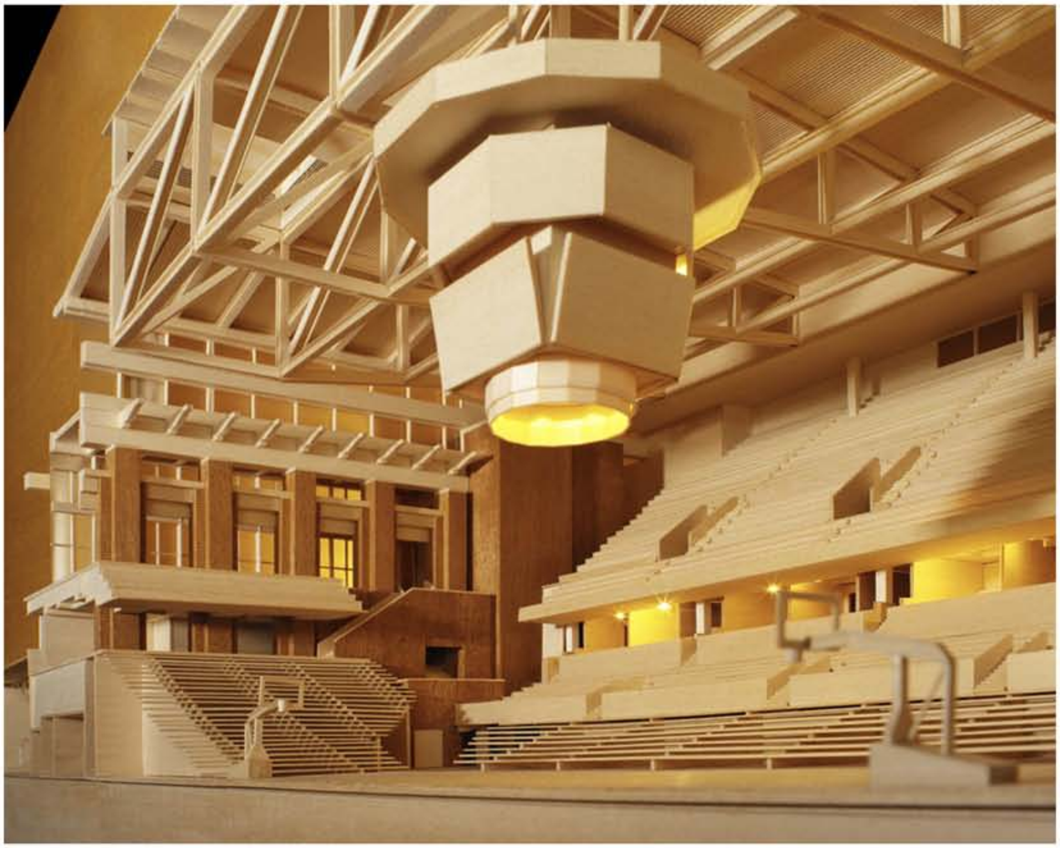
JOHN PAUL JONES ARENA

CHARLOTTESVILLE, VIRGINIA



LOGAN BROWN

ARCHITECTURAL ENGINEERING SENIOR THESIS PROJECT

FINAL REPORT

LIGHTING / ELECTRICAL OPTION

PRESENTED APRIL 28, 2009

ADVISORS: DR. RICHARD MISTRICK

MR. TED DANNERTH

EXECUTIVE SUMMARY

The analysis of the John Paul Jones Arena on the University of Virginia campus looked at a various number of system redesigns and how the changes would affect the already existing system and building.

The lighting depth was focused on the redesign of four spaces. The spaces included an academic and study area, a large athletic dining room and gathering space, the western colonnade and façade and finally the entry lobby. All of the designs were created to invoke reactions and carry concepts of openness and cohesion through the building while at the same time being able to enhance architectural features and elements. Each design went through a process of conceptual ideas to finalized renderings by taking into account criteria found in the IESNA handbook and ASHRAE 90.1.

The electrical depth focused on the coordination of the redesign with the existing systems. This was performed through existing panelboard and feeder analysis and the subsequent resizing of panelboards to account for the new additional loads. A study was also done to analyze the benefits of modifying the transformers to a more energy and cost efficient system. The results showed a significant decrease in energy consumption, reduced yearly electric bill and a more beneficial effect on the environment. Cost analysis was also done comparing the old system to the new and the result was a higher initial cost for the new system, but a relatively short payback period. A second study was done comparing the use of copper and aluminum feeders. The results showed that although the aluminum was cheaper, the benefits of copper were too great to actually change the system.

An architectural and structural study was done to analyze the feasibility of installing a green roof on the flat surfaces of the arena. Through schematics, cost studies, square footage analysis and a structural model, the study showed that the idea of putting a green roof is feasible.

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JOHN PAUL JONES ARENA

295 MASSIE ROAD
CHARLOTTESVILLE, VA 22903

PROJECT FEATURES

TOTAL COST: $129.8 MILLION
SIZE: 365,916 SQ. FT.
FUNCTION: ARENA & PERFORMANCE
OCCUPANCY: ASSEMBLY, A-3
LEVELS: 3 ABOVE GRADE
DURATION: 5.30.2003 - 8.1.2006
METHOD: DESIGN-BID-BUILD

ARCHITECTURE

-GLAZED ALUMINUM CURTAIN WALL SYSTEM
-4" WOOD MOULDED OLD VIRGINIA STYLE RED BRICKS
-FULLY ADHERED EPDM ROOFING ON 3" RIGID INSULATION
-COLONNADE FACADE ECHOES TRADITIONAL STYLE OF CAMPUS BUILDINGS

STRUCTURAL

-CAST-IN PLACE ONE-WAY CONCRETE SLABS
-PRECAST CONCRETE STAIR/STAIR SLABS
-CONCRETE MOMENT RESISTANT FRAME
-SLAB ON GRADE POUR UNDER COURT FLOOR
-4000 PSI SPREAD FOOTINGS & FOUNDATION WALLS

ELECTRICAL

-(2) 12.47 KVA PRIMARY ELECTRIC SERVICE CONNECTIONS WITH 2 FUTURE SPACES
-(5) MAIN TRANSFORMERS (2000-2500 KVA) SPLITTING MAIN POWER
-2000 KW EMERGENCY GENERATOR
-15 KV PAD-MOUNTED SWITCHGEAR (600A, 25000 AIC)

MECHANICAL

-(18) AIRPAK AHU'S, AIRFOIL FAN TYPE WITH HEATING HOT WATER PREHEAT COIL
-(3) 3600 GPM CHILLED WATER LOOP COOLING TOWERS
-(21) 900 TO 2500 CFM TRANE BLOWER COIL UNITS
-(4) FLEXIBLE, NATURAL GAS WATER TUBE BOILERS

PROJECT TEAM

OWNER: THE UNIVERSITY OF VIRGINIA
ARCHITECT: VMDO ARCHITECTS P.C.
ASSOC. ARCHITECT: ELLERBE BECKET
MEP ENGINEER: ELLERBE BECKET
STRUCTURAL ENGINEER: ELLERBE BECKET
CIVIL ENGINEER: PATTON HARRIS RUST & ASSOC. P.C.
GENERAL CONTRACTOR: BARTON MALOW

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HTTP://WWW.ENGR.PSU.EDU/AE/THESIS/PORTFOLIOS/2009/LWB117

SECTION TWO: Overall Background & Project Overview

The John Paul Jones Arena, situated on the campus of The University of Virginia, is a perfect match between the classic architectural style founded by Thomas Jefferson over 200 years ago and the modern amenities of a top-of-the-line performance venue. One enters the arena through a monumental colonnade accented by 16 Doric style columns covered by a pergola style roof system. After passing through the entrance, the lobby and upper concourse level become visible. This large opening allows the spectator to get a sneak peek into the court area, yet at the same time create a bit of mystery as to what lies beyond.

As one moves around the concourse, there are team shops, numerous concession stands, restrooms and executives suites. Across the arena from the main entrance is the second most important architectural feature, an elevated terrace with another colonnade that mimics its monumental counterpart. This feature is rare to see in an arena because it allows an increased level of exterior lighting into the actual court and seating area. The theme of bringing the outside in is one that is successfully achieved throughout the arena.

The arena is broken up into 3 main floors: the event level, which is where the court and team locker rooms are located; the lower concourse, which has an athletic dining room and the Hall of Fame museum and finally the upper concourse, which is the main level of entry through the colonnade and where access to all the seating is located.

Most of the spaces throughout the building are more than a standard floor height which eliminates the use of indirect lighting. The majority of luminaires are direct, recessed or surfaced mounted, with the lamping either compact fluorescent or metal halide. The lighting design is one that tries to take the dullness away from the grey concrete structure and give it life by creating an inviting environment to all those who enter the space.

The overall goal for the Architectural Engineering senior thesis is to give those involved an opportunity to be part of in-depth and substantial analysis project that culminates only after exhausting all aspects of what the AE major entails.

SECTION THREE: Building Statistics & Description

General Building Data:

Building Name: John Paul Jones Arena
Location & Site: Massie Road, The University of Virginia, Charlottesville, Virginia
Occupant Name: The University of Virginia
Occupancy & Function: The arena will house a variety of events including concerts and basketball games, as well as being home to numerous shops, concession stands, practice facilities and a University Hall of Fame.
Size: 365,916 Square Feet
Number of Stories: 3 above grade

Key Architectural Features:

A façade adorned with a monumental colonnade that echoes the traditional architecture of the campus that was started by Thomas Jefferson when the college was founded over 200 years ago. It has a mixture of the traditional archetypes along with all the modern amenities of a top-of-the-line arena and concert venue. The exterior is clad in over 600,000 wood-molded, old Virginia bricks that mimic other buildings on campus. A custom steel roof trussing systems supports a large dome that is taken from old estates built in the colonial times.

Primary Project Team:

Owner: The University of Virginia
Architect: VMDO Architects P.C.
Assoc. Architect: Ellerbe Becket
General Contractor: Barton Malow
Civil Engineer: Patton Harris Rust & Associates P.C.
Structural Engineer: Ellerbe Becket
MEP Engineer: Ellerbe Becket
Arena Signage and Wayfinding: Workshop Design LLC

Dates of Construction:

Groundbreaking: May 30, 2003
Completion: August 1, 2006

Overall Cost: 129.8 million dollars
Project Delivery Method: Design-Bid Build
Major Building Codes:

VUSBC 1996 edition with 2000 amendments
National Electric Code, 1996 edition
Uniform Federal Accessibility Standards, 1988 edition
International Mechanical Code, 1996 edition
International Plumbing Code, 1995 edition with 1996 supplement

Construction Method:

The construction for JPJ Arena began in May 2003 and was completed in August of 2006. The general contractor for the project was Barton Malow, and was delivered as a design-bid-build method. Since the university is a public institution, the contract type is GMP (Guaranteed Maximum Price), which allows for companies to bid on the project and have the university pick the best overall option.

Electrical System:

The electrical service for the John Paul Jones Arena is provided by the University of Virginia physical plant and is located on the northeast side of the site. Primary service is run underground through a duct-bank system where it is connected to 2 exterior pad-mounted switch gear systems, with space for 2 future connections. The service enters at 12.47KV and is stepped down to 4 transformers on a 480Y/277V system (2000, 2000, 1500, 1500 KVA) and 1 transformer at 4160/2400V (2500 KVA). All transformers are owned and operated by the University of Virginia.

The main transformers feed distribution panels throughout the building and are located on 3 levels: event, lower concourse and upper concourse. The standard power branches are either run off 2000A or 3000A feeders. Additional transformers are located on each floor, within a given quadrant's electrical room, where the voltage is stepped down to 208Y/120V.

The emergency system is run from a four cycle, diesel fueled, direct injection generator mounted on a steal base with vibration isolation. The generator is rated at 2000KW and supports a main emergency switchboard.

Throughout the system there are 6 automatic transfer switches, 3 in the central plant and 3 located around the arena. All the switches are run on the 480Y/277V system and range from 70A to 1200A. There is one designated for the life safety branch, legally required as a standby system and the final one left as an optional standby system.

Lighting Systems:

The lighting systems for the arena are predominantly a mixture of fluorescent and metal halide fixtures with a few incandescent and halogen fixtures spread throughout the space. The fluorescent luminaires are combinations of linear strips, downlights, wall sconces, step lights, pendants and recessed fixtures. These systems are primarily used along the concourse level where pedestrian traffic is prevalent, as well as in the more private spaces of the arena including the locker rooms, training spaces, work areas and meeting spaces. The metal halide fixtures are a mixture of high bay pendants, recessed downlights, surface mounted downlights and step lights. They are used around the concourse in coordination with the fluorescent fixtures to aid in pedestrian movement as well as in the main gymnasium for event lighting. The combination of systems provides higher Illuminance levels through the spaces that have higher ceilings and are generally larger in comparison to the smaller spaces. The catwalks above the arena floor use a system of quartz-type fixtures.

The exterior lighting systems follow those of the interior by using fluorescent and metal halide fixtures. The uniformity of systems makes it easy for the occupants to adjust from outside conditions to those of the interior. It also creates visual unity between the interior and exterior through the large glass curtain wall that makes up the entry corridor. The metal halide fixtures are pole mounted on the entrance colonnade to give a monolithic appearance and create a strong visual image upon entering the arena.

Mechanical System:

The mechanical system for the building is a fan-powered constant volume terminal unit with a reheat coil. The majority of the equipment is located in a central plant on the event level and kept away from the main arena spaces. There are (3) main AHUs located in the central plant that range from 6000 to 23000 scfm and feed (15) additional AHUs located around the arena. The additional AHUs are spaced 4 per floor, one per quadrant, and range from 2000 to 85000 scfm.

There are (4) flexible water tube boilers with an entering temperature of 170 deg. F and exiting temperature of 240 deg. F. The boilers are in line with heat exchangers that are connected to the other equipment systems throughout the building. The exchangers supply the necessary hot and cold water to the load equipment (AHUs, VAVs and fan coil units) that are needed to run the building system. They also run on temperature cycle of 160 deg. F entering and 190 deg. F leaving. The 190 deg. F is the temperature required for the initial reheat temp. of the AHUs.

There are (3) cooling towers that total 10800 GPM and consist of 85 degree condensed water. The towers are connected to (3) chiller units located in the central plant with a total capacity of 2800 tons and have a flow rate of8400 GPM. Throughout the building there are also (21) blower coil fan units used for smaller, more specific areas that range from 900 to 2500 cfm.

Structural System:

The majority of the arena is a concrete structure. It consists of a Raker system that supports the arena seating and major walkways. This also allows for the precast stair and stair slabs to be easily put into the proper location when construction calls for it. There is a slab-on-grade below the actual court level that assists in supporting the structure along with spread footings and foundation walls. All the concrete on the job is rated to be at 4000 psi. The rest of the arena is supported by a one-way concrete slab system with a typical span being 25’-30’ and a lateral support system consisting of an ordinary concrete moment resistant frame.

The roofing system is completely custom design. It consists of long-span custom trusses that cover the court and seating area, with the concourse levels being the precast concrete and Raker system. The truss is made up of W-14 members with varying weights.

Transportation System:

There are (4) electric operated, oil-hydraulic elevators throughout the building, (3) being for passengers and (1) being for general service. The passenger elevators all carry a capacity of 3500 pounds and run on 480V-3 phase-60 cycle at 50 HP. The service elevator runs on a variable voltage, 2-way leveling system with a carrying capacity of 800 pounds. There is one elevator located in each quadrant of the building, with the service one being located near the dining room and kitchen area.

There are (7) main staircases throughout the arena located in high traffic areas and near the team locker rooms. The entrances to the court area are fed by (14) half level staircases for occupants to get to the seating areas.

Telecommunication System:

The telecom system for the arena comes from (4) underground conduit feeds off of the main university communication system. They enter the building on the north face and run into the central plant where they are distributed throughout the rest of the arena. Each quadrant of the arena is serviced by a standard telecom room, as well as one run by the university.

The voice and data networks will run through the entire building and provide services to all the spaces in the arena. There is also a large audio visual system that is used in the actual arena and court area and integrated through the speakers that are spaced around the concourse levels. Along with the AV system, there are flat-screen televisions placed around the arena to give visitors information about upcoming events and happenings that are occurring at the arena.

Fire Protection System:

The sprinkler and standpipe service main enters the building on the suite level, with the fire department connection being located in the grass area near the southeast corner of the building. All specific locations of sprinklers follow general layout requirements unless they violate any NFPA 13 or VUSBC codes. There is also a 6-inch Siamese connection pipe located 5 feet from the structure near the southeast entrance.

Standpipes are to be located in each of the four quadrants on the event level of the building per the drawings. The system is designed as a manual wet system with the piping sized to provide 500 GPM. There are 22” drain risers located at each of the standpipe locations.

The protection system for the building is a pre-action system. The water for fire suppression will only enter the system once the heat/smoke detectors are tripped and will only be released into the space when the fuse within the detector is broken. All suppression densities will use the area/density method and the system shall be sized to provide a 10% pressure margin at the required flow.

SECTION FOUR: LIGHTING DEPTH

General Overview

The John Paul Jones Arena on the University of Virginia campus was built and designed to be one the top performance and athletic venues on the east coast, thus the lighting design needs to be a reflection of that overall impression. With the multitude of uses and events, the systems put in place need to be flexible and adequate enough to handle the high demand. A general feeling of warmth and overall high ambience levels are the common theme throughout every space and are used to enhance the end users experience at the arena.

While redesigning four of the primary spaces in the arena (the academic center, the dining room, the western exterior façade and entry lobby), the design themes were meant to focus on the creation of a clean, open environment by limiting the appearance of luminaires. But at the same time mimicking, and respecting, the historical theme that is prevalent throughout the rest of campus. The main drive and motivation behind the design was creating an idea of bringing the outdoors in. Much of the space is located below grade and has no access to windows. It was important to make the spaces appear larger and more inviting than they actually are. The spaces are, by themselves very different in their functions and appearance, but an overall simple and minimalistic theme is what ties them all together.

Space One: Academic Center and Study Lounge

Description:

The academic center is located on the event floor and faces the western elevation. It is broken up into multiple spaces including individual study rooms, tutor rooms, offices, a classroom and the reading room. The reading room is approximately 12' x 40' with exact dimensions being hard to figure out due to the curved exterior wall and spaces being broken up into irregular shapes. The main entrance is situated on the northern side of the building right outside of the elevator lobby. It is an open floor-plan located in the center of the academic center surrounded by the offices and tutor rooms. The space is broken up with tables and chairs that allow for individual or group tasks. It is also used as a circulation space due to the surrounding spaces on the perimeter of the space.

There is no direct light from the exterior because the event level is located below grade. The entire space is artificially lit by fluorescent fixtures.

Surface Materials:

Wall A (East Wall): Is an interior wall that separates the reading room from the offices behind and breaks up the open plan. It is a painted (material PT-21) plastic glazing assembly over a steel stud support. There is a steel sign located on the lower half of the wall toward the center of the room.

Wall B (South Wall): This wall is broken up with an opening for a study area. It is finished with two different paint colors (PT-21, PT-24) and opens to a wall finished in wooden panels.

Wall C (West Wall): The West wall is the most interesting of the entire space. It is the wall that houses the individual tutor rooms. Each of the room's walls alternates between an etched glass (GL-1) and clear glass (GL-2). Above the doors there is painted wood veneer (PT-23)

Wall D (North Wall): Is a common wall for the academic center that the reading room uses. It is painted (PT-20) gypsum board over a metal stud support system.

Floor: The entire floor is stained concrete (STC-3).

Ceiling: The ceiling is painted gypsum wall board (PT-21) over the reading room, with parts of the academic center being exposed.

Furniture:

The space is furnished with typical chairs and tables that would be found in a typical classroom. There is custom cabinetry along the peripheral walls with lounge style chairs located sporadically throughout.

Design Criteria:

The space will be primarily used as a general educational facility, where reading, writing and paper tasks are the predominant activities.

IESNA Very Important Criteria:

- Reflected Glare
- Horizontal Illuminance: Category D (30 FC)

IESNA Important Criteria:

- Direct Glare
- Flicker (and Strobe)
- Light Distribution on Surfaces
- Luminances of Room Surfaces
- Point(s) of interest
- Source / Task / Eye Geometry
- Surface Characteristics

IESNA Somewhat Important Criteria:

- Appearances of Space and Luminaires
- Color Appearance (and Color Contrast)
- Light Distribution on Task Plane (Uniformity)
- Modeling of Faces or Objects
- Shadows
- System Control and Flexibility

ASHRAE / IESNA 90.1 Standards:

Table 9.6.1 allows for a light power density of 1.4 W/ft² for a classroom / lecture / training space. If necessary, an additional 1.0 W/ft² can be applied to the design for any decorative lighting that may be used.

Pre-Design Discussion:

The IESNA criteria provide recommendations for the way spaces should be lit based on the tasks being performed, the environment that needs to be set and the overall general logistics for how a space is laid out. Although they are recommendations, certain items may need to be looked at in more depth depending on the space and context in relation to surrounding areas. For an academic center, but more specifically a reading room, the most important criteria are related to the distribution of light across the horizontal surfaces, the glare and reflections that occur due to materials and surface characteristics and the relationship of the light source to task plane.

The reading room in the JPJ arena is at the heart of the academic center and acts as a connection between offices, study rooms and a classroom. This makes it a rather important space that needs to be uniformly lit with limited shadow and visual discomfort. A level of 30 FC (horizontal) should be met in order to accomplish all the tasks on the work plane and assure uniformly distributed light throughout the space. The color appearance of the space should be uniform due to the openness of the floor plan and importance of visual tasks. Visual clarity is a key factor when it comes to an academic center. A warm CCT would be ideal because it creates a relaxed environment that at the same time allows for work to be done. Because of the level of work that is accomplished in the space, the eye-task geometry is important. Luminaires should be placed in relation to the desks to create no overhead shadows or veiling reflections on the work plane while at the same time limiting the glare from surrounding surfaces. They should be spaced evenly to not create visual discomfort when it comes to the hierarchy of the space. Their appearance does not need to be the focal point of the space, just one that accomplishes the goals of the reading room while at the same time being appealing to the eye.

Dealing with the modeling of faces and other vertical tasks is important to the space because of group work, tutoring and face-to-face communication. A uniform level of vertical illuminance, around 5 FC, should be planned into the design. The luminance of the room surfaces will need to be looked at in order to account for the dark painted walls and how the stained concrete floor will deal with the amount of direct light that is present in the room. The controls for the space should be varied enough to deal with the amount of people in the room at one time and to account for the tasks that occur during the day. Creating a setting that allows for movement through the space while no one is using the tables is important, but at the same time being able to control part of the room for task plane usage when there are only a few occupants.
Since there are no windows in the space due to it being located below grade, dealing with daylighting is not an issue because the space is entirely artificially lit. There are no real points of interest throughout the reading room other than the etched glass walls that are at the rear of the study rooms on the western wall. This allows for a limited need for accent or focused lighting.

Design Goals:

1. Create a relaxed and open environment
2. Achieve uniform and proper light distribution on the task plane
3. The integration of room zones to account for occupancy issues

Design Approach:

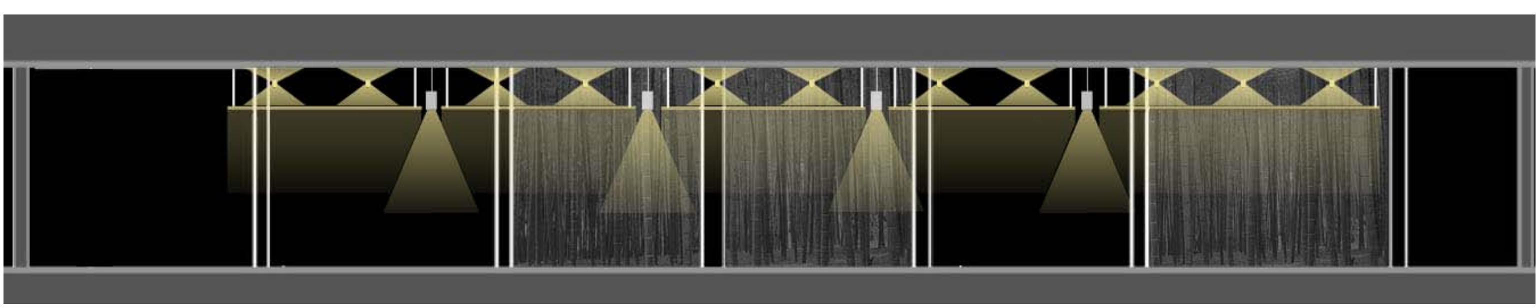
1. The use of bright, warm light levels on the peripheral walls and ceiling in order to give the space volume and make it appear as if the occupants were outside and not below grade. It is also important to avoid visual discomfort and glare as it is a space for reading and working.
2. While focusing on the perimeter of the space for openness, the central spaces (work areas) need to be designed with more direct illumination to meet the required light levels.
3. Using varied circuiting and control zones within the large space to create smaller, more personal environments that can be used for low occupancy but be adapted for higher occupancy levels.

Schematic Designs:

The following images and renderings depict pre-design concepts and ideas and may not be a full representation of the final proposed design.

FIGURE 4.1.1 – Photoshop rendering of proposed solution.

FIGURE 4.1.2 – Photoshop rendering of proposed elevation.



Redesign:

The new lighting system throughout the main academic center and the surrounding study lounges is one that is a predominantly down lit space to account for task illuminance values. It also incorporates indirect and peripheral lighting to give the space volume and assist in making it more open and inviting.

The primary design consideration for this space was achieving the adequate illuminance levels on the task plane that would account for the reading and writing that will take place while the space is in use. This can be seen in the redesign of the ceiling area located directly over the work tables. A combination of recessed downlights (Fixture A) focused on the tables gives the direct light that is required for paper tasks, while an indirect fixture (Fixture F) is placed behind a frosted glass inlay between the beams will illuminate the ceiling and give the space a larger, more open feeling.

The remainder of the space is lit by pendants (Fixture C) that are suspended at 11' and are used as a means to light the main circulation and common areas that are not affected by the requirements for task illuminance. A wall sconce (Fixture E) is also used to assist in the way-finding and circulation through the space, while also showing locating doorways. The overall clean appearance and open design is completed through the wall slots (Fixture B) that are located on the periphery of the general study area and give the space more height and inviting environment.

Computer Renderings:

All images were rendered using AGI32radiaosity and raytrace calculations. Full size images can be found in Appendix C.

FIGURE 4.1.3 – Academic center looking north.

FIGURE 4.1.4 – Study lounge area looking toward entry.

FIGURE 4.1.5 – Entry looking south through space.

Luminaires:

TYPE	DESCRIPTION	QTY.	PURPOSE
TYPE A	Triple Tube CFL Downlight	18	Task Lighting
TYPE B	T5 Linear Wall Washer	14	General Downlighting
TYPE C	Triple Tube CFL Downlight	21	General Downlighting
TYPE D	T5 Linear Direct / Indirect	20	Task Lighting
TYPE E	CFL Wall Sconce	17	General Lighting
TYPE F	T8 Linear Indirect / Direct	6	General Lighting

A full luminaire schedule can be found in Appendix A. Luminaire, lamp and ballast cut sheets and specifications can be found in Appendix D.

Controls:

This space will be controlled by a series of switches located at the main entrances and important places of circulation throughout the rest of the study area. The overall room will be split up into three zones: the entry and general lounge area, the main study area and the meeting rooms located in the center of the space. Each meeting room located in the center will have its own switching system and occupancy censors to account for the various times in which they will be occupied. The other two zones will be separate to also account for occupancy issues and allow for one area to be on while the other is not.

Lighting Plans:

Refer to Appendix B for full size lighting plans.

Performance Criteria Numerical Summary:

	Academic Center Illuminance Data (fc)	
	Work Tables	Meeting Room Tables
Average	28.94	28.59
Max	34.8	42.7
Min	21.3	12.1
Avg/Min	1.36	2.36
Max/Min	1.63	3.53

POWER DENSITY ANALYSIS									
SPACE	AREA (SF)	EXISTING WATTS	REDESIGN WATTS	LESS THAN EXISTING	ALLOWABLE LPD (W/SF)	REDESIGN LPD (W/SF)	% OF ALLOWABLE	ALLOWABLE WATTS	ASHRAE ACCEPTABLE ?
Academic Center	4000	3694	3618	NO	1.4	0.905	65%	5065	YES

Performance Images:

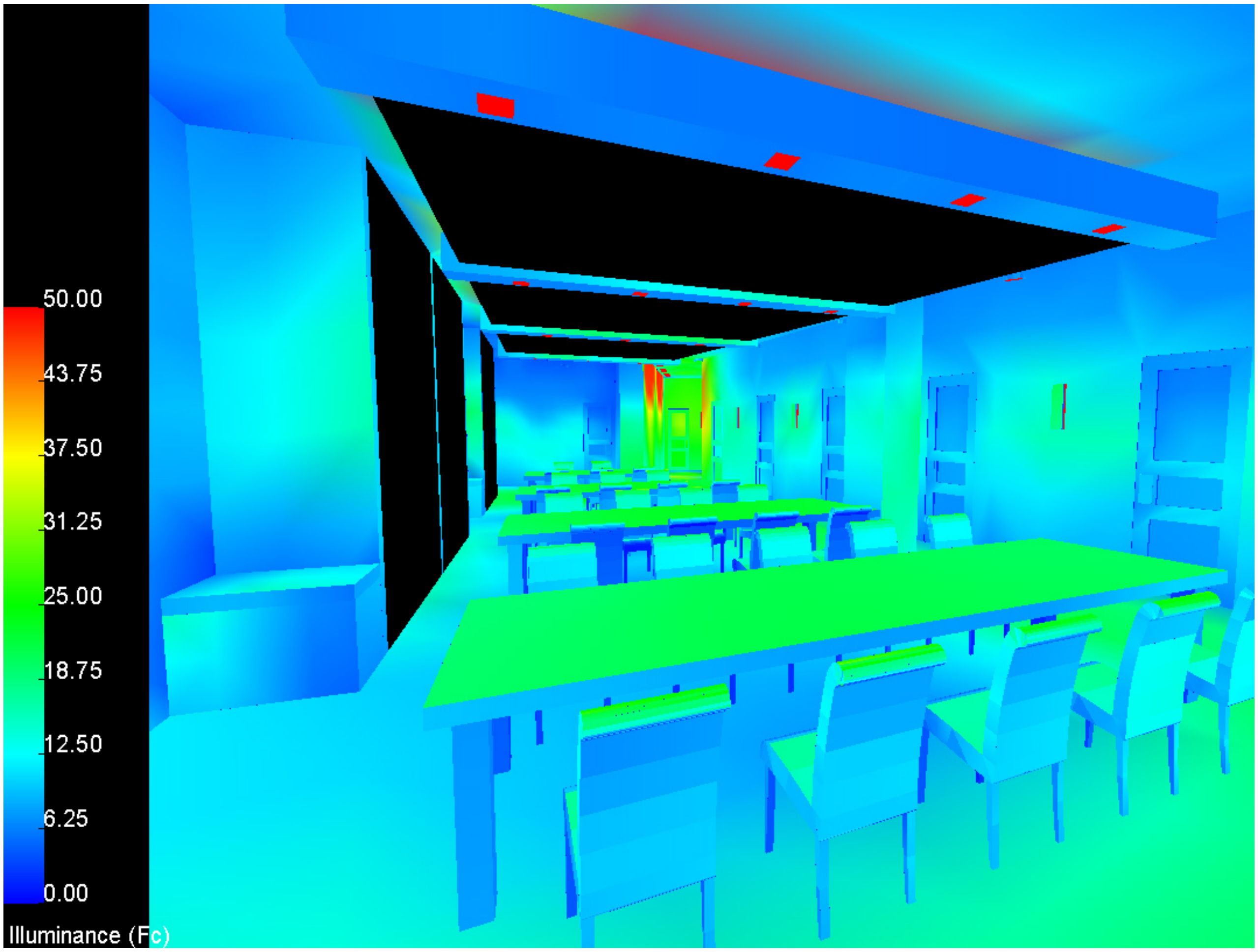


FIGURE 4.1.6 – Pseudo color rendering of the academic center looking north (Illuminance: fc).

