unit substation. A 1500kW/1875kVA diesel generator supplies 480Y/277V, 3Ph, 4W power to the campus for emergency and standby systems.

Lighting

Backstage areas of The Clark use energy efficient linear fluorescent sources. Halogen MR-16 sources are used extensively in the guest of the facility. Much of the exterior envelope is constructed of a glazed curtain wall system, allowing for many daylit spaces. The exterior lighting system is controlled with a photosensor and time-clock and uses primarily ceramic-metal-halide and LED sources.

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Project Background

The Clark Art Institute is a educational and exhibit facility dedicated to advancing the arts. This report deals with an addition to the campus that will be construction in two phases. Phase IIA consists of a utility plant and phase IIB consists of a Visitors, Exhibition and Conference Center. The minimalist design of Tadao Ando invites the serene and contemplative impression that fits The Clark well. However, the building does not reach out well to the younger guests that The Clark is attempting to appeal to. The lighting and space design, therefore, must respect and complement the simple material palette and clean lines of the architecture but allow younger guests to more fully appreciate the beauty of art.

Lighting Depth

South Terrace

Architectural Description

Function and Layout

The south terrace and façade will be used as a year-round gathering space. In the summer months it will be a place to admire the beauty and tranquility of the extensive array of reflecting pools. In the winter months it will be used as a launch pad for ice-skating on the largest and closest reflecting pool. The south terrace and façade is located on the south side of the VECC portion of The Clark and is 220' x 40'. The south façade has three entrances: one to the south entrance of the vestibule, one into the retail space, and one into the link between the VECC/plant additions and the original 1955 building.

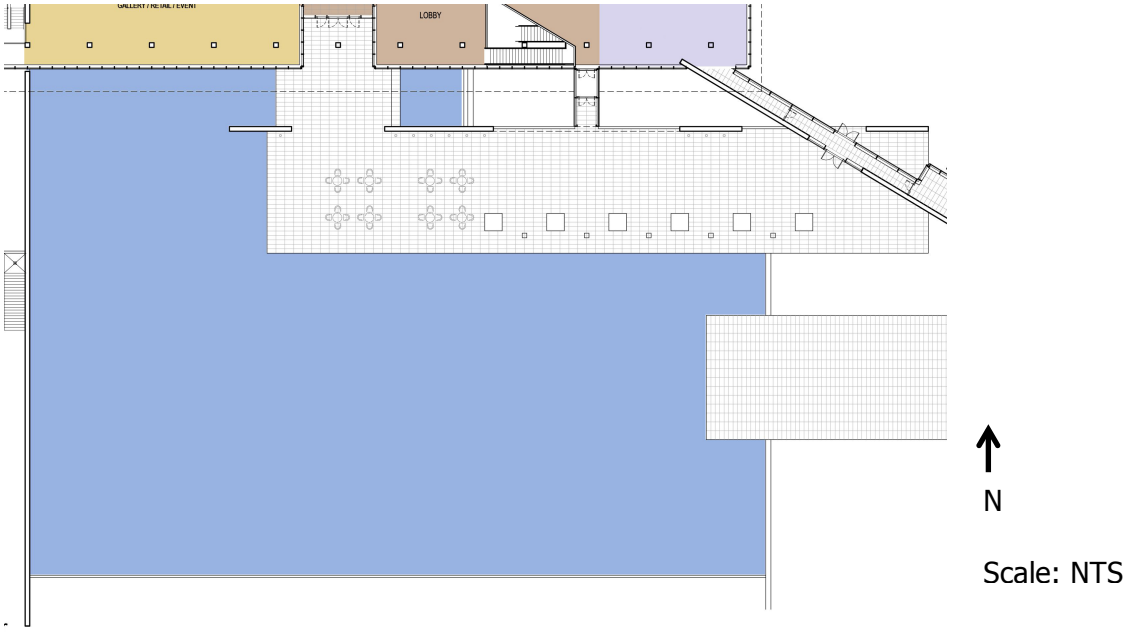


Figure 1: South Terrace

Materials

Location	Material	Color	Reflectance	Description
Floor	Concrete Pavers	Tan	0.2	Precast concrete pavers, matte
Wall	Architectural Concrete	Off White	0.34	Standard 4' x 8' panels
Wall	Granite	Brown	0.18	Semigloss finish
Ground	Grass	Green	0.18	

Design Criteria and Considerations

Lighting

Recommended Illuminances (IES Lighting Handbook, 10th Edition)

Building Entrance, Covered (LZ2)
- Horizontal Illuminance – 20 lux
- Vertical Illuminance – 10 lux
- Avg:Min – 2:1 (4:1)

Plaza (LZ2)
- Horizontal Illuminance – 4 lux
- Vertical Illuminance – 2 lux

Recommended Uniformity (IES Lighting Handbook, 10th Edition)

Building Entrance, Uncovered (LZ2)
- Avg:Min – 2:1 (4:1)

Plaza (LZ2)
- Avg:Min – 4:1
- Max:Min – 5:1 (10:1)

Wayfinding and Space Transitions
- To maintain safe conditions during the night time, especially when ice skating events are being held on the reflecting pools, light must be used to clearly identify circulation pathways.
- The terrace-pool border must be clear to prevent guests from stepping off the pavers into the shallow water

Energy

Power Density (ANSI/ASHRAE/IES Standard 90.1)
Walkways and Plazas
- Walkways less than 10ft wide – 1 W/linear foot
- Plazas and walkways greater than 10ft wide – 0.2 W/SF

Entrances

- Main entrances – 30 W/linear foot of door width
- Other entrances – 20 W/linear foot of door width

Building Façade

- 0.2 W/SF of illuminated wall or surfaces
- 5 W/linear foot of illuminated wall or surface

Environmental (LEED for new construction Version 2.2)

SS Credit 8: Light Pollution Reduction

- Reduce light pollution via options discussed in Appendix A.

EA Credit 1

- Perform a whole building energy simulation and demonstrate a 12-48% improvement in performance compared with the baseline building performance rating (for 1-19 points)
- Baseline building shall be based on ASHRAE 90.1 standards

Concept

The concept for the exterior is based upon the two main materials used for exterior vertical surfaces. Freestanding walls, highlighted in red in Figure 2 are made of Tadao Ando's signature concrete. The walls highlighted in green finished with brown granite. This granite wall forms the "7" that is common in much of Tadao Ando's architecture. The material also helps create a continuous experience for the guest as they move in and out of the facility. Washing the architectural concrete walls with light softens them and the reflected light provides the circulation light necessary for the terrace. Grazing the granite walls from the bottom accentuates their cold, dark material. These two lighting design elements are carried into the interior of the space, specifically in the Lobby/Retail area, where the granite wall is again grazed, but from the top instead of the base.

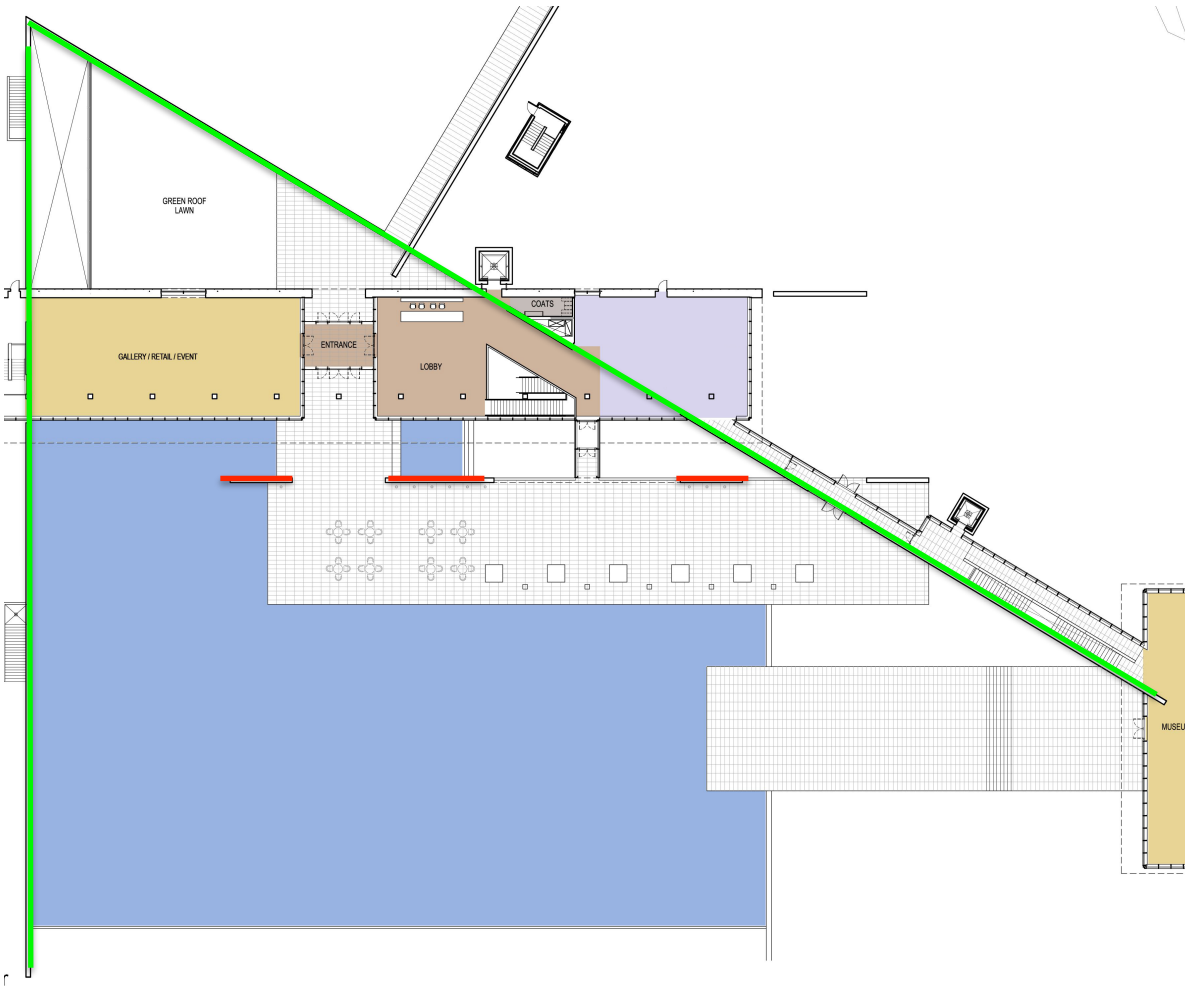


Figure 2: Terrace Plan

Design Execution

General Description

As mentioned, differentiating the architectural concrete walls from the granite walls is an important part of the design concept. Linear LEDs are used to graze the granite walls and recessed LED fixtures are used to wash the freestanding architectural concrete walls. As seen in the lighting plans in Appendix A, the west boundary of the terrace is moved eight feet further to the west. This allows two fixtures to be mounted by the base of the west-most architectural concrete instead of in the reflecting pool. This prevents maintenance issues that are associated with having to remove and reinstall waterbased fixtures on an annual basis. Additionally, throughout the guest spaces, 3000K light sources are used. To maintain color consistency, the same fixtures are used to illuminate the architectural concrete surfaces.

The fixtures used to graze the west-most granite wall are mounted in a protected concrete cove just below the surface of the water. This allows them to remain installed year round, as the reflecting pool water level is lowered each winter before it freezes.

Equipment

Type	Description	Mounting	Manufacturer	Product ID	Lamps	Input Watts
F20	Low profile linear LED fixture , 4.5 W/ft, 4ft length, IP66, Anodized aluminum finish, 3000K	Surface	Winona	Winline Surface Linear 103W	LED	18
F21	Low profile linear LED fixture , 4.5 W/ft, 3ft lenght, IP66, Anodized aluminum finish, 3000K	Surface	Winona	Winline Surface Linear 103W	LED	13.5
F22	Low profile linear LED fixture , 4.5 W/ft, 2ft lenght, IP66, Anodized aluminum finish, 3000K	Surface	Winona	Winline Surface Linear 103W	LED	9
F23	Linear LED fixture, PMMA acrylic housing combined with re-enforced composite end caps, 5 W/ft, 0-10V dimming, IP68, 3000K	Surface	Lumenpulse	Lumenpulse SLC 24V 48 30K	LED	20
F24	Recessed inground linear LED strip, tempered glass lens, stainless steel housing, IP67, 3000K	Recessed, in-grade	Hess America	LEDIA-LL-OD 36 12 W	LED	12
F25	Recessed inground linear LED strip, tempered glass lens, stainless steel housing, IP67, 3000K	Recessed, in-grade	Hess America	LEDIA-LL-OD 27 9 W	LED	9
F26	Flexible LED rope light, flexible tubing, waterproof, shatterproof, 3000K	Surface	Jesco Lighting Group	LLMFH-1 24V-30	LED	0.8 W/ft
F27	LED ingrade fixture, cast aluminum housing, silver reflector, wallwasher lens, stainless steel frame, IP68, 3000K	Recessed, in-grade	Erco	Tesis 33667	LED	27
F29	Recessed CMH uplight, 30° aiming direction, die-cast aluminum housing, stainless steel top plate, PVC fixture sleeve, tempered glass lens, IP67	Recessed In-grade	Intense	PHE 1/20W/CMH/ MR16 GX10	CMH	23
F30	Recessed exterior LED downlight, aluminum reflector, 50° cutoff, 3000K	Recessed	Philips Lightolier	C6X6L1520DL	LED	27

Power supplies for the various LED fixtures are given below.

Type	Description	Manufacturer	Product ID	Input Watts
F31	120V AC to 24V DC transformer	Winona	TW500	400
F32	120V AC to 24V DC transformer	Winona	TW300	240
F33	120V AC to 24V DC transformer	Winona	TW150	120
F34	120V AC to 24V DC transformer, 0-10V dimming	Lumenpulse	PSBOX100D	100
F35	120V AC to 24V DC transformer	Jesco	DL-PS-150/24-JB	150
F36	120V AC to 24V DC transformer	Jesco	DL-PS-35/24-JB	35
F39	120V AC to 24V DC transformer, 96W 24V Wet Location 0-10V Dimming	Intense	IB-OT96-DIM	96

Light Loss Factor Calculations

Fixture	BF	LLD	LDD	LLF
In grade or water based LED	-	0.70	0.73	0.51
HID CMH in grade	1	0.85	0.73	0.62
LED downlight	1	0.70	0.73	0.51

Design Performance

Summary

The terrace lighting system exceeds the illumination requirements for the building entries. On the terrace itself, however, that horizontal average recommendations are met but the uniformity criteria is not. The power densities restrictions are met for both tradable and nontradable surfaces. Determining whether the site lighting meets LEED criteria requires additional work outside the scope of this project – namely a full energy model and a full site lighting design.

Lighting

Tabulated Illuminance and Uniformity design results can be found in Figure 3. The building entrance recommendations are reached or exceeded. The illumination levels for the building entrances, although they are higher than required, are acceptable because much of the light is spill light from the interior. In the case of the retail entrance, the use of a handrail puts high levels of illumination to certain points on the calculation plane, thereby driving the average horizontal illuminance above the recommended levels.

Calculation Area	E_{avg}	E_{max}	E_{avg}/E_{min}	E_{Vavg}	E_{Vavg}/E_{Vmin}
Main Entrance	4.28	12.1	6.1	2.23	2.89
Retail Entrance	13.5	17.7	1.57	0.92	1.305
Terrace	0.7	13.1	N.A.	0.56	-
Pool	0.45	11.7	N.A.	0.38	-

Figure 3: Light Calculation Results

The terrace lighting results are above the recommended levels as well. However, the uniformity ratios of 4:1 (Vertical Avg:Min) and 10:1 (Horizontal Avg:Min) are not met, as the minimum calculated values are zero. This is to be expected for the vertical illuminance minimum, as several of the calculation points face to the south and are sufficiently fare away enough from the south handrail lighting to have a measurable mount of illumination. If looking strictly at the numbers, the horizontal minimum is more of a cause for concern, as circulation illumination is important for guest safety. Adequate way finding illumination on the terrace is especially important for the guests during the nighttime skating activities at the VECC. However, what is important is not necessarily that guests can see every detail of the terrace floor, but rather that they can distinguish the difference between the terrace surface and the reflecting pool water/ice surface. This is accomplished in the VECC terrace lighting design proposal by a strip of cove mounted high output LED rope light that lines the perimeter of the terrace, as seen in Figures 4 and 5.

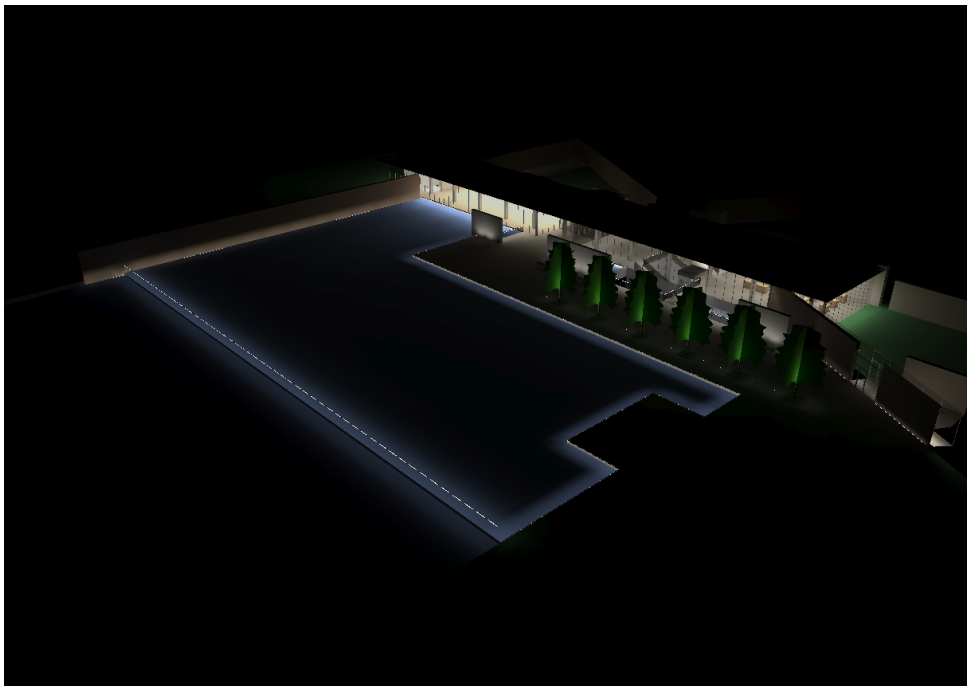


Figure 4: Terrace

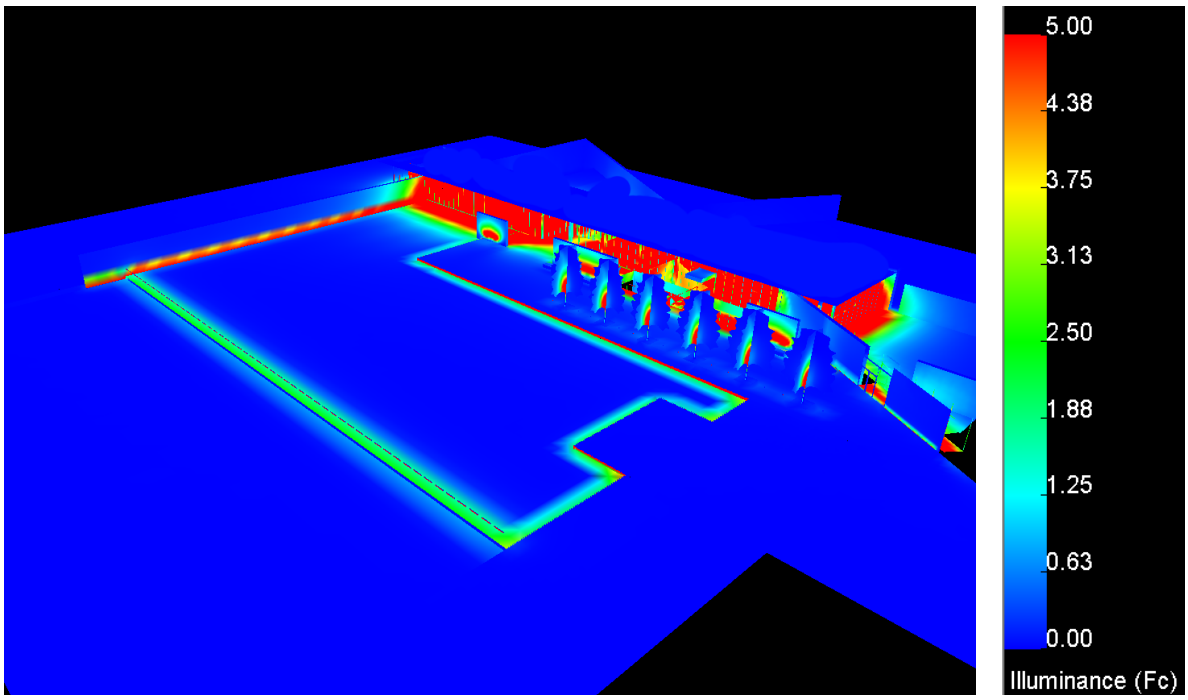


Figure 5: Terrace Pseudocolor

Energy

Total power is tabulated for tradable and nontradable elements separately in Figures 6 and 7. Total allowable tradable and nontradable wattage is tabulated in Figures 8 and 9. Comparing the tables, the design wattage falls significantly below the maximum allowable wattage for both tradable and nontradable elements.

Tag	Wattage	Quantity	Sum Wattage
F39	96	19	1824
F31	400	1	400
F32	240	2	480
F33	120	1	120
F23	22	40	880
F25	150	2	300
F36	35	1	35
F27	23	12	276
F30	27	14	378
F25	9	1	9
F26	12	9	108
		Total	2986

Figure 6: Power Usage – Tradable

Tag	Wattage	Quantity	Sum Wattage
wp linear	5	9	45
		Total	45

Figure 7: Power Usage – Non Tradable

Type		Allowance	Quantity		Wattage
Plaza areas		0.2 W/SF	28366.9	SF	5673
Entrances	Main	30 W/LF	14.5	LF	435
	Other	20 W/LF	6.5	LF	130
Overhangs		1.25 W/SF	2382.65	SF	2978
				Total	9217

Figure 8: Power Allowance – Tradable

Type		Allowance	Quantity		Wattage
Building Façade	either/ or	0.2 W/SF	-	SF	-
		5 W/LF	36.8333	LF	184
				Total	184

Figure 9: Power Allowance - Nontradable

Environmental

The calculations for SSc8 – skyglow and trespass, can be found in Figures 10 and 11.

Tag	**Lumens**	**Quantity**	**Sum Lumens**
F19	636	76	48336
F20	430	41	17630
F21	322	1	322
F22	215	1	215
F23	316	49	15484
F19	1000	12	12000
F30	1515	14	21210
F27	818	8	6544
F26	77	86	6622
F24	26	9	234
F25	20	1	20
		Total	128617

Figure 10: Exterior Lumens

Eavg	Calc. Grid Area (SF)	Lumens
0.006	1699425	11000

Figure 11: Skyglow Lumens

Dividing 11,000 lumens by 128617 lumens yields a nine percent skyglow, which is above the two percent allowable for LZ2 in LEED for new construction. However, the total lumens going upwards – 11,000 is not very substantial. While the percent skyglow for this exterior space does not meet LEED criteria for the space the site as a whole may very well meet the skyglow criteria. Skyglow is based on percentage of lumens going upwards. Therefore, as parking lot, pathway and other site lighting is added, and full cutoff fixtures are selected where possible, the site may very well meet the skyglow criteria for this space. All perimeter (light trespass) illuminance readings were 0, as the site perimeter for The Clark is several hundred feet from the VECC at the closest point.

EAc1 is outside of the scope of this study, although the replacement of most of the 50W MR-16 fixtures will certainly aid in reducing the energy footprint of the building.

Lobby and Retail Space

Architectural Description

Function and Layout

The lobby and retail area is located immediately east of the main entrance vestibule as seen in Figure 12. The overall dimensions of the lobby and retail area is 120’ x 48’. The lobby is the second welcome point for the facility (the first being the exterior ticket booth). The lobby contains an info desk on the north side of the space and a staircase to the basement level on the south side of the space. An angled walkway connects the lobby to the adjacent retail space and continues down a hall to the existing museum building. An elevator is located on the north side of the lobby space.

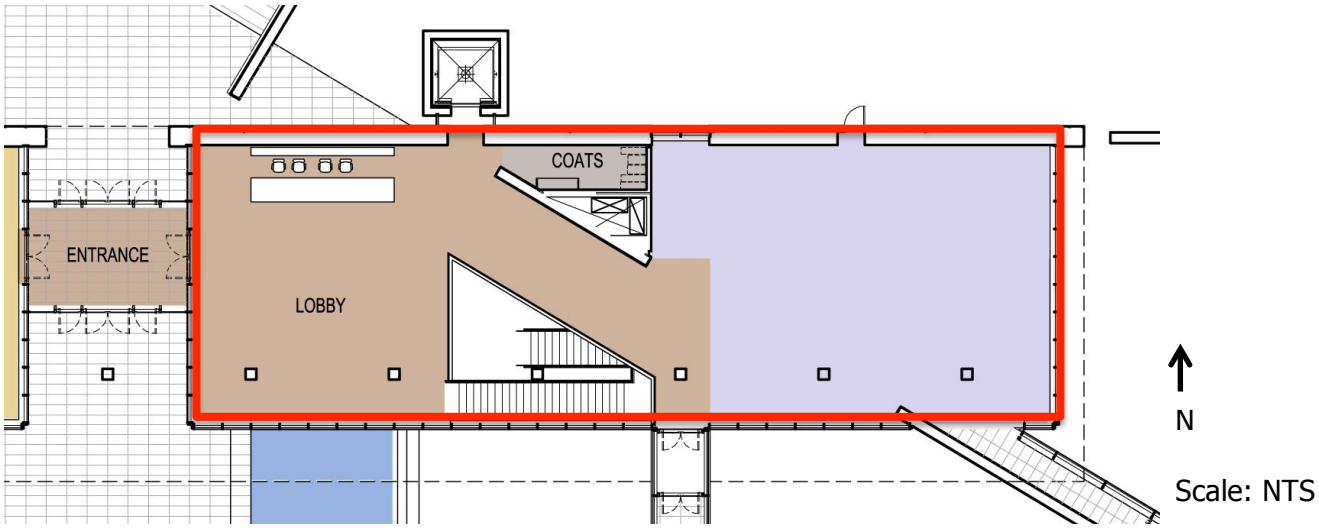


Figure 12: Lobby/Retail Plan

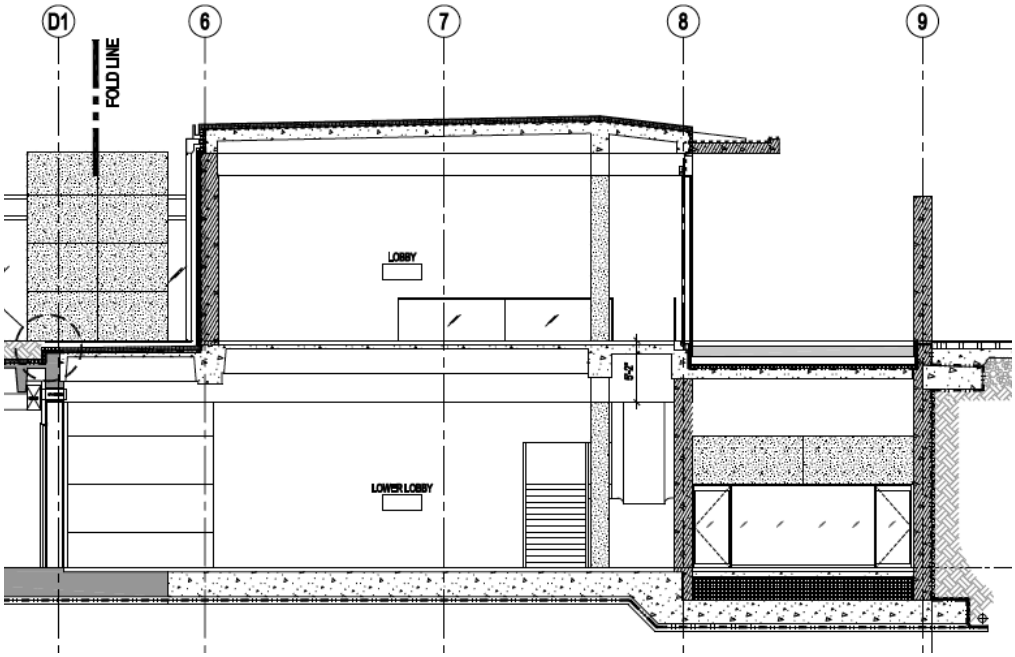


Figure 13: North-South Lobby Section

Materials

Location	Material	Color	Reflectance	Description
Ceiling	GWB	White	0.8	Painted matte finish
Wall	Architectural Concrete	Off White	0.34	Standard 4' x 8' panels
Wall	Aluminum Mullions	Gray	0.3	Matte anodized aluminum
Wall	Glass	No color	Tvis = 0.63	Low E, spectrally selective
Wall	Granite	Brown	0.18	Semigloss finish
Floor	Concrete Pavers	Tan	0.2	Precast concrete pavers, matte

Design Criteria and Considerations

Lighting

Recommended Illuminances (IES Lighting Handbook, 10th Edition)

Near Building Entry
- Day, Horizontal – 100 lux
- Day, Vertical – 30 lux
- Night, Horizontal – 50 lux
- Night, Vertical – 20 lux

Distant from Building Entry
- Horizontal – 100 lux
- Vertical – 30 lux

Desk

- Horizontal – 150 lux
- Vertical – 50 lux

Circulation Spaces
- Horizontal – 40 lux
- Vertical – 40 lux

Retail Spaces
- Horizontal – 300 lux
- Vertical – 200 lux

Coat Room
- Horizontal – 300 lux
- Vertical – 100 lux

Recommended Uniformity (IES Lighting Handbook, 10th Edition)

At Building Entry
- At Building Entry, Day, Avg:Min – 4:1
- At Building Entry, Night, Avg:Min – 4:1
- Distant from Building Entry, Avg:Min – 4:1
- Desk, Avg:Min – 4:1
- Circulation Spaces, Avg:Min – 4:1
- Retail Spaces, Avg:Min – 3:1 (H) 6:1 (V)
- Coat Room, Avg:Min – 3:1

Modeling of Faces
- The social nature of a lobby requires that there be adequate vertical illuminance for accurate modeling of faces
- The lobby desk area must have sufficient vertical illumination to allow the guests to interact easily with the museum staff

UV Radiation
- Merchandise needs to be protected from harmful UV rays

Glare
- Glare from the exterior reflecting pool could make the lobby space unpleasant if not cared for properly

Flexibility
- In a museum facility, every surface is a possible display surface, and the lighting must be flexible enough, even in general lobby spaces, to support temporary exhibits

Energy

Power Density (ANSI/ASHRAE/IES Standard 90.1)
- Lobby – 1.0 W/SF
- Additional Interior Lighting Power: Decorative Light Allowance – 1.0 W/SF

Environmental (LEED for new construction Version 2.2)

SS Credit 8: Light Pollution Reduction
- Reduce light pollution via options discussed in Appendix A.

