Tech I

The Sterling and Francine Clark Art Museum

225 South Street, Williamstown, MA 01267-2878

2 October 2011

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Executive Summary

The Sterling and Francine Clark Art Museum is undergoing a two-phase addition that consists of a plant facility and a Visitor, Exhibition and Conference Center (VECC). The following analysis assesses the lighting design for this addition in the following spaces:

Wood Shop (Work Space)
Multi-Use/Display Room (Special Purpose Space)
Entrance vestibule and lobby (Circulation Space)
South Façade and Terrace (Exterior Space)
Retail (Additional Studies space)

This report describes the architectural environment and existing lighting conditions for each of the spaces mentioned. Lighting and energy criteria are provided from the IESNA Lighting Handbook 10th Edition, ASHRAE 90.1 2007 and LEED v2.2 and each of the spaces are evaluated based on this criteria.

The lighting system in The Sterling and Francine Clark Art Institute (The Clark) consists primarily of halogen and fluorescent sources for the interior and metal halide and LED sources for the exterior. From a purely technical point of view, the lighting design for the additions to The Clark fulfill most of the illuminance requirements but very few of the power density requirements.

The guest areas, which are designed with flexibility and aesthetics in mind, the design appropriately reflects the minimalistic architecture. The lighting recessed linear fluorescent fixtures and small recessed downlights blend into the space well, and do not act as an eyesore for the clean lines of the architecture. Much of the building envelope is an aluminum glazed curtain wall system. As a reaction to this, automated blind systems and photosensor dimming systems help mitigate the UV risks associated with daylight as well as provide the space with a usable natural light.

Overall, the lighting systems for The Clark Plant and VECC addition are successful at enhancing the architectural environment and communicating the division and integration of the spaces to the occupant. Although the illuminance criteria are met, much improvement can be made in decreasing energy consumption.

Building Overview

Building Name: Sterling and Francine Clark Art Institute
Location and Site: 225 South Street, Williamstown, MA 01267-2878
Building Occupant Name: The Sterling and Francine Clark Art Institute
Occupancy: Utility Plant and Museum Space
Size: 78,000 SF
Stories above Grade: 1
Primary Project Team:

Design Architect:	Tadao Ando Architects and Associates *www.*tadao-ando.com/index_eng.htm
Architect of Record:	Gensler *www.*gensler.com
Landscape Architect:	Reed Hilderbrand Associates *www.reedhilderbrand.com*
MEP Engineer:	Altieri Sebor Wieber, LLC *www.*altieriseborwieber.com
Structural Engineer:	Buro Happold Consulting Engineers, PC *www.*burohappold.com
Civil Engineer:	Guntlow & Associates *www.*guntlowassociates.com
Code Consultant:	Technical Solutions Associates, Inc. *www.*techsola.com
General Contractor:	Turner *www.*turnerconstruction.com

Construction Dates
Excavation Start – 6.3.2010
Substantially Complete (Plant) – 12.13.2011
Project Delivery Method: GMP

Overview of Lighting Systems:
The lighting system in The Sterling and Francine Clark Art Institute (The Clark) is composed of halogen, fluorescent, and LED sources for the major spaces. Halogen MR-16 sources are used for the gallery and guest spaces. Linear fluorescent sources are used for the plant and non-guest areas. Exterior lighting is accomplished primarily with LEDs and HID. Dimmable track lighting systems are present in all gallery spaces and a daylight control system is used to regulate exterior fixtures. The guest areas are designed with flexibility and aesthetics in mind, while the non-guest areas are designed primarily for functionality.

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.

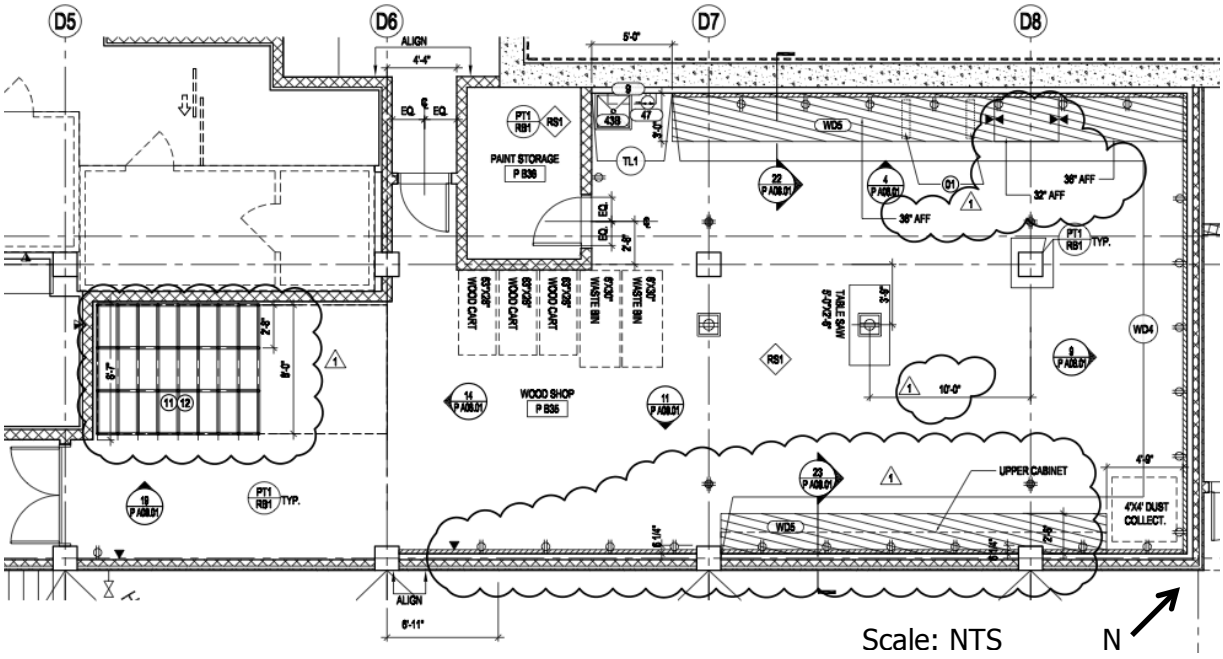


Figure 1: Wood Shop Plan

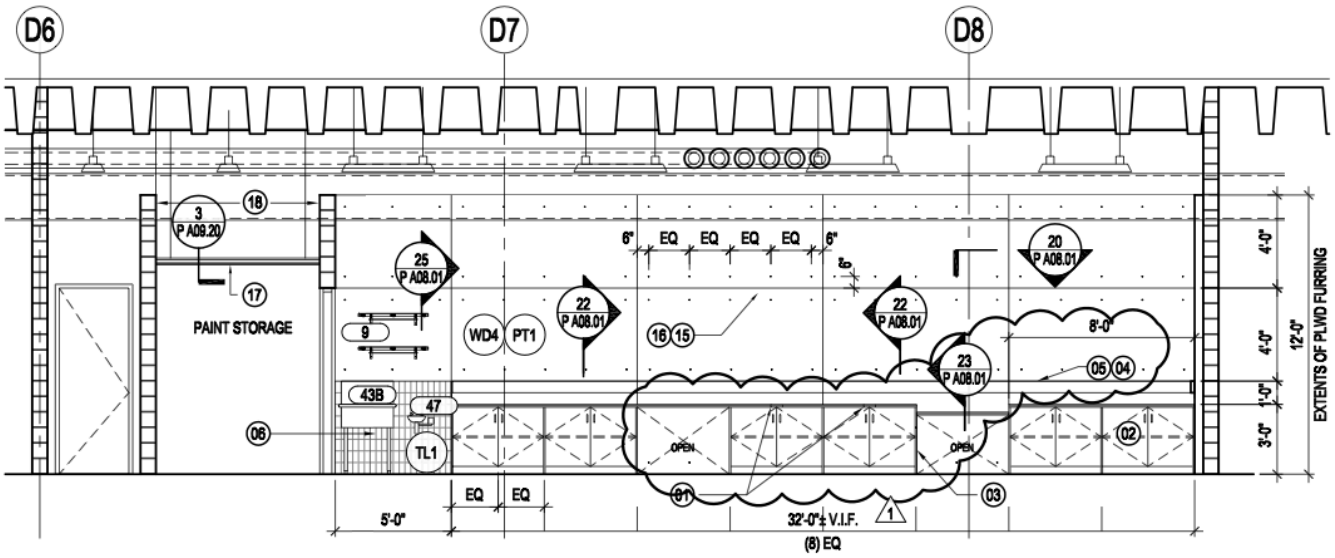


Figure 2: Wood Shop Interior Elevation

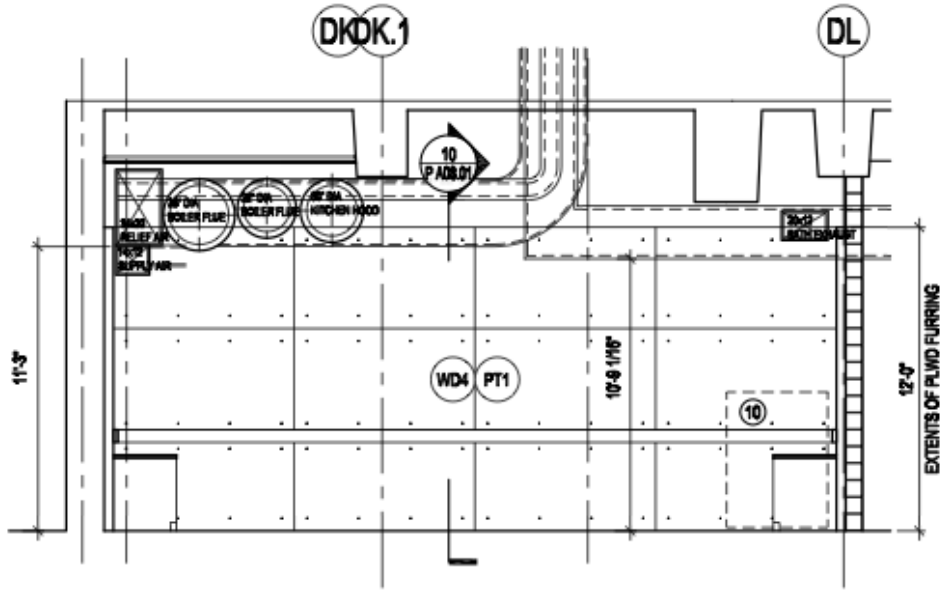


Figure 3: Wood Shop Work Bench Section

Materials

The majority of the vertical surfaces are finished with 3/4" plywood panels that measure 4' x 8'. The cabinets used in the spaces have plywood finishes as well. The paint room is constructed of painted 12" CMU's and has a finished GWG ceiling 9' above the finished floor. Rubber flooring is used with ceramic tile baseboard.

Reflectances

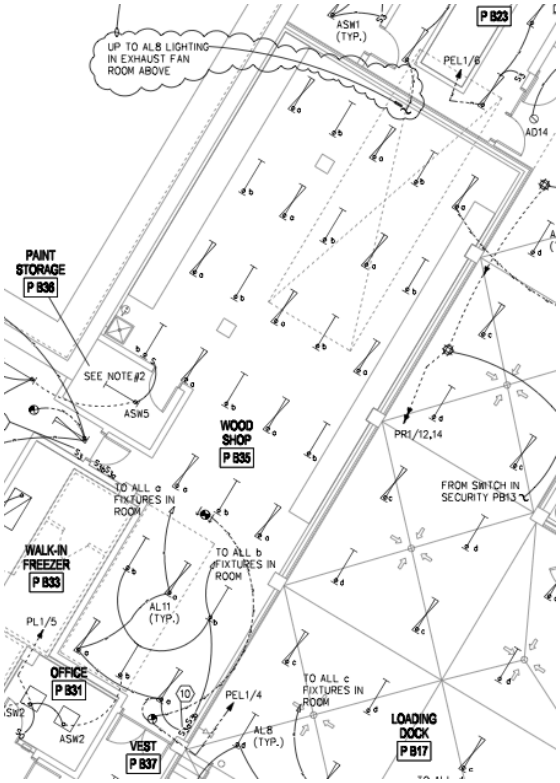
- Plywood Reflectance: 0.4
- Painted Surface reflectance: 0.8
- Rubber flooring reflectance: 0.2
- Ceramic tile reflectance: 0.3

- Concrete reflectance: 0.34

Description of lighting systems

Luminaires and Lamps

Suspended 4’ linear fluorescent fixtures with wire guards are used exclusively in the wood shop. The luminaires are mounted below the concrete beams and perpendicular to them. The fixtures use 32W T8 sources. The fixture in the paint room is explosion-proof to withstand the industrial environment.



Scale: NTS

Figure 4: Wood shop lighting system plan

Ballasts

The fixtures have integral electronic dimming ballasts.

Controls

The fixtures in the wood shop are controlled with a three-way switching system. The single luminaire used for the paint room is controlled via a single pole switch.

Daylighting

The space has no outside windows.

Description of lighting criteria

IESNA Lighting Handbook, 10th Edition | Table 30.2

Recommended Illuminances

- Horizontal – 500 lx
- Vertical – 500 lx

Uniformity Targets
- Max:Min – 3:1

ASHRAE 90.1 Requirements

Maximum Power Density: Workshop – 1.9 W/SF

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

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

Criteria Discussion

The wood shop is exclusively a functional space and needs to have adequate illumination on the working surfaces. The IESNA handbook recommends 500 lux for both horizontal and vertical illuminance for medium scale component manufacturing. This should be followed closely to allow the occupants to work safely around cutting equipment, which may utilize both horizontal and vertical work surfaces. A sufficient uniformity gradient, such as the recommended Max/Min ratio of 3:1, is needed to allow the raw materials to be treated properly as they inspected for use.

Reflected glare and shadow considerations are necessary throughout the entire space as wood products may be painted or treated. Additional glare considerations must be made for the metallic horizontal surface of the table saw to ensure safe and desirable operating conditions. Moderate to excellent CRI is needed to ensure that the frame colors render well when they are being painted and stained.