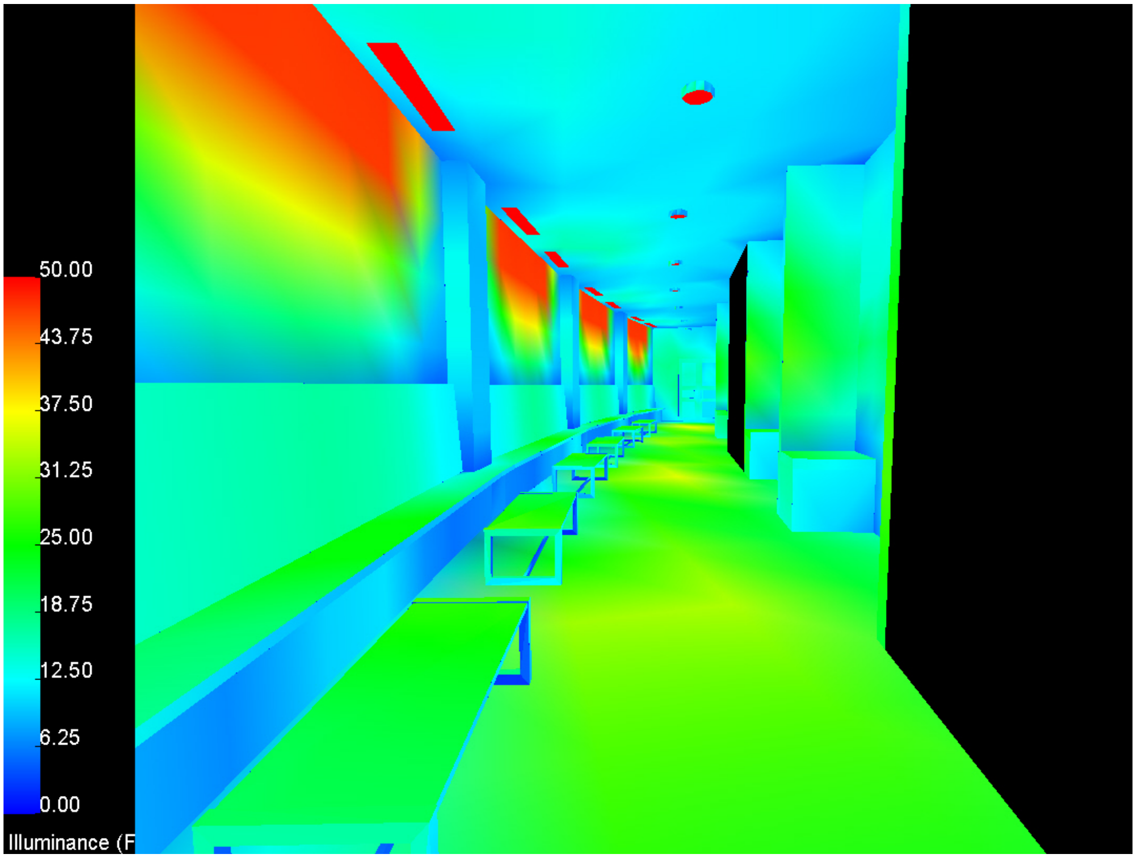
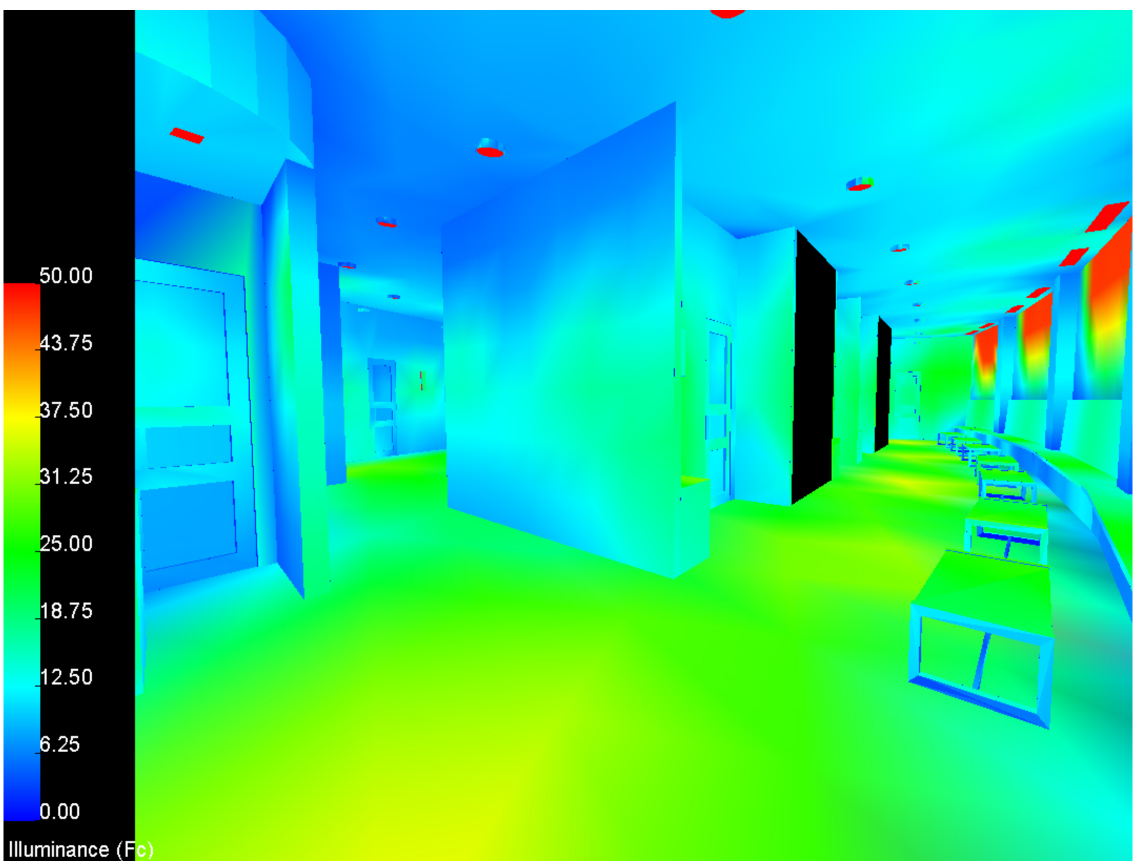


FIGURE 4.1.7 – Pseudo color rendering of the study lounge looking toward the entry (Illuminance: fc).

FIGURE 4.1.8 – Pseudo color rendering of the entry looking through the space (Illuminance: fc).



Performance Criteria Analysis:

The overall major design criteria for the space was to reach proper illuminance values for reading and paper tasks on the work plane. Target values for paper tasks were at 30 fc, with this space reaching close to 29 per work plane. Although the designed values are lower than the target, they are acceptable for the space because there is a decent amount of ambient light that will also assist in performing paper tasks.

Along with reaching adequate light levels, the space is also more open and spacious due to an increased ceiling height and the use of perimeter downlights. The downlights are used on the longest of the walls to make the space seem larger and more inviting, as well as along the lone corridor toward the back of the space. By wall washing the corridor, it gives that open feeling rather than being a cramped and dark hallway.

Overall the redesign of the space is a success. Through proper light levels, the addition of new architectural features (frosted glass assembly and increased ceiling heights) and the integration of three main room zones; this space gives an impression that is conducive to learning and will encourage student athletes to attend study sessions and focus on school work just as much as they focus on basketball.

Space Two: Athletic Dining Room

Description:

The dining room is located on the lower concourse on the western side of the building facing the western elevation. It is positioned right above the academic center and reading room. The entrance is on the northern side of the room right off of the elevator shaft. The Dimensions of the reading room are around 26' x 30' with exact measurements being hard to get due to cutouts, open vestibules and spatial irregularities around the perimeter of the room. The entrance leads into a reception desk that has a corridor leading to the dining room bathrooms behind. There are service storage closets that line the western wall that lead into a servery and beverage bar on the southwestern wall. Along the curved eastern wall is a projection screen that comes down from the ceiling. Exit vestibules are located on either side of the curved wall. There are no windows on the western wall due to the lower concourse level being under grade. The ceiling is made up of a pattern that mimics the carpet layout throughout the space. It consists of a low soffit at 10' with the actual ceiling height being at 11'-6". The lowest part of the ceiling, 9'-6", is on the eastern wall directly behind the projection screen. Among the open floor plan there are four structural concrete columns that go through the ceiling at the 10' soffit level.

Surface Materials:

Walls: There is a combination of paint colors (PT-16, PT-17) throughout the entire space. There is no pattern to which walls are painted which color, but the majority of the western and eastern walls are PT-17 with the other two walls being PT-16.

Floor: The pattern on the floor is designated by the varied materials that mimic the soffit layout overhead. The large inner trapezoids are a multi-colored carpet (CPT-13) with the infill being a blue carpet (CPT-14). Around the outside of the room and at the reception area is a wooden cherry vinyl flooring material (VF-1).

Ceiling: A combination of painted gypsum (PT-6) and acoustical tiles (ACT-3) make up the various surfaces of the ceiling. The highest parts are the gridded ceiling and the lower ones are the painted gypsum.

Furniture:

Actual furniture schedule for the dining room are not available, but it is assumed that it will be furnished with typical restaurant furniture and accessories. Wooden tables and chairs make up the majority of space in the middle of the room with wooden cabinetry on the periphery for storage. There will also be metal serving carts / trays that are used from time to time during events and parties.

Design Criteria:

The space will be used primarily as a dining service facility and gathering spot.
IESNA Very Important Criteria:
Color Appearance (and Color Contrast)

IESNA Important Criteria:
Appearance of Space and Luminaires
Direct Glare
Point(s) of Interest
System Control and Flexibility

IESNA Somewhat Important Criteria:
Light Distribution on Surfaces
Light Distribution on Task Plane (Uniformity)
Modeling of Faces or Objects
Sparkle / Desirable Reflected Highlights
Horizontal Illuminance: Category C (10 FC)
Vertical Illuminance: Category A (3 FC)

ASHRAE / IESNA 90.1 Standards:
Table 9.6.1 allows for a light power density of 1.4 W/ft^2 for a dining Area – bar lounge / leisure dining. If necessary, an additional 1.0 W/ft^2 can be applied to the design for any decorative lighting that may be used.

Pre-Design Discussion:

The athletic dining room located on the lower concourse level is one of the most dynamic spaces in the JPJ arena. It accounts for a lot of heavy traffic and continual usage. This space is used before, during and after each game or event to feed the players, celebrities and boosters for the university.

It is important for this space to be well lit and come off as one of the more professional looking areas around the arena. One of the most important criteria is selecting a proper CCT to account for the varying uses. A warm CCT with a high CRI would be ideal to create a space that is inviting and has a uniform level of visual clarity without creating any visual contrast. A high CRI will allow for people to see each other in the best possible way for face-to-face communication, while also putting an emphasis on the floor space through a mixture of vinyl-wood flooring and University of Virginia themed colored carpet. To account for the face-to-face aspect of the room, a vertical illuminance level of 3 FC should be sufficient in the design. An analysis of the control system and its flexibility is important to take into consideration because there is a projection screen located on the eastern side of the room. Being able to account for high volumes of traffic and eating at the work plane is a very different lighting scenario when compared to dealing with a room that has been designed and setup for movie projection. The projection setting will have to give enough light on the periphery to allow for occupant traffic, but at the same time limit the glare and veiling reflections on the screen as to not take away from the presentation. There are also numerous flat screen televisions located around the room that will have to be accounted for when it comes to lighting the walls and peripheral ae8064areas of the space.

One of the major architectural features of the space is the varied level of the ceiling grids. The ceiling ranges in height from 8'-6" to 11'-6". This is pivotal to consider during the design because a uniform level of light is important on the task plane, as well as on the other surfaces around the room. The space is for eating and the food should look as good as it can under the designed lighting system. A horizontal illuminance level of around 10 FC would be suggested for the task plane.

The appearance of the space according to the IESNA is important, but since there are no pendant fixtures and every fixture is recessed in the ceiling, only the finishes and coating of the housings will need to be looked at closely. With the fixtures being recessed and primarily downlights, direct glare should be considered and designed for, but will not really be an issue unless a lamp is aimed improperly or an incorrect fixture finish is selected. There are a few points of interest that need to be designed for. A reception desk at the entrance is important to put emphasis on to direct occupants toward as they are initially introduced to the space. It is also important to put focus along the western wall because that's where the food service is located and when needed, put a focus on the projection screen by lowering the lighting levels around the room.

Since the space is again located below grade like the reading room, the integration of daylight and the controls will not need to be designed for.

<u>Design Goals:</u>

1. Emphasize the various ceiling heights as architectural features
2. Create a spacious and professional environment
3. The use of a visual hierarchy that begins at the reception desk and moves through the space
4. Integration of controls that allow for a video projection setting

Design Approach:

1. A combination of uplight / cove system to enhance the architectural vault that is located in the center of the room, while also using downlights at various mounting heights to emphasize the remaining ceiling heights.
2. Modifying the height of the original linear ceiling alcoves to create the more spacious and open environment that carries an appearance of more formal and traditional.
3. The use of varying types of fixtures and light levels to draw the occupants from the entry to the seating area and then continuing on to the periphery of the space.
4. Implementation of dimming controls and zones that will allow for adequate projection settings when necessary.

Schematic Designs:

The following images and renderings depict pre-design concepts and ideas and may not be a full representation of the final proposed design.

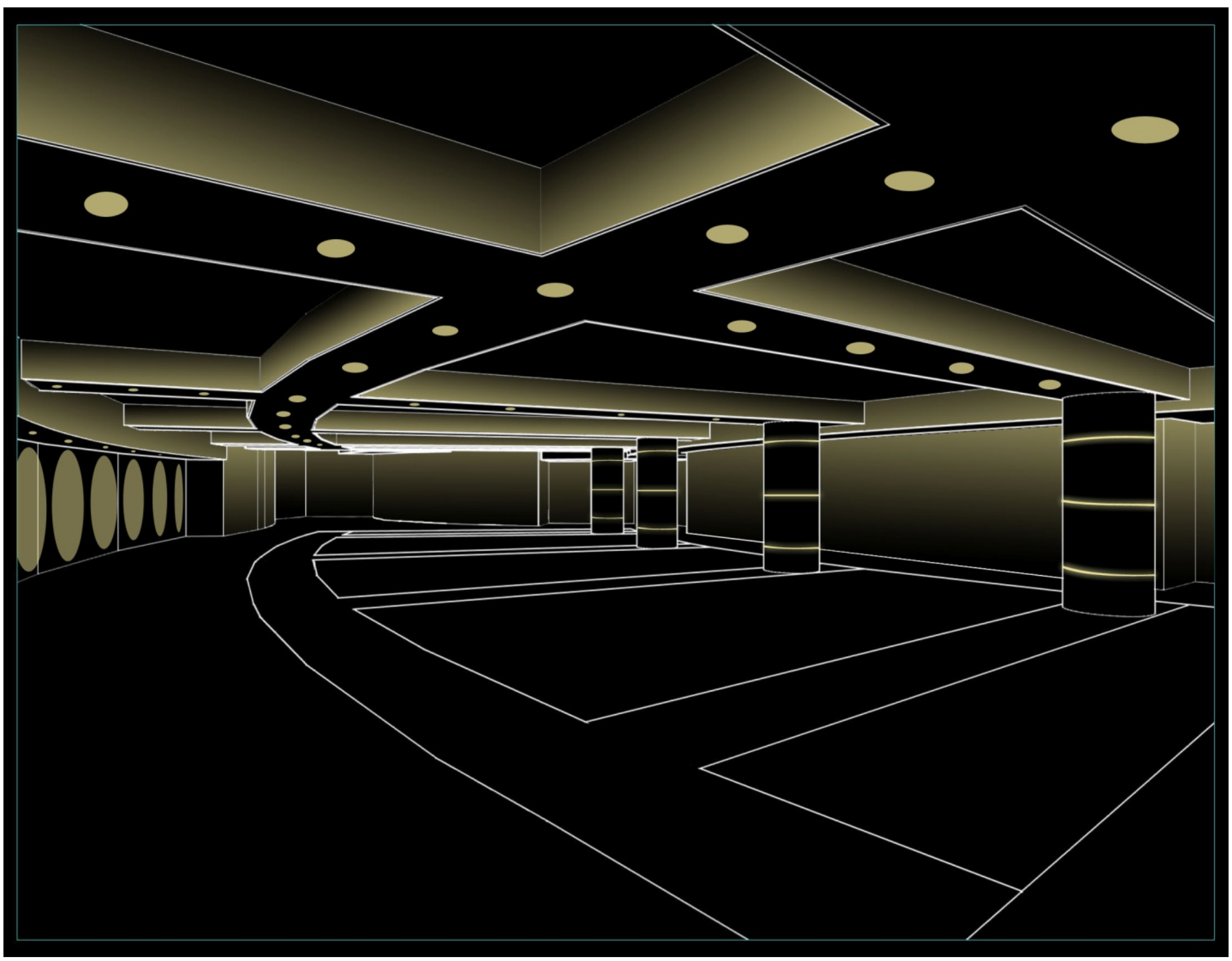


FIGURE 4.2.1 – Photoshop rendering of proposed solution.

FIGURE 4.2.2 – Photoshop rendering of proposed elevation.

Redesign:

The new lighting system throughout the dining room is one that is a combination of indirect uplight for general ambience and visual aesthetics, but also uses downlight effectively to light the main circulation and serving areas.

As occupants enter the space, they are met with a newly designed ceiling that is meant to function as an architectural feature. The backlight, frosted glass is a nice way to ease people into the space and creates the initial stages of a visual hierarchy that will eventually have people in the main eating space. After moving through the entry, the main eating area is easily identifiable. The ceilings in this area were raised 3' to a height of 15' and molded into a vaulted design. The arched vault allows for indirect light to reflect from the cove fixtures (Fixture M) and bounce downward onto the task plane or tabletops. It was important to avoid direct overhead light here to limit glare and visual discomfort that could exist when occupants are having face to face conversation and enjoying a meal. The direct downlight comes from the recessed fixtures (Fixture O) over the main circulation areas that occur between the eating and serving areas. The final stage of the hierarchy is the surrounding perimeter areas. These were lit using either downlights (Fixture P) or recessed wall washers (Fixture N) and make the space appear larger and more spacious.

The primary design consideration behind the raised ceilings and use of peripheral lighting is to account for a projection screen located on the east wall. The varied ceiling heights allow for dimming and lower illuminance values on the task plane. This is used in connection with the perimeter lighting as a means for way finding and general circulation during time the projector is in use

__Computer Renderings:__

All images were rendered using AGI32radiaosity and raytrace calculations. Full size images can be found in Appendix C.

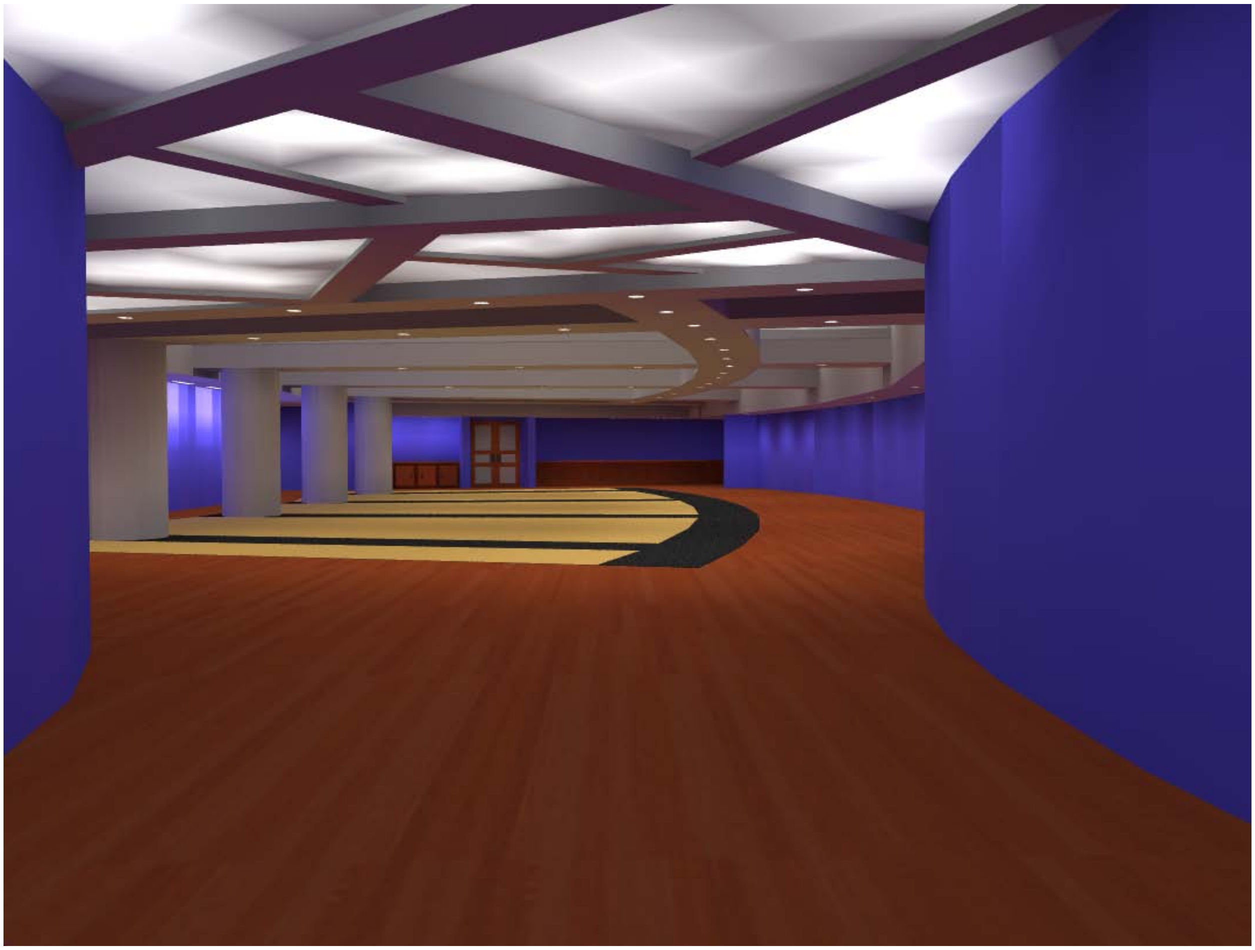
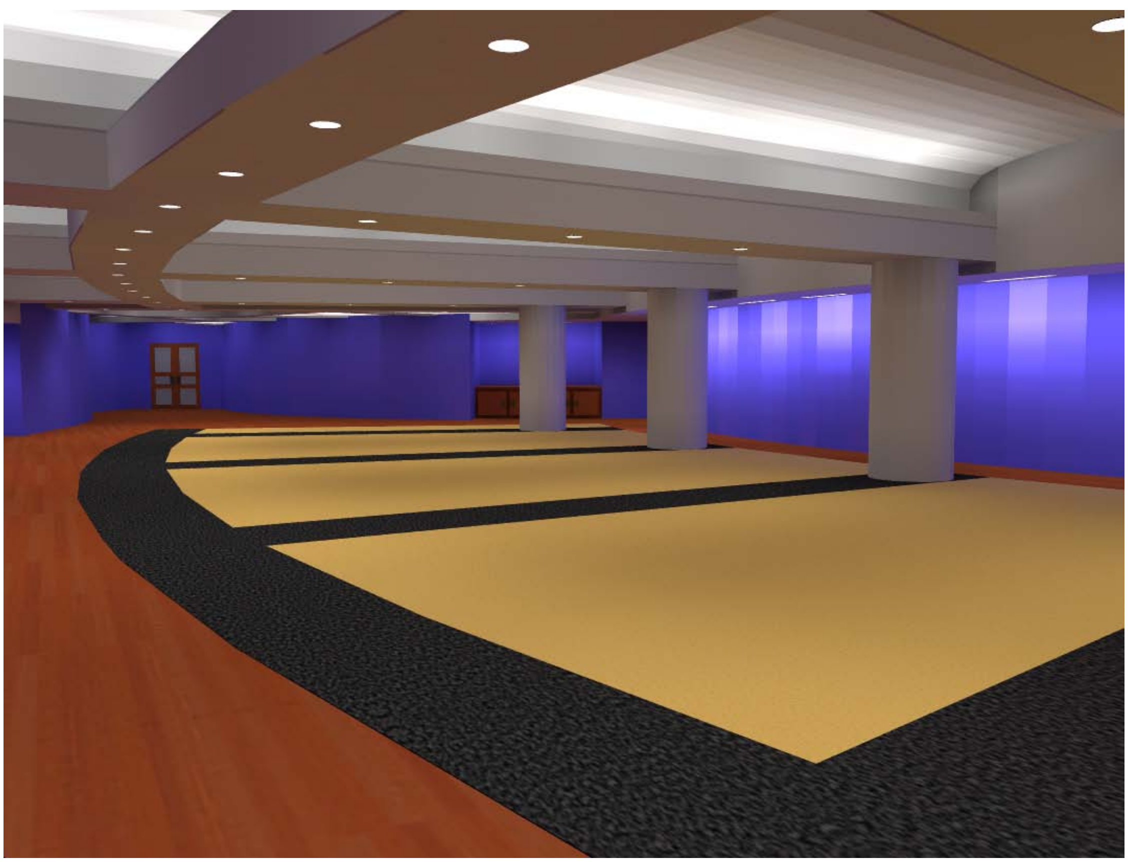


FIGURE 4.2.3 – Dining room entry looking south.

FIGURE 4.2.4 – Dining room, showing ceiling levels looking south

FIGURE 4.2.5 – Dining room looking north toward entry



Luminaires:

TYPE	DESCRIPTION	QTY.	PURPOSE
TYPE M	T8 Linear Cove	36	General Lighting
TYPE N	T8 Linear Wall Washer	8	General Lighting
TYPE O	T4 CFL Downlight	60	Task Lighting
TYPE P	T8 Linear Downlight	34	General Lighting

A full luminaire schedule can be found in Appendix A. Luminaire, lamp and ballast cut sheets and specifications can be found in Appendix D.

Controls:

This space will be controlled by a series of switches located at either the main entrance, the two exits or from the back of the room. There will be a system of five zones. Zone one will include the redesigned vaulted ceiling over the main eating area and zone two consists of the architectural feature and downlights at the entry. The third zone will control all the downlights located over the circulation areas. The last two zones, one controlling the downlights over the serving area (southern wall) and the lights used in the beverage service areas, and the final zone required for the wall washers located on the front wall behind the projection screen.

These controls will allow for every fixture to be dimmable in order to accommodate a projection setting, but still be able to use the space for general dining and gathering before, during and after all events in the arena.

Lighting Plans:

Refer to Appendix B for full size lighting plans.

Performance Criteria Numerical Summary:

	Dining Room Illuminance Data (fc)	
	Main Floor	Center of Room Tables
Average	15.80	13.79
Max	30.00	28.50
Min	5.90	7.00
Avg/Min	2.68	1.97
Max/Min	5.08	4.07

POWER DENSITY ANALYSIS									
SPACE	AREA (SF)	EXISTING WATTS	REDESIGN WATTS	LESS THAN EXISTING	ALLOWABLE LPD (W/SF)	REDESIGN LPD (W/SF)	% OF ALLOWABLE	ALLOWABLE WATTS	ASHRAE ACCEPTABLE ?
Dining Room	8120	6520	0	YES	1.4	0.000	0%	0	YES

Performance Images:

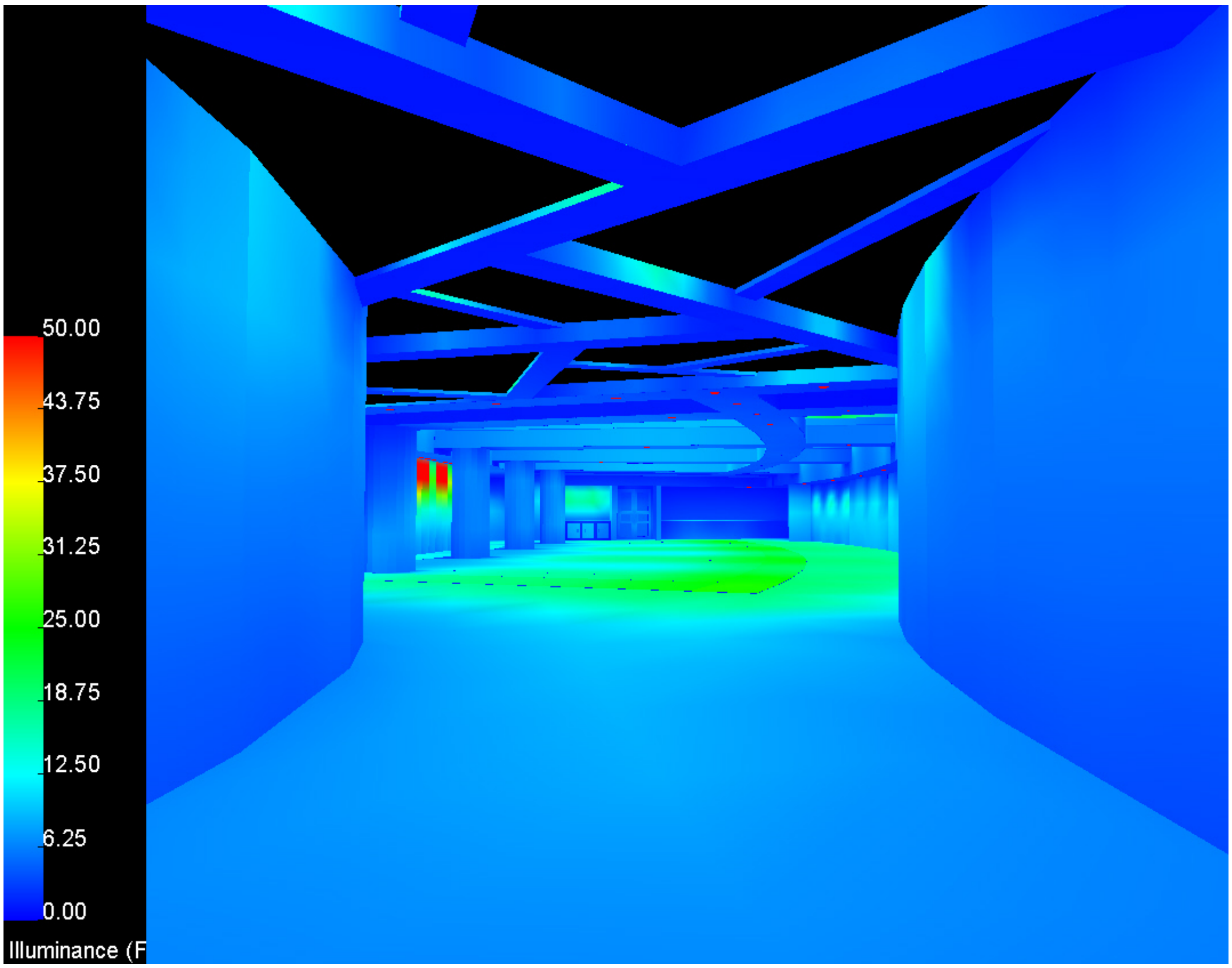


FIGURE 4.2.6 – Pseudo color rendering from the entry into the space (Illuminance: fc).