EA Credit 1
- Perform a whole building energy simulation and demonstrate a 12-48% improvement in performance compared with the baseline building performance rating (for 1-19 points)
- Baseline building shall be based on ASHRAE 90.1 standards

IEQ Credit 8.1 Daylight and Views – Daylight
- Achieve daylight in at least 75% of occupied spaces as described by the options in Appendix B

IEQ Credit 8.2 Daylight and Views – Views
- Achieve direct line of sight to the outdoor environment via vision glazing between 30 inches and 90 inches above the finish floor for building occupants in 90% of all regularly occupied areas

Concept

The concept for the Lobby and Retail space reflects Tadao Ando's minimalist design elements and clean lines. The focus for this space, as with the Multi-Use and Terrace, is on the walls, as this is Ando's favorite architectural element. The lighting for the Lobby/Retail area, and for the Multi-Use as well, is used as subtly as possible, accenting walls and elements only when necessary to play off of the simple material palette and clean lines. Specifically, the diagonal granite wall highlighted in Figure 14 is contrasted with the rest of the architectural elements and materials in the space.

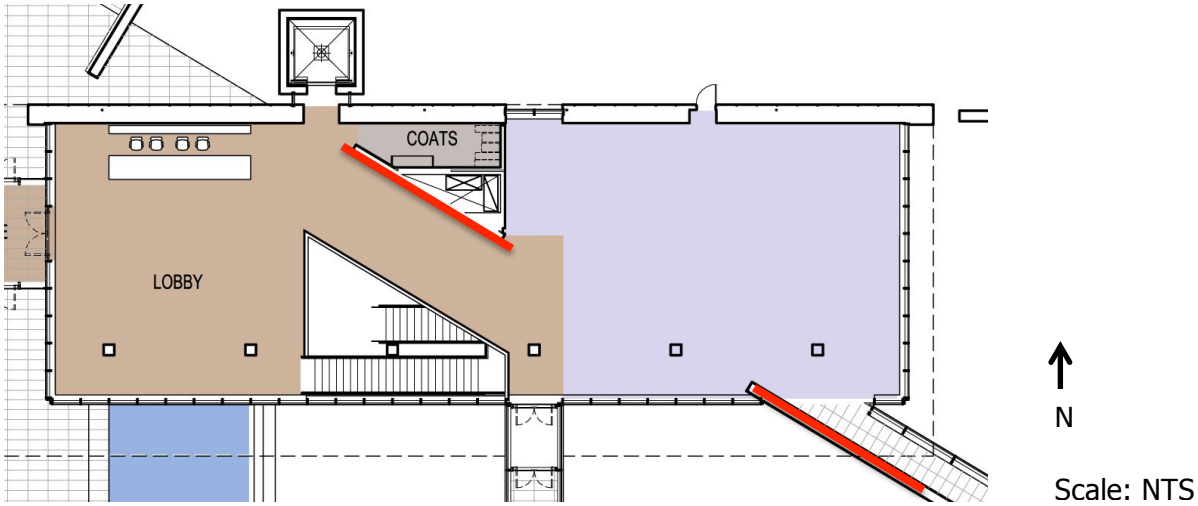


Figure 14: Lobby/Retail Plan

Design Execution

General Description

The diagonal wall mentioned above is illuminated by grazing it with light from the ceiling using a recessed linear fluorescent T5 fixture. This complements the exterior design elements, as the exterior granite walls are grazed from the bottom. Full lighting plans are available in Appendix A.

Throughout the space, flush mounted fixtures are used as much as possible. This complements the seeming simplicity of the architecture and does not take attention away from the wall surfaces. In the case of the wall behind the lobby desk, it is necessary to illuminate it to higher levels than normal to draw the guests' attention when entering the lobby space. To do this, recessed downlights/wall washers are used both to accent the wall and to provide useful illumination to the lobby desks.

As any space in a museum facility can temporarily turn into a small display area, it is necessary for the designed system to have the flexibility to support a variety of layouts. Therefore, two-circuit track down lighting is used in both the lobby and retail area. T5 linear fluorescent fixtures add light to the retail space to allow it to reach the illuminance design criteria. This linear fluorescent system will be on a photosensor dimming system to conserve energy throughout the day.

The two-circuit track lighting allows one circuit to be permanently dedicated to providing general illumination while the other track can be used as needed for small displays that will be set up in the lobby area. Having field flexibility with the length of the track allows the system to neatly complement the 30° diagonal wall, as recessed downlights would have made the ceiling busy and typical linear fluorescents would have not aligned well with the 30° diagonal.

To avoid having several dozen track fixtures protruding from the ceiling plan, the tracks were recessed as seen in Figure 15. This allows the ceiling to read as one plane and directs the focus of the space back onto the vertical surfaces in the space.

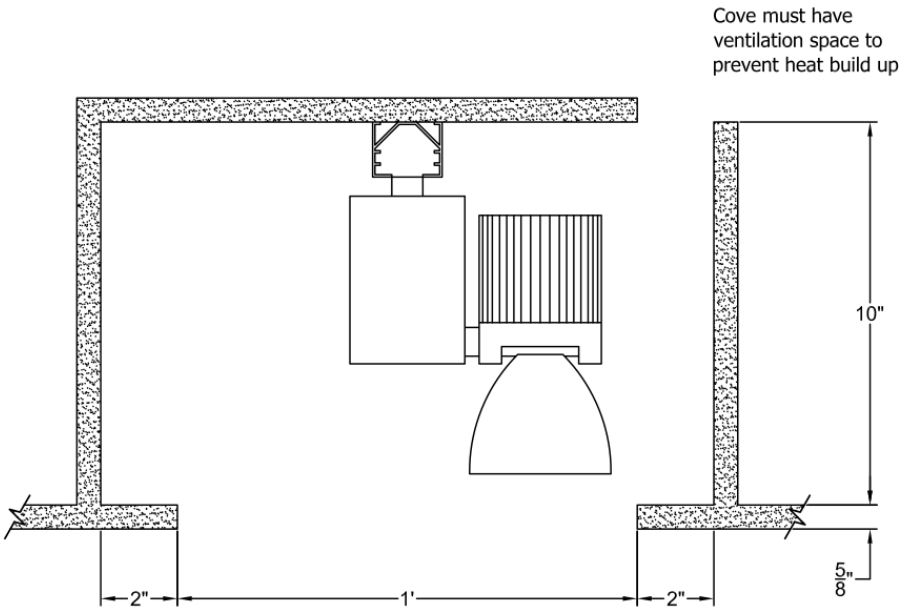


Figure 15: Track Fixture Mounting

Equipment

Type	Description	Mounting	Manufacturer	Product ID	Lamps	Input Watts
F15	LED 40° spotlight designed for the Xicato LED module, aluminum housing, interchangeable reflectors, lens and attachment accessories available, white, 3000K	Track	Lighting Services Inc.	LX200-H3M4	Xicato LED module	40
F16	LED 60° spotlight designed for the Xicato LED module, aluminum housing, interchangeable reflectors, lens and attachment accessories available, white, 3000K	Track	Lighting Services Inc.	LX200-C3M6	Xicato LED module	15
F17	High performance T5 linear fluorescent wall grazer, 20 ga steel housing, CNC roll-formed specular aluminum reflector	Ceiling	Focal Point	SL6F 4 GB 1T5	(1) F28T5	64
F18	Wash light (downlight and wall wash), 40° cutoff angle, cast aluminum housing, aluminum mirror finish anodized reflector, frosted glass diffuser, 3000K	Ceiling	Erco	46728	Xicato LED module	20
F19	Handrail light, heavy duty extuded Alumiinum Alloy construction, assymetric distribution, 3000K	railing	Intense		LED	4.2 W/ft

Light Loss Factor Calculations

Fixture	BF	LLD	LDD	LLF
ERCO downlight	-	0.70	0.91	0.64
ERCO downlight/wallwash	-	0.70	0.91	0.64
Mark Slot 6	1	0.92	0.91	0.84
Focalpoint Minigrazer	0.88	0.92	0.91	0.74
Lighting Services Inc. track fixtures	-	0.70	0.91	0.64

Design Performance

Summary

The performance of the lighting systems for the Lobby/Retail area is generally sufficient. The circulation illumination comes in high at thirteen footcandles – three footcandles over the recommended amount. The lighting system for the retail spaces is within the generally accepted 10% deviation: twenty-nine footcandles rather than thirty. To meet the power density requirements, it is necessary to limit the average dimmer output to 650W per circuit as is acceptable practice per ANSI/ASHRAE/IES Standard 90.1. SSc8 is attainable in the lobby space via Option 1, and IEQc8.1 is achieved due to the large expanses of glass curtain wall in the space.

Lighting

The lighting for the lobby was designed to the most demanding lighting situation; in this case, daytime conditions near the building entry. Even so, as previously mentioned, the illumination for lobby circulation is slightly high, while the retail space is within 10% of the IES recommendations. All spaces

fall within the uniformity ratios with the exception of the retail entrance vestibule. This is most likely due to the fact that handrail lighting is causing high illuminances at several calculation points.

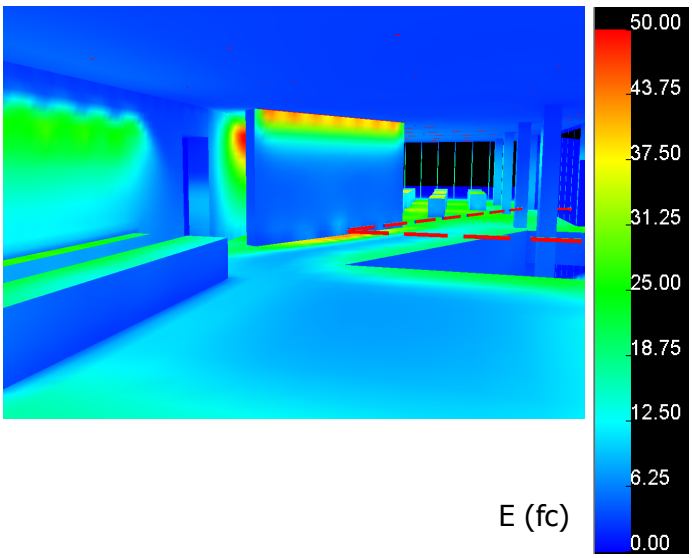
Three out of four exterior walls are a glazed curtain wall system; therefore, the spaces will be largely affected by daylight. A daylight study was performed to analyze the conditions throughout the year. Figure 16 tabulates the nine conditions that were analyzed and their results. A shading system was necessary to reduce daylight penetration. The specific shade properties are discussed more thoroughly in the Multi-Use section of the report.

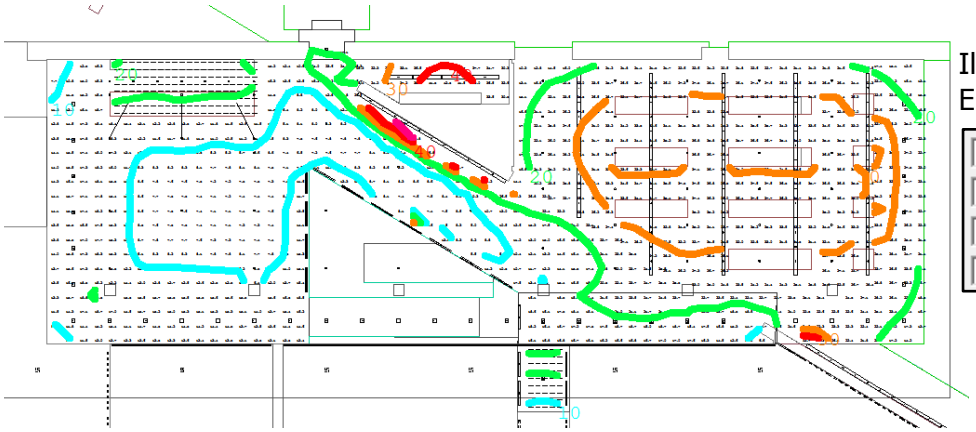
Condition	Description	Calculation Area	E_{avg}	E_{max}	E_{avg}/E_{min}	E_{Vavg}	E_{Vavg}/E_{Vmin}
1	Electric Light	Circulation	13.1	52.8	3.12	4.4	8.6
		Retail	29	37.9	2.82	11.3	4.8
		Lobby Desk	21	27	1.65	5.8	1.34
		Coatroom	33.6	42	2.05	-	-
		Retail Vestibule	54.2	241	9.34	-	-
2	9/21 at 12:00, clear	Circulation	789	4317			
		Retail	162	287			
3	9/21 at 12:00, overcast	Circulation	73	277			
		Retail	59	313			
4	9/21 at 9:00, clear	Circulation	569	2578			
		Retail	790	2783			
5	9/21 at 9:00, clear, with shades	Circulation	74	352			
		Retail	83	212			
6	9/21 at 15:00, clear	Circulation	595	3605			
		Retail	108	213			
7	9/21 at 15:00, clear, with shades	Circulation	60	262			
		Retail	35	167			
8	6/21 at 12:00, clear	Circulation	156	445			
		Retail	143	291			
9	12/21 at 12:00, clear	Circulation	913	2296			
		Retail	445	2037			

Figure 16: Illumination Results

Renderings from condition one, electric lighting can be seen in Figure 16. Illuminance contours for conditions two through nine can be found in Figures 18 through 26.

Figure 17: Condition 1, Electric Lighting





Illuminance Contour Key (fc):
Electric Light (Condition 1)

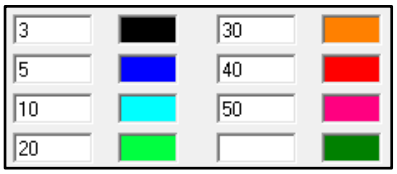
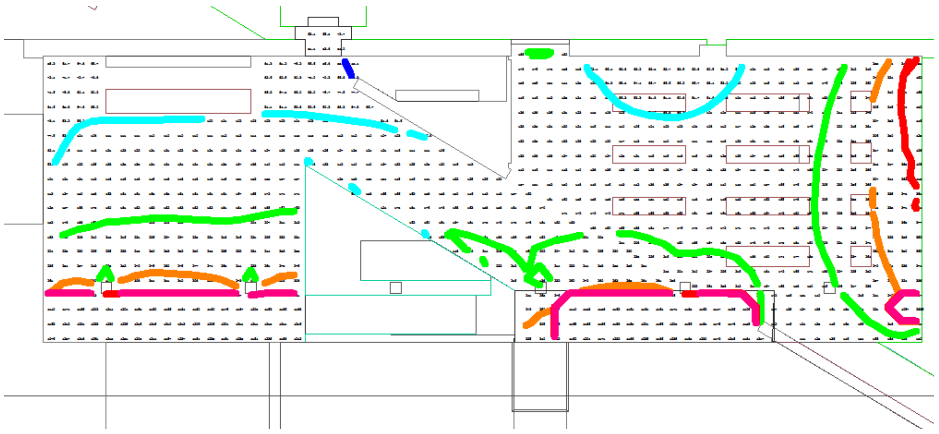


Figure 18: Condition 1 – Electric Light



Illuminance Contour Key (fc):
Daylight (Conditions 2-9)

Figure 19: Condition 2 – 9/21 at 12:00, clear

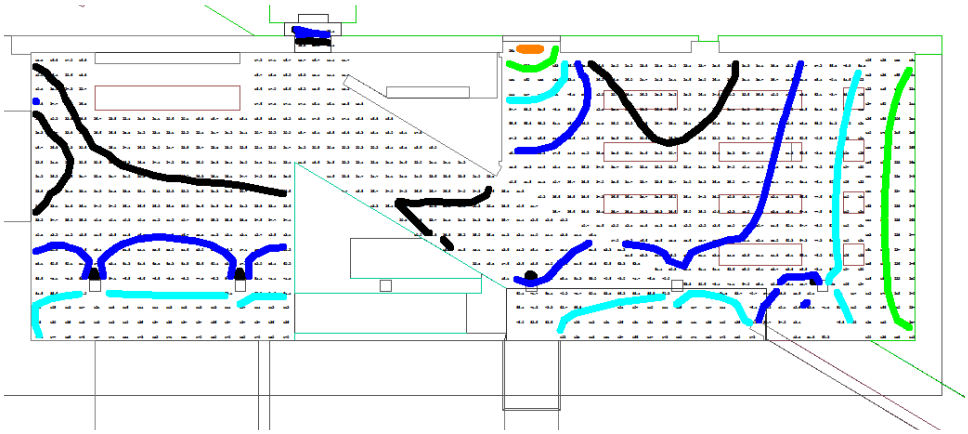


Figure 20: Condition 3 – 9/21 at 12:00, overcast

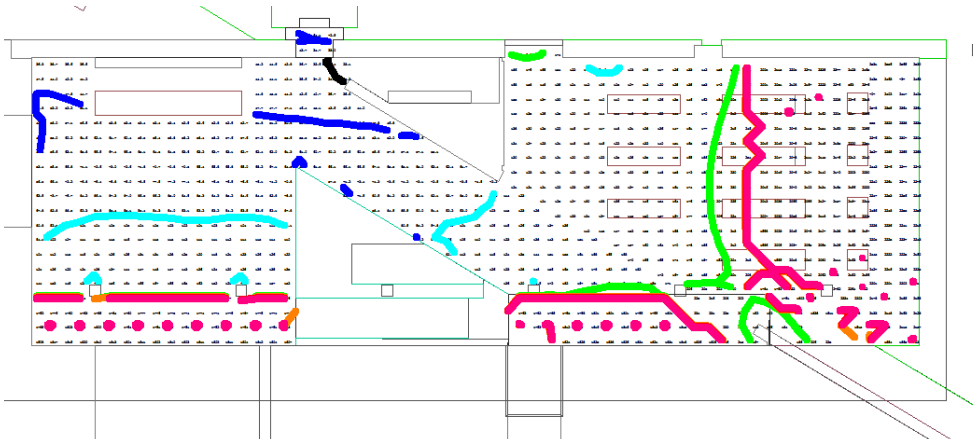


Figure 21: Condition 4 – 9/21 at 9:00, clear

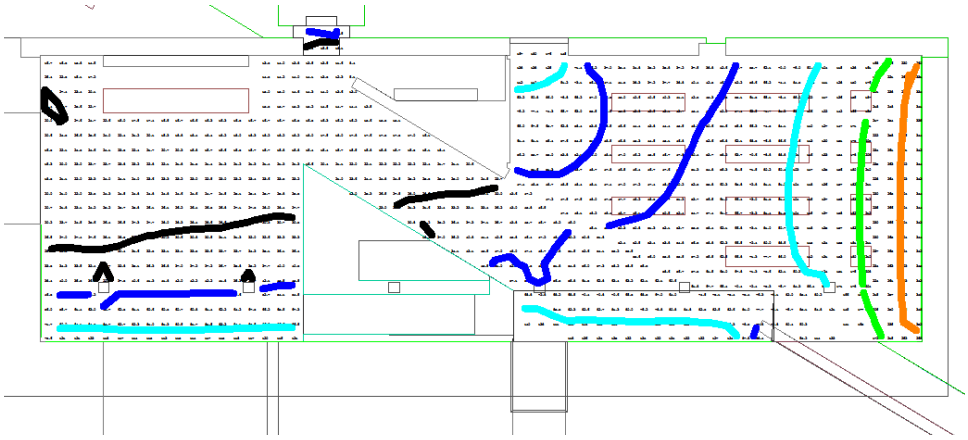


Figure 22: Condition 5 – 9/21 at 9:00, clear, with shades

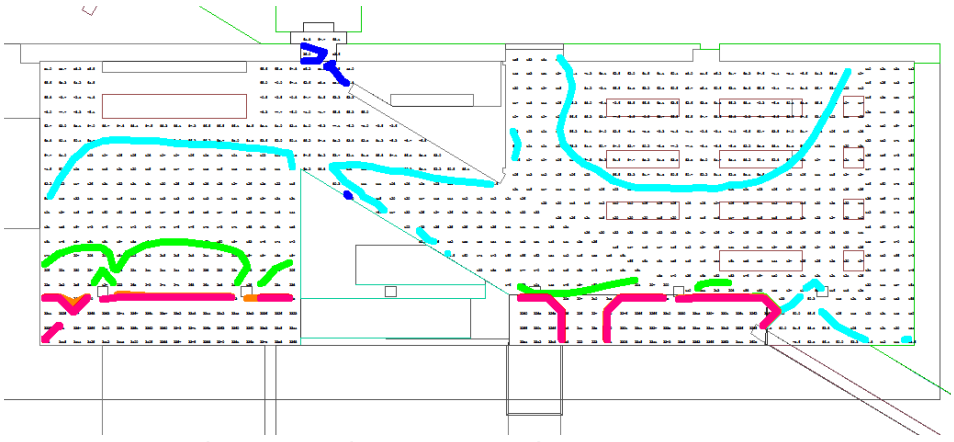


Figure 23: Condition 6 – 9/21 at 15:00, clear

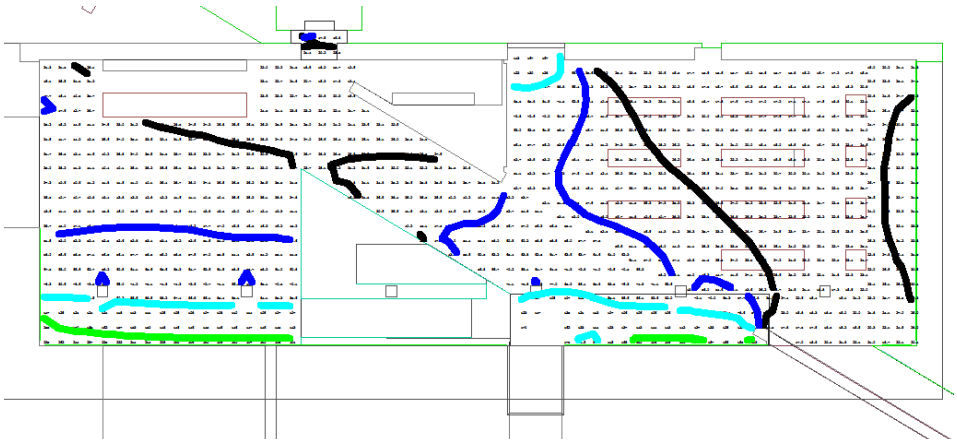


Figure 24: Condition 7 – 9/21 at 15:00, clear, with shades

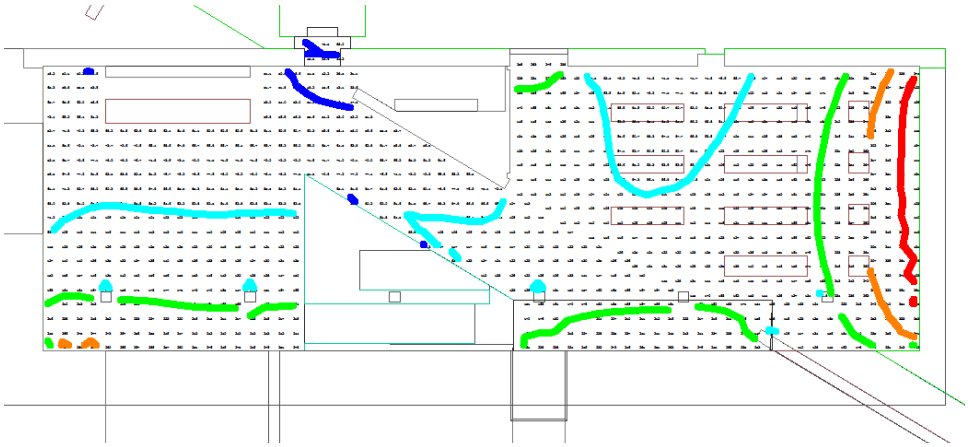


Figure 25: Condition 8 – 6/21 at 12:00, clear

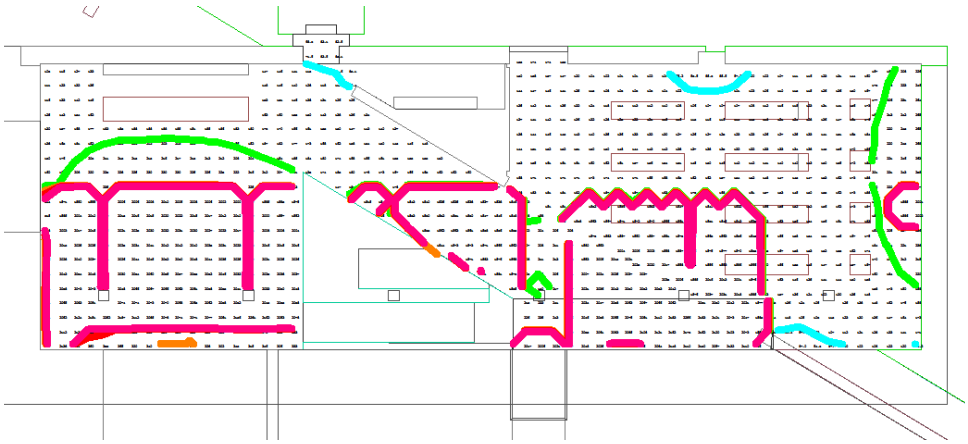


Figure 26: Condition 9 – 12/21 at 12:00, clear

Energy

To meet the power density requirements, it is necessary to limit the output of the Lutron dimming system to an average of 650W per circuit as is acceptable practice per ANSI/ASHRAE/IES Standard 90.1. This will cause no problems, as each LED track fixture uses only 15 watts. Power calculations are shown in Figure 27.

Tag	Wattage	Quantity	Sum Wattage
F5	27	37	999
F6	33	33	1089
F7	64	4	256
F8	650	8	5200
F16	33	6	198
F18	27	7	189
F39	96	4	384
		Total	8315
		Area (SF)	4210
		W/SF	**2.0**

Figure 27: Power Usage

Environmental

SSc8 is attainable in the lobby space via Option 1, as the Lutron control system can be configured to operate on a timeclock. EAc1 is outside of the scope of this study, although the replacement of most of the 50W MR-16 fixtures will certainly aid in reducing the energy footprint of the building. IEQc8.2 is easily achievable, as three out of four exterior walls in both the Multi-Use and Lobby/Retail spaces are constructed of a glass and aluminum curtain wall system.

Multi-Use Area

Architectural Description

Function and Layout

The multi-use/display area is located on the first floor of the Visitors, Exhibition, and Conference Center (VECC) portion of The Clark. It will be used as flex space for events, conferences and displays. The multi-use/display area measures 39’ x 86’ and has an area of 3,317 SF. Interior columns are located 7’ off of the glass curtain wall on the South side of the space. The main entrances to the VECC/plant addition are located in a class vestibule that is adjacent to the west wall of the multi-use/display area space. A stairs at the west end of the space, adjacent to an elevator and behind a concrete wall leads to the basement floor. A pantry is located at the extreme west end of the space. Other than these few elements of the space, the Multi-Use space is generally empty, allowing easy transformation into whatever form is best for the needed activity.

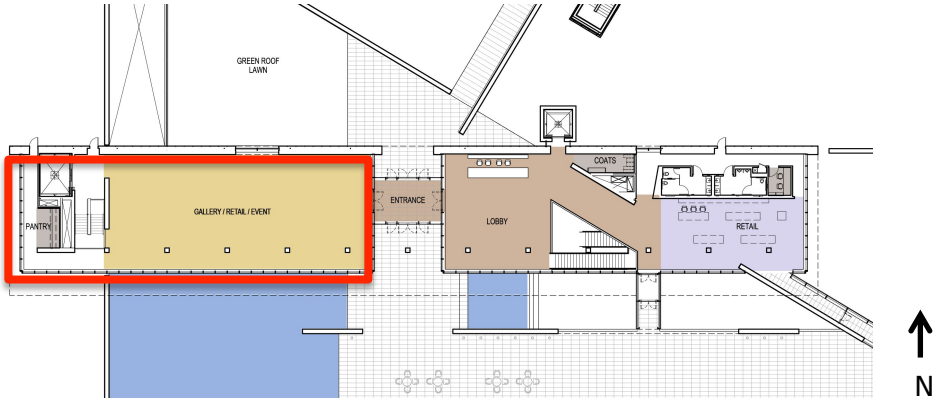


Figure 28: Multi-Use Space

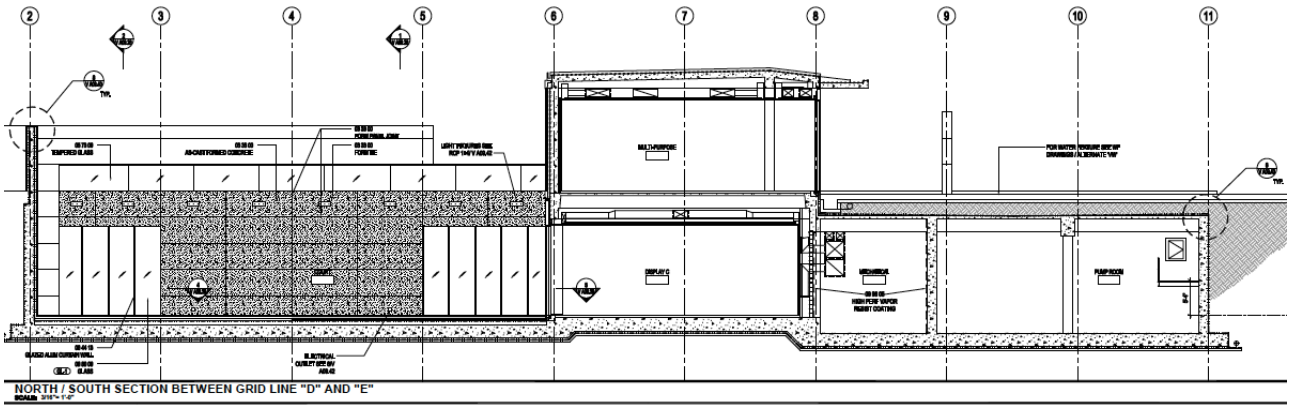


Figure 29: Multi-Use North South Section

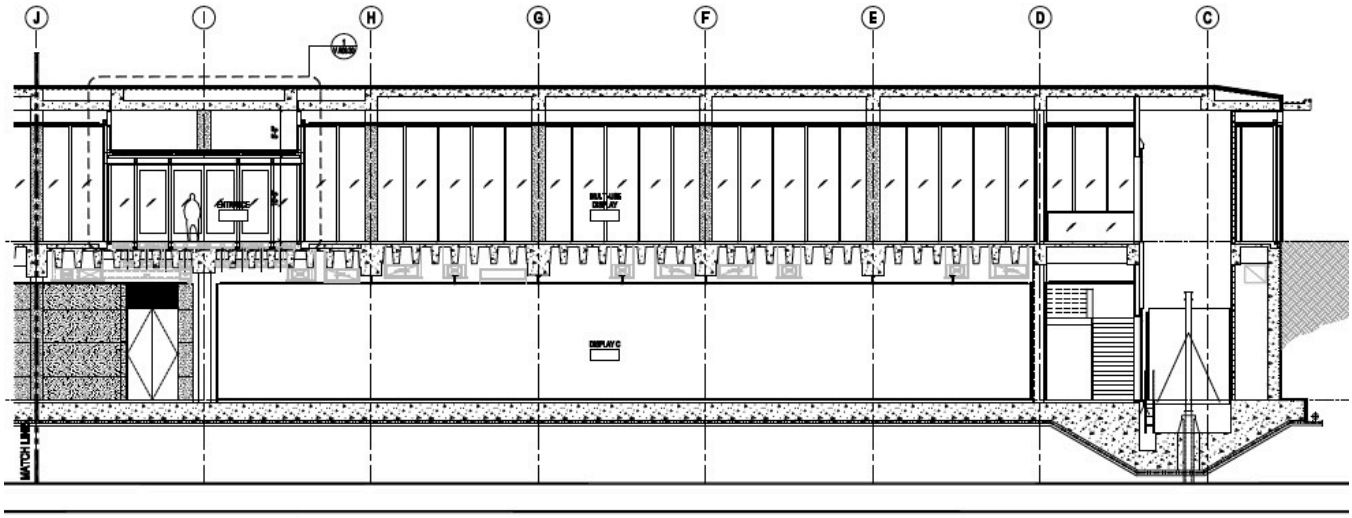


Figure 30: Multi-Use East West Section

Materials

Location	Material	Color	Reflectance	Description
Ceiling	GWB	White	0.8	Painted matte finish
Wall	Architectural Concrete	Off White	0.34	Standard 4' x 8' panels
Wall	Aluminum Mullions	Gray	0.3	Matte anodized aluminum
Wall	Glass	No color	Tvis = 0.63	Low E, spectrally selective
Floor	Wood	Brown	0.2	White Oak, semigloss finish

Design Criteria and Considerations

Lighting

Recommended Illuminances (IES Lighting Handbook, 10th Edition)

- Circulation Spaces, Horizontal – 40 lux
- Circulation Spaces, Vertical Illuminance – 40 lux
- Object, Artwork Spaces, Horizontal Illuminance – 200 lux
- Object, Artwork Spaces, Vertical Illuminance – 200 lux
- Conferencing, Horizontal Illuminance – 300 lux
- Conferencing, Vertical Illuminance – 75 lux
- Reading and Writing, Horizontal Illuminance – 500 lux
- Reading and Writing, Vertical Illuminance – 75 lux
- Pantry, Horizontal Illuminance – 200 lux
- Pantry, Vertical illuminance – 100 lux

Recommended Uniformity (IES Lighting Handbook, 10th Edition)

- Circulation Spaces, Avg:Min – 4:1
- Object/Artwork spaces, Avg:Min – 2:1
- Conferencing, Avg:Min – 1.5:1
- Reading and Writing, Avg:Min – 1.5:1
- Pantry, Avg:Min – 2:1

UV Radiation

- Expensive artwork needs to be protected from harmful UV rays which could leech color and deteriorate artwork

Glare

- Glare can cause discomfort while viewing artwork
- Glare from the floor and exterior reflecting pools can make viewing artwork difficult or impossible

Flexibility

- The Multi-Use space, as the name suggests, must have a flexible and versatile lighting system that will serve the needs of many functions
- The lighting system needs to be able to be controlled with separate zones, should partitions be used

Energy

Power Density (ANSI/ASHRAE/IES Standard 90.1)

- Maximum Power Density: Museum General Exhibition – 1.0 W/SF
- Additional Interior Lighting Power: Decorative Light Allowance – 1.0 W/SF

Environmental (LEED for new construction Version 2.2)

SS Credit 8: Light Pollution Reduction

- Reduce light pollution via options discussed in Appendix X.