The power requirement of 1.9 W/SF should be relatively easy to achieve, given the fact that highly efficient linear fluorescent fixtures would be suitable for this spaces. There are no windows in the wood shop with a direct line of sight to the exterior so LEED credits SSc8, IEQc8.1 and IEQc8.1 need not be considered. However, EAc1 and IEQc6 are applicable to this space. The energy requirements of EAc1 should be easy to accommodate for reasons just mentioned, whereas IEQc6.1 are more difficult, given the fact that the majority of the lighting in the space is controlled together.

Prioritized Criteria List

1. Meet energy codes
2. Provide adequate and appropriate light for space functions
3. Avoid technical problems such as glare and unwanted reflections
4. Meet LEED requirements

Critique of lighting conditions

Aesthetics and Architectural Integration

The lighting design of the wood shop reflects the utilitarian nature of the spaces. The lighting design seems to disregard plywood panels as an architectural element, but integrates well with the one-way concrete structure that composes the ceiling. Mounting the fixtures perpendicular to the concrete beams allows light to fill in the voids, preventing pockets of light and darkness on the ceiling.

Relevance to space use

The large light-emitting surfaces of the linear fluorescent fixtures are well suited for use in the wood shop because they lend themselves to low amounts of reflected glare and increased uniformity on the work plane. The increased uniformity give the space a sense of visual clarity which is beneficial for technical fabrication tasks. High CRI linear fluorescent lamps, while not comparable to incandescent sources, offer sufficient color rendering for wood shop tasks.

Quantitative evaluation

The efficient linear fluorescent fixtures result in a power density of 0.59 W/SF for the wood shop. The calculated light levels are within 10% of the recommended light levels. This satisfies both ASHRAE 90.1 and aids the building in obtaining LEED EAc1. LEED IEQ Credit 6.1 is not obtainable in this space due to its lack of flexibility in controlling the lighting systems. LEED IEQc8.1 and IEQc8.2 are not obtainable in the space due to the lack of a direct view out of the building.

Illuminance Calculation Results [See Figure 5]
Average – 52.8 fc
Maximum – 66.3 fc
Minimum – 8.5 fc
Avg/Min – 6.2 fc

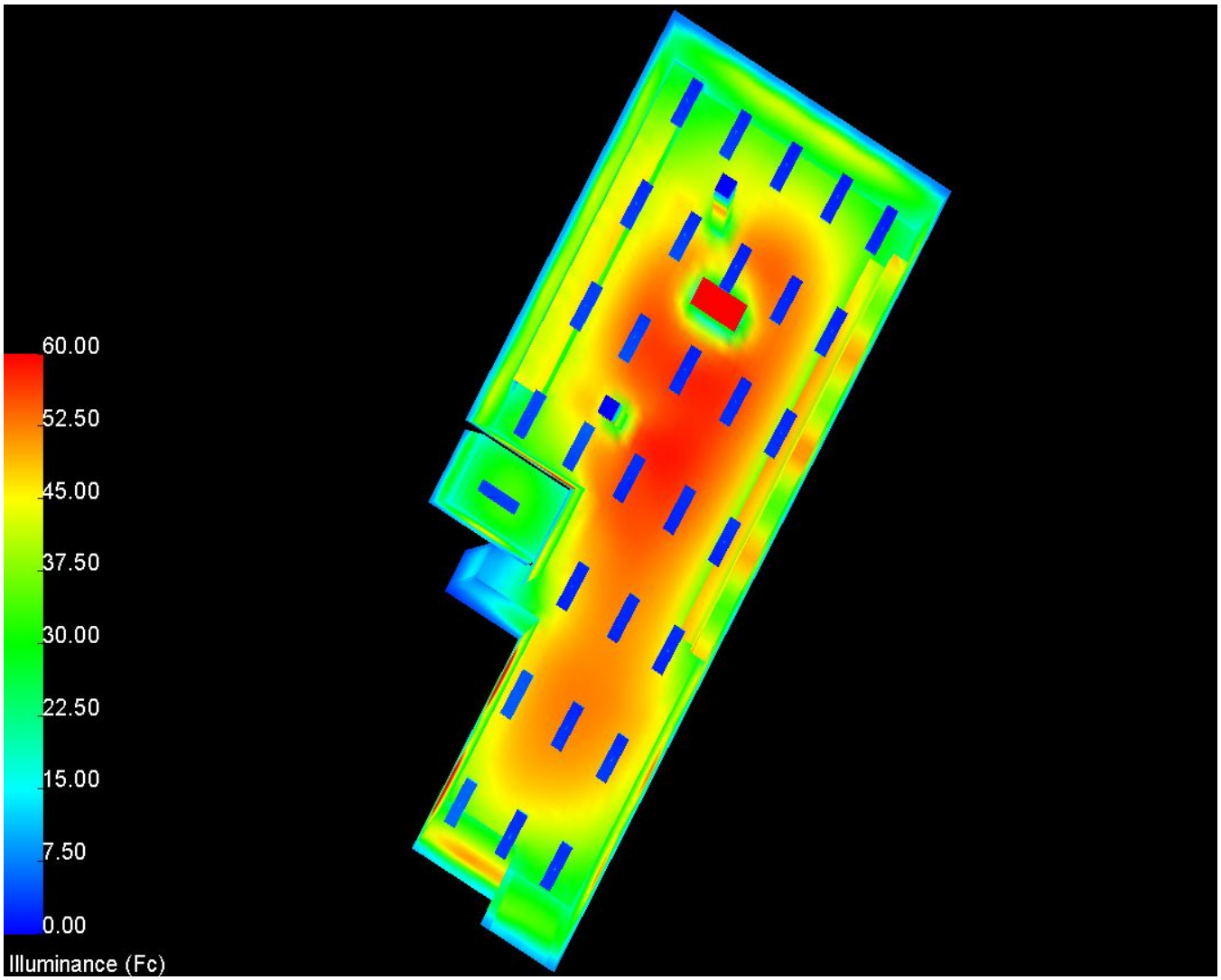


Figure 5: Wood Shop Electric Light Illuminance Results

Multi-Use/Display 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.

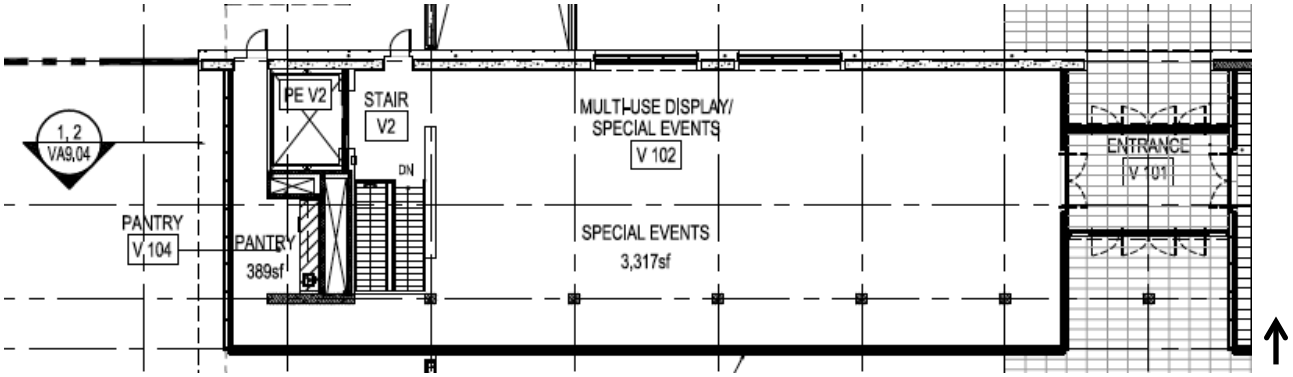


Figure 6: Multi-Use Plan Scale: NTS

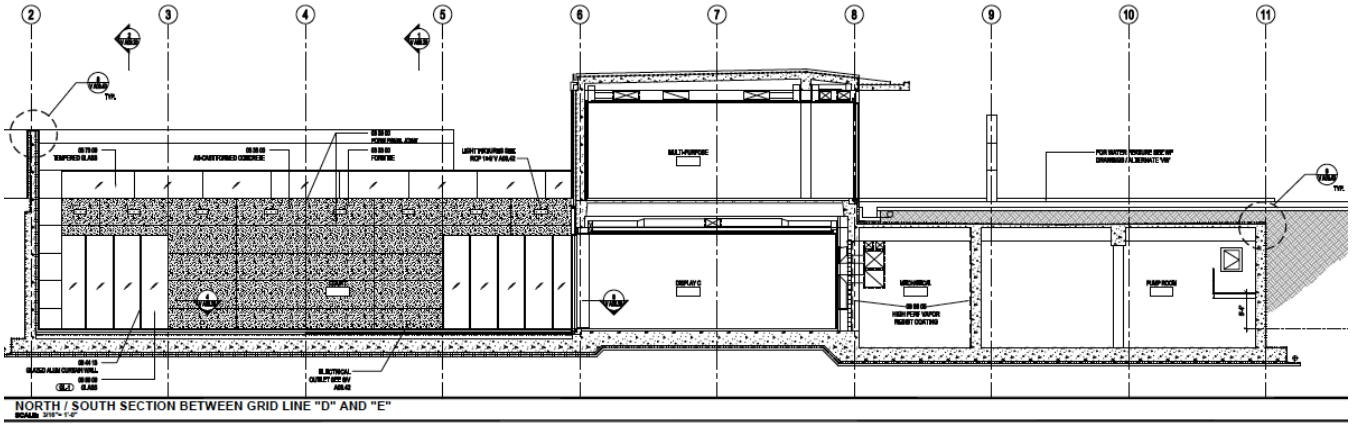


Figure 7: Multi-Use North/South Section Scale: NTS

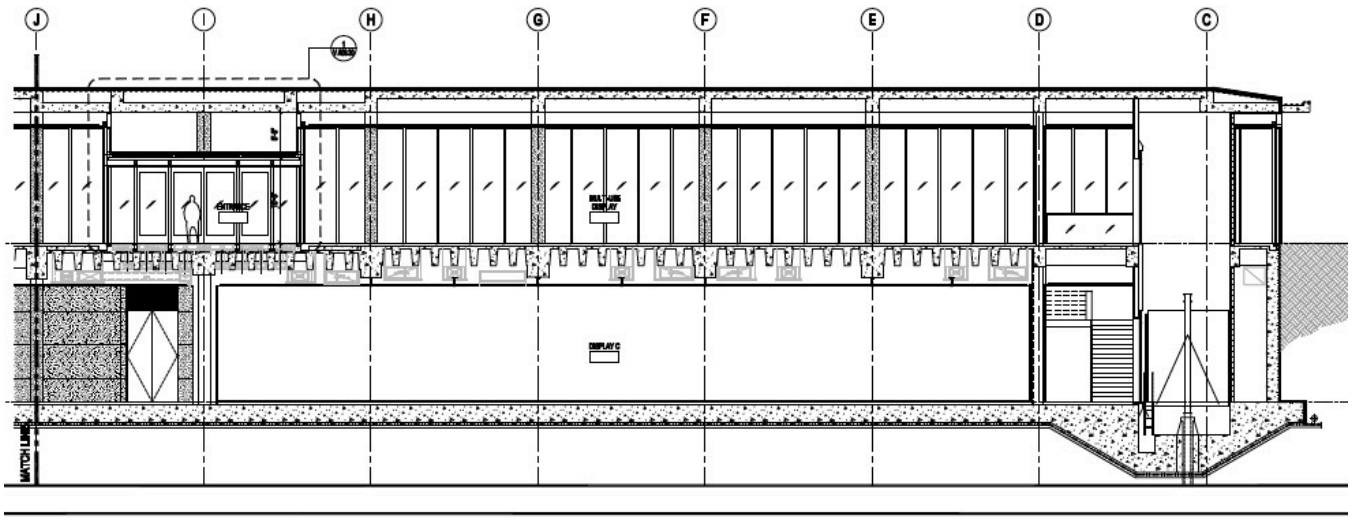


Figure 8: Multi-Use East/West Section Scale: NTS

Materials

The North wall of the multi-use space is finished with painted GWB. A glazed aluminum curtain system makes up the South wall of the space. Architectural concrete is used for the interior columns. The flooring of the space is a white oak slab system and acoustic plaster is used for the ceiling finish.

Reflectances

- Painted GWB: 0.8
- Architectural Concrete: 0.34
- White oak hardwood floors: 0.36
- Acoustic plaster: 0.76
- Louvers: 0.25
- Automated motorized shades: 0 to 30% transmittance, 60% to 20% reflection
- Glazed aluminum curtain wall: 63% transmittance, 4% reflection

Description of lighting systems

Luminaires and Lamps

A summary of the luminaires, lamps, and their locations are listed below:

- Recessed downlight fixtures with 50W halogen MR-16 lamps (AD1) are used around the perimeter of the ceiling plane
- Recessed linear fluorescent fixtures, which use (2) 28W T5 3500K lamps (AL3), run north south in the space
- A two-circuit track system runs in between the recessed linear fluorescent fixtures (AT1). No luminaires or lamps have been specified for use with the track lighting system.