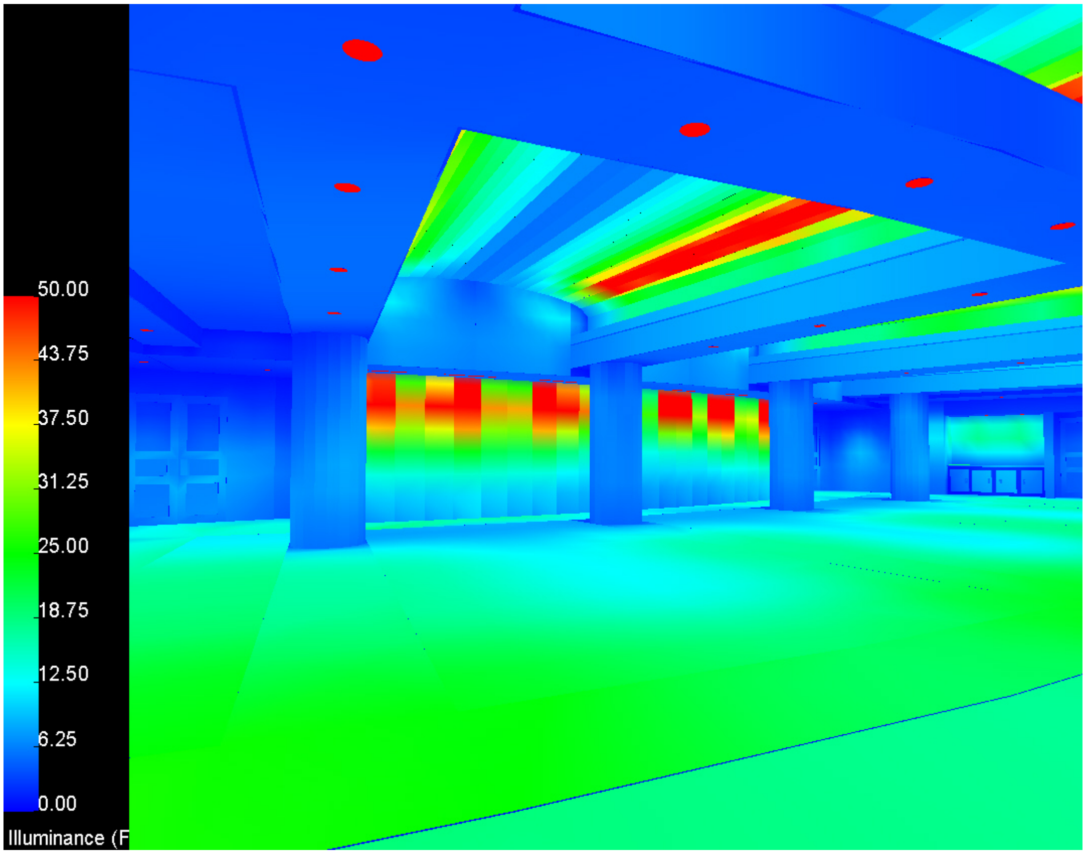
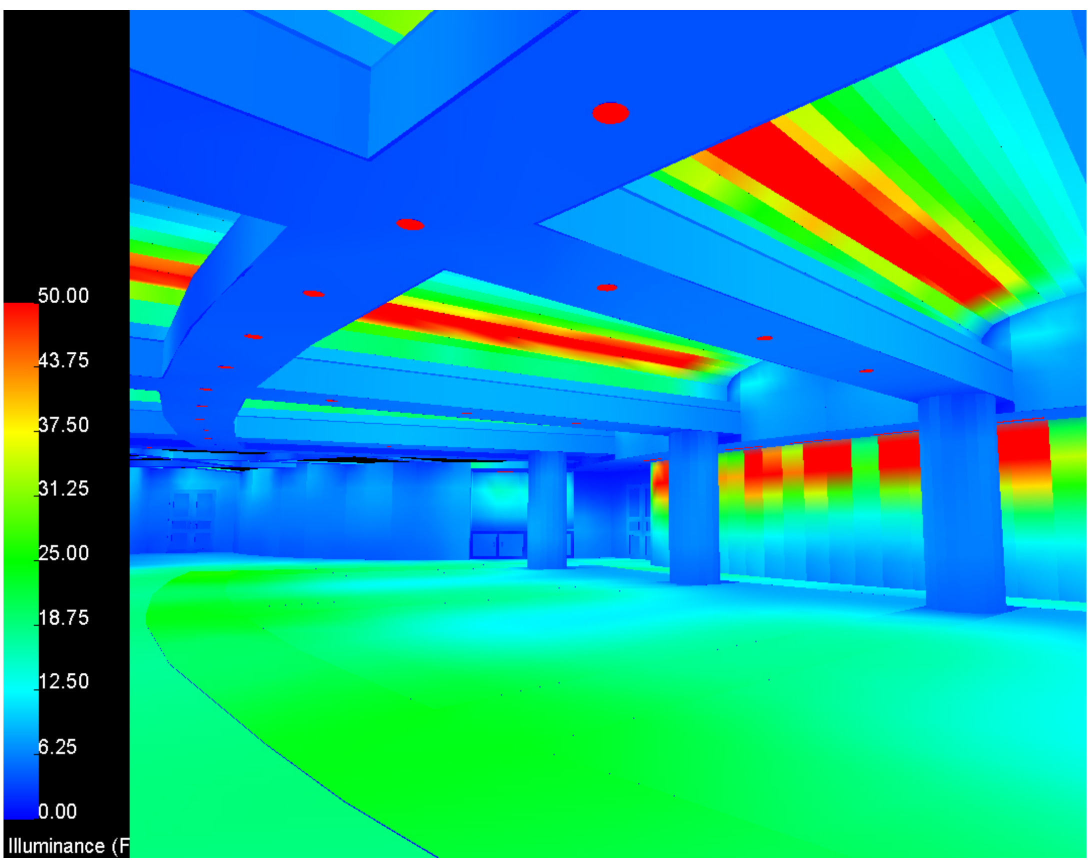


FIGURE 4.2.7 – Pseudo color rendering looking east toward projection area (Illuminance: fc).

FIGURE 4.2.8 – Pseudo color rendering looking north toward entry (Illuminance: fc).



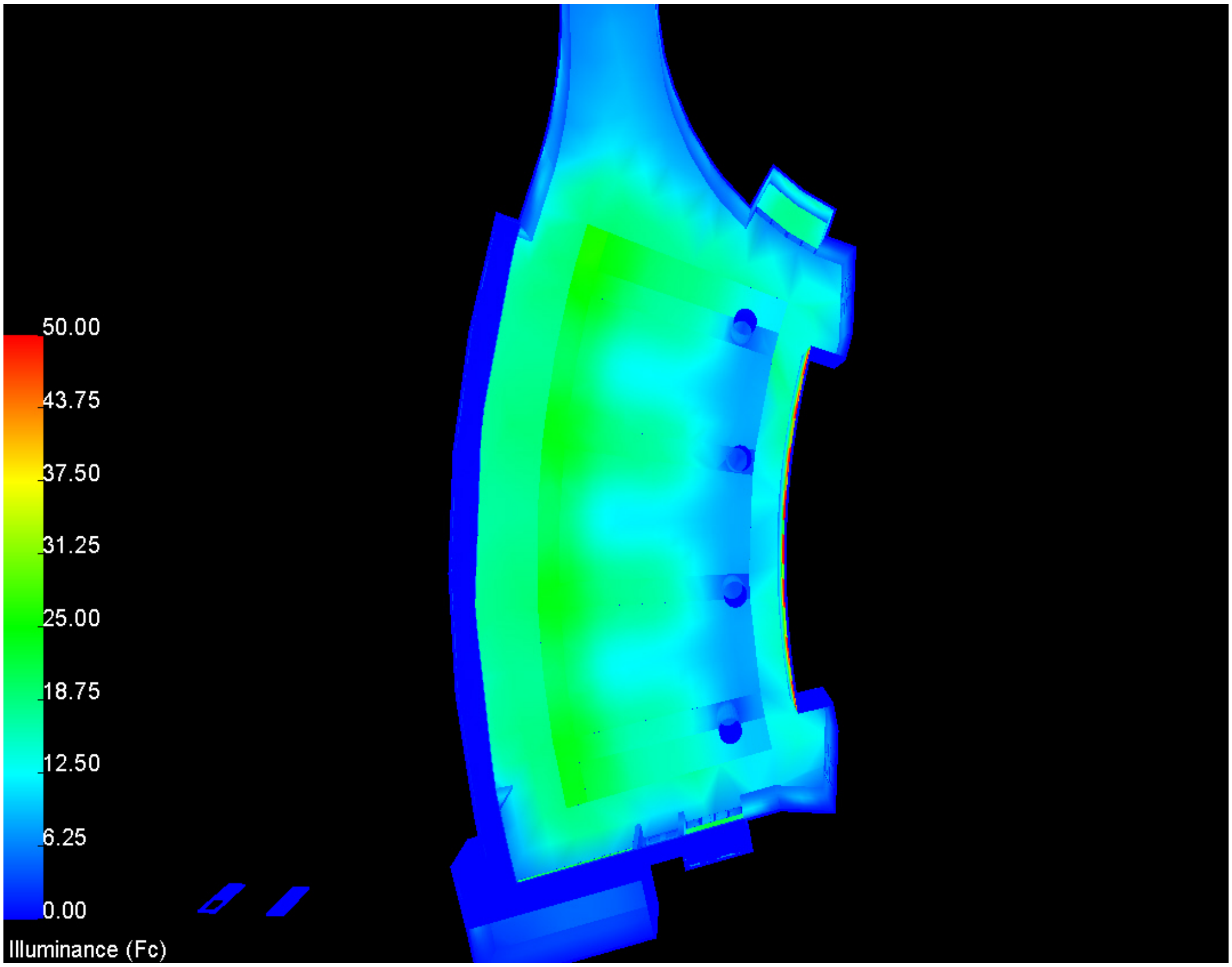


FIGURE 4.2.9 – Pseudo color rendering floor plan (Illuminance: fc).

<u>Performance Criteria Analysis:</u>

The dining room is a signature space for the arena. It is a space where important boosters and alumni come to gather and enjoy the events that are taking place throughout the arena at any given time. This is why it was important to make the space seem professional and stand apart from the other common areas around the arena. People want to feel privileged and have a sense of honor when they are in a grand space such as this one.

A spacious environment was achieved using the elevated and vaulted ceilings over the central area. The vaults give a sense of timelessness and class that comes along with being a privileged. But not only do they give an elegant appearance, they are also used to supply the task plane with proper illuminance values. The horizontal target for this space was 10 fc. The redesign has an average of 14 fc. Although the value is high, these fixtures can be dimmed if the levels are too high and create discomfort.

Another success of the redesign is the creation of a visual hierarchy. Occupants can move from the entry (values around 5-7 fc) to the main circulation spaces (values between 12-25 fc) and finally to the peripheral serving areas (max values at 20 fc). The general progression from the lowest levels to the highest levels where circulation is required is easy to follow and moves occupants as necessary from area to area.

The last success of the design is the use of zones. With five dimmable zones, the possibilities would seem to be endless. Settings can be used to allow for a projection screen, lowered light levels for a more private setting and even just normal levels for everyday use.

The dining room is s dynamic area meant for entertaining and functionality and with the redesign, the space is able to accommodate anything and everything in-between.

Space Three: Western Elevation and Façade

Description:

The west exterior elevation is the most prominent feature of the John Paul Jones Arena. There are 16 Doric style columns that mimic the style and architectural theme of the University of Virginia campus. The initial campus was designed by Thomas Jefferson and the architects have done everything in their power to honor the traditions of one of the oldest schools in the nation as well as one of our founding fathers. The columns are stepped away from the front of the building and topped with a pergola like structure. Each column is 30' tall and weighs close 21,000 pounds. The exterior is also comprised of close to 600,000 "old-Virginia" style bricks, while at the same time being able to incorporate a modern touch with metal curtain wall systems.

Surface Materials:

The exterior is comprised of a mixture of finishes. There is an off-white stucco (STUCCO), the majority of the building is covered in the 'Old-Virginia' style brick (BR-1), metal wall panel systems (MTL1, MTL-2) that surround and accent most of the glass around the building and sealed concrete columns (SL-3) that make up the colonnade at the entry.

Design Criteria:

This space is categorized as a building exterior – prominent structure because of the importance of the colonnade as a focal point and its relation to the overall campus theme.

IESNA Very Important Criteria:

- Appearance of Space and Luminaires
- Light Distribution on Surfaces
- Light Pollution / Trespass
- Point(s) of Interest
- Reflected Glare
- Shadows
- Source / Task / Eye Geometry
- Surface Characteristics
- Vertical Illuminance: Category A (3 FC)

IESNA Important Criteria:

- Color Appearance (and Color Contrast)
- Direct Glare
- Modeling of Faces or Objects
- Horizontal Illuminance: Category B (5 FC)

IESNA Somewhat Important Criteria:

- Peripheral Detection
- Sparkle / Desirable Reflected Highlights

ASHRAE / IESNA 90.1 Standards:

Table 9.4.5 allows for a light power density of 0.2 W/ft² for a building façade or 5.0 W per linear foot for each illuminated wall. It also states that on building grounds, walkways 10' wide or greater / plaza areas are allowed 0.2 W/ft². Building entrances and exits at main entry points are granted 30 w per linear foot of door width.

Pre-Design Discussion:

The exterior façade is the focal point for the JPJ arena. It stands out due a large colonnade and the use of "Old Virginia" style red bricks that are prevalent throughout the rest of the campus. These features make the lighting design very important as to convey the feelings and emotions of the university.

IESNA lays out very important design criteria that are necessary to the design of this space. The appearance of space and the luminaires are important because they do not want to detract from the overall look of the pure white columns and brick façade. But the space at the same time needs to be lit well enough to assert the dominance and show the magnitude to which the architects were trying to achieve. This is done by ensuring a non-uniform light distribution between all surfaces, with a vertical illuminance around 3 FC and controlling the shadows that occur from the overhanging roof members. Shadows are one of the hardest things to design for and need to be taken care of during the aiming and placement phase of design. By controlling and designing for shadows, the façade can take on a whole new appearance and create a strong visual.

Creating an appearance with clean lines and uniformity through a system of spot lights with a mid-range CRI (3000-3500K) to match the interior lighting system. The last very important criterion that deals with the façade is taking into account the points of interest that accent the exterior. There are two spaces that need to stand out and not take away from the overall exterior: the ticket window and the entry doors. Each space needs to be lit with proper horizontal illuminance (5 FC) on the task planes in order to allow for the occupants to use the space properly without visual discomfort or glare. Fixtures need to be placed to limit reflected glare off of the curtain wall and the direct glare from any other overhead fixtures in the peripheral of the user.

Color appearance and contrast are important to look at because the design specifically calls out the use of a brick color from around campus. The color of the brick needs to match all the others and create a visual unity from building to building. The large white columns also require a proper CRI due to the relation of the arena to the first building built on campus, the library. A strong colonnade is a focal point to all the major buildings on campus.

Light trespass needs to be designed for and looked at because it can detract from any exterior, but since the arena is located in an area on campus by itself, there is limited trespass from surrounding buildings. And due to the majority of the exterior being downlit and illuminated from within, the light pollution is negligible.

Design Goals:

1. Match the historic theme and context of the rest of the campus.
2. Clean and minimal luminaire appearance
3. Accent the major features of the façade while providing enough luminance for tasks
4. Use of light to create visual depth and interest

Design Approach:

1. Illumination of the column faces while also creating an ambient glow and subsequent depth behind the colonnade.
2. Hide and limit the visual exposure of the fixtures to all spectators as they approach and interact with the façade.
3. Focus on reaching the desired illuminance values necessary for way-finding, but not as to limit the overall appearance of the colonnade and buttress structure.
4. Use varying light levels to create a visual hierarchy with the created shadows and voids from the light output of the fixtures.

Schematic Designs:

The following images and renderings depict pre-design concepts and ideas and may not be a full representation of the final proposed design.

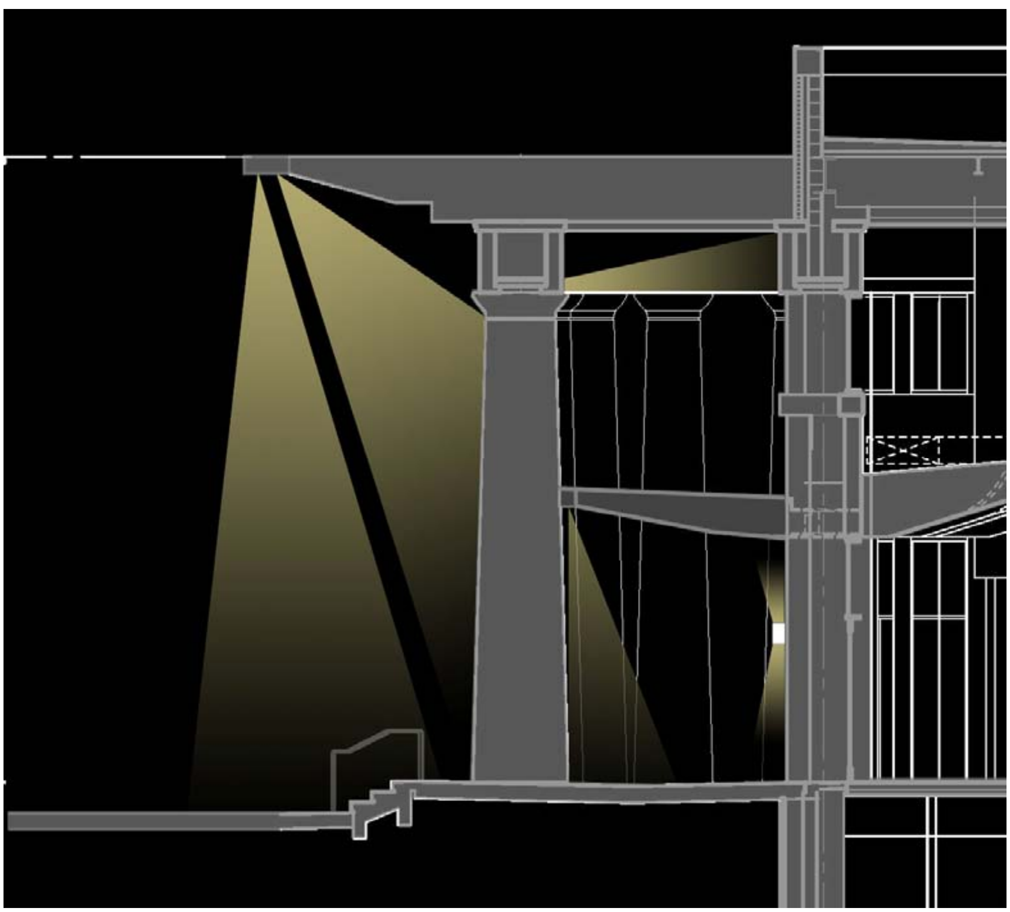


FIGURE 4.3.1 – Photoshop rendering of proposed entry section.

Redesign:

The overall redesign of the exterior façade was one that needed to be representative of the entire campus as a whole. With the campus being over 200 years old and based on the designs and planning of Thomas Jefferson, a classical yet dynamic appearance is what the 16-doric column colonnade requires. It was imperative that the exterior be about the structure and columns and not about being able to see fixtures and where the light is coming from. The design called for hiding as many fixtures as possible to keep the appearance clean and minimalistic. It was also important to convey a sense of depth and visual interest through the creation of shadows and voids between the front colonnade and the main entrance. The last goal was to make sure that once the visual interest was created that there was still proper levels of light on the ground for spectators to make it safely through the space and into the arena.

Computer Renderings:

All images were rendered using AGI32radiaosity and raytrace calculations. Full size images can be found in Appendix C.

FIGURE 4.3.2 – Rendering of the façade looking through the entry.

FIGURE 4.3.3 – Façade looking down toward entry and ticket window.

FIGURE 4.3.4 – Western façade looking through entry.

Luminaires:

TYPE	DESCRIPTION	QTY.	PURPOSE
TYPE G	MH Wall Sconce	16	General Lighting
TYPE H	MH Downlight	16	Task Lighting
TYPE I	MH Downlight	32	General Lighting

A full luminaire schedule can be found in Appendix A. Luminaire, lamp and ballast cut sheets and specifications can be found in Appendix D.

Controls:

The controls for the exterior of the space are simple and easy. The fixtures will be on every night regardless of there being an event or basketball game. This due to importance of the building and grandiose appearance it carries throughout the campus. When there is a chance of a game or event, the fixtures will be turned on prior to the starting of the event to make sure spectators have no difficulty in entering the arena.

Lighting Plans:

Refer to Appendix B for full size lighting plans.

Performance Criteria Numerical Summary:

	Western Elevation Illuminance Data (fc)
	Ground Level
Average	5.50
Max	25.20
Min	2.00
Avg/Min	2.75
Max/Min	12.60

POWER DENSITY ANALYSIS									
SPACE	AREA (SF)	EXISTING WATTS	REDESIGN WATTS	LESS THAN EXISTING	ALLOWABLE LPD (W/SF)	REDESIGN LPD (W/SF)	% OF ALLOWABLE	ALLOWABLE WATTS	ASHRAE ACCEPTABLE ?
Exterior Façade	2830	5970	3520	YES	0.2	1.244	622%	704	NO

Performance Images:

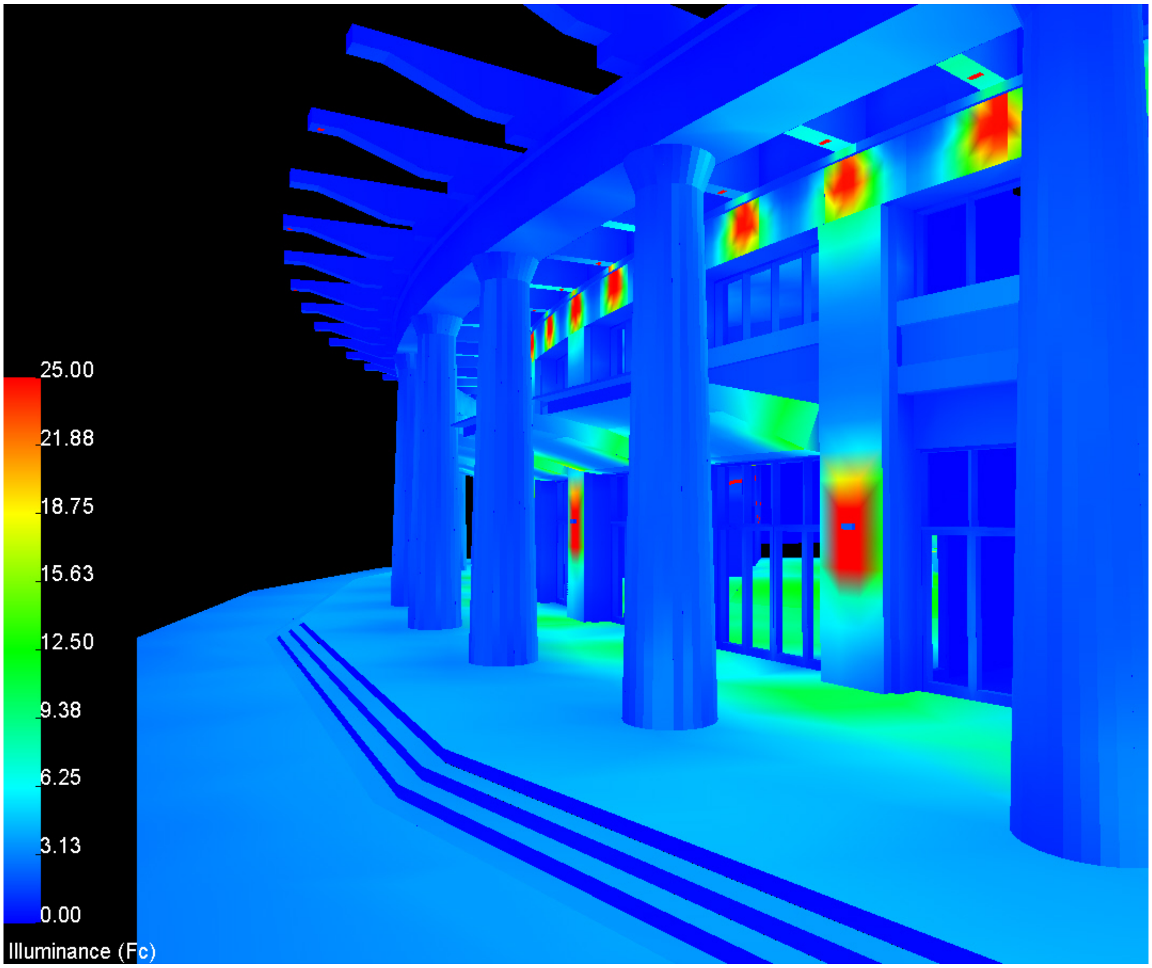


FIGURE 4.3.5 – Pseudo color rendering of the entry facade (Illuminance: fc).

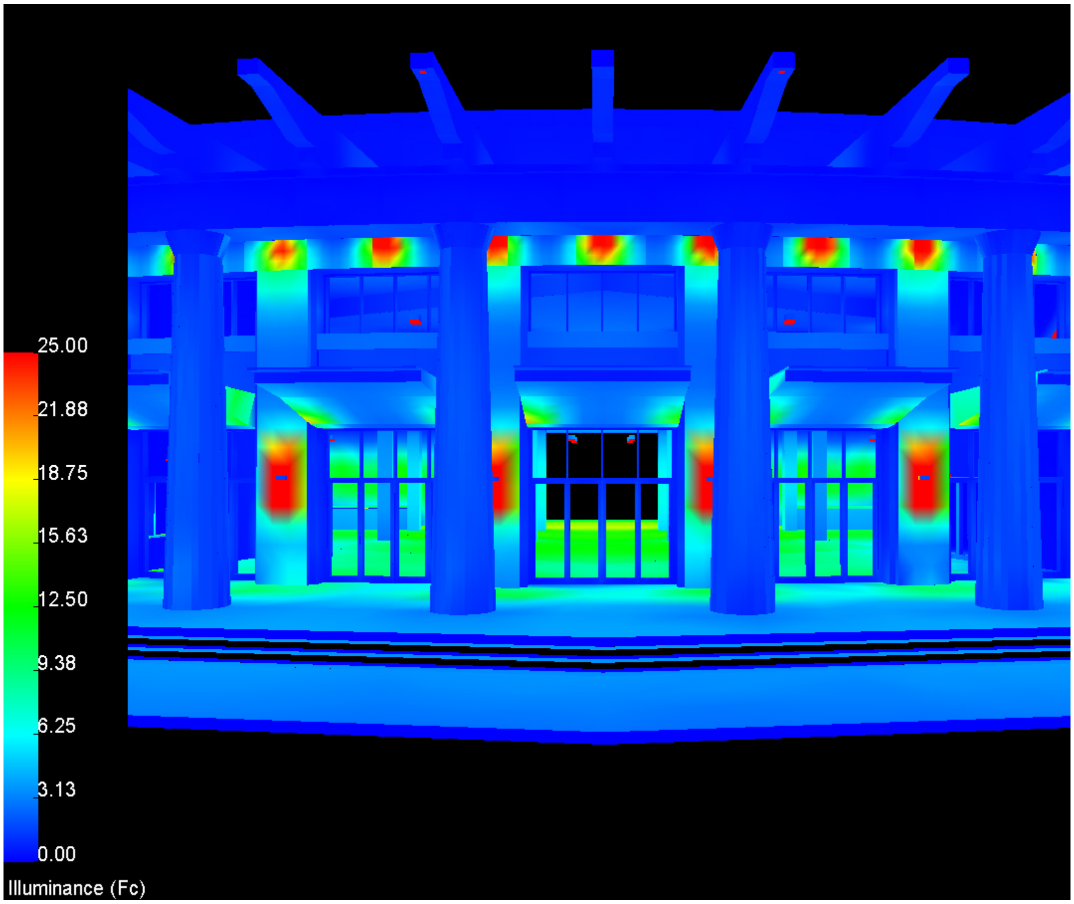
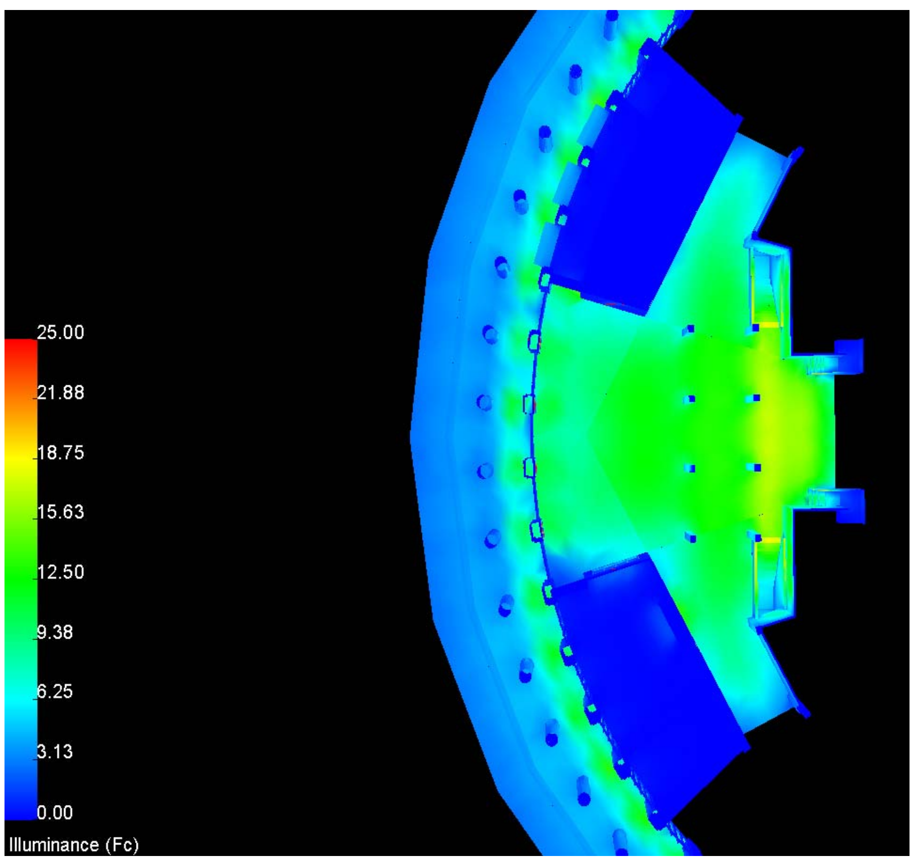


FIGURE 4.3.6 – Pseudo color rendering through entry (Illuminance: fc).

FIGURE 4.3.7 – Pseudo color rendering floor plan (Illuminance: fc).



Performance Criteria Analysis:

The sheer size and spectacle that is a 16 column colonnade attracts a lot of attention, regardless of whether Thomas Jefferson designed the campus or not. This redesign was used to accentuate that fact. It started from the columns and worked its way into the exterior face. A visual hierarchy and depth was created using downlights (Fixture H) on the outstretched piers to illuminate the columns from the front and show their impending nature. Once past the columns, a combination of wall mounted direct / indirect fixtures (Fixture G) and properly aimed wall washers (Fixture I) focused on the only constant horizontal band on the exterior enhance the in-between space and express the visual interest desired through the planning stages. The appearance of the exterior is a gentle, but a powerful image of the grand columns juxtaposed on an arena that is state-of-the-art and capable of handling thousands of people.

Through this visual hierarchy and depth that is created, proper circulation levels are achieved. The target level is 5 fc and the redesign is capable of putting an average of 5.5 fc on the horizontal surfaces on the western exterior.

Overall the redesign of the western façade is an example of a modern building being able to handle the high standards of a historical campus, while at the same time creating a visual interest that Thomas Jefferson could have only dreamed about.

