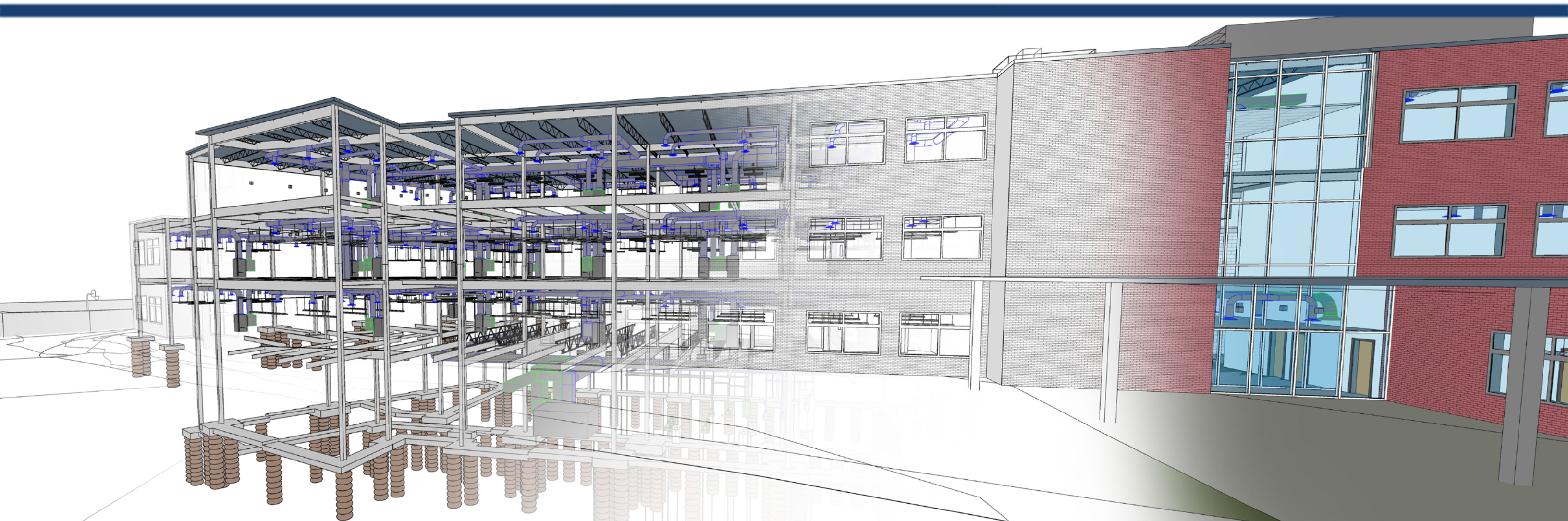
Reading
Elementary
School

AEI Team 10-2013

Lighting + Electrical



February 22, 2013

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Executive Summary

Lighting and electrical systems are designed to deliver a high quality learning environment by stimulating productivity through a clear visual environment, promoting various interactive educational opportunities, while ensuring occupants safety. Additionally, lighting and electrical systems are designed to control cost and optimize energy efficiency with technologies that are easily operated and maintained by the administration and personnel.

Student productivity is enhanced by supplemented daylight in all classrooms in conjunction with indirect/direct luminaires supplying illumination at a color temperature to seamlessly combine with that of daylight. Open, bright classrooms applying light levels in accordance with recommendations by IESNA to student work planes and appropriate illuminance to vertical instruction surfaces including but not limited to walls, white boards and bulletin boards promote a productive educational environment.

Interactive projectors supported by document cameras, DVD/Blu-ray, iPads, iPhones, audio and VCRs allow instructors to easily educate students through a range of technologies and methods. Traditional education methods are supplemented by exposed building systems, highlighted by paint colors to clearly describe organized system integration. Touch screens in the main lobby and large group instructional areas receive building performance data from digital ballasts and metering, linking comprehensive building design concepts with building performance to students.

Student and instructor safety is ensured by card swipe access into the school, in addition to security systems located in the security room of the East Wing to monitor automatic locks and security cameras throughout the facility and site. The administration also receives security camera feeds to regulate the people entering the school. Security camera quantities are limited to avoid negative influences to student's perception of the facility, instead placed in strategic areas to monitor key access points of the site and facility. Vandalism, crime and safety are monitored by cameras and exposed by illuminaition of the site at night. Electrical systems focus on reliability and safety through high quality automatic transfer switches, breakers, grounds, receptacle layouts, emergency lighting and fire alarm design in accordance with IEC, FEMA, and IBC. The multipurpose space is designed to function as a community shelter in during emergencies. The electrical and mechanical equipment are provided emergency power by a dual-fuel generator located in the basement.

Initial and lifetime system costs are balanced to optimize energy savings throughout the building. Daylighting shading strategies reduce mechanical loads at peak operating hours. Dimming technologies calibrated at optimal times and positions reduce lighting electricity consumption when daylight contributions are substantial. Additionally, facility lighting energy consumption is minimized at night in accordance with LEED 2009 for Schools New Construction and Major Renovations – to achieve LEED silver accreditation.

Lighting and electrical systems take advantage of the best technologies the industry has to offer, while considering flexibility and future renovations incorporating future technologies. Electrical loads are organized and circuited by the spaces served in an effort to allow maintenance on specific spaces rather than large groups of areas. Electrical loads are organized by type, for similar reasons, and to allow metering of panels accurately relaying energy consumption and performance by load type. Digital lighting controls are simplified to allow instructors to change educational lighting scenes easily and efficiently. Lighting in the pool eliminates luminaires directly above the pool, instead locating luminaires along the perimeter of the space to be lowered to the pool deck for maintenance.

SECTION 1: LIGHTING/ELECTRICAL NARRATIVE

Building as an Teaching Tool

Reading Elementary School is intended to utilize the most innovative technologies to educate students in new ways. Building systems are exposed throughout the building to provide teachers with an opportunity to creatively educate students. Large group instructional areas and lobby areas are equipped with interactive touch screen monitors that summarize building characteristics and energy consumption to further educate students and the community. Exposed systems throughout the building will bridge the gap between the information presented in the monitors and the building design. A curriculum educating students is to be coordinated with the administration.

Figure 1: Large group instruction next to the green roof rendering

Figure 2: Classroom rendering

Classrooms showcase exposed ductwork between suspended ceiling panels, light shelves, structural elements above the ceiling, and suspended luminaires. The corridor exposes cable trays and color-coded hot and cold water pipes along the perimeter of the suspended ceiling tiles in the corridor. The gym and community pool will showcase integration and exposed systems. A 3rd floor large group instructional area enclosed by an exterior curtain wall will provide views to an adjacent green roof above the 2nd floor.

Figure 3: Corridor rendering

Building Envelope

Daylight serves as a primary lighting and electrical design component. Effective daylight design for Reading Elementary is integrated across numerous design disciplines by establishing the optimal glazing aperture size, locations, glazing types, and exterior and interior shading systems in the initial elementary school design considerations. Extensive daylight calculations balance structural considerations when developing the building envelope, cooling loads, interior and exterior aesthetics, occupant views to the exterior, daylight harvesting to reduce heating energy consumption, luminaire dimming energy savings, and both initial and life-cycle costs associated with the designed systems. The Reading Elementary building envelope provides windows to various rooms, in combination with curtain wall systems to numerous circulation areas that all benefit from daylight and exterior views.

Windows

Each classroom is designed to incorporate two typical windows along the school façade. Typical window dimensions are sized to 10 ft. in length by 6 ft. in width. Each classroom has two windows. Typical windows have a 3 ft. sill height as depicted in **Figure 4**. Typical window dimensions throughout Reading Elementary remain the same size to decrease the installation time, allowing for cost savings and construction schedule benefits.

SHGC	Shading Coefficient	Visible Light Transmission	U-Value	Outdoor Visible Light Reflectance	Interior Reflectance	UV	Light to Solar Gain Ratio
0.4	0.46	74%	0.28	11%	12.4%	25%	1.85

Table 1 - SOLARBAN 60 Performance Referenced by PPG Certified Fabricator

Glazing specifications utilizing a low-e coating within a double pane clear glass construction maximize the amount of visible light entering the interior, while balancing the amount of heat transferred into the school. **Table 1** summarizes the performance characteristics of the SOLARBAN 60 (2) Starphire + Starphire glazing product.

Multiple interior and exterior shading devices were analyzed to reduce glare and control solar contributions to the building load profiles. Initially the façade of the building incorporated exterior and interior light shelves along the East, South, and West sides of the school. Additionally, exterior light fins integrated within East and West-facing window apertures were initially proposed. However the final proposal includes exterior light shelf along the South and East-facing façades. The South-facing façades integrate an interior light shelf into the window design. **Figure 4** outlines the 3 ft. aluminum exterior light shelf, located 7 ft. above the ground to exceed the 80 in. minimum allowance as required by I.B.C. The interior light shelf is integrated into the window design, 2 ft. in length, located 7 ft. above the ground. A thermal break exists between the exterior and interior light shelf, reducing heat transfer through the window. The exterior light shelf is continuous along the exterior façade of the building. The optimal light shelf dimensions were determined by solar profile angle analysis for a site located at 40° N latitude (see **SECTION 2: Figure(s) 16-25**). Analysis concluded differing light shelf dimensions, depending on the orientation of the façade encasing the window apertures. To provide consistent window dimensions throughout the building, to decrease installation time, the optimal light shelf dimensions for the South façades were selected – as the South façade receives maximal solar exposure throughout the course of a school day.

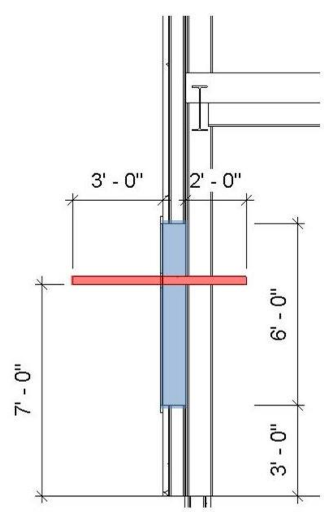


Figure 4: Typical window section

Orientation	Dimensions (WxD)	DA_{300}
SE	28’-0” x 40’-0”	37.86
NW	27’-0” x 30’-0”	53.81
NE	33’-0” x 28’-0”	63.95
S	26’-0” x 31’-0”	60.37

Table 2: Classroom DA_{300}

Annual Daylight metrics were computed using the DAYSIM computer analysis software. DAYSIM provides annual daylight metrics including Daylight Autonomy (DA), Continuous Daylight Autonomy (cDA), and Useful Daylight Illuminance (UDI) for spaces modeled three-dimensionally in AutoCAD software. DA, cDA, and UDI provided feedback on the effectiveness of shading devices in relation to classrooms throughout the entire year. **Table 2** provides a summary of DA data in different classrooms, with experimented shading conditions. The DA is dependent upon the shading conditions modeled, the dimensions of the classroom, and the window orientation along the façade.

Results indicate that an interior and exterior light shelf is most effective along the South, and Southeast classrooms, when looking at DA. Additionally, UDI further determines the effectiveness of the designed light shelves to reduce solar glare on the South and Southeast façades. Results also indicate that the impact of light fins to reduce solar glare along the Northeast and Northwest façades is minimal, and therefore does not warrant the cost of the light fins.

Another important characteristic of effective daylight design is controlling the heat gain to reduce cooling loads during warmer months, and allowing for daylight harvesting during heating months. Interior light shelves are designed to reduce glare, but provide minimal effectiveness in optimizing solar heat gain. Therefore, exterior light shelves were analyzed to study the effectiveness of light shelves along every façade. Interior shade options were also analyzed to study the performance of the entire window assembly. Interior shades with a transmittance of 10% were specified for the analysis. **SECTION 2: Figure(s) 26-29** summarizes the solar heat gain characteristics of different exterior and shade conditions.

The aforementioned analysis of both annual daylight metrics and solar heat gain calculations allowed for the façade of the building to be customized to provide optimized performance, ultimately delivering a comfortable and energy efficient window and façade design.

Equally as important as determining the proper window locations along the building façade are determining where to exclude window apertures along the building façade. Façades facing West utilize fewer window apertures to reduce the cooling loads during warmer months of the school year. The multipurpose space is designed without any window apertures, to reduce the amount of solar heat gain during cooling seasons and to provide a secure space to be used as a community shelter. The multipurpose space serves as a Risk Category IV space per I.B.C. Openings in the CMU walls reduce the strength of the structure. The pool, located in the basement, could benefit from natural daylight. However, the pool structure is designed utilizing load-bearing walls supporting 3 floors of the elementary school above, allowing minimal space for window apertures. The necessary excavation to allow for windows below grade and the heat transfer through the windows negate the benefits of natural daylight in the pool.

Roof

Clerestories and skylights were initially proposed on the 3rd floor roof, and the location of the green roof above the 2nd floor. Clerestories, providing additional side-lighting to the school windows were eliminated early in the design, due to structural complications and additional cost of additional structural columns. Skylights were then analyzed to provide top lighting daylight design strategies. Two commercial skylight products were analyzed. **Table 3** summarizes both skylight options characteristics.

Manufacturer	Opening (LxW)	Well depth	U-value	SHGC	VLT (%)	Cost ($)
Sunoptics	4'-0" x 4'-0"	2'-0"	0.62	0.33	63%	$1,000.00
VELUX	4'-0" x 4'-0"	0'-9"	0.69	0.49	51%	$1,000.00

Table 3: Skylight performance characteristics Referenced from Velux and Sunoptics Specifications

Annual Daylight metrics were computed using the DAYSIM computer analysis software to study the impact of two skylights in each classroom, in combination with the previously discussed classroom glazing. Solar heat gain calculations were also performed, to determine the solar heat gain energy performance of the skylights. Ultimately, the analysis was performed to compare the heating and cooling costs and solar heat gain energy performance to the cost savings and electric lighting energy reduction from luminaire dimming. Cost savings were calculated using an average electric cost of $0.14 kWh and heating fuel cost of $1.01/Therm. A summary of the energy performance and cost savings from the aforementioned analysis are included in **SECTION 2: Table(s) 12, 13**. Refer to **SECTION 2: Figure(s) 30-33** for further DAYSIM calculation analysis data.

Skylights proved to be energy efficient, and provide life-cycle cost benefits. However, it is unlikely that a 10-year payback period will be accepted in the Reading Elementary school district. The low initial cost of a prefabricated commercial skylight results in a product that is not energy efficient enough to provide a shorter payback period. For customized skylights, performing more efficiently, the cost initial cost would increase dramatically. Additionally, the proposed interior classroom design presented in **Section 4.1** does not lend itself to a cost-effective skylight design. Furthermore, the proposed location of the green roof further adds structural costs and installation issues to integrate skylights into the green roof design. Therefore, skylights are omitted from the final design proposal.