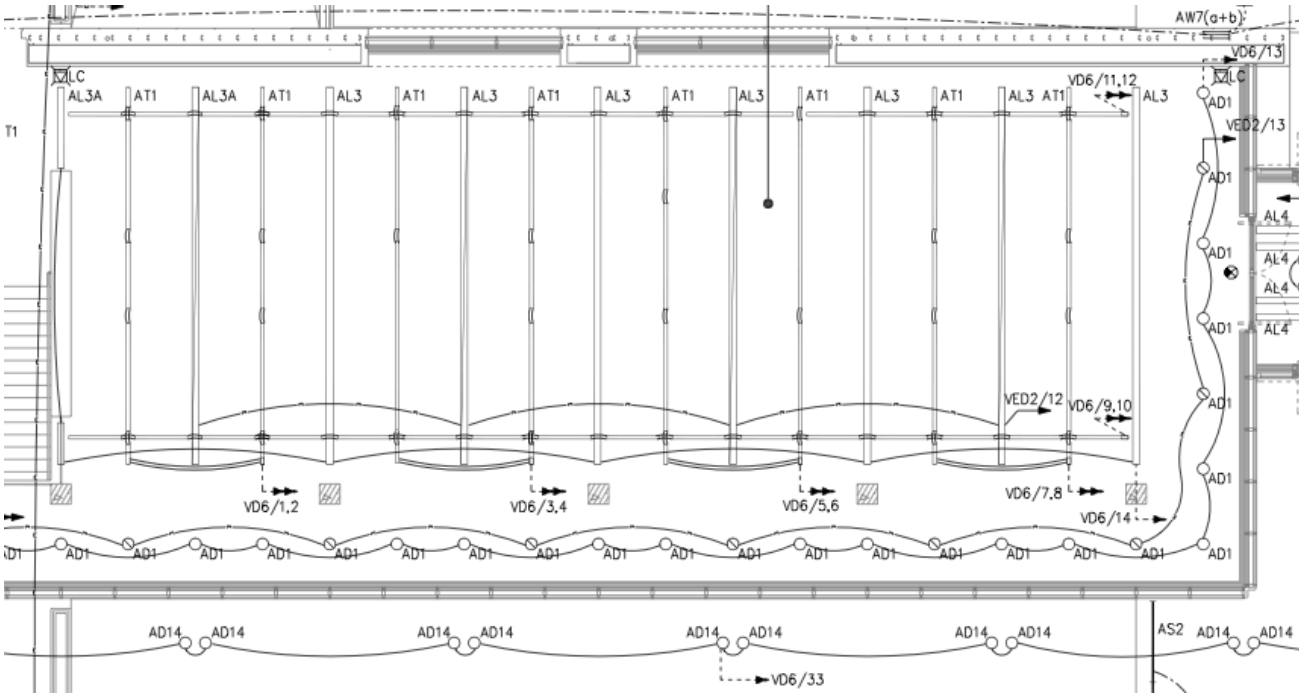


Figure 9: Multi-Use Lighting System Plan Scale: NTS

Ballasts

The recessed linear fluorescent fixtures have integral electronic dimming ballasts. No ballasts are required for the tracks or MR-16 halogen fixtures.

Controls

Lutron SO-4SN controller with 4-button/off/raise and lower capabilities provide control for the halogen and fluorescent sources, as well as for the track lighting system.

Daylighting

Two out of the four walls of the space are composed mostly of a glazed aluminum curtain wall system. Therefore, daylighting is a significant element in the lighting of the Multi-Use space. A concrete overhang blocks the summer sun from entering the space. An automated blind system provides three different shading capabilities: 0 transmittance, 6% transmittance and 24% transmittance.

Description of lighting criteria

IESNA Lighting Handbook, 10th Edition | Table 21.2

Recommended Illuminances

- Circulation spaces
  - Horizontal Illuminance – 40 lux
  - Vertical Illuminance – 40 lux
  - Avg:Min – 4:1

- Object/Artwork spaces
  - Horizontal Illuminance – 200 lux
  - Vertical Illuminance – 200 lux
  - Avg:Min – 2:1

ASHRAE 90.1 Requirements

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

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

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

Criteria Discussion

The many functions that will be performed in the multi-use space require careful attention to both the aesthetic and functional aspects of lighting. To create dramatic displays of artwork, providing a general illuminance just 10% of display illuminance is necessary. For moderate focal points, this percentage is increased to 20%; for subdued focal points, 50%.

Preservation of the artwork necessitates consideration of UV radiation in the space. To prevent daylight damage to susceptible pieces of art, the daylight range below 400 nm must be removed as much as possible. As for UV radiation created by the artificial lighting systems, less than 75uW/lm of UV radiation is allowable, otherwise UV filters are necessary. To prevent the damaging wavelengths of light, glass with a low T_{df} (damage factor transmittance) is best. A projection system will be used on the West side of the multi-use space during "conference mode." Therefore lighting system must be able to respond accordingly with controllable scenes and daylight control.

Due to the large amount of glass used in the space, reflected glare must be carefully controlled to allow the occupants to accurately and comfortably view the artwork. Additional reflected daylight glare coming from the hardwood flooring needs to be dealt, perhaps by using the automatic shading system.

Prioritized Criteria List

1. Meet energy codes
2. Provide adequate and appropriate light for space functions
3. Ensure that the lighting systems protect the artwork, especially from UV radiation
4. Provide lighting systems to highlight artwork
5. Avoid technical problems such as glare and unwanted reflections
6. Meet LEED requirements

Critique of lighting conditions

Aesthetics and Architectural Reinforcement

The lighting design of the multi-use space meshes well with the minimalism of the architecture. Lines of linear fluorescent fixture reflect the straight, clean lines of The Clark. The border of light provided by the downlights around the perimeter of the space help to define the space.

Relevance to Space Use

The lighting system for the multi-use space is very applicable to the uses and aesthetic needs of the space. Uniform lighting is necessary for the conference events and meeting to be held in the space, and the linear fluorescents are very effective at this. The uniformity of the lighting design helps give the space a sense of visual clarity. When the space is used to display artwork, non-uniform light levels are necessary, and having the ability to direct the light onto temporary displays is extremely important. The track lighting system is a good match for both of these needs. When the systems are dimmed for projector use in a conference setting, the perimeter downlights will provide necessary light for circulation without washing out the projected image. The 3500K white light provided by the recessed linear fluorescent fixtures warms up the space which could potentially feel cold due to the geometric angles, unsaturated colors and high ceilings.

Quantitative evaluation

The power density for the multi-use space is 1.31 W/SF. This number excludes the fixtures that will be put on the track lighting system, as per ASHRAE 9.2.2.3a. The track lighting system will be given an allowance of 1.0 W/SF for the purpose of decoratively lighting the museum display element. The outrageous energy consumption of the system, even without the track lighting system included, does not aid the building in achieving LEED EAc1. One of the reasons for the high power density is the overdesigned light levels for the multi-use space; the illuminance levels provided are more than twice than those recommended by IES.

The large glazed surfaces in the space aid the building in achieving IEQc8.2. IEQc8.1 is not obtainable for the multi-use space by option 2 (VLT*WFR=0.22). According to Figures 10b and 10c, IEQc8.1 is not obtainable by option 2, either. It is therefore doubtful that this LEED credit will be obtainable by either of all the other options for this space. However, SSc8 is obtainable via option 1. LEED EAc6.1 is not practical due to the largely public nature of the space.

Calculation Results: Electric Light [See Figure 10a]
Average – 40.3 fc
Maximum – 55.9 fc
Minimum – 11.9 fc
Avg/Min – 3.5 fc

Calculation Results: Daylight September 21, 9am [See Figure 10b]
Average – 337.4 fc
Maximum – 2228 fc
Minimum – 43.8 fc
Avg/Min – 7.7 fc

Calculation Results: Daylight September 21, 3pm [See Figure 10c]
Average – 338.0 fc
Maximum – 2216 fc
Minimum – 28.3 fc
Avg/Min – 11.9 fc