Space Four: West Entry Lobby

Description:

The Main entrance lobby to John Paul Jones arena is the first interior space that spectators will experience while attending an event. It is located on the western side of the building through a large colonnade that defines the entrance. Once through the large glass doors, there is nearly a 3-story opening that welcomes the occupant. Large windows above the doors continue the use of glass and help to bring light into the space and create an idea of bringing the outdoors in. This theme is something that most indoor arenas are unable to achieve due to their large size and need to take up exterior surfaces for structural support. The lobby is the central circulation space that filters everyone to other parts of the arena. It that has an entrance to the University of Virginia team store, access to the ticket sales booth and most importantly an entrance to the court and seating areas. In the center of the lobby are six large concrete columns that help to support the upper level seats. It mimics the exterior colonnade and adds to the theme of bringing the outdoors in. The main attraction of the lobby is a large university logo that sits in just past the entry doors. To either side of the logo are corridors that take spectators to other areas of the arena through signs that are placed overhead.

Surface Materials:

Wall A (East Wall): The wall that everyone sees as they enter the space is comprised of a cmu style wall system (CMU-1). It is a main interior wall and continues all the way around the inner concourse.

Wall B (South Wall): This wall contains the entrance to the team store and has a pattern of a basketball painted on gypsum wall board (PT-1).

Wall C (West Wall): The western wall is the interior side of the entry. It consists of brick (BR-1) columns made from the same style of brick prevalent throughout the rest of the campus and painted gypsum wall board (PT-5). There is also a metal canopy that hangs over the entry doors and protrudes into the lobby.

Wall D (North Wall): The wall mirrors that of the south wall. Except instead of an entrance to the team store, there is a window into the ticket sales office. It is a painted gypsum wall board (PT-1) with a basketball pattern inscribed on it.

Floor: The floor of the entry is split between two types of terrazzo tile. There is a 'V-shape' as the spectators enter the space with the closest area being darker (TZ-2) and the majority of the rest of the space, including some of the concourse being the lighter color (TZ-1).

Ceiling: Since this is the entry and goes up 3-stories, the material is the underside of the upper level seats. The concrete is painted (PT-6) and the rest of the space is exposed.

Furniture:

There is no specific furniture in this space due to it being a heavy circulation area.

Design Criteria:

This space is going to be considered a museum – lobby / general gallery area / corridor because of the points of interest (trophy cases, concession stands and hall of fame space) located in close proximity to the entry vestibule. It is also important to use these criteria because of the amount of walking that takes place around the arena.

IESNA Very Important Criteria:

Appearance of Space and Luminaires
Daylighting Integration and Control
Points(s) of Interest

IESNA Important Criteria:

Modeling of Faces or Objects
Surface Characteristics
Horizontal Illuminance: Category C (10 FC)
Vertical Illuminance: Category A (3 FC)

IESNA Somewhat Important Criteria:

Color Appearance (and Color Contrast)
Direct Glare
Flicker (and Strobe)
Light Distribution on Surfaces
Light Distribution on Task Plane (Uniformity)
Luminances of Room Surfaces
System Control and Flexibility

ASHRAE / IESNA 90.1 Standards:

Table 9.6.1 allows for a light power density of 3.3 W/ft² for a lobby – Performing Arts Theater. This is because there are performances that occur in the arena throughout the year and may require varying light levels depending on the intended audience for the show. If necessary, an additional 1.0 W/ft² can be applied to the design for any decorative lighting that may be used.

Pre-Design Description:

Aside from the main gymnasium and court area, the entrance lobby is the most important space that people will first see when they enter the JPJ arena. Thus it is important to look closely at all the design criteria.

The appearance of the space and the luminaires is one of the most important things to look at. The lobby space is nearly three stories tall, so a fixture needs to be selected that can adequately light the floor with a level of 10 FC, while at the same time set an appearance of the space that is inviting and relaxed. The majority of fixtures over the main part of the entry lobby are metal halide with a CRI between 3000-3500k. There are compact fluorescents right as one enters the space to create a lighting hierarchy that draws the visitors through the space toward the main gym area. Another important aspect of the entrance is the curtain wall that makes up the entire western wall. This will be pivotal in the design of daylighting and control systems. Because the architects of the space want to say they ‘brought the outside in’ in a space that does not usually account for exterior light, daylighting will be a strong criteria for events and performances that occur early in the day. Once darkness falls on the arena, the fixtures need to be able to cover the light that is being brought in from the daylight. The last main criterion to design for is dealing with points of interest that are present in the space. There is a large university emblem embedded in the middle of the lobby that is the main focal point and needs to be lit with uniformity and shown its prominence within the space. Along the exterior of the space is the entrance to the team store and a ticket window that both require uniformity and some type of visual distinction from the surrounding spaces.

One important criterion to look at is the light distribution on the task plane. Since walking is the main task of the space, the floor needs to be uniformly lit and not have dark spots that could be considered a hazard to occupants. The lights should be able to create movement through the space as to draw people around the arena and to the concession stands and other areas that surround the court. The floor is a combination of terrazzo tile which would possibly create glare and visual discomfort if incorrect lamps are chosen. Terrazzo tile is a reason that color appearance and color contrast is important to look at it. The space is vibrantly colored and if it is lit incorrectly could take away from the overall appearance of the space and make it less inviting. Color contrast should be covered in the fact that most of the lights are metal halide in the main area and the compact fluorescents are kept to the immediate entry area.

Controlling the system is not really an issue because the space is used primarily for walking and traffic flow. If there was to be an event held there, there may need to be some alternative controls to set a more relaxed and personal feel, but the main purpose is to move people from one area to another. This setting may be required to have a level of vertical illuminance close to 3-5 FC to ensure an adequate amount of light for face-to-face communication.

Overall the space needs to be lit with uniformity and visual clarity as to allow the occupants to move easily through the space, while at the same time putting prominence on those objects that need to stand out.

Design Goals:

1. Clean and uniform layout and appearance of luminaires.
2. Creation of a visual hierarchy from entryway to the arena.
3. Emphasize basketball details located on the periphery.

Design Approach:

1. Minimize the mixture of different types of fixtures and create a layout that is pleasing to the eye and continues the theme of cleanliness and uniformity.
2. After entering the arena through the façade, the use of increasing light levels to draw the spectators toward the arena and general seating area.

3. The use of an illuminated material to accent to space and give it visual interest and show that the primary function of the arena is for basketball games.

Schematic Designs:

The following images and renderings depict pre-design concepts and ideas and may not be a full representation of the final proposed design.

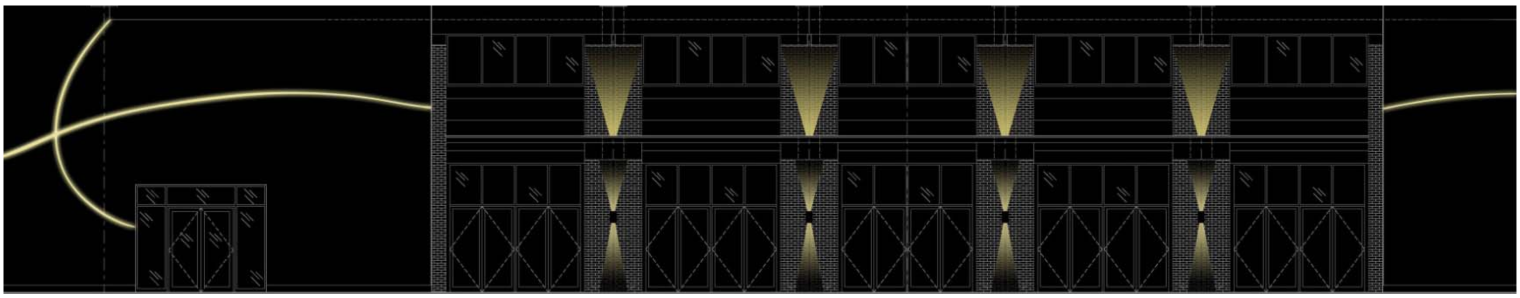
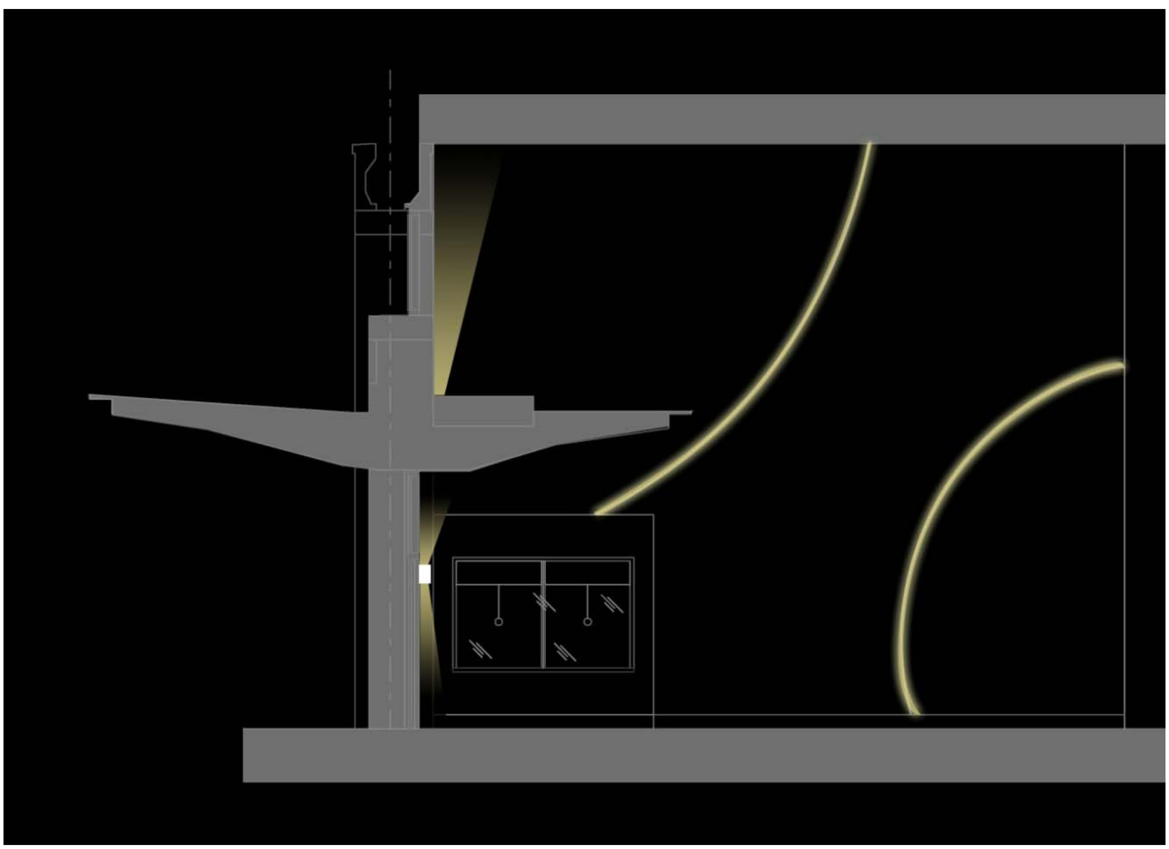


FIGURE 4.4.1 – Photoshop rendering of proposed entry.

FIGURE 4.4.2 – Photoshop rendering of proposed section at the ticket window.



Redesign:

The overall redesign concepts of the lobby were some of the simplest ideas, but had a big impact on the final appearance of the most important circulation space. The primary goals were to limit the clutter and appearance of fixtures while at the same time lighting the space to same standards and levels as the façade. The two spaces are hard to differentiate because of the glass curtain wall that encases the majority of the entry. Circulation and movement are the predominant functions of the lobby and it was important to convey that through a visual hierarchy. As occupants move through the entrance and continue through the arena, light levels should gradually increase until they reach their highest levels at the entrance to the general seating area. Adequate light levels for movement and circulation need to be designed for and come as the result of proper overhead downlighting and general ambience of a large open space. Movement can also be seen through the basketball shaped outlines located along the majority of corridor walls. By emphasizing these designs as architectural features, the theme of circulation can be felt through the curvilinear motion that is on the walls and drawing occupants to other areas of the arena.

Computer Renderings:

All images were rendered using AGI32radiaosity and raytrace calculations. Full size images can be found in Appendix C.

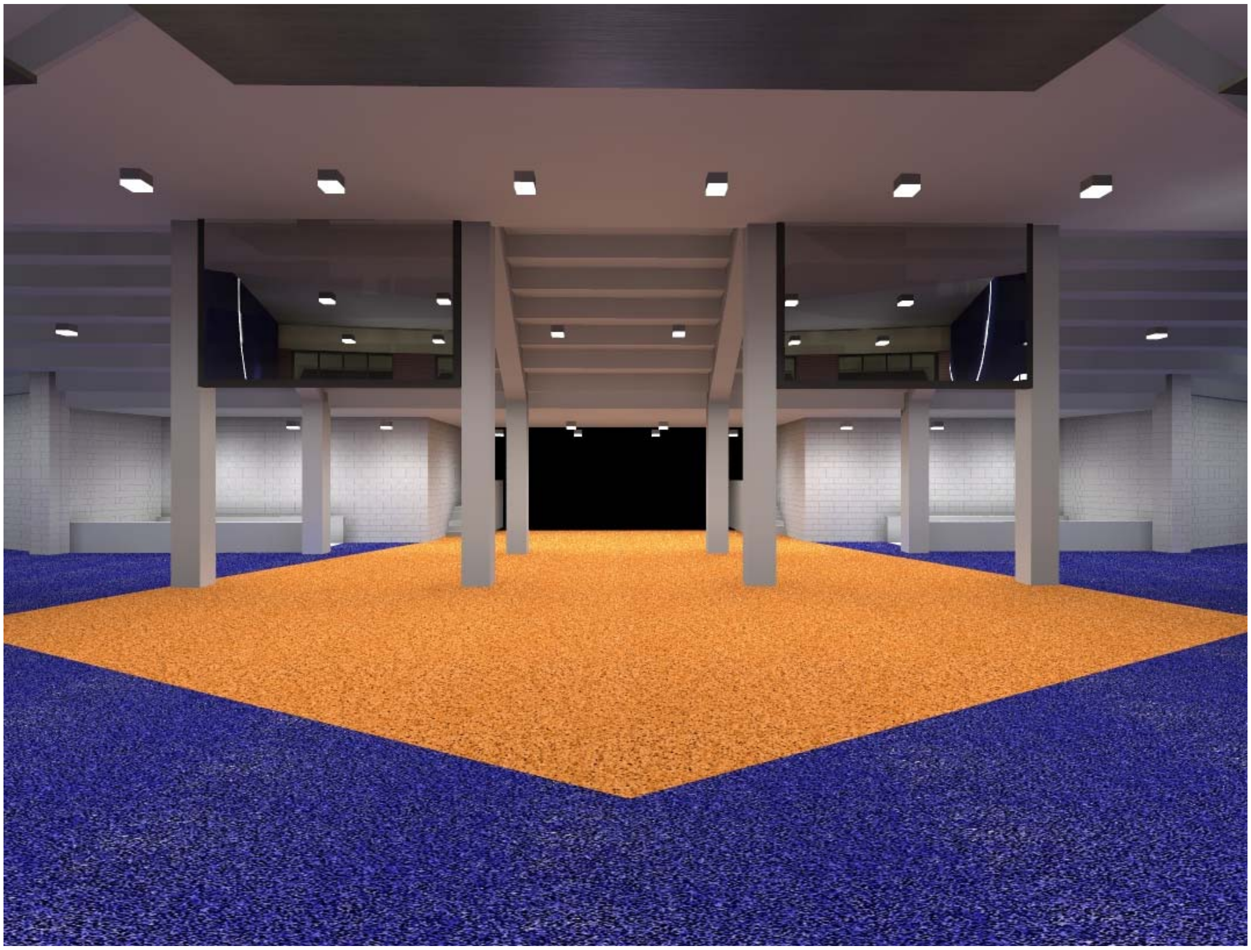


FIGURE 4.4.3 – Entry lobby looking east into the arena.

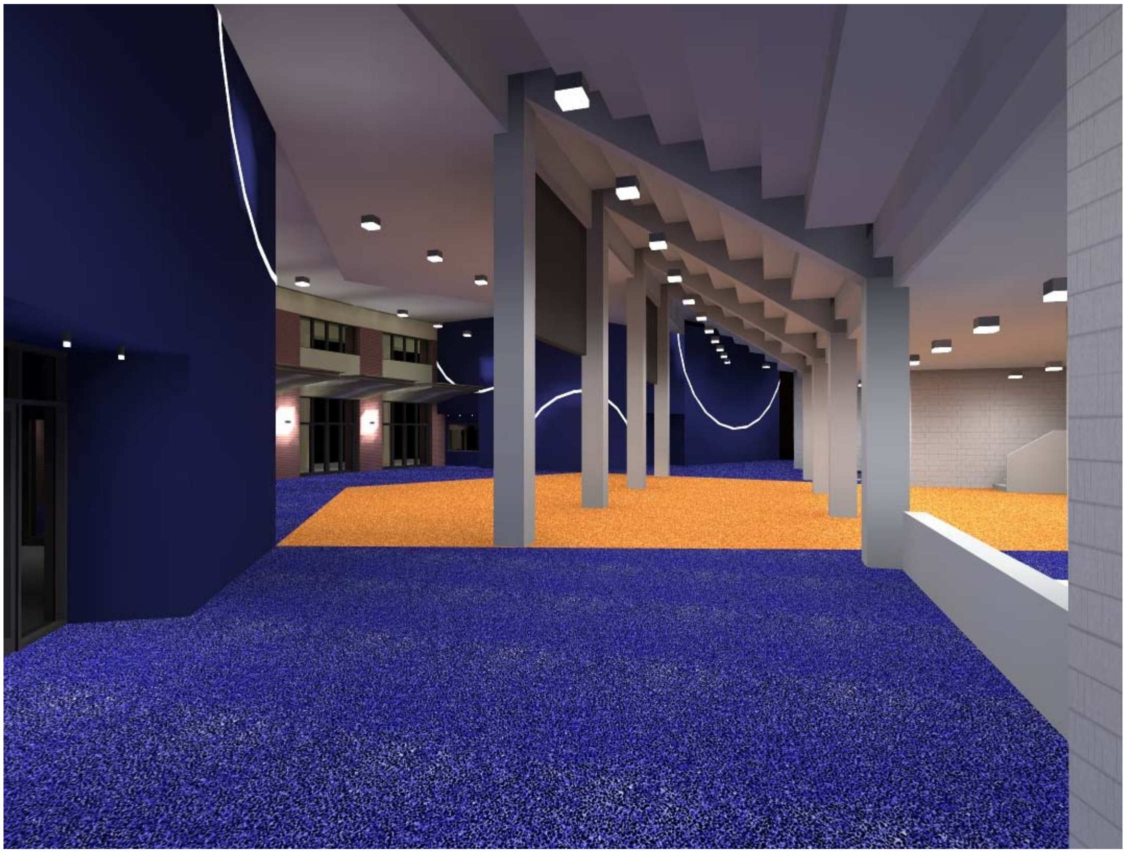


FIGURE 4.4.4 – Looking toward the entry from south corridor.

FIGURE 4.4.5 – Lobby looking west toward entrance.

Luminaires:

TYPE	DESCRIPTION	QTY.	PURPOSE
TYPE G	MH Wall Sconce	4	General Lighting
TYPE J	T80 CFL Pendant	42	General Lighting
TYPE K	MR16 Halogen Downlight	9	Task Lighting
TYPE L	Light Tape	200'	Accent Lighting

A full luminaire schedule can be found in Appendix A. Luminaire, lamp and ballast cut sheets and specifications can be found in Appendix D.

Controls:

The controls for the lobby area are simple. The fixtures will be turned on during all nighttime activities and used occasionally for other events when the time is warranted. Due to the large amount of glass on the façade, daylight will penetrate the building into the lobby and give general ambience levels when the sun is out. There will be an additional zone that accounts for the light tape (Fixture L) and downlights (Fixture K) located at the ticket window and team store entrance for times when the space is in use, but there is no real need for architectural accents or ticket purchasing.

Lighting Plans:

Refer to Appendix B for full size lighting plans.

Performance Criteria Numerical Summary:

	Western Entry Illuminance Data (fc)
	Ground Level
Average	10.32
Max	33.30
Min	3.20
Avg/Min	3.23
Max/Min	10.41

POWER DENSITY ANALYSIS									
SPACE	AREA (SF)	EXISTING WATTS	REDESIGN WATTS	LESS THAN EXISTING	ALLOWABLE LPD (W/SF)	REDESIGN LPD (W/SF)	% OF ALLOWABLE	ALLOWABLE WATTS	ASHRAE ACCEPTABLE ?
Lobby	10230	5912	3990	YES	3.3	0.390	12%	13167	YES

Performance Images:

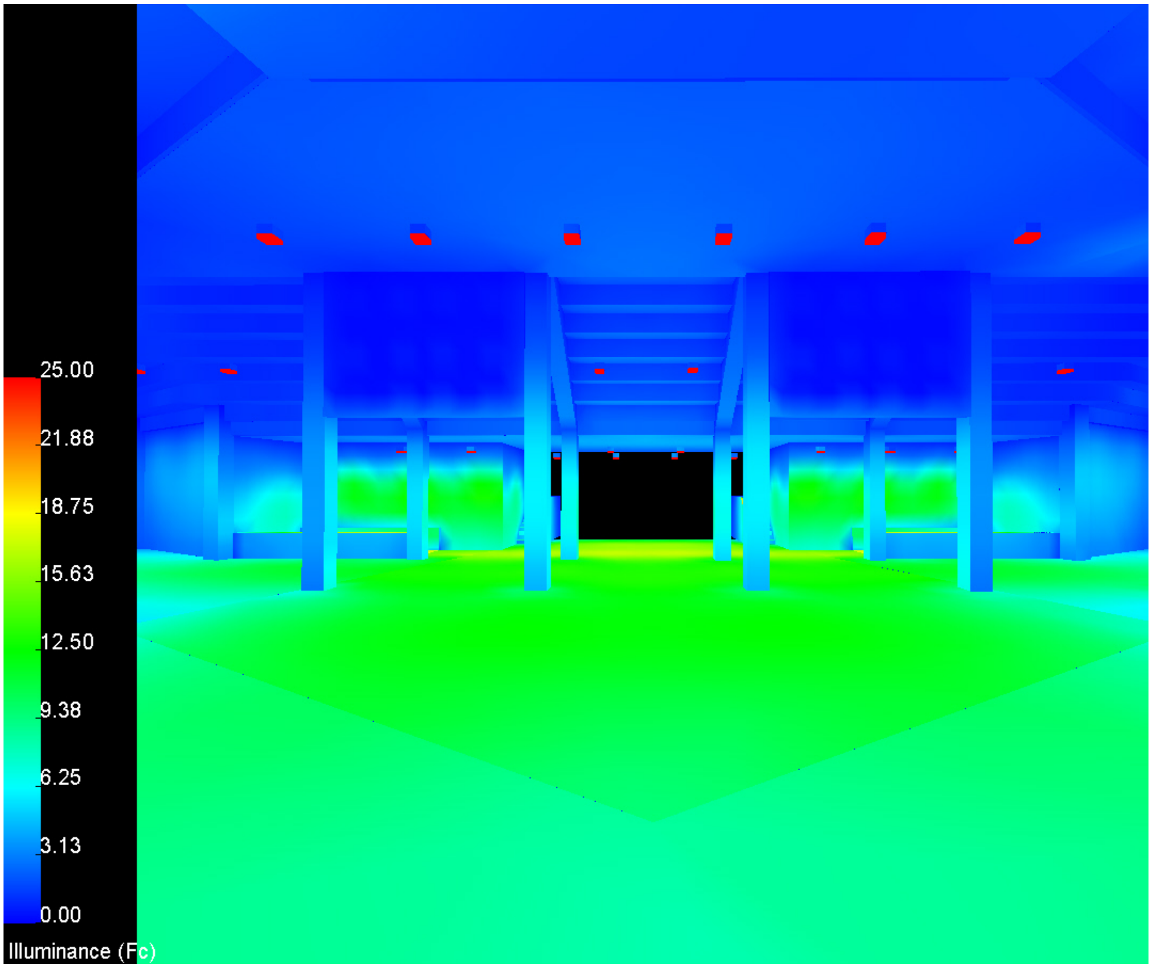


FIGURE 4.4.6 – Pseudo color rendering of the lobby facing the arena (Illuminance: fc).

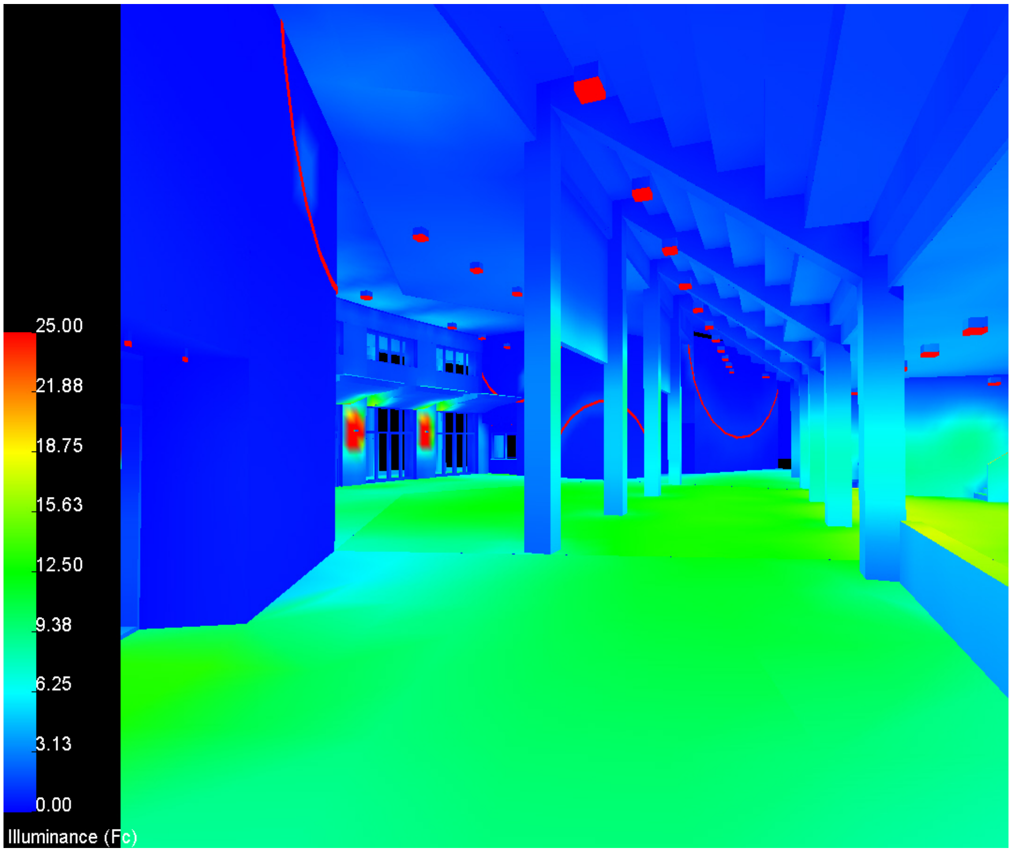
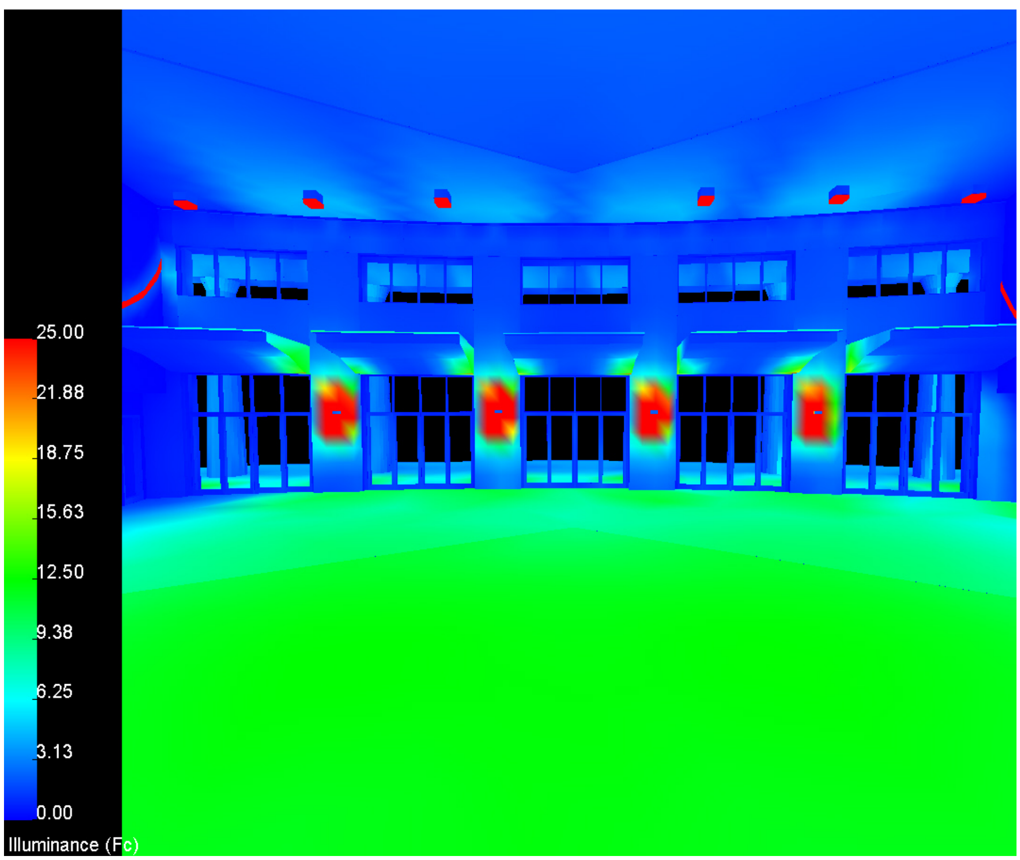


FIGURE 4.4.7 – Pseudo color rendering through lobby looking north (Illuminance: fc).

FIGURE 4.4.8 – Pseudo color of lobby facing entry (Illuminance: fc).



Performance Criteria Analysis:

The overall redesign of the lobby is successful in continuing the visual hierarchy that begins with the façade, but also integrates architectural elements as a means to facilitate movement from low light levels to the more dominant higher levels. The fixtures used continue the clean and minimalistic approach that all of the redesigned spaces attempt to accomplish. It is clear from the moment spectators enter the arena that they are either supposed to be funneled into the main seating area straight ahead or walk around the corridors by following the illuminated basketball details on the walls. The subconscious messages that are sent through the various light levels facilitate circulation and movement through an arena that superbly designed.

The target horizontal illuminance level for proper movement and way finding is 10 fc. The redesigned solution has an average just over 10 fc of 10.32 fc. With a maxes coming at the entrance to the main seating area as occupants enter the space, as well as at the exit doors as occupants leave the arena and head home after an event.

The redesign of the lobby may appear to be the simplest and easiest to come up with solutions for, but sometimes the simplest solutions are the best solutions. The entrance lobby is a space that takes simple concepts and applies a simple solution to achieve a product that extraordinary and successful on all levels of design.

SECTION FIVE: ELECTRICAL DEPTH

Coordination of Electrical Redesign

Introduction:

As the lighting design for each of the spaces was modified and adapted to fit the new criteria and design goals, portions of the electrical system changed and subsequently required additional coordination. For each space, the original panelboards that are being modified are shown with the changes being highlighted. Following the existing panelboard is a worksheet that was used in resizing the new panelboard with the additional loads, as well as the new panelboard with the new loads also being highlighted.

All feeder and conduit sizes for the original and revised panelboards were sized using NEC 2008.