EA Credit 1

- Perform a whole building energy simulation and demonstrate a 12-48% improvement in performance compared with the baseline building performance rating (for 1-19 points)
- Baseline building shall be based on ASHRAE 90.1 standards

IEQ Credit 8.1 Daylight and Views – Daylight

- Achieve daylight in at least 75% of occupied spaces as described by the options in Appendix B

IEQ Credit 8.2 Daylight and Views – Views

- Achieve direct line of sight to the outdoor environment via vision glazing between 30 inches and 90 inches above the finish floor for building occupants in 90% of all regularly occupied areas

Concept

The concept for the Multi-Use space follows in the footsteps of the lobby design concept. The focus is again on the walls (with the aid of the track lighting). Clean, straight fixture lines reflect the elemental style of the architecture and do not detract and fill up the space. This supports the open "emptiness" that Ando's buildings are known for.

Design Execution

General Description

Flush mounted, recessed linear fluorescent fixtures illuminate the space to the 50 footcandles for the more light intensive tasks in the space. A perimeter of square, recessed LED lights illuminate the circulation area around the outside rim of the space, and will be switched off most of the day due to the plentiful amount of daylight. Linear fluorescent fixtures provide ambient illumination and will be on a photosensor dimming system to conserve energy. In between the rows of linear fluorescent fixtures tracks are mounted in recessed coves. High CRI LED track mounted fixtures will be the primary source of illumination when the space is being used for displays. Lighting levels for the display system were not calculated due to the highly variable nature of track lighting in display spaces.

On the west end of the space, a recessed cove system illuminates the elevator and stair wall. 11" x 17" lighting plans can be found in Appendix A.

Throughout the space, flush mounted fixtures were used when possible. Similarly to the Lobby/Retail space, the track fixtures were mounted in a recessed cove, allowing the ceiling to render as an uncluttered plane to the viewer.

Equipment

Type	Description	Mounting	Manufacturer	Product ID	Lamps	Input Watts
F5	Recessed LED square downlight, cast aluminum housing, darklight aluminum reflector with satin matt anodised finish, 40° cut-off angle, frosted diffuser, 3000K	Ceiling	Erco	3671-2000	LED	27
F6	Recessed linear fluorescent downlight, 4' length, cold-rolled steel housing, aluminum trim, matte white finish, steel reflector (white), 1/4" frosted clear acrylic lens (flush)	Ceiling	Mark Architectural	SL6F 4 GB 2T5	(2) F28T5	64
F7	Recessed linear fluorescent downlight, 4' length, cold-rolled steel housing, aluminum trim, matte white finish, steel reflector (white), 1/4" frosted clear acrylic lens (flush)	Ceiling	Mark Architectural	SL6F 4 GB 1T5	(1) F28T5	33
F8	Extruded aluminum surface track, 4' lengths, two circuit 40 amp capacity, separate neutral for each circuit, white finish	Ceiling	Lighting Services Inc.	Surface Track 120/250	-	40 Amps per track across two circuits*
F9	Extruded aluminum surface track, 4' lengths, two circuit 40 amp capacity, separate neutral for each circuit, white finish	Ceiling	Lighting Services Inc.	Recessed Track 120/250	-	40 Amps per track across two circuits*
F10	Recessed perimeter linear fluorescent, steel housing, high-reflectance aluminum reflector, extruded aluminum wall rail	Ceiling	Litecontrol	Wall/Slot 2100	(1) F28T5	33
F11	Directional Downlight designed for Xicato LED module, rotation and tilt easily changed in the field from below, specular Alzac cone reflector, 3000K	Ceiling	Kurt Versen	A5145	Xicato LED module	23
F12	LED 60° spotlight designed for the Xicato LED module, aluminum housing, interchangeable reflectors, lens and attachment accessories available, white finish, 3000K	Track	Lighting Services Inc.	LX2000-D3M6	Xicato LED module	15
F13	LED 20° spotlight designed for the Xicato LED module, aluminum housing, interchangeable reflectors, lens and attachment accessories available, white finish, 3000K	Track	Lighting Services Inc.	LX2000-C3M2	Xicato LED module	15
F14	LED 40° spotlight designed for the Xicato LED module, aluminum housing, interchangeable reflectors, lens and attachment accessories available, white finish, 3000K	Track	Lighting Services Inc.	LX2000-C3M4	Xicato LED module	15

*40 Amps per track is equivalent to 4800 VA or 3936 W with the proposed fixtures (BF=0.82)

Light Loss Factor Calculations

Fixture	BF	LLD	LDD	LLF
Mark Slot 6	1	0.92	0.91	0.84
Kurt Versen	1	0.70	0.91	0.64
Lightcontrol Wallslot	0.88	0.92	0.91	0.74
Erco Downlight	1	0.7	0.91	0.64

Design Performance

Summary

The lighting system analyzed provided the necessary 50 footcandles of horizontal illumination with an average of 48.8 footcandles. To meet the vertical illumination of the perimeter circulation zone, the amount of lumens put on the circulation are was increased, which drove circulation horizontal average up to 13.4, which was significantly above the necessary 4 footcandles. The pantry lighting requirement was high, but achieved with a horizontal illuminance average of 25 footcandles. To meet ANSI/ASHRAE/IES Standard 90.1, a maximum of 300 watts must be programmed on each Lutron dimmer. Shades were necessary to meet LEED IEQc6.1.

Lighting

The lighting for the spaces was designed to 50 footcandles to meet the requirements for the most light intensive tasks that would be performed in the space. Per the occupants' request, dimmer preset levels can be programmed into the Lutron control system. The extra costs of the dimming ballast are already present as the linear fluorescent system will be operating on a photosensor dimming system to take full advantage of the large amount of daylight that the system gets throughout the year as seen in Figures 31 and 32.

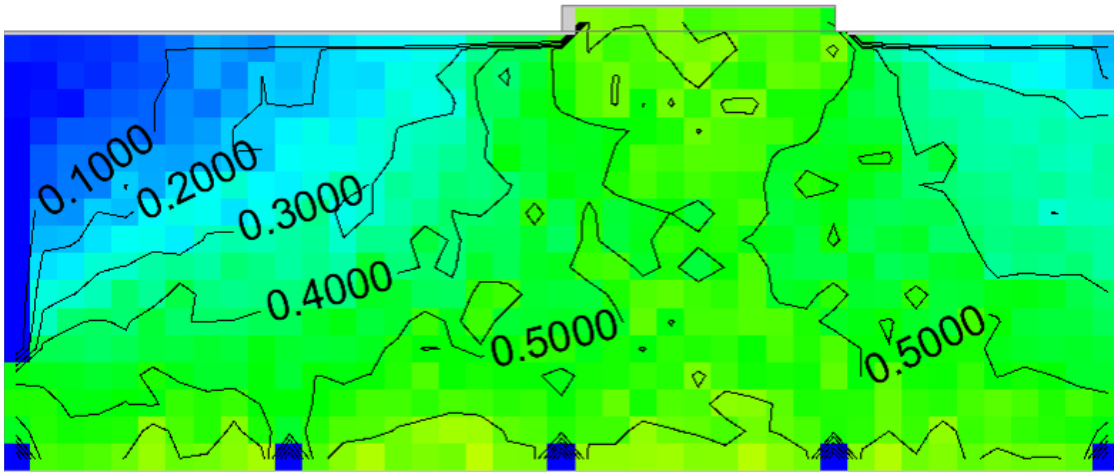


Figure 31: Useful Daylight Autonomy – Display Area

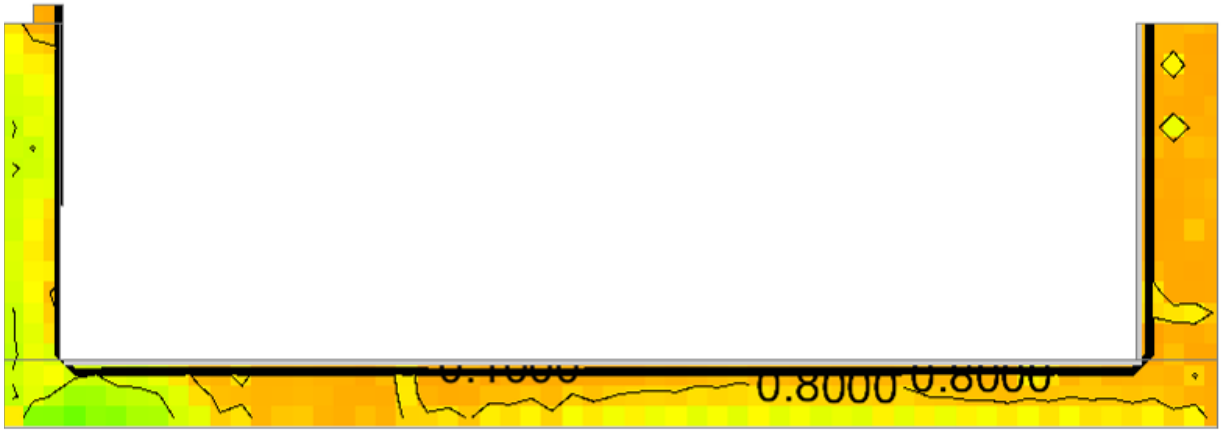


Figure 32: Useful Daylight Autonomy – Circulation Area

Eight separate lighting conditions were analyzed determine the space's performance throughout the year, as a large portion of the space will be daylight for most of the occupied hours. Condition 1 below is the electric light, and detailed performance data for the separate lighting requirements in the space is given in Figure 33. Figure 34 shows a rendering of the space with the electric lighting conditions and Figures 35 through 43 show the light distribution for the eight conditions.

Condition	Description	Calculation Area	E_{avg}	E_{max}	E_{avg}/E_{min}	E_{Vavg}	E_{Vavg}/E_{Vmin}
1	Electric Light	Circulation	13.44	23.2	3.95	4.4	5.3
		Gallery	48.8	61.7	2.33	23.1	7.9
		Pantry	25.4	28.5	1.3	8.1	1.25
2	9/21 at 12:00, clear	Circulation	2309	4568			
		Gallery	251.9	463			
3	9/21 at 12:00, overcast	Circulation	155	362			
		Gallery	66	290			
4	9/21 at 9:00, clear	Circulation	927	1980			
		Gallery	148	264			
5	9/21 at 9:00, clear, with shades	Circulation	74	224			
		Gallery	46	152			
6	9/21 at 15:00, clear	Circulation	2309	4676			
		Gallery	202	385			
7	9/21 at 15:00, clear, with shades	Circulation	184	442			
		Gallery	66	174			
8	6/21 at 12:00, clear	Circulation	286	490			
		Gallery	152	277			
9	12/21 at 12:00, clear	Circulation	1743	4232			
		Gallery	1284	2359			

Figure 33: Lighting Condition Data

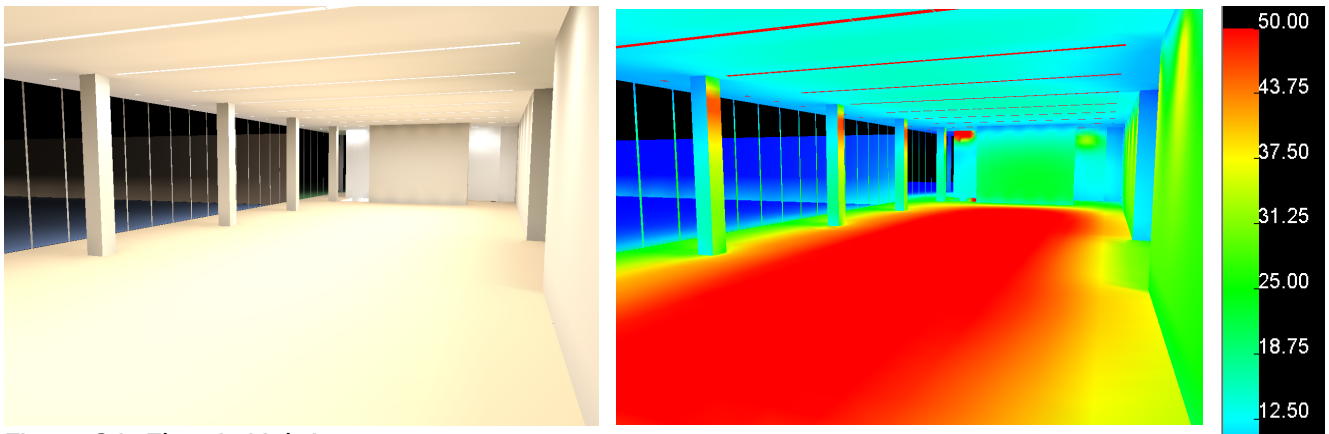
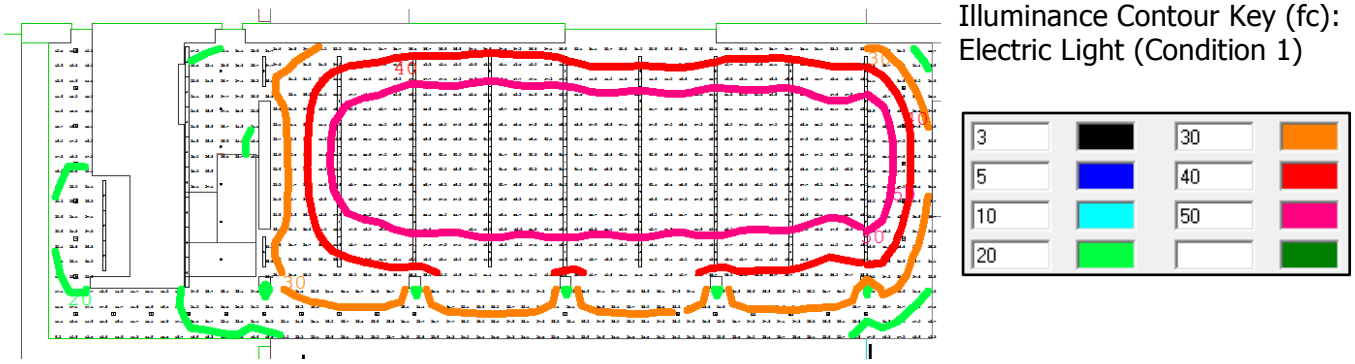


Figure 34: Electric Lighting



Fixture 35: Condition 1 - Electric Light

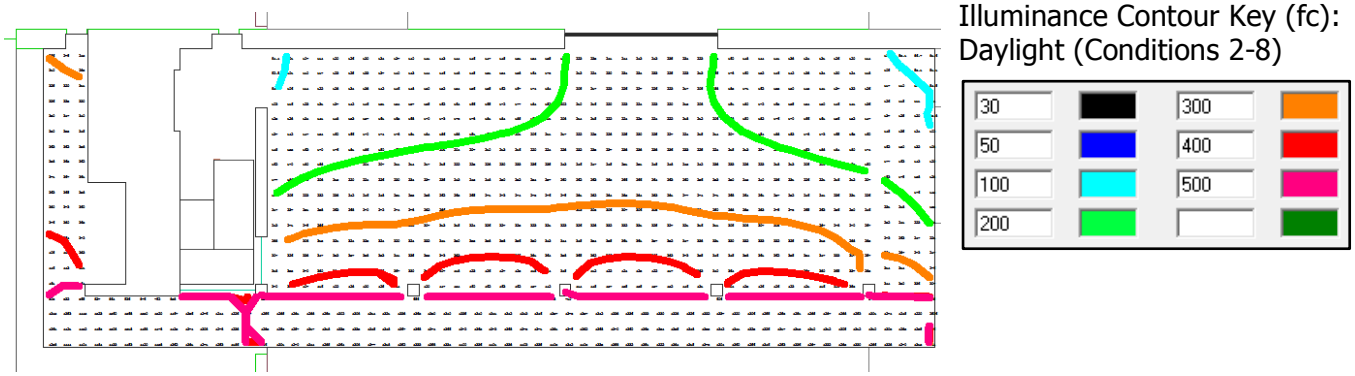


Figure 36: Condition 2 – 9/21 at 12:00, clear

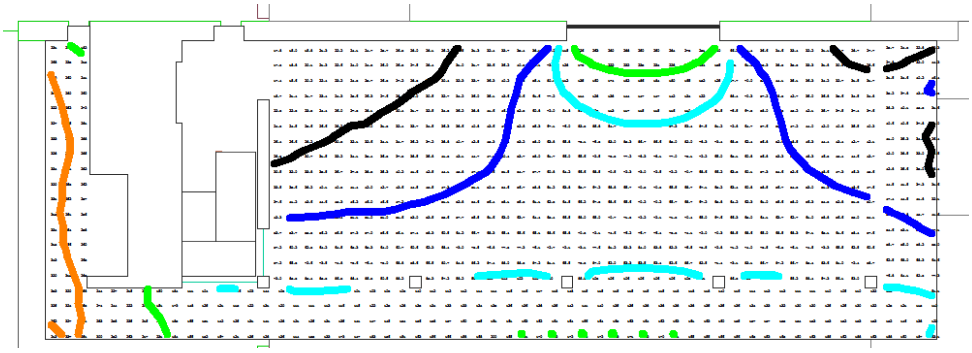


Figure 37: Condition 3 – 9/21 at 12:00, overcast

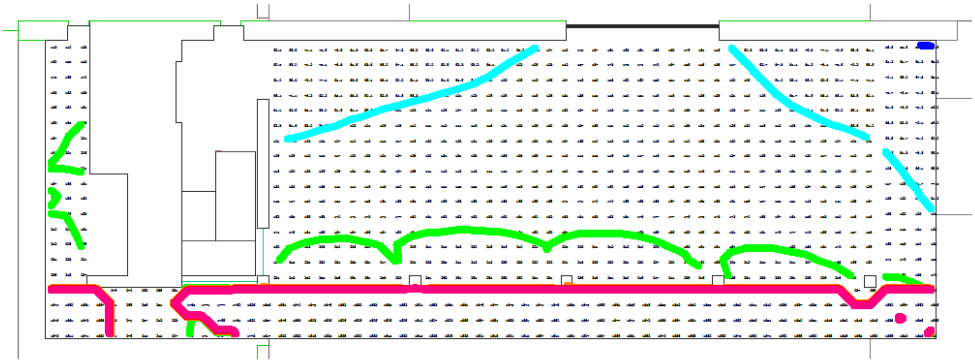


Figure 38: Condition 4 – 9/21 at 9:00, clear

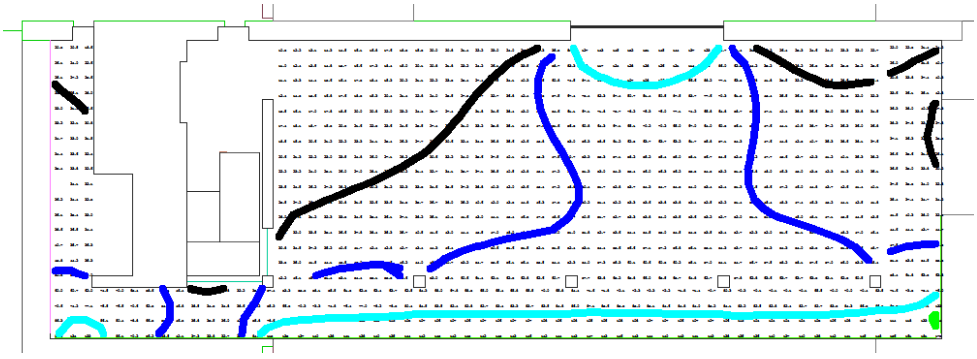


Figure 39: Condition 5 – 9/21 at 9:00, clear, with shades

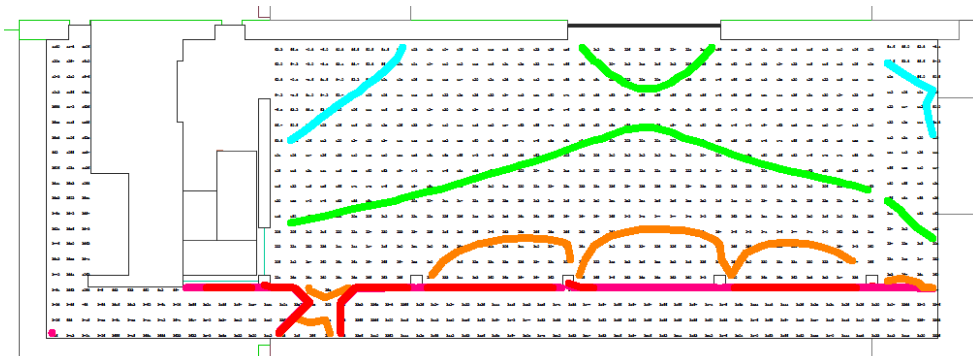


Figure 40: Condition 6 – 9/21 at 15:00, clear

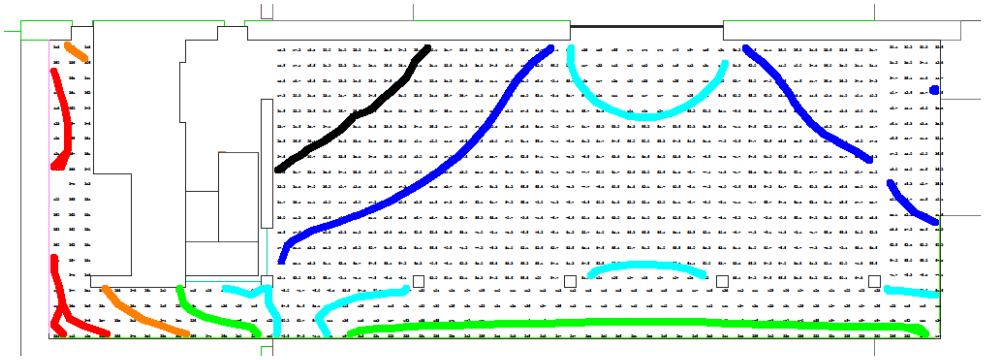


Figure 41: Condition 7 – 9/21 at 15:00, clear, with shades

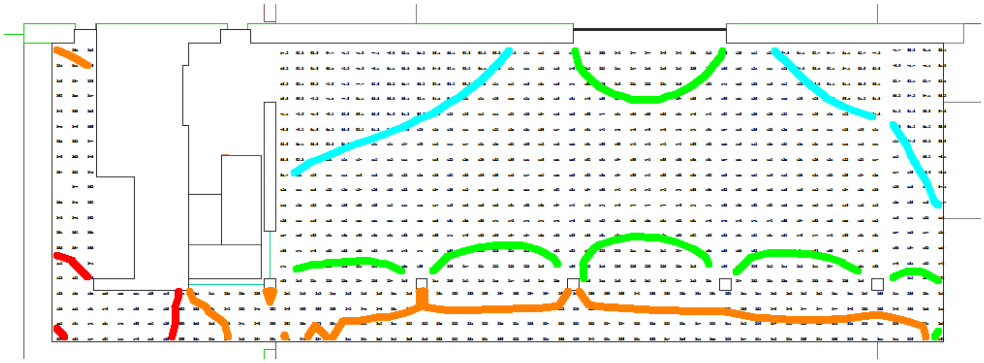


Figure 42: Condition 8 – 6/21 at 12:00, clear

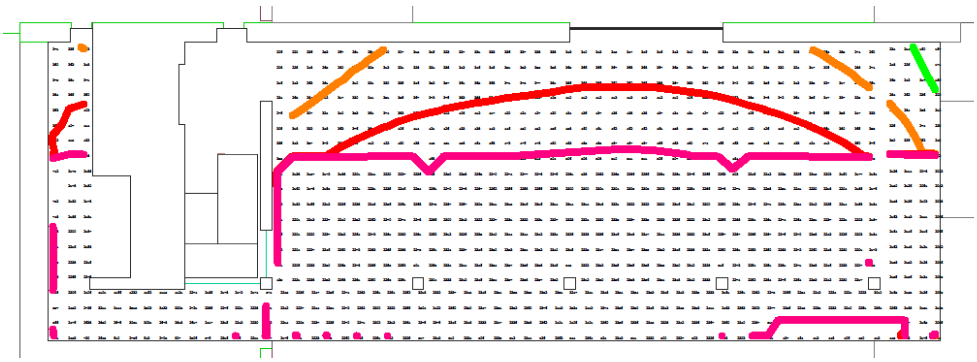


Figure 43: Condition 9 – 12/21 at 12:00, clear

To achieve LEED IEQc6.1 it was determined that shades were necessary to reduce the afternoon equinox sunlight penetration. Pearl/Sable colored SheerShade by Lutron (see Figure 44) was chosen and used to reduce the work plane illuminance maximum to below 500 footcandles on 9/21 at 3pm. Pearl/Sable SheerShade provides the space with a visible transmittance of 11% and a reflectance of 33%. The design of the shades also preserves a view of the exterior, which is important for LEED IEQc6.1.

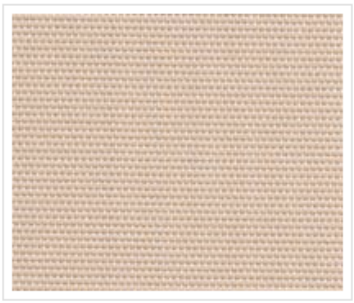


Figure 44: SheerShade

Energy

The power density of the multipurpose space exceeds the 2 W/SF limit (includes 1 W/SF decorative allowance) if the standard of 30 W/LF is used for the track system. However, the newest ANSI/ASHRAE/IES Standard 90.1 allows the control system to limit the power output, which in this case, is 500W per circuit.

Tag	Wattage	Quantity	Sum Wattage
F5	27	36	972
F6	64	58	3712
F7	33	3	99
F8/F9	11	300	3300
F10	33	8	264
F11	23	17	391
		Total	8347
		Area (SF)	4161
		W/SF	**2.0**

Figure 45: Power Density

Environmental

SSc8 can be met by Option 1, as the transmittance of the shades is inadequate for Option 2. (See Appendix E) EAc1 is outside of the scope of this study, although the replacement of most of the 50W MR-16 fixtures will certainly aid in reducing the energy footprint of the building. IEQc8.2 is easily achievable, as three out of four exterior walls in both the Multi-Use and Lobby/Retail spaces are constructed of a glass and aluminum curtain wall system.

Wood Shop

Architectural Description

Function and Layout

The wood shop is located on the basement floor in the plant portion of The Clark. It is used to fabricate frames for non-standard sizes of artwork. The maximum dimensions of the space are 70’ x 30’. It contains workbenches along the Northwest and Southeast walls of the room and a table saw in the center of the room. There is 7’ x 9’ paint storage room in the west-most corner of the space and a large storage rack towards the south end of the space.