Curtain Wall

Curtain Wall allows large amounts of daylight into transitional spaces throughout the school. Refer to **Figure(s) 6-7** for curtain wall locations. Additionally, curtain wall spanning vertically around transitional spaces connects the exterior school grounds with the interior of the school, while providing a pleasant architectural aesthetics. Luminaire dimming energy savings are anticipated in transitional spaces experiencing large amounts of daylight, providing daylight harvesting. Glazing specified in **Table 1** ensures excellent daylight and heat transfer performance. Curtain wall locations facing West (see **Figure 6**), where direct solar exposure in the afternoon can drastically increase peak building loads, are partially shaded by

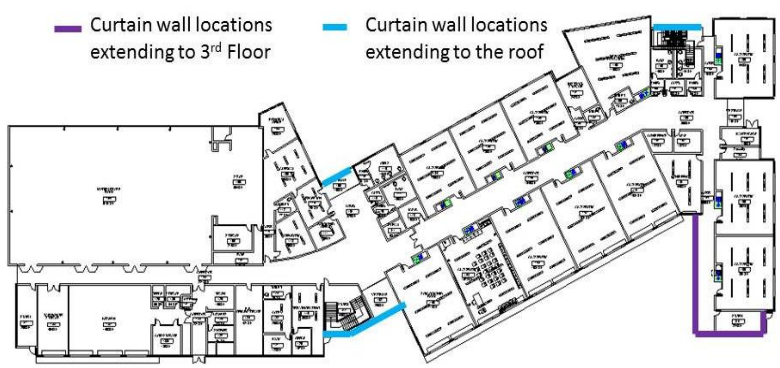


Figure 6: 1st floor curtain wall locations

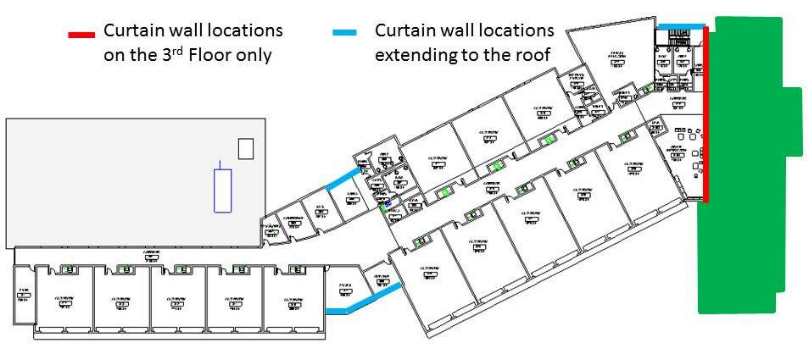


Figure 7: 3rd floor curtain wall location

other areas of the building. Additionally, the Western solar exposure late in the day during summer months will occur outside of the normal school year. Curtain wall on the 3rd floor provides unobstructed views from the large group instruction area onto the green roof depicted in **Figure 7**.

Electrical Systems

Electrical systems in Reading Elementary are designed to provide a safe facility for students, faculty, building maintenance, and the community. Electrical systems are intended to provide state-of-the art learning opportunities for students, while also providing energy savings, and monitoring of power consumption.

Power Distribution

Power is delivered underground from the grid, into the Electrical Room located in the basement, where it is stepped down by a 1000kVA dry type transformer. Power is then distributed from the switchgear to 480/277V lighting panels and stepped down to a 208/120V distribution panel. Refer to **SECTION 3: E-400** for a one-line diagram describing power distribution throughout the school. Lighting equipment uses 480/277V to minimize wire size, while receptacles, security cameras, telecom, card swipe access, automatic door locks, clocks, speakers, and fire alarm electronics are powered on 208/120V. (2) 480/277V lighting panels are provided on each floor, with (3) 208/120V panels provided on each floor. Enough panel boards are located to allow for future growth. A 480/277V panelboard is located on the third floor to serve roof top air handling units (RTUs). A 480/277V panelboard is located in the basement to provide power to the heat pumps outside of each classroom. Meters upstream of panel boards provide building maintenance with energy consumption data. DALI controls provide lighting energy consumption feedback, eliminating the necessity of meters upstream of panelboards that serve lighting equipment. Panelboards are organized by load type and circuits are organized by room. Organization of panelboards and circuits will allow future system retrofit to be conducted easily. Additionally, the organization of electric loads will provide accurate and organized energy consumption data by load type.

Telecom

Telecommunications equipment is housed in the Main Distribution Frame (M.D.F.), and Intermediate Distribution Frame (I.D.F). The M.D.F. is centrally located on each floor of the school, so as not to exceed 90m (300ft.) in horizontal distribution length. The M.D.F. is sized to 11ft. x 11ft. to serve about 10,000 ft^2 of useable floor space. Each floor of the elementary totals about 20,000 ft^2 of useable floor space, requiring the I.D.F. as an additional room for telecommunications equipment, sized at 13 ft. x 11 ft. to serve an additional 10,000 ft^2 of useable floor space. The I.D.F. is intended to primarily serve the Eastern portion of the elementary school, while the M.D.F. is intended to primarily serve the central core and the Western portions of the school (see **Figure 8**). Cable trays distribute CAT5 cable throughout each floor through the corridors. In many instances, cable trays are located along the perimeter of the corridor, where they are exposed. Refer to **SECTION 3: L-305** for a section of the proposed exposed cable trays, and additional cable trays located above the suspended corridor ceiling.

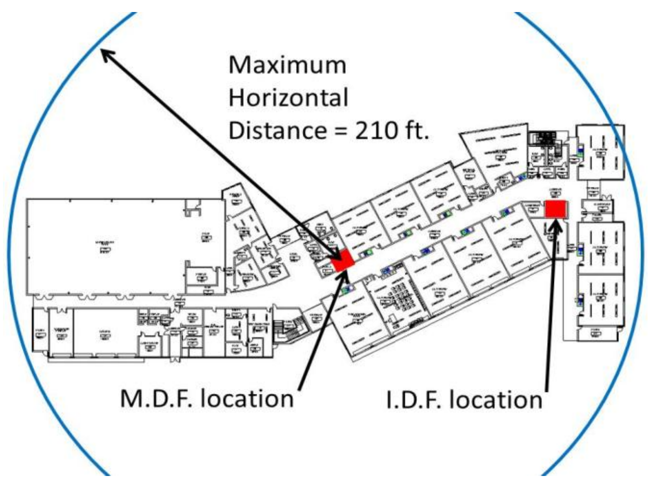


Figure 8: Maximum telecom distribution diagram

Lighting Controls

Luminaires throughout the building are controlled by a Digital Addressable Lighting Interface (DALI). DALI enables dimmable ballasts, transformers, relay modules, emergency fittings and controllers from different manufacturers to be incorporated together; providing the building managers and users a flexible system. The multiple scene controls and varying activity types demanded to deliver a functional and comfortable learning environment, can easily be controlled by DALI, warranting the high initial cost. Additionally, because DALI is designed to support products from varying manufacturers, retrofit and renovation transitions between existing and new products will be simplified. Because future lighting system retrofits are predicted, the DALI system will allow the Reading Elementary to improve future energy efficiency as lighting technologies become more efficient in the future. The DALI system will provide energy feedback, to be analyzed by building managers, enabling the building managers to improve the efficiency of installed products. Energy feedback will also provide teachers with an opportunity to educate students in a curriculum teaching about the building.

Main Ethernet Switches are located on each floor of the building in the M.D.F. and I.D.F. CAT5 cable connects the main Ethernet Switches to the administration computer for building monitoring, and to another Ethernet Switch, which then feeds a Wall Control Panel and DALI Line Controllers. DALI Line Controllers control a DALI LOOP, providing control of up to 64 devices.

As previously stated, the DALI system provides building managers, maintenance contractors, and building occupants with numerous benefits. **Table 5** outlines the benefits.

Building manager's and maintenance benefits	Building occupant's benefits
• Reporting of lamp and ballast status • Simple modification without having to rewire and vacate spaces to be modified • Reduced maintenance costs • Energy savings provided by dimming and control capabilities	• Customized lighting preferences • Comfort • Individual control • Easy modification

Table 5: DALI benefits Referenced by Schneider Electric

School occupants can individually control lighting scenes by accessing wall panel touch screens located within each space. Wall switches, located within room access points, provide basic ON/OFF, and occupant dimming lighting control. DALI monitoring allows for lighting energy usage to be monitored, eliminating the necessity for metering upstream of lighting panel boards to monitor lighting power usage.

Safety Systems

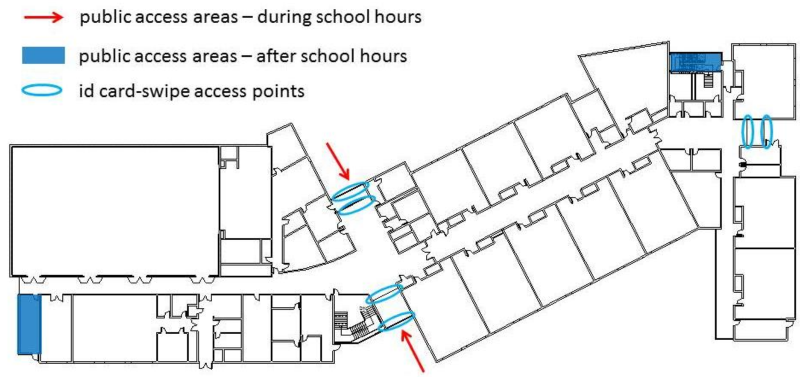


Figure 9: Normal operating security

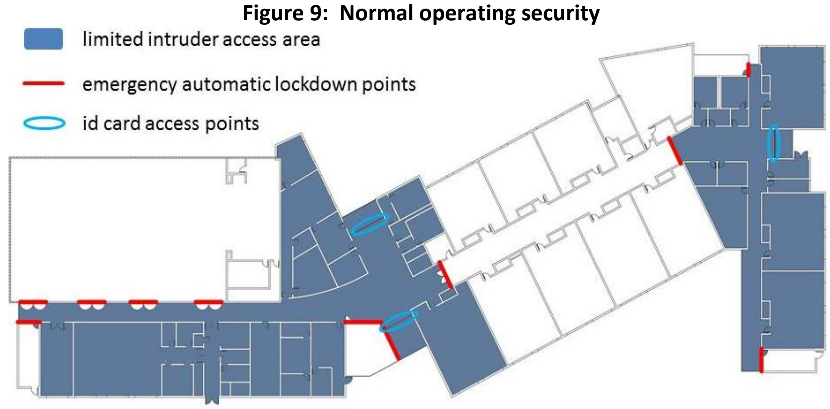


Figure 10: Emergency intruder lockdown

Low profile security cameras monitoring areas of interest, automatic locks, and i.d. card swipe access ensure a safe and secure learning environment. Site lighting provides illumination to the site during the night, as discussed in later sections. Normal operating security measures include limited points of entry to the school. The public is permitted access during school hours through the main entrances located in the core area of the first floor (see **Figure 9**), to provide a direct line-of-sight between the administration to the public entering the school. One wishing to enter the school must be allowed into the building by the administration. Once the administration has verified the person wishing to enter through a security camera feed into the administration area. I.D. card-swipe is required outside and within the vestibules to further control access into the area. The public will be granted access to other areas of the building after school hours. Numerous security strategies were explored to provide safety to students in the event of an emergency intruder (see **Figure 10**). However, we decided the most effective security strategy was to monitor and control the public access into the building. The emergency intruder lockdown procedure is not included in the proposed design.

The main entrance to the East of the school is monitored by the security room next to the East entrance. I.D. card swipe access is required at this entrance. The entrance is intended to be for playground access primarily. I.D. card access areas located within entry vestibules are shown in **Figure 9**.

Automatic locks are able to be scheduled and controlled from the previously mentioned security room location. Automatic locks will ensure the building is locked after school hours, and will restrict the public to limited areas of the building that are intended for community use. Automatic locks on double-doors in the corridors provide the ability to restrict the public from certain areas of the building.

A dual-fuel emergency generator running off diesel or natural gas is located in the Electrical Room, providing 72 hours of service as recommended by FEMA, initiated by an automatic transfer switch (ATS). Power is then supplied to a 480V emergency distribution panel primarily serving emergency lighting and mechanical equipment; and a 208V emergency distribution panel serving fire alarm systems, mechanical equipment, and automatic locks. Refer to **SECTION 3: E-400** for emergency power distribution diagrams. Equipment serving the multi-purpose space is also provided emergency power when the multi-purpose space is used as a community shelter.

Spaces

The following critical spaces are discussed in depth, to provide detailed information and design criteria for the primary learning and community areas. Additional critical spaces are briefly discussed in **SECTION 2: SUPPORTING DOCUMENTATION**.

Classroom

Classrooms throughout the building utilize electric light in combination with daylight to provide a comfortable and productive primary learning environment for students. Indirect/Direct luminaires are used to apply electric light in combination with supplemented daylight to achieve uniform work plane illuminance throughout the classroom. Refer to **SECTION 3: L-400** for luminaire information. Indirect/direct luminaires illuminate the ceiling and walls to the recommended light levels and uniformity throughout the room, creating a pleasant learning environment. Philips “ROVR” digital ballasts are tandem wired to serve two luminaires housing one T5HO lamp each, mounted within the luminaires to provide dimming capabilities. Evenly spaced luminaires, mounted at 7’-6” A.F.F. further ensure uniformity throughout the space, and allow for mechanical supply and return air to be integrated between luminaire rows. The suspended ceiling is mounted at 10’-0” A.F.F. Cool color temperature lamps ensure seamless blending with daylight. Fluorescent lamps are used to provide excellent lamp life, good efficacy and excellent dimming capabilities. **Table 6** demonstrates the illuminance levels designed and modeled using the AGI32 lighting analysis software. Different applications within classrooms require scene controls to provide a comfortable and effective learning environment.

Application		**$E_{horizontal}$ (fc.)**		**$E_{vertical}$ (fc.)**		**$E_{avg.}/E_{min}$**	
AV viewing	Ev @ 4’-0” AFF Eh @ 2’6” AFF	5*	**5.6**	3*	**3.7**	2:1*	**2.5:1**
White Board	--	--	**--**	30*	**18.8**	3:1*	**1.1:1**
Writing	Ev @ 5’-0” AFF Eh @ 2’6” AFF	30*	**31.5**	15*	**19.1**	2:1*	**2.4:1**

Table 6: Classroom Illuminance levels

*As recommended by IESNA Lighting Handbook 9th Edition

Electric lighting in classrooms is supplied by twelve indirect/direct luminaires; in addition to 6” 26W CFL recessed square down lights as needed throughout different classrooms. Suspended acoustical ceiling panels reflect indirect light to the work plane. The indirect/direct luminaire light distribution spreads light evenly throughout the classrooms, providing optimal illuminance uniformity in conjunction with daylight. High reflectance materials are specified in classrooms to optimize energy savings. Ceiling, wall and floor materials are 90/60/20 percent reflective respectively. Phillips energy efficient linear fluorescent lamps provide energy savings and contain reduced Mercury content. **SECTION 3: L-304** depicts luminaire placement and mounting heights for classrooms.

Suspended acoustical ceiling panels divide the ceiling, allowing for even air distribution supplied by diffusers between suspended systems. Gaps between ceiling panels provide views to exposed mechanical, electrical and structural systems above the panels. Acoustical ceiling panels allow for easy maintenance to systems above the ceiling while also organizing downlights, occupancy sensors, and photosensors in the ceiling.

Light Level Control

Ceiling mounted photosensors are located between the luminaire rows controlled by the particular daylight sensor. Luminaire dimming is divided into two control zones in classrooms. Both rows closest to the window are "dimmed zones", each row controlled by a separate closed-loop proportional photosensor, continuously dimming in accordance with altering daylight contributions throughout the day. The row furthest from the windows is a "non-dimmed" zone, to be controlled by switching and scene controls at the occupant's discretion. **Figure 11** demonstrates the photosensor position, and luminaires controlled. DAYSIM analysis software provided luminaire energy savings predictions for each row of luminaires in different classrooms. Energy savings are calculated based on ballast minimum ballast dimming levels, a selected critical point to ensure the room is illuminated to the target light level of 30 fc. and annual weather data for the site. **Table 7** summarizes the energy savings for the classrooms with different façade orientations and room dimensions. The room width and depth are important considerations, along with façade orientation, when evaluating the value of photosensors throughout classrooms. Rooms with a greater depth are less likely to provide effective Return On Investment (ROI) to offset the initial photosensor cost.