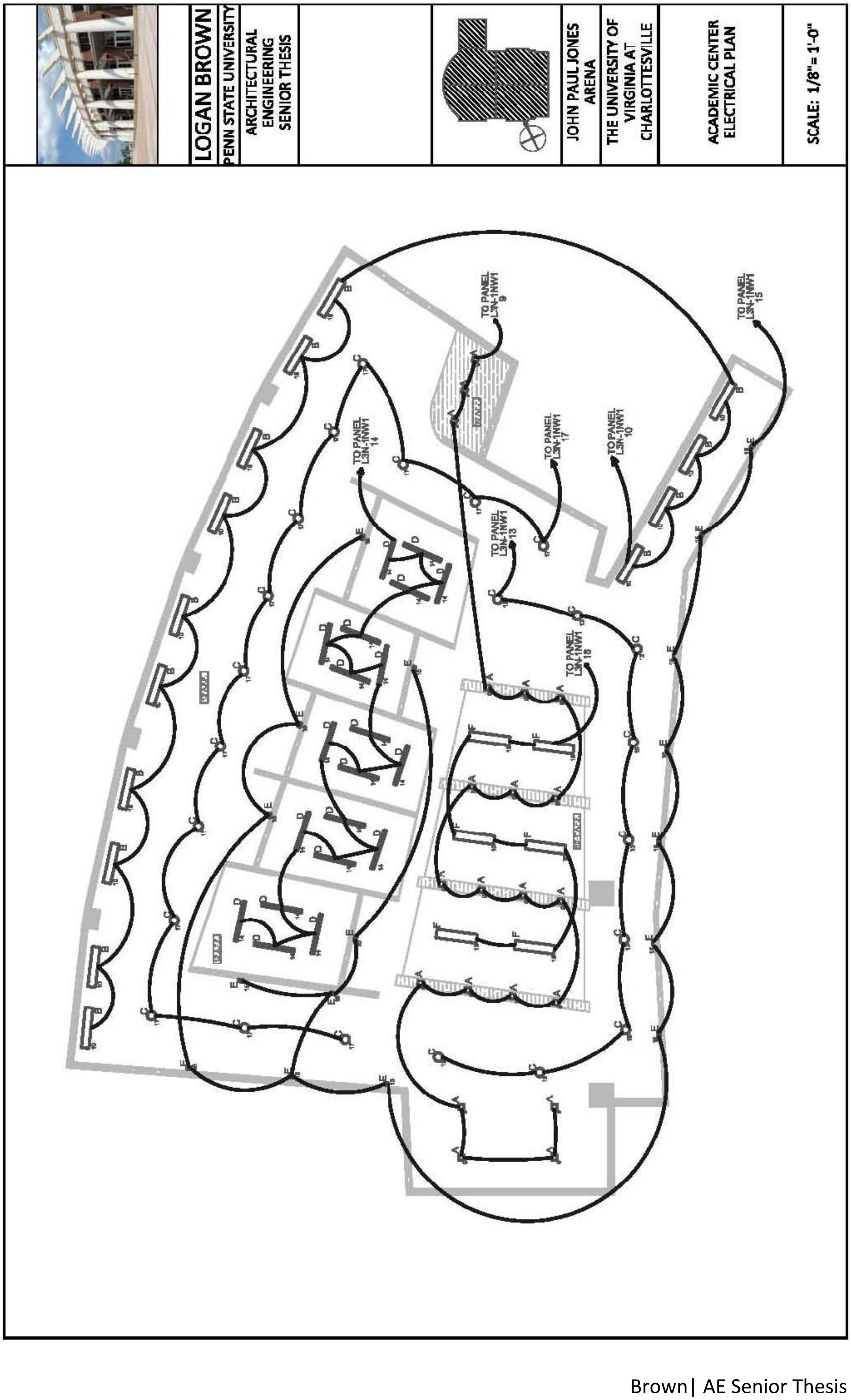
Academic Center and Study Lounge:

The redesign of the academic center was pretty thorough compared to the original design with large emphasis being put on task illuminance and creating an open, inviting environment. It was important to focus on the task illuminance, but also making sure enough light was being placed on the high circulation areas and being able to control the room for various types of occupancy.

The panel that was affected and required redesigning was L3N-1NW1, which is located in Electric Room 1C32 on the event level of the arena.

The controls for the space will remain on the lighting panel and will operate with standard switching on a series of three zones. The main zone will be over the work tables located in the heart of the space, with another zone controlling the pendants over the circulation space through the entrance and the final zone being able to control the enclosed meeting rooms located between the circulation space and the main study area.

AFFECTED EXISTING LIGHTING PANELS						
Panel	Breaker	Feeder				Conduit
		Sets	Phase	Neutral	Ground	
L3N-1NW1	100A, 3P	1	(3)-#4	#4	#8	1"


LOGAN BROWN
PENN STATE UNIVERSITY
ARCHITECTURAL ENGINEERING SENIOR THESIS
JOHN PAUL JONES ARENA
THE UNIVERSITY OF VIRGINIA AT CHARLOTTESVILLE
ACADEMIC CENTER ELECTRICAL PLAN
SCALE: 1/8"= 1'-0"
TO PANEL L3N-1NW1 8
TO PANEL L3N-1NW1 15
TO PANEL L3N-1NW1 14
TO PANEL L3N-1NW1 17
TO PANEL L3N-1NW1 10
TO PANEL L3N-1NW1 13
TO PANEL L3N-1NW1 18

PANELBOARD SCHEDULE

PANEL NAME:	L3N-1NW1	PROJECT:	University of Virgina Arena - 1236.0001.00		
BUS AMP RATING:	100A	VOLTAGE	277 / 480	[ ] MAIN CIRCUIT BREAKER	[X] SURFACE MOUNT
PANEL LOCATION:	Elec. Room 1C32	PHASE	3	[X] MAIN LUGS ONLY	[ ] FLUSH MOUNT
I.C. RATING:	22000 RMS SYM AMPS	WIRE	4	[ ] SUB FEED LUGS	[X] SINGLE NEUTRAL BUS
		[X] GROUND BUS		[ ] FEED THROUGH LUGS	[ ] DOUBLE NEUTRAL BUS

REV. NO.	NOTE NO.	CIRCUIT DESCRIPTION:	KVA A	KVA B	KVA C	DEVICE AMP/POLE	CIRCUIT NUMBER	CIRCUIT NUMBER	DEVICE AMP/POLE	KVA A	KVA B	KVA C	CIRCUIT DESCRIPTION	NOTE NO.	REV. NO.
1.2	1	LTG, North Corridors	1.33			20/1	1	2	20/1	2.50			LTG, Exterior		2
1.2		LTG, Restrooms		2.58		20/1	3	4	20/1		2.23		LTG, Exterior		2
1		LTG, Maint Lockers/Fan Room			1.12	20/1	5	6	20/1			0.10	LTG, Elev. Pit		
1.2		LTG, Maint Shop/Sytems Room	2.73			20/1	7	8	20/1	0.40			LTG, West Corridor	1	
1		LTG, Future Storage		3.72		20/1	9	10	20/1		3.35		LTG, Study Area	1	2
1		LTG, Future Operations			1.44	20/1	11	12	20/1				SPARE		2,3
1.2						20/1	13	14	20/1				SPARE		2,3
		Spare				20/1	15	16	20/1		1.31		LTG, Tutor room	1	2
		Spare				20/1	17	18	20/1			1.95	LTG, Offices	1	2
		Spare				20/1	19	20	20/1				Spare		
		Spare				20/1	21	22	20/1				Spare		
		Spare				20/1	23	24	20/1				Spare		
		Spare				20/1	25	26	20/1				Spare		
		Spare				20/1	27	28	20/1				Spare		
		Spare				20/1	29	30	20/1				Spare		
		Spare				20/1	31	32	20/1				Spare		
		Spare				20/1	33	34	20/1				Spare		
		Spare				20/1	35	36	20/1				Spare		
		Spare				20/1	37	38	20/1				Spare		
		Spare				20/1	39	40	20/1				Spare		
		Spare				20/1	41	42	20/1				Spare		

TOTAL KVA/PHASE:	PHASE A	7	PHASE B	13	PHASE C	5
TOTAL AMPS/PHASE:	PHASE A	25	PHASE B	48	PHASE C	17

TOTAL CONNECTED LOAD (KVA):	25
TOTAL CONNECTED CURRENT (AMPS):	30
TOTAL DEMAND CURRENT (AMPS):	37

NOTES:
1 Circuit controlled by a relay. See relay panel schedule RP-1NW1.

FIGURE 5.1.1 – L3N-1NW1 Original Panelboard Schedule

PANELBOARD SIZING WORKSHEET

Panel Tag-------------------------->	L3N-1NW1	Panel Location:	Elec. Room 1C32
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	North Corridor	3		1330	w	0.95	1330	1400		
2	A	Exterior LTG.	3		2500	w	0.95	2500	2632		
3	B	Restrooms	3		2580	w	0.95	2580	2716		
4	B	Exterior LTG.	3		2230	w	0.95	2230	2347		
5	C	Maint. Locker / Fan	3		1120	w	0.95	1120	1179		
6	C	Elevator Pit	3		100	w	0.95	100	105		
7	A	Maint. Shop / System	3		2730	w	0.95	2730	2874		
8	A	West Corridor	3		400	w	0.95	400	421		
9	B	Fluorescent LTG	3		486	w	0.95	486	512		
10	B	Fluorescent LTG	3		602	w	0.95	602	634		
11	C	Future Storage	3		3720	w	0.95	3720	3916		
12	C	Future Operations	3		1440	w	0.95	1440	1516		
13	A	Fluorescent LTG	3		300	w	0.95	300	316		
14	A	Fluorescent LTG	3		660	w	0.95	660	695		
15	B	Fluorescent LTG	3		391	w	0.95	391	412		
16	B	Fluorescent LTG	3		480	w	0.95	480	505		
17	C	Fluorescent LTG	3		300	w	1.00	300	300		
18	C	Spare			3601	w	1.00	3601	3601		
19	A	Spare			3601	w	1.00	3601	3601		
20	A	Spare			3601	w	1.00	3601	3601		
21	B	Spare			3601	w	1.00	3601	3601		
22	B	Spare			3601	w	1.00	3601	3601		
23	C	Spare			3601	w	1.00	3601	3601		
24	C	Spare			3601	w	1.00	3601	3601		
25	A				0	w		0	0		
26	A				0	w		0	0		
27	B				0	w		0	0		
28	B				0	w		0	0		
29	C				0	w		0	0		
30	C				0	w		0	0		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								46.6	47.7	Amps=	57.4

PHASE LOADING		kW	kVA	%	Amps
PHASE TOTAL	A	15.1	15.5	33%	56.1
PHASE TOTAL	B	14.0	14.3	30%	51.7
PHASE TOTAL	C	17.5	17.8	37%	64.3

LOAD CATAGORIES			Connected			Demand				Ver. 1.03
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		21.4	22.5		21.4	22.5	0.95		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		25.2	25.2		25.2	25.2	1.00		
Total Demand Loads						46.6	47.7			
Spare Capacity			45%			21.0	21.5			
Total Design Loads						67.5	69.1	0.98	Amps=	83.2

FIGURE 5.1.2 – L3N-1NW1 Panelboard Worksheet

PANELBOARD SCHEDULE		
VOLTAGE: 208Y/120V,3PH,4W SIZE/TYPE BUS: 100A SIZE/TYPE MAIN: 225A/3P C/B	PANEL TAG: L3N-1NW1 PANEL LOCATION: Elec. Room 1C32 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
North Corridor		1330	20A/1P	1	*			2	20A/1P	2500		Exterior LTG.
Restrooms		2580	20A/1P	3		*		4	20A/1P	2230		Exterior LTG.
Maint. Locker / Fan		1120	20A/1P	5			*	6	20A/1P	100		Elevator Pit
Maint. Shop / System		2730	20A/1P	7	*			8	20A/1P	400		West Corridor
Fluorescent LTG		486	20A/1P	9		*		10	20A/1P	602		Fluorescent LTG
Future Storage		3720	20A/1P	11			*	12	20A/1P	1440		Future Operations
Fluorescent LTG		300	20A/1P	13	*			14	20A/1P	660		Fluorescent LTG
Fluorescent LTG		391	20A/1P	15		*		16	20A/1P	480		Fluorescent LTG
Fluorescent LTG		300	20A/1P	17			*	18	20A/1P	3601		Spare
Spare		3601	20A/1P	19	*			20	20A/1P	3601		Spare
Spare		3601	20A/1P	21		*		22	20A/1P	3601		Spare
Spare		3601	20A/1P	23			*	24	20A/1P	3601		Spare
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	15.12	TOTAL DESIGN LOAD (KW)	67.54
CONNECTED LOAD (KW) - B	13.97	POWER FACTOR	0.98
CONNECTED LOAD (KW) - C	17.48	TOTAL DESIGN LOAD (AMPS)	83

FIGURE 5.1.3 – L3N-1NW1 Revised Panelboard Schedule

REDESIGNED LIGHTING PANELS AND FEEDER SIZING							
Panel	Voltage	Design Load (Amps)	Feeder Protection (Amps)	New Wire Size	Neutral Size	Ground Size	New Conduit Size
L3N-1NW1	480Y/277	83.0	100.0	(3) 3 AWG	(1) 3 AWG	8 AWG	1-1/4"

FIGURE 5.1.4 – Academic Center Feeder Sizing Chart

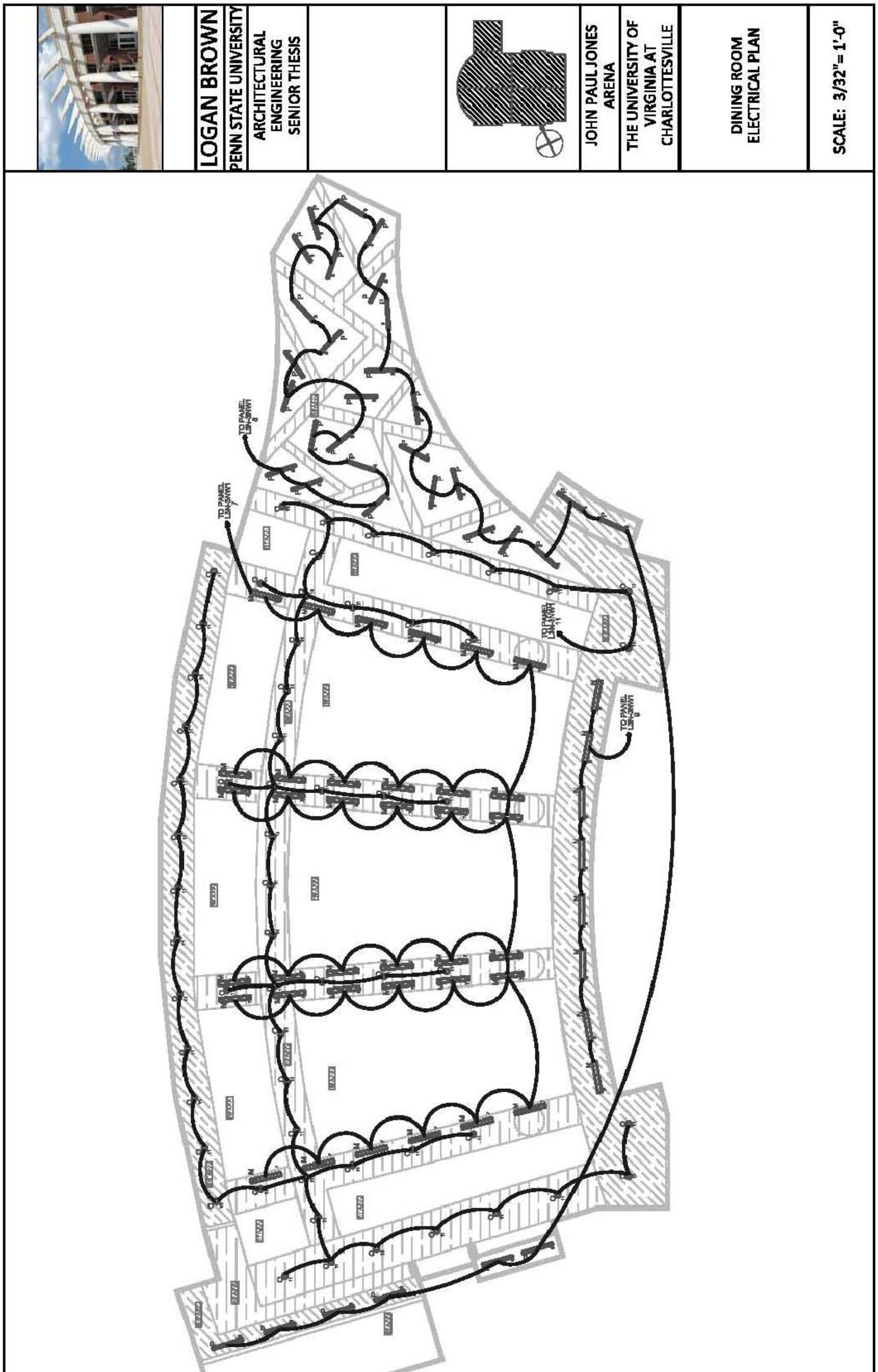
Dining Room:

The redesign of the dining room was the most drastic of the four spaces due to the desire to have a more professional and spacious feel while creating a visual hierarchy through the space by putting strong emphasis on the various ceiling heights. A transformation of the space took place by removing the linear coves that were part of the original design and replacing them with a vaulted ceiling system that peaks at 15' above the finished floor. The vaulting was used as means to pull the occupant through the space from the entryway to on the north side of the room. A decorative, architectural ceiling was also installed over the entry to create added visual interest in a space that has numerous uses and functions. Task illuminance was not a big factor other than being able to allow for adequate illuminance levels for a presentation setting and to make sure there was enough light on the floor for way-finding.

The panel that was affected and required redesigning was L3N-3NW1, which is located in Electric Room 3C19 on the lower concourse level of the arena.

The controls for the space will remain on the lighting panel and will operate with standard switching on a series of five zones. The first zone will consist of the redesigned vaulted ceiling located over the main eating area at the heart of the space. Zone two will be focused over the entry and consist of the downlights that make up the architectural ceiling and zone three is reserved for the downlights that make up the serving area (southern wall) and the two beverage service areas (one on each of the north and south walls). The two remaining zones, one consisting of the downlights located throughout the space and the final being the wall washers placed at the front of the space behind the projection screen. These controls will allow for each type of fixture to be dimmable, yet at the same time flexible enough to account for the projection screen setting as well as dealing with typical occupancy.

AFFECTED EXISTING LIGHTING PANELS						
Panel	Breaker	Feeder				Conduit
		Sets	Phase	Neutral	Ground	
L3N-3NW1	100A, 3P	1	(3)-#6	#6	#10	1"


LOGAN BROWN
PENN STATE UNIVERSITY
ARCHITECTURAL
ENGINEERING
SENIOR THESIS
JOHN PAUL JONES
ARENA
THE UNIVERSITY OF
VIRGINIA AT
CHARLOTTESVILLE
DINING ROOM
ELECTRICAL PLAN
SCALE: 3/32"= 1'-0"

PANELBOARD SCHEDULE

PANEL NAME: L3N-3NW1	PROJECT: University of Virgina Arena - 1236.0001.00		
BUS AMP RATING: 100A	VOLTAGE 277 / 480	[ ] MAIN CIRCUIT BREAKER	[X] SURFACE MOUNT
PANEL LOCATION: Elec. Room 3C19	PHASE 3	[X] MAIN LUGS ONLY	[ ] FLUSH MOUNT
I.C. RATING: 14000 RMS SYM AMPS	WIRE 4	[ ] SUB FEED LUGS	[X] SINGLE NEUTRAL BUS
	[X] GROUND BUS	[ ] FEED THROUGH LUGS	[ ] DOUBLE NEUTRAL BUS

REV. NO.	NOTE NO.	CIRCUIT DESCRIPTION:	KVA A	KVA B	KVA C	DEVICE AMP/POLE	CIRCUIT NUMBER		DEVICE AMP/POLE	KVA A	KVA B	KVA C	CIRCUIT DESCRIPTION	NOTE NO.	REV. NO.
	1	LTG, North Concourse	1.14			20/1	1	2	20/1	1.46			SITE LTG, North Plaza		1
		LTG, Restrooms		2.94		20/1	3	4	20/1		1.90		SITE LTG, North Plaza		1
		LTG, Concessions/First Aid			1.20	20/1	5	6	20/1			0.79	LTG, West Concourse	1	1
	1	LTG, Coves	1.58			20/1	7	8	20/1	0.47			LTG, Athletic Dining	1	1,2
1,2	1	LTG, Athletic Dining		1.98		20/1	9	10	20/1		1.77		LTG, Athletic Dining	1	1
1	1	LTG, A/V Control			0.12	20/1	11	12	20/1			1.74	LTG, Athletic Dining	1	1
2		LTG, Athletic Dining	0.15			20/1	13	14	20/1	0.41			LTG, Athletic Dining		2
		Spare				20/1	15	16	20/1				Spare		
		Spare				20/1	17	18	20/1				Spare		
		Spare				20/1	19	20	20/1				Spare		
		Spare				20/1	21	22	20/1				Spare		
		Spare				20/1	23	24	20/1				Spare		
		Spare				20/1	25	26	20/1				Spare		
		Spare				20/1	27	28	20/1				Spare		
		Spare				20/1	29	30	20/1				Spare		
		Spare				20/1	31	32	20/1				Spare		
		Spare				20/1	33	34	20/1				Spare		
		Spare				20/1	35	36	20/1				Spare		
		Spare				20/1	37	38	20/1				Spare		
		Spare				20/1	39	40	20/1				Spare		
		Spare				20/1	41	42	20/1				Spare		

TOTAL KVA/PHASE:	PHASE A	5	PHASE B	9	PHASE C	4
TOTAL AMPS/PHASE:	PHASE A	19	PHASE B	31	PHASE C	14

TOTAL CONNECTED LOAD (KVA):	18
TOTAL CONNECTED CURRENT (AMPS):	21
TOTAL DEMAND CURRENT (AMPS):	26

NOTES:
1 Circuit controlled by a relay. See relay panel schedule RP-3NW1.

FIGURE 5.2.1 – L3N-3NW1 Original Panelboard Schedule

PANELBOARD SIZING WORKSHEET

Panel Tag-------------------------->	L3N-3NW1	Panel Location:	Elec. Room 3C19
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	North Concourse	3		1140	w	0.95	1140	1200		
2	A	North Plaza	3		1460	w	0.95	1460	1537		
3	B	Restrooms	3		2940	w	0.95	2940	3095		
4	B	North Plaza	3		1900	w	0.95	1900	2000		
5	C	Concessions/First Aic	3		1200	w	0.95	1200	1263		
6	C	West Concourse	3		790	w	0.95	790	832		
7	A	Fluorescent LTG	3		1116	w	0.95	1116	1175		
8	A	Fluorescent LTG	3		1054	w	0.95	1054	1109		
9	B	Fluorescent LTG	3		336	w	0.95	336	354		
10	B	A/V Control	3		120	w	0.95	120	126		
11	C	Fluorescent LTG	3		3240	w	0.95	3240	3411		
12	C	Spare			3601	w	1.00	3601	3601		
13	A	Spare			3601	w	1.00	3601	3601		
14	A	Spare			3601	w	1.00	3601	3601		
15	B	Spare			3601	w	1.00	3601	3601		
16	B	Spare			3601	w	1.00	3601	3601		
17	C	Spare			3601	w	1.00	3601	3601		
18	C	Spare			3601	w	1.00	3601	3601		
19	A				0	w		0	0		
20	A				0	w		0	0		
21	B				0	w		0	0		
22	B				0	w		0	0		
23	C				0	w		0	0		
24	C				0	w		0	0		
25	A				0	w		0	0		
26	A				0	w		0	0		
27	B				0	w		0	0		
28	B				0	w		0	0		
29	C				0	w		0	0		
30	C				0	w		0	0		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								40.5	41.3	Amps=	49.7

PHASE LOADING							kW	kVA	%	Amps
PHASE TOTAL	A						12.0	12.2	30%	44.1
PHASE TOTAL	B						12.5	12.8	31%	46.1
PHASE TOTAL	C						16.0	16.3	39%	58.9

LOAD CATAGORIES			Connected			Demand					Ver. 1.03
			kW	kVA	DF	kW	kVA	PF			
1	receptacles		0.0	0.0		0.0	0.0				
2	computers		0.0	0.0		0.0	0.0				
3	fluorescent lighting		15.3	16.1		15.3	16.1	0.95			
4	HID lighting		0.0	0.0		0.0	0.0				
5	incandescent lighting		0.0	0.0		0.0	0.0				
6	HVAC fans		0.0	0.0		0.0	0.0				
7	heating		0.0	0.0		0.0	0.0				
8	kitchen equipment		0.0	0.0		0.0	0.0				
9	unassigned		25.2	25.2		25.2	25.2	1.00			
Total Demand Loads						40.5	41.3				
Spare Capacity			45%			18.2	18.6				
Total Design Loads						58.7	59.9	0.98	Amps=		72.1

FIGURE 5.2.2 – L3N-3NW1 Panelboard Worksheet

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W SIZE/TYPE BUS: 100A SIZE/TYPE MAIN: 225A/3P C/B	PANEL TAG: L3N-3NW1 PANEL LOCATION: Elec. Room 3C19 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
North Concourse		1140	20A/1P	1	*			2	20A/1P	1460		North Plaza
Restrooms		2940	20A/1P	3		*		4	20A/1P	1900		North Plaza
Concessions/First Ai		1200	20A/1P	5			*	6	20A/1P	790		West Concourse
Fluorescent LTG		1116	20A/1P	7	*			8	20A/1P	1054		Fluorescent LTG
Fluorescent LTG		336	20A/1P	9		*		10	20A/1P	120		A/V Control
Fluorescent LTG		3240	20A/1P	11			*	12	20A/1P	3601		Spare
Spare		3601	20A/1P	13	*			14	20A/1P	3601		Spare
Spare		3601	20A/1P	15		*		16	20A/1P	3601		Spare
Spare		3601	20A/1P	17			*	18	20A/1P	3601		Spare
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	11.97	TOTAL DESIGN LOAD (KW)	58.73
CONNECTED LOAD (KW) - B	12.50	POWER FACTOR	0.98
CONNECTED LOAD (KW) - C	16.03	TOTAL DESIGN LOAD (AMPS)	72

FIGURE 5.2.3 – L3N-3NW1 Revised Panelboard Schedule

REDESIGNED LIGHTING PANELS AND FEEDER SIZING							
Panel	Voltage	Design Load (Amps)	Feeder Protection (Amps)	New Wire Size	Neutral Size	Ground Size	New Conduit Size
L3N-3NW1	480Y/277	95.0	100.0	(3) 3 AWG	(1) 3 AWG	8 AWG	1-1/4"

FIGURE 5.2.4 – Dining Room Feeder Sizing Chart

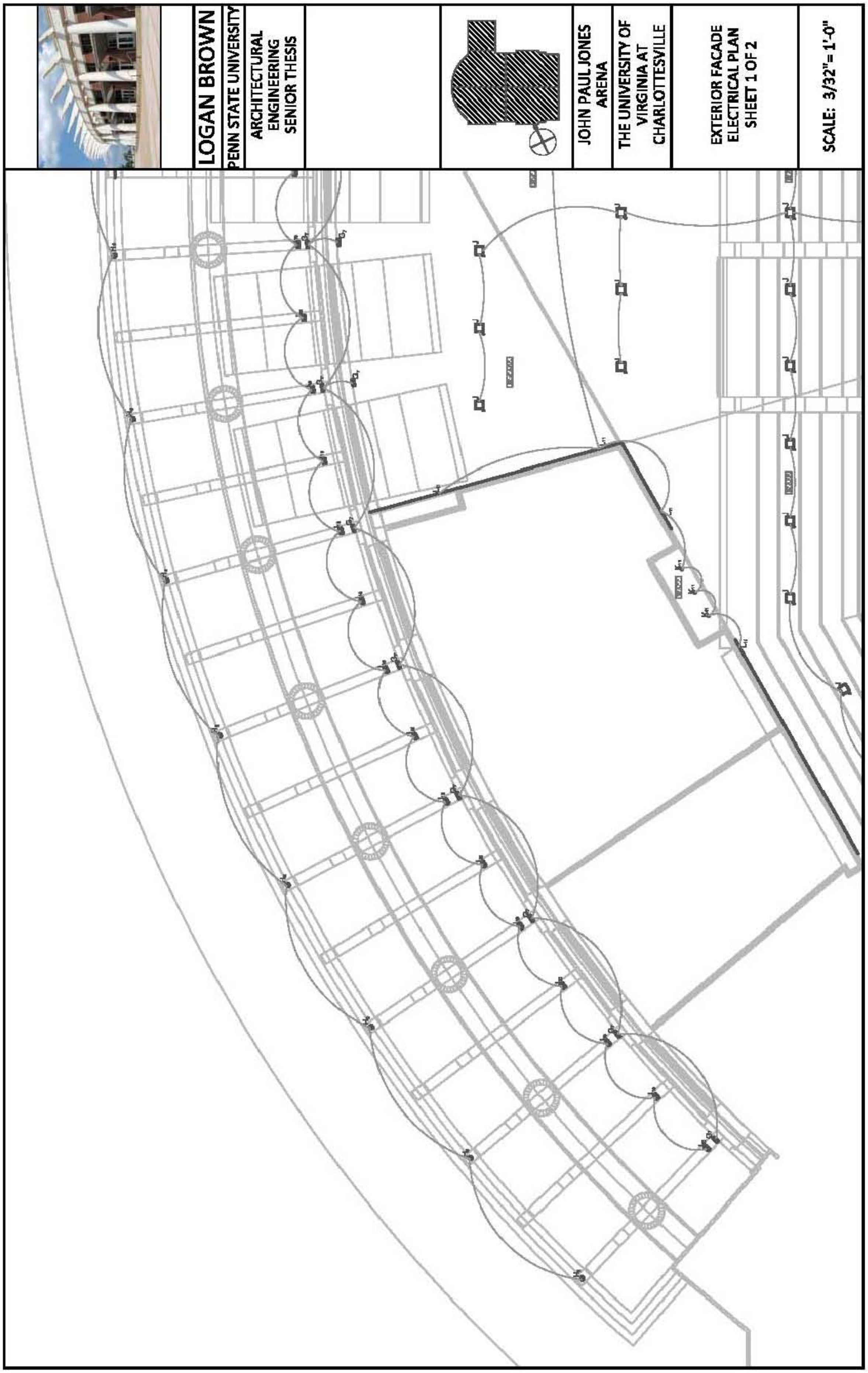
Exterior Façade & Entrance Lobby:

The redesign of the last two spaces coincided with each other due to their proximity and relative similar design goals. The new design does not differ too much from the existing other than that fixtures were changed and a more uniform and clean appearance was achieved. There was emphasis put on keeping illuminance levels equal from the exterior through the entry way in order to avoid visual discomfort and create a visual hierarchy that eventually leads the spectator into the general seating area. The last important part of the redesign was including an accent fixture along the entry walls and along the corridors that resembles the pattern on a basketball. This adds an extra element to the overall sports theme and ties what would normally be a disjointed lobby, into a space that feels like it belongs to be part of the environment.

The panel that was affected and required redesigning was L3N-4NW1, which is located in Electric Room 4C32 on the upper concourse level of the arena.

There are no special controls other than keeping the exterior lights and interior lights on their own respected switching systems. The exterior lights will be on most hours of the day, regardless if there is an event or not. This is due to the prominence of the façade as a part of the overall campus. The interior lights will be switched on during all events and occasionally at other times depending if there is an activity going on elsewhere within the arena.