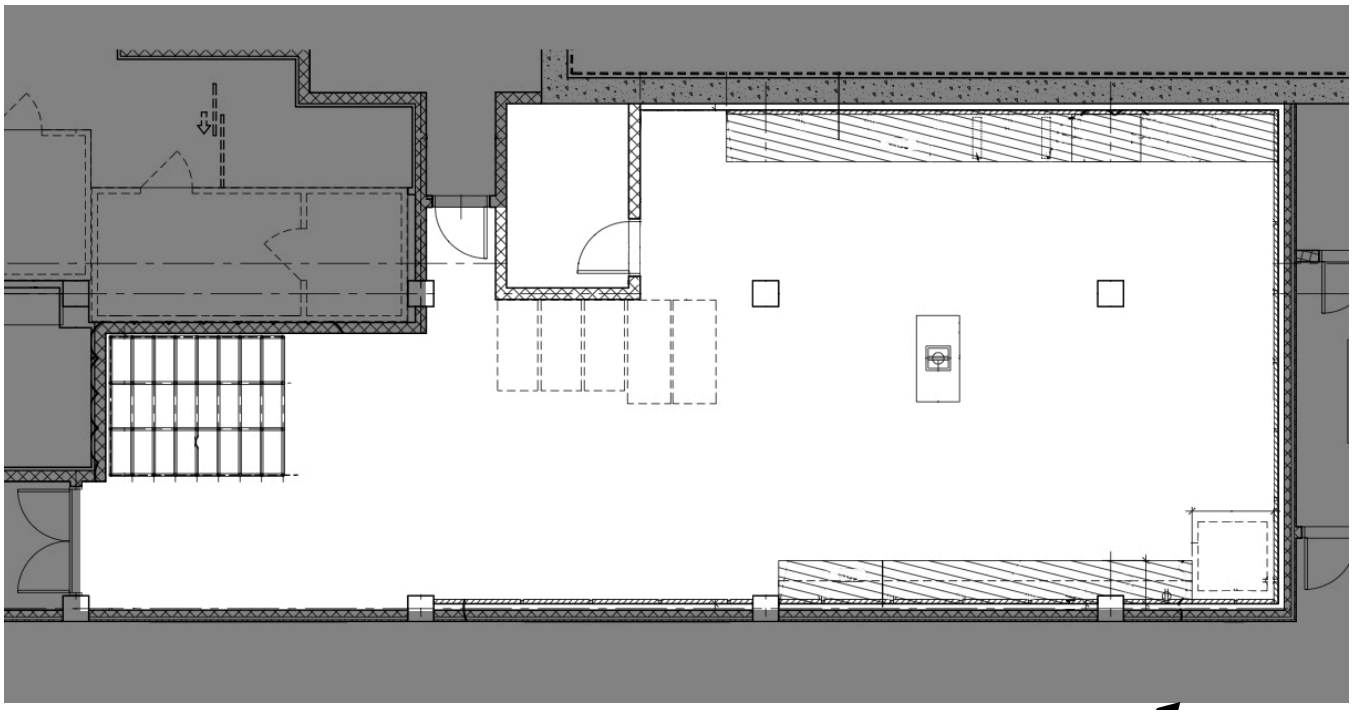


Figure 46: Wood Shop Plan Scale: NTS N

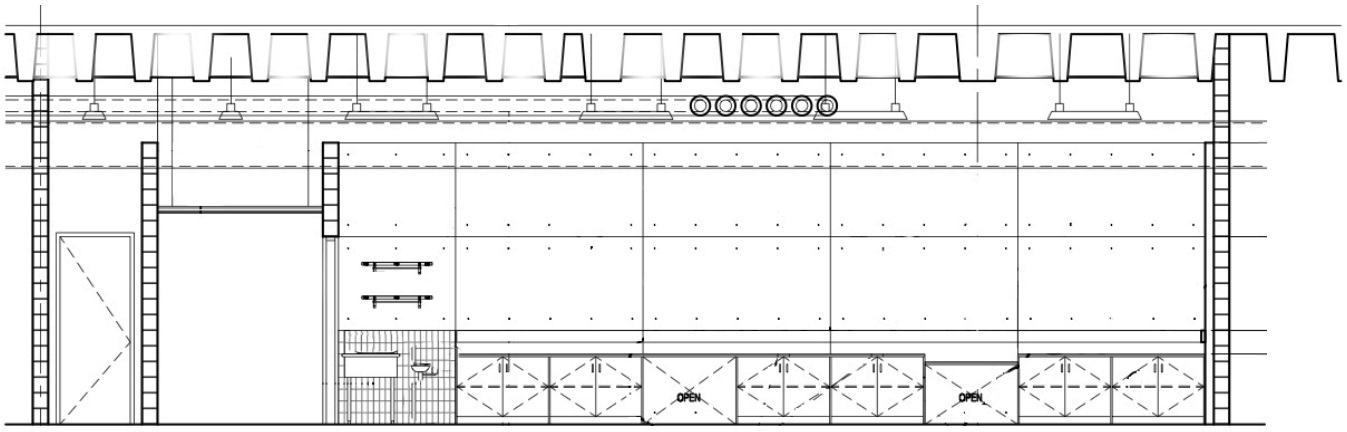


Figure 47: Wood Shop Section Scale: NTS

Materials

Location	Material	Color	Reflectance	Description
Ceiling	Concrete	Gray	0.34	Cast in place structural system
Wall	Plywood	Brown	0.4	Standard 4' x 8' panels
Floor	Rubber Flooring	Dark Gray	0.2	N/A
Wall	CMU	Off White	0.8	Painted matte finish
Paint Storage Ceiling	GWB	Off White	0.8	Painted matte finish

Design Criteria and Considerations

Lighting

Recommended Illuminances (IES Lighting Handbook, 10th Edition | Table 30.2)

- Work Area, Horizontal – 500 lux
- Work Area, Vertical – 500 lux
- Paint Storage, Horizontal – 150 lux
- Paint Storage, Vertical – 75 lux

Uniformity Targets (IES Lighting Handbook, 10th Edition | Table 30.2)

- Work Area, Avg:Min – 3:1
- Paint Storage, Avg:Min – 5:1

Glare

- Reflected glare can create difficult and dangerous working conditions.

Light Distribution

- Sufficient uniformity in the main space is needed for a pleasant working environment.
- Higher illumination on the workbenches is needed for more detailed work.

Maintenance
- The dirty environment of a wood shop necessitates fixtures that will not accumulate dirt particles and wood dust.
- Vapor resistant lighting equipment is needed for the paint storage room.

Desired Subjective Impression: Visual Clarity (IES Handbook, 10th Edition | Table 12.2)
- Create bright, uniform lighting.
- Create bright ceiling and work surfaces with some peripheral emphasis.

Energy

Power Density (ANSI/ASHRAE/IES Standard 90.1)
- Workshop – 1.9 W/SF

Environmental (LEED for new construction Version 2.2)

EA Prerequisite 2
- Meet minimum energy requirements based on ANSI/ASHRAE/IES Standard 90.1.

EA Credit 1
- Perform a whole building energy simulation and demonstrate a 12-48% improvement in performance compared with the baseline building performance rating (for 1-19 points)
- Baseline building shall be based on ANSI/ASHRAE/IES Standard 90.1 standards

IEQ Credit 6.1
- Provide lighting controls for at least 90% of the building occupants to enable adjustments to suit individual task needs and preferences.

Concept
The concept for the wood shop was to illuminate alternating voids in between the beams of the structural system. After significant computer modeling efforts, it was discovered that this concept was not feasible due to the mechanical equipment that is suspended from the ceiling of the wood shop. Additionally, the mid semester critique revealed that this space was more utilitarian than previously observed. Consequently, the focus of the lighting design for the space turned primarily to the functional purposes of lighting design, namely providing adequate lighting that supports the purpose of the space.

Design Execution

General Description
The lighting for the wood shop reflects the utilitarian nature of the space. Four-foot industrial linear fluorescent fixtures illuminate the main workspace evenly and economically. Using a larger quantity of shorter fixtures increases the uniformity of the work plane and does not significantly contribute to visual clutter in the space, as the ceiling of the space contains exposed equipment for several building systems. The fixture type was chosen for its performance in dusty environments, and is designed to prevent the accumulation of debris. A sealed vapor resistant fixture was chosen for adjacent paint

storage room. LED task lights provide light to the workbench located beneath the cabinets and along the southeast wall of the space.

Equipment

Type	Description	Mounting	Manufacturer	Product ID	Lamps	Input Watts
F1	Industrial linear fluorescent semi-direct, embossed reflectors with inward flange to prevent debris accumulation	Pendant	Cooper	EIM-232	(2) F32T8XL SPX35HCVG by GE	69
F2	Industrial linear fluorescent semi-direct, embossed reflectors with inward flange to prevent debris accumulation	Pendant	Cooper	EIM-332	(3) F32T8XL SPX35HCVG by GE	104
F3	Industrial linear fluorescent direct, reinforced fiberglass housing with high impact diffuser to withstand exposure to corrosive vapors	Ceiling	Cooper	VT2	(2) F32T8XL SPX35HCVG by GE	69
F4	Direct line voltage LED, extruded aluminum and polycarbonate housing, gray powder coat finish	Surface (under cabinet)	Color Kinetics	523-000028-80	LED	20

Light Loss Factor Calculations

Fixture	BF	LLD	LDD	LLF
Cooper EIM-232	1.15	0.94	0.73	0.79
Cooper EIM-332	1.18	0.94	0.73	0.81
Cooper VT2	0.77	0.94	0.85	0.62
ColorKinetics eW Profile Powercore	-	0.7	0.73	0.51

Design Performance

Summary

The lighting systems fulfill their primarily functional objective of illuminating the workspace and provide 528 lux and 254 lux to the workspace and paint storage area, respectively. The power density for the space is 1.3 W/SF and falls beneath the required 1.9 W/SF, aiding the building in potentially qualifying for LEED EA Credit 1.

Lighting

The work area illuminance at the 2.5’ work plane average 528 lux. The value

The workspace area is within the 10% of the recommended value of 500 lux. The many pieces of mechanical equipment hung from the ceiling of the space were not included in the computer lighting analysis and will trap some light. An average of 528 lux allows the actual illuminance enough room to fall and still remain within the desired limits. The illuminance level of 254 lux in the paint storage room is significantly over the 150 lux recommended for storage spaces. However, rather than reduce the amount of light provided for the space, the levels were accepted. This was done to prevent the space from seeming exceptionally dark when entering the space after being exposed to higher light levels.

The EIM fixtures from Cooper provide approximately 20% uplight and 80% downlight. This allows enough light to reach the ceiling to prevent it from seeming void and aids in the impression of spaciousness. Uniform light around the space is the main contributor to the impression of spaciousness. Peripheral emphasis is provided by the task light on the southeast wall of the space, below the cabinets.

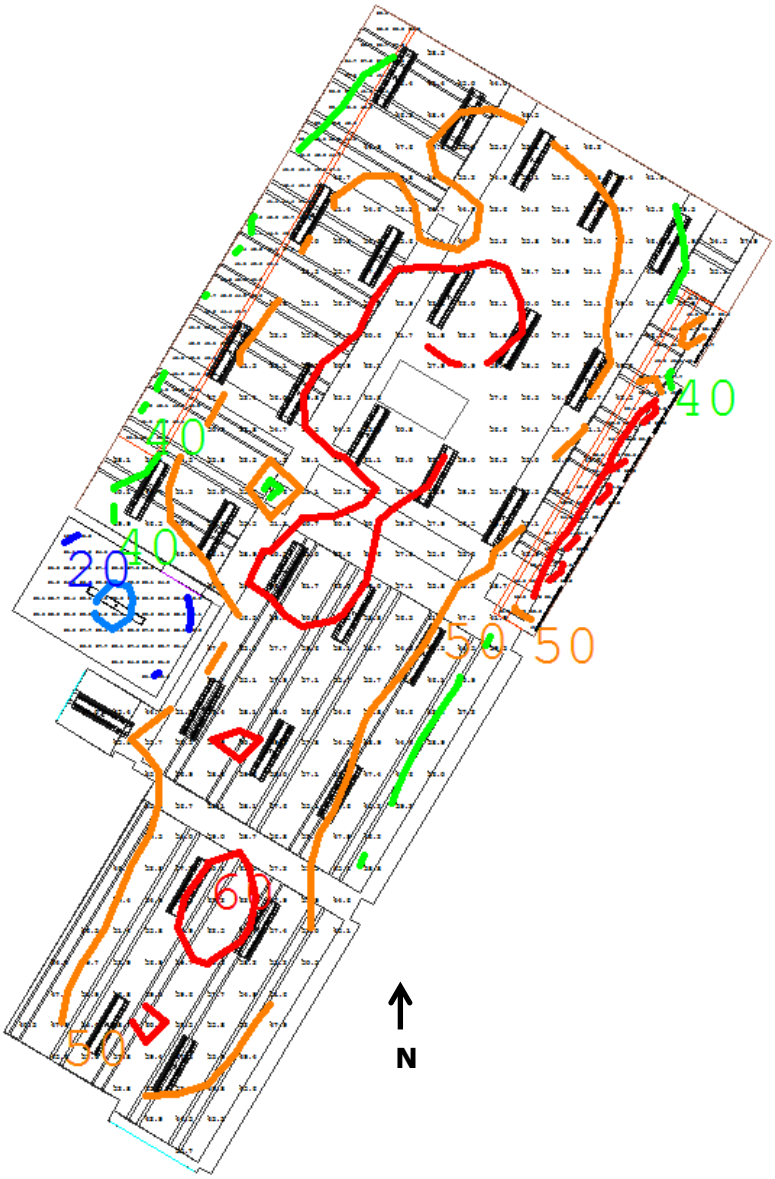


Figure 48: Work Plane Illuminance contours

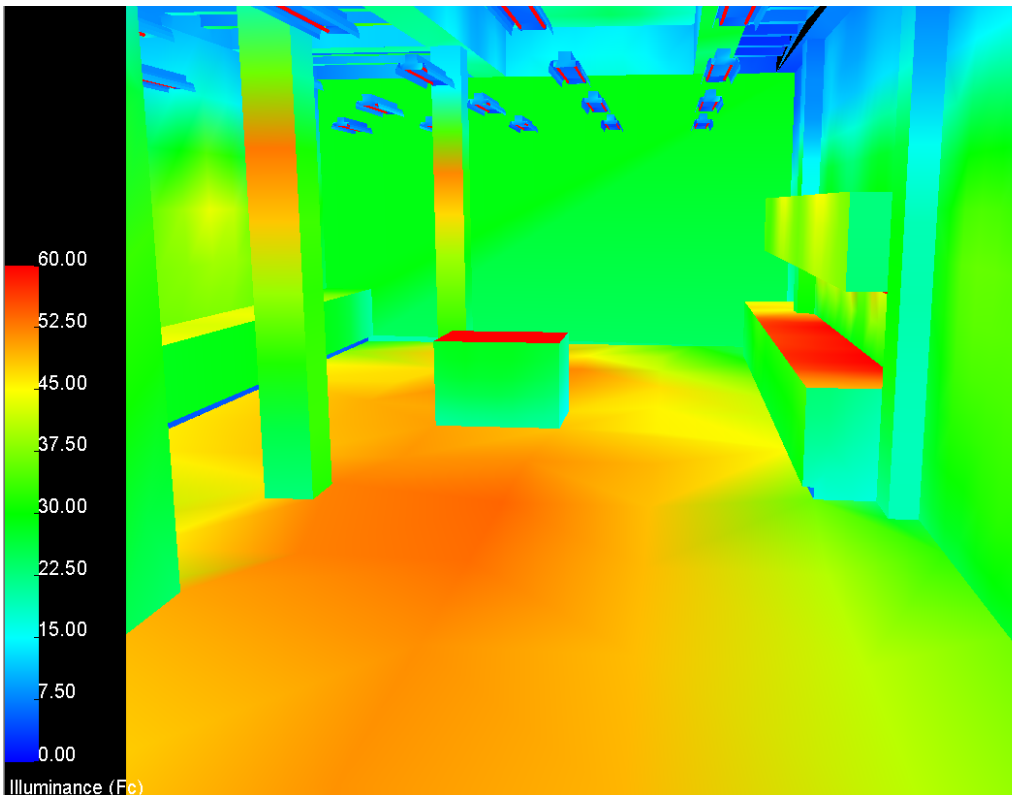


Figure 49: Illuminance Pseudocolor Rendering

Energy

The power density of the workspace and paint storage room combined is 1.3 W/SF, which falls below the maximum allowable 1.9 W/SF.

Tag	Wattage	Quantity	Input Wattage
F1	69	24	1656
F2	104	4	416
F3	69	1	69
F4	20	6	120
		Total	2261
		Area (SF)	1739
		W/SF	**1.30**

Figure 50: Power Densities

Environmental

The lighting design fulfills the requirements set forth by ANSI/ASHRAE/IES Standard 90.1 and therefore allows the space to acquire LEED EA Prerequisite 2. Falling significantly below the power density requirements also enables the space to aid the building in obtaining points from LEED EA Credit 1. IEQ Credit 6.1 is achieved for this space, as it is a backstage area and will only be accessible to authorized personnel. Further study is required to see if LEED EA Credit 1 and IEQ Credit 6.1 are fulfilled and credited building-wide.

Electrical Depth

Space Summary

South Terrace
The south terrace is the border between the VECC and the reflecting pools. The lighting redesign for the space involves adding linear LED fixtures to the base of the VECC and the freestanding granite wall running north-south. The electrical system should support the lighting system and be able to operate in extreme temperatures, as the first reflecting pool will be used as a skating rink.

Lobby/Retail
The lobby redesign involves replacing the recessed linear fluorescent with a track mounted downlight system. The electrical redesign should allow the space flexibility of controls to accommodate small temporary exhibits. LED downlight fixtures replace halogen downlight fixtures around the perimeter of the space.

Multi-Use Area
The multi-use are redesign involves replacing several of the suspended track systems with recessed track systems and recessed directional focus lights. Design objects for the electrical system include providing flexibility of control as well as ensuring that the track lighting system not go over allowable power densities.

Wood Shop
The woodshop is a 1700 SF utilitarian space located in the plant portion of the project. The proposed lighting design consists of pendant mounted four foot T8 linear fluorescent fixture. Additional fixtures provide light for the workbench on the southeast wall of the space. As much as possible, fixtures in the space should use 277V power to allow for shorter cable runs, as most of the plant utilizes 480Y/277V, 3Ph power.

Existing Panelboards

PANELBOARDS						
Panel Tag	**Voltage**	**System**	**South Terrace**	**Lobby/Retail**	**Multi-Use**	**Wood Shop**
PL1	480Y/277V	N				X
PEL1	480Y/277V	N/E				X
PWS	208Y/120V	N				X
VR1	208Y/120V	N			X	
VR2	208Y/120V			X		
VD5	208Y/120V	N		X		
VD6	208Y/120V	N	X		X	
VED2	208Y/120V	N/E			X	
VED4	208Y/120V	N/E		X		

Controls System Summary

South Terrace, Lobby, Multi-Use Area

The control system for the Terrace, Lobby, and Multi-Use areas will use a building wide, low voltage control system provided by Lutron. Dimmers will be located in a hallway on the basement floor adjacent to the existing private dining area. 4-button raise/lower stations will be located at the closest non-glazed wall to building entrances and at the lobby desk.

Wood Shop

The controls for all lighting systems in the woods shop will operate with line voltage switching. The main workspace area will be controlled using a three-way switch system, with switches being located by the southwest door and northwest door. A single pole switch located by the cabinets on the southeast wall will be used to control the workbench task lighting.

For each space, provide a description of how the luminaires will be controlled (line voltage switching, low voltage dimming, etc.) Identify where the controls will be located and where the dimmer will be located, if applicable. All of this information must also be shown on the floor plans.

System Layout

See Appendix C for all lighting layouts and wiring diagram

Existing Panelboard Schedules

208 Y/120V — **VR2** — BUS: 100 AMP

22K AIC — 3Ø-4W — MAIN: MAIN LUGS ONLY

	LOAD SERVED	WIRE SIZE	TRIP	POLE	LOAD IN kVA ØA		ØB		ØC		POLE	TRIP	WIRE SIZE	LOAD SERVED	
1	1ST FLR LINK RECEPT.	2#12 + G	20	1	0.80	0.40					1	20G	2#10 + G	TERRACE RECEPTACLES	2
3	1ST FLR FOYER RECP.	2#12 + G	20	1			0.80	0.40			1	20	2#12 + G	1ST FLR FOYER RECP.	4
5	TERRACE V115	2#10 + G	20G	1					0.60	0.30	1	20	2#12 + G	FC-2E	6
7	SPARE		20G	1	0.00	0.40					1	20	2#12 + G	1ST FLR LOBBY RECEPT	8
9	1ST FLR LOBBY RECEPT	2#12 + G	20	1			0.60	0.40			1	20G	2#12 + G	BATHROOM RECEPT	10
11	1ST FLR RETAIL RECEPT	2#12 + G	20	1					0.60	0.40	1	20	2#12 + G	1ST FLR RETAIL RECEPT	12
13	1ST FLR RETAIL RECEPT	2#12 + G	20	1	0.60	0.00					1	20	2#12 + G	MULTIPURP RECEPT.	14
15	1ST FLR RETAIL RECEPT	2#12 + G	20	1			0.40	0.80			1	20	2#12 + G	DISPLAY D RECEPT.	16
17	STORAGE RECEPTACLE	2#12 + G	20	1					0.40	0.80	1	20	2#12 + G	DISPLAY E RECEPT.	18
19	MAIL ROOM RECEPT	2#12 + G	20	1	1.20	0.80					1	20G	2#12 + G	MECH RM RECEPTACLE	20
21	HAND DRYER	2#12 + G	20	1			1.50	0.00			1	20		SPARE	22
23	HAND DRYER	2#12 + G	20	1					1.50	0.13	1	20	2#12 + G	FC-14E	24
25	GREEN ROOM LIGHTS	2#12 + G	20	1	1.00	1.80					1	20	2#12 + G	TV MONITORS	26
27	RESTROOM LIGHTS	2#12 + G	20	1			0.40	0.60			1	20	2#12 + G	TV MONITOR	28
29	PANTRY LIGHTS	2#12 + G	20	1					0.60	0.60	1	20	2#12 + G	1ST FLR RETAIL RECEPT	30
31	MAIL/STORAGE LIGHTS	2#12 + G	20	1	1.00	0.80					1	20	2#12 + G	1ST FLR RETAIL RECEPT	32
33	MULTIPURPOSE LIGHTS	2#12 + G	20	1			1.00	0.00			1	20		SPARE	34
35	DESK & COAT LTS	2#10 + G	20	1					0.52	0.00	1	20		SPARE	36
37	SPARE		20	1	0.00	0.00					1	20		SPARE	38
39	SPARE		20	1			0.00	0.00			1	20		SPARE	40
41	SPARE		20	1					0.00	0.00	1	20		SPARE	42
	LOAD PER PHASE				8.80		6.90		6.45						

TOTAL = 22.15 kVA — 61 AMPS — A = AFI BREAKER

NOTES: ☐ FEED THROUGH LUGS ☐ FLUSH ☐ 600KCM LUGS ☐ ISOLATED GROUND BUS G = GFI BREAKER

1.

2.

The current designs us an 84 circuit panelboard for panel VR1. For the purposes of this study, the redesign will include separating circuits 1-42 (Panel VR1A) from circuits 43-84 (Panel VR1B). Panel VR1B will be modified and reported on below.

208 Y/120V — **VR1** — BUS: 225 AMP

22K AIC — 3Ø-4W — MAIN: MAIN LUGS ONLY

	LOAD SERVED	WIRE SIZE	TRIP	POLE	LOAD IN kVA ØA		ØB		ØC		POLE	TRIP	WIRE SIZE	LOAD SERVED	
43	GUTTER DE-ICING	2#12+G	20	2	0.80	0.80					2	20	2#12+G	GUTTER DE-ICING	44
45							0.80	0.80							46
47	PANTRY LIGHTING	2#12+G	20	1					0.30	1.00	1	20	2#12+G	DEFFERED LIGHTING	48
49	OZONE GENERATOR	2#10+G	30	1	2.00	1.00					1	20	2#12+G	DEFFERED LIGHTING	50
51	OZONE GENERATOR	2#10+G	30	1			2.00	1.00			1	20	2#12+G	DEFFERED LIGHTING	52
53	OZONE GENERATOR	2#12+G	20	1					1.40	1.00	1	20	2#12+G	DEFFERED LIGHTING	54
55	OZONE GENERATOR	2#12+G	20	1	1.40	1.00					1	20	2#12+G	DEFFERED LIGHTING	56
57	OZONE GENERATOR	2#12+G	20	1			1.40	1.00			1	20	2#12+G	DEFFERED LIGHTING	58
59	OZONE GENERATOR	2#12+G	20	1					1.40	0.20	1	20	2#12+G	RECEPT. EXTERIOR	60
61	OZONE GENERATOR	2#12+G	20	1	1.40	1.00					1	20	2#12+G	PROJECTION SCREEN	62
63	(2) ERD-1	2#12+G	20	1			1.50	1.50			1	20	2#12+G	PROJECTOR	64
65	(2) ERD-1	2#12+G	20G	1					1.50	0.60	1	20	2#12+G	RECEP. PRIVATE DINING	66
67	SPARE		20G	1	0.00	0.20					1	20	2#12+G	RECEP. PRIVATE DINING	68
69	GREEN ROOF RECEPT	2#10+G	20G	1			0.72	0.40			1	20	2#12+G	RECEP. PRIVATE DINING	70
71	HAND DRYER	2#12+G	20	1					1.50	0.00	1	20		SPARE	72
73	HAND DRYER	2#12+G	20	1	1.50	0.00					1	20		SPARE	74
75	SPARE		20	1			0.00	0.00			1	20		SPARE	76
77	SPARE		20	1					0.00	0.00	1	20		SPARE	78
79	SPARE		20	1	0.00	0.00					1	20		SPARE	80
81	SPARE		20	1			0.00	0.00			1	20		SPARE	82
83	SPARE		20	1					0.00	0.00	1	20		SPARE	84
	LOAD PER PHASE				20.20		23.57		22.44						
	TOTAL =				66.21 kVA						184 AMPS			A = AFI BREAKER	

NOTES: ☐ FEED THROUGH LUGS ☐ FLUSH ☐ 600KCM LUGS ☐ ISOLATED GROUND BUS G = GFI BREAKER

1.

2.

480 Y/277V
65K AIC 3Ø-4W

PL1

BUS: 100 AMP
MAIN: MAIN LUGS ONLY

	LOAD SERVED	WIRE SIZE	TRIP	POLE	LOAD IN kVA ØA		ØB		ØC		POLE	TRIP	WIRE SIZE	LOAD SERVED	
1	TUNNEL LTG	2#10+G	20	1	1.44	2.40					1	20	2#12+G	PLANT LTG	2
3	PLANT LTG	2#12+G	20	1			2.04	0.00			1	20		SPARE	4
5	PLANT LTG	2#12+G	20	1					1.79	0.90	1	20	2#12+G	PLANT LTG	6
7	ENTRY DRIVE LTG	2#10+G	20	1	0.50	0.00					1	20		SPARE	8
9	WALKWAY LTG	2#10+G	20	1			0.83	0.00			1	20		SPARE	10
11	N. PARKING LOT LTG	2#10+G	20	1					0.61	0.00	1	20		SPARE	12
13	SPARE		20	1	0.00	0.00					1	20		SPARE	14
15	SPARE		20	1			0.00	0.00			1	20		SPARE	16
17	SPARE		20	1					0.00	0.00	1	20		SPARE	18
19	SPARE		20	1	0.00	0.00					1	20		SPARE	20
21	SPARE		20	1			0.00	0.00			1	20		SPARE	22
23	SPARE		20	1					0.00	0.00	1	20		SPARE	24
25	SPARE		20	1	0.00	0.00					1	20		SPARE	26
27	SPARE		20	1			0.00	0.00			1	20		SPARE	28
29	SPARE		20	1					0.00	0.00	1	20		SPARE	30
31	SPARE		20	1	0.00	0.00					1	20		SPARE	32
33	SPARE		20	1			0.00	0.00			1	20		SPARE	34
35	SPARE		20	1					0.00	0.00	1	20		SPARE	36
37	SPARE		20	1	0.00	0.00					1	20		SPARE	38
39	SPARE		20	1			0.00	0.00			1	20		SPARE	40
41	SPARE		20	1					0.00	0.00	1	20		SPARE	42
		LOAD PER PHASE			4.34		2.87		3.30						

TOTAL = 10.51 kVA 13 AMPS A = AFI BREAKER

NOTES: ☐ FEED THROUGH LUGS ☐ FLUSH ☐ 600KCM LUGS ☐ ISOLATED GROUND BUS G = GFI BREAKER

1.

2.

480 Y/277V
42K AIC 3Ø-4W

PEL1

BUS: 100 AMP
MAIN: MAIN LUGS ONLY

	LOAD SERVED	WIRE SIZE	TRIP	POLE	LOAD IN kVA ØA		ØB		ØC		POLE	TRIP	WIRE SIZE	LOAD SERVED	
1	TUNNEL LTG	2#10+G	20	1	0.44	1.83					1	20	2#12+G	PLANT LTG	2
3	TUNNEL LTG	2#10+G	20	1			1.33	1.62			1	20	2#12+G	PLANT LTG	4
5	PLANT LTG	2#12+G	20	1					1.83	1.26	1	20	2#12+G	PLANT LTG	6
7	PLANT LTG	2#12+G	20	1	1.09	0.00					1	20		SPARE	8
9	SPARE		20	1			0.00	0.00			1	20		SPARE	10
11	SPARE		20	1					0.00	0.00	1	20		SPARE	12
13	SPARE		20	1	0.00	0.00					1	20		SPARE	14
15	SPARE		20	1			0.00	0.00			1	20		SPARE	16
17	SPARE		20	1					0.00	0.00	1	20		SPARE	18
19	SPARE		20	1	0.00	0.00					1	20		SPARE	20
21	SPARE		20	1			0.00	0.00			1	20		SPARE	22
23	SPARE		20	1					0.00	0.00	1	20		SPARE	24
25	SPARE		20	1	0.00	0.00					1	20		SPARE	26
27	SPARE		20	1			0.00	0.00			1	20		SPARE	28
29	SPARE		20	1					0.00	0.00	1	20		SPARE	30
31	SPARE		20	1	0.00	0.00					1	20		SPARE	32
33	SPARE		20	1			0.00	0.00			1	20		SPARE	34
35	GENERATOR BLOCK HEATER	2#12+G IN 3/4"C.	20	2					3.22	0.00	1	20		SPARE	36
37					3.22	0.00									38
39	GENERATOR BLOCK HEATER	2#12+G IN 3/4"C.	20	2			3.22	0.00			3	50		SPARE	40
41									3.22	0.00					42
	LOAD PER PHASE				6.58		6.17		9.53						

TOTAL = 22.28 kVA 27 AMPS A = AFI BREAKER

NOTES: ☐ FEED THROUGH LUGS ☐ FLUSH ☐ 600KCM LUGS ☐ ISOLATED GROUND BUS G = GFI BREAKER

1.
2.