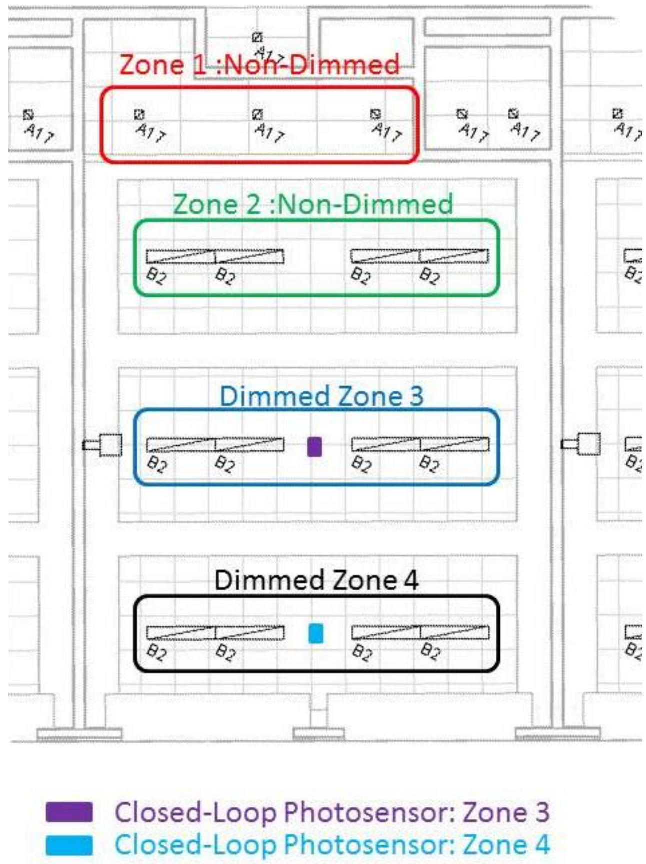


Figure 11: Typical classroom photosensor location and control

Dual technology occupancy sensors are positioned to ensure direct line of sight to occupants while avoiding direct line of sight of the doorway. Occupancy sensors are placed as far from diffusers and mechanical equipment as possible to avoid disruptions from air flow. Time delays ensure that occupancy sensors are not constantly switching the lights on and off. Restrooms throughout the elementary school use dual-technology photosensors to conserve electricity.

Orientation	Dimensions (WxD)	Quantity of classrooms	Annual energy savings (KWh)	Annual cost savings
SE	28'-0" x 40'-0"	15	9,150	$1,281.00
NW	27'-0" x 30'-0"	12	8,270	$1,157.80
NE	33'-0" x 28'-0"	7	6,870	$961.00
S	26'-0" x 31'-0"	5	4,900	$686.00

Table 7: Classroom luminaire dimming annual energy and cost savings (daylight only)

Electric lighting scene control is controlled on DALI wall controllers. 4 scenes are provided to be simple and easy for instructors to adjust electric light levels. Scenes provided include 100% light output, 50% light output, front row off, and an AV viewing scene. The illuminance levels described in **Table 6** require different light levels for different activities conducted within the classrooms. **Figure(s) 11-12** demonstrates the scene settings aside from 100% light output in a second floor classroom. **Figure(s) 13-**

14 illustrates the illuminance levels in a pseudo color rendering of classrooms under the scene setting previously discussed.

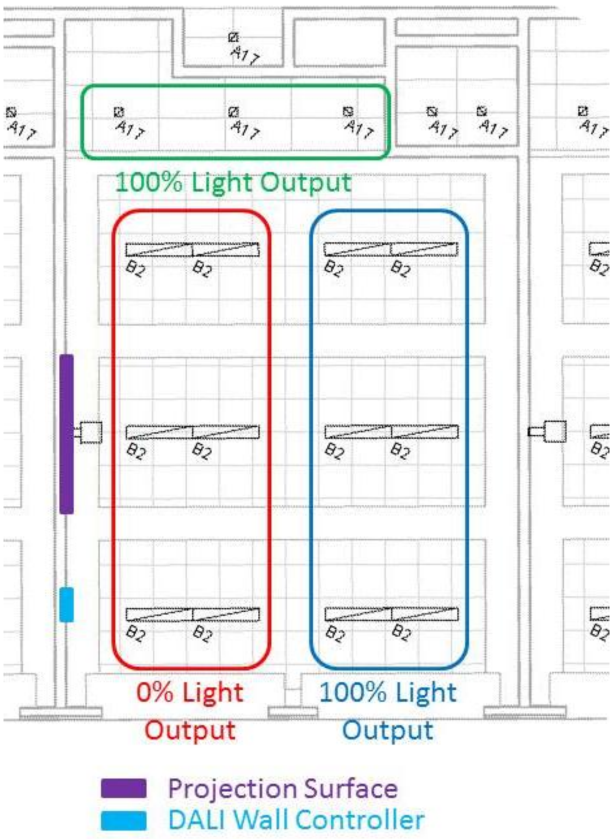


Figure 11: AV viewing scene

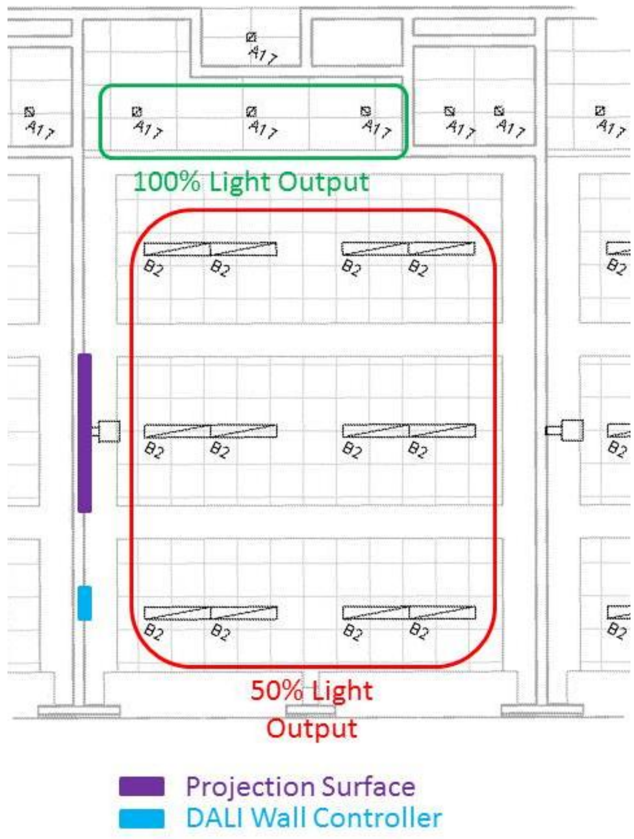


Figure 12: 50% light output scene

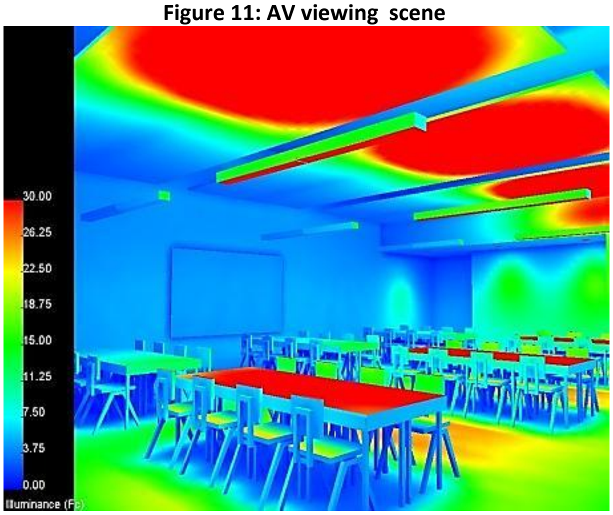


Figure 13: AV viewing scene pseudo

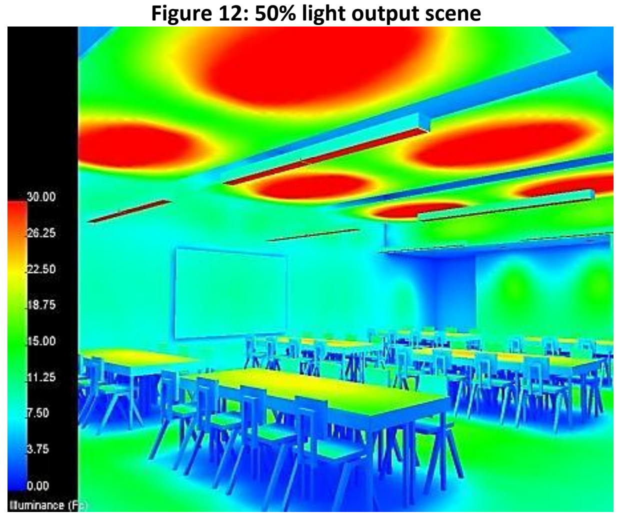


Figure 14: 50% light output scene pseudo

Multipurpose Space

The lighting and electrical design of the multipurpose space centers on flexibility and functionality. Lighting is intended to provide the necessary light levels and uniform distributions for recreational, social and academic activities. Lighting controls in the multipurpose space allow the user to alter light levels in accordance with the activity intended. Linear fluorescent lamping provides ambient lighting for the space. Scene control will incorporate continuous dimming. Linear fluorescent lamping allows for instantaneous restrike time and continuous dimming for high performance. Even luminaire spacing allows for uniform light levels, and the spacing is integrated between structural trusses. Additionally, even luminaire spacing allows for mechanical ductwork runs between luminaire runs, so the ceiling is organized. Linear fluorescent lamps provide good lamp life, so that maintenance will be seldom. High-bay luminaires have a lens th at protects the lamps from sporting activities. Refer to **SECTION 3: L-400** for further luminaire data.

Application		$E_{horizontal}$ (fc.)		$E_{vertical}$ (fc.)		CV		$E_{avg.}/E_{min}$	
Dancing social	Ev @ 5'-0" AFF Eh @ Ground	5*	**5.4**	3*	**2.71**	--	**--**	3:1*	**1.8:1**
Testing	Ev @ 4'-0" AFF Eh @ 2'6" AFF	30*	**28.32**	10*	**14.56**	--	**--**	2:1*	**2.36:1**
Assembly	Ev @ 5'-0" AFF Eh @ 2'6" AFF	15*	**15.93**	5*	**8.16**	--	**--**	3:1*	**3.14:1**
Phys Ed.	Ev @ 5'-0" AFF Eh @ 2'6" AFF	25*	**28.32**	20*	**14.56**	--	**--**	3:1*	**1.32:1**
Basketball (Class IV)	Ev @ 5'-0" AFF Eh @ 3'-0" AFF	30*	**28.32**	10*	**14.56**	0.3*	**0.21**	--	**--**

Table 8: Multipurpose Illuminance levels

*As recommended by IESNA Lighting Handbook 9th Edition

Community Pool

Figure 15: Community indoor pool rendering

The community pool lighting and electrical design provides spectators and swimmers with a fun, but safe venue. The water surface is primarily illuminated by adjustable 400W metal halide indirect truss mounted luminaires. Indirect illumination allows for uniform illumination, while eliminated veiling reflection hazards for swimmers and lifeguards on the pool deck. The truss mounted luminaires are mounted along the perimeter of the pool, to provide school maintenance personnel with the opportunity to easily change lamps and clean the luminaires. Suspended direct linear fluorescent luminaires are located above the pool deck and bleacher areas.

The restrike time for the metal halide lamps in the truss-mounted indirect luminaires, required additional lighting in the case of an emergency, to instantly illuminate the pool deck in case of an emergency. The suspended linear fluorescent luminaire center beam candlepower was chosen to be perpendicular to the deck surface, eliminating the possibility of shallow incident beam angles to the water surface. The linear fluorescent luminaires are located along the perimeter of the pool, above the pool deck, to allow school maintenance personnel to access the luminaires. (2)-lamp suspended linear fluorescent luminaires are located above the bleachers, while (3)-lamp suspended linear fluorescent luminaires are located along the bleachers (see **SECTION 3: L-400**). 100% full light output by the linear fluorescent luminaires is not needed during normal operating hours and are dimmable by a digital ballast. An overview of the illumination levels in the community pool is provided in **Table 9**.

Application	$E_{horizontal}$ (fc.)		CV		E_{max}/E_{min}	
Water surface	30*	**25.3**	0.25*	**0.1**	3:1*	**1.6:1**
Deck surface	10*	**19.3**	0.30*	**0.29**	4:1*	**2.9:1**
Emergency Lighting	20*		--	**--**	10:1*	

Table 9: Pool illuminance levels

*As recommended by IESNA Lighting Handbook 9th Edition

Site

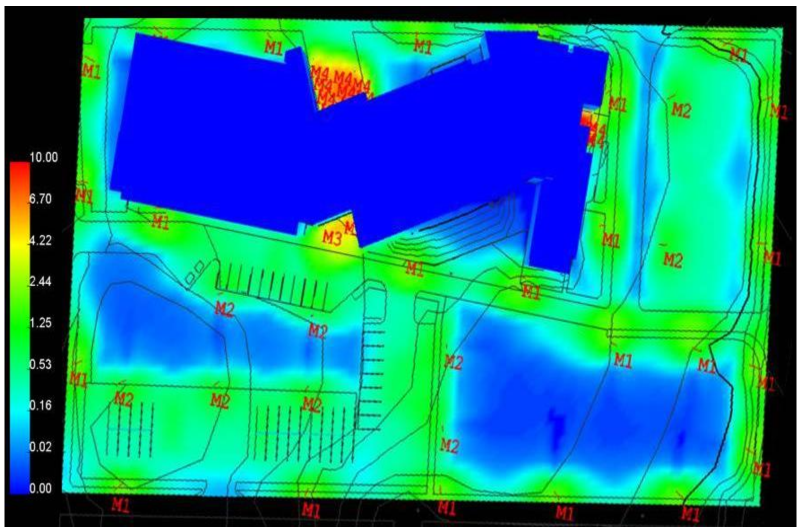


Figure 16: Site illuminance pseudo

Lighting provides a safe and secure environment during the night. Site lighting is designed to accommodate a nighttime outdoor lighting zone LZ3, as recommended by IESNA Lighting Handbook 9th Edition. Building entries, vehicular access to the site areas, playground, parking lot, and building perimeter are provided illuminance levels to be able to be monitored by security cameras (if desired by the school), and to discourage loitering and delinquent activities. Pole-mounted luminaires are controlled by photocell and time schedules, to best respond to environmental changes while providing energy savings. An overview of the site illuminance levels is provided in **Table 10**. 32 Pole-mounted Beta LED luminaires, mounted at 20'-0" above grade provide the general illuminance to the school site. Refer to **SECTION 3: L-400** for luminaire product information. The North and East building entries are illuminated using recessed LED downlights. The North entry totals 12 LED downlights. The East entry totals 4 LED downlights. The South entry is illuminated using two wall-mounted Beta LED fixtures.

Site security is achieved with a concept employing "3 layers of defense". The concept utilizes a perimeter component achieved with a passive half-wall surrounding the playground and tee-ball field. The half-wall is inscribed with quotes and artwork to connect the community and students to educational concepts. The half-wall is intended to limit the number of access points to the playground during the day. The intermediate zone utilizes electric lighting to provide illuminance at night to the school grounds. The inner zone utilizes security cameras at building entries and/or areas of interest within the site boundaries. Pole-mounted LED luminaires are integrated into the half wall, to provide vertical illuminance to the half wall surface at night (see **SECTION 2: Figure 56** for a schematic).

Uniformity ratios described in **Table 10** provides even illumination to the site, ensuring that security cameras will be effective at night**. Figure 16** provides illuminance distribution across the site.