AFFECTED EXISTING LIGHTING PANELS						
Panel	Breaker	Feeder				Conduit
		Sets	Phase	Neutral	Ground	
L3N-4NW1	100A, 3P	1	(3)-#4	#4	#8	1"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JOHN PAUL JONES
ARENA
THE UNIVERSITY OF
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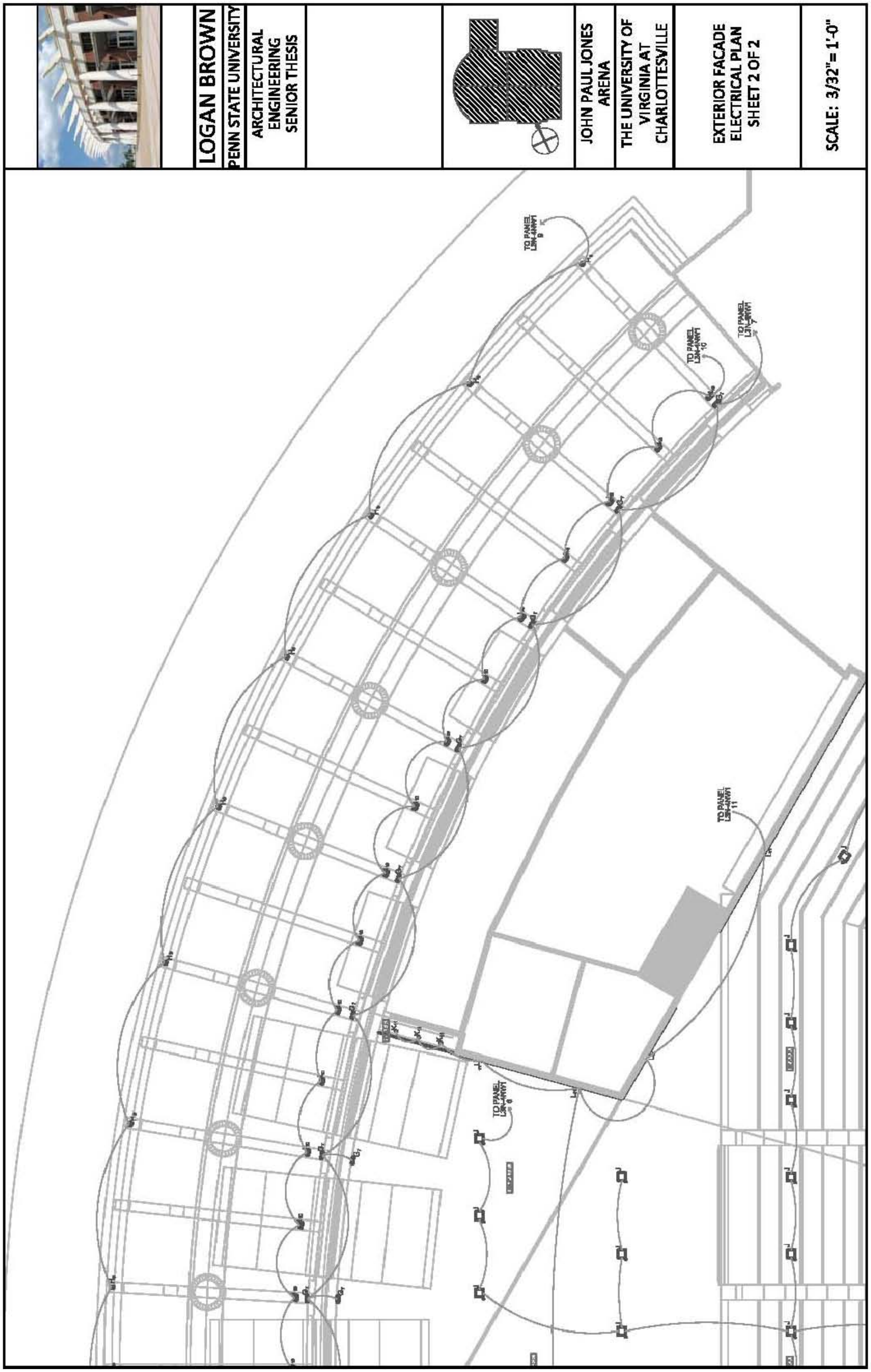
CHARLOTTESVILLE
EXTERIOR FACADE
ELECTRICAL PLAN
SHEET 1 OF 2
SCALE: 3/32"= 1'-0"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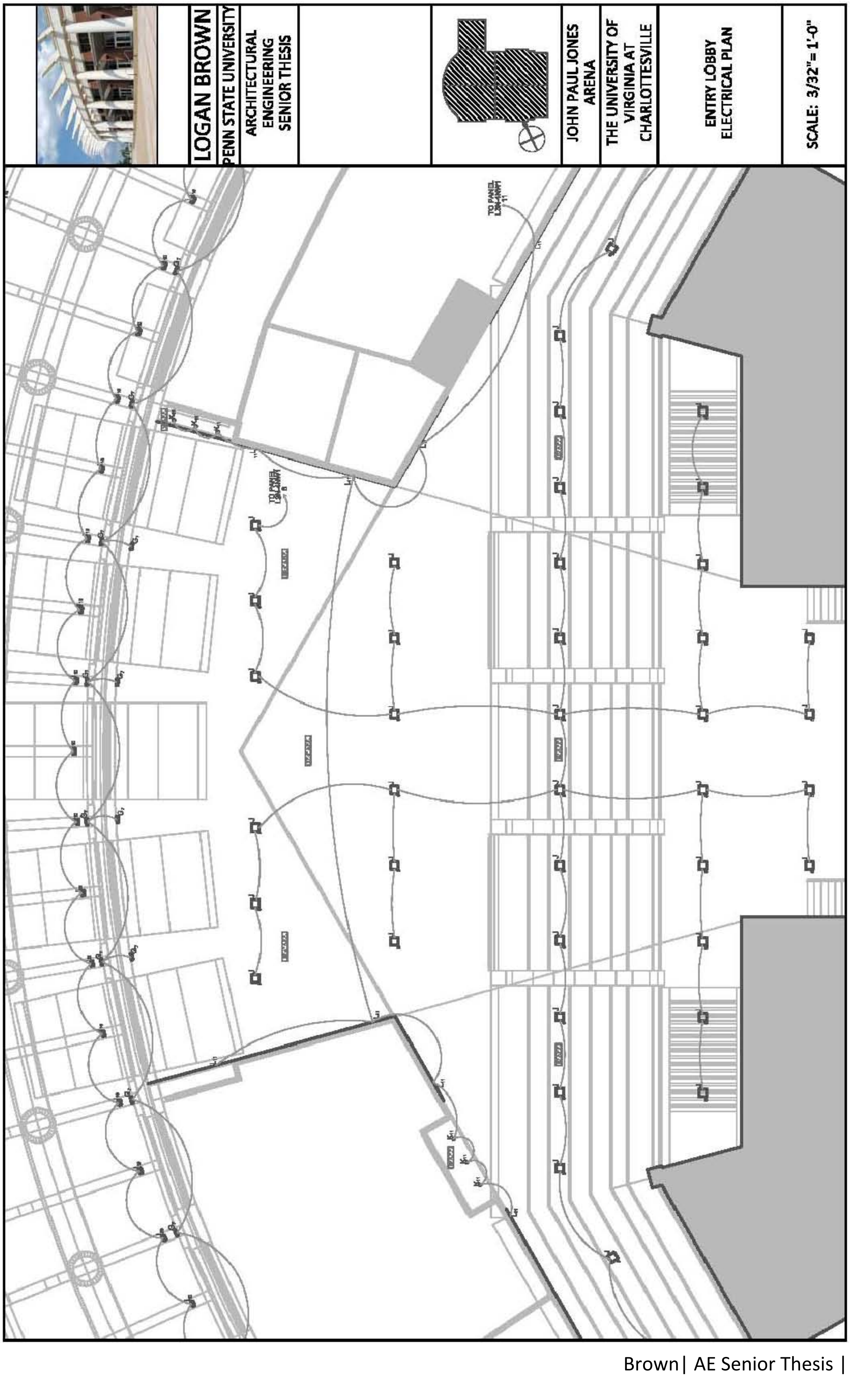
EXTERIOR FACADE ELECTRICAL PLAN SHEET 2 OF 2
SCALE: 3/32"= 1'-0"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THE UNIVERSITY OF VIRGINIA AT CHARLOTTESVILLE
ENTRY LOBBY ELECTRICAL PLAN
SCALE: 3/32"= 1'-0"

PANELBOARD SCHEDULE

PANEL NAME: L3N-4NW1
PROJECT: University of Virgina Arena - 1236.0001.00
BUS AMP RATING: 100A
VOLTAGE: 277 / 480
PANEL LOCATION: Elec. Room 4C23
PHASE: 3
I.C. RATING: 14000 RMS SYM AMPS
WIRE: 4

[X] GROUND BUS
[ ] MAIN CIRCUIT BREAKER
[X] MAIN LUGS ONLY
[ ] SUB FEED LUGS
[ ] FEED THROUGH LUGS
[X] SURFACE MOUNT
[ ] FLUSH MOUNT
[X] SINGLE NEUTRAL BUS
[ ] DOUBLE NEUTRAL BUS

REV. NO.	NOTE NO.	CIRCUIT DESCRIPTION:	KVA A	KVA B	KVA C	DEVICE AMP/POLE	CIRCUIT NUMBER	CIRCUIT NUMBER	DEVICE AMP/POLE	KVA A	KVA B	KVA C	CIRCUIT DESCRIPTION	NOTE NO.	REV. NO.
	1	LTG, Concourse	1.95			20/1	1	2	20/1	1.32			LTG, West Concourse	1	
	1	LTG, West Lobby		3.00		20/1	3	4	20/1				Spare		
	1	LTG, Food Court/Queue			2.95	20/1	5	6	20/1				Spare		
		LTG, Restrooms	1.90			20/1	7	8	20/1				Spare		
		LTG, Concessions		2.32		20/1	9	10	20/1				Spare		
		LTG, Ticketing area			3.71	20/1	11	12	20/1				Spare		
	1	LTG, Exterior	2.83			20/1	13	14	20/1				Spare		
		Spare				20/1	15	16	20/1				Spare		
							17	18							
							19	20							
							21	22							
							23	24							
							25	26							
							27	28							
							29	30							
							31	32							
							33	34							
							35	36							
							37	38							
							39	40							
							41	42							

TOTAL KVA/PHASE:	PHASE A	8	PHASE B	5	PHASE C	7
TOTAL AMPS/PHASE:	PHASE A	29	PHASE B	19	PHASE C	24

TOTAL CONNECTED LOAD (KVA):	20
TOTAL CONNECTED CURRENT (AMPS):	24
TOTAL DEMAND CURRENT (AMPS):	30

NOTES:
1 Circuit controlled by a relay. See relay panel schedule RP-4NW1.

FIGURE 5.3.1 – L3N-4NW1 Original Panelboard Schedule

PANELBOARD SIZING WORKSHEET											
Panel Tag--------------------------->					L3N-4NW1	Panel Location:			Elec. Room 4C23		
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	Concourse	3		1950	w	0.95	1950	2053		
2	A	Restrooms	3		1900	w	0.95	1900	2000		
3	B	Food Court/Queue	3		2950	w	0.95	2950	3105		
4	B	Concessions	3		2320	w	0.95	2320	2442		
5	C	Ticketing Area	3		3710	w	0.95	3710	3905		
6	C	Fluorescent LTG	3		3360	w	0.95	3360	3537		
7	A	HID LTG	4		3300	w	0.80	3300	4125		
8	A	Spare			3601	w	1.00	3601	3601		
9	B	HID LTG	4		1376	w	0.80	1376	1720		
10	B	HID LTG	4		1792	w	0.80	1792	2240		
11	C	Fluorescent LTG	3		650	w	0.95	650	684		
12	C	Spare			3601	w	1.00	3601	3601		
13	A	Spare			3601	w	1.00	3601	3601		
14	A	Spare			3601	w	1.00	3601	3601		
15	B	Spare			3601	w	1.00	3601	3601		
16	B	Spare			3601	w	1.00	3601	3601		
17	C	Spare			3601	w	1.00	3601	3601		
18	C	Spare			3601	w	1.00	3601	3601		
19	A				0	w		0	0		
20	A				0	w		0	0		
21	B				0	w		0	0		
22	B				0	w		0	0		
23	C				0	w		0	0		
24	C				0	w		0	0		
25	A				0	w		0	0		
26	A				0	w		0	0		
27	B				0	w		0	0		
28	B				0	w		0	0		
29	C				0	w		0	0		
30	C				0	w		0	0		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								52.1	54.6	Amps=	65.7
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					18.0	19.0	35%	68.5
PHASE TOTAL			B					15.6	16.7	31%	60.3
PHASE TOTAL			C					18.5	18.9	35%	68.3
LOAD CATAGORIES				Connected			Demand				Ver. 1.03
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0		0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			16.8	17.7		16.8	17.7	0.95		
4	HID lighting			6.5	8.1		6.5	8.1	0.80		
5	incandescent lighting			0.0	0.0		0.0	0.0			
6	HVAC fans			0.0	0.0		0.0	0.0			
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			28.8	28.8		28.8	28.8	1.00		
Total Demand Loads							52.1	54.6			
Spare Capacity				45%			23.5	24.6			
Total Design Loads							75.6	79.2	0.95	Amps=	95.3

FIGURE 5.3.2 – L3N-4NW1 Panelboard Worksheet

PANELBOARD SCHEDULE		
VOLTAGE: 208Y/120V,3PH,4W SIZE/TYPE BUS: 225A SIZE/TYPE MAIN: 225A/3P C/B	PANEL TAG: L3N-4NW1 PANEL LOCATION: Elec. Room 4C23 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
Concourse		1950	20A/1P	1	*			2	20A/1P	1900		Restrooms
Food Court/Queue		2950	20A/1P	3		*		4	20A/1P	2320		Concessions
Ticketing Area		3710	20A/1P	5			*	6	20A/1P	3360		Fluorescent LTG
HID LTG		3300	20A/1P	7	*			8	20A/1P	3601		Spare
HID LTG		1376	20A/1P	9		*		10	20A/1P	1792		HID LTG
Fluorescent LTG		650	20A/1P	11			*	12	20A/1P	3601		Spare
Spare		3601	20A/1P	13	*			14	20A/1P	3601		Spare
Spare		3601	20A/1P	15		*		16	20A/1P	3601		Spare
Spare		3601	20A/1P	17			*	18	20A/1P	3601		Spare
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	17.95	TOTAL DESIGN LOAD (KW)	75.57
CONNECTED LOAD (KW) - B	15.64	POWER FACTOR	0.95
CONNECTED LOAD (KW) - C	18.52	TOTAL DESIGN LOAD (AMPS)	95

FIGURE 5.3.3 – L3N-4NW1 Revised Panelboard Schedule

REDESIGNED LIGHTING PANELS AND FEEDER SIZING							
Panel	Voltage	Design Load (Amps)	Feeder Protection (Amps)	New Wire Size	Neutral Size	Ground Size	New Conduit Size
L3N-4NW1	480Y/277	72.0	85.0	(3) 4 AWG	(1) 4 AWG	8 AWG	1"

FIGURE 5.3.4 –Exterior Façade & Entry Lobby Feeder Sizing Chart

Energy Efficient Transformer Analysis

Introduction:

With sustainability and energy efficiency becoming part of the mainstream in the building industry and affecting everything from materials to electrical equipment, it is important to analyze the cost and benefits of a standard transformer system to more efficient and energy conscious transformers. This analysis will deal with swapping out existing K-Rated transformers and replacing them with Powersmith T1000-C3 energy efficient transformers. A cost / energy savings analysis will be done using the Powersmith ESP Calculator.

INDIVIDUAL TRANSFORMER TABLE								
TAG	PRIMARY VOLTAGE	SECONDARY VOLTAGE	SIZE	TYPE	TEMP. RISE	TAPS	MOUNTING	REMARKS
T-1	12470V, 3PH, 3W	480Y/277V, 3PH, 4W	2000	DRY TYPE	150 DEGREE C	(2) 5%	PAD MOUNTED ON FLOOR	K-RATED
T-2	12470V, 3PH, 3W	480Y/277V, 3PH, 4W	2000	DRY TYPE	150 DEGREE C	(2) 5%	PAD MOUNTED ON FLOOR	K-RATED
T-3	12470V, 3PH, 3W	480Y/277V, 3PH, 4W	1500	DRY TYPE	150 DEGREE C	(2) 5%	PAD MOUNTED ON FLOOR	K-RATED
T-4	12470V, 3PH, 3W	4160/2400V, 3PH, 4W	2500	DRY TYPE	150 DEGREE C	(2) 5%	PAD MOUNTED ON FLOOR	K-RATED
T-SP	12470V, 3PH, 3W	480Y/277V, 3PH, 4W	1500	DRY TYPE	150 DEGREE C	(2) 5%	PAD MOUNTED ON FLOOR	K-RATED
T3N-1CP1	4160V, 3PH, 3W	480Y/277V, 3PH, 4W	4160	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T1N-1CP1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T1E-1CP1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-1NW1	480V, 3PH, 3W	120/208, 3PH, 3W	225	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-1NW2	480V, 3PH, 3W	120/208, 3PH, 3W	75	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-3NW1	480V, 3PH, 3W	120/208, 3PH, 3W	150	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-4NW1	480V, 3PH, 3W	120/208, 3PH, 3W	225	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-1SW1	480V, 3PH, 3W	120/208, 3PH, 3W	150	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-3SW1	480V, 3PH, 3W	120/208, 3PH, 3W	300	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-4SW1	480V, 3PH, 3W	120/208, 3PH, 3W	225	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-3SW2	480V, 3PH, 3W	120/208, 3PH, 3W	300	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-1NE1	480V, 3PH, 3W	120/208, 3PH, 3W	225	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-3NE1	480V, 3PH, 3W	120/208, 3PH, 3W	150	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-4NE1	480V, 3PH, 3W	120/208, 3PH, 3W	225	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-7NE1	480V, 3PH, 3W	120/208, 3PH, 3W	225	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED ON CATWALK	
T-1SE1	480V, 3PH, 3W	120/208, 3PH, 3W	150	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-3SE3	480V, 3PH, 3W	120/208, 3PH, 3W	150	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-4SE1	480V, 3PH, 3W	120/208, 3PH, 3W	225	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED	
T-7SE1	480V, 3PH, 3W	120/208, 3PH, 3W	500	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED ON CATWALK	
TE-1NE1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-3NE1	480V, 3PH, 3W	120/208V, 3PH, 3W	15	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-4NE1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-7NE1	480V, 3PH, 3W	120/208, 3PH, 3W	75	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED ON CATWALK	
TE-1NW1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-3NW1	480V, 3PH, 3W	120/208V, 3PH, 3W	15	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-3NW2	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-4NW1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-7NW1	480V, 3PH, 3W	120/208, 3PH, 3W	75	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED ON CATWALK	
TE-1SE1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-3SE1	480V, 3PH, 3W	120/208V, 3PH, 3W	15	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-4SE1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-7SE1	480V, 3PH, 3W	120/208, 3PH, 3W	75	DRY TYPE	150 DEGREE C	(2) 5%	FLOOR MOUNTED ON CATWALK	
TE-1SW1	480V, 3PH, 3W	120/208V, 3PH, 3W	30	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-3SW1	480V, 3PH, 3W	120/208V, 3PH, 3W	15	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
TE-4SW1	480V, 3PH, 3W	120/208V, 3PH, 3W	15	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
T-SP5	480V, 3PH, 3W	120/208V, 3PH, 3W	750	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	
T-SP6	480V, 3PH, 3W	120/208, 3PH, 3W	225	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	K13 SHIELDED
T-SP7	480V, 3PH, 3W	120/208, 3PH, 3W	300	DRY TYPE	150 DEGREE C	(2) 5%	WALL MOUNTED	K13 SHIELDED

FIGURE 5.1 – EXISTING TRASNFORMER SCHEDULE

Project Transformers		RS Means Cost	Total	Powersmith Cost (+25%)
Quantity	kVA			
5	15	$1,825.00	$9,125.00	$11,406.25
10	30	$2,125.00	$21,250.00	$26,562.50
0	45	-	-	-
4	75	$3,850.00	$15,400.00	$19,250.00
0	112.5	-	-	-
5	150	$6,675.00	$33,375.00	$41,718.75
8	225	$9,050.00	$72,400.00	$90,500.00
3	300	$11,400.00	$34,200.00	$42,750.00
1	500	$18,900.00	$18,900.00	$23,625.00
1	750	$33,200.00	$33,200.00	$41,500.00
0	1000	-	-	-
2	1500	$35,000.00	$70,000.00	$87,500.00
2	2000	$40,000.00	$80,000.00	$100,000.00
1	2500	$45,000.00	$45,000.00	$56,250.00
1	4160	$60,000.00	$60,000.00	$75,000.00
43	-	-	$492,850.00	$616,062.50

FIGURE 5.2 – PROJECT TOTALS & ESTIMATES

A number of assumptions were made during the analysis to account for real world variables and provide a result that is, as beneficial through cost and energy efficiency, as possible for the end user of the arena.

Operating Hours /Day	12	Nameplate Efficiency (Normal Hours)	95%
Operating Days / Year	365	Existing Efficiency (Outside Normal Hours)	91%
Load During Normal Hours	40%	A/C System Performance	1.2
Load Outside Normal Hours	15%	Powersmith Efficiency (Normal Hours)	98.8%
KWh Rate	$0.04	Powersmith Efficiency (Outside Normal Hours)	98.4%
Demand Rate	$12.00		

FIGURE 5.3 – PROJECT ASSUMPTION VALUES

POWERSMITHS

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ESP for LEED Calculator™

Energy Savings Payback Calculator

Project Description	**John Paul Jones Arena**
Date	**15-Apr-09**

Data Entry

Transformers on Project

QTY	kVA
5	15
10	30
0	45
4	75
5	150
8	225
3	300
1	500
1	750
2	1500
2	2000
1	2500
1	4160

Available Full Load kW	**19035**		
Average kVA (calc)	**443**		
equipment operating hrs/ day	**12**		
equipment operating days/yr	**365**	Calc Load kW	Calc Annual kWh
Load during normal operating hours	**40%**	7614	33,349,320
Load outside operating hours	**15%**	2855	12,505,995
		Total Annual Load kWh:	**45,855,315**

Annual Cost to Operate Load Only

kWh rate	$ **0.040**	Annual Consumption:	$ 1,852,555
demand rate ($/kW/mo) ex. $10.00	**$12.00**	Annual Demand:	$ 1,096,690
		Total Cost to run load	**$ 2,949,245**

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

Nameplate Linear efficiency (normal op hrs)	**95.0%**	% electronics or current THD	**25.0%**
Calculated operating efficiency	93.8%		
Transformer kW Losses (Normal Operation)	507.6 kW		
Status quo Efficiency (Outside op. hrs)	**91.0%**		
Transformer kW Losses (Outside op. hrs)	282.4 kW		
Annual addititional kWh from transformers	3,460,145 kWh		
Annual Cost of Transformer Losses	$ 212,903		
A/C System Performance (kW/ton)	**1.20**		
Additional Tons of Cooling (on peak)	144.20 tons		
Annual addititional kWh from A/C	1,179,595 kWh		
Annual Cost of Associated A/C	$ 72,580		

Summary with Status Quo Transformer

Annual Cost of feeding Building Load	$ 2,949,245
Annual Cost of Transformer Losses	$ 212,903
Annual Cost of Associated A/C	$ 72,580
Electrical Bill (Status Quo Transformer)	**$ 3,234,728**

IMPORTANT: By using the ESP Calculator™, you are agreeing the TERMS OF USE section on page 3

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POWERSMITHS

17-Jan-09

POWERSMITHS | Page 2 | **ESP for LEED Calculator™**

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Energy Savings Payback Calculator

Using Powersmiths instead of status quo transformers

Powersmiths Efficiency (Normal Operation)	98.8%	
Powersmiths kW Losses (Normal Operation)	92.5	kW
Powersmiths Efficiency (Outside op. hrs)	98.4%	
Transformer kW Losses (Outside op. hrs)	46.4	kW
Annual addititional kWh from transformers	608,402	kWh
Annual Cost of Powersmiths Losses	$ 37,900	
Additional Tons of Cooling (on peak)	26.27	tons
Annual addititional kWh from A/C	207,410	kWh
Annual Cost of Associated A/C	$ 12,920	

Comparing Status Quo & Powersmiths

	Status Quo	Powersmiths	Reduction
Annual Cost of feeding Building Load	$ 2,949,245	$ 2,949,245	
Annual Cost of Transformer Losses	$ 212,903	$ 37,900	
Annual Cost of Associated A/C	$ 72,580	$ 12,920	
Annual estimated Electrical Bill	$ 3,234,728	$ 3,000,065	**7%**

Peak kW reduction (normal op hours)	**556.6**	**kW**
Annual kWh reduction	**3,823,928**	**kWh**
Reduction in Air Conditioning Load (on peak)	**117.93**	**tons**

Cost Analysis (calc)

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

	Annual Operating Cost	Life Cycle Operating Cost & Savings 20 years	32 years
Status Quo Transformers	$285,483	$10,312,278	$23,524,549
Powersmiths Transformers	$50,820	$1,835,727	$4,187,692
Savings with Powersmiths	**$234,663**	**$8,476,552**	**$19,336,857**

Cost

	Cost
Powersmiths Transformers	$616,063
Status Quo Transformers	**$493,850**

Payback on total cost	**0.52**	**years**	current kWh rate:
Cost of Energy Savings	**$ 0.001**	**/kWh**	**$0.040**
Cost - Benefit Ratio	**40.5**	**times less to save a kWh than to buy a kWh**	

Leasing Option	60 Month Term	48 Month Term	36 Month Term
Total Annual Leasing Payments	**$155,765**	**$189,994**	**$241,743**
Net Annual Cost with savings	($78,898)	($44,669)	$7,080

Summary of Environmental Benefits

Annual Reduction in Greenhouse Gases (per EPA)		Equivalence	
2,822	**tons of CO2**	**527**	**Acres trees planted**
9,144	**tons of Coal**	**376**	**Car Emissions**
22,125	**kgs of SO2**	**384**	**homes heated**
9,525	**kgs of NOx**		

Conclusion:

The overall analysis of switching from a standard K-rated transformer to one that is more energy efficient shows that, not only will the University of Virginia benefit from lowered cost and energy consumption per year, but they will also be responsible for significantly reducing the affects felt on the environment.

The initial cost difference between the two systems is $122,200, with that amount being paid back in full in just over half a year, or six months. With the implementation of the new transformer system, the University of Virginia will be able to reduce their annual electrical bill for the arena by $230,000, a 7% reduction. The money that is being saved will be available to university officials as a means to help make other aspects of the campus more energy efficient and beneficial to the environment.

Although saving money is a goal for any university, the more important and beneficial impact of changing transformers is the affect on the surrounding environment. Each year, the Powersmith transformers will reduce the amount of CO_2 released into the atmosphere by 2,822 tons or 9,144 tons of coal. These values relate to the planting 527 acres of trees, removing 376 cars and their emissions from the world and heating 384 houses.

The removal of the K-rated transformers and the implementation of the new Powersmith transformers is a completely feasible and beneficial course of action. The new transformers will be able to reduce the energy consumption by 3,823,928 kWh, thus significantly minimizing the annual operating cost, while at the same time benefitting the environment by limiting the greenhouse gases that are being emitted into the atmosphere.

Copper Feeder to Aluminum Feeder Analysis

Introduction:

John Paul Jones Arena is the type of structure that requires a larger than life electrical system to account for the nearly 365,000 square feet of space it takes up. With the system being so large, there are endless amounts of distribution panels, transformers, switchboards and branch panels located all over the arena in electrical closets, storage rooms and even regular rooms. Attached and connecting to all the equipment is 60 different feeder types, all with their own special classifications.

Any typical project being built today will use cooper feeders because of its electrical conductivity, its durability and low thermal coefficient of expansion. The only real downside to copper is the cost. Although aluminum feeders may not be the best physical alternative to copper feeders, a cost estimate was conducted to see if the differences in material would be beneficial to the owner, designer and contractor.

Assumptions:

QUESTION	ASSUMPTION	REASON
Conduit Type	EMT	Typical type of conduit for university institutions
Wire Type	THHN / THWN	RS Means does not account for aluminum THHN/THWN
Aluminum Cost	Use THW	THW copper values are similar to those of THHN/THWN, thus for aluminum THW values will be used
Bend / Elbow Pricing	NO	Need to be performed no matter what, can assume the values are negligible
Aluminum Price Under #6 AWG	Use Copper Value	RS Means does not account for feeders under #6 AWG

1. Due to the sheer size and scope of the building, a calculated average will be tallied as a means to analyze the cost comparing copper and aluminum feeders. There are a total of (6) main distribution panels, but when panels MS-EM and MS-4 are combined, their size and amount of panelboards is similar to that of all the rest. With that being said, all final answers will be multiplied by a factor of (5) in order to get a value that is close to the actual.

2. The arena is broken up into (4) quadrants: NE, NW, SE and SW. With that being the case, assumptions were made regarding the runs. For every run that goes from one quadrant to the same quadrant (NE to NE), the distance is 50' and for every run that goes to a different quadrant (NE to SE), the distance is 100'.

3. A general floor allowance was assumed due to the consistency between floors. The assumptions are as follows: Floor 1 to Floor 3, the distance is 45'; Floor 3 to Floor 4, the distance it 20' and Floor 4 to Floor 7, the distance is 35'.

Conclusion:

After performing the cost analysis between copper and aluminum feeders being used in the John Paul Jones Arena, aluminum feeders were considerably cheaper by almost $2 million dollars. Although this result is just an average based on the assumptions made due to the large nature of the space, it still shows that by switching to aluminum the university could have saved a considerable amount of money. Even though they would be saving money, the switch also introduced (3) new wire sizes and (1) additional conduit size. These added sizes could in the long run slow a building team down and actually end up hindering the project more than it could benefit. Whether it's the cost or preference for aluminum that makes contactors use the cheaper product, in the end it comes down to the fact that no matter how expensive copper gets it will still be used for conduit and wiring.