208 Y/120V
22K AIC 3Ø-4W

PWS

BUS: 100 AMP
MAIN: 100 AMP CB

	LOAD SERVED	WIRE SIZE	TRIP	POLE	LOAD IN kVA ØA		ØB		ØC		POLE	TRIP	WIRE SIZE	LOAD SERVED	
1	NEMA 6-20R'S	2#12+G	20	2	1.30	2.00					2	30	2#10+G	NEMA 6-30R	2
3							1.30	2.00							4
5	NEMA 6-20R'S	2#12+G	20	2					1.30	2.00	2	20	2#10+G	NEMA 6-30R	6
7					1.30	2.00									8
9	NEMA 6-20R'S	2#12+G	20	2			1.30	0.00			2	20		SPARE	10
11									1.30	0.00					12
13	SPARE		20	2	0.00	0.00					3	20		SPARE	14
15							0.00	0.00							16
17	NEMA 15-30R	3#10+G	30	3					2.30	0.00					18
19					2.30	0.36					1	20	2#12+G	RECEPTACLES	20
21							2.30	0.36			1	20	2#12+G	RECEPTACLES	22
23	NEMA 15-30R	3#10+G	30	3					0.00	0.36	1	20	2#12+G	RECEPTACLES	24
25					0.00	0.36					1	20	2#12+G	RECEPTACLES	26
27							0.00	0.36			1	20	2#12+G	RECEPTACLES	28
29	SPARE		20	1					0.00	0.36	1	20	2#12+G	RECEPTACLES	30
31	SPARE		20	1	0.00	0.90					1	20	2#12+G	RECEPTACLES	32
33	SPARE		20	1			0.00	0.36			1	20	2#12+G	RECEPTACLES	34
35	SPARE		20	1					0.00	0.36	1	20	2#12+G	RECEPTACLES	36
37	SPARE		20	1	0.00	0.36					1	20	2#12+G	RECEPTACLES	38
39	SPARE		20	1			0.00	0.00			1	20		SPARE	40
41	SPARE		20	1					0.00	0.00	1	20		SPARE	42
	LOAD PER PHASE				10.88		7.98		7.98						

TOTAL = 26.84 kVA 75 AMPS A = AFI BREAKER

NOTES: ☑ FEED THROUGH LUGS ☐ FLUSH ☐ 600KCM LUGS ☐ ISOLATED GROUND BUS G = GFI BREAKER

1. PROVIDE WITH SHUNT-TRIP MCB WIRED TO LOCAL EMERGENCY-OFF PUSHBUTTON
2.

Existing Dimmer Schedules

120
) A.I.C.
4 WIRE

DIMMER PANEL VD6

LUTRON # GP48 - 120 4 ML -20
MAIN LUGS ONLY

CONTROLS	CIRCUIT # NORM.	CIRCUIT # EMERG.	ZONE	DESCRIPTION	# OF LAMPS	TOTAL WATT	IN	LV	ND	FL	WIRE & CONDUIT	REMARKS
LC#9	1			TRACK	NA	1120		X			2#12+G	
LC#9	2			TRACK	NA	1120		X			2#12+G	
LC#9	3			TRACK	NA	1120		X			2#12+G	
LC#9	4			TRACK	NA	1120		X			2#12+G	
LC#9	5			TRACK	NA	1120		X			2#12+G	
LC#9	6			TRACK	NA	1120		X			2#12+G	
LC#9	7			TRACK	NA	1120		X			2#12+G	
LC#9	8			TRACK	NA	1120		X			2#12+G	
LC#9	9			TRACK	NA	1280		X			2#12+G	
LC#9	10			TRACK	NA	1280		X			2#12+G	
LC#9	11			TRACK	NA	1280		X			2#12+G	
LC#9	12			TRACK	NA	1280		X			2#12+G	
LC#9	13			DOWNLIGHTS	23	1150		X			2#12+G	
LC#9	14			LINEAR FLUOR.	NA	1210		X			2#10+G	
LC#12	15			FLOODLIGHTS	7	350			X		2#10+G	
LC#12	16			SMALL FLOOD	1	50			X		2#10+G	
LC#12	17			SMALL FLOOD	1	50			X		2#10+G	
LC#12	18			SMALL FLOOD	1	50			X		2#10+G	
LC#12	19			SMALL FLOOD	1	50			X		2#10+G	
LC#12	20			SMALL FLOOD	1	50			X		2#10+G	
LC#12	21			SMALL FLOOD	1	50			X		2#10+G	
LC#12	22			SMALL FLOOD	1	50			X		2#10+G	
LC#12	23			SMALL FLOOD	1	50			X		2#10+G	
LC#12	24			SMALL FLOOD	1	50			X		2#10+G	
LC#12	25			SMALL FLOOD	1	50			X		2#10+G	
LC#12	26			SMALL FLOOD	1	50			X		2#10+G	
LC#12	27			SMALL FLOOD	1	50			X		2#10+G	
LC#12	28			SMALL FLOOD	1	50			X		2#10+G	
LC#12	29			SMALL FLOOD	1	50			X		2#10+G	
LC#12	30			SMALL FLOOD	1	50			X		2#10+G	
LC#12	31			JUNCTION BOXES	NA	200			X		2#10+G	GFI CIRCUIT BREAKER
LC#12	32			JUNCTION BOXES	NA	200			X		2#10+G	GFI CIRCUIT BREAKER
LC#12	33			DOWNLIGHTS	26	520			X		2#8+G	
	34			LINEAR LED	NA	880			X		2#12+G	
LC#12	35			WALL LIGHTS	4	320			X		2#10+G	
LC#12	36			TREE LIGHTS		180			X		2#8+G	
LC#12	37			INGROUND	9	450			X		2#8+G	
LC#12	38			LINEAR LED		1340			X		2#8+G	
LC#12	39			LINEAR LED		800			X		2#8+G	
	40			SPARE								
	41			SPARE								
	42			SPARE								
	43			SPARE								
	44			SPARE								
	45			SPARE								
	46			SPARE								
	47			SPARE								
	48			SPARE								

INPUT FROM

TOTAL LOAD IN KW: 22.43
TOTAL LOAD IN AMPS: 62.31

208V Y/ 120
65000 A.I.C.
3 PHASE 4 WIRE

DIMMER PANEL VD5

LUTRON # GP36 - 120 4 ML -20
MAIN LUGS ONLY

ROOM/AREA	CONTROLS	CIRCUIT # NORM.	CIRCUIT # EMERG.	ZONE	DESCRIPTION	# OF LAMPS	TOTAL WATT	IN	LV	ND	FL	WIRE & CONDUIT	REMARKS
CAFÉ	LC#2	1			TRACK	NA	760		X				
CAFÉ	LC#2	2			TRACK	NA	760		X				
CAFÉ	LC#2	3			TRACK	NA	840		X				
CAFÉ	LC#2	4			TRACK	NA	840		X				
CAFÉ	LC#2	5			TRACK	NA	840		X				
CAFÉ	LC#2	6			TRACK	NA	840		X				
CAFÉ	LC#2	7			LINEAR FLUOR.	NA	200				X		
LOBBY	LC#10	8			LINEAR FLUOR.	NA	1080				X		
LOBBY	LC#10	9			DOWNLIGHTS	11	550		X				
RETAIL	LC#10	10			DOWNLIGHTS	16	800		X				
RETAIL	LC#10	11			TRACK	NA	1530		X				
RETAIL	LC#10	12			TRACK	NA	1530		X				
RETAIL	LC#10	13			TRACK	NA	900		X				
RETAIL	LC#10	14			TRACK	NA	900		X				
RETAIL	LC#10	15			TRACK	NA	1800		X				
RETAIL	LC#10	16			TRACK	NA	1800		X				
RETAIL	LC#10	17			LINEAR FLUOR.	NA	384				X		
CAFÉ	LC#2	18			DOWNLIGHTS	20	1000		X				
VESTIBULE	LC#10	19			DOWNLIGHTS	9	450		X				
LOBBY/RETAIL	LC#10	20			WALL WASHERS	15	1125		X				
FAMILY ROOM	LC#4	21			WALL WASHERS	13	650		X				
FAMILY ROOM	LC#4	22			TRACK	NA	1706		X				
FAMILY ROOM	LC#4	23			TRACK	NA	1706		X				
FAMILY ROOM	LC#4	24			TRACK	NA	1050		X				
FAMILY ROOM	LC#4	25			TRACK	NA	1050		X				
FAMILY ROOM	LC#4	26			TRACK	NA	1140		X				
FAMILY ROOM	LC#4	27			TRACK	NA	1140		X				
FAMILY ROOM	LC#4	28			TRACK	NA	1575		X				
FAMILY ROOM	LC#4	29			TRACK	NA	1575		X				
FAMILY ROOM	LC#4	30			COVE FLUOR.	NA	352				X		
FAMILY ROOM	LC#4	31			LINEAR FLUOR.	NA	256		X				
		32			SPARE		0		X				
		33			SPARE		0		X				
		34			SPARE		0		X				
		35			SPARE		0		X				
		36			SPARE		0		X				

NORMAL INPUT FROM

TOTAL LOAD IN KW: 31.13
TOTAL LOAD IN AMPS: 86.47

208V Y/ 120
65000 A.I.C.
3 PHASE 4 WIRE

DIMMER PANEL VED4

LUTRON # GP24 - 120 4 ML -20
MAIN LUGS ONLY

ROOM/AREA	CONTROLS	CIRCUIT # NORM.	CIRCUIT # EMERG.	ZONE	DESCRIPTION	# OF LAMPS	TOTAL WATT	IN	LV	ND	FL	WIRE & CONDUIT	REMARKS
DISPLAY D		1			LINEAR FLUOR.	NA	860				X		
CORRIDOR		2			DOWNLIGHTS	10	500		X				
CAFÉ	LC#2	3			DOWNLIGHTS	8	600		X				
CAFÉ	LC#2	4			LINEAR FLUOR.	NA	192				X		
LOBBY		5			LINEAR FLUOR.	NA	700				X		
RETAIL		6			LINEAR FLUOR.	NA	420				X		
RETAIL		7			DOWNLIGHTS	25	1250		X				
LINK		8			LINEAR FLUOR.	NA	710				X		
LINK		9			DOWNLIGHTS	6	300		X				
		10			SPARE				X				
DISPLAY FOYER		11			DOWNLIGHTS	10	500		X				
LINK		12			LED STEPLIGHTS	NA	400		X				
LINK		13			LINEAR FLUOR.	NA	1000				X		
FAMILY ROOM	LC#4	14			LINEAR FLUOR.	NA	224		X				
FAMILY ROOM	LC#4	15			DOWNLIGHTS	4	200		X				
		16			SPARE		0		X				
		17			SPARE		0		X				
		18			SPARE		0		X				
		19			SPARE		0		X				
		20			SPARE		0		X				
		21			SPARE		0		X				
		22			SPARE		0		X				
		23			SPARE		0		X				
		24			SPARE		0		X				

NORMAL INPUT FROM

TOTAL LOAD IN KW: 7.86
TOTAL LOAD IN AMPS: 21.82

208V Y/ 120
65000 A.I.C.
3 PHASE 4 WIRE

DIMMER PANEL VED2

LUTRON # GP24 - 120 4 ML -20
MAIN LUGS ONLY

ROOM/AREA	CONTROLS	CIRCUIT # NORM.	CIRCUIT # EMERG.	ZONE	DESCRIPTION	# OF LAMPS	TOTAL WATT	IN	LV	ND	FL	WIRE & CONDUIT	REMARKS
DISPLAY A			1		TRACK	NA	300		X				
DISPLAY B			2		TRACK	NA	750		X				
DISPLAY B			3		TRACK	NA	750		X				
DISPLAY C			4		TRACK	NA	1050		X				
DISPLAY C			5		TRACK	NA	1050		X				
LOBBY			6		LINEAR FLUOR.	NA	780				X		
LOBBY			7		DOWNLIGHTS	20	1000		X				
			8		SPARE		0		X				
			9		SPARE		0		X				
VESTIBULE			10		DOWNLIGHTS	8	400		X				
EXT. STAIR			11		STEPLIGHTS	7	140		X				
MULTI-USE			12		LINEAR FLUOR.	NA	1120				X		
MULTI-USE			13		DOWNLIGHTS	12	600		X				
ENTRANCE			14		DOWNLIGHTS	6	0		X				
STAIR			15		TRACK	NA	1100		X				
STAIR			16		TRACK	NA	1100		X				
			17		SPARE		0		X				
			18		SPARE		0		X				
			19		SPARE		0		X				
			20		SPARE		0		X				
			21		SPARE		0		X				
			22		SPARE		0		X				
			23		SPARE		0		X				
			24		SPARE		0		X				

NORMAL INPUT FROM

TOTAL LOAD IN KW: 10.14
TOTAL LOAD IN AMPS: 28.17

Panelboard and Dimmer Worksheets

PANELBOARD SIZING WORKSHEET

Panel Tag---------->					VR2	Panel Location:			VECC		
Nominal Phase to Neutral Voltage------->					120	Phase:			3		
Nominal Phase to Phase Voltage-------->					208	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	1ST FL LINK RCPT	1	VECC	800	VA	0.75	600	800		
2	A	TERRACE RCPT	1	VECC	400	VA	0.75	300	400		
3	B	1ST FL FOYER RCPT	1	VECC	800	VA	0.75	600	800		
4	B	1ST FL FOYER RCPT	1	VECC	400	VA	0.75	300	400		
5	C	TERRACE V115	1	TERRACE	600	VA	0.95	570	600		
6	C	FC-2E	1	VECC	300	VA	0.95	285	300		
7	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
8	A	1ST FL LBBY RCPT	1	LOBBY	400	VA	0.75	300	400		
9	B	1ST FL LBBY RCPT	1	LOBBY	600	VA	0.75	450	600		
10	B	BATHROOM RCPT	1	VECC	400	VA	0.75	300	400		
11	C	1ST FL RTL RCPT	1	RETAIL	600	VA	0.75	450	600		
12	C	1ST FL RTL RCPT	1	RETAIL	400	VA	0.75	300	400		
13	A	1ST FL RTL RCPT	1	RETAIL	600	VA	0.75	450	600		
14	A	MULT RCPT	1	VECC	0	VA	0.75	0	0		
15	B	1ST FL RTL RCPT	1	RETAIL	400	VA	0.75	300	400		
16	B	DISPLAY D RCPT	1	DISPLAY D	800	VA	0.75	600	800		
17	C	STORAGE RCPT	1	VECC	400	VA	0.75	300	400		
18	C	DISPLAY E RCPT	1	DISPLAY E	800	VA	0.75	600	800		
19	A	MAIL RM RCPT	1	VECC	1200	VA	0.75	900	1200		
20	A	MECH RM RCPT	1	PLANT	800	VA	0.75	600	800		
21	B	HAND DRYER	8	VECC	150	VA	0.90	135	150		
22	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
23	C	HAND DRYER	8	VECC	1500	VA	0.90	1350	1500		
24	C	FC-14E	1	VECC	130	VA	0.95	124	130		
25	A	GREEN RM LTG	5	GREEN RM	1000	VA	0.95	950	1000		
26	A	TV MONITORS	1	VECC	1800	VA	0.95	1710	1800		
27	B	RESTROOM LTG	3	VECC	400	VA	0.95	380	400		
28	B	TV MONITOR	1	VECC	600	VA	0.95	570	600		
29	C	PANTRY LTG	3	VECC	600	VA	0.95	570	600		
30	C	1ST FL RTL RCPT	1	RETAIL	600	VA	0.75	450	600		
31	A	MAIL/STRG LTG	3	PLANT	1000	VA	0.95	950	1000		
32	A	1ST FL RTL RCPT	1	RETAIL	800	VA	0.75	600	800		
33	B	MULT LIGHTING	3	VECC	1000	VA	0.95	950	1000		
34	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
35	C	DESK & COAT LTG	3	LOBBY	256	VA	0.95	243	256		
36	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
37	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
38	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
39	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
40	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
41	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
42	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
PANEL TOTAL								46.0	56.5	Amps=	157.1

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					16.0	19.6	36%	163.4
PHASE TOTAL	B					16.1	20.0	36%	166.3
PHASE TOTAL	C					13.9	15.5	28%	129.6

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		11.7	14.6	1.00	11.7	14.6	0.80		
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		3.1	3.3	1.00	3.1	3.3	0.95		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		1.0	1.0	1.00	1.0	1.0	0.95		
6	LED lighting		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	other equipment		1.5	1.7	1.00	1.5	1.7	0.90		
9	unassigned		28.8	36.0		28.8	36.0	0.80		
Total Demand Loads						46.0	56.5			
Spare Capacity			20%			9.2	11.3			
Total Design Loads						55.2	67.9	0.81	Amps=	188.5

PANELBOARD SIZING WORKSHEET

Panel Tag---------->					VR1B	Panel Location:			VECC		
Nominal Phase to Neutral Voltage------->					120	Phase:			3		
Nominal Phase to Phase Voltage-------->					208	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	GUTTER DE-ICING	7	VECC	800	VA	1.00	800	800		
2	A	GUTTER DE-ICING	7	VECC	800	VA	1.00	800	800		
3	B	GUTTER DE-ICING	7	VECC	800	VA	1.00	800	800		
4	B	GUTTER DE-ICING	7	VECC	800	VA	1.00	800	800		
5	C	PANTRY LIGHTING	3	MULTI-USE	101	VA	0.95	96	101		
6	C	DEFFERED LTG	9	VECC	1000	VA	0.98	980	1000		
7	A	OZONE GEN	8	VECC	2000	VA	0.85	1700	2000		
8	A	DEFFERED LTG	9	VECC	1000	VA	0.95	950	1000		
9	B	OZONE GEN	8	VECC	2000	VA	0.85	1700	2000		
10	B	DEFFERED LTG	9	VECC	1000	VA	0.95	950	1000		
11	C	OZONE GEN	8	VECC	1400	VA	0.85	1190	1400		
12	C	DEFFERED LTG	9	VECC	1000	VA	0.95	950	1000		
13	A	OZONE GEN	8	VECC	1400	VA	0.85	1190	1400		
14	A	DEFFERED LTG	9	VECC	1000	VA	0.95	950	1000		
15	B	OZONE GEN	8	VECC	14000	VA	0.85	11900	14000		
16	B	DEFFERED LTG	9	VECC	1000	VA	0.95	950	1000		
17	C	OZONE GEN	8	VECC	1400	VA	0.85	1190	1400		
18	C	EXTERIOR RCPT	1	VECC	1000	VA	0.75	750	1000		
19	A	OZONE GEN	8	VECC	1400	VA	0.85	1190	1400		
20	A	PROJ SCREEN	8	MULTI-USE	1000	VA	0.85	850	1000		
21	B	(2) ERD-1	8	VECC	1500	VA	0.80	1200	1500		
22	B	PROJECTOR	8	VECC	1500	VA	0.80	1200	1500		
23	C	(2) ERD-1	8	VECC	1500	VA	0.80	1200	1500		
24	C	DINING RECEPT	1	VECC	600	VA	0.75	450	600		
25	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
26	A	DINING RECEPT	1	VECC	200	VA	0.75	150	200		
27	B	GREEN RF RCPT	1		7200	VA	0.75	5400	7200		
28	B	DINING RECEPT	1	VECC	400	VA	0.75	300	400		
29	C	HAND DRYER	8	VECC	1500	VA	0.90	1350	1500		
30	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
31	A	HAND DRYER	8	VECC	1500	VA	0.90	1350	1500		
32	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
33	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
34	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
35	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
36	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
37	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
38	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
39	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
40	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
41	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
42	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
PANEL TOTAL								80.7	97.6	Amps=	271.2

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					21.5	25.5	27%	212.5
PHASE TOTAL	B					36.7	44.6	46%	371.7
PHASE TOTAL	C					22.6	26.1	27%	217.2

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		7.1	9.4	1.00	7.1	9.4	0.75		
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		0.1	0.1	1.00	0.1	0.1	0.95		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0	1.00	0.0	0.0			
6	LED lighting		0.0	0.0		0.0	0.0			
7	heating		3.2	3.2		3.2	3.2	1.00		
8	other equipment		27.2	32.1	1.00	27.2	32.1	0.85		
9	unassigned		43.2	52.8		43.2	52.8	0.82		
Total Demand Loads						80.7	97.6			
Spare Capacity			20%			16.1	19.5			
Total Design Loads						96.9	117.1	0.83	Amps=	325.4

Due to several different types of fixtures sharing the same circuit in the wood shop area, power factors and loads were tabulated in excel and are shown below.

Panel	Circuit	Fixture Type	Wattage	Quantity	Wattage	VA
PL1	3	F1	69	21	1449	1525
		F2	104	4	416	424
		F3	69	1	69	70
		Circuit PF: **0.96**		Circuit Totals:	**1934**	**2020**
PEL	4	F1	69	3	207	218
		Circuit PF: **0.95**		Circuit Totals:	**207**	**218**
PWS	29	F4	20	6	120	121
		Circuit PF: **0.99**		Circuit Totals:	**120**	**121**

Figure 51: Power Factor Calculations

PANELBOARD SIZING WORKSHEET

Panel Tag---------->					PL1	Panel Location:			Electrical Room		
Nominal Phase to Neutral Voltage------->					277	Phase:			3		
Nominal Phase to Phase Voltage-------->					480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	TUNNEL LTG	3	PLANT	1440	VA	0.95	1368	1440		
2	A	PLANT LTG	3	PLANT	2400	VA	0.95	2280	2400		
3	B	PLANT LTG	3	PLANT	2020	VA	0.96	1939	2020		
4	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
5	C	PLANT LTG	3	PLANT	1790	VA	0.95	1701	1790		
6	C	PLANT LTG	3	PLANT	900	VA	0.95	855	900		
7	A	ENTRY DRIVE LTG	4	ENTRY	500	VA	0.95	475	500		
8	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
9	B	WALKWAY LTG	6	WALKWAY	830	VA	0.60	498	830		
10	B	SPARE (LOAD)	5		3601	VA	0.80	2881	3601		
11	C	PARKING LOT LTG	6	PRKNG LOT	610	VA	0.60	366	610		
12	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
13	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
14	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
15	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
16	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
17	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
18	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
19	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
20	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
21	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
22	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
23	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
24	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
25	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
26	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
27	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
28	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
29	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
30	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
31	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
32	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
33	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
34	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
35	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
36	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
37	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
38	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
39	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
40	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
41	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
42	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601		
PANEL TOTAL								107.4	132.9	Amps=	160.0

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					35.8	44.0	33%	158.7
PHASE TOTAL	B					37.0	46.1	35%	166.3
PHASE TOTAL	C					34.6	41.5	32%	149.7

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		8.1	8.6	1.00	8.1	8.6	0.95		
4	HID lighting		0.5	0.5	1.00	0.5	0.5	0.95		
5	incandescent lighting		2.9	3.6	1.00	2.9	3.6	0.80		
6	LED lighting		0.9	1.4	1.00	0.9	1.4	0.60		
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		95.1	118.8	1.00	95.1	118.8	0.80		
Total Demand Loads						107.4	132.9			
Spare Capacity			20%			21.5	26.6			
Total Design Loads						128.9	159.5	0.81	Amps=	191.9

PANELBOARD SIZING WORKSHEET

Panel Tag---------->				PEL1	Panel Location:			Electrical Room		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	TUNNEL LTG	3	TUNNEL	440	VA	0.95	418	440	
2	A	TUNNEL LTG	3	TUNNEL	1830	VA	0.95	1739	1830	
3	B	PLANT LTG	3	PLANT	1330	VA	0.96	1277	1330	
4	B	PLANT LTG	5	SHOP	1602	VA	0.95	1522	1602	
5	C	PLANT LTG	3	PLANT	1830	VA	0.95	1739	1830	
6	C	PLANT LTG	3	PLANT	1260	VA	0.95	1197	1260	
7	A	PLANT LTG	4	ENTRY	1090	VA	0.95	1036	1090	
8	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
9	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
10	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
11	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
12	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
13	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
14	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
15	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
16	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
17	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
18	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
19	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
20	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
21	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
22	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
23	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
24	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
25	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
26	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
27	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
28	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
29	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
30	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
31	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
32	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
33	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
34	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
35	C	GEN BLOCK HTR	5		3220	VA	1.00	3220	3220	
36	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
37	A	GEN BLOCK HTR	5		3220	VA	1.00	3220	3220	
38	A	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
39	B	GEN BLOCK HTR	5		3220	VA	1.00	3220	3220	
40	B	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
41	C	GEN BLOCK HTR	5		3220	VA	1.00	3220	3220	
42	C	SPARE (LOAD)	9		3601	VA	0.80	2881	3601	
PANEL TOTAL								111.1	133.9	Amps= 161.1

PHASE LOADING		kW	kVA	%	Amps
PHASE TOTAL	A	35.2	42.6	32%	153.8
PHASE TOTAL	B	37.7	45.8	34%	165.2
PHASE TOTAL	C	38.2	44.8	34%	161.8

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		6.4	6.7	1.00	6.4	6.7	0.95		
4	HID lighting		1.0	1.1	1.00	1.0	1.1	0.95		
5	incandescent lighting		14.4	14.5	1.00	14.4	14.5	0.99		
6	LED lighting		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		89.3	111.6	1.00	89.3	111.6	0.80		
Total Demand Loads						111.1	133.9			
Spare Capacity			20%			22.2	26.8			
Total Design Loads						133.3	160.7	0.83	Amps=	193.3

PANELBOARD SIZING WORKSHEET

Panel Tag---------->					PWS	Panel Location:			Electrical Room		
Nominal Phase to Neutral Voltage------->					277	Phase:			3		
Nominal Phase to Phase Voltage-------->					480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	NEMA 6-20R'S	3	SHOP	1300	VA	0.85	1105	1300		
2	A	NEMA 6-30R	3	SHOP	2000	VA	0.85	1700	2000		
3	B	NEMA 6-20R'S	3	SHOP	1300	VA	0.85	1105	1300		
4	B	NEMA 6-30R	5	SHOP	2000	VA	0.85	1700	2000		
5	C	NEMA 6-20R'S	3	SHOP	1300	VA	0.85	1105	1300		
6	C	NEMA 6-30R	3	SHOP	2000	VA	0.85	1700	2000		
7	A	NEMA 6-20R'S	4	SHOP	1300	VA	0.85	1105	1300		
8	A	NEMA 6-30R	5	SHOP	2000	VA	0.85	1700	2000		
9	B	NEMA 6-20R'S	6	SHOP	1300	VA	0.85	1105	1300		
10	B	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
11	C	NEMA 6-20R'S	6	SHOP	1300	VA	0.85	1105	1300		
12	C	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
13	A	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
14	A	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
15	B	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
16	B	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
17	C	NEMA 15-30R	5	SHOP	2300	VA	0.85	1955	2300		
18	C	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
19	A	NEMA 15-30R	5	SHOP	2300	VA	0.85	1955	2300		
20	A	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
21	B	NEMA 15-30R	5	SHOP	2300	VA	0.85	1955	2300		
22	B	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
23	C	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
24	C	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
25	A	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
26	A	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
27	B	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
28	B	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
29	C	BENCH LTG	6	SHOP	121	VA	0.99	120	121		
30	C	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
31	A	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
32	A	RECEPTACLES	1	SHOP	900	VA	0.75	675	900		
33	B	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
34	B	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
35	C	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
36	C	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
37	A	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
38	A	RECEPTACLES	1	SHOP	360	VA	0.75	270	360		
39	B	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
40	B	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
41	C	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
42	C	SPARE (LOAD)	9	SHOP	3601	VA	0.80	2881	3601		
PANEL TOTAL								74.4	91.8	Amps=	110.4

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					23.5	28.9	32%	104.3
PHASE TOTAL	B					26.8	33.2	37%	119.8
PHASE TOTAL	C					24.1	28.3	31%	102.0

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		3.1	4.1	1.00	3.1	4.1	0.75		
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		6.7	7.9	1.00	6.7	7.9	0.85		
4	HID lighting		1.1	1.3	1.00	1.1	1.3	0.85		
5	incandescent lighting		9.3	10.9	1.00	9.3	10.9	0.85		
6	LED lighting		2.3	2.7	1.00	2.3	2.7	0.86		
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		51.9	64.8		51.9	64.8	0.80		
Total Demand Loads						74.4	91.8			
Spare Capacity			20%			14.9	18.4			
Total Design Loads						89.2	110.1	0.81	Amps=	132.5

DIMMER SYSTEM SIZING WORKSHEET

Dimmer Tag---------->					VD5	Dimmer Location:			VECC		
Nominal Phase to Neutral Voltage------->					120	Phase:			3		
Nominal Phase to Phase Voltage-------->					208	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	TRACK	1	CAFÉ	760	W	1.00	760	760		
2	A	TRACK	1	CAFÉ	760	W	1.00	760	760		
3	B	TRACK	1	CAFÉ	840	W	1.00	840	840		
4	B	TRACK	1	CAFÉ	840	W	1.00	840	840		
5	C	TRACK	1	CAFÉ	840	W	1.00	840	840		
6	C	TRACK	1	CAFÉ	840	W	1.00	840	840		
7	A	LINEAR FLOUR.	2	CAFÉ	200	W	0.95	200	211		
8	A	LINEAR FLOUR.	2	LOBBY	198	W	0.98	198	202		
9	B	DOWNLIGHTS	4	LOBBY	540	W	0.90	540	600		
10	B	WALL WASHERS	2	LOBBY	140	W	0.90	140	156		
11	C	TRACK	4	RETAIL	1680	W	0.82	1680	2049		
12	C	TRACK	4	RETAIL	1680	W	0.82	1680	2049		
13	A	TRACK	4	RETAIL	840	W	0.82	840	1024		
14	A	TRACK	4	RETAIL	840	W	0.82	840	1024		
15	B	TRACK	4	RETAIL	1680	W	0.82	1680	2049		
16	B	TRACK	4	RETAIL	1680	W	0.82	1680	2049		
17	C	LINEAR FLOUR.	2	RETAIL	627	W	0.98	627	640		
18	C	DOWNLIGHTS	1	CAFÉ	1000	W	1.00	1000	1000		
19	A	DOWNLIGHTS	1	VESTIBULE	450	W	1.00	450	450		
20	A	SPARE (LOAD)	9		10	A	0.80	960	1200		
21	B	WALL WASHERS	1	FAMILY RM	650	W	1.00	650	650		
22	B	TRACK	1	FAMILY RM	1706	W	1.00	1706	1706		
23	C	TRACK	1	FAMILY RM	1706	W	1.00	1706	1706		
24	C	TRACK	1	FAMILY RM	1050	W	1.00	1050	1050		
25	A	TRACK	1	FAMILY RM	1050	W	1.00	1050	1050		
26	A	TRACK	1	FAMILY RM	1140	W	1.00	1140	1140		
27	B	TRACK	1	FAMILY RM	1140	W	1.00	1140	1140		
28	B	TRACK	1	FAMILY RM	1575	W	1.00	1575	1575		
29	C	TRACK	1	FAMILY RM	1575	W	1.00	1575	1575		
30	C	COVE FLUOR.	2	FAMILY RM	352	W	0.95	352	371		
31	A	LINEAR FLUOR.	2	FAMILY RM	256	W	0.95	256	269		
32	A	TRACK	4	LOBBY	960	W	0.82	960	1171		
33	B	TRACK	4	LOBBY	960	W	0.82	960	1171		
34	B	SPARE (LOAD)	9		10	A	0.80	960	1200		
35	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
36	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
37	A	SPARE (LOAD)	9		10	A	0.80	960	1200		
38	A	SPARE (LOAD)	9		10	A	0.80	960	1200		
39	B	SPARE (LOAD)	9		10	A	0.80	960	1200		
40	B	SPARE (LOAD)	9		10	A	0.80	960	1200		
41	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
42	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
PANEL TOTAL								40.2	45.0	Amps=	124.9

PHASE LOADING					kW	kVA	%	Amps
PHASE TOTAL	A				10.3	11.7	26%	97.2
PHASE TOTAL	B				14.6	16.4	37%	136.5
PHASE TOTAL	C				15.2	16.4	37%	137.0

LOAD CATAGORIES			Connected			Demand				Ver. 1.02
			kW	kVA	DF	kW	kVA	PF		
1	incandescent lighting		17.9	17.9	1.00	17.9	321.2	0.06		
2	fluorescent lighting		1.8	1.8	1.00	1.8	3.3	0.54		
3	non-dimmed		0.0	0.0	1.00	0.0	0.0			
4	LED lighting		10.9	13.2		10.9	13.2	0.82		
5			0.0	0.0		0.0	0.0			
6			0.0	0.0		0.0	0.0			
7			0.0	0.0		0.0	0.0			
8			0.0	0.0		0.0	0.0			
9	unassigned		9.6	12.0		9.6	12.0	0.80		
Total Demand Loads						40.2	349.7			
Spare Capacity			20%			8.0	69.9			
Total Design Loads						48.2	419.6	0.11	Amps=	1165.5