Application	$E_{horizontal}$ (fc.)		$E_{avg.}/E_{min}$		E_{max}/E_{min}	
Perimeter fence	0.5*	**0.83**	4:1*	**1.5:1**	--	**--**
Large open areas	0.5*	**0.55**	4:1*	**2.5:1**	--	**--**
Walkways with high criminal activity	0.6*	**0.49**	4:1*	**3.5:1**	--	**--**
Parking lots	0.5*	**0.49**	--	**--**	15:1*	**10.8:1**
Building Entries	10*	**8.47**	2:1*	**3.4:1**	4:1*	**7.6:1**

Table 10: Site Illuminance levels *As recommended by IESNA Lighting Handbook 9th Edition

LEED

Category	Credit #	Description	Possible points	Points pursued
SS	8	Light pollution reduction	1	0
EA	3	Enhanced commissioning	2	2
IEQ	6.1	Controllability of systems - lighting	1	1
IEQ	8.1	Daylight and views – daylight	1-3	0
IEQ	8.2	Daylight and views – views	1	1
ID	3	The School as a teaching tool	1	1

Table 11: LEED criteria *Referenced from LEED

The client wished to achieve LEED certification. The designed elementary school achieves LEED Silver. Our design team pursued LEED points that benefited the overall project and the community. **Table 11** outlines the main LEED credits pertaining to lighting and electrical system design. **SS-8** requires reduced input power of all nonemergency interior luminaires with a direct line of sight to any openings in the envelope by at least 50% between 11:00 PM and 5:00 AM. This will be achieved by turning off lights at night. However, to meet the requirements for SS-8, the exterior lighting must reduce light trespass to very low levels. Light trespass is an important goal of the community; however the proposed site lighting design does not meet the required light trespass conditions outlined by LEED. Illumination along the perimeter of the site and along the sidewalk was determined to be more important than the SS-8 light pollution reduction credit. However, full cutoff exterior luminaires are used to reduce sky glow at the site. **EA-3** requires enhanced commissioning. Metering up-stream of panel boards that are organized by load type, allow for EA-3 enhanced commissioning. The DALI control system will provide building maintenance with lighting energy feedback. **IEQ-6.1** requires that classrooms be provided at least two scene settings (general illumination and A/V setting). The proposed design provides four scene settings for classrooms. **IEQ-8.1** requires demonstration through computer simulations that 75% or 90% or more of all regularly occupied spaces achieve daylight illuminance levels of a minimum of 25 fc and a maximum of 500 fc in a clear sky condition on September 21 at 9:00 AM and 3:00 PM. The proposed design incorporates the necessary requirements in the classrooms, but not the administration areas, pool, multipurpose space, or many of the corridors. The point is not anticipated to be achieved. **IEQ-8.2** requires a direct line of sight to the exterior of the building in at least 90% of occupied areas. Through the use of curtain wall and windows throughout the school, this point is pursued. **ID-3** requires a curriculum to be developed to educate students about the building. The curriculum is intended to be developed with the school administration. The building design lends itself to a rewarding educational curriculum.

SECTION 2: SUPPORTING DOCUMENTATION

Window

Solar profiles for a 40° N site latitude were considered. The furniture layout provided, showed that 4'-0" direct solar penetration through classroom windows would not reach the students desks. The determined solar profile angle for a 2' – 0" and 3' – 0" deep exterior light shelf were calculated based on a 4' – 0" solar penetration allowance into the classroom (see **Figure(s) 16-17**). Additionally, the computer monitors located near the windows of the classrooms were moved away from the windows, to provide better monitor viewing conditions.

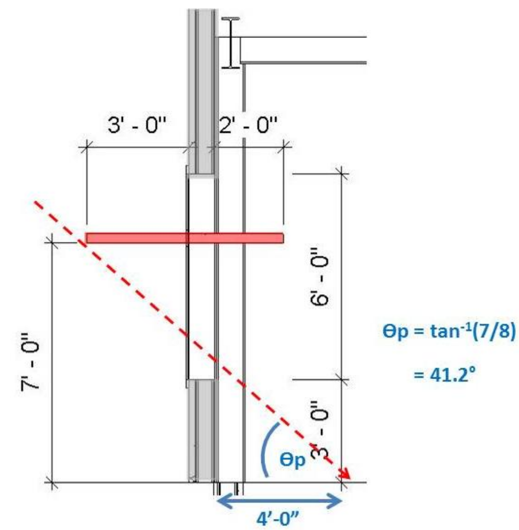


Figure 16: 3'-0" exterior light shelf profile angle calc.

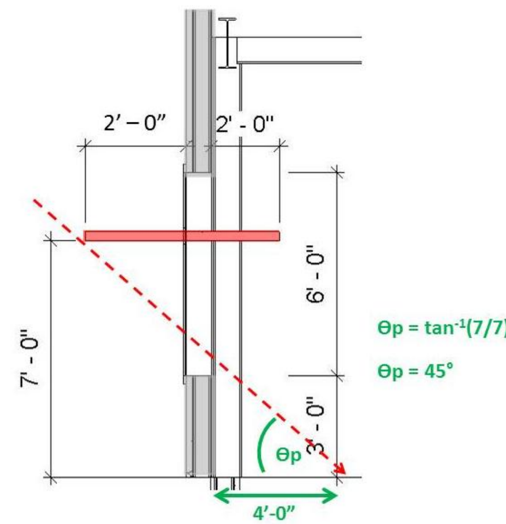


Figure 17: 2'-0" exterior light shelf profile angle calc.

The profile angle of a 3'-0" exterior light shelf is smaller than the profile angle of a 2'-0" exterior light shelf. The profile angles for both light shelf options are imposed on a graph displaying the solar altitude angles versus the solar azimuth angle to gain an understanding of the times of the year that direct solar gain can be expected beyond 4'-0" into the classroom. The imposed profile angles (red lines), are shifted along the x-axis to account for the façade orientation, with South at 0°. **Figure(s) 18, 20** use color to depict the periods of the year that direct solar gain will penetrate classrooms beyond 4'-0" from the window. Direct solar heat gain is also considered in **Figure(s) 19, 21**.

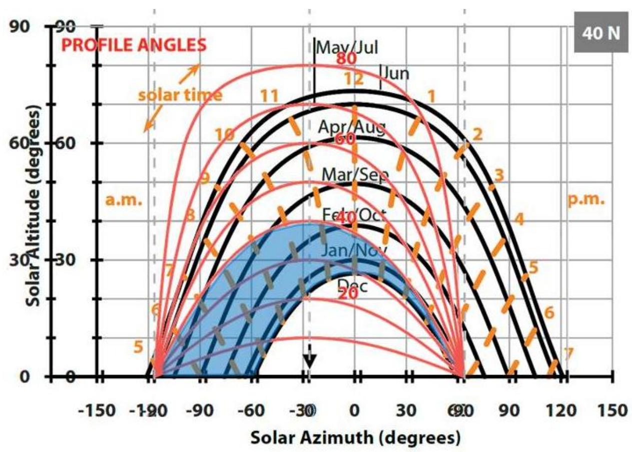


Figure 18: 3’-0” SE exterior light shelf profile angle analysis

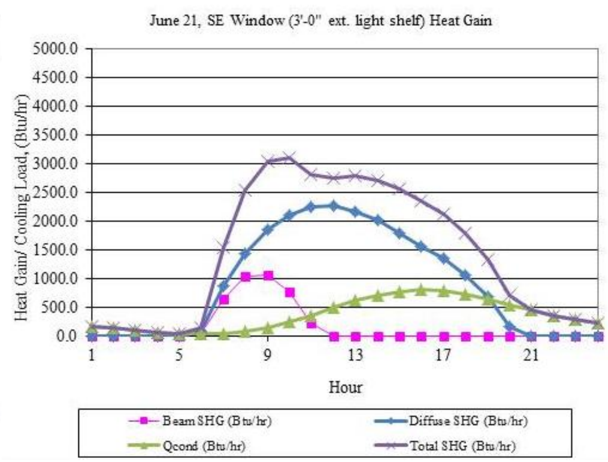


Figure 19: 3’-0” SE exterior light shelf heat gain analysis

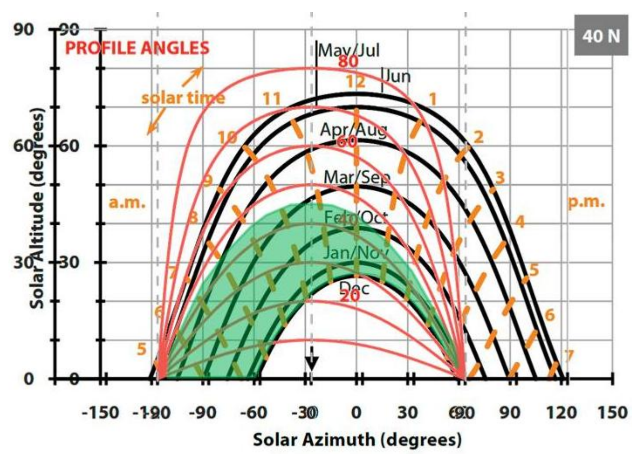


Figure 20: 2’-0” SE exterior light shelf profile angle analysis

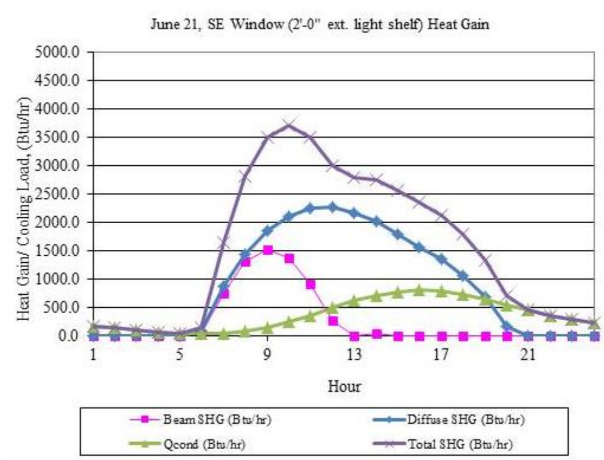
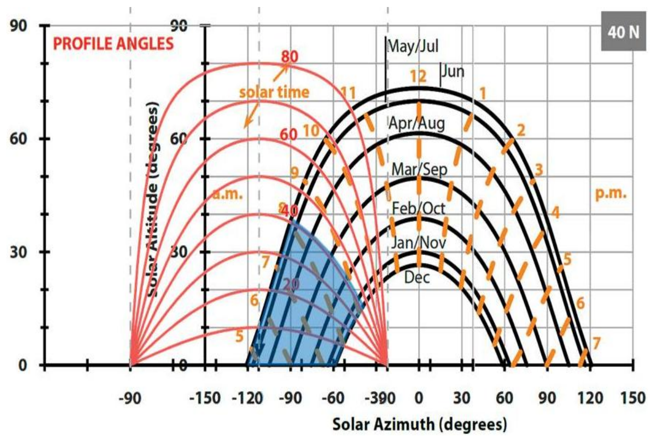


Figure 21: 2’-0” SE exterior light shelf heat gain analysis

Both light shelf depth options perform similarly along the South-east façade, when comparing **Figure(s) 18, 20**. The figures show that direct solar rays will penetrate the classrooms beyond 4’-0” in the mornings during winter months. The light shelf effectiveness at controlling heat gain during June is considered in **Figure(s) 19, 21** to determine whether the 3’-0” light shelf is worth the additional material cost, compared to the 2’-0” light shelf. The heat gain is computed for a single window only. The heat gain differences between the two options amount to a substantial load, when considering all the windows along the South-east façade. The 3’-0” light shelf option was selected, mainly due to the improved effectiveness at reducing the cooling load in the summer.

The North-east façade was also considered. **Figure(s) 22-25** show similar performance, with morning hours in the winter months allowing direct solar rays beyond 4’-0” into the classroom. The heat gain characteristics for both options are also similar. The North-east light shelves were excluded from the proposed school design. This analysis was also performed along the North-east and South facades.



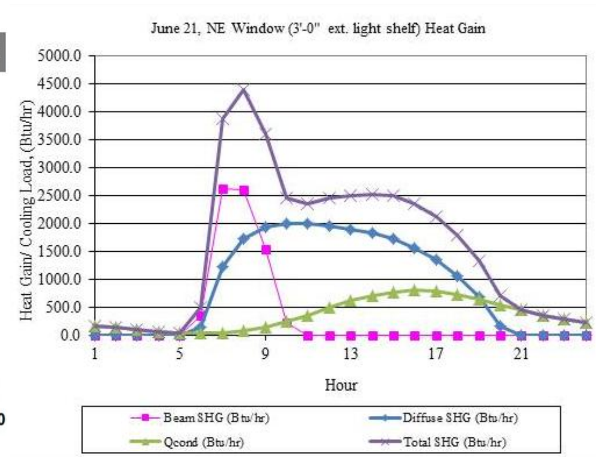
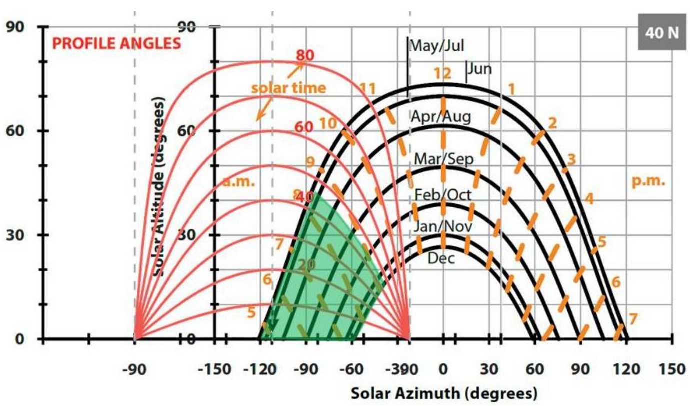


Figure 22: 3’-0” NE exterior light shelf profile angle analysis **Figure 23: 3’-0” NE exterior light shelf heat gain analysis**



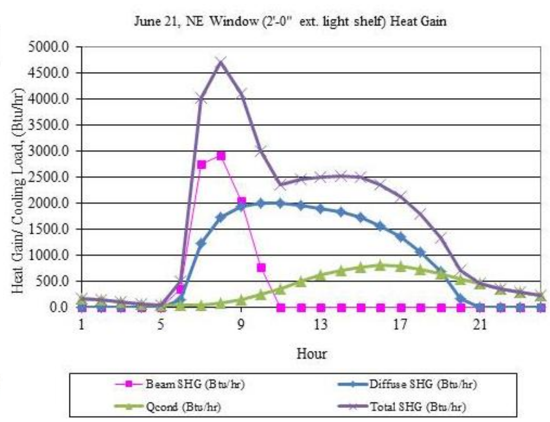


Figure 24: 2’-0” NE exterior light shelf profile angle analysis **Figure 25: 2’-0” NE exterior light shelf heat gain analysis**

Daylight Autonomy (DA) and Useful Daylight Illuminance (UDI) were considered for a bare window (as proposed by the initial architectural plans by the client), a 3’-0” exterior light shelf, a 3’-0” exterior light shelf and 2’-0” interior light shelf, and both the exterior and interior light shelf with the interior shades down. The solar heat gain is also considered (see **Figure(s) 26-29**). The classroom is 28’-0” x 40’-0”.