COPPER FEEDER ANALYSIS								
WIRE (THHN/THWN)	UNITS	LINEAR FEET	CUBIC LINEAR FEET	COST / CLF	TOTAL COST (MATERIALS)	LABOR COST / CLF	TOTAL COST (LABOR)	OVERALL TOTAL
#10	CLF	2400	24.00	$25.00	$600.00	$37.50	$900.00	$1,500.00
#8	CLF	4140	41.40	$43.50	$1,800.90	$47.00	$1,945.80	$3,746.70
#6	CLF	845	8.45	$67.50	$570.38	$58.00	$490.10	$1,060.48
#4	CLF	1675	16.75	$106.00	$1,775.50	$71.00	$1,189.25	$2,964.75
#3	CLF	3960	39.60	$134.00	$5,306.40	$75.00	$2,970.00	$8,276.40
#3/0	CLF	150	1.50	$410.00	$615.00	$150.00	$225.00	$840.00
#4/0	CLF	3730	37.30	$515.00	$19,209.50	$171.00	$6,378.30	$25,587.80
#350 KCMIL	CLF	2230	22.30	$850.00	$18,955.00	$209.00	$4,660.70	$23,615.70
#500 KCMIL	CLF	7240	72.40	$1,175.00	$85,070.00	$2,355.00	$170,502.00	$255,572.00
						INITIAL SUM		$323,163.83
						TOTAL SUM (w/ multiplier)		$1,615,819.13

CONDUIT (EMT)	UNITS	LINEAR FEET	COST / LF	TOTAL COST (MATERIALS)	LABOR COST / LF	TOTAL COST (LABOR)	OVERALL TOTAL
3/4"	CLF	3005	$0.86	$2,584.30	$1.49	$4,477.45	$7,061.75
1"	CLF	2470	$1.44	$3,556.80	$1.82	$4,495.40	$8,052.20
1-1/4"	CLF	3460	$2.45	$8,477.00	$2.17	$7,508.20	$15,985.20
2"	CLF	3880	$4.05	$15,714.00	$2.89	$11,213.20	$26,927.20
3"	CLF	430	$10.90	$4,687.00	$5.10	$2,193.00	$6,880.00
4"	CLF	7240	$14.25	$103,170.00	$6.60	$47,784.00	$150,954.00
					INITIAL SUM		$215,860.35
					TOTAL SUM (w/ multiplier)		$1,079,301.75

COPPER ESTIMATE	$2,695,120.88

COPPER FEEDER SCHEDULE

FROM	TO	FEEDER ID NO.	SETS	CONDUIT		CONDUCTORS (PER SET)									OVERCURRENT PROTECTION	LENGTH (ft)	FLOOR ALLOWANCE (ft)	GROUND LENGTH	TOTAL LENGTH
						PHASE			NEUTRAL			GROUND							
				SIZE	TYPE	NO.	SIZE	TYPE	NO.	SIZE	TYPE	NO.	SIZE	TYPE					
D3E-1NE1	TE-1NE1	2	1	3/4"	EMT	3	#10	CU THWN	-	-	-	1	#10	CU THWN	30	50	0	50	150
P3E-3SW1	TE-3SW1	2	1	3/4"	EMT	3	#10	CU THWN	-	-	-	1	#10	CU THWN	30	50	0	50	150
P3E-3NW1	TE-3NW1	2	1	3/4"	EMT	3	#10	CU THWN	-	-	-	1	#10	CU THWN	30	50	0	50	150
P3E-1SE1	TE-3NE1	2	1	3/4"	EMT	3	#10	CU THWN	-	-	-	1	#10	CU THWN	30	100	0	100	300
P3E-3NE1	TE-3NE1	2	1	3/4"	EMT	3	#10	CU THWN	-	-	-	1	#10	CU THWN	30	50	0	50	150
D3E-1SE1	P3E-1SE1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D3E-1SW1	P3E-3SW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	45	95	195
D3N-1SW1	P3N-4SW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	65	115	215
D3N-1NW1	T-1NW2	6	1	1-1/4"	EMT	3	#3	CU THWN	-	-	-	1	#8	CU THWN	100	50	0	50	150
D1N-1NW1	P1N-1NW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D1N-1NW1	P1N-1SW3	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	100	0	100	300
D3N-1NW1	P3N-1NW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D3N-1NW1	P3N-3NW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	45	95	195
D3N-1NW1	P3N-4NW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	65	115	215
TE-1NW1	P1E-1NW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D3E-1NW3	P3E-3NW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	45	95	195
D3E-1NE1	P3E-3NE1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	45	95	195
D1N-3SW1	P1N-3SW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D1N-3SW1	P1N-3SW2	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D1N-3SW2	F1N-3SW5	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D1N-3NW1	P1N-3NW2	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
TE-3NW2	P1E-3NW2	206	1	1-1/4"	EMT	3	#3	CU THWN	2	#1/0	CU THWN	1	#8	CU THWN	100	50	0	50	150
TE-4SE1	P1E-4SE1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D1N-4SW1	P1N-4SW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
TE-4NW1	P1E-4NW1	26	1	1-1/4"	EMT	3	#3	CU THWN	1	#3	CU THWN	1	#8	CU THWN	100	50	0	50	150
D3N-1SW1	P3N-1SW1	30	1	2"	EMT	3	#3/0	CU THWN	1	#3/0	CU THWN	1	#6	CU THWN	200	50	0	50	150
D3N-1SW1	T-4SW1	13	1	3"	EMT	3	#350 KCMIL	CU THWN	-	-	-	1	#4	CU THWN	310	50	65	115	215
D3N-1NW1	T-4NW1	13	1	3"	EMT	3	#350 KCMIL	CU THWN	-	-	-	1	#4	CU THWN	310	50	65	115	215
MS-2	ATS-1	35	2	4"	EMT	3	#350 KCMIL	CU THWN	2	#350 KCMIL	CU THWN	2	#1	CU THWN	600	100	0	200	600
D1N-3SW1	F1N-3SW1	35	2	4"	EMT	3	#350 KCMIL	CU THWN	2	#350 KCMIL	CU THWN	2	#1	CU THWN	600	50	0	100	300
D1N-4NW1	F1N-4NW2	35	2	4"	EMT	3	#350 KCMIL	CU THWN	2	#350 KCMIL	CU THWN	2	#1	CU THWN	600	50	0	100	300
T-4NW1	D1N-4NW1	35	2	4"	EMT	3	#350 KCMIL	CU THWN	2	#350 KCMIL	CU THWN	2	#1	CU THWN	600	50	0	100	300
ATS-1	D3E-1NW3	35	2	4"	EMT	3	#350 KCMIL	CU THWN	2	#350 KCMIL	CU THWN	2	#1	CU THWN	600	50	0	100	300
TE-1SE1	P1E-1SE1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	0	50	150
D3N-1SW1	L3N-1SW1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	0	50	150
D3N-1SW1	L3N-3SW1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	45	95	195
D3N-1SW1	L3N-4SW1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	65	115	215
D3N-1NW1	L3N-1NW1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	0	50	150
D3N-1NW1	L3N-4NW1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	65	115	215
TE-1NE1	P1E-1NE1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	0	50	150
D1N-3SW2	F1N-3SW3	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	0	50	150
TE-1SW1	P1E-1SW1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	90	50	0	50	150
TE-4NE1	P1E-4NE1	25	1	1"	EMT	3	#4	CU THWN	1	#4	CU THWN	1	#8	CU THWN	85	50	0	50	150
D1N-1SW1	P1N-1SW1	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-1SW1	P1N-1SW2	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D3N-1SW1	P3N-3SW1	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	45	95	195
D3N-1NW1	T-3NW1	11	1	2"	EMT	3	#4/0	CU THWN	-	-	-	1	#4	CU THWN	230	50	45	95	195
MS-2	T-1SW1	11	1	2"	EMT	3	#4/0	CU THWN	-	-	-	1	#4	CU THWN	230	100	0	100	300
MS-2	T-1NW1	11	1	2"	EMT	3	#4/0	CU THWN	-	-	-	1	#4	CU THWN	230	100	0	100	300
D1N-1NW1	P1N-1NW3	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-1NW1	P1N-1SW4	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	100	0	100	300
T-1NW2	P1N-1NW2	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-3SW1	F1N-3SW2	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-3SW2	F1N-3SW4	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-3SW2	F1N-3SW1	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-3NW1	P1N-3NW1	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-3NW1	F1N-3NW1	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-4SW1	P1N-4SW2	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150

D1N-4SW1	F1N-4SW1	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-4SW1	F1N-3SW2	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	20	70	170
D1N-4SW1	F1N-3SW3	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	20	70	170
D1N-4NW1	P1N-4NW1	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-4NW1	P1N-4NW2	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D1N-4NW1	F1N-4NW1	31	1	2"	EMT	3	#4/0	CU THWN	1	#4/0	CU THWN	1	#4	CU THWN	230	50	0	50	150
D3N-1SW1	T-3SW1	14	1	4"	EMT	3	#500 KCMIL	CU THWN	-	-	-	1	#3	CU THWN	380	50	45	95	195
T-1SW1	D1N-1SW1	34	1	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#3	CU THWN	400	50	0	50	150
MS-2	T-3SW2	14	1	4"	EMT	3	#500 KCMIL	CU THWN	-	-	-	1	#3	CU THWN	380	100	45	145	345
MS-2	D3N-1NW1	36	2	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#1/0	CU THWN	750	100	0	100	600
MS-2	D3N-1SW1	37	3	4"	EMT	3	#500 KCMIL	CU THWN	3	#500 KCMIL	CU THWN	3	#2/0	CU THWN	1140	100	0	300	900
T-1NW1	D1N-1NW1	37	3	4"	EMT	3	#500 KCMIL	CU THWN	3	#500 KCMIL	CU THWN	3	#2/0	CU THWN	1140	50	0	150	450
T-2	MS-2	101	8	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	-	-	-	3000	100	0	100	2400
D3E-1NW3	MCC3E-7NW1	14	1	4"	EMT	3	#500 KCMIL	CU THWN	-	-	-	1	#3	CU THWN	400	50	100	150	250
D3E-1NW3	D3E-1SW1	34	1	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#3	CU THWN	400	100	0	100	300
D3E-1NW3	D3E-1SE1	34	1	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#3	CU THWN	400	100	0	100	300
D3E-1NW3	D3E-1NE1	34	1	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#3	CU THWN	400	100	0	100	300
T-3NW1	D1N-3NW1	34	1	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#3	CU THWN	400	50	0	50	150
T-3SW1	D1N-3SW1	36	2	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#1/0	CU THWN	750	50	0	50	300
T-3SW2	D1N-3SW2	36	2	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#1/0	CU THWN	750	50	0	50	300
T-4SW1	D1N-4SW1	36	2	4"	EMT	3	#500 KCMIL	CU THWN	1	#500 KCMIL	CU THWN	1	#1/0	CU THWN	750	50	0	50	300
D3N-1NW1	L3N-3NW1	24	1	1"	EMT	3	#6	CU THWN	1	#6	CU THWN	1	#10	CU THWN	65	50	45	95	195
D1N-3SW1	DR1N-3SW1	24	1	1"	EMT	3	#6	CU THWN	1	#6	CU THWN	1	#10	CU THWN	65	50	0	50	150
D1N-3NW1	DR1N-3NW1	24	1	1"	EMT	3	#6	CU THWN	1	#6	CU THWN	1	#10	CU THWN	65	50	0	50	150
TE-3NW1	P1E-3NW1	24	1	1"	EMT	3	#6	CU THWN	1	#6	CU THWN	1	#10	CU THWN	65	50	0	50	150
TE-3NE1	P1E-3NE1	24	1	1"	EMT	3	#6	CU THWN	1	#6	CU THWN	1	#10	CU THWN	65	50	0	50	150
D3E-1SE1	TE-4SE1	3	1	3/4"	EMT	3	#8	CU THWN	-	-	-	1	#10	CU THWN	50	50	65	115	215
D3E-1SE1	TE-1SE1	3	1	3/4"	EMT	3	#8	CU THWN	-	-	-	1	#10	CU THWN	50	50	0	50	150
D3E-1SW1	TE-1SW1	3	1	3/4"	EMT	3	#8	CU THWN	-	-	-	1	#10	CU THWN	50	50	0	50	150
D3E-1SW1	TE-4SW1	3	1	3/4"	EMT	3	#8	CU THWN	-	-	-	1	#10	CU THWN	50	50	65	115	215
D3E-1NW3	TE-1NW1	3	1	3/4"	EMT	3	#8	CU THWN	-	-	-	1	#10	CU THWN	50	50	0	50	150
D3E-1NW3	TE-4NW1	3	1	3/4"	EMT	3	#8	CU THWN	-	-	-	1	#10	CU THWN	50	50	65	115	215
D3E-1NW3	TE-3NW2	3	1	3/4"	EMT	3	#8	CU THWN	-	-	-	1	#10	CU THWN	50	50	45	95	195
D3E-1NE1	TE-4NE1	3	1	3/4"	EMT	3	#8	CU THWN	-	-	-	1	#10	CU THWN	50	50	65	115	215
TE-3SW1	P1E-3SW1	23	1	3/4"	EMT	3	#8	CU THWN	1	#8	CU THWN	1	#10	CU THWN	50	50	0	50	150
TE-3NE1	P1E-3SE1	23	1	3/4"	EMT	3	#8	CU THWN	1	#8	CU THWN	1	#10	CU THWN	50	100	0	100	300
TE-4SW1	P1E-4SW1	23	1	3/4"	EMT	3	#8	CU THWN	1	#8	CU THWN	1	#10	CU THWN	50	50	0	50	150

ALUMINUM FEEDER ANALYSIS								
WIRE (THHN/THWN)	UNITS	LINEAR FEET	CUBIC LINEAR FEET	COST / CLF	TOTAL COST (MATERIALS)	LABOR COST / CLF	TOTAL COST (LABOR)	OVERALL TOTAL
#8	CLF	2400	24.00	$43.50	$1,044.00	$47.00	$1,128.00	$2,172.00
#6	CLF	4140	41.40	$31.50	$1,304.10	$47.00	$1,945.80	$3,249.90
#4	CLF	945	9.45	$39.50	$373.28	$58.00	$548.10	$921.38
#2	CLF	3235	32.35	$53.50	$1,730.73	$71.00	$2,296.85	$4,027.58
#1	CLF	4250	42.50	$78.50	$3,336.25	$83.50	$3,548.75	$6,885.00
#2/0	CLF	600	6.00	$112.00	$672.00	$104.00	$624.00	$1,296.00
#3/0	CLF	250	2.50	$138.00	$345.00	$114.00	$285.00	$630.00
#4/0	CLF	550	5.50	$154.00	$847.00	$121.00	$665.50	$1,512.50
#250 KCMIL	CLF	150	1.50	$188.00	$282.00	$130.00	$195.00	$477.00
#300 KCMIL	CLF	3730	37.30	$259.00	$9,660.70	$139.00	$5,184.70	$14,845.40
#500 KCMIL	CLF	2230	22.30	$340.00	$7,582.00	$188.00	$4,192.40	$11,774.40
#750 KCMIL	CLF	7240	72.40	$505.00	$36,562.00	$235.00	$17,014.00	$53,576.00
						INITIAL SUM		$101,367.15
						TOTAL SUM (w/ multiplier)		$506,835.75

CONDUIT (EMT)	UNITS	LINEAR FEET	COST / LF	TOTAL COST (MATERIALS)	LABOR COST / LF	TOTAL COST (LABOR)	OVERALL TOTAL
3/4"	CLF	3005	$0.86	$2,584.30	$1.49	$4,477.45	$7,061.75
1"	CLF	1675	$1.44	$2,412.00	$1.82	$3,048.50	$5,460.50
1-1/4"	CLF	795	$2.45	$1,947.75	$2.17	$1,725.15	$3,672.90
1-1/2"	CLF	3460	$3.18	$11,002.80	$2.46	$8,511.60	$19,514.40
2"	CLF	3730	$4.05	$15,106.50	$2.89	$10,779.70	$25,886.20
2-1/2"	CLF	150	$9.50	$1,425.00	$4.09	$613.50	$2,038.50
4"	CLF	9470	$14.25	$134,947.50	$6.60	$62,502.00	$197,449.50
					INITIAL SUM		$63,634.25
					TOTAL SUM (w/ multiplier)		$318,171.25

ALUMINUM ESTIMATE	$825,007.00

ALUMINUM FEEDER SCHEDULE																			
FROM	TO	FEEDER ID NO.	SETS	CONDUIT		CONDUCTORS (PER SET)									OVERCURRENT PROTECTION	LENGTH (ft)	FLOOR ALLOWANCE (ft)	GROUND LENGTH	TOTAL LENGTH
						PHASE			NEUTRAL			GROUND							
				SIZE	TYPE	NO.	SIZE	TYPE	NO.	SIZE	TYPE	NO.	SIZE	TYPE					
D3E-1NE1	TE-1NE1	2	1	3/4"	EMT	3	#8	ALTHWN	-	-	-	1	#8	ALTHWN	30	50	0	50	150
P3E-3SW1	TE-3SW1	2	1	3/4"	EMT	3	#8	ALTHWN	-	-	-	1	#8	ALTHWN	30	50	0	50	150
P3E-3NW1	TE-3NW1	2	1	3/4"	EMT	3	#8	ALTHWN	-	-	-	1	#8	ALTHWN	30	50	0	50	150
P3E-1SE1	TE-3NE1	2	1	3/4"	EMT	3	#8	ALTHWN	-	-	-	1	#8	ALTHWN	30	100	0	100	300
P3E-3NE1	TE-3NE1	2	1	3/4"	EMT	3	#8	ALTHWN	-	-	-	1	#8	ALTHWN	30	50	0	50	150
D3E-1SE1	P3E-1SE1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D3E-1SW1	P3E-3SW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	45	95	195
D3N-1SW1	P3N-4SW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	65	115	215
D3N-1NW1	T-1NW2	6	1	1-1/2"	EMT	3	#1	ALTHWN	-	-	-	1	#6	ALTHWN	100	50	0	50	150
D1N-1NW1	P1N-1NW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D1N-1NW1	P1N-1SW3	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	100	0	100	300
D3N-1NW1	P3N-1NW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D3N-1NW1	P3N-3NW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	45	95	195
D3N-1NW1	P3N-4NW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	65	115	215
TE-1NW1	P1E-1NW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D3E-1NW3	P3E-3NW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	45	95	195
D3E-1NE1	P3E-3NE1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	45	95	195
D1N-3SW1	P1N-3SW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D1N-3SW1	P1N-3SW2	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D1N-3SW2	F1N-3SW5	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D1N-3NW1	P1N-3NW2	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
TE-3NW2	P1E-3NW2	206	1	1-1/2"	EMT	3	#1	ALTHWN	2	#3/0	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
TE-4SE1	P1E-4SE1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D1N-4SW1	P1N-4SW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
TE-4NW1	P1E-4NW1	26	1	1-1/2"	EMT	3	#1	ALTHWN	1	#1	ALTHWN	1	#6	ALTHWN	100	50	0	50	150
D3N-1SW1	P3N-1SW1	30	1	2-1/2"	EMT	3	#250 KCMIL	ALTHWN	1	#250 KCMIL	ALTHWN	1	#4	ALTHWN	200	50	0	50	150
D3N-1SW1	T-4SW1	13	1	4"	EMT	3	#500 KCMIL	ALTHWN	-	-	-	1	#2	ALTHWN	310	50	65	115	215
D3N-1NW1	T-4NW1	13	1	4"	EMT	3	#500 KCMIL	ALTHWN	-	-	-	1	#2	ALTHWN	310	50	65	115	215
MS-2	ATS-1	35	2	4"	EMT	3	#500 KCMIL	ALTHWN	2	#500 KCMIL	ALTHWN	2	#2/0	ALTHWN	600	100	0	200	600
D1N-3SW1	F1N-3SW1	35	2	4"	EMT	3	#500 KCMIL	ALTHWN	2	#500 KCMIL	ALTHWN	2	#2/0	ALTHWN	600	50	0	100	300
D1N-4NW1	F1N-4NW2	35	2	4"	EMT	3	#500 KCMIL	ALTHWN	2	#500 KCMIL	ALTHWN	2	#2/0	ALTHWN	600	50	0	100	300
T-4NW1	D1N-4NW1	35	2	4"	EMT	3	#500 KCMIL	ALTHWN	2	#500 KCMIL	ALTHWN	2	#2/0	ALTHWN	600	50	0	100	300
ATS-1	D3E-1NW3	35	2	4"	EMT	3	#500 KCMIL	ALTHWN	2	#500 KCMIL	ALTHWN	2	#2/0	ALTHWN	600	50	0	100	300
TE-1SE1	P1E-1SE1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	0	50	150
D3N-1SW1	L3N-1SW1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	0	50	150
D3N-1SW1	L3N-3SW1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	45	95	195
D3N-1SW1	L3N-4SW1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	65	115	215
D3N-1NW1	L3N-1NW1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	0	50	150
D3N-1NW1	L3N-4NW1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	65	115	215
TE-1NE1	P1E-1NE1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	0	50	150
D1N-3SW2	F1N-3SW3	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	0	50	150
TE-1SW1	P1E-1SW1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	90	50	0	50	150
TE-4NE1	P1E-4NE1	25	1	1"	EMT	3	#2	ALTHWN	1	#2	ALTHWN	1	#6	ALTHWN	85	50	0	50	150
D1N-1SW1	P1N-1SW1	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-1SW1	P1N-1SW2	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D3N-1SW1	P3N-3SW1	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	45	95	195
D3N-1NW1	T-3NW1	11	1	2"	EMT	3	#300 KCMIL	ALTHWN	-	-	-	1	#2	ALTHWN	230	50	45	95	195
MS-2	T-1SW1	11	1	2"	EMT	3	#300 KCMIL	ALTHWN	-	-	-	1	#2	ALTHWN	230	100	0	100	300
MS-2	T-1NW1	11	1	2"	EMT	3	#300 KCMIL	ALTHWN	-	-	-	1	#2	ALTHWN	230	100	0	100	300
D1N-1NW1	P1N-1NW3	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-1NW1	P1N-1SW4	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	100	0	100	300
T-1NW2	P1N-1NW2	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-3SW1	F1N-3SW2	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-3SW2	F1N-3SW4	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-3SW2	F1N-3SW1	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-3NW1	P1N-3NW1	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-3NW1	F1N-3NW1	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-4SW1	P1N-4SW2	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150
D1N-4SW1	F1N-4SW1	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	50	0	50	150

D1N-4SW1	P1N-3SW2	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	30	20	70	170
D1N-4SW1	P1N-3SW3	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	30	20	70	170
D1N-4NW1	P1N-4NW1	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	30	0	50	150
D1N-4NW1	P1N-4NW2	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	30	0	50	150
D1N-4NW1	P1N-4NW1	31	1	2"	EMT	3	#300 KCMIL	ALTHWN	1	#300 KCMIL	ALTHWN	1	#2	ALTHWN	230	30	0	50	150
D3N-1SW1	T-3SW1	14	1	4"	EMT	3	#750 KCMIL	ALTHWN	-	-	-	1	#1	ALTHWN	380	30	45	95	195
T-1SW1	D1N-1SW1	34	1	4"	EMT	3	#750 KCMIL	ALTHWN	1	#750 KCMIL	ALTHWN	1	#1	ALTHWN	400	30	0	50	150
MS-2	T-3SW2	14	1	4"	EMT	3	#750 KCMIL	ALTHWN	-	-	-	1	#1	ALTHWN	380	100	45	145	345
MS-2	D3N-1NW1	36	2	4"	EMT	3	#750 KCMIL	ALTHWN	1	#750 KCMIL	ALTHWN	1	#3/0	ALTHWN	750	100	0	100	500
MS-2	D3N-1SW1	37	3	4"	EMT	3	#750 KCMIL	ALTHWN	3	#750 KCMIL	ALTHWN	3	#4/0	ALTHWN	1140	100	0	300	900
T-1NW1	D1N-1NW1	37	3	4"	EMT	3	#750 KCMIL	ALTHWN	3	#750 KCMIL	ALTHWN	3	#4/0	ALTHWN	1140	30	0	150	450
T-2	MS-2	101	8	4"	EMT	3	#750 KCMIL	ALTHWN	1	#750 KCMIL	ALTHWN	-	-	-	3000	100	0	100	2400
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T-3NW1	D1N-3NW1	34	1	4"	EMT	3	#750 KCMIL	ALTHWN	1	#750 KCMIL	ALTHWN	1	#1	ALTHWN	400	30	0	50	150
T-3SW1	D1N-3SW1	36	2	4"	EMT	3	#750 KCMIL	ALTHWN	1	#750 KCMIL	ALTHWN	1	#3/0	ALTHWN	750	30	0	50	300
T-3SW2	D1N-3SW2	36	2	4"	EMT	3	#750 KCMIL	ALTHWN	1	#750 KCMIL	ALTHWN	1	#3/0	ALTHWN	750	30	0	50	300
T-4SW1	D1N-4SW1	36	2	4"	EMT	3	#750 KCMIL	ALTHWN	1	#750 KCMIL	ALTHWN	1	#3/0	ALTHWN	750	30	0	50	300
D3N-1NW1	L3N-3NW1	24	1	1-1/4"	EMT	3	#4	ALTHWN	1	#4	ALTHWN	1	#8	ALTHWN	65	30	45	95	195
D1N-3SW1	DR1N-3SW1	24	1	1-1/4"	EMT	3	#4	ALTHWN	1	#4	ALTHWN	1	#8	ALTHWN	65	30	0	50	150
D1N-3NW1	DR1N-3NW1	24	1	1-1/4"	EMT	3	#4	ALTHWN	1	#4	ALTHWN	1	#8	ALTHWN	65	30	0	50	150
TE-3NW1	P1E-3NW1	24	1	1-1/4"	EMT	3	#4	ALTHWN	1	#4	ALTHWN	1	#8	ALTHWN	65	30	0	50	150
TE-3NE1	P1E-3NE1	24	1	1-1/4"	EMT	3	#4	ALTHWN	1	#4	ALTHWN	1	#8	ALTHWN	65	30	0	50	150
D3E-1SE1	TE-4SE1	3	1	3/4"	EMT	3	#6	ALTHWN	-	-	-	1	#8	ALTHWN	30	30	65	115	215
D3E-1SE1	TE-1SE1	3	1	3/4"	EMT	3	#6	ALTHWN	-	-	-	1	#8	ALTHWN	30	30	0	50	150
D3E-1SW1	TE-1SW1	3	1	3/4"	EMT	3	#6	ALTHWN	-	-	-	1	#8	ALTHWN	30	30	0	50	150
D3E-1SW1	TE-4SW1	3	1	3/4"	EMT	3	#6	ALTHWN	-	-	-	1	#8	ALTHWN	30	30	65	115	215
D3E-1NW3	TE-1NW1	3	1	3/4"	EMT	3	#6	ALTHWN				1	#8	ALTHWN	30	30	0	50	150
D3E-1NW3	TE-4NW1	3	1	3/4"	EMT	3	#6	ALTHWN	-	-	-	1	#8	ALTHWN	30	30	65	115	215
D3E-1NW3	TE-3NW2	3	1	3/4"	EMT	3	#6	ALTHWN	-	-	-	1	#8	ALTHWN	30	30	45	95	195
D3E-1NE1	TE-4NE1	3	1	3/4"	EMT	3	#6	ALTHWN	-	-	-	1	#8	ALTHWN	30	30	65	115	215
TE-3SW1	P1E-3SW1	23	1	3/4"	EMT	3	#6	ALTHWN	1	#6	ALTHWN	1	#8	ALTHWN	30	30	0	50	150
TE-3NE1	P1E-3SE1	23	1	3/4"	EMT	3	#6	ALTHWN	1	#6	ALTHWN	1	#8	ALTHWN	30	100	0	100	300
TE-4SW1	P1E-4SW1	23	1	3/4"	EMT	3	#6	ALTHWN	1	#6	ALTHWN	1	#8	ALTHWN	30	30	0	50	150

SECTION SIX: ARCHITECTURAL / STRUCTURAL BREADTH

Introduction

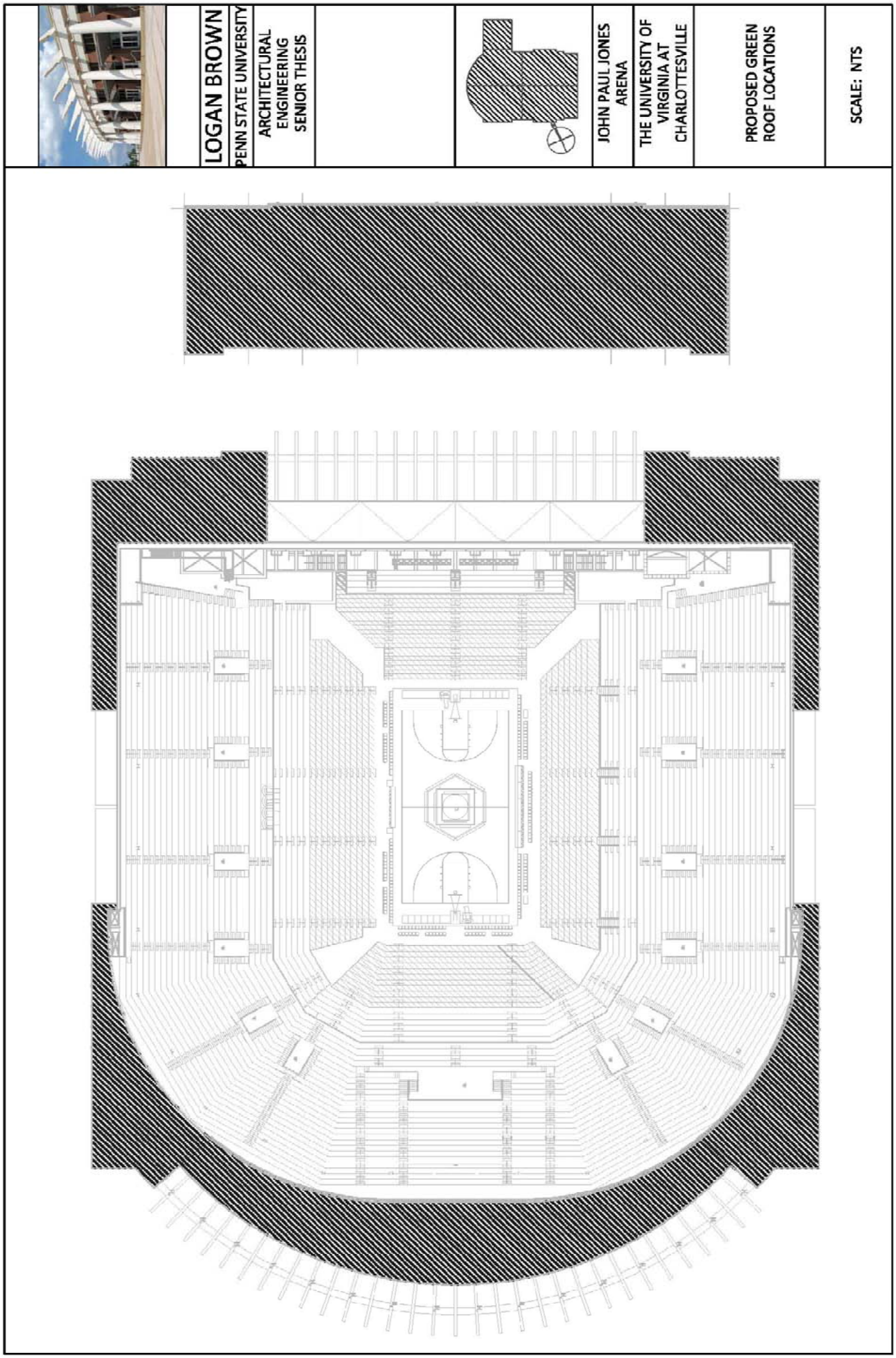
Sustainable and green architecture had become a very serious topic of interest over the past few years. The demand from the public and from potential clients has grown exponentially to a point where they want buildings that not only meet their needs and desires, but also fit into the environment and 'sustain' or improve the footprint in which they are building. This process of creating a sustainable building may come anywhere from selecting products grown in close proximity to the building site, using natural energy to power the systems of the project and even down to the amount glass that is facing certain directions to accept solar light throughout the day. Needless to say there are numerous ways that any given project can be sustainable and give back to the environment. One of the most popular and beneficial to clients is the installation of a green roof system.

A green roof is an extremely feasible solution for any building due to their simplicity of installation and eventual payback to the owner. The system is comprised of a roof that is covered in some type of soil or vegetation (growing medium) and placed over a waterproofing membrane that keeps all the excess water from draining into the building. With the addition of the growing medium on the roof, these systems are capable of cleaning up the environment the minute they are installed. Other benefits include lowering the energy consumption of the building, improving storm water management issues, purifying the air of the area around the structure as well as reducing temperature extremes that occur within a standard building footprint.

Although the benefits outweigh the costs, one downside to the system is that it significantly increase the demand loads on the structural system of a building. Unless a design is conceived and worked through during the construction document phase of a project, retrofitting a large building is a difficult task. Retrofitting is feasible and easily done for smaller projects and rural designs, but adding one to a structure that is larger than 200,000 square feet can create a large hassle and in the long be unsuccessful.