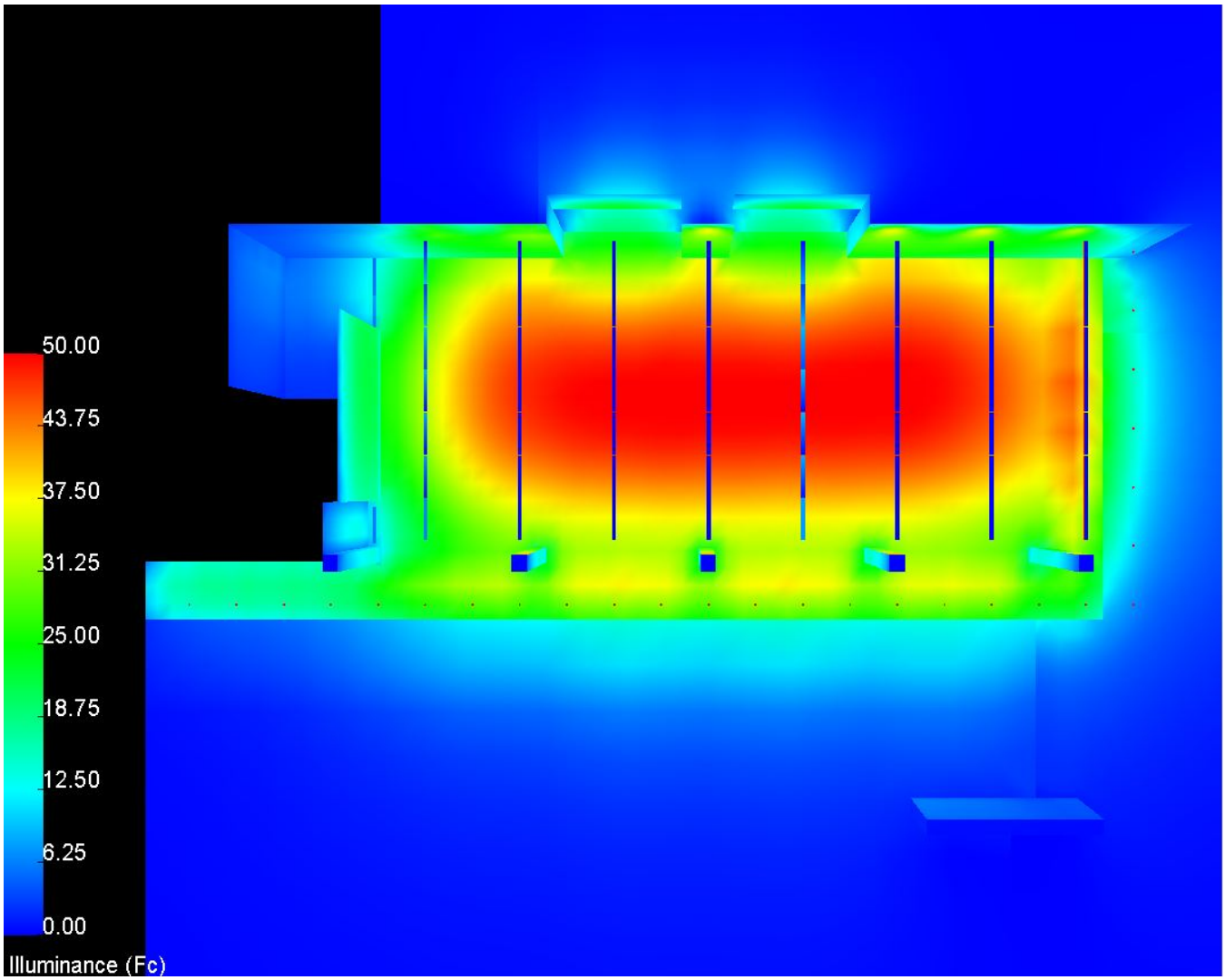


Figure 10a: Multi-Use Electric Light Illuminance Results

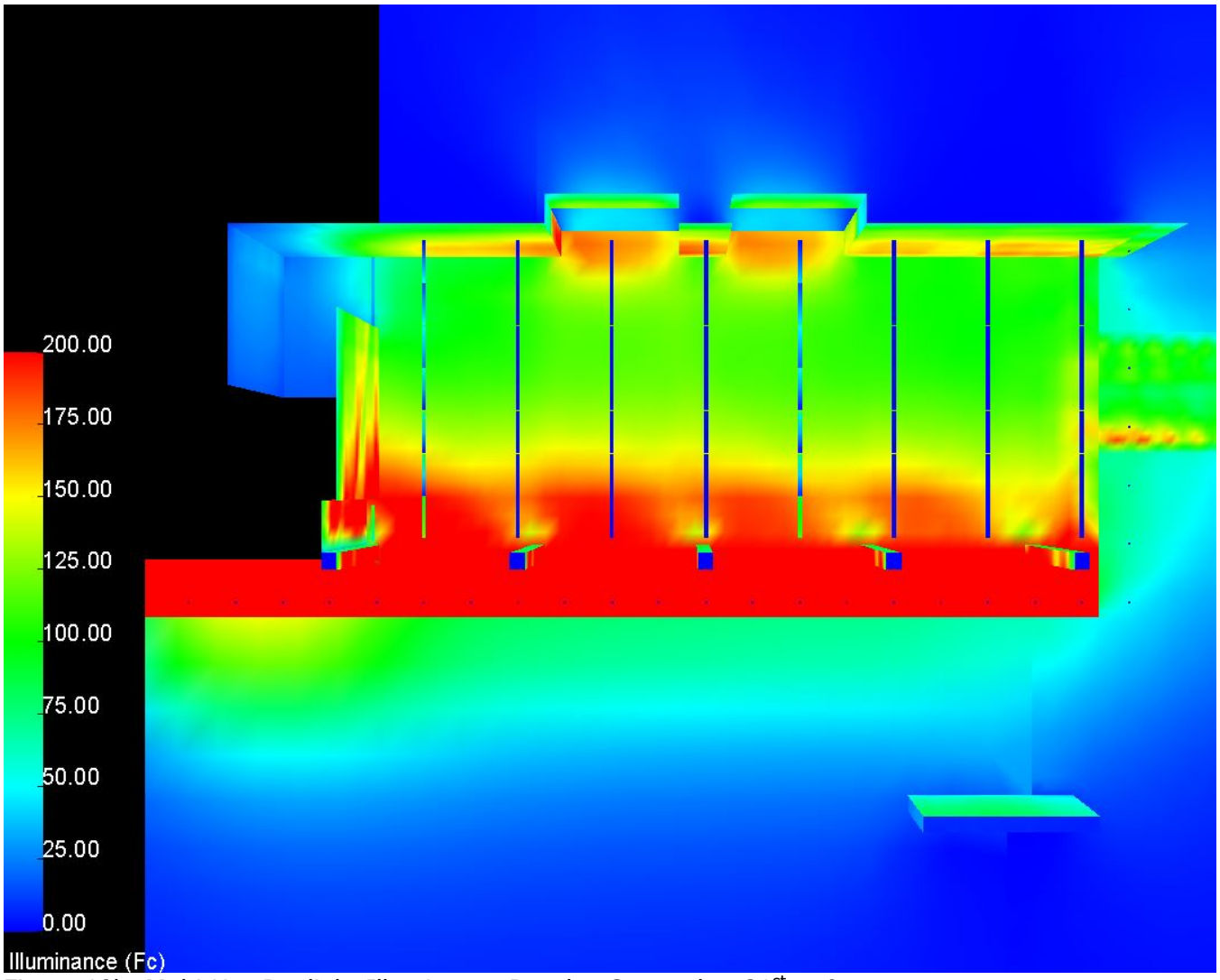


Figure 10b: Multi-Use Daylight Illuminance Results, September 21st at 9am

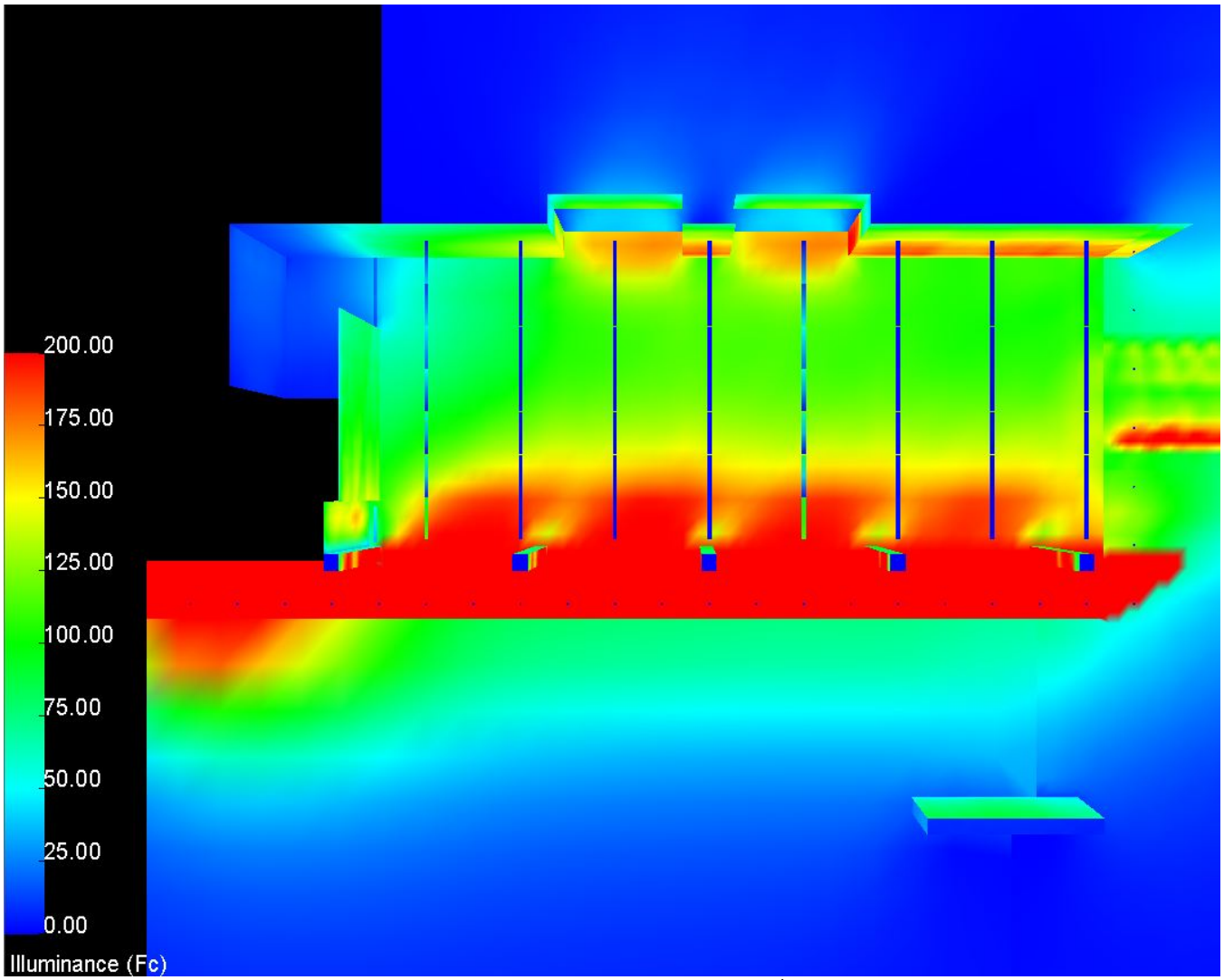


Figure 10c: Multi-Use Daylight Illuminance Results, September 21st at 3pm

First floor Entrance Vestibule and Lobby

Architectural Description

Function and Layout

The entrance vestibule and lobby are used to welcome the guest into The Clark. The dimensions for the vestibule are 12’ x 17’ and the dimensions for the lobby are 39’ x 62’. The vestibule is located to the west of the lobby. Occupants may enter the vestibule from either the north or the south. 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.

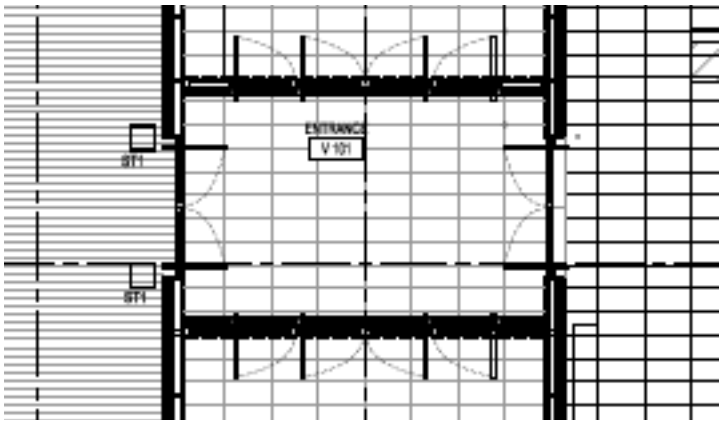


Figure 11: Entrance Vestibule Plan Scale: NTS

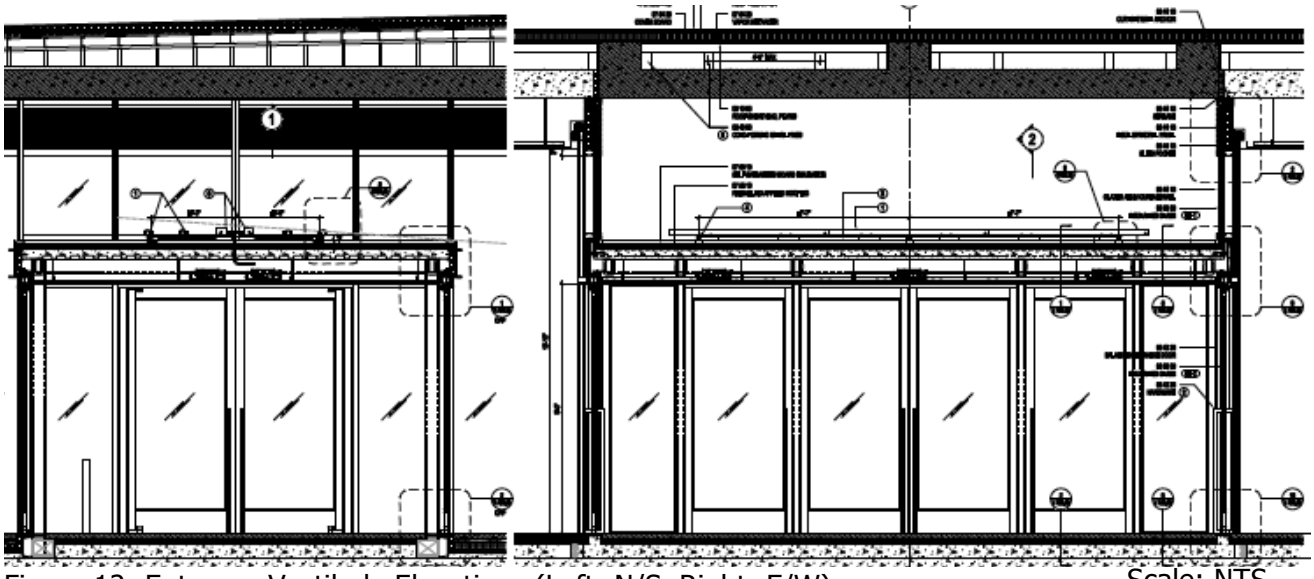


Figure 12: Entrance Vestibule Elevations (Left: N/S, Right: E/W) Scale: NTS

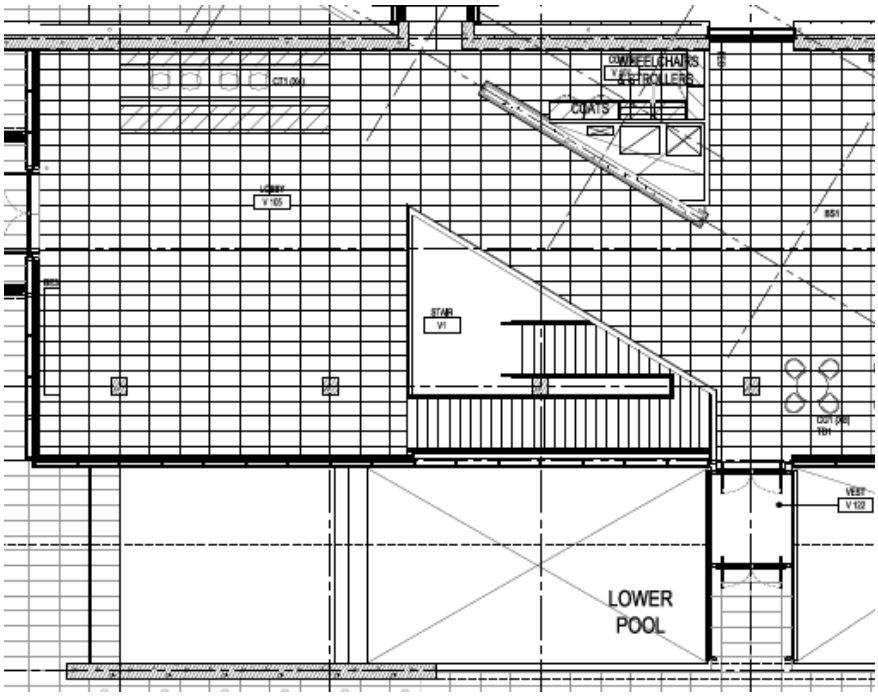


Figure 13: Lobby Plan

Scale: NTS

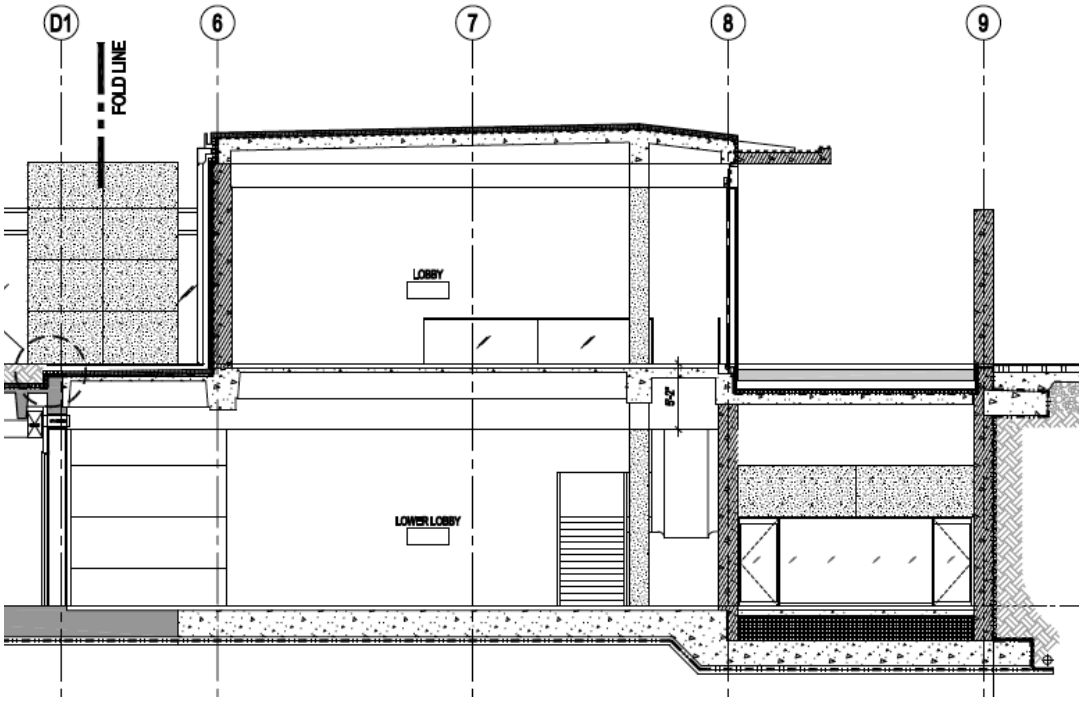


Figure 14: Lobby Section (E/W)

Scale: NTS

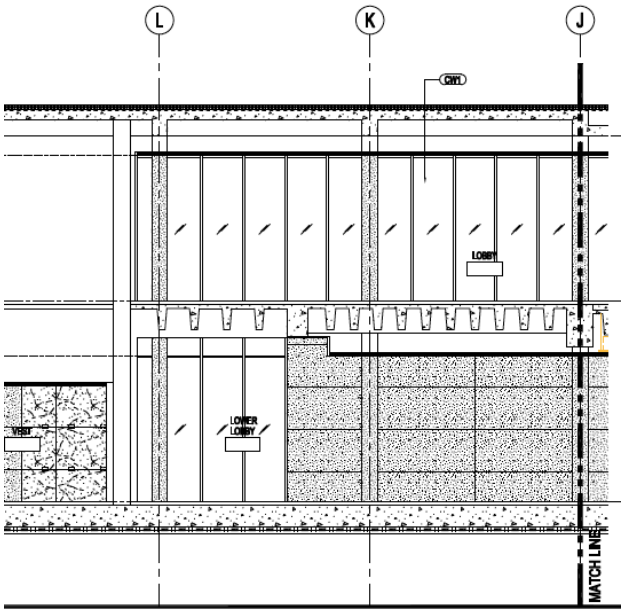


Figure 15: Lobby Section (N/S) Scale: NTS

Materials

All of the vertical surfaces of the vestibule are composed of a glazed curtain wall system, as is the south facing wall of the lobby. The north wall of the lobby has an architectural concrete finish, and the angled wall that connects the lobby and retail space is finished with granite. All other walls in the space have a painted GWB finish. The flooring is concrete pavers and the ceiling is finished with acoustic plaster.