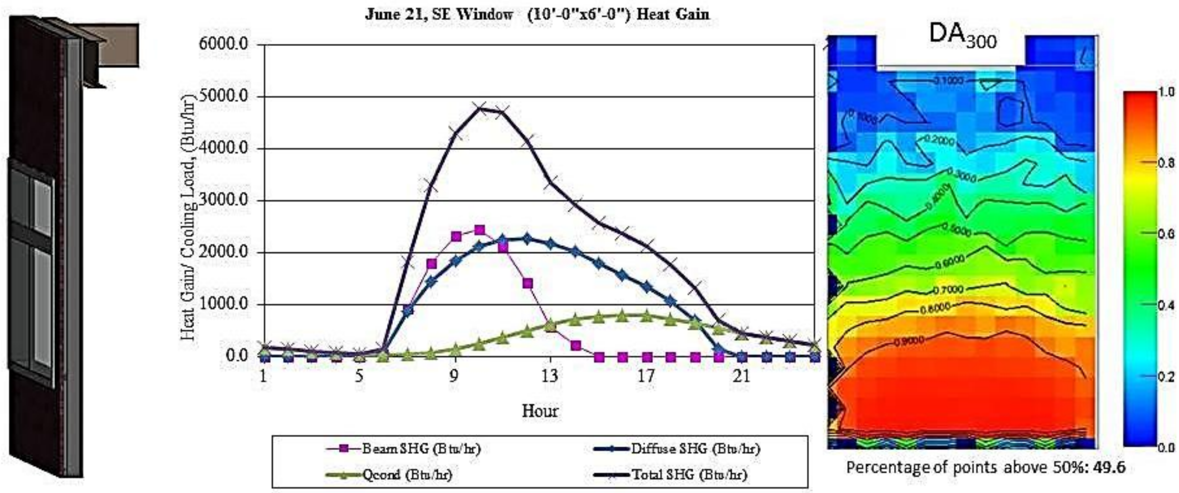


Figure 26: SE bare window solar heat gain and DA_{300}

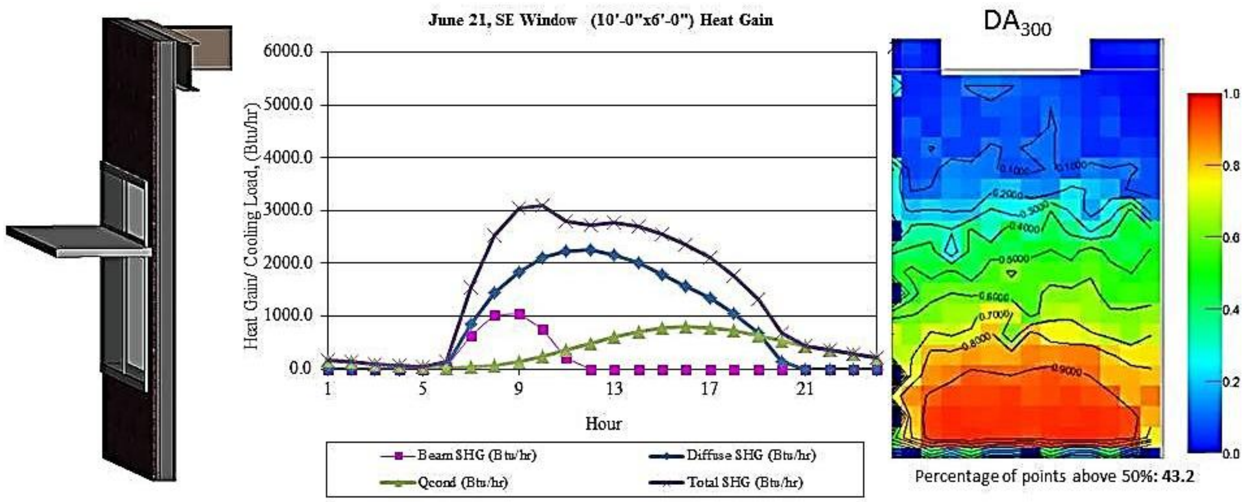


Figure 27: SE exterior light shelf impact on solar heat gain and DA_{300}

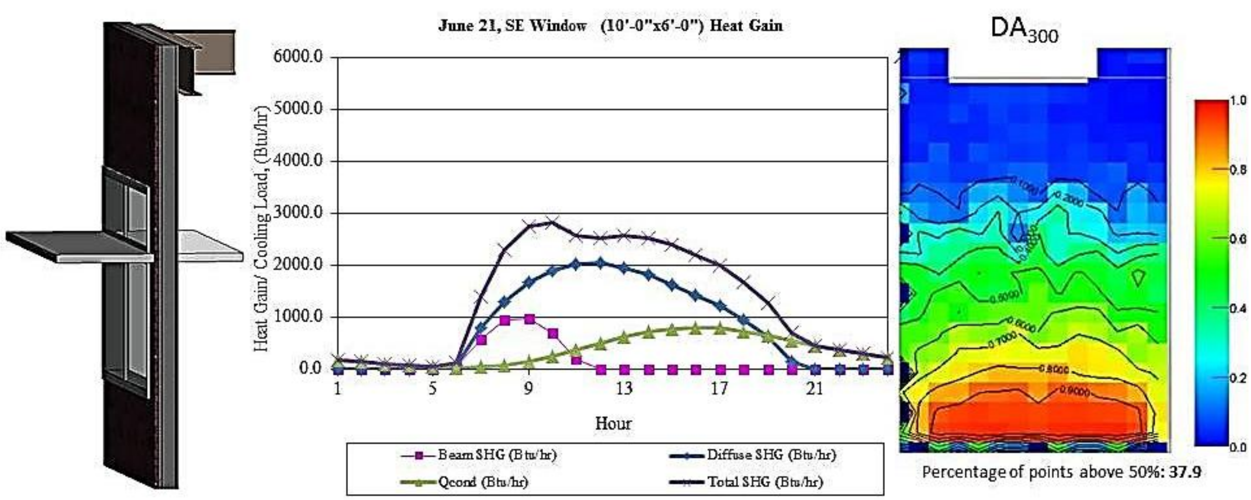


Figure 28: SE interior light shelf impact on solar heat gain and DA_{300}

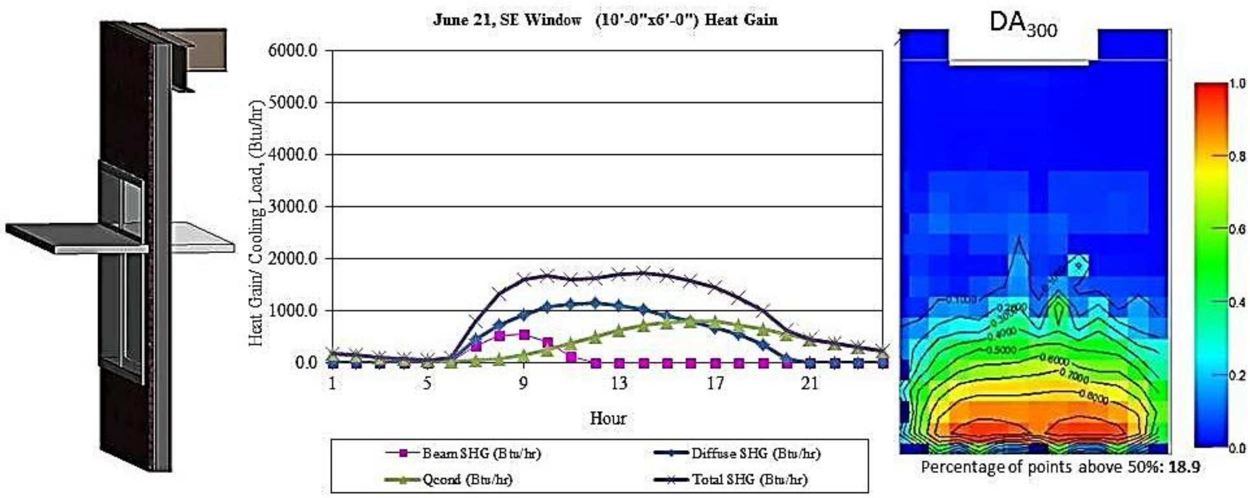


Figure 29: SE interior blinds impact on solar heat gain and DA_{300}

Figure(s) 28, 29 display the performance of the window design for the South-east façade. When the blinds are down, the daylight autonomy and solar hear gain is reduced. The interior and exterior light-shelf proves to reduce the solar heat gain, while providing a more comfortable working environment for students. Similar analysis was conducted along other façade orientations to determine to best window design for each individual façade.

Roof

Skycalc was first used to approximate the ideal skylight to floor ratio (SFR) for different sized classrooms, in order to maximize the annual energy savings (kWh/yr). **Figure 30** shows that the peak SFR is about 4% for a 1,100 ft^2 classroom. The designed SFR is closer to 3%, which still provide effective annual energy savings.

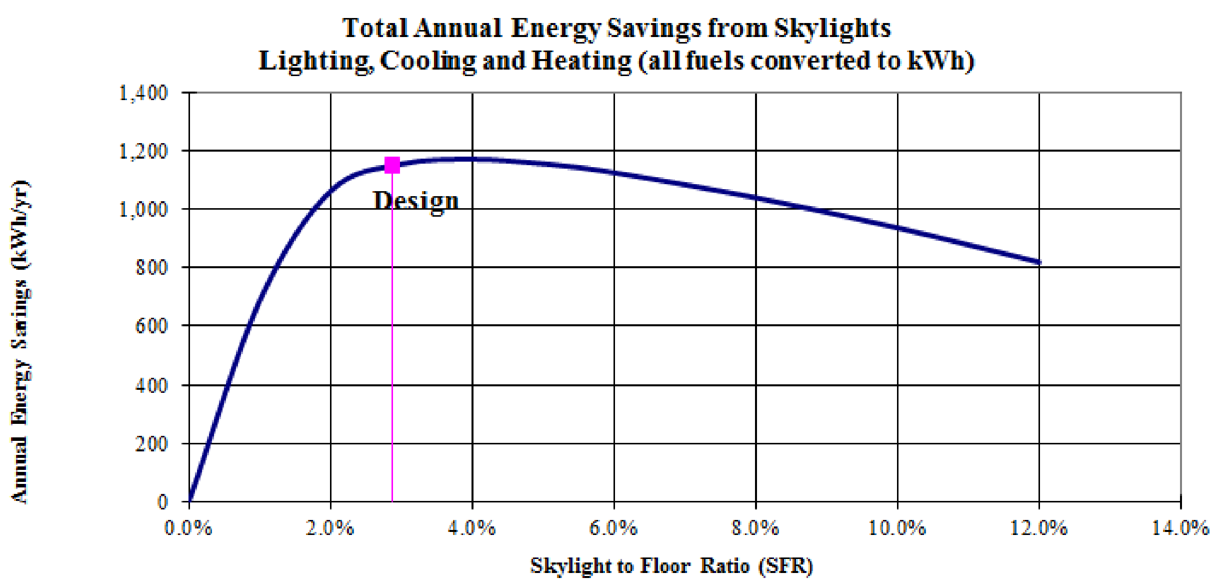


Figure 30: Annual energy savings vs. Skylight to floor area ratio

The net energy savings due to heat transfer through the skylight are then calculated by Skycalc, and used to compare with the energy savings as a result of dimming the luminaires. Because Skycalc considers electric light savings based on the skylight only (the windows and specific room design should be taken into account),the luminaire dimming energy savings are computed within DAYSIM, to utilize more accurate open loop photosensor dimming calculation algorithms, and a more exact model of the classroom. Additionally, DAYSIM allows for a calibration date and time to be set, and control over dim zones. Two skylight locations were analyzed in **Figure(s) 32,33**, to determine the best design.

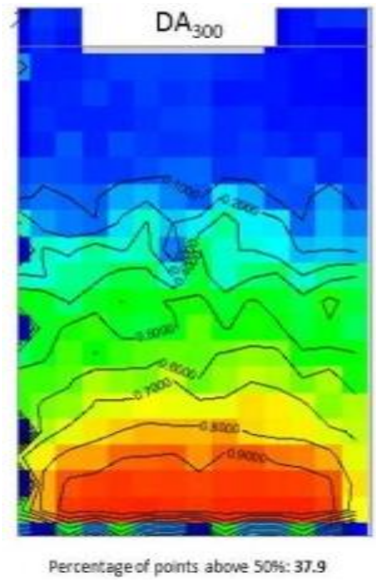


Figure 31: DA_{300} – no skylights

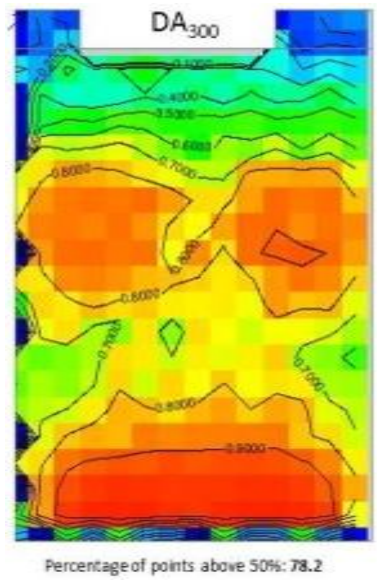


Figure 32: DA_{300} – skylights in middle

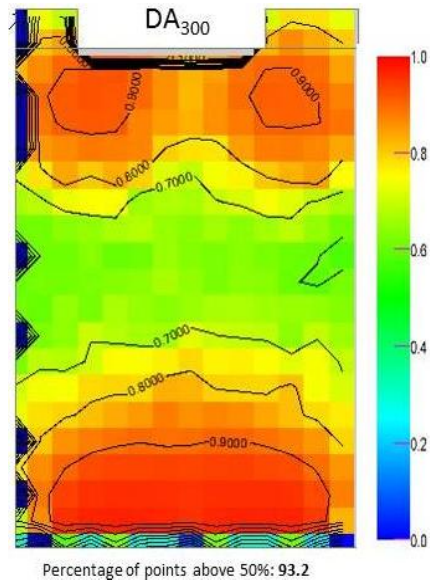


Figure 33: DA_{300} skylights in back

Table 12 summarizes the energy savings from dimming zone 2 and zone 3 in a South-east classroom on the 3rd floor of the school. Zone 2 and zone 3 are compared because they are will provide the interested energy savings from the placement of the skylights. Refer to **SECTION 1: Figure** for the luminaire zone locations. The South-east classroom was analyzed first, because it is the deepest classroom in the school, therefore if the skylights prove to be ineffective in the classroom with the greatest span from a perimeter window, they will be ineffective in classrooms that have shorter interior depth from the perimeter windows.

Model	Dimensions (WxD)	Zone 2 annual energy savings (KWh)	Zone 3 annual energy savings (KWh)	Annual cost savings per classroom
No skylights	28’-0” x 40’-0”	84	278	$50.68
Skylights back	28’-0” x 40’-0”	979	1,673	$371.28
Skylights middle	28’-0” x 40’-0”	1,685	3,440	$711.90

Table 12: Classroom skylights luminaire dimming annual energy and cost savings

Table 13 summarizes the overall energy efficiency, taking into account the luminaire dimming (calculated in DAYSIM), and heat transfer energy performance (calculated in Skycalc). **Table 13** accounts for a total of 36 skylights in 18 different classrooms.

Model	Dimming annual energy savings (KWh)	Heating and cooling annual energy losses (KWh)	Total annual energy savings (KWh)	Total annual cost savings
No skylights	6,516	0	6,516	$912.24
Skylights back	47,736	18,540	29,196	$4,087.44
Skylights middle	91,530	18,540	72,990	$10,218.60

Table 13: Building skylights luminaire dimming annual energy and cost savings

Cost savings were calculated using an average electric cost of $0.14 kWh and heating fuel cost of $1.01/Therm .After analyzing the lighting energy savings resulting from dimming luminaires based on , and accounting for the energy losses from heat transfer through the skylights (calculated using Skycalc), a simple payback period is calculated. The simple payback uses the design of the skylights in the back of the room, because it was determined that skylights in the center of the room would result in difficult for teachers to adjust light levels, more specifically making the room darker for AV settings.