DIMMER SYSTEM SIZING WORKSHEET

Dimmer Tag---------->					VED4	Dimmer Location:			VECC		
Nominal Phase to Neutral Voltage------->					120	Phase:			3		
Nominal Phase to Phase Voltage-------->					208	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	LINEAR FLUOR.	2	DISPLAY D	860	W	0.95	860	905		
2	A	DOWNLIGHTS	1	CORRIDOR	500	W	1.00	500	500		
3	B	DOWNLIGHTS	1	CAFÉ	600	W	1.00	600	600		
4	B	LINEAR FLUOR.	2	CAFÉ	192	W	0.95	192	202		
5	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
6	C	LINEAR FLUOR.	2	RETAIL	462	W	0.98	462	471		
7	A	DOWNLIGHTS	4	RETAIL	459	W	0.80	459	574		
8	A	LINEAR FLUOR.	2	LINK	710	W	0.95	710	747		
9	B	DOWNLIGHTS	1	LINK	300	W	1.00	300	300		
10	B	SPARE (LOAD)	9		10	A	0.80	960	1200		
11	C	DOWNLIGHTS	1	DISP. FOYER	500	W	1.00	500	500		
12	C	LED STRIPLIGHTS	4	LINK	400	W	0.80	400	500		
13	A	LINEAR FLUOR.	2	LINK	1000	W	0.95	1000	1053		
14	A	LINEAR FLUOR.	2	FAMILY RM	224	W	0.95	224	236		
15	B	DOWNLIGHTS	1	FAMILY RM	200	W	1.00	200	200		
16	B	TRACK	4	LOBBY	1920	W	0.82	1920	2341		
17	C	TRACK	4	LOBBY	1920	W	0.82	1920	2341		
18	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
19	A	SPARE (LOAD)	9		10	A	0.80	960	1200		
20	A	SPARE (LOAD)	9		10	A	0.80	960	1200		
21	B	SPARE (LOAD)	9		10	A	0.80	960	1200		
22	B	SPARE (LOAD)	9		10	A	0.80	960	1200		
23	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
24	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
25	A	DOES NOT EXIST			0	W		0	0		
26	A	DOES NOT EXIST			0	W		0	0		
27	B	DOES NOT EXIST			0	W		0	0		
28	B	DOES NOT EXIST			0	W		0	0		
29	C	DOES NOT EXIST			0	W		0	0		
30	C	DOES NOT EXIST			0	W		0	0		
31	A	DOES NOT EXIST			0	W		0	0		
32	A	DOES NOT EXIST			0	W		0	0		
33	B	DOES NOT EXIST			0	W		0	0		
34	B	DOES NOT EXIST			0	W		0	0		
35	C	DOES NOT EXIST			0	W		0	0		
36	C	DOES NOT EXIST			0	W		0	0		
37	A	DOES NOT EXIST			0	W		0	0		
38	A	DOES NOT EXIST			0	W		0	0		
39	B	DOES NOT EXIST			0	W		0	0		
40	B	DOES NOT EXIST			0	W		0	0		
41	C	DOES NOT EXIST			0	W		0	0		
42	C	DOES NOT EXIST			0	W		0	0		
PANEL TOTAL								18.9	22.3	Amps=	61.9

PHASE LOADING					kW	kVA	%	Amps
PHASE TOTAL	A				5.7	6.4	29%	53.5
PHASE TOTAL	B				6.1	7.2	33%	60.4
PHASE TOTAL	C				7.1	8.6	39%	71.8

LOAD CATAGORIES			Connected			Demand				Ver. 1.02
			kW	kVA	DF	kW	kVA	PF		
1	incandescent lighting		2.1	2.1		2.1	2.1	1.00		
2	fluorescent lighting		3.4	3.6		3.4	3.6	0.95		
3	non-dimmed		0.0	0.0		0.0	0.0			
4	LED lighting		4.7	5.8		4.7	5.8	0.82		
5			0.0	0.0		0.0	0.0			
6			0.0	0.0		0.0	0.0			
7			0.0	0.0		0.0	0.0			
8			0.0	0.0		0.0	0.0			
9	unassigned		8.6	10.8		8.6	10.8	0.80		
Total Demand Loads						18.9	22.3			
Spare Capacity			20%			3.8	4.5			
Total Design Loads						22.7	26.7	0.85	Amps=	74.2

DIMMER SYSTEM SIZING WORKSHEET

Dimmer Tag---------->				VED2	Dimmer Location:			VECC			
Nominal Phase to Neutral Voltage------->				120	Phase:			3			
Nominal Phase to Phase Voltage-------->				208	Wires:			4			
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	TRACK		DISPLAY A	300	W		300	375		
2	A	TRACK		DISPLAY B	750	W		750	938		
3	B	TRACK		DISPLAY B	750	W		750	938		
4	B	TRACK		DISPLAY C	1050	W		1050	1313		
5	C	TRACK		DISPLAY C	1050	W		1050	1313		
6	C	LINEAR FLUOR.		LOBBY	780	W		780	975		
7	A	DOWNLIGHTS		LOBBY	1000	W		1000	1250		
8	A	SPARE (LOAD)			10	A	0.80	960	1200		
9	B	SPARE (LOAD)			10	A	0.80	960	1200		
10	B	DOWNLIGHTS		VESTIBULE	400	W		400	500		
11	C	STEPLIGHTS		EXT. STAIR	140	W		140	175		
12	C	LINEAR FLUOR.		MULTI-USE	1792	W		1792	2240		
13	A	DOWNLIGHTS		MULTI-USE	324	W		324	405		
14	A	DOWNLIGHTS		ENTRANCE	0	W		0	0		
15	B	TRACK		STAIR	840	W		840	1050		
16	B	TRACK		STAIR	840	W		840	1050		
17	C	SPARE (LOAD)			10	A	0.80	960	1200		
18	C	SPARE (LOAD)			10	A	0.80	960	1200		
19	A	SPARE (LOAD)			10	A	0.80	960	1200		
20	A	SPARE (LOAD)			10	A	0.80	960	1200		
21	B	SPARE (LOAD)			10	A	0.80	960	1200		
22	B	SPARE (LOAD)			10	A	0.80	960	1200		
23	C	SPARE (LOAD)			10	A	0.80	960	1200		
24	C	SPARE (LOAD)			10	A	0.80	960	1200		
25	A	DOES NOT EXIST			0	W		0	0		
26	A	DOES NOT EXIST			0	W		0	0		
27	B	DOES NOT EXIST			0	W		0	0		
28	B	DOES NOT EXIST			0	W		0	0		
29	C	DOES NOT EXIST			0	W		0	0		
30	C	DOES NOT EXIST			0	W		0	0		
31	A	DOES NOT EXIST			0	W		0	0		
32	A	DOES NOT EXIST			0	W		0	0		
33	B	DOES NOT EXIST			0	W		0	0		
34	B	DOES NOT EXIST			0	W		0	0		
35	C	DOES NOT EXIST			0	W		0	0		
36	C	DOES NOT EXIST			0	W		0	0		
37	A	DOES NOT EXIST			0	W		0	0		
38	A	DOES NOT EXIST			0	W		0	0		
39	B	DOES NOT EXIST			0	W		0	0		
40	B	DOES NOT EXIST			0	W		0	0		
41	C	DOES NOT EXIST			0	W		0	0		
42	C	DOES NOT EXIST			0	W		0	0		
PANEL TOTAL								19.6	24.5	Amps=	68.1

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					5.3	6.6	27%	54.7
PHASE TOTAL	B					6.8	8.5	34%	70.4
PHASE TOTAL	C					7.6	9.5	39%	79.2

LOAD CATAGORIES			Connected			Demand				Ver. 1.02
			kW	kVA	DF	kW	kVA	PF		
1	incandescent lighting		0.0	0.0	1.00	0.0	0.0			
2	fluorescent lighting		0.0	0.0	1.00	0.0	0.0			
3	non-dimmed		0.0	0.0	1.00	0.0	0.0			
4			0.0	0.0		0.0	0.0			
5			0.0	0.0		0.0	0.0			
6			0.0	0.0		0.0	0.0			
7			0.0	0.0		0.0	0.0			
8			0.0	0.0		0.0	0.0			
9	unassigned		19.6	24.5		19.6	24.5	0.80		
Total Demand Loads						19.6	24.5			
Spare Capacity			20%			3.9	4.9			
Total Design Loads						23.5	29.4	0.80	Amps=	81.7

DIMMER SYSTEM SIZING WORKSHEET

Dimmer Tag---------->				VD6	Dimmer Location:			VECC			
Nominal Phase to Neutral Voltage------->				120	Phase:			3			
Nominal Phase to Phase Voltage-------->				208	Wires:			4			
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	TRACK	4	VECC TYP	1680	W	0.82	1680	2049		
2	A	TRACK	4		1680	W	0.82	1680	2049		
3	B	TRACK	4		1680	W	0.82	1680	2049		
4	B	TRACK	4		1680	W	0.82	1680	2049		
5	C	TRACK	4		1680	W	0.82	1680	2049		
6	C	TRACK	4		1680	W	0.82	1680	2049		
7	A	TRACK	4		1680	W	0.82	1680	2049		
8	A	TRACK	4		1680	W	0.82	1680	2049		
9	B	TRACK	4		450	W	0.82	450	549		
10	B	WALL GRAZE	2		264	W	0.98	264	269		
11	C	ACCENT LTG	4		184	W	0.80	184	230		
12	C	ACCENT LTG	4		207	W	0.80	207	259		
13	A	DOWNLIGHTS	4		648	W	0.80	648	810		
14	A	LINEAR FLUOR.	2		1920	W	0.98	1920	1959		
15	B	FLOODLIGHTS	5		350	W	0.80	350	438		
16	B	SMALL FLOOD	5		50	W	0.80	50	63		
17	C	SMALL FLOOD	5		50	W	0.80	50	63		
18	C	SMALL FLOOD	5		50	W	0.80	50	63		
19	A	SMALL FLOOD	5		50	W	0.80	50	63		
20	A	SMALL FLOOD	5		50	W	0.80	50	63		
21	B	SMALL FLOOD	5		50	W	0.80	50	63		
22	B	SMALL FLOOD	5		50	W	0.80	50	63		
23	C	SMALL FLOOD	5		50	W	0.80	50	63		
24	C	SMALL FLOOD	5		50	W	0.80	50	63		
25	A	SMALL FLOOD	5		50	W	0.80	50	63		
26	A	SMALL FLOOD	5		50	W	0.80	50	63		
27	B	SMALL FLOOD	5		50	W	0.80	50	63		
28	B	SMALL FLOOD	5		50	W	0.80	50	63		
29	C	SMALL FLOOD	5		50	W	0.80	50	63		
30	C	SMALL FLOOD	5		50	W	0.80	50	63		
31	A	JUNCTION BOXES	4		200	W	0.80	200	250		
32	A	JUNCTION BOXES	4		200	W	0.80	200	250		
33	B	EXT DOWNLIGHTS	4		378	W	0.80	378	473		
34	B	LINEAR LED	4		880	W	0.80	880	1100		
35	C	WALL LIGHTS	5		320	W	0.80	320	400		
36	C	EXT WALL WASH	4		297	W	0.80	297	371		
37	A	TREE LIGHTS	5		276	W	0.80	276	345		
38	A	POOL PERMITER	4		335	W	0.80	335	419		
39	B	HANDRAIL	4		576	W	0.80	576	720		
40	B	WALL GRAZE	4		900	W	0.80	900	1125		
41	C	POOL HANDRAIL	4		1248	W	0.80	1248	1560		
42	C	LED COVE	4		600	W	0.80	600	750		
43	A	LL LTG	4		500	W	0.80	500	625		
44	A	WALL GRAZE	4		117	W	0.80	117	146		
45	B	SPARE (LOAD)	9		10	A	0.80	960	1200		
46	B	SPARE (LOAD)	9		10	A	0.80	960	1200		
47	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
48	C	SPARE (LOAD)	9		10	A	0.80	960	1200		
PANEL TOTAL								28.9	35.2	Amps=	97.7

PHASE LOADING		kW	kVA	%	Amps
PHASE TOTAL	A	11.0	13.1	45%	109.1
PHASE TOTAL	B	7.0	8.6	29%	71.5
PHASE TOTAL	C	6.6	7.7	26%	63.8

LOAD CATAGORIES			Connected			Demand				Ver. 1.02
			kW	kVA	DF	kW	kVA	PF		
1	incandescent lighting		0.0	0.0		0.0	0.0			
2	fluorescent lighting		2.2	2.2		2.2	2.2	0.98		
3	non-dimmed		0.0	0.0		0.0	0.0			
4	LED lighting		21.2	26.0		21.2	26.0	0.81		
5	HID lighting		1.7	2.1		1.7	2.1	0.80		
6			0.0	0.0		0.0	0.0			
7			0.0	0.0		0.0	0.0			
8			0.0	0.0		0.0	0.0			
9	unassigned		3.8	4.8		3.8	4.8	0.80		
Total Demand Loads						28.9	35.2			
Spare Capacity			20%			5.8	7.0			
Total Design Loads						34.7	42.2	0.82	Amps=	117.3

Revised Panelboard and Dimmer Schedules

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

PANEL TAG: VR2
PANEL LOCATION: VECC
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
1ST FL LINK RCPT	VECC	600	20A/1P	1	*			2	20A/1P	300	VECC	TERRACE RCPT
1ST FL FOYER RCPT	VECC	600	20A/1P	3		*		4	20A/1P	300	VECC	1ST FL FOYER RCPT
TERRACE V115	TERRACE	570	20A/1P	5			*	6	20A/1P	285	VECC	FC-2E
SPARE (LOAD)		2881	20A/1P	7	*			8	20A/1P	300	LOBBY	1ST FL LBBY RCPT
1ST FL LBBY RCPT	LOBBY	450	20A/1P	9		*		10	20A/1P	300	VECC	BATHROOM RCPT
1ST FL RTL RCPT	RETAIL	450	20A/1P	11			*	12	20A/1P	300	RETAIL	1ST FL RTL RCPT
1ST FL RTL RCPT	RETAIL	450	20A/1P	13	*			14	20A/1P	0	VECC	MULT RCPT
1ST FL RTL RCPT	RETAIL	300	20A/1P	15		*		16	20A/1P	600	DISPLAY D	DISPLAY D RCPT
STORAGE RCPT	VECC	300	20A/1P	17			*	18	20A/1P	600	DISPLAY E	DISPLAY E RCPT
MAIL RM RCPT	VECC	900	20A/1P	19	*			20	20A/1P	600	PLANT	MECH RM RCPT
HAND DRYER	VECC	135	20A/1P	21		*		22	20A/1P	2881		SPARE (LOAD)
HAND DRYER	VECC	1350	20A/1P	23			*	24	20A/1P	124	VECC	FC-14E
GREEN RM LTG	GREEN RM	950	20A/1P	25	*			26	20A/1P	1710	VECC	TV MONITORS
RESTROOM LTG	VECC	380	20A/1P	27		*		28	20A/1P	570	VECC	TV MONITOR
PANTRY LTG	VECC	570	20A/1P	29			*	30	20A/1P	450	RETAIL	1ST FL RTL RCPT
MAIL/STRG LTG	PLANT	950	20A/1P	31	*			32	20A/1P	600	RETAIL	1ST FL RTL RCPT
MULT LIGHTING	VECC	950	20A/1P	33		*		34	20A/1P	2881		SPARE (LOAD)
DESK & COAT LTG	LOBBY	243	20A/1P	35			*	36	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	37	*			38	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	39		*		40	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	41			*	42	20A/1P	2880.8		SPARE (LOAD)

CONNECTED LOAD (KW) - A Ph.	16.00	TOTAL DESIGN LOAD (KW)	55.19
CONNECTED LOAD (KW) - B Ph.	16.11	POWER FACTOR	0.81
CONNECTED LOAD (KW) - C Ph.	13.88	TOTAL DESIGN LOAD (AMPS)	188

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W	PANEL TAG: VR1B	MIN. C/B AIC: 10K
SIZE/TYPE BUS: 225A	PANEL LOCATION: VECC	OPTIONS: PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN: 225A/3P C/B	PANEL MOUNTING: SURFACE	FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
GUTTER DE-ICING	VECC	800	20A/1P	1	*			2	20A/1P	800	VECC	GUTTER DE-ICING
GUTTER DE-ICING	VECC	800	20A/1P	3		*		4	20A/1P	800	VECC	GUTTER DE-ICING
PANTRY LIGHTING	MULTI-USE	96	20A/1P	5			*	6	20A/1P	980	VECC	DEFFERED LTG
OZONE GEN	VECC	1700	20A/1P	7	*			8	20A/1P	950	VECC	DEFFERED LTG
OZONE GEN	VECC	1700	20A/1P	9		*		10	20A/1P	950	VECC	DEFFERED LTG
OZONE GEN	VECC	1190	20A/1P	11			*	12	20A/1P	950	VECC	DEFFERED LTG
OZONE GEN	VECC	1190	20A/1P	13	*			14	20A/1P	950	VECC	DEFFERED LTG
OZONE GEN	VECC	11900	20A/1P	15		*		16	20A/1P	950	VECC	DEFFERED LTG
OZONE GEN	VECC	1190	20A/1P	17			*	18	20A/1P	750	VECC	EXTERIOR RCPT
OZONE GEN	VECC	1190	20A/1P	19	*			20	20A/1P	850	MULTI-USE	PROJ SCREEN
(2) ERD-1	VECC	1200	20A/1P	21		*		22	20A/1P	1200	VECC	PROJECTOR
(2) ERD-1	VECC	1200	20A/1P	23			*	24	20A/1P	450	VECC	DINING RECEPT
SPARE (LOAD)	0	2881	20A/1P	25	*			26	20A/1P	150	VECC	DINING RECEPT
GREEN RF RCPT		5400	20A/1P	27		*		28	20A/1P	300	VECC	DINING RECEPT
HAND DRYER	VECC	1350	20A/1P	29			*	30	20A/1P	2881		SPARE (LOAD)
HAND DRYER	VECC	1350	20A/1P	31	*			32	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	33		*		34	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	35			*	36	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	37	*			38	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	39		*		40	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	41			*	42	20A/1P	2880.8		SPARE (LOAD)

CONNECTED LOAD (KW) - A Ph.	21.45	TOTAL DESIGN LOAD (KW)	96.88
CONNECTED LOAD (KW) - B Ph.	36.72	POWER FACTOR	0.83
CONNECTED LOAD (KW) - C Ph.	22.56	TOTAL DESIGN LOAD (AMPS)	325

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

PANEL TAG: PEL1
PANEL LOCATION: Electrical Room
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
TUNNEL LTG	TUNNEL	418	20A/1P	1	*			2	20A/1P	1739	TUNNEL	TUNNEL LTG
PLANT LTG	PLANT	1277	20A/1P	3		*		4	20A/1P	1522	SHOP	PLANT LTG
PLANT LTG	PLANT	1739	20A/1P	5			*	6	20A/1P	1197	PLANT	PLANT LTG
PLANT LTG	ENTRY	1036	20A/1P	7	*			8	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)	0	2881	20A/1P	9		*		10	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)	0	2881	20A/1P	11			*	12	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	13	*			14	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	15		*		16	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	17			*	18	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	19	*			20	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	21		*		22	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	23			*	24	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	25	*			26	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	27		*		28	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	29			*	30	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	31	*			32	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	33		*		34	20A/1P	2881		SPARE (LOAD)
GEN BLOCK HTR		3220	20A/1P	35			*	36	20A/1P	2881		SPARE (LOAD)
GEN BLOCK HTR		3220	20A/1P	37	*			38	20A/1P	2881		SPARE (LOAD)
GEN BLOCK HTR		3220	20A/1P	39		*		40	20A/1P	2881		SPARE (LOAD)
GEN BLOCK HTR		3220	20A/1P	41			*	42	20A/1P	2880.8		SPARE (LOAD)

CONNECTED LOAD (KW) - A Ph.	35.22	TOTAL DESIGN LOAD (KW)	133.33
CONNECTED LOAD (KW) - B Ph.	37.71	POWER FACTOR	0.83
CONNECTED LOAD (KW) - C Ph.	38.18	TOTAL DESIGN LOAD (AMPS)	193

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

PANEL TAG: PEL1
PANEL LOCATION: Electrical Room
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
TUNNEL LTG	TUNNEL	418	20A/1P	1	*			2	20A/1P	1739	TUNNEL	TUNNEL LTG
PLANT LTG	PLANT	1277	20A/1P	3		*		4	20A/1P	1522	SHOP	PLANT LTG
PLANT LTG	PLANT	1739	20A/1P	5			*	6	20A/1P	1197	PLANT	PLANT LTG
PLANT LTG	ENTRY	1036	20A/1P	7	*			8	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)	0	2881	20A/1P	9		*		10	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)	0	2881	20A/1P	11			*	12	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	13	*			14	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	15		*		16	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	17			*	18	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	19	*			20	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	21		*		22	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	23			*	24	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	25	*			26	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	27		*		28	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	29			*	30	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	31	*			32	20A/1P	2881		SPARE (LOAD)
SPARE (LOAD)		2881	20A/1P	33		*		34	20A/1P	2881		SPARE (LOAD)
GEN BLOCK HTR		3220	20A/1P	35			*	36	20A/1P	2881		SPARE (LOAD)
GEN BLOCK HTR		3220	20A/1P	37	*			38	20A/1P	2881		SPARE (LOAD)
GEN BLOCK HTR		3220	20A/1P	39		*		40	20A/1P	2881		SPARE (LOAD)
GEN BLOCK HTR		3220	20A/1P	41			*	42	20A/1P	2880.8		SPARE (LOAD)

CONNECTED LOAD (KW) - A Ph.	35.22	TOTAL DESIGN LOAD (KW)	133.33
CONNECTED LOAD (KW) - B Ph.	37.71	POWER FACTOR	0.83
CONNECTED LOAD (KW) - C Ph.	38.18	TOTAL DESIGN LOAD (AMPS)	193

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

PANEL TAG: PWS
PANEL LOCATION: Electrical Room
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
NEMA 6-20R'S	SHOP	1105	20A/1P	1	*			2	20A/1P	1700	SHOP	NEMA 6-30R
NEMA 6-20R'S	SHOP	1105	20A/1P	3		*		4	20A/1P	1700	SHOP	NEMA 6-30R
NEMA 6-20R'S	SHOP	1105	20A/1P	5			*	6	20A/1P	1700	SHOP	NEMA 6-30R
NEMA 6-20R'S	SHOP	1105	20A/1P	7	*			8	20A/1P	1700	SHOP	NEMA 6-30R
NEMA 6-20R'S	SHOP	1105	20A/1P	9		*		10	20A/1P	2881	SHOP	SPARE (LOAD)
NEMA 6-20R'S	SHOP	1105	20A/1P	11			*	12	20A/1P	2881	SHOP	SPARE (LOAD)
SPARE (LOAD)	SHOP	2881	20A/1P	13	*			14	20A/1P	2881	SHOP	SPARE (LOAD)
SPARE (LOAD)	SHOP	2881	20A/1P	15		*		16	20A/1P	2881	SHOP	SPARE (LOAD)
NEMA 15-30R	SHOP	1955	20A/1P	17			*	18	20A/1P	2881	SHOP	SPARE (LOAD)
NEMA 15-30R	SHOP	1955	20A/1P	19	*			20	20A/1P	270	SHOP	RECEPTACLES
NEMA 15-30R	SHOP	1955	20A/1P	21		*		22	20A/1P	270	SHOP	RECEPTACLES
SPARE (LOAD)	SHOP	2881	20A/1P	23			*	24	20A/1P	270	SHOP	RECEPTACLES
SPARE (LOAD)	SHOP	2881	20A/1P	25	*			26	20A/1P	270	SHOP	RECEPTACLES
SPARE (LOAD)	SHOP	2881	20A/1P	27		*		28	20A/1P	270	SHOP	RECEPTACLES
BENCH LTG	SHOP	120	20A/1P	29			*	30	20A/1P	270	SHOP	RECEPTACLES
SPARE (LOAD)	SHOP	2881	20A/1P	31	*			32	20A/1P	675	SHOP	RECEPTACLES
SPARE (LOAD)	SHOP	2881	20A/1P	33		*		34	20A/1P	270	SHOP	RECEPTACLES
SPARE (LOAD)	SHOP	2881	20A/1P	35			*	36	20A/1P	270	SHOP	RECEPTACLES
SPARE (LOAD)	SHOP	2881	20A/1P	37	*			38	20A/1P	270	SHOP	RECEPTACLES
SPARE (LOAD)	SHOP	2881	20A/1P	39		*		40	20A/1P	2881	SHOP	SPARE (LOAD)
SPARE (LOAD)	SHOP	2881	20A/1P	41			*	42	20A/1P	2880.8	SHOP	SPARE (LOAD)

CONNECTED LOAD (KW) - A Ph.	23.45	TOTAL DESIGN LOAD (KW)	89.25
CONNECTED LOAD (KW) - B Ph.	26.84	POWER FACTOR	0.81
CONNECTED LOAD (KW) - C Ph.	24.08	TOTAL DESIGN LOAD (AMPS)	133

DIMMER SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

DIMMER TAG: VD5
DIMMER LOCATION: VECC
DIMMER MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
TRACK	CAFÉ	760	20A/1P	1	*			2	20A/1P	760	CAFÉ	TRACK
TRACK	CAFÉ	840	20A/1P	3		*		4	20A/1P	840	CAFÉ	TRACK
TRACK	CAFÉ	840	20A/1P	5			*	6	20A/1P	840	CAFÉ	TRACK
LINEAR FLOUR.	CAFÉ	200	20A/1P	7	*			8	20A/1P	198	LOBBY	LINEAR FLOUR.
DOWNLIGHTS	LOBBY	540	20A/1P	9		*		10	20A/1P	140	LOBBY	WALL WASHERS
TRACK	RETAIL	1680	20A/1P	11			*	12	20A/1P	1680	RETAIL	TRACK
TRACK	RETAIL	840	20A/1P	13	*			14	20A/1P	840	RETAIL	TRACK
TRACK	RETAIL	1680	20A/1P	15		*		16	20A/1P	1680	RETAIL	TRACK
LINEAR FLOUR.	RETAIL	627	20A/1P	17			*	18	20A/1P	1000	CAFÉ	DOWNLIGHTS
DOWNLIGHTS	VESTIBULE	450	20A/1P	19	*			20	20A/1P	960	0	SPARE (LOAD)
WALL WASHERS	FAMILY RM	650	20A/1P	21		*		22	20A/1P	1706	FAMILY RM	TRACK
TRACK	FAMILY RM	1706	20A/1P	23			*	24	20A/1P	1050	FAMILY RM	TRACK
TRACK	FAMILY RM	1050	20A/1P	25	*			26	20A/1P	1140	FAMILY RM	TRACK
TRACK	FAMILY RM	1140	20A/1P	27		*		28	20A/1P	1575	FAMILY RM	TRACK
TRACK	FAMILY RM	1575	20A/1P	29			*	30	20A/1P	352	FAMILY RM	COVE FLUOR.
LINEAR FLUOR.	FAMILY RM	256	20A/1P	31	*			32	20A/1P	960	LOBBY	TRACK
TRACK	LOBBY	960	20A/1P	33		*		34	20A/1P	960	0	SPARE (LOAD)
SPARE (LOAD)	0	960	20A/1P	35			*	36	20A/1P	960	0	SPARE (LOAD)
SPARE (LOAD)	0	960	20A/1P	37	*			38	20A/1P	960	0	SPARE (LOAD)
SPARE (LOAD)	0	960	20A/1P	39		*		40	20A/1P	960	0	SPARE (LOAD)
SPARE (LOAD)	0	960	20A/1P	41			*	42	20A/1P	960	0	SPARE (LOAD)

CONNECTED LOAD (KW) - A	10.33	TOTAL DESIGN LOAD (KW)	48.19
CONNECTED LOAD (KW) - B	14.63	POWER FACTOR	0.11
CONNECTED LOAD (KW) - C	15.19	TOTAL DESIGN LOAD (AMPS)	1166

DIMMER SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

DIMMER TAG: VED4
DIMMER LOCATION: VECC
DIMMER MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LINEAR FLUOR.	DISPLAY D	860	20A/1P	1	*			2	20A/1P	500	CORRIDOR	DOWNLIGHTS
DOWNLIGHTS	CAFÉ	600	20A/1P	3		*		4	20A/1P	192	CAFÉ	LINEAR FLUOR.
SPARE (LOAD)	0	960	20A/1P	5			*	6	20A/1P	462	RETAIL	LINEAR FLUOR.
DOWNLIGHTS	RETAIL	459	20A/1P	7	*			8	20A/1P	710	LINK	LINEAR FLUOR.
DOWNLIGHTS	LINK	300	20A/1P	9		*		10	20A/1P	960		SPARE (LOAD)
DOWNLIGHTS	DISP. FOYER	500	20A/1P	11			*	12	20A/1P	400	LINK	LED STRIPLIGHTS
LINEAR FLUOR.	LINK	1000	20A/1P	13	*			14	20A/1P	224	FAMILY RM	LINEAR FLUOR.
DOWNLIGHTS	FAMILY RM	200	20A/1P	15		*		16	20A/1P	1920	LOBBY	TRACK
TRACK	LOBBY	1920	20A/1P	17			*	18	20A/1P	960		SPARE (LOAD)
SPARE (LOAD)		960	20A/1P	19	*			20	20A/1P	960		SPARE (LOAD)
SPARE (LOAD)		960	20A/1P	21		*		22	20A/1P	960		SPARE (LOAD)
SPARE (LOAD)		960	20A/1P	23			*	24	20A/1P	960		SPARE (LOAD)
DOES NOT EXIST		0	20A/1P	25	*			26	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	27		*		28	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	29			*	30	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	31	*			32	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	33		*		34	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	35			*	36	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	37	*			38	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	39		*		40	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	41			*	42	20A/1P	0		DOES NOT EXIST

CONNECTED LOAD (KW) - A	5.67	TOTAL DESIGN LOAD (KW)	22.66
CONNECTED LOAD (KW) - B	6.09	POWER FACTOR	0.85
CONNECTED LOAD (KW) - C	7.12	TOTAL DESIGN LOAD (AMPS)	74

DIMMER SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

DIMMER TAG: VED2
DIMMER LOCATION: VECC
DIMMER MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
TRACK	DISPLAY A	300	20A/1P	1	*			2	20A/1P	750	DISPLAY B	TRACK
TRACK	DISPLAY B	750	20A/1P	3		*		4	20A/1P	1050	DISPLAY C	TRACK
TRACK	DISPLAY C	1050	20A/1P	5			*	6	20A/1P	780	LOBBY	LINEAR FLUOR.
DOWNLIGHTS	LOBBY	1000	20A/1P	7	*			8	20A/1P	960		SPARE (LOAD)
SPARE (LOAD)		960	20A/1P	9		*		10	20A/1P	400	VESTIBULE	DOWNLIGHTS
STEPLIGHTS	EXT. STAIR	140	20A/1P	11			*	12	20A/1P	1792	MULTI-USE	LINEAR FLUOR.
DOWNLIGHTS	MULTI-USE	324	20A/1P	13	*			14	20A/1P	0	ENTRANCE	DOWNLIGHTS
TRACK	STAIR	840	20A/1P	15		*		16	20A/1P	840	STAIR	TRACK
SPARE (LOAD)		960	20A/1P	17			*	18	20A/1P	960		SPARE (LOAD)
SPARE (LOAD)		960	20A/1P	19	*			20	20A/1P	960		SPARE (LOAD)
SPARE (LOAD)		960	20A/1P	21		*		22	20A/1P	960		SPARE (LOAD)
SPARE (LOAD)		960	20A/1P	23			*	24	20A/1P	960		SPARE (LOAD)
DOES NOT EXIST		0	20A/1P	25	*			26	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	27		*		28	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	29			*	30	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	31	*			32	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	33		*		34	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	35			*	36	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	37	*			38	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	39		*		40	20A/1P	0		DOES NOT EXIST
DOES NOT EXIST		0	20A/1P	41			*	42	20A/1P	0		DOES NOT EXIST

CONNECTED LOAD (KW) - A	5.25	TOTAL DESIGN LOAD (KW)	23.54
CONNECTED LOAD (KW) - B	6.76	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C	7.60	TOTAL DESIGN LOAD (AMPS)	82

DIMMER SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

DIMMER TAG: VD6
DIMMER LOCATION: VECC
DIMMER MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
TRACK	VECC TYP	1680	20A/1P	1	*			2	20A/1P	1680		TRACK
TRACK		1680	20A/1P	3		*		4	20A/1P	1680		TRACK
TRACK		1680	20A/1P	5			*	6	20A/1P	1680		TRACK
TRACK		1680	20A/1P	7	*			8	20A/1P	1680		TRACK
TRACK		450	20A/1P	9		*		10	20A/1P	264		WALL GRAZE
ACCENT LTG		184	20A/1P	11			*	12	20A/1P	207		ACCENT LTG
DOWNLIGHTS		648	20A/1P	13	*			14	20A/1P	1920		LINEAR FLUOR.
FLOODLIGHTS		350	20A/1P	15		*		16	20A/1P	50		SMALL FLOOD
SMALL FLOOD		50	20A/1P	17			*	18	20A/1P	50		SMALL FLOOD
SMALL FLOOD		50	20A/1P	19	*			20	20A/1P	50		SMALL FLOOD
SMALL FLOOD		50	20A/1P	21		*		22	20A/1P	50		SMALL FLOOD
SMALL FLOOD		50	20A/1P	23			*	24	20A/1P	50		SMALL FLOOD
SMALL FLOOD		50	20A/1P	25	*			26	20A/1P	50		SMALL FLOOD
SMALL FLOOD		50	20A/1P	27		*		28	20A/1P	50		SMALL FLOOD
SMALL FLOOD		50	20A/1P	29			*	30	20A/1P	50		SMALL FLOOD
JUNCTION BOXES		200	20A/1P	31	*			32	20A/1P	200		JUNCTION BOXES
EXT DOWNLIGHTS		378	20A/1P	33		*		34	20A/1P	880		LINEAR LED
WALL LIGHTS		320	20A/1P	35			*	36	20A/1P	297		EXT WALL WASH
LED COVE		276	20A/1P	37	*			38	20A/1P	335		LL LTG
WALL GRAZE		576	20A/1P	39		*		40	20A/1P	900		SPARE (LOAD)
SPARE (LOAD)		1248	20A/1P	41			*	42	20A/1P	600		SPARE (LOAD)
SPARE (LOAD)		500	20A/1P	43	*			44	20A/1P	117		SPARE (LOAD)
SPARE (LOAD)		960	20A/1P	45		*		46	20A/1P	960		SPARE (LOAD)
0	0	960	20A/1P	47			*	48	20A/1P	960	0	0

CONNECTED LOAD (KW) - A	10.99	TOTAL DESIGN LOAD (KW)	34.66
CONNECTED LOAD (KW) - B	7.01	POWER FACTOR	0.82
CONNECTED LOAD (KW) - C	6.59	TOTAL DESIGN LOAD (AMPS)	117

Wiring Diagrams

Control wiring diagrams can be found in Appendix C. Appendix C includes Lutron control diagrams for the electric lighting dimming system and system component specifications.