Reflectances

- Architectural Concrete: 0.34
- Painted GWB: 0.8
- Granite: 0.17
- Glazed aluminum curtain wall: 63% transmittance, 4% reflection
- Concrete Pavers: 0.25
- Acoustic Plaster: 0.76

Description of lighting systems

Luminaires and Lamps

A summary of the luminaires, lamps, and their locations are listed below:

- Recessed down light fixture with 37W MR-16 lamps (AD4) are used in the entrance vestibule
- Linear LED fixtures (AL4) are used in the entrance vestibule.
- Recessed downlight fixtures with 37W MR-16 lamps (AD10) are used over the reception/ info desk
- Recessed downlight fixtures with 50W MR-16 lamps (AD1) are used around the perimeter of the ceiling plane
- Recessed downlight fixtures with 71W MR-16 lamps (AD5) are used over the staircase
- Recessed downlight fixtures with a 32W compact triple tube fluorescent lamps (AD9) are used in a back stage location in the north of the lobby

- Recessed linear fluorescent fixtures that use (2) 28W T5 3500K lamps (AL3) run North-South in the space
- Wall Grazer with (2) 28W T5 lamps (AL5) are used to illuminating the architectural concrete wall adjacent to the retail-lobby circulation space

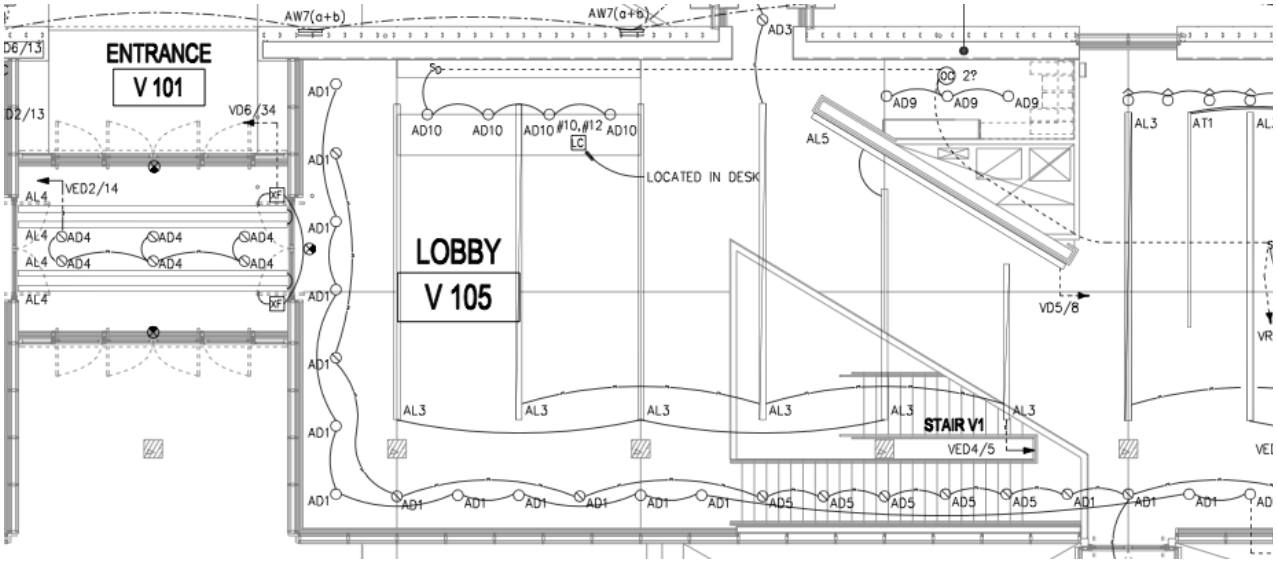


Figure 14: Entrance Vestibule and Lobby Lighting Plan Scale: NTS N

Ballasts

The recessed linear fluorescent and recessed compact fluorescent fixtures will have integral electronic dimming ballasts. The two linear LED fixtures used in the entrance vestibule will have remote electronic drivers.

Controls

Lutron SO-4SN controller with 4-button/off/raise and lower capabilities provide control for the halogen and fluorescent sources.

Daylighting

All of the vertical surfaces of the vestibule, and two out of the four vertical surfaces of the lobby are composed mostly of a glazed aluminum curtain wall system. Daylighting is therefore an important consideration for the space. A concrete overhang on both spaces blocks the summer sun from entering. An automated blind system near the glazed curtain wall system provides three different shading capabilities: 0 transmittance, 6% transmittance and 24% transmittance.

Description of lighting criteria

IESNA Lighting Handbook, 10th Edition | Table 22.2

Recommended Illuminances

- At Building Entry
  - Day

        - Horizontal Illuminance – 100 lux
        - Vertical Illuminance – 30 lux
        - Avg:Min – 4:1
    - Night
        - Horizontal Illuminance – 50 lux
        - Vertical Illuminance – 20 lux
        - Avg:Min – 4:1
- Distant from Entry
    - Horizontal Illuminance – 100 lux
    - Vertical Illuminance – 30 lux
    - Avg:Min – 4:1
- Desk
    - Horizontal Illuminance – 150 lux
    - Vertical Illuminance – 50 lux
    - Avg:Min – 4:1

ASHRAE 90.1 Requirements

Maximum Power Density: Lobby – 1.0 W/SF

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

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

Criteria Discussion

All of the illuminance and uniformity criteria found in the IES handbook seem to be very applicable to this specific situation. The only deviation would be to perhaps define the building entry to apply to the

vestibule entrance as well as to the lobby entrance. This is because the exterior environment stretches farther into the interior of the building due to the extensive use of glass.

Meeting power density in this space should not be very difficult, but due to the use of incandescent sources, a power density above ASHRAE 90.1 is to be expected.

Applying LEED IEQc6.1 to the space, and the facility in general, will be very difficult and impractical because of the public nature of the building. Because the lobby and the entrance vestibule use a matte material for the flooring, less considerations of glare caused by the exterior environment reflecting off of the floor will have to be made. However, reflections of luminaires off the glass itself may still be an issue.

Prioritized Criteria List

1. Meet energy codes
2. Provide adequate and appropriate light for space functions
3. Ensure that lighting systems guide occupants through the space
4. Avoid technical problems such as glare and unwanted reflections
5. Meet LEED requirements

Critique of lighting conditions

Aesthetics and Architectural Reinforcement

The lighting design of the lobby reflects the minimalism of the architecture, much like the lighting design of the multi-use space. Lines of linear fluorescent fixture reflect the straight, clean lines of The Clark and the light provided by the downlights around the perimeter of the space define the space with a border of light. Grazing the granite wall in the space brings focus to this material. Additionally, this gesture aids occupants in way finding. By illuminating this wall, which is borders the retail space, occupants are drawn from the lobby into the retail space. Additionally, uniform emphasis along the wall, in combination with the uniform downlight in the space, gives the space a sense of clarity and spaciousness.

Relevance to Space Use

The linear fluorescent fixtures are a good choice for providing the necessary circulation illuminance in the space. The use of incandescent sources for the recessed downlight fixtures is not one that is a wise choice given the increasing importance placed on energy efficiency. It would make sense to used metal halide or ceramic metal halide sources instead. Dimming for daylight can be achieved by dimming the fluorescent fixtures and the fixtures in the lobby do not need to be used for dimming to accommodate for presentations or artwork as in the multipurpose space. This leaves little reason to use halogen sources in place metal halide or ceramic metal halide in the space. The 3500K white light provided by the recessed linear fluorescent fixtures warms up the space and generates a more welcoming atmosphere.

Quantitative evaluation

The power density of the lobby and vestibule combined is 1.51 W/SF, which is above the 1.00 W/SF recommended by ASHRAE 90.1. This is largely due to the significant amount of incandescent sources used in the space. The high energy consumption of the system does not aid the building in achieving

LEED EAc1. SSc8 is obtainable via Option 1, and the large use of the glazed aluminum curtain wall system in the lobby does aid the building in achieving IEQc8.2. IEQc8.1 is not obtainable for the multi-use space by Option 2 (VLT*WFR is above 0.18), though it may be obtainable via other options. Additionally, EAc6.1 is not practical in this space, or in the building in general, for the same reasons as mentioned previously.

South Terrace and Facade

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.