PP = I/A

Where:

PP =	simple payback period (years)	=	**8.8 years**
A =	incremental annual cash flow (annual savings)	=	$4,087.00
I =	initial investment	=	$36,000.00

The simple payback period of 8.8 years is high, even for a school that is likely to operate for over 30 years. Ideally, the simple payback period would be between 3-5 years.

To provide the client with a discounted payback and rate of return, a comparison of the building energy use without skylights to the building with implemented skylights in the classrooms was conducted, yielding a discounted payback period of 14 years (see **Figure(s) 34, 35**).

Discount Rate	5.00%

Year	Baseline Model Without Skylights				Design Model With Skylights				Fuel Cost Escalation (From Table Ca-1)
	Net Initial Capital	Annual Maintenance	Annual Energy Consumption	**Total Present Value**	Net Initial Capital	Annual Maintenance	Annual Energy Consumption	**Total Present Value**	
0	$0.00	$0.00	$112,829.00	$0.00	$36,000.00	$300.00	$108,742.00	$36,300.00	1.00
1		$0.00	$109,444.13	$104,232.50		$300.00	$105,479.74	$137,042.61	0.97
2		$0.00	$108,315.84	$202,478.16		$300.00	$104,392.32	$232,001.63	0.96
3		$0.00	$107,187.55	$295,070.80		$300.00	$103,304.90	$321,499.44	0.95
4		$0.00	$107,187.55	$383,254.26		$300.00	$103,304.90	$406,735.45	0.95
5		$0.00	$107,187.55	$467,238.51		$300.00	$103,304.90	$487,912.60	0.95
6		$0.00	$108,315.84	$548,065.46		$300.00	$104,392.32	$566,035.62	0.96
7		$0.00	$109,444.13	$625,845.36		$300.00	$105,479.74	$641,211.30	0.97
8		$0.00	$111,700.71	$701,448.80		$300.00	$107,654.58	$714,279.21	0.99
9		$0.00	$112,829.00	$774,179.38		$300.00	$108,742.00	$784,568.66	1.00
10		$0.00	$115,085.58	$844,831.94		$300.00	$110,916.84	$852,846.15	1.02
11		$0.00	$116,213.87	$912,779.78		$300.00	$112,004.26	$918,508.12	1.03
12		$0.00	$118,470.45	$978,748.56		$300.00	$114,179.10	$982,254.37	1.05
13		$0.00	$119,598.74	$1,042,174.33		$300.00	$115,266.52	$1,043,541.76	1.06
14		$0.00	$120,727.03	$1,103,149.68		$300.00	$116,353.94	$1,102,459.93	1.07
15		$0.00	$122,983.61	$1,162,306.90		$300.00	$118,528.78	$1,159,618.61	1.09
16		$0.00	$124,111.90	$1,219,163.99		$300.00	$119,616.20	$1,214,553.60	1.10
17		$0.00	$125,240.19	$1,273,805.87		$300.00	$120,703.62	$1,267,347.08	1.11
18		$0.00	$127,496.77	$1,326,783.41		$300.00	$122,878.46	$1,318,530.27	1.13
19		$0.00	$128,625.06	$1,377,684.72		$300.00	$123,965.88	$1,367,706.50	1.14
20		$0.00	$129,753.35	$1,426,587.39		$300.00	$125,053.30	$1,414,950.84	1.15
21		$0.00	$130,881.64	$1,473,566.36		$300.00	$126,140.72	$1,460,335.77	1.16
22		$0.00	$132,009.93	$1,518,693.93		$300.00	$127,228.14	$1,503,931.25	1.17
23		$0.00	$133,138.22	$1,562,039.92		$300.00	$128,315.56	$1,545,804.79	1.18
24		$0.00	$134,266.51	$1,603,671.65		$300.00	$129,402.98	$1,586,021.52	1.19
25		$0.00	$136,523.09	$1,643,987.30		$300.00	$131,577.82	$1,624,965.40	1.21

Figure 34: Life cycle cost comparison

The analysis accounts for an inflation rate at 5% over a 25 year span, and ASHRAE energy cost escalation predictions for the next 25 years. The cost savings annually remain the same ($3,528.00). The discounted payback for the skylight proposal accounts for an estimated $300.00 in annual maintenance to clean the skylights. The initial investment totals $36,000.00 for 36 total skylights.

The calculated discounted payback period of 14 years proves to be an ineffective investment for the client. Additionally, there would be additional structural and labor costs to integrate the skylights into the proposed design of the building that are not calculated. The skylights were therefore excluded from the proposed building design.

Year	Baseline NPV	Design NPV	Design Savings
0	$0.00	$36,300.00	-$36,300.00
1	$104,232.50	$137,042.61	-$32,810.10
2	$202,478.16	$232,001.63	-$29,523.47
3	$295,070.80	$321,499.44	-$26,428.64
4	$383,254.26	$406,735.45	-$23,481.18
5	$467,238.51	$487,912.60	-$20,674.08
6	$548,065.46	$566,035.62	-$17,970.16
7	$625,845.36	$641,211.30	-$15,365.94
8	$701,448.80	$714,279.21	-$12,830.41
9	$774,179.38	$784,568.66	-$10,389.28
10	$844,831.94	$852,846.15	-$8,014.21
11	$912,779.78	$918,508.12	-$5,728.34
12	$978,748.56	$982,254.37	-$3,505.81
13	$1,042,174.33	$1,043,541.76	-$1,367.44
14	$1,103,149.68	$1,102,459.93	$689.75
15	$1,162,306.90	$1,159,618.61	$2,688.30
16	$1,219,163.99	$1,214,553.60	$4,610.39
17	$1,273,805.87	$1,267,347.08	$6,458.80
18	$1,326,783.41	$1,318,530.27	$8,253.14
19	$1,377,684.72	$1,367,706.50	$9,978.22
20	$1,426,587.39	$1,414,950.84	$11,636.55
21	$1,473,566.36	$1,460,335.77	$13,230.58
22	$1,518,693.93	$1,503,931.25	$14,762.68
23	$1,562,039.92	$1,545,804.79	$16,235.13
24	$1,603,671.65	$1,586,021.52	$17,650.14
25	$1,643,987.30	$1,624,965.40	$19,021.90

Figure 35: Discounted payback

Power Distribution

The 1000 kVA dry-type transformer was sized based on typical loads for schools. **Table 14** provides a sample of the typical loads in different space types. A 50% growth factor incorporated into the final size of the transformer. The calculated demand is 630 kVA. With a 50% growth factor, the calculated demand is 950 kVA.

		VA/ft^2					
				Air conditioning			
Space	**Area (ft^2)**	**Lighting**	**Misc. Power**	**Electric**	**Non-electric**	**Space VA/ft^2**	**Total VA**
Kitchen	1,414	2.5	2	10	4.5	14.5	20,503
Classroom	798	2.5	2	5	2.2	9.5	7,581
Corridor	1,528	0.5	0	0	0	0.5	764
Library	1,854	2	0.5	7	3.2	9.5	17,613

Table 14: Sample of projected electrical loads by space

Reference: Stein; Reynolds; Grondzik, Kwok. Mechanical and Electrical Equipment for Buildings, Tenth Edition.

Safety Systems

Refer to **Figure 50** for the emergency lighting for the shelter. Luminaire type B2 and B3 are set to 40% light output in the pool area for emergency lighting. **Table 15** provides an overview of illumination levels for the emergency pool lighting. **Figure 36** provides the illumination calculation in AGI 32.

Application	$E_{horizontal}$ (fc.)		E_{avg}/E_{min}		E_{max}/E_{min}	
High degree of hazard – high circulation activity	5*	**6.8**	2:1*	**2.2:1**	10:1*	**8.4:1**

Table 15: Emergency lighting illumination levels in the pool *As recommended by IESNA Lighting Handbook 9th Edition

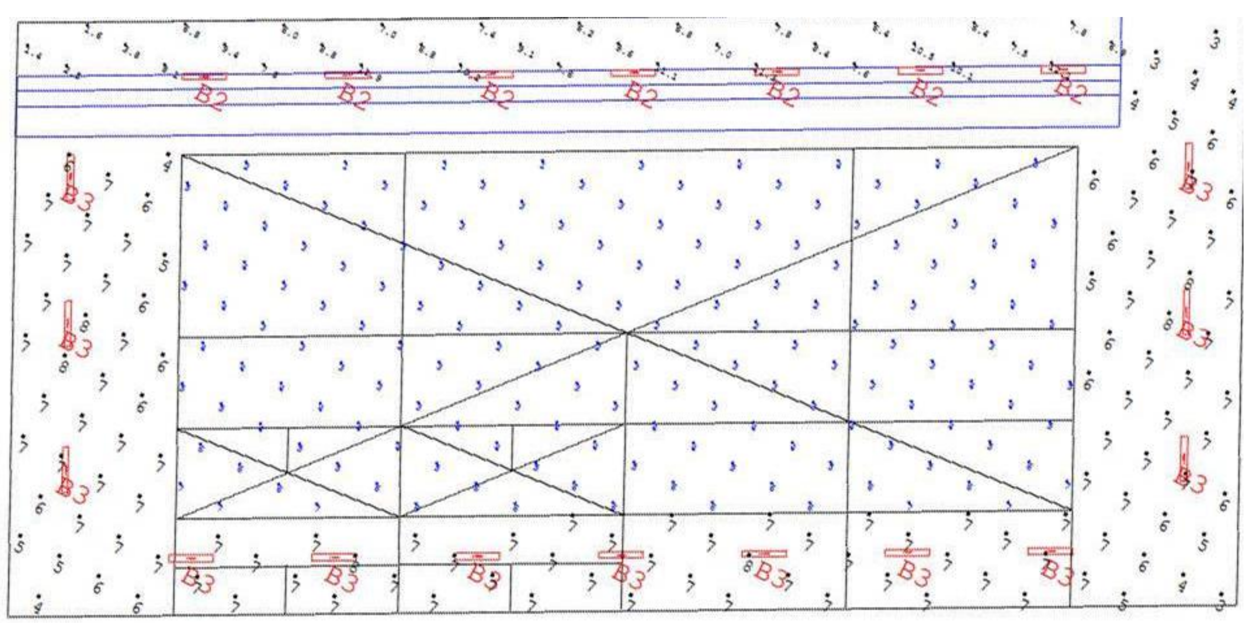


Figure 35: Emergency illumination in the pool

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Classroom

Energy savings were computed in DAYSIM. The following section outlines the energy savings for luminaire dimming control utilizing closed-loop photosensors to dim the individual rows of luminaires in response to daylight in the classrooms (see **SECTION 1: Figure 11**). The following data pertains to a North-east classroom on the first floor. The dim zones in **SECTION 1: Figure 11** is the same as in the North-east classroom. **SECTION 1: Table 7** outlines the dimensions of the classroom. A critical point is selected for each dim zone, to ensure the required illumination for the classroom. **Figure(s) 36-38** shows the critical point location for each dim zone (depicted by the black "X"). The critical point is selected on March 17th at 6:00 PM. The critical point is selected with all the dim zones at 100% light output.

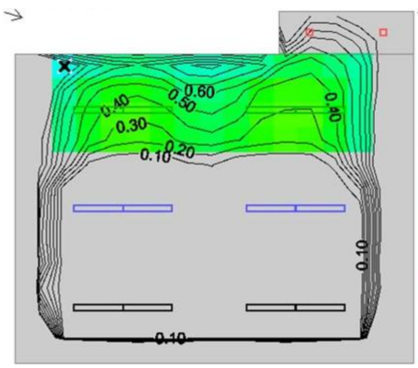


Figure 36: Dim Zone 2 critical point

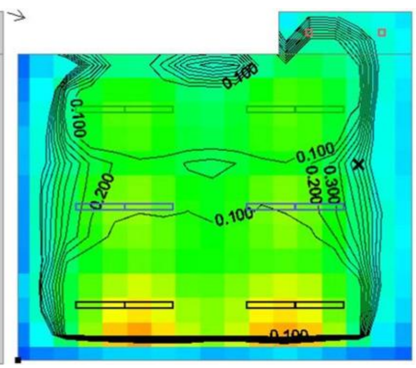


Figure 37: Dim Zone 3 critical point

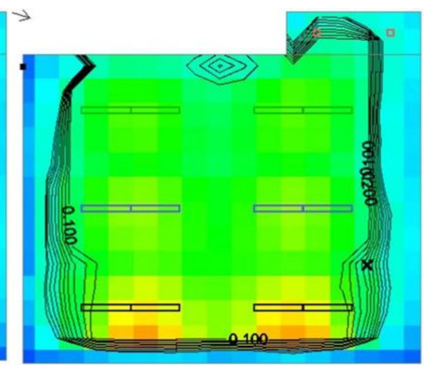


Figure 38: Dim Zone 4 critical point

Dimming energy savings are first calculated for Dim Zone 4 with the other Dim Zones turned on. Dim Zone 4 is calculated first because it is positioned closest to the window. Dimming energy savings for Dim Zone 3 are calculated with Dim Zone 4 turned off and Dim Zone 2 turned on. Dimming energy savings for Dim Zone 2 are calculated with both Dim Zones 4 and 3 turned off. The process to determine the dimming energy savings for each Dim Zone is conducted in the previously mentioned order to represent the environment of the classroom when the particular Dim Zone will actually begin to be dimmed. **Table 16** shows the calibration conditions for each Dim Zone.

		Dim Zone 4	Dim Zone 3	Dim Zone 2
Night Condition	Illuminance (Elec)	291.9 fc.	304.0 fc.	244.7 fc.
	Target illuminance	291.9 fc.	304.0 fc.	244.7 fc.
	Signal at target	95.7 fc.	111.7 fc.	112.4 fc.
Day Condition	Daylight Illuminance	81.0 fc.	31.0 fc.	24.0 fc.
	Daylight signal	72.0 fc.	36.0 fc.	24.0 fc.
	Non-dimmed	151.1 fc.	167.9 fc.	76.5 fc.
	Target illuminance	291.9 fc.	304.0 fc.	244.7 fc.
	Dimming level	42.4%	77.2%	85.6%
	Signal	141.6 fc.	137.5 fc.	128.6 fc.

Table 16: Calibration statistics (3/17 6:00 PM) *Computed using DAYSIM

Figure 39 shows the light output level versus illuminance signal detected by the closed-loop photosensor controlling Dim Zone 2. The correlation shows that the light output decreases as the Daylight signal increases. The linear correlation is consistent with the characteristics of a properly functioning closed-loop photosensor control algorithm. The outliers to the right of the linear correlation indicate times of the year that the luminaires are not dimming to levels as low as they could be. Ideally, the outliers would not be present. Overall, the strong linear correlation shows that the system is functioning properly.

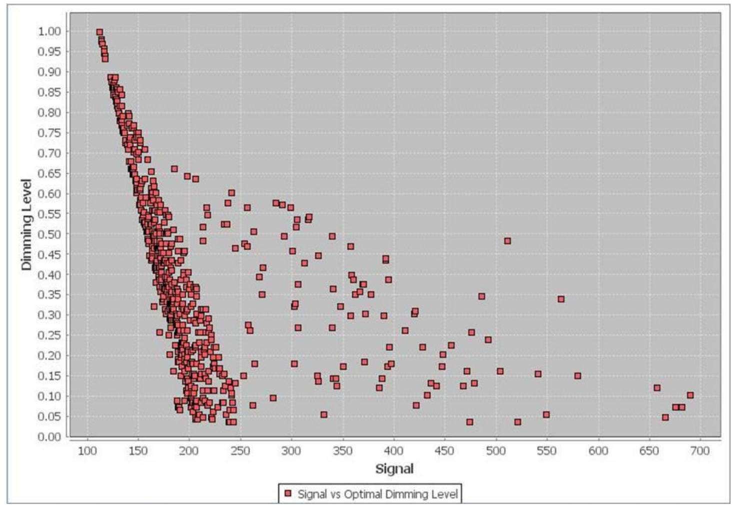


Figure 39: Light output vs. Signal for Dim Zone 2

Figure 40 shows an annual histrogram for Dim Zone 2. The blue bar represents the ideal case, and the green bar represents the designed case. In the signal range along the x-axis from 0-200 lux, the designed system over-dims (providing the critical point with less light than needed) for about 1% of the time during the year. In the signal range along the x-axis from 0-400 lux, the designed system under-dims (providing the critical point with more light than needed) for about 2% of the time during the year. Overall, the annual histrogram indicates the system is operating as desired.