The John Paul Jones arena is one such structure that is extremely large and does not currently have a green roof system. Proposing putting a green roof on an arena has not been done numerous times before and designs for them are untypical due to the complex nature of the design and creation of a sports stadium. The arena appears to be a perfect candidate for a green roof due to its large size (huge potential for payback), flat and open roof sections that already have been designed for bigger than normal rain and runoff loads and the structural system is custom designed to successfully handle all the loads an arena carries.

This analysis will show if it feasible to install a typical green roof system on the arena, not only in terms of architecture and environmental payback, but by also performing a structural analysis to see if the structural system will be affected.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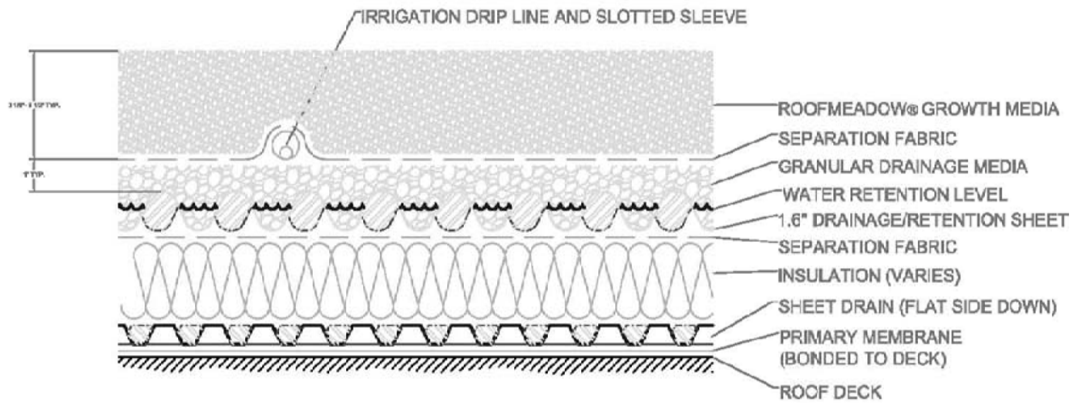
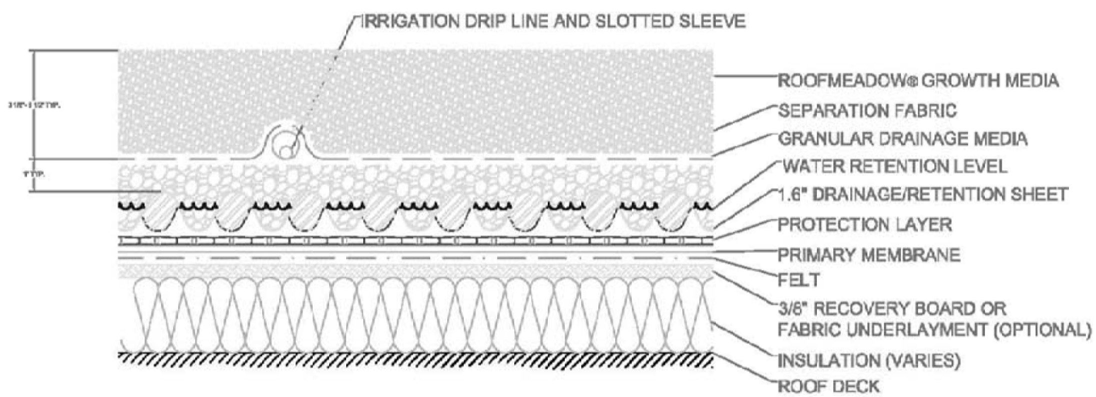
PENN STATE UNIVERSITY
ARCHITECTURAL ENGINEERING SENIOR THESIS
JOHN PAUL JONES ARENA
THE UNIVERSITY OF VIRGINIA AT CHARLOTTESVILLE
PROPOSED GREEN ROOF LOCATIONS
SCALE: NTS



2 ROOFMEADOW® HEATH

PRM CONFIGURATION



3 ROOFMEADOW® HEATH

PRM CONFIGURATION

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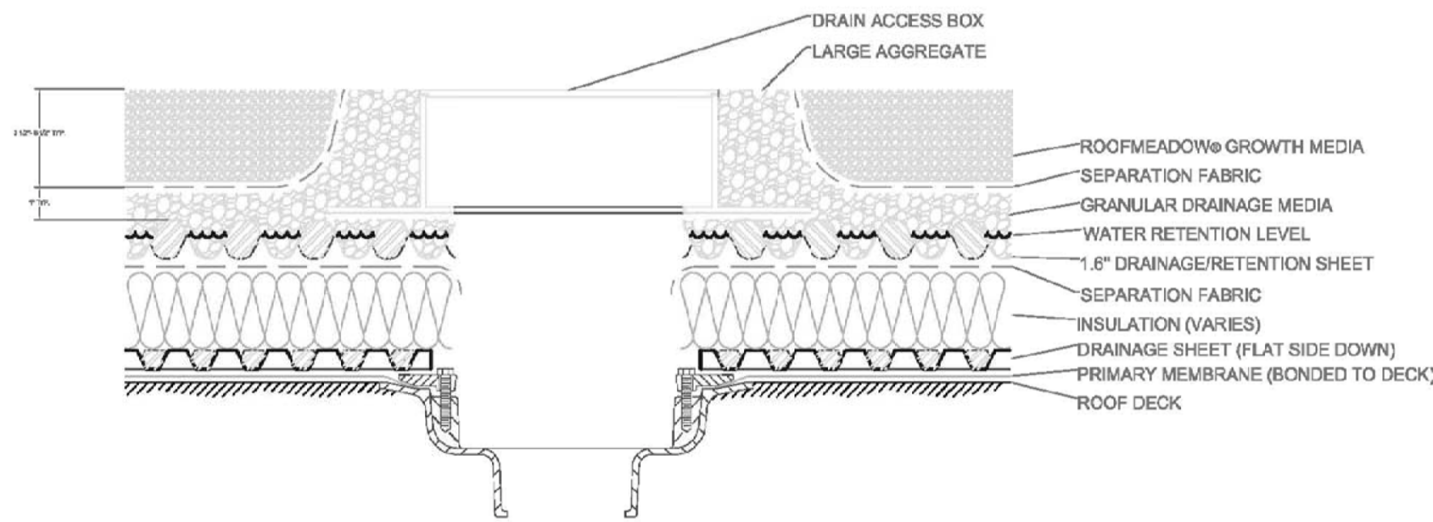
JOHN PAUL JONES ARENA

THE UNIVERSITY OF VIRGINIA AT CHARLOTTESVILLE

GREEN ROOF SECTIONS

SCALE: NTS



1 ROOFMEADOW® DRAIN DETAIL

PRM CONFIGURATION

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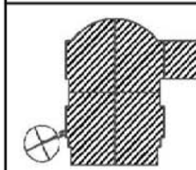
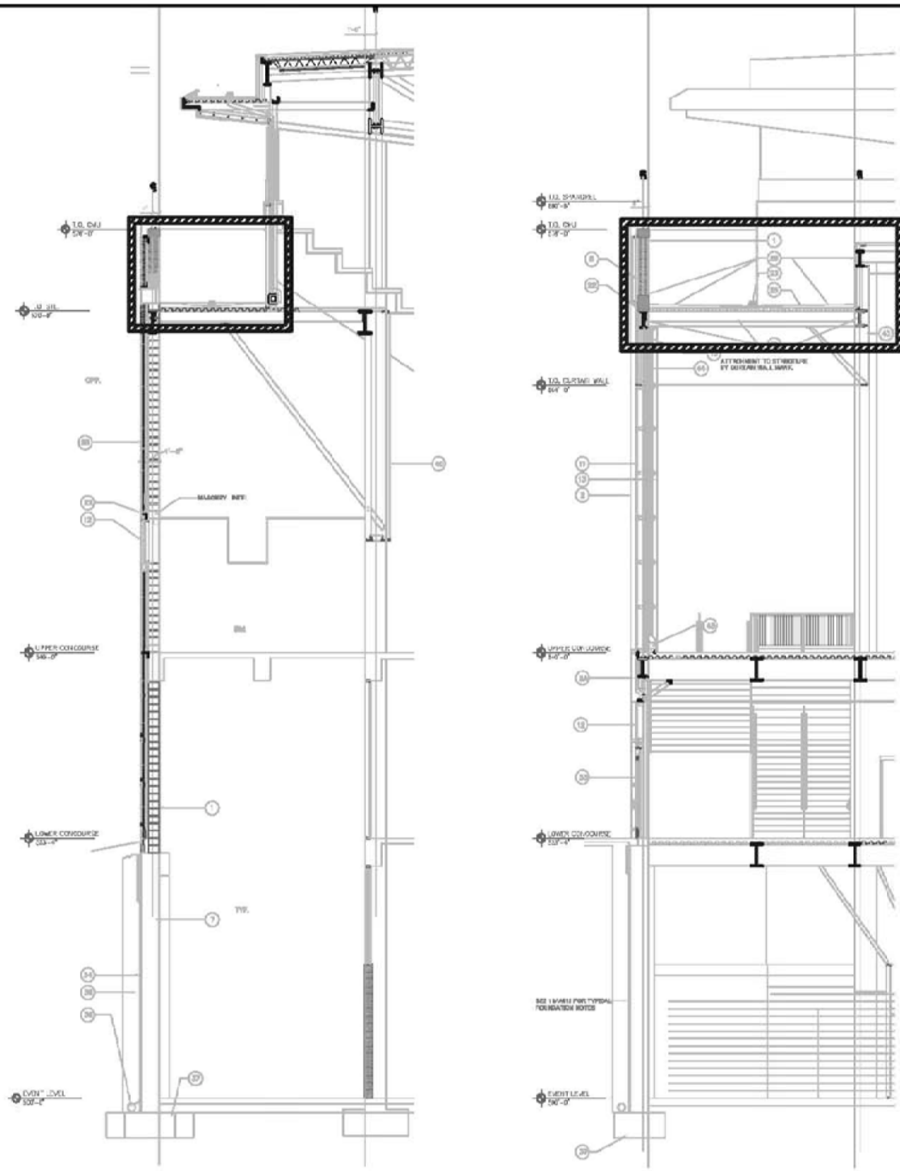


JOHN PAUL JONES ARENA

THE UNIVERSITY OF VIRGINIA AT CHARLOTTESVILLE

GREEN ROOF SECTIONS

SCALE: NTS



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BUILDING SECTIONS
WITH PROPOSED
GREEN ROOF AREA

SCALE: NTS

	TOTAL AREA (SF)	COST / SF	TOTAL COST	% ENTIRE ROOF	% FLAT ROOF
EXSITING ENTIRE ROOF	126740	$150.00	$19,011,000.00	-	-
EXISTING FLAT ROOF	72011	-	-	56.8%	-
PROPOSED GREEN ROOF	40599	$20.00	$811,980.00	32.0%	56.4%

Structural Analysis

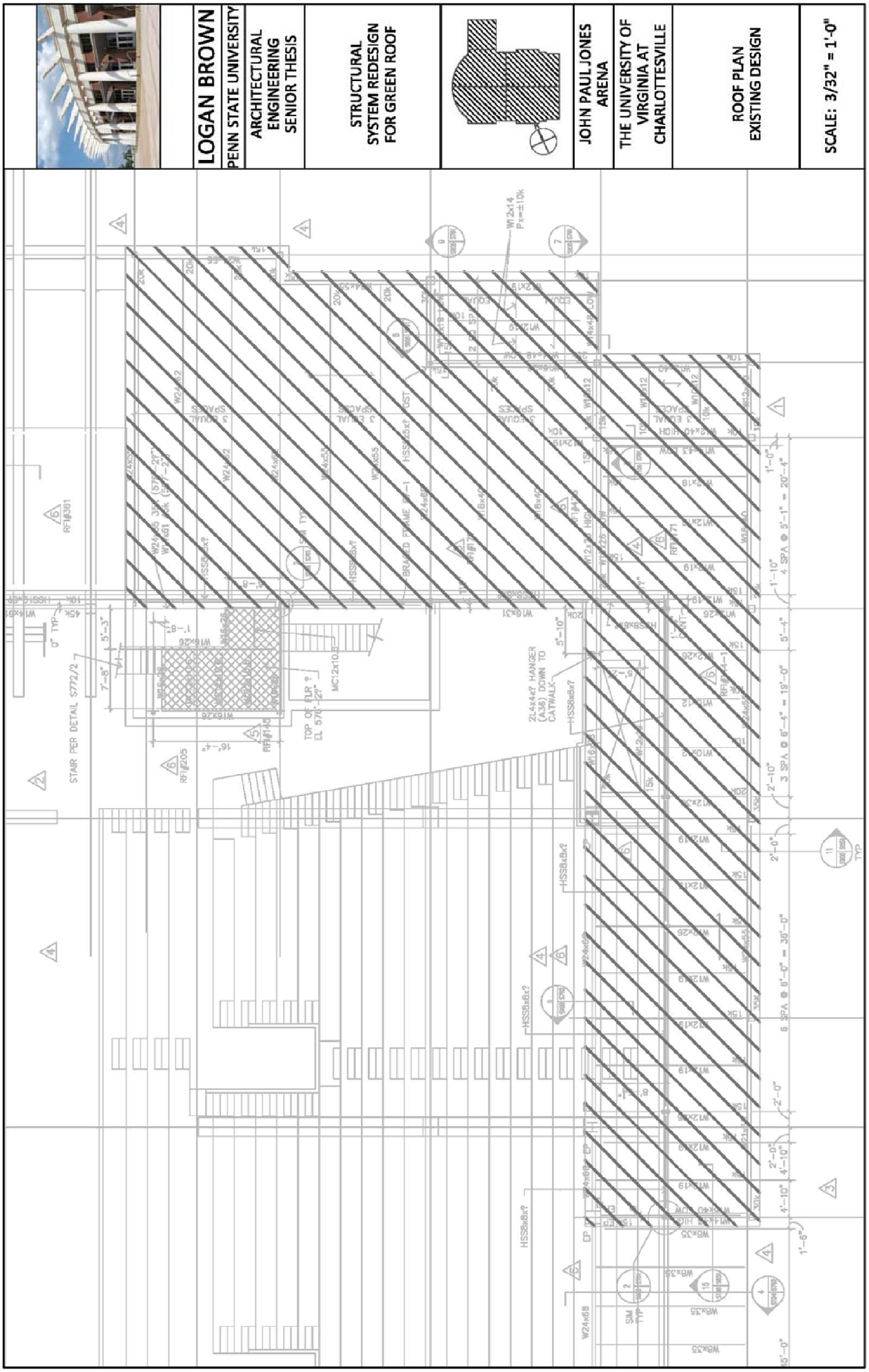
Introduction:

A green roof is a great addition to any space. But thinking past the aesthetics and environmental paybacks, the structural system is almost as important. In order to account for the added loads of the system (dry and saturated), a structural redesign was analyzed based on a specific section of the proposed roof area.

Structural System Assumptions:

DESIGN CONSIDERATION	ASSUMPTION
Concrete (Nominal Weight)	145 psf
Live Load	100 psf
Superimposed Dead Load	25 psf
Snow Load	20 psf
Green Roof Load	54 psf
Steel Decking	ACW 3 (composite metal with 5" slab)

1. Due to the complex nature of the actual structural system, simplifications were made when inputting information into the RAM model.
2. A small section was selected to be tested due to its uniformity and standard bay sizes. Other parts of the building were not modeled due to their size and uniformity.
3. Layouts were used that most closely represented the actual building design. In some cases where concrete slabs were used or a large opening existed, steel members were substituted and assumed to have equal spacing to in order to account for the load that would be assumed from the concrete.
4. The only space under consideration for this analysis was the roof because of how it directly affected by the additional loads from the green roof system.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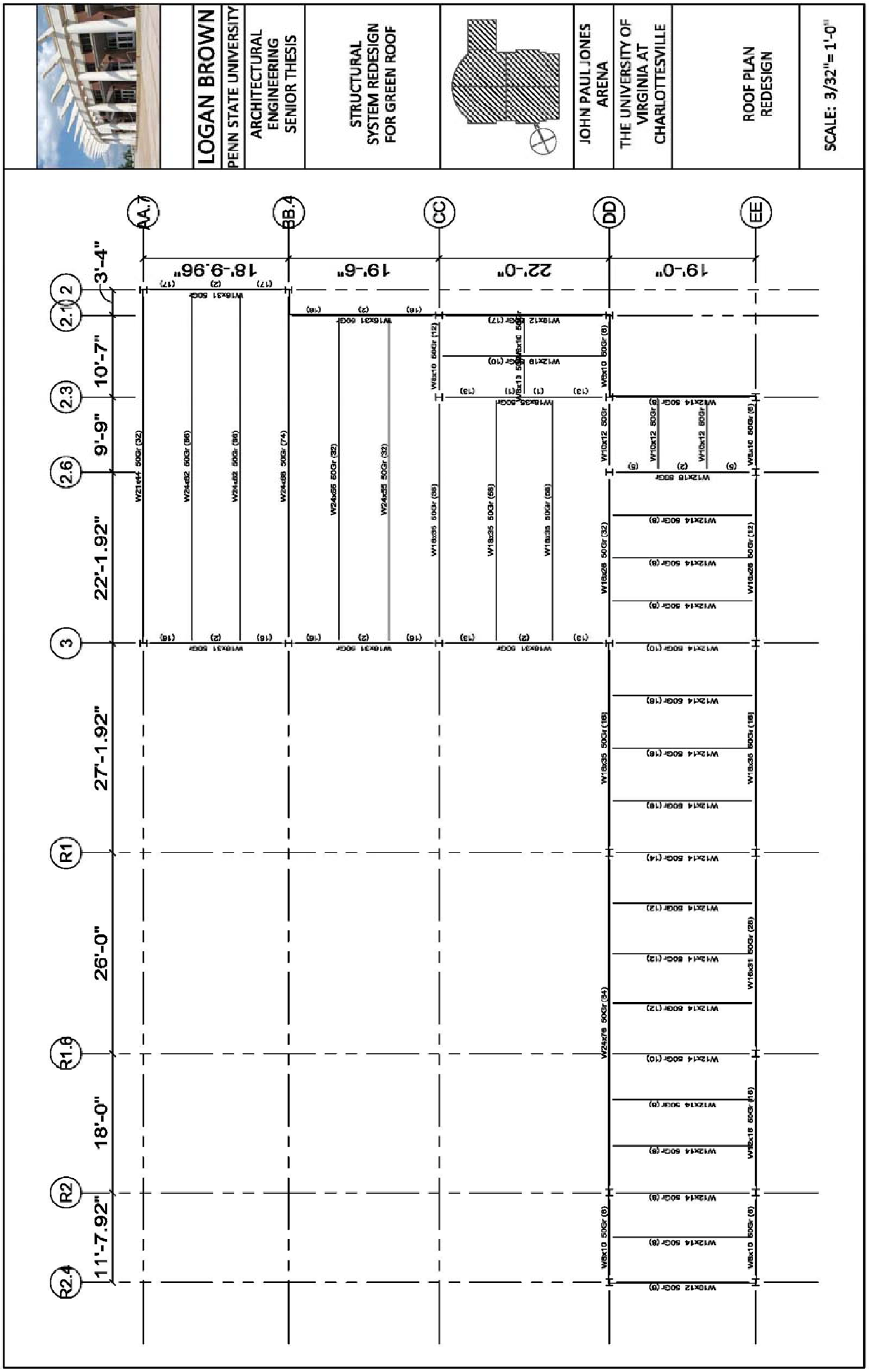
STRUCTURAL SYSTEM REDESIGN FOR GREEN ROOF
JOHN PAUL JONES ARENA
THE UNIVERSITY OF VIRGINIA AT CHARLOTTESVILLE
ROOF PLAN EXISTING DESIGN
SCALE: 3/32" = 1'-0"



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STRUCTURAL SYSTEM REDESIGN FOR GREEN ROOF
JOHN PAUL JONES ARENA
THE UNIVERSITY OF VIRGINIA AT CHARLOTTESVILLE
ROOF PLAN REDESIGN
SCALE: 3/32"=1'-0"
AA.7
BB.4
CC
DD
EE
2
2.1
2.3
2.6
3
R1
R1.6
R2
R2.4
3'-4"
10'-7"
9'-9"
22'-1.92"
27'-1.92"
26'-0"
18'-0"
11'-7.92"
18'-9.96"
19'-6"
22'-0"
19'-0"

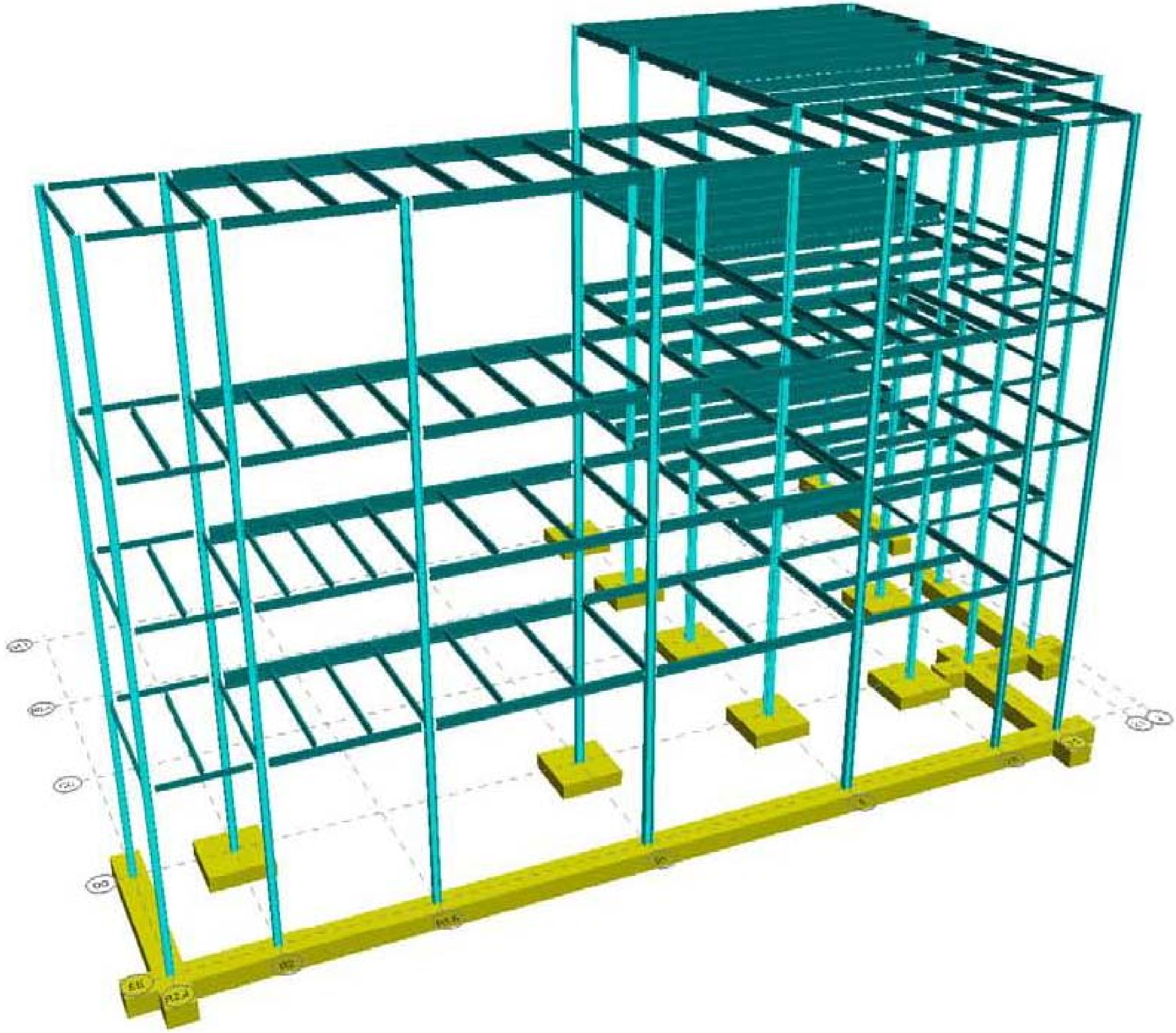

FIGURE 6.1.1 – RAM Concept Model of proposed structural redesign

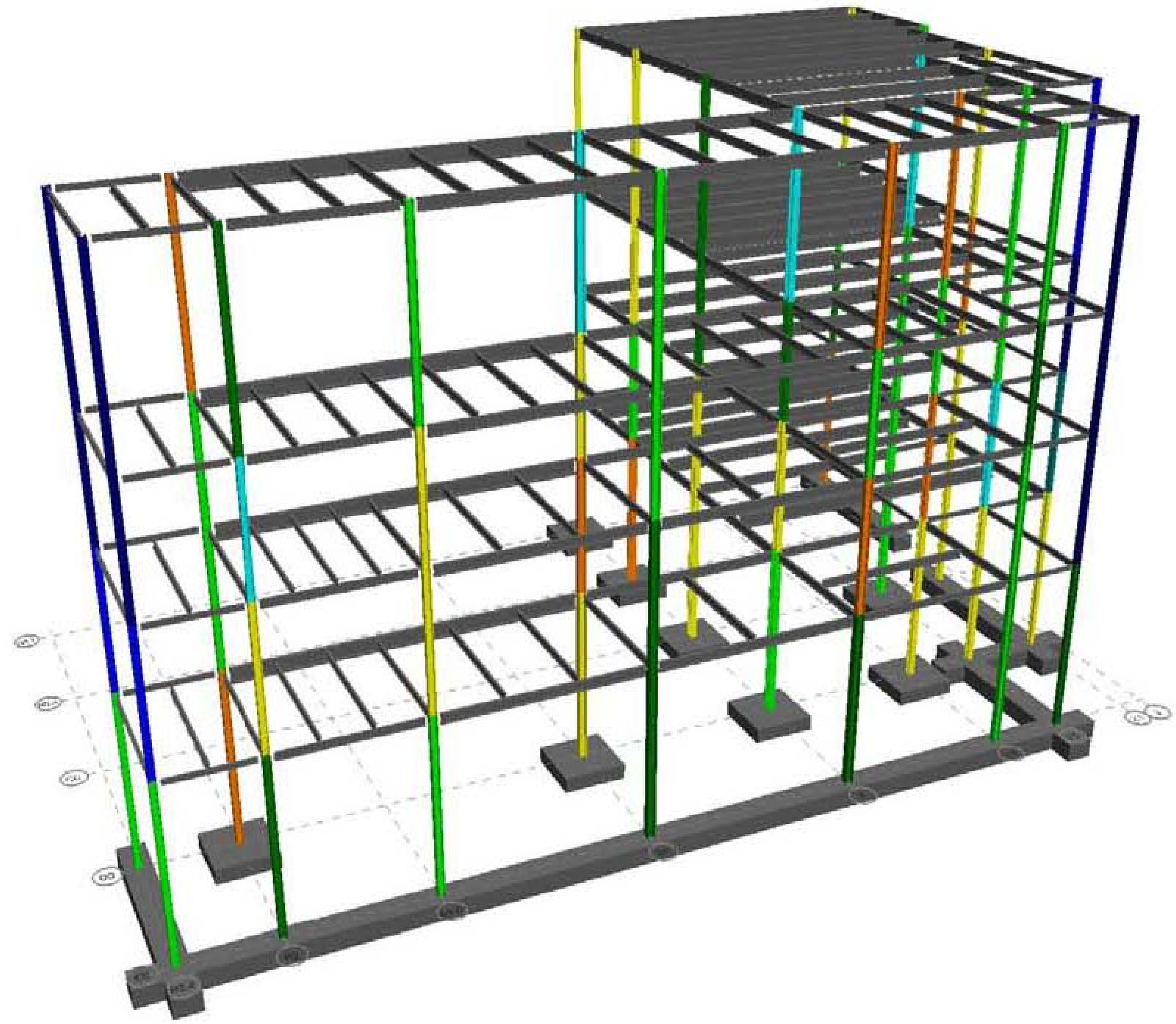

FIGURE 6.1.2 – RAM Concept Model of proposed structural redesign with column loads

<u>Conclusion:</u>

The redesign of the structural system to account for a green roof is feasible. The results from RAM show that this section of the arena will be able to hold the added weight due to soil and growth. Due to no lateral loads being applied to the model, some of the redesign members are smaller then what is already in place. It is necessary to consider the lateral loads on this section of the building at the roof level; it is 80 feet off the ground and will have substantial wind affects because of the lack of vegetation and barriers in close proximity. Another reason for the smaller member could be due to the engineers overdesigning the original project because of how custom the arena is. Either way, both methods are acceptable and the proposed redesign would work if the University does indeed decide to retrofit the arena.

SECTION SEVEN: CONCLUSIONS AND SUMMARY

The John Paul Jones Arena is a perfect mixture of form and function. The exterior mimics a campus that was designed by Thomas Jefferson and still strives for the excellence that he professed as one of the founding fathers of our country. The spaces within are just as grandiose as the Doric colonnade that adorns the western façade. From concession spaces to meeting rooms to a state of the art practice facility and gym, no expensive was spared when designing one of the top arenas on the east coast.

A theme of circulation and spaciousness was created in order to help tie all aspects of the building together. Two of the three floors are located below grade and lack natural illumination. That is in direct opposite comparison to the lobby and entry area that is covered in a curtain wall system that makes going from the exterior to the interior seem seamless. The idea of bringing that light from the lobby down through the rest of the spaces was accomplished by using lighting techniques that focused on the general illumination more than direct, pin-pointed light. It was imperative that all lighting within the arena was used to accent and highlight objects and walkways instead of drawing attention away from the architecture. The cohabitation of spaces and lighting were the reason redesign tried to reiterate these ideas of spaciousness, circulation and the melding of interior and exterior.

The electrical changes that occurred in the building were the result of the lighting modifications and the desire to make the space more sustainable. Panelboards were modified to account for the added loads of new lighting systems and to handle the circuiting that is required for being able to control various zones in each of the redesigned spaces. An analysis of converting to energy efficient transformers showed a significant cost savings and relatively short payback period. A study into switching from copper to aluminum feeders was done and showed that there was s significant cost difference, but in the long run aluminum will never be the metal alloy that copper is.

An analysis looking into whether a green roof system would be feasible for an arena showed mixed results. Aesthetically the green roof system would be hard to see from the ground level and exterior due to the sheer height of the building, but the added benefits to the environment and energy consumption are outstanding. Along with the addition of a green roof, a structural analysis was performed to see if the custom steel and concrete building could support the weight from soil and saturation. The conclusion showed it was feasible and that the structure could survive from adding a green roof with minimal structural steel upgrades and beam resizing.

SECTION EIGHT: REFERENCES

Additional information and resources that aided in the completion of the senior thesis project and design analysis:

The IESNA Lighting Handbook, 9th ed., Illuminating Engineering Society of North America, New York, NY, 2000.

National Electric Code 2008, Quincy, MA: National Fire Protection Association, Inc., 2007.

ASHRAE Standard 90.1 – 2007: Energy Standard for Building Except Low-Rise Residential Buildings. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA. 2007.

The following computer programs were used in renderings, calculations and additional analysis:

AutoCAD 2009
AGI 32
RAM Concept
Adobe Photoshop CS3
Microsoft Office

SECTION NINE: ACKNOWLEDGEMENTS

Gracious thanks to all those individuals who assisted in making this senior thesis report possible and for supporting me in one of the most challenging learning experiences of my young adult life. Thank you all very much!

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- Dad
- Mom
- Little Broski
- Bill and Connie
- Nana
- Gram

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- Brick Box Girls
- Anyone and everyone in AE

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- Professor Ted Dannerth
- Professor Robert Holland
- Professor Kevin Parfitt

Ellerbe Becket

- Jim Hamm
- Paula Gillette
- Vittorio Ansourian

VMDO Architects

- Bob Moje

The University of Virginia

- Jon Oliver
- Jason Bauman