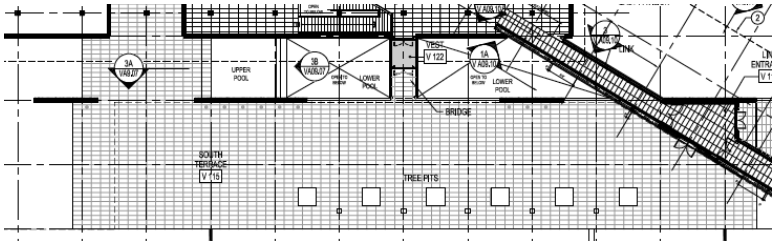


Figure 16: South Terrace Key Plan

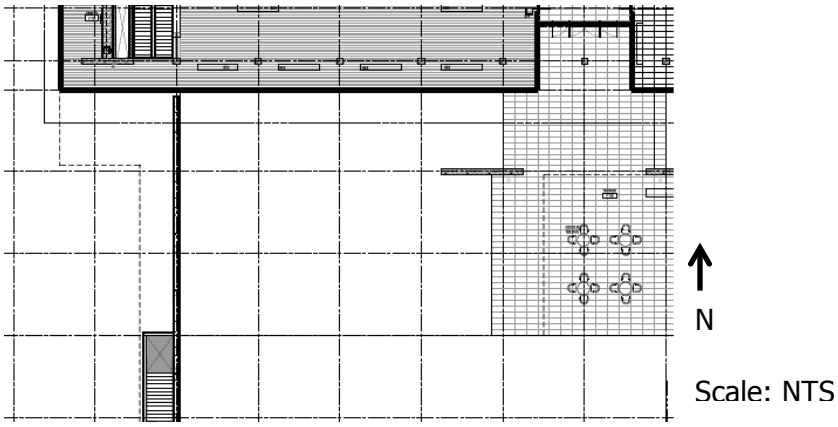


Figure 17a: South Terrace Furniture Plan

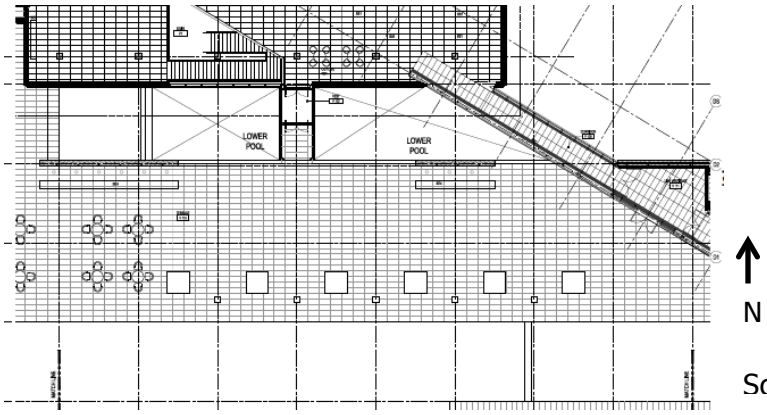


Figure 17b: South Terrace Furniture Plan

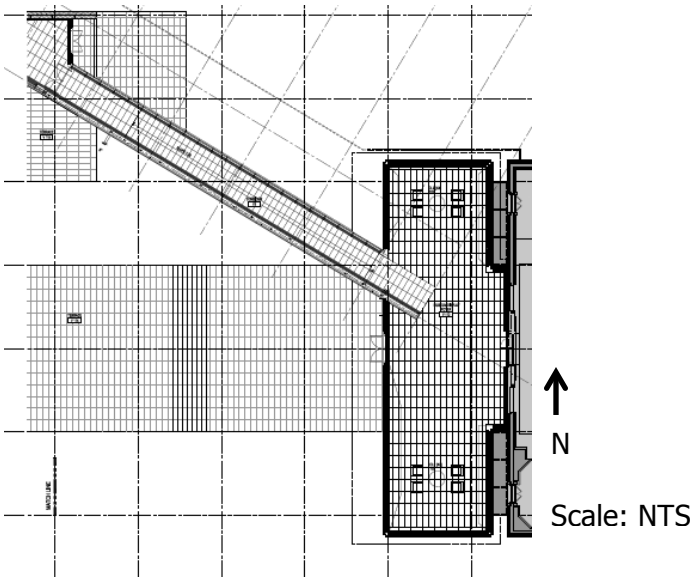


Figure 17c: South Terrace Furniture Plan

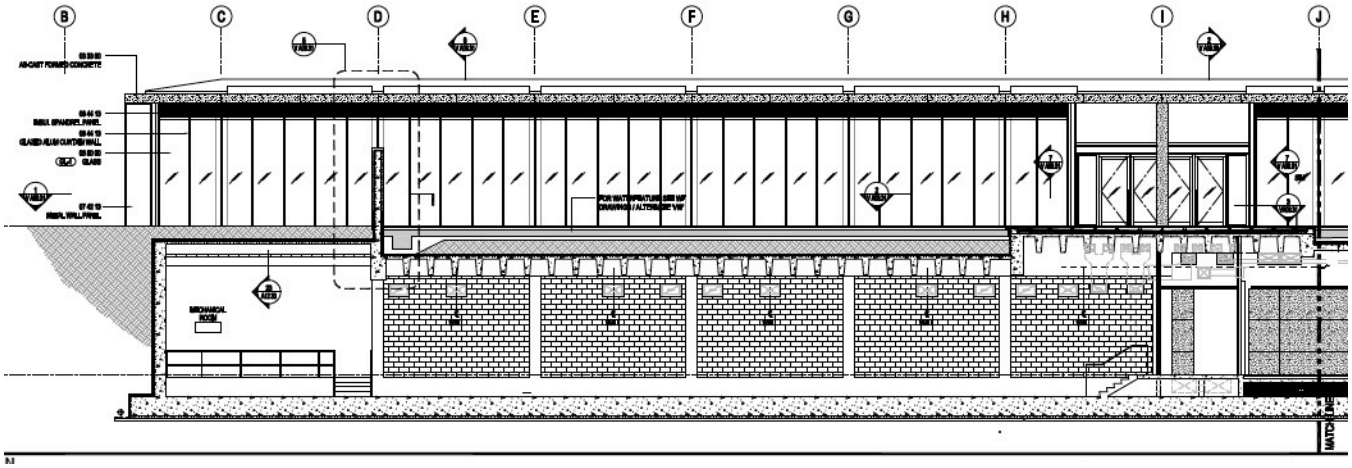


Figure 18a: South Façade Elevation

Scale: NTS

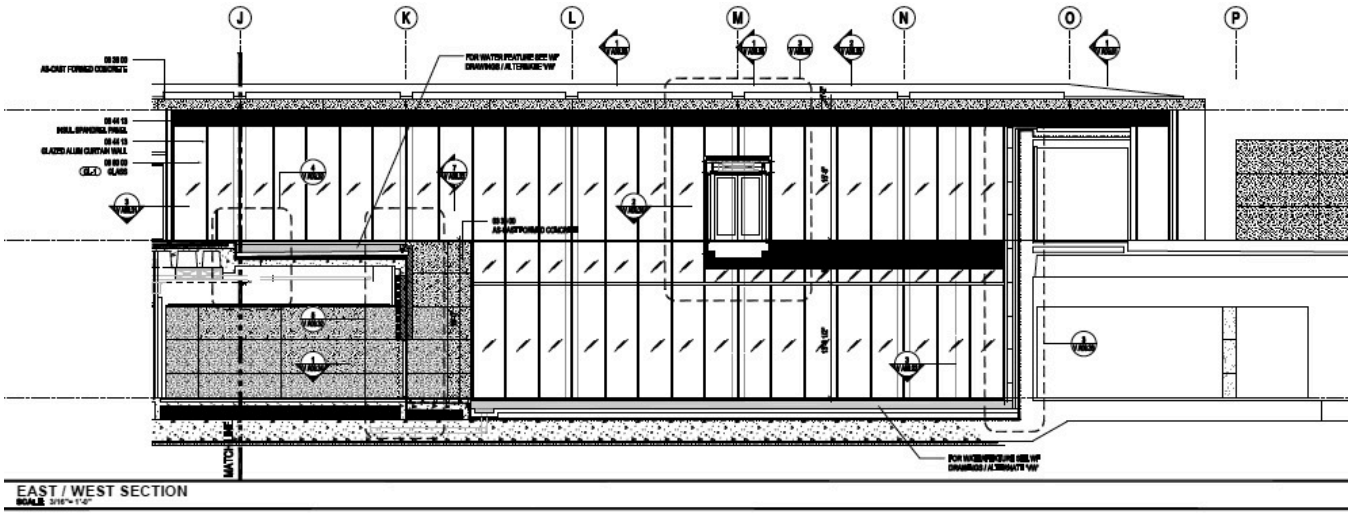


Figure 18b: South Façade Elevation Scale: NTS

Materials

South façade is constructed of a glazed aluminum curtain wall system with portions of architectural concrete. The flooring of the terrace is constructed of precast concrete pavers.

Reflectances
Architectural Concrete: 0.34
Glazed aluminum curtain wall: 63% transmittance, 4% reflection
Concrete Pavers: 0.25

Description of lighting systems

Luminaires and Lamps

A summary of the luminaires, lamps, and their locations are listed below:

- Recessed downlight fixtures with 37W MR-16 lamps (AD4) are used under the bridge adjacent to the lower pools
- Recessed downlight fixtures (AD15) with 20W MH sources are used under the bridge adjacent to the lower pools
- In-grade wall washing fixtures with 39W MH sources illuminate the freestanding exterior walls adjacent to the upper and lower pools. (AE9)
- Recessed step lights with metal halide sources are mounted in the freestanding walls to illuminate the terrace (AW6)
- In-grade LED fixtures illuminate the greenery in the tree pits (AE8)

Note: The fixture designated "AD14" in the drawings is not used

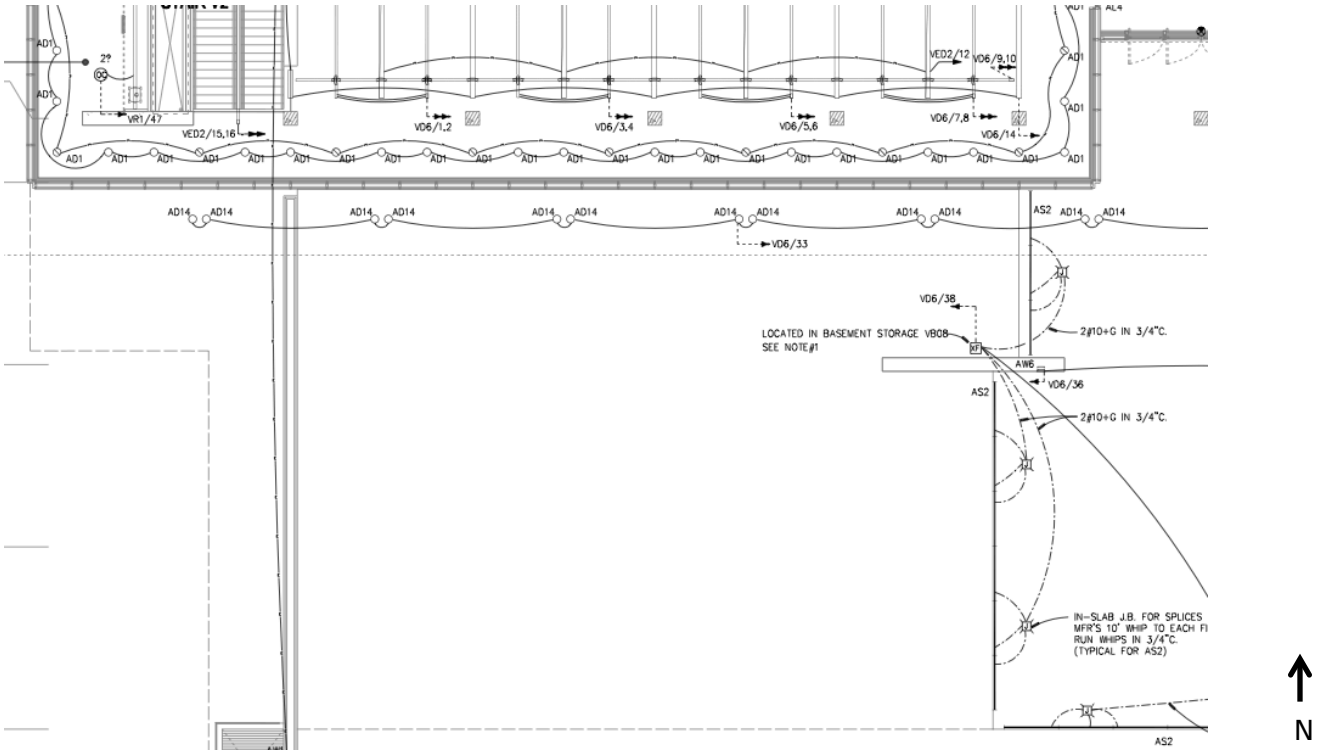


Figure 19a: South Exterior Lighting Plan Scale: NTS

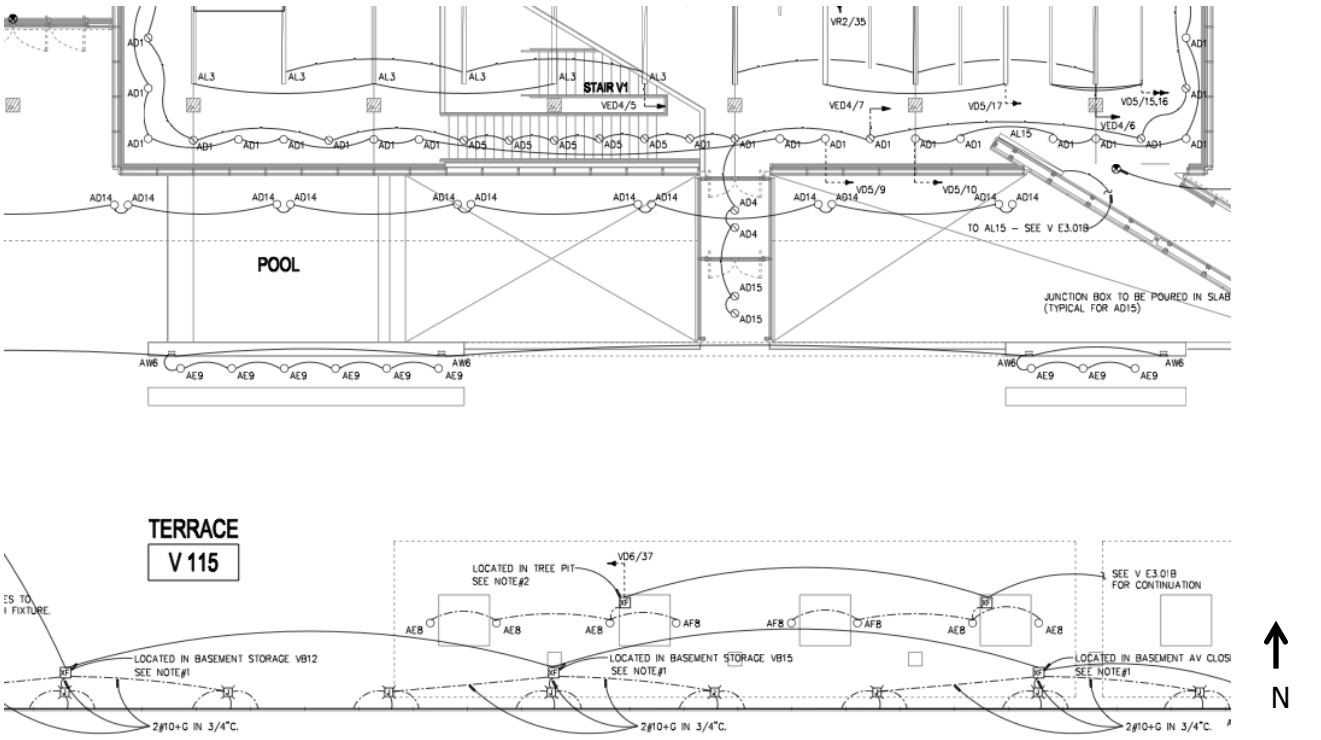


Figure 19b: South Exterior Lighting Plan Scale: NTS

Ballasts
The metal halide fixtures have integral electromagnetic ballasts. The LED fixtures have integral drivers.

Controls
The exterior lighting for The Clark is controlled by a Lutron system that uses a daylight photosensor to switch off the lighting when sufficient natural light is available.

Daylighting
The space is illuminated via daylight until the Lutron control system determines that sufficient daylight is not available.

Description of lighting criteria

IESNA Lighting Handbook, 10th Edition | Tables 26.2, 28.2 and 34.2

Recommended Illuminances

- Façade (LZ2)
  - Apply 40 lux strategically to less than 15% of building façade
  - Avg:Min – 3:1
  - Max:Min – 10.1
- Plaza (LZ2)
  - Horizontal Illuminance – 4 lux
  - Vertical Illuminance – 2 lux
  - Avg:Min – 4:1
  - Max:Min – 5:1 (10:1)
- Ramps, Stairs and Steps
  - Horizontal Illuminance – 6 lux
  - Vertical Illuminance – 2 lux
  - Avg:Min – 4:1
  - Max:Min – 5.1 (10.1)
- Pool
  - Horizontal Illuminance – 6 lux
  - Vertical Illuminance – 2 lux
  - Avg:Min – 4:1 (8:1)

ASHRAE 90.1 Requirements

- 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

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

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

Criteria Discussion

The IES illumination criteria generally fit very well to this exterior application and should be followed. A possible deviation would be the criteria for the pool. The pool criteria are intended to recommend lighting levels for the areas around swimming pools, not reflecting pools and exterior ice skating rinks. More light may be necessary for smaller task such as tying ice skates laces. A high importance must be placed on providing adequate illumination for safety in the space as well.

One important consideration for illuminating the façade is the creation of veiling reflections on the curtain wall surface. This would be an issue if the architect and owner intend for guests to observe activities going on inside of the VECC. The in-grade fixtures used to illuminate both the exterior freestanding walls and trees must be carefully selected and directed to prevent direct glare for occupants. Care must be taken to mitigate the upward flux of light by in-grade fixtures to allow the space to achieve SSc8.

Prioritized Criteria List

1. Meet energy codes
2. Ensure that lighting systems provide adequate illumination for safety functions around pool and ice rink
3. Provide adequate and appropriate light for space functions
4. Avoid technical problems such as glare and unwanted reflections
5. Meet LEED requirements

Critique of lighting conditions

Aesthetics and Architectural Reinforcement

The lighting of the exterior environment to the south of the VECC highlights all of the major architectural and landscape elements. The texture of the architectural concrete used for the freestanding exterior walls is a focal point as well as the patio trees. Although the fixtures originally intended to illuminate the façade of the building are no longer used, this does not detract from the beauty of the façade. The light from the interior of the VECC will illuminate the glazed façade and create a pleasant statement on its own.