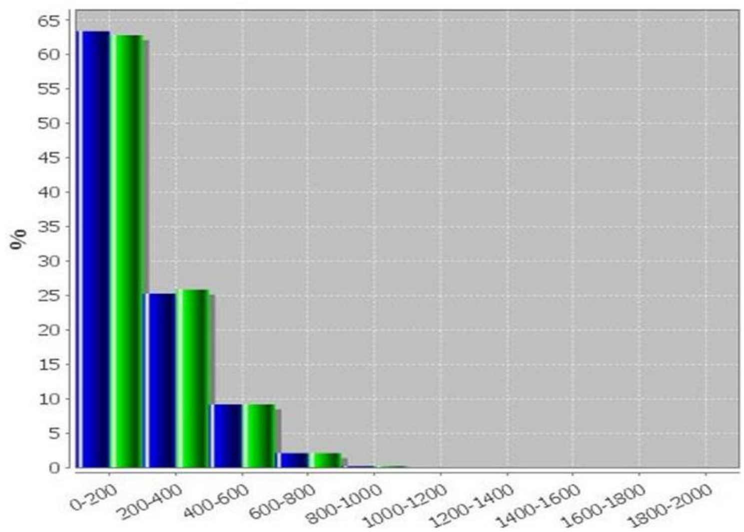


Figure 40: Annual histogram for Dim Zone 2

The previously described process was conducted for each Dim Zone, in each classroom. A summary of the dimming energy savings from daylight and the cost savings are provided in **SECTION 1**: **Table 7**. **Table 17** shows the dimming energy savings for each row.

Orientation	Room Quantity	Dim zone	Annual energy savings (KWh)	Total Annual energy savings (KWh)	Total annual cost savings
SE	15	2	84	420	$58.80
		3	278	1,390	$194.60
		4	332	1,660	$232.40
NW	12	2	100	400	$56.00
		3	341	1,364	$190.96
		4	348	1,392	$194.88
NE	7	2	307	921	$128.94
		3	331	993	$139.02
		4	344	1,032	$144.48
S	5	2	291	291	$203.79
		3	348	348	$243.60
		4	341	341	$238.70

Table 17: Total energy savings by façade orientation and dim zone

Table 17 can be used to determine which Dim Zones will be cost effective. For example, Dim Zone 2 in both the SE and NW classrooms are excluded from the typical classroom design (see **SECTION 1: Figure 11**, where there is not a photosensor for Dim Zone 2).

EPSON BrightLink ultra-short-throw interactive projectors are specified for classrooms and the large group instruction area. The projectors are compatible wirelessly with iPads and iPods, laptops, document cameras, VCR's, and DVD players. The product will provide teachers with multiple opportunities to educate students.

Light Level Control

Figure 41: 100% light output scene rendering

Figure 42: 100% light output scene pseudo color

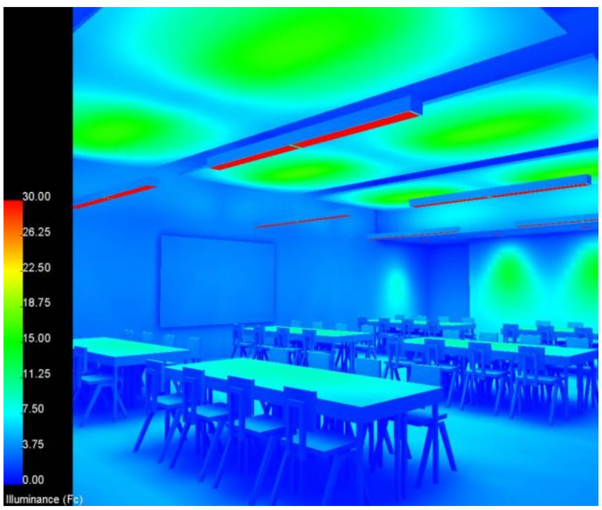


Figure 43: AV viewing pseudo color

The classroom at 100% light output is bright and meets the illuminance recommendations by IESNA. Indirect luminaires fill the classroom with light, providing a comfortable and engaging learning environment for students (see **Figure(s) 41, 42**).

10% light output provides a comfortable AV viewing environment, where the front wall is dark, and will provide an excellent vertical surface to project videos onto (see **Figure(s) 43, 44**).