Feeder Sizing Calculations

Conduit sizes from 2011 NEC Table C.1.

Panelbord	
Tag	VR2
Voltage System	208Y/120, 3PH, 4W
Calculated Design Load (kW)	46
Calculated Power Factor	0.812720848
Calculated Design Load (kVA)	56.6
Calculated Design Load (A)	157
Feeder	
Feeder Protection Size	175
Number of Sets	1
Wire Size	
Phase	(3) #2/0 AWG
Neutral	(1) #2/0 AWG
Ground	(1) #6 AWG
Conduit Size	2"
Feeder Length	110
Final Voltage Drop (V)	3.02
Final Voltage Drop (%)	1.451923077
Was feeder re-sized?	No

Panelbord	
Tag	VR1B
Voltage System	208Y/120, 3PH, 4W
Calculated Design Load (kW)	80
Calculated Power Factor	0.819672131
Calculated Design Load (kVA)	97.6
Calculated Design Load (A)	271
Feeder	
Feeder Protection Size	300
Number of Sets	1
Wire Size	
Phase	(3) 300 KCM
Neutral	(1) 300 KCM
Ground	(1) #4 AWG
Conduit Size	2.5"
Feeder Length	105
Final Voltage Drop (V)	2.88
Final Voltage Drop (%)	1.384615385
Was feeder re-sized?	No

Panelbord	
Tag	PL1
Voltage System	480Y/277, 3PH, 4W
Calculated Design Load (kW)	107.4
Calculated Power Factor	0.808126411
Calculated Design Load (kVA)	132.9
Calculated Design Load (A)	160
Feeder	
Feeder Protection Size	175
Number of Sets	1
Wire Size	
Phase	(3) #2/0 AWG
Neutral	(1) #2/0 AWG
Ground	(1) #6 AWG
Conduit Size	2"
Feeder Length	35
Final Voltage Drop (V)	0.96
Final Voltage Drop (%)	0.2
Was feeder re-sized?	No

Panelbord	
Tag	PEL1
Voltage System	480Y/277, 3PH, 4W
Calculated Design Load (kW)	111.1
Calculated Power Factor	0.819672131
Calculated Design Load (kVA)	133.9
Calculated Design Load (A)	161.1
Feeder	
Feeder Protection Size	175
Number of Sets	1
Wire Size	
Phase	(3) #2/0 AWG
Neutral	(1) #2/0 AWG
Ground	(1) #6 AWG
Conduit Size	2"
Feeder Length	40
Final Voltage Drop (V)	1.1
Final Voltage Drop (%)	0.229166667
Was feeder re-sized?	No

Panelbord	
Tag	PWS
Voltage System	208Y/120, 3PH, 4W
Calculated Design Load (kW)	74.4
Calculated Power Factor	0.819672131
Calculated Design Load (kVA)	91.8
Calculated Design Load (A)	110.4
Feeder	
Feeder Protection Size	125
Number of Sets	1
Wire Size	
Phase	(3) #2 AWG
Neutral	(1) #2 AWG
Ground	(1) #6 AWG
Conduit Size	1.25"
Feeder Length	40
Final Voltage Drop (V)	1.1
Final Voltage Drop (%)	0.528846154
Was feeder re-sized?	No

Protective Device Coordination and Short Circuit Study

Device Coordination Study

The overcurrent protection devices discussed in this study are PHMB, VDB1 and VP1. They are 3000A, 600A and 100A respectively. From the time/current graphs in Figure 52, we see that the devices are properly coordinated. The curves for the upstream equipment are above those downstream and no curves are overlapping.

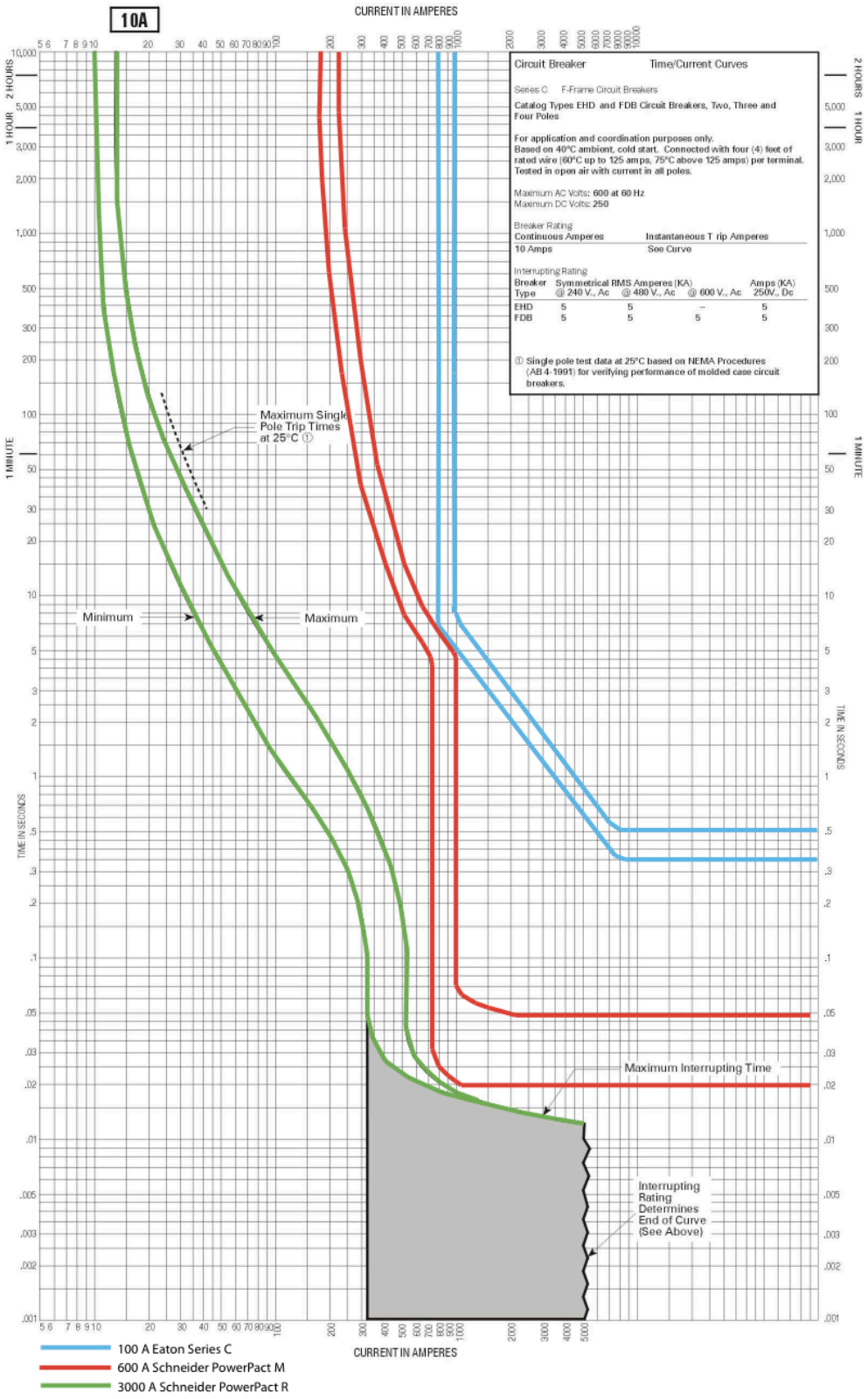


Figure 52: Time/Current Graphs

Short Circuit Calculations

The short circuit calculations shown below are for devices PHMB, VDB1 and VP1.

Base kVA	1000
Utility Contribution (kVA)	100000

Utility				
	X= Base kVA/Utility S.C. kVA =	0.01		
Switchboard PHMB	**∑X**	**∑R**	**∑Z**	**Isc**
Wire = 500 KCM	0.000048	0.000032	0.000048	25058605.43
Length = 8				
Sets = 8	X = (L/1000)*XL*(1/# of Sets)			
XL = 0.048	R = (L/1000)*R*(1/# of Sets)			
R = 0.032				
Switchboard VDB1				
Wire = 350 KCM	0.0012	0.00117	0.0012	1002344.217
Length = 60				
Sets = 2	X = (L/1000)*XL*(1/# of Sets)			
XL = 0.04	R = (L/1000)*R*(1/# of Sets)			
R = 0.039				
Panelboard VP1				
Wire = #2 AWG	0.005	0.005	0.005	240562.6122
Length = 25				
Sets = 1	X = (L/1000)*XL*(1/# of Sets)			
XL = 0.2	R = (L/1000)*R*(1/# of Sets)			
R = 0.2				

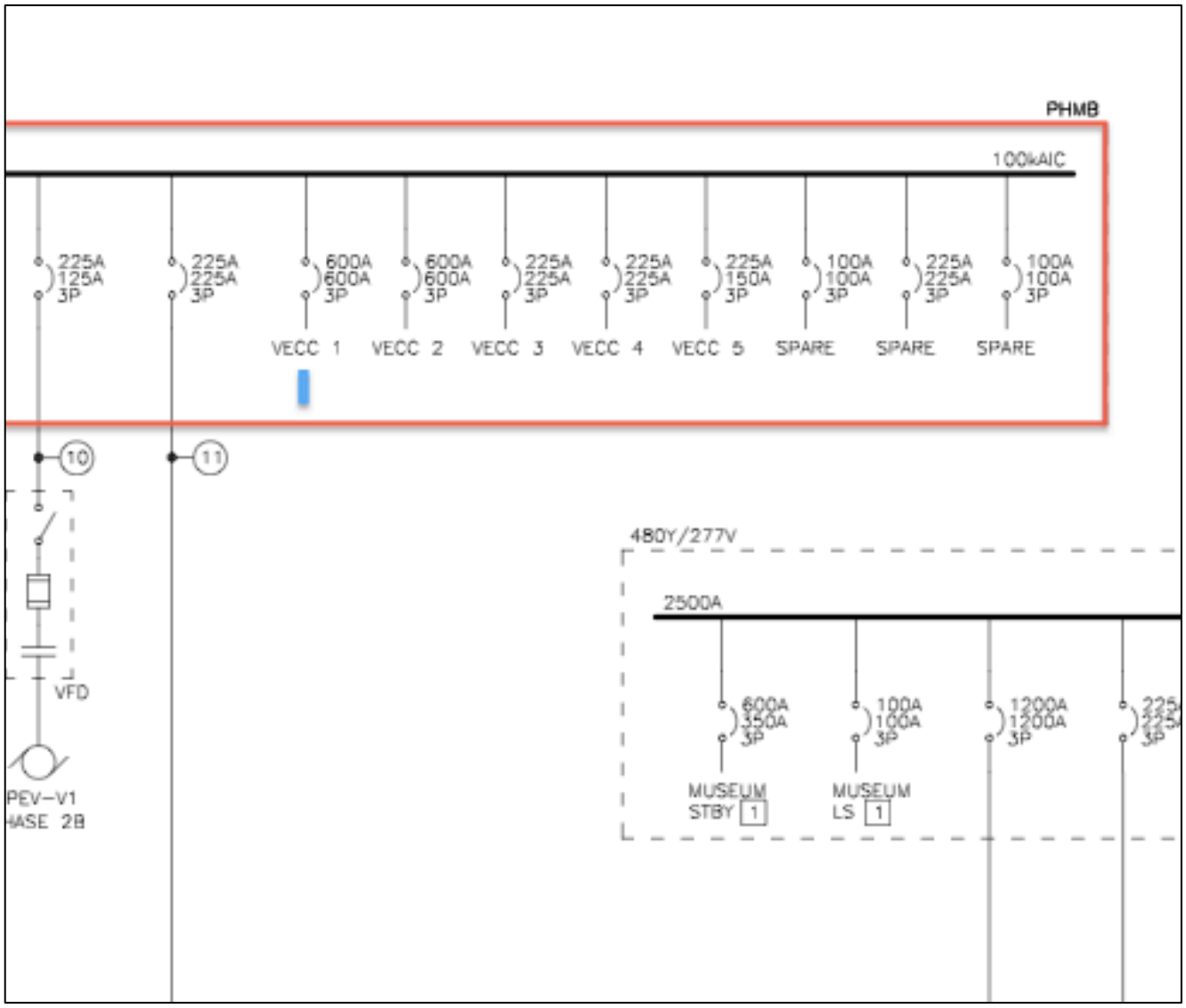


Figure 53: Single Line Cutout – Plant
Note: Blue Line Continues into Figure 53: Single Line Cutout - VECC

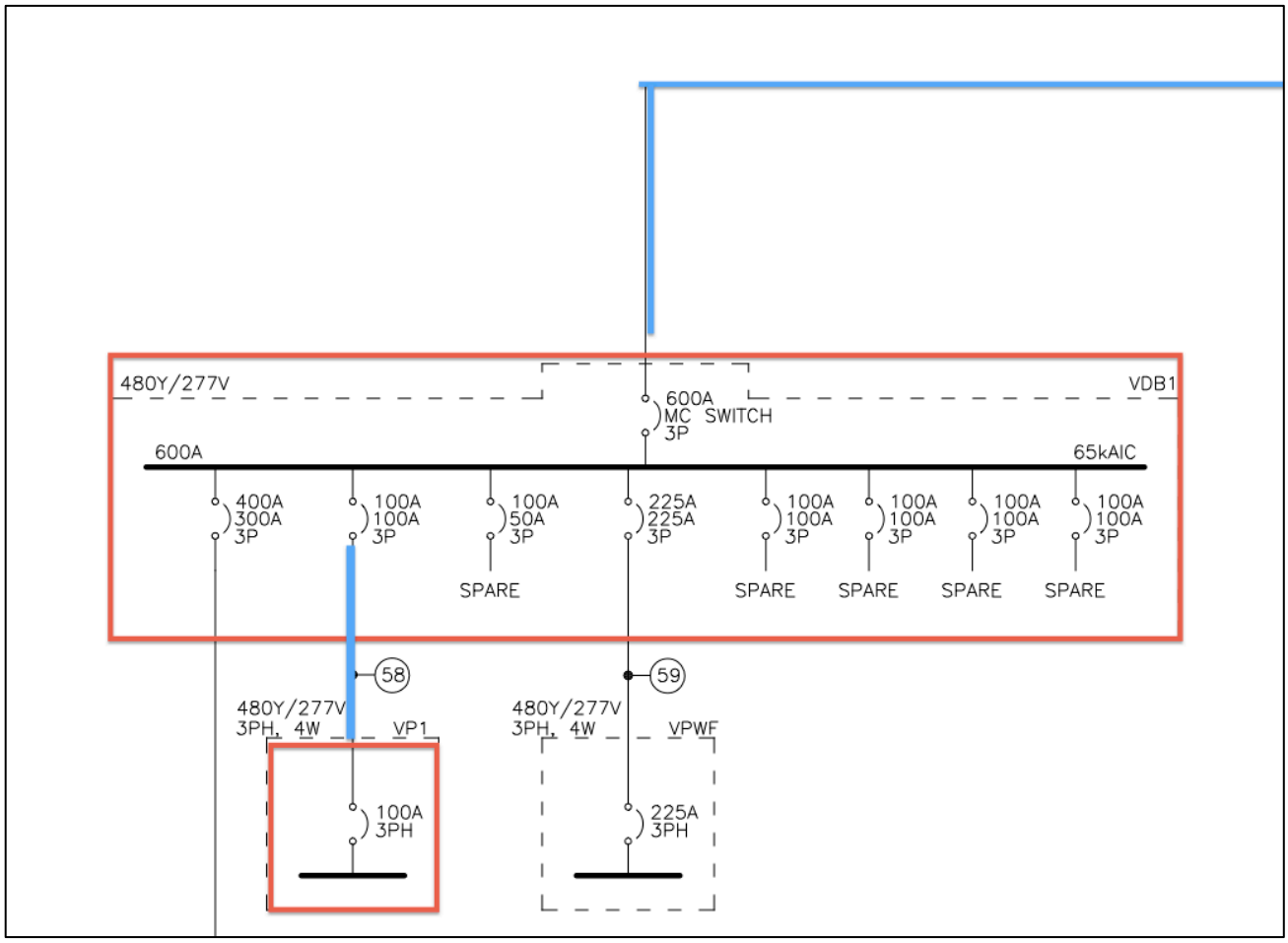


Figure 54: Single Line Cutout - VECC

Electrical Depth I: Photovoltaic Study

Introduction

This study investigates the feasibility adding a photovoltaic array to the roof of the VECC. An analysis of the site, including shade and solar angle calculations has been performed in addition to studies involving the specific equipment selected. Based on the results, the PV system is not a wise financialy investment. The Clark, however, may want to follow through with the design if they would like to use the PV system as a learning opportunity for guests or establish the facility as a green and sustainable model for other facilities.

Hypothesis

Adding a photovoltaic system on the roof of the VECC The Clark will not be a wise financial investment for the owner.

Methods

Shading Survey

The Clark is located on the scenic outskirts of Williamstown, and therefore has no sunlight obstruction from adjacent buildings. The trees that surround the VECC are not close enough or large enough to obstruct sunlight to the roof of the VECC. Figure 55 shows the closest tree plantings (outlined in green). These trees will initially be of similar height to the VECC roof (see rendering in Fixure 56) and are far enough from the roof to avoid shading potential PV panel locations.

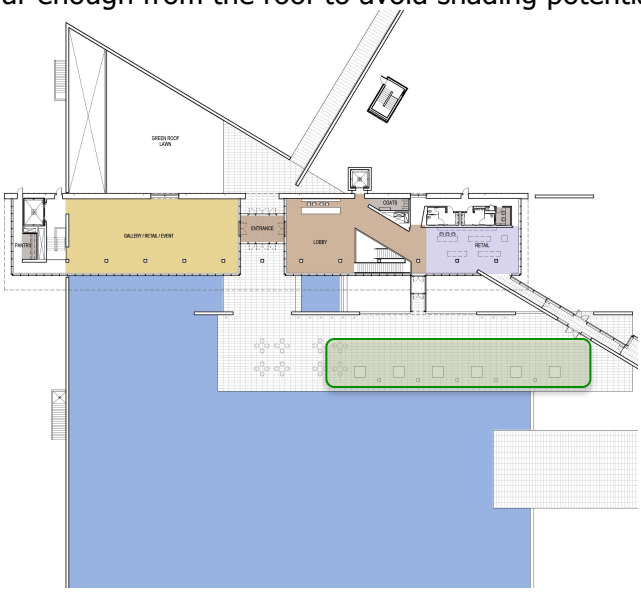


Figure 55: Surrounding Vegetation (Plan)

Scale: NTS N

Figure 56: Surrounding Vegetation (Rendering)

The roof of the VECC is relatively free of obstructions as see in Figures 55 and 56. The HVAC equipment is located in the mechanical rooms and the hydraulic elevator does not require a tall mechanical service space that would extend above the roof slab. The highlighted sections of Figures 57 and 58 are where PV panels would be located. This area was chosen based on aesthetic and structural considerations. It was important for the PV array to avoid being an eyesore that looms heavily on the south overhang. Therefore no panels were located on the concrete overhang. The dark areas of the roof were avoided as they have insufficient structure for a PV panel array and were not redesigned for reasons discussed in the structural breadth portion of this report.

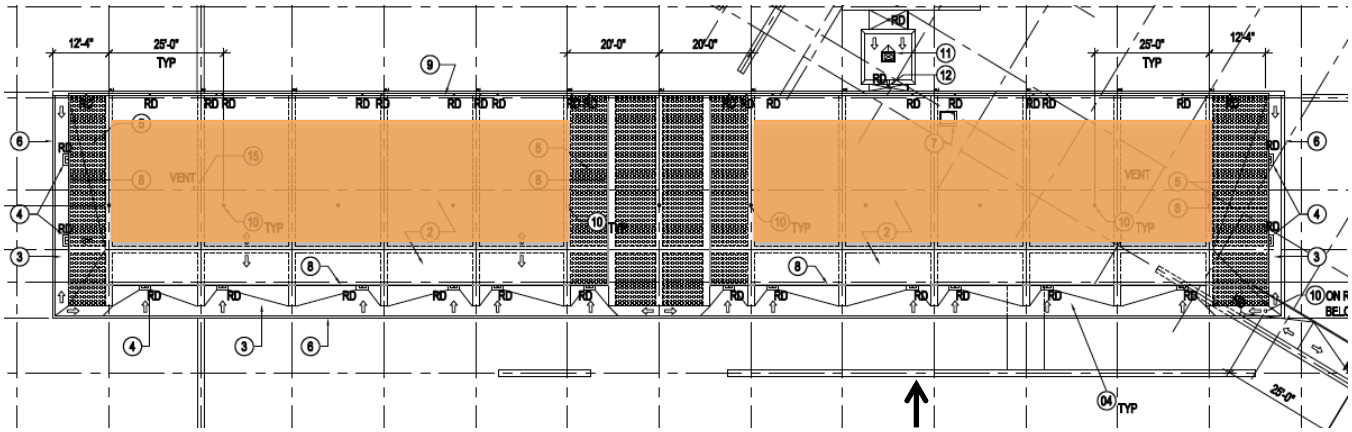


Figure 58: VECC Roof Plan

Scale: NTS

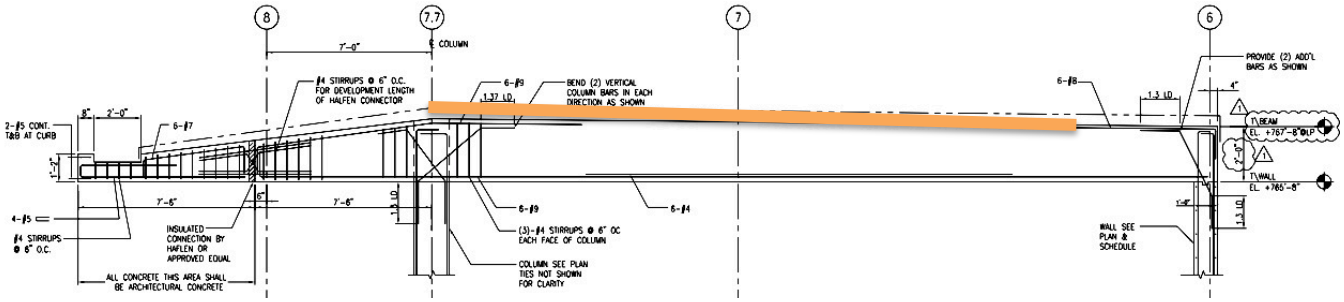


Figure 59: VECC Roof Section

Solar Survey

The Clark is located in the Northwest United States, and therefore has a significant amount of cloudy days. Figure 60 shows the annual breakdown of clear, partly cloudy and cloudy days as reported by www.ncdc.noaa.gov for the nearby Albany, NY. The daylight conditions do not favor PV power as much as they might in the southwestern United States, but are still a viable option with northeastern light conditions.

	Clear	Partly Cloudy	Cloudy
Days	69	111	185
Percent	0.19	0.30	0.51

Figure 60: Clear, Partly Cloudy and Cloudy Days

Design

Layout and Orientation

Williamstown, Massachusetts is located at 42° north latitude. Therefore, the array tilt angle should be approximately 42°. However, because most of the clear days in the northeastern United States occur during the summer, the array angle is tilted -15° from 42°, or 27° to maximize summer gains. Additionally, this adjustment was accepted because the lower angle allows the panels to make less of an architectural impact on the VECC. The panels will be placed on a roof that is sloped 0.5787° away from south. Therefore, the design angle from the roof surface will be approximately 28°. However, during the calculations to follow, the slope of the roof was ignored, as it would have a negligible effect on the height and spacing of the array.

A PV panel was selected from one of the largest PV panel manufacturers, Suntech. The panel measures 65" x 39" x 2". With these dimensions and the 27° tilt angle, it was determined that the panel has to be placed approximately 11'-7" away from the perimeter of the roof to keep a guest from seeing the panel at a distance of 100'-0" away. This will help reduce the impact that the array has on the architecture of The Clark.

To maximize gains, the goal was to prevent the panels from shading themselves during hours of 9:00 AM and 3:00 PM during the winter solstice. Doing this ensures that there will be no self-shading during any portion of the year.

Array Height

$\sin(27) = h / 39$

$h = 17.7"$

Array Spacing

h = height of the tilted array
d = length of shadow (minimum spacing)
t_s = standard time in decimal hours
t_{local} = local time
ET = equation of time
J = Julian day
t = solar time in decimal hours
SM = standard meridian for the time zone in degrees
L = longitude in degrees
∂ = solar declination
ℓ = latitude
a_t = solar altitude in radians
a_s = solar azimuth in radians
a_e = elevation (panel) azimuth in radians

The following equations were entered into an excel worksheet to determine the spacing, first by finding the height of the array, then the solar time, and finally the profile angle of the sun (at 9:00 AM and 3:00 PM).

$t_s = t_{local} - 1$
$ET = 0.1644 \sin(4\pi (J-81.6) / 365.25) - 0.1273 \sin(2\pi (J-2.5) / 365.25)$
$t = ts + ET + (12 (SM-L)/180)$

$\partial = 0.4039 \sin(2\pi (J-81) / 368)$
$a_t = \arcsin(\sin \ell \sin \partial - \cos \ell \cos \partial \cos(\pi t/12))$
$a_s = \arctan[(-\cos \partial \sin(\pi t/12))/-(\cos \ell \sin \partial + \sin \ell \cos \partial \cos(\pi t/12))]$
$a_z = a_s - a_e$
$a_p = \arctan(\tan a_t / \cos a_z)$

The solar array is being designed for maximum sunlight exposure. Therefore, the quantity SM-L was assumed to be zero, as it is of no concern how the 9:00 AM or 3:00 PM time recommendations correspond to the time zone that The Clark resides in. The result of the calculation shows that the minimum profile angle to be designed for is 16.3°. Using the knowledge that panels will be faced due south, the following equation was used to determine spacing:

$h/d = \tan(a_p)$
d = 60.53”

r/39”=cos(27°)
r = 34.75”

Where r is the run of the PV panel along the roof.

Therefore, the total width of one row of PV panels is 34.75” + 60.53” = 95.28” or 7’-11 9/32”. For design and construction purposes this value will be rounded to a row width of 8’-0”.

The width of the two useable portions of the roof is 100’-0”. Using the spacing requirements (both from roof perimeter and shading requirements) the roof VECC will accommodate six rows of 11 PV

panels, for a total of 66 panels. The dark regions of Figure 61 indicate where the panel rows will be placed.

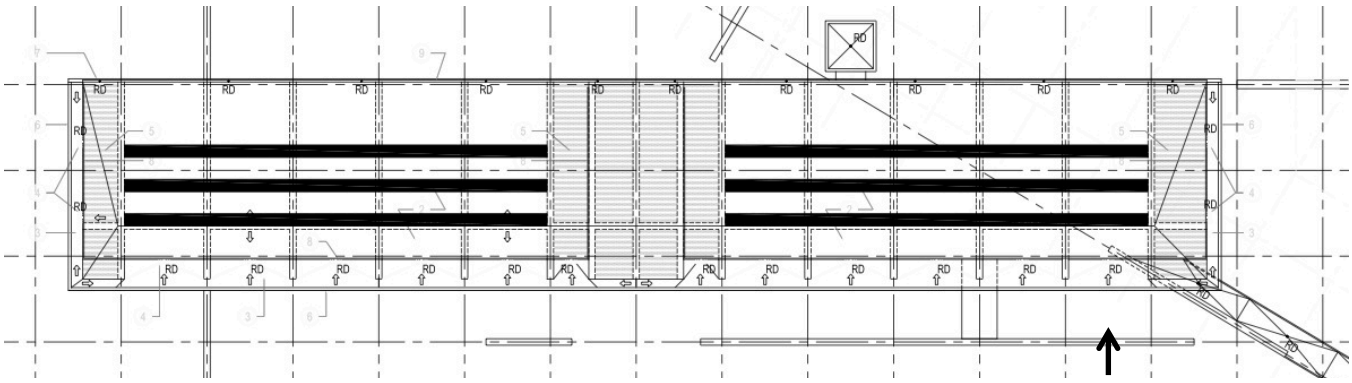


Figure 61: Proposed PV panel layout

Equipment

Suntech STP280-24/Vd panels were selected for this study. The electrical characteristics are listed in Figure 57. Full specifications can be found in Appendix H. As previously mentioned, the panels will generally be free from building and tree shading. Therefore several large inverters were selected instead of implementing micro inverters, as optimizing partly shaded conditions are not as important in this case. Three Fronius IG Plus 6.0-1_{UNI} inverters will be used: one per two strings of (11) PV panels. The electrical characteristics in for the inverter can be seen in Figure 62, and full specifications can be found in Appendix H.