Relevance to Space Use

Choosing fixtures and systems that respond well in cold environments was appropriate choice. The metal halide and LED sources will provide more light with better consistency than a fluorescent source would during the frigid winters in Northern Massachusetts. Metal halide and LED sources are also a wise choice because of source efficacy.

Quantitative evaluation

The exterior lighting system uses less power than the requirements set by ASHRAE 90.1. The façade uses 0.46 W/LF and the patio uses 0.04 W/SF. Further analysis is needed to determine if the space meets the LEED requirements for SSc8. However, as a note, this may be difficult to achieve for this space because the metric is based on a percentage of total fixture lumens not on total upwards flux. Nevertheless, all other elements of SSc8 could be, or are achieved in this space; the power density is below ASHRAE 90.1 levels, the lighting system is controlled by a photo sensor system, and the site boundary is sufficiently far away from the building so that light trespass should not be an issue. The lighting system of the space does well to improve the efficiency of the building as required for EAc1. Once again, IEQc6.1 is not practical for the space for previously mentioned reasons. Given that it is an outdoor space, IEQc8.1 and IEQc8.2 are not applicable.

Retail Space

Architectural Description

Function and Layout

The retail space, which is immediately to the east of the lobby, is a space that will be used to store and sell souvenirs and other items to the guests. The retail space also has several tables for meeting and relaxing. Two are located towards south end of the space and one larger table is located in the northeast corner of the space. A small check out counter is located on the north side of the space. The retail space is connected to the lobby on the west side and to the original 1955 building via the corridor in its southeast corner.

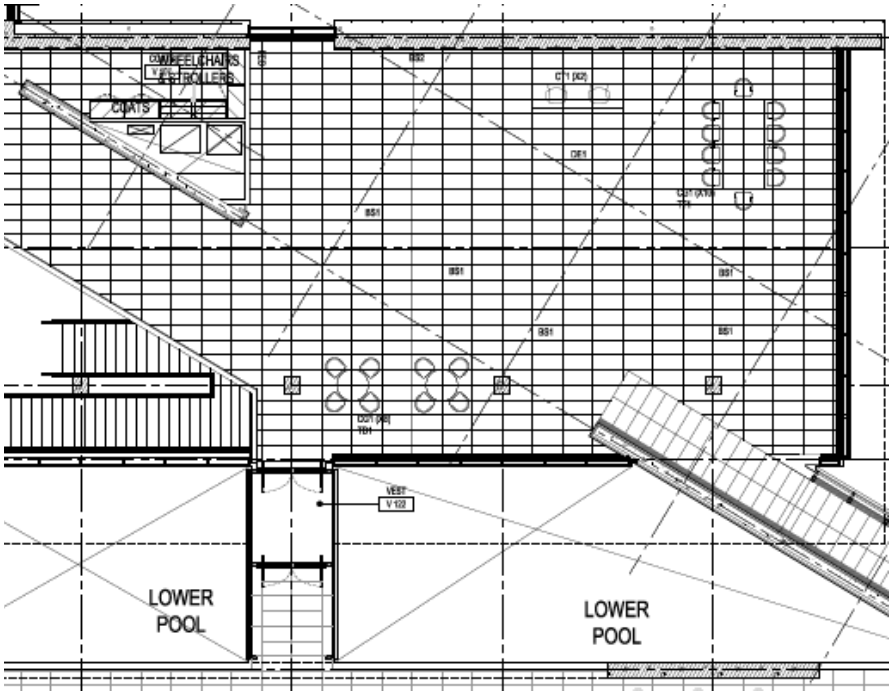


Figure 20: Retail Furniture Plan

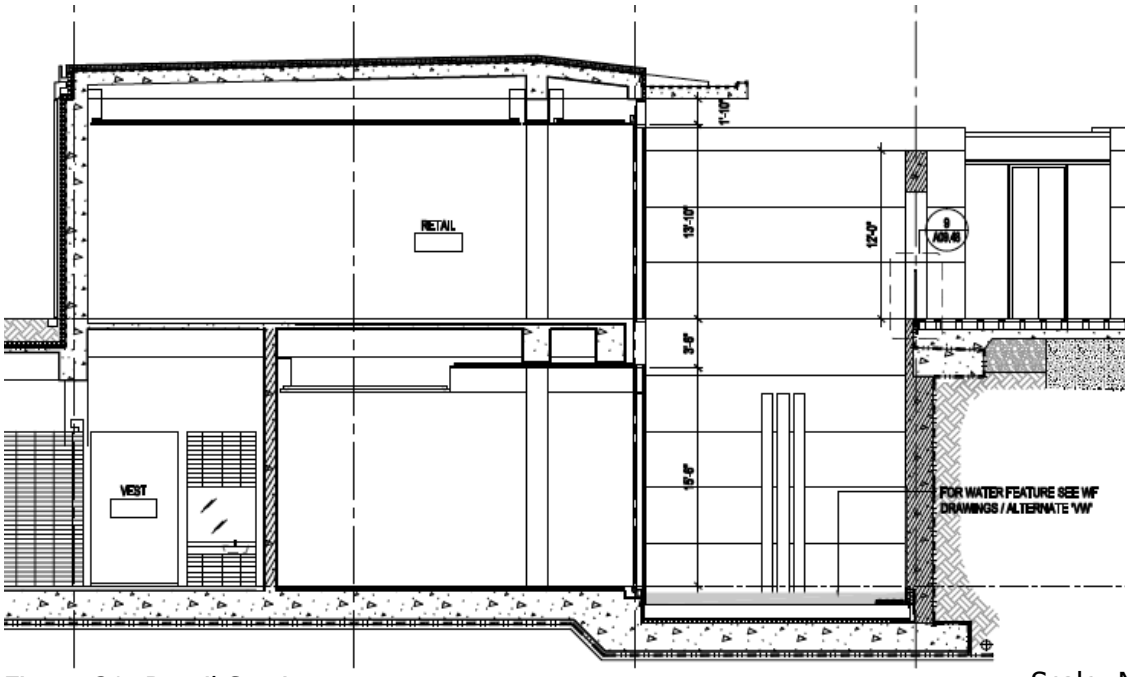


Figure 21: Retail Section Scale: NTS

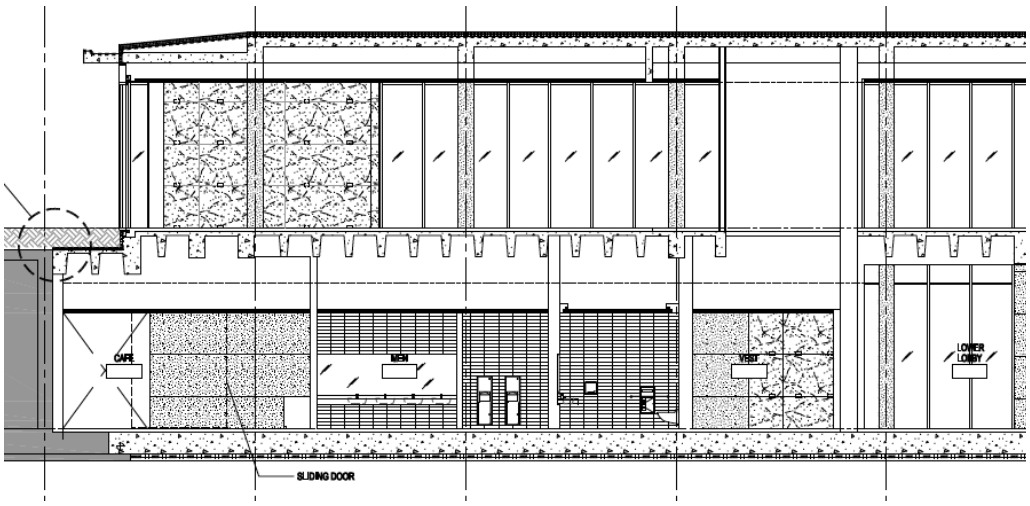


Figure 22: Retail Section Scale: NTS

Materials

Similar to the lobby, the north wall is finished with architectural concrete. A glazed aluminum curtain wall system is used for the south and west walls of the space. The corridor in the southeast corner of the space uses granite and glass for its vertical surfaces; granite on the south wall and a glazed aluminum curtain wall system on the north wall. The ceiling in both the retail space and the connecting corridor is made of acoustic plaster, and both spaces use concrete pavers for the flooring.

Reflectances

- Architectural Concrete: 0.34
- Granite: 0.17
- Glazed aluminum curtain wall: 63% transmittance, 4% reflection
- Concrete Pavers: 0.25

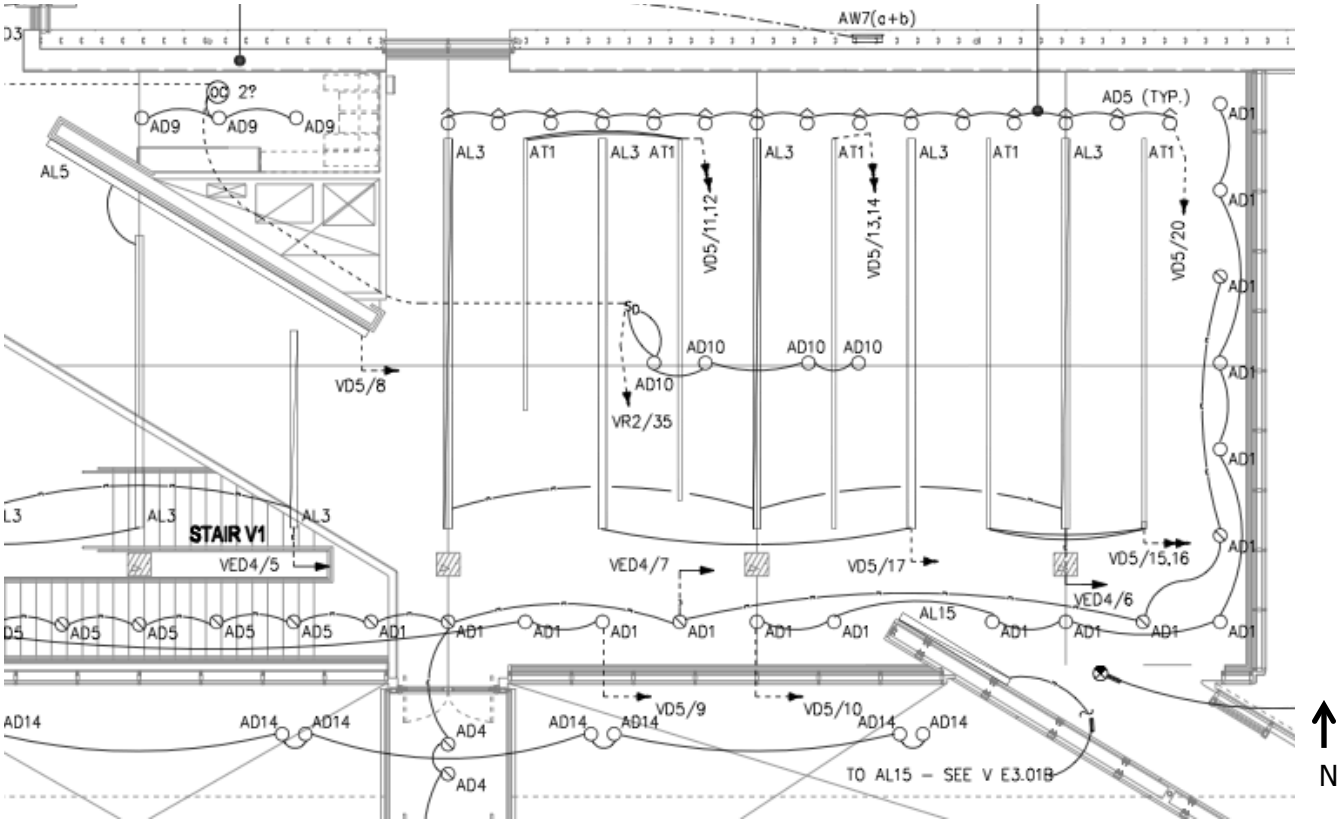
- Acoustic Plaster: 0.76

Description of lighting systems

Luminaires and Lamps

A summary of the luminaires, lamps, and their locations are listed below:

- Recessed downlight fixtures with 50W MR-16 lamps (AD1) are used around the perimeter of the ceiling plane
- Recessed linear fluorescent fixtures that use (2) 28W T5 3500K lamps (AL3) run north-south in the space
- Recessed down light fixtures with 71W MR-16 lamps (AD5) wall wash the north wall of the retail space
- A two-circuit track system runs in between the recessed linear fluorescent fixtures (AT1). No luminaires or lamps have been specified for use with the track lighting system.
- Recessed downlight fixtures with 37W MR-16 lamps (AD10) are used in the center of the retail space



Scale: NTS

Figure 23: Retail Lighting Plan

Ballasts

The recessed linear fluorescent fixtures have integral electronic dimming ballasts.

Controls
Lutron SO-4SN controller with 4-button/off/raise and lower capabilities provide control for the halogen and fluorescent sources.

Daylighting
Two out of the four boundaries of the spaces are composed mostly of a glazed aluminum curtain wall system. A concrete overhang blocks the summer sun from entering the space. An automated blind system provides three different shading capabilities: 0 transmittance, 6% transmittance and 24% transmittance.

Description of lighting criteria

IESNA Lighting Handbook, 10th Edition | Table 34.2

Recommended Illuminances
- Circulation
  - Horizontal Illuminance – 150 lux
  - Vertical Illuminance – 50 lux
  - Avg:Min – 1.2:1
- General retail
  - Horizontal Illuminance – 400 lux
  - Vertical Illuminance – 150 lux
  - Avg:Min – 3:1/6:1

ASHRAE 90.1 Requirements

Maximum Power Density: Retail – 1.7 W/SF

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

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

Criteria Discussion

The illuminance recommendations provided by IES are very applicable to this retail application. However, the illuminances listed for retail are for general retail only. Therefore, it may be necessary to provide significantly more light on certain merchandise to draw attention to certain displays. Per suggestions by the IES handbook, 25% of the feature display should be lighted to five times the base retail illuminance and an additional 10% can be included for additional emphasis.

Sources with a CRI of 80 or greater should be used to ensure that the merchandise colors are rendered accurately and an attempt to match CRI's from different sources should be made to ensure that there is not cacophony of color. Although UV damage is not as much of a consideration in the retail space as it is in the display galleries, certain merchandise may still be susceptible to UV damage, and this must be considered.

Prioritized Criteria List

1. Meet energy codes
2. Provide adequate and appropriate light for space functions
3. Ensure that lighting systems guide occupants through the space
4. Avoid technical problems such as glare and unwanted reflections
5. Ensure that the lighting systems protect the artwork, especially from UV radiation
6. Meet LEED requirements

Critique of lighting conditions

Aesthetics and Architectural Reinforcement

The lighting design of the retail space, which is similar to the lighting design for both the multi-use and lobby spaces, reflects the minimalism of the architecture. Lines of linear fluorescent fixture reflect the straight, clean lines of The Clark and the light provided by the downlights around the perimeter of the space define the space with border of light. Washing the architectural concrete on the north side of the space with light will bring focus the material that has become one of the reoccurring themes not just for the additions to The Clark, but for the entire campus as well. This gesture not only reflects the architectural precedence of The Clark, but gives the space a sense of spaciousness and visual clarity.

Relevance to Space Use

The lighting system for the multi-use space is very applicable to uses and aesthetic needs of the space. Uniform lighting, provided by the linear fluorescent fixtures, is necessary for the ambient light and circulation light. Because the space is used to display merchandise, and certain focal points may be desired, non-uniform light levels are necessary. The ability to direct the light onto temporary merchandise displays is extremely important and the track lighting system accomplishes this task. Using incandescent sources in the space is not a good use of energy, but does allow the colors of the merchandise to be rendered extremely well. The 3500K white light provided by the recessed linear fluorescent fixtures warms up the space and gives the merchandise area a more homely feel.

Quantitative evaluation

The lighting systems for the retail space fall above the ASRAE 90.1 power requirements with a power density of 1.84 W/SF. This is due to the large amount of incandescent fixtures used in the space. It is important to note that this number does not reflect the wattage consumed by the track lighting fixtures, as no fixtures are currently specified for this system. The energy consumption numbers do not aid the building in achieving LEED EAc1. The space does lend itself to obtaining LEED SSc8 via Option 1 as well as IEQ Credit 8.2. IEQc8.1 is not obtainable for the multi-use space by Option 2 (VLT*WFR is above 0.18), but further analysis will determine whether it is obtainable by other options. Again, IEQc6.1 is not practical for the space for previously mentioned reasons.

Summary

The lighting systems for the spaces studied succeed at providing adequate, appropriate light. The lighting design reflects and encourages the straight, clean lines of The Clark, while providing sufficient way finding and functional light to the facility. Warm 3500K sources help warm up the potentially cold feeling spaces created by the large-scale simple geometric forms of the building. These simple geometric forms function as a blank slate upon which the lighting design can draw emotion and evoke psychological impressions. However, more often than not, the lighting design reinforces a sense of visual clarity and spaciousness. Variety in emotional impression is something that could be improved upon or studied in the five spaces evaluated in this report.

Light levels are at or above the IES recommended levels for all of the studied spaces. However, using large amounts of incandescent sources for the interior spaces results in extremely inefficient lighting systems. Power densities criteria and results for the space-by-space method can be seen below. Further study would be needed to determine if The Clark satisfies the 1.1 W/SF museum allowance using the ASHRAE 90.1 building area method.

Space	ASHRAE 90.1 2007 Allowable Power Density	Designed Power Density
Wood Shop	1.9 W/SF	0.6 W/SF
Multi-Use	1.0 W/SF	1.3 W/SF
Entrance Vestibule and Lobby	1.0 W/SF	1.5 W/SF
South Façade	5 W/LF	0.5 W/LF
South Terrace	0.2 W/SF	0.04 W/SF
Retail	1.7 W/SF	1.8 W/SF

Figure 23: Power Density Summary

Aside from the high CRI, the controllability and dimmability of incandescent fixtures is one of the reasons that halogen MR-16 sources are used so extensively in The Clark. Alternative sources and control solutions must be studied to determine if another source can be used appropriately to satisfy ASHRAE 90.1 energy requirements.

The integration of the control and sensor system into the lighting system is of utmost importance for The Clark. Much of the building envelope is an aluminum glazed curtain wall system. This demands significant consideration for daylight control and dimmable lighting systems, both for functionality and to mitigate the UV risks associated with daylighting museum spaces.

Appendix A: LEED Credit Options and Descriptions

SS Credit 8: Light Pollution Reduction

Interior

- OPTION 1: Reduce the input power to luminaires with a direct line of sight to any openings in the envelope (translucent or transparent) by at least 50% between 11 p.m. and 5 a.m.

- OPTION 2: All openings in the envelope (translucent or transparent) with a direct line of sight to any nonemergency luminaires must have shielding (controlled/closed by automatic device for a resultant transmittance of less than 10% between 11 p.m. and 5 a.m.).

Exterior

- Lighting power densities shall not exceed those specified in ASHRAE 90.1-2007
- Lighting controls shall comply with section 9.4.1.3 of ASHRAE 90.1-2007
- All site and building-mounted luminaires produce a maximum illuminance of no greater than 0.10 horizontal and vertical footcandles at site boundry and no greater than 0.01 horizontal footcandles 10 feet beyond the site boundary according to requirements for LX2
- No more than 2% of the total initial designed fixture lumens are emitted above 90 degrees from nadir

IEQ Credit 8.1 Daylight and Views – Daylight

- OPTION 1: Demonstrate by computer simulation that a minimum of 10 fc and maximum of 500 fc on the work plan in clear sky conditions on Sept. 21 at 9am and 3pm.

- OPTION 2: Achieve a value between 0.150 and 0.180 for the product of the Visible Light Transmittance (VLT) and window-to-floor area ratio (WFR)

- OPTION 3: Measure minimum daylight illumination levels of 10 fc and a maximum of 500 fc in daylight spaces

Appendix B: Building Key plans

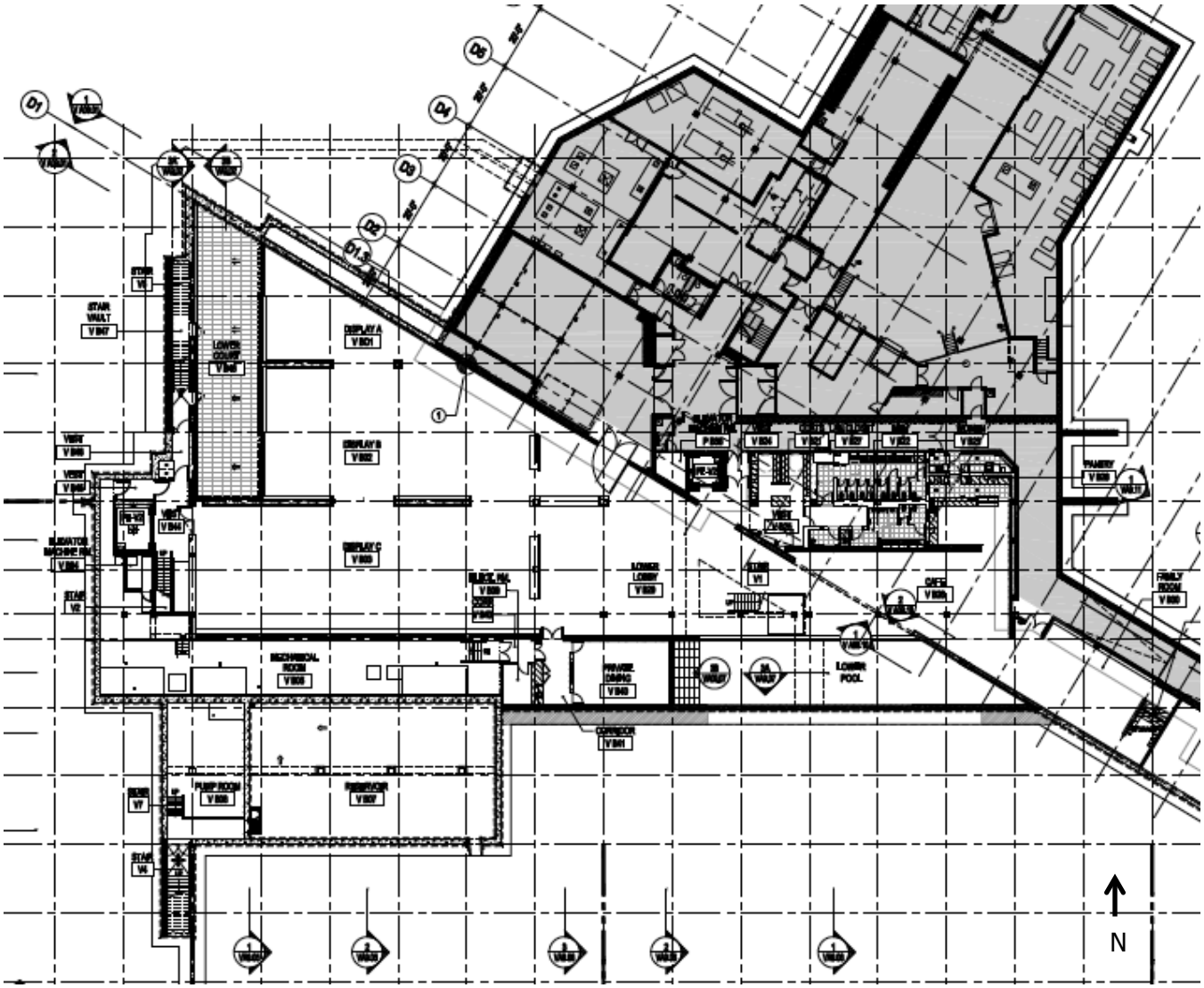


Figure B1: Basement Level

Scale: NTS

Note: Gray indicates phase 2A of the building project, which is the plant addition

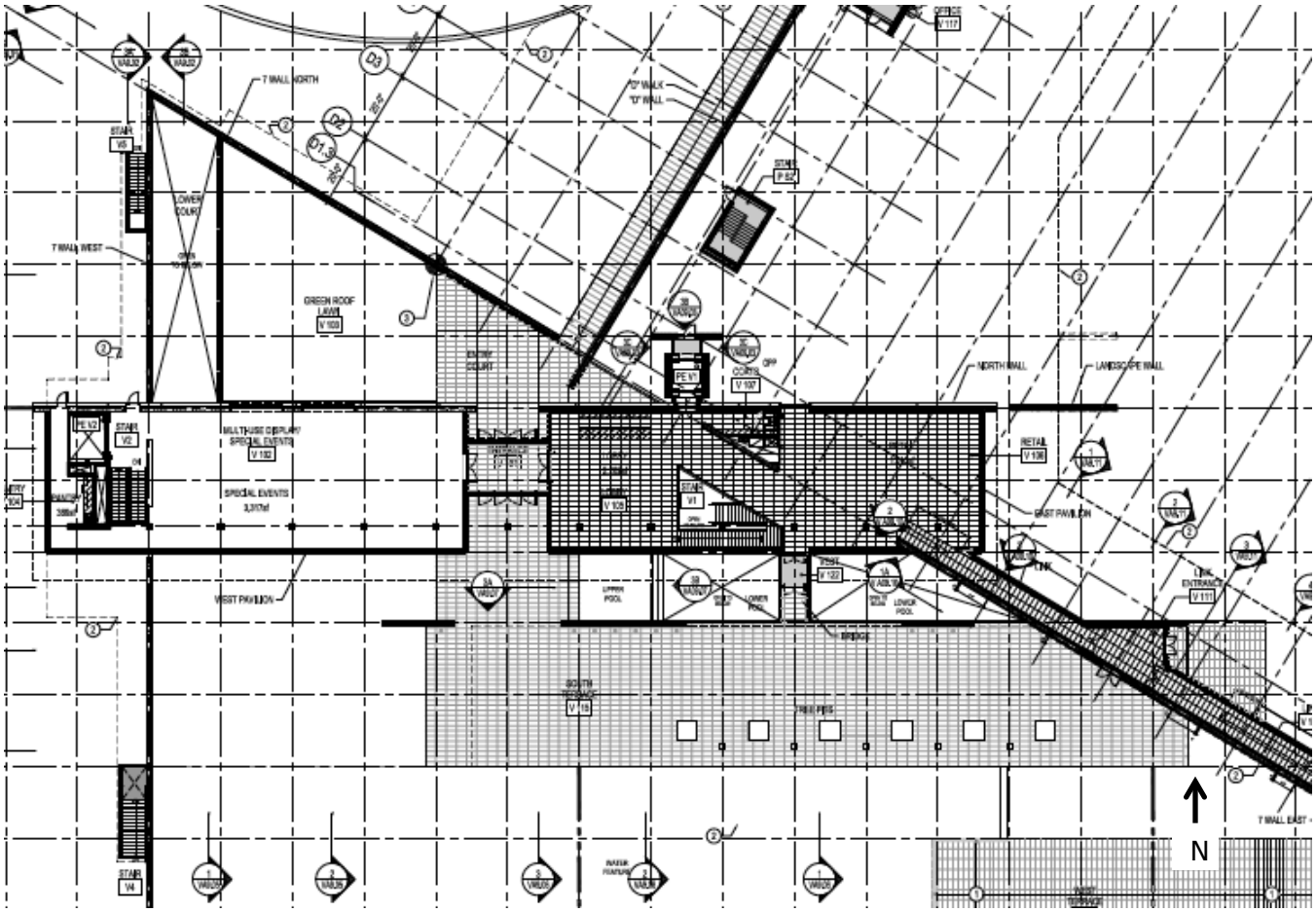


Figure B2: First Floor Level

Scale: NTS