STC	STP275-24/Vd	STP280-24/Vd
Optimum Operating Voltage (Vmp)	35.1 V	35.2 V
Optimum Operating Current (Imp)	7.84 A	7.95 A
Open - Circuit Voltage (Voc)	44.7 V	44.8 V
Short - Circuit Current (Isc)	8.26 A	8.33 A
Maximum Power at STC (Pmax)	275 W	280 W
Module Efficiency	14.2%	14.4%
Operating Module Temperature	-40 °C to +85 °C	
Maximum System Voltage	600 V DC (UL)/ 1000 V DC (IEC)	
Maximum Series Fuse Rating	20 A	
Power Tolerance	0/+5 %	

STC: Irradiance 1000 W/m², module temperature 25 °C, AM=1.5;
Best in Class AAA solar simulator (IEC 60904-9) used, power measurement uncertainty is within +/-3%

Figure 62: PV Panel Electrical Characteristics

Pronius IG Plus 6.0		
PV Array	2100-6900	W
MPPT Min Voltage	230	V
Max Voltage	600	V

Figure 63: Inverter Electrical Characteristics

Electrical Calculations

Low Temperature Voltage

$V_{MAX} = V_{OC} + V_{OC} (C_T \times (T_{MIN} - STC_L))$
$V_{MAX} = 44.8 + 44.8 (0.0033 \times (-21-25)$
$V_{MAX} = 567.61 < 600$ V: *OK*

High Temperature Voltage

$V_{MIN} = V_{MP} + V_{MP} (T_{RM} - STC_H)$
$T_{RM} = T_{MAX} + T_{ROOF}$
$T_{RM} = 30 + 30$
$T_{RM} = 60$
$V_{MIN} = 35.2 + 35.2 (60-25)$
$V_{MIN} = 285.40 > 230$ V: *OK*

Where:
VMAX = maximum voltage
VMP = max power voltage
VOC = open circuit voltage
CT = Temperature coefficient (˚C)
TMIN = minimum temperature (˚C)
TRM = maximum roof temperature (˚C)
STC_L = low temperature at Standard Testing Conditions (˚C)
STC_H = high temperature at Standard Testing Conditions (˚C)

An overall system summary is given in Figure 64. The PV system will connect into the main switchgear via a 100 A panelboard connected to one of the spare 100A switches on the main switchgear as seen in Figure 60 and the following wiring diagram. Each inverter is capable of producing 21.7 Amps of single-phase power at 277V. The three inverters will therefore be supplying power across all of the phases and the neutral.

Nameplate Capacity	18.464	kW
Total Direct Cost	76,269.25	$
Total Installed Cost	84,514.07	$
Total Installed Cost per Capacity	4,577.24	$/kW
Analysis Period	30	years
Inflation Rate	2.5	%
Real Discount Rate	5.2	%

Figure 64: Overall System Summary

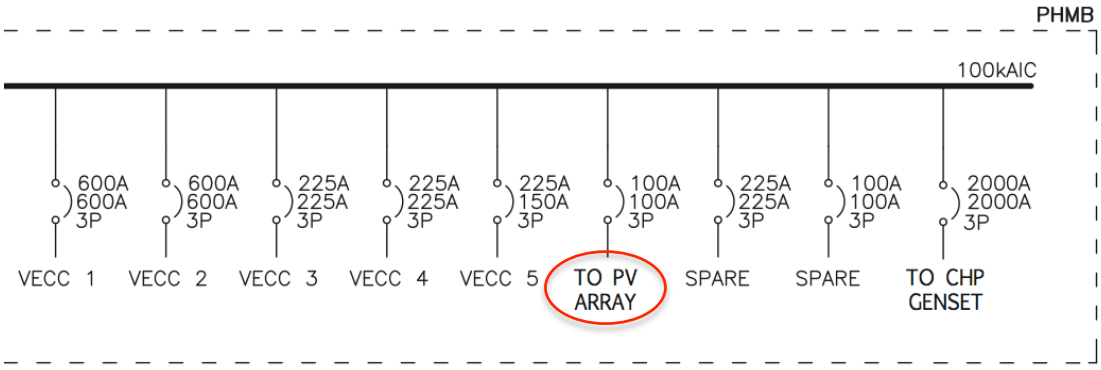
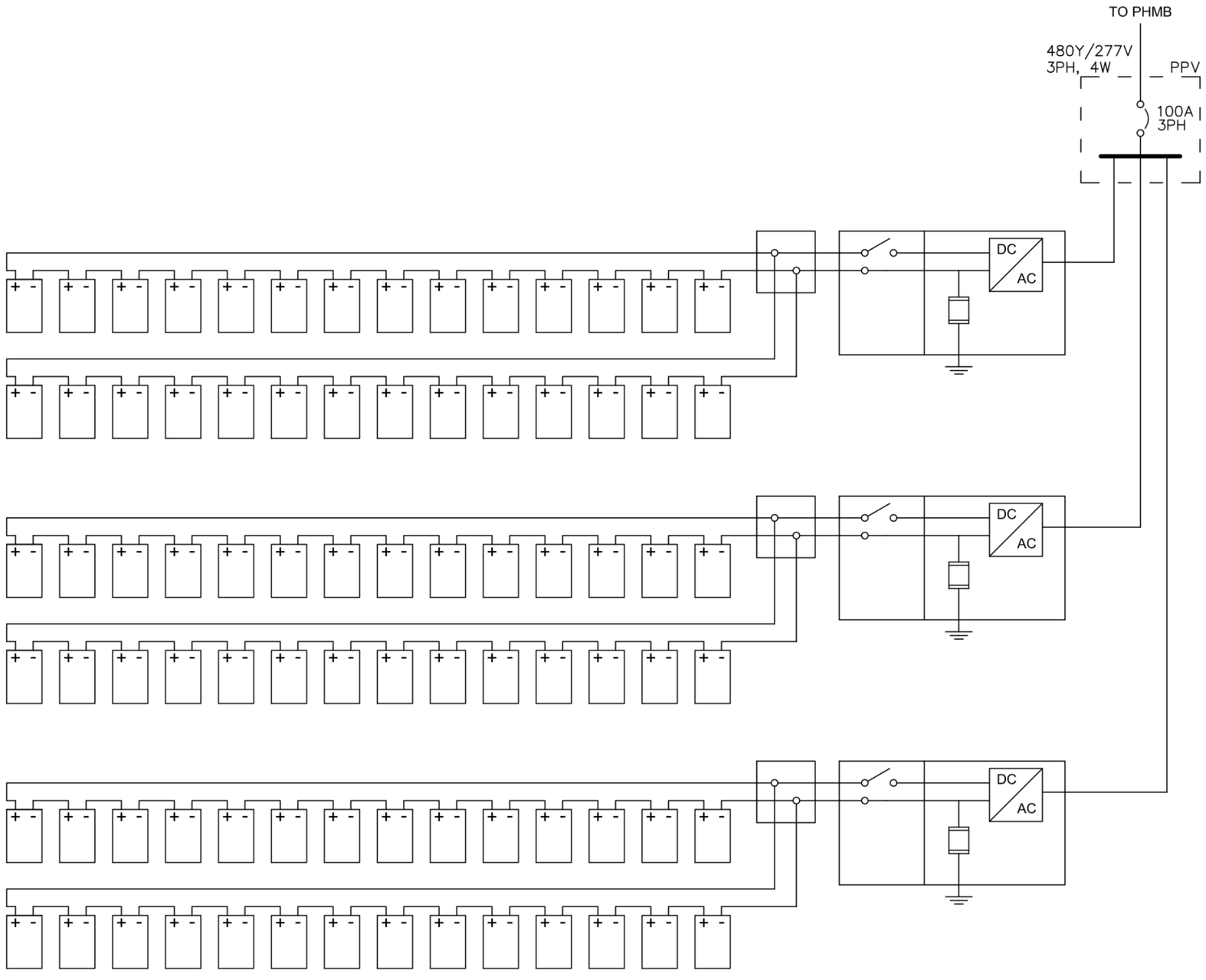


Figure 65: Connecting to the Unit Substation



THE CLARK

Description
PV wiring

Scale
NTS

Drawing

VPV-01

Results

The proposed system was analyzed in System Advisor Model. Results are shown in Figure 66. A 30 year analysis period was set and it was found that the system paid for itself within 7.6 years. Figure 67 shows the Levelised Cost of Energy. Figure 68 shows the yearly cashflow of the system. Although the payback period is generally acceptable for a PV system, it is not acceptable when compared to other investments (energy saving an otherwise) that yield a more acceptable payback period of three to five years. The Clark, however, may want to follow through with the design if they would like to use the PV system as a learning opportunity for guests or establish the facility as a green and sustainable model for other facilities.

Metric	Base
Net Annual Energy	21,162 kWh
LCOE Nominal	10.78 ¢/kWh
LCOE Real	8.27 ¢/kWh
First Year Revenue without System	$ -2,400.00
First Year Revenue with System	$ 668.45
First Year Net Revenue	$ 3,068.45
After-tax NPV	$ 3,628.44
Payback Period	7.58972 years
DC-to-AC Capacity Factor	13.1 %
First year kWhac/kWdc	1,146
System Performance Factor	0.87
Total Land Area	0.08 acres

Figure 66: Analysis Results

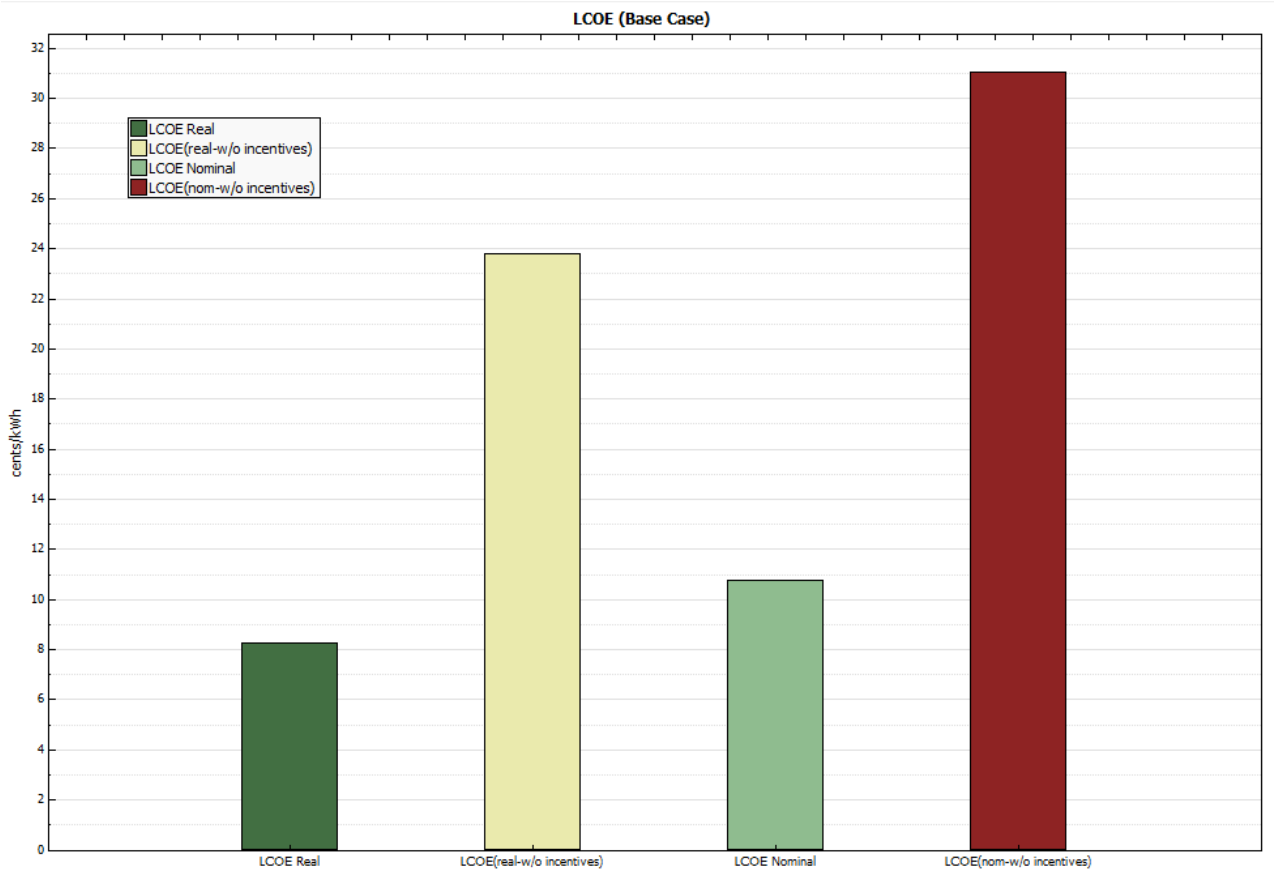


Figure 67: Levelised Cost Of Energy

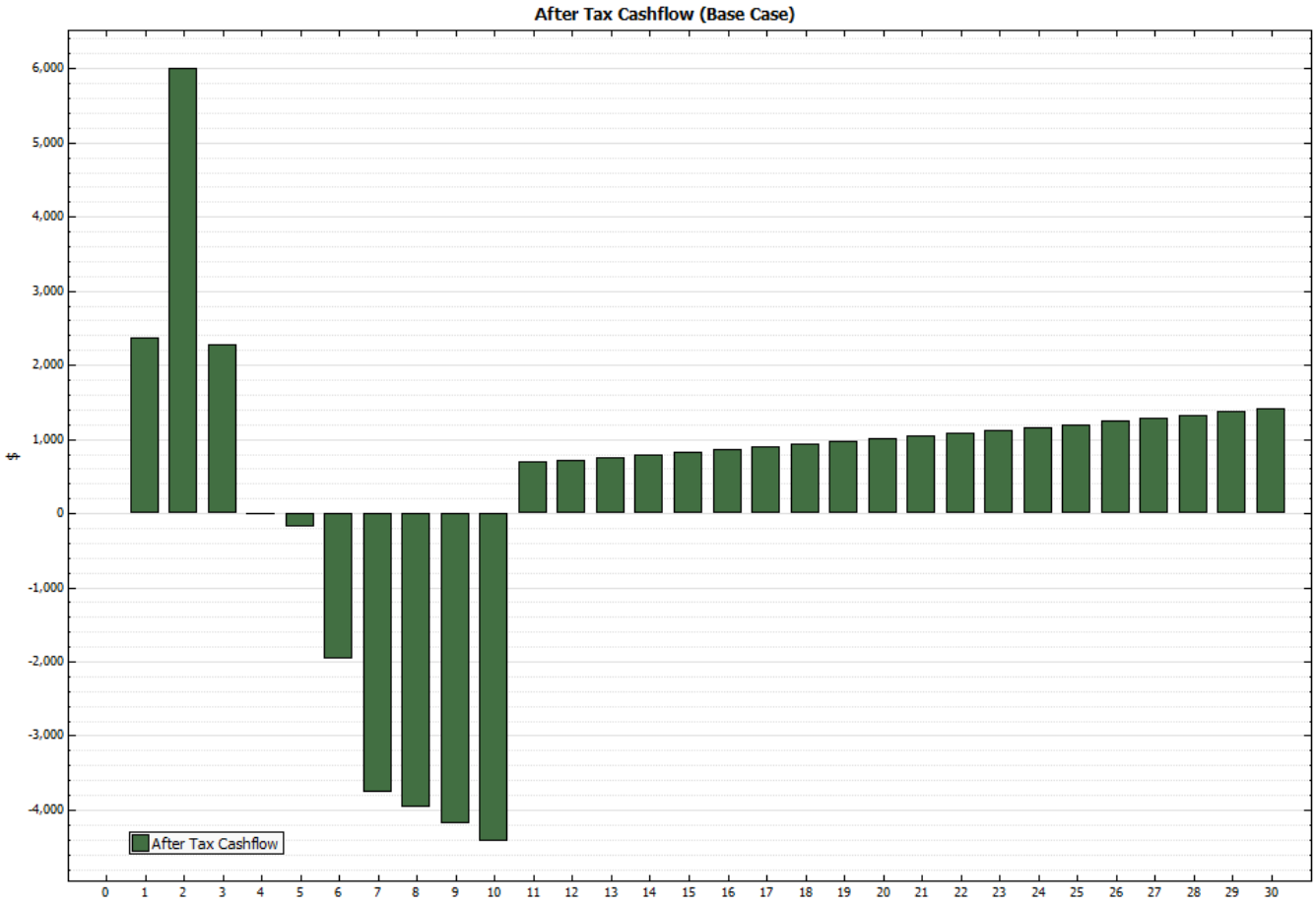


Figure 68: Cashflow

Electrical Depth II: Engine Cogeneration Study

Introduction

This study will investigate adding a cogeneration system to the Clark's campus. This system will have a natural gas prime mover and will be sized to supply the power necessary for the VECC and plant facility. The generation system will be remotely located so as not to disturb the serenity of the Clark's scenic campus. A feasibility analysis will be performed and will discuss the costs and payback period for the system.

Hypothesis

Adding a cogeneration system to The Clark's campus will not be a wise financial investment.

Methods

Site Survey

One of the reasons the Clarks chose to locate their art institute in the Berkshires was because of its serene beauty. The facility's takes advantage of the surroundings with many pleasant outdoor spaces and walking paths. Adding generator noise to the environment would conflict many previous design choices. Therefore, having a remote location for the generator would be the best option, though it would add to cost and decrease system efficiency. The proposed location for the generator is shown in Figure 69. Its will be placed behind a maintenance building, approximately 600 feet away from the Plant's electrical room.

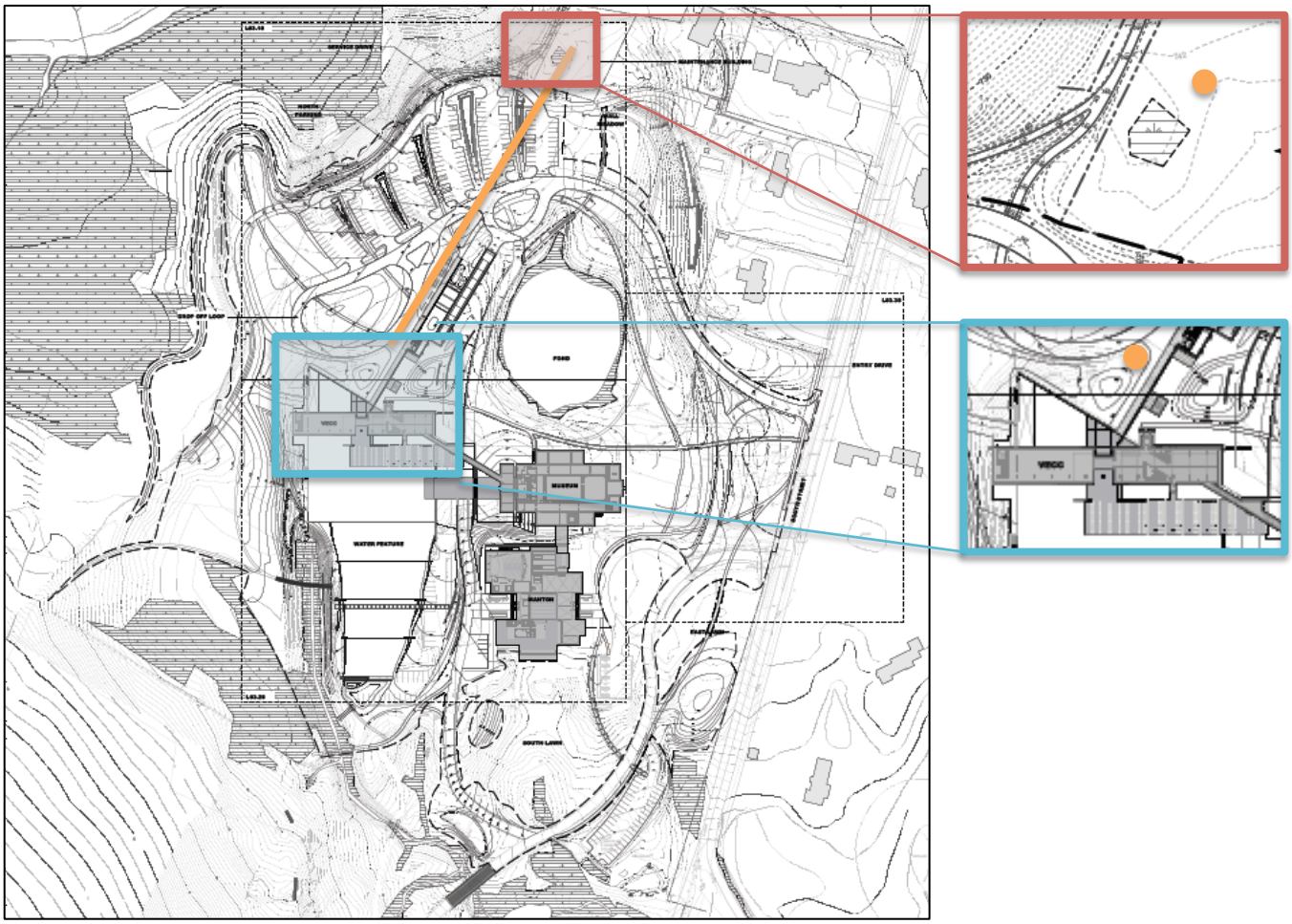


Figure 69: Proposed Generator Location

The VECC is outlined in teal and the proposed generator location is outlined in red. Orange points indicate the specific locations of the electrical room and proposed generator location. The orange line indicates the 600' run between the two locations.

Design

Loads

Originally the generator was being sized to provide similar heat output to half of the existing heating system (boilers one and three). This approach was taken because boilers one and three would have a large chance of being on most of the time. (Boilers two and four were designed to be on standby, ensuring that the HVAC system of The Clark had enough redundancy to protect artwork.) Sizing the generator based on heat output would allow the generator to substantially supplement the HVAC system through waste heat and cooling via absorption chillers. Any excess electricity could be then sold back to the utility company.

However, sizing the generator to provide required the generator to be significantly larger than was required for the electrical needs of the facility. Electricity sold back to the grid would most likely be sold at a fraction of what it costs to produce it. Therefore, because of the large amount of excess electricity, it was decided that the generator would be sized according to the electrical needs of the facility. A

summary of the VECC and Plant loads was compiled from VECC electrical drawings and is shown in Figure 70.

Working Drawings - Actual Loading			
Load Type	**Connected Load (kVA)**	**Demand Factor**	**Demand Load (kVA)**
Lighting	218.38	1	218.38
Receptacles	149.41	1.0 (<10000), 0.5 (REST)	79.71
Mechanical Equipment	865.66	0.8	692.52
Plumbing Equipment	131.81	1	131.81
Architectural Equipment	113.61	0.8	90.89
Kitchen Equipment	41.68	0.75	31.26
Other Equipment	11.00	1	11.00
Audio, Video and Security System	17.49	1	17.49
Total kVA	1273.06		
Total kVA (With 25% spare capacity)	1591.32		
Current at 480Y/277V, 3Ph, 4W (Amps)	1914.06		
Switchboard Size (Amps)	2000		

Figure 70: Building Demand Loads

Equipment

The Clark's heating system operates on natural gas. Therefore, a natural gas generator was chosen as the fuel is readily available to the site and avoids the hassle of having fuel oil shipped to and stored on the site. As mentioned above, sizing the generator based on heat output was not practical. As a result, Caterpillars 1300 ekW G351B generator set was chosen as it would be able to produce the 1273.06 kVA (1018.45 kW @ 0.8 PF) needed by the facility. The next smallest size that operated on pipeline natural gas, a 770 ekW generator, was not sufficient for The Clark's needs.

Package Performance			
Power rating @ 1.0 pf (unity)	ekW	1410	1310
Power rating @ 0.8 pf (3)	ekW	1400	1300
	kVA	1750	1625

Figure 71: Caterpillar 1300 ekW G351B Specifications

Electrical Calculations

Verify generator set size

Demand < Generator Set Capacity

1018.45 kW < 1410 kW: *OK*

1273.06 kVA < 1750 kVA: *OK*

Sizing Electrical Cables

Cable from generator terminals to generator distribution panel were sized per NEC 2011 445.13. A feeder schedule is based on calculation results shown in Figure 72 and can be found in Figure 75.

Generator Power Specifications			
Capacity	**Voltage system**	**Amps**	**115% Amps**
1625 kVA	480Y/277	1954.63	2247.82

Figure 72: Generator Wire Sizing

Voltage Drop

Voltage Drop was of significant concern when sizing the feeders running from the generator distribution panel to the unit substation, as the run is a significant 620'. (7) 500 MCM Aluminum feeders were initially sized. A voltage drop calculator, shown in Figure 73, was used to determine the best cable configuration, and the results were verified using the formulas and calculations below.

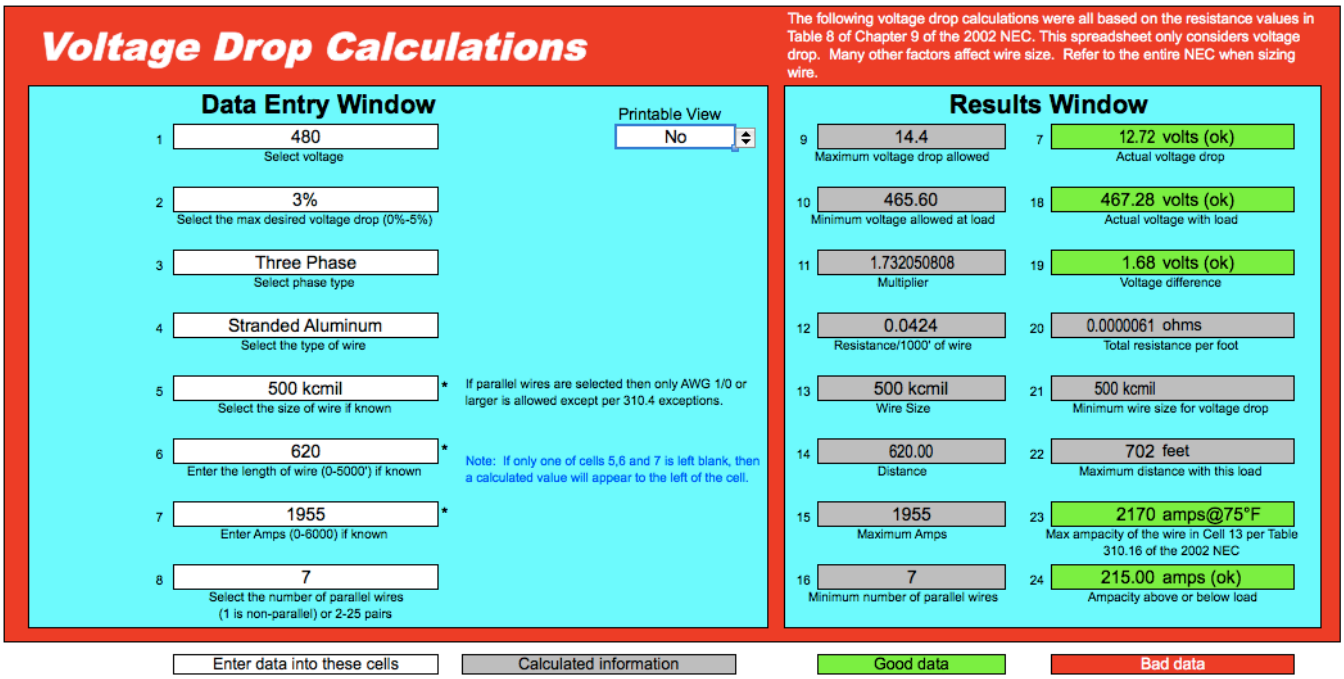


Figure 73: Voltage Drop Calculator

$V_d = (I \times R \times L \times M) / (1000 \times P)$
$V_d = (1955A \times 0.0424\Omega \times 620' \times 1.732) / (1000 \times 7)$
$V_d = 12.72\ V$

$V_d\ \% = (Vd/Vi) \times 100$
$V_d\ \% = 12.72/480 \times 100$
$V_d\ \% = 2.65\% < 3\%\ OK$

Where:
V_d = voltage drop
V_d % = percent voltage drop
L = Length in feet
R = Resistance (in Ohms / 1000 feet: 0.0367 Ohms / 1000 ft for 350 MCM
I = current in amps
P = number of parallel runs
M = multiplier (2 for single phase, 1.732 for three phase)

Connecting to the Existing System
The CHP generator system will connect to the main unit substation via a new 2000A breaker as seen in Figure 74.

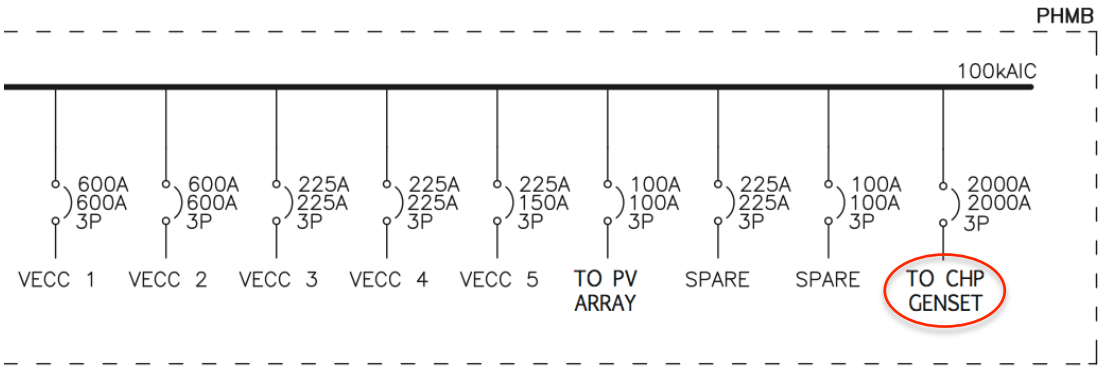
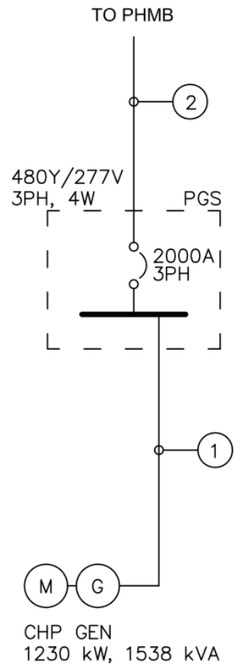


Figure 74: Connecting the Unit Substation



THE CLARK

Description

SINGLE-LINE-DIAGRAM
CHP GENERATOR

Scale

NTS

Drawing

VGS-01

Feeder Schedule																	
						Conductors (Per Set)											
				Conduit (Per Set)		Phase Conductors			Neutral Conductors			Ground Conductors			Size of Overcurrent Protection	Frame or Switch Size	Remarks
Tag	From	To	No. of Sets	Size	Type	No.	Size	Type	No.	Size	Type	No.	Size	Type			
1	CHP GENERATOR	PGS	2	3"	EMT	18	400 KCM	CU-THWN	6	400 KCM	CU-THWN	6	#1/0 AWG	CU-THWN	2000	2000	
2	PGS	PHMB	7	3.5"	EMT	21	500 KCM	AL-THWN	7	500 KCM	AL-THWN	7	#3/0 AWG	AL-THWN	2000	2000	

Figure 75: CHP Feeder Schedule