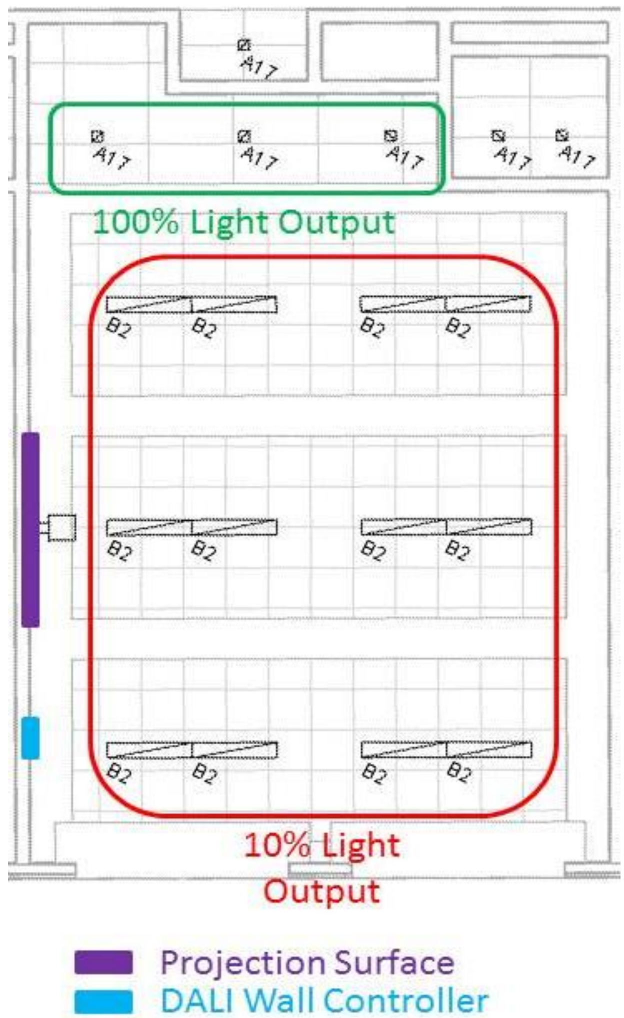


Figure 44: AV viewing scene control

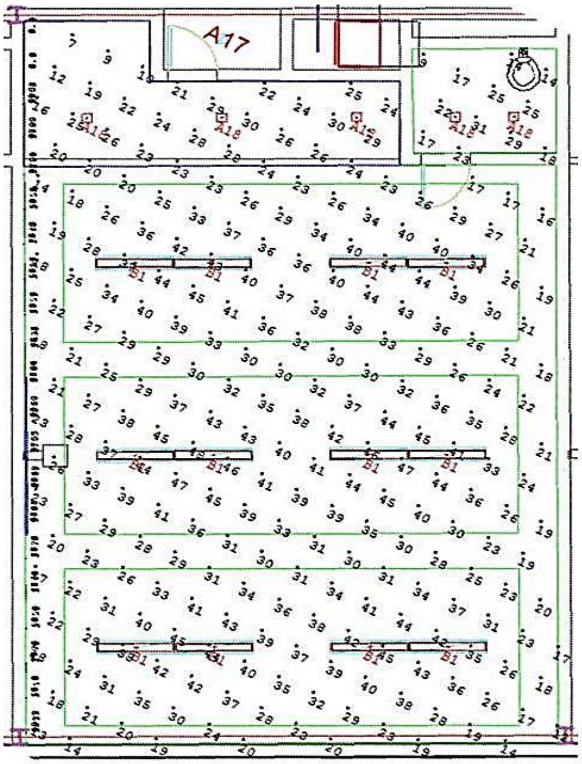


Figure 45: 100% B1 & 100% A18 light output scene

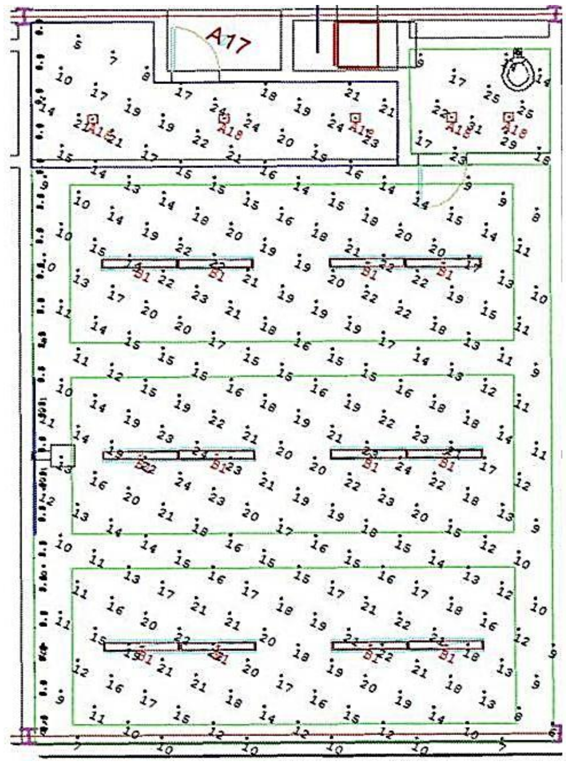


Figure 46: 50% B1 & 100% A18 light output scene

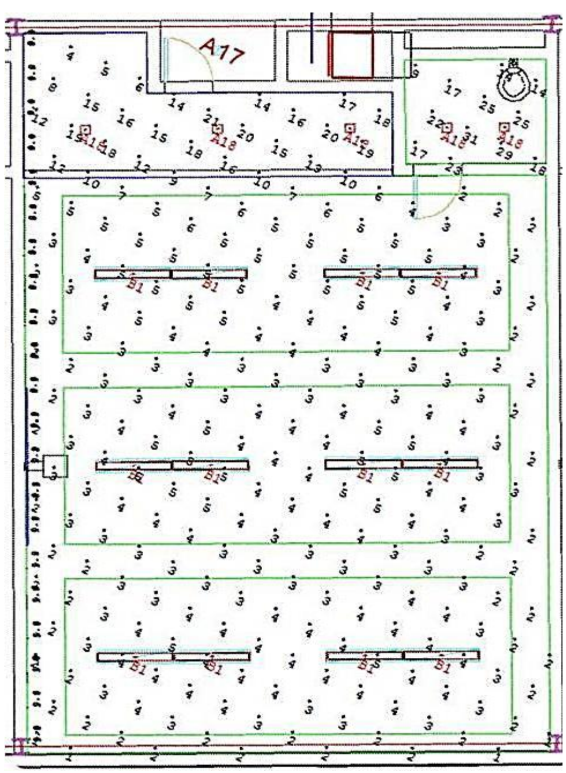


Figure 47: 10% B1 & 100% A18 light output scene

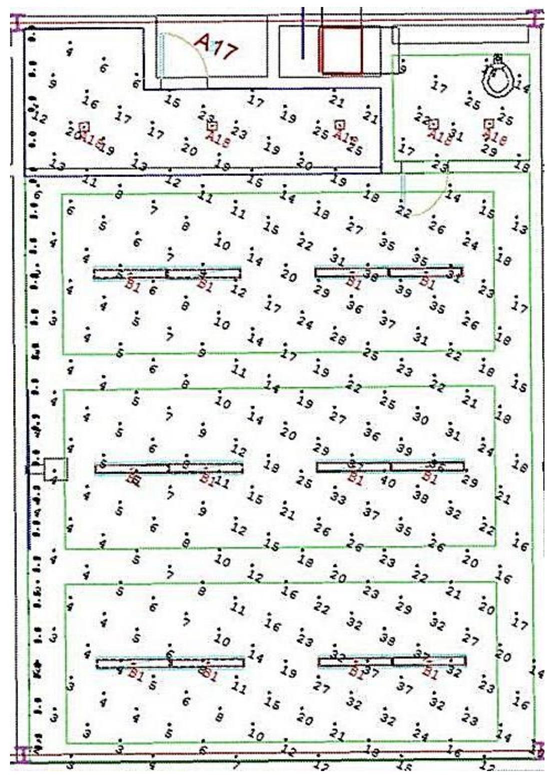


Figure 48: Front row off 100% output all others scene

Multipurpose Space

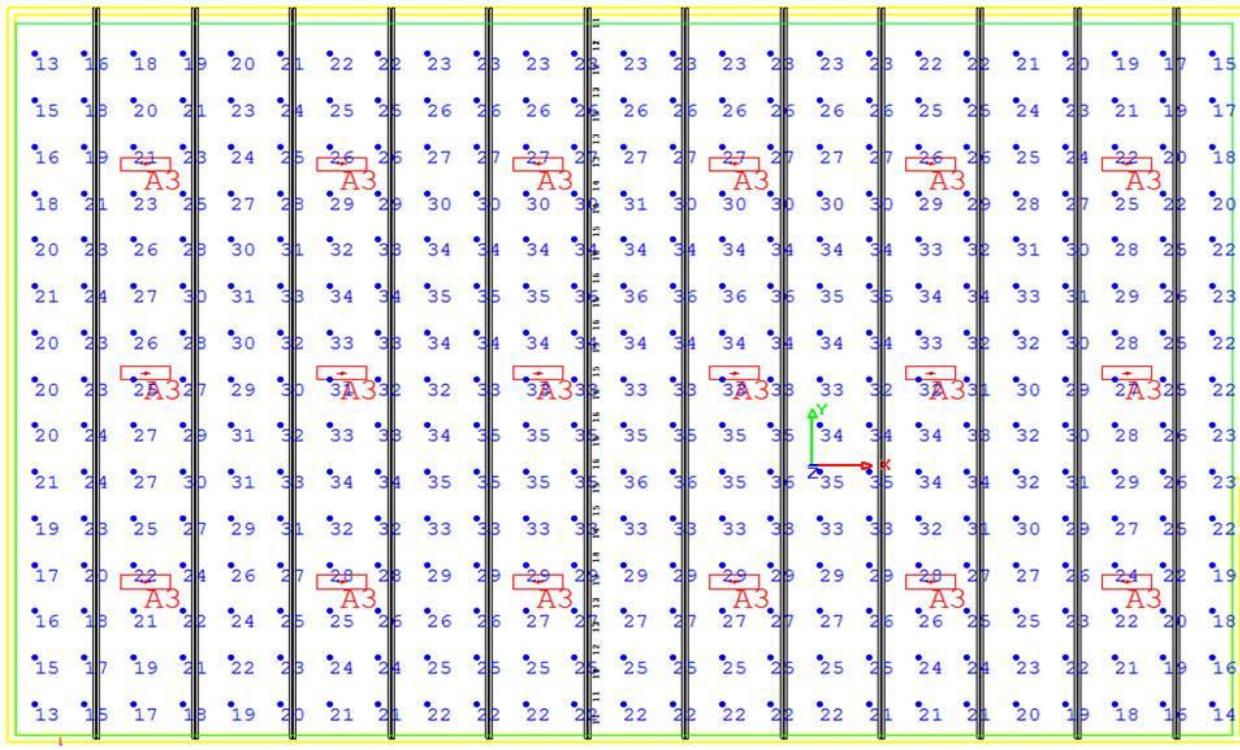


Figure 49: Gym and basketball (100% light output) scene setting

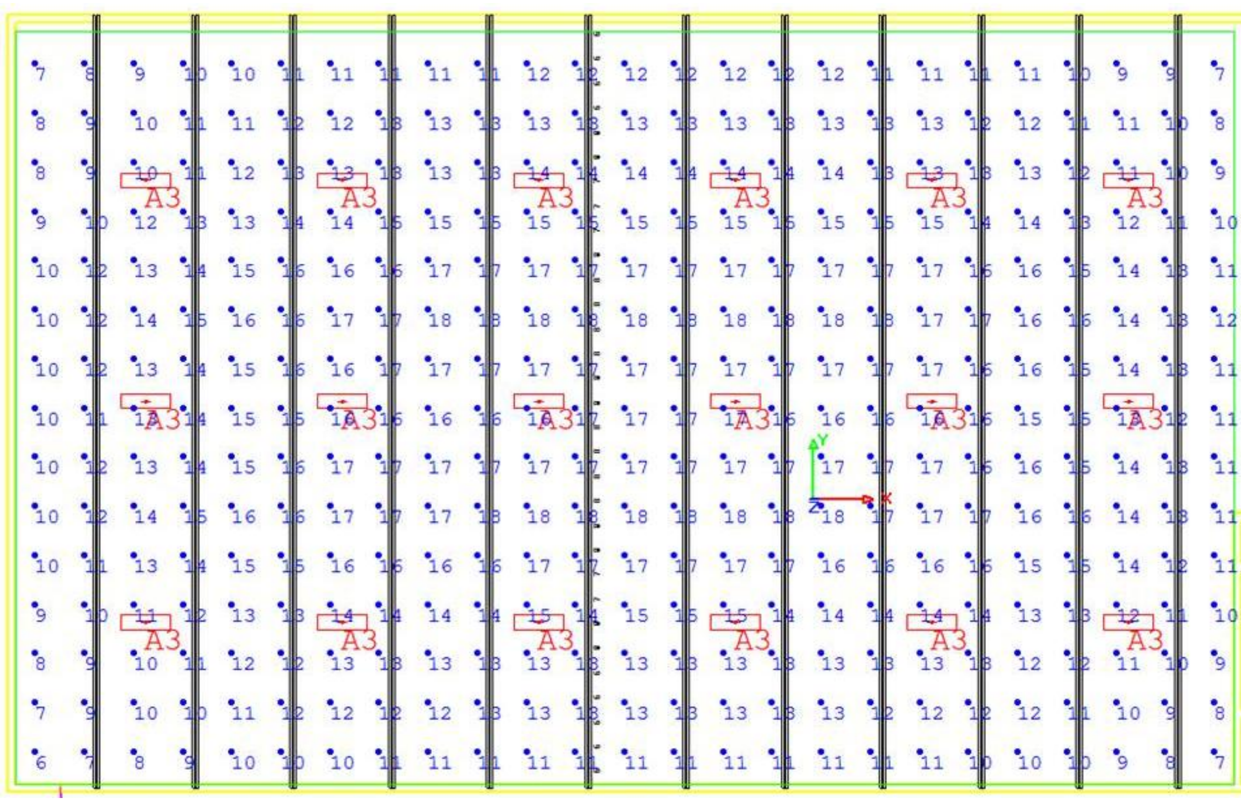


Figure 50: Auditorium & Emergency (50% light output) scene setting

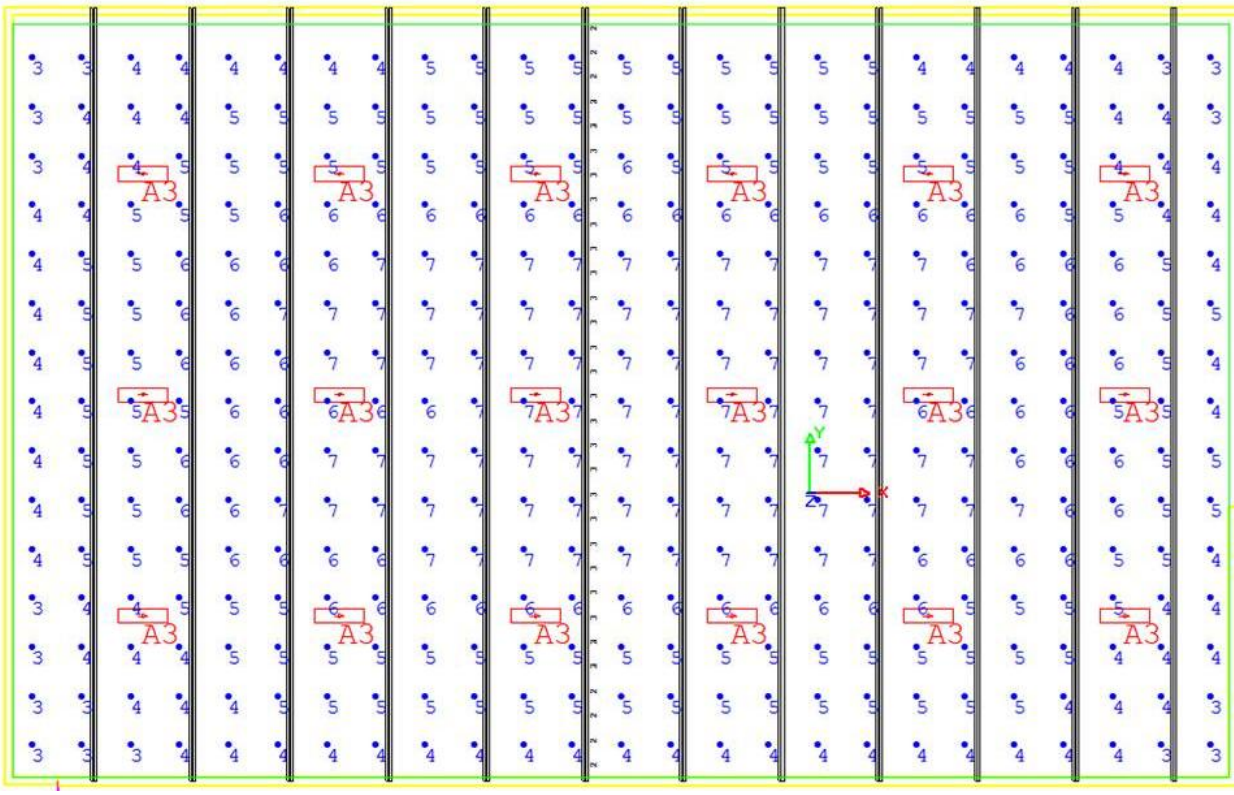


Figure 51: Dance social (20% light output) scene setting

Pool

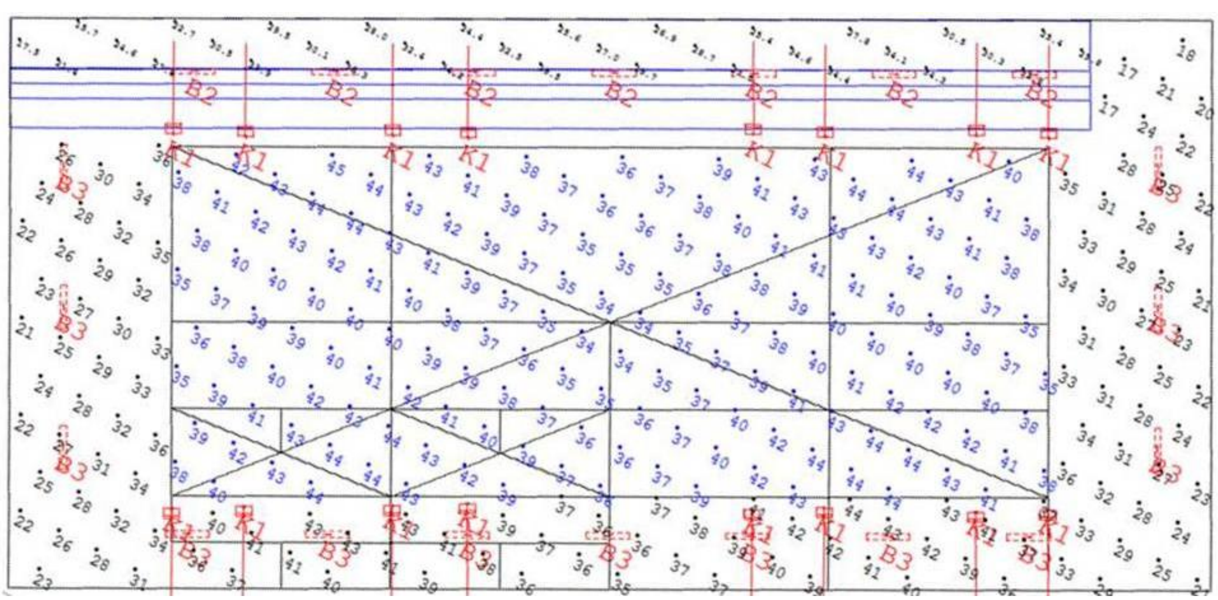


Figure 52: Pool illuminance under normal operation (K1 at 100% light output)

An image of luminaire type K1 is provided. The ballast is located in the junction box below the luminaire. The luminaire and junction box are mounted to the straight pole truss.

Normal operation of the pool is intended to utilize type K1 luminaires. B2 and B3 luminaires are intended to provide higher illuminance levels to the turning lanes, for competitive events, and primarily for emergency use.

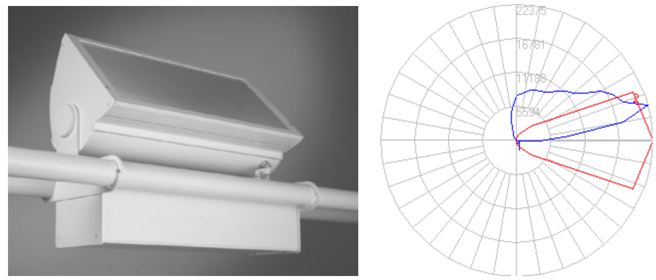


Figure 53: Truss mounted indirect pool luminaire (type K1)

Site

The LED luminaire specified provides full cutoff and Type I-V distributions. Types I and IV are used on the project. Luminaire type M1 provides a type I distribution, while luminaire type M2 provides a type IV distribution. **Figure 56** demonstrates a schematic of the pole mounted luminaires integrated into the passive half wall and providing vertical illumination to the passive half wall.

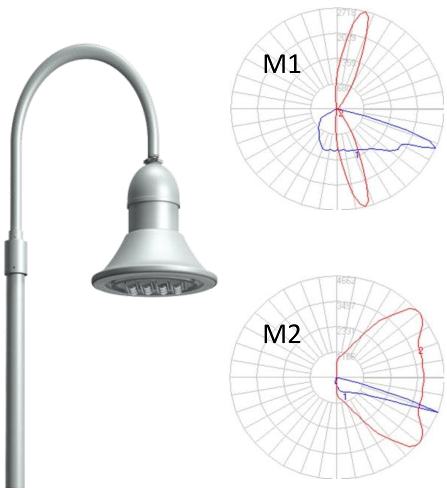


Figure 54: Beta LED luminaire (M1 & M2)

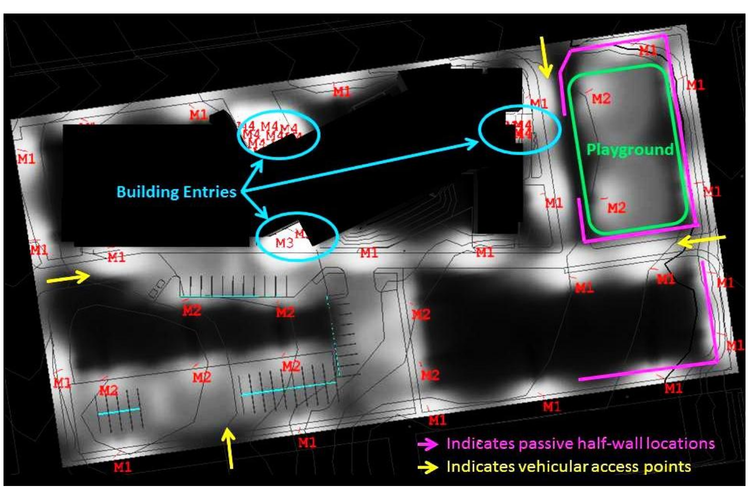


Figure 55: Site illumination diagram

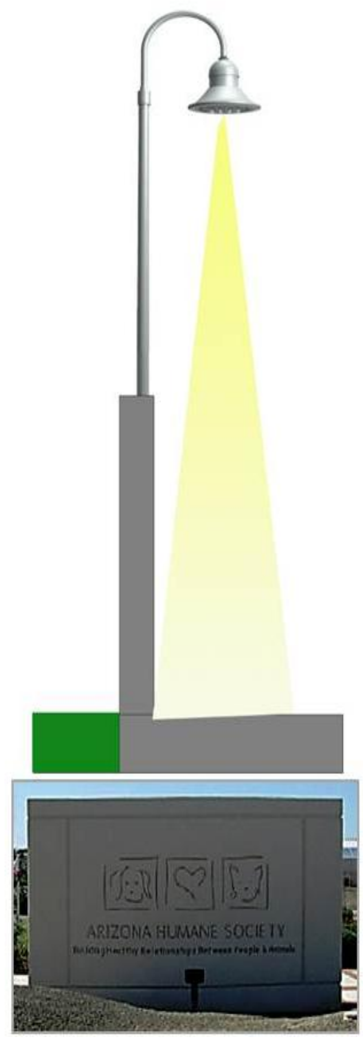


Figure 56: Half-wall schematic

Lighting power density

The designed L.P.D. throughout the building is below the recommended L.P.D. by ASHRAE 90.1. The pool uses more power than allowed by ASHRAE, mainly due to the additional type B2 and B3 luminaires needed for emergency lighting. The building as a whole meets guidelines of ASHRAE 90.1. **Table18** provides the L.P.D. for typical spaces.

Room	Room area (ft^2)	Total lighting power (W)	Allowable L.P.D. (W/ft^2)	L.P.D. (W/ft^2)
SE classroom (typ.)	1,120	783	1.24*	0.70
2nd floor SE classroom	1,120	837	1.24*	0.75
NW classroom (typ.)	810	783	1.24*	0.97
NE classroom (typ.)	924	783	1.24*	0.85
S classroom (typ.)	806	783	1.24*	0.97
1st floor corridor	4,895	3,464	0.99*	0.71
Multipurpose space	6,043	3,888	1.12*	0.64
Community pool	6,993	9,527	1.12*	1.36

Table 18: Lighting power density

*Referenced from ASHRAE 90.1

Lamps

Description	Full product name	CCT	CRI	Initial lumens	Average life	Luminous efficacy (35°C)
32W triple tube 4-pin base compact fluorescent	PL-T 32W/841/4P 1CT	4100K	82	2400	16,000 hrs.	69 Lm/W
26W triple tube 4-pin base compact fluorescent	PL-T 26W/841/4P 1CT	4100K	82	1800	16,000 hrs.	75 Lm/W
54W 4'-0" T5 HO linear fluorescent	F54T5/841 HO EA A ALTO 49W	4100K	82	4950	25,000 hrs.	101 Lm/W

Table 19: Classroom lamps

*Referenced from Philips

Transitional spaces

The type A4 luminaires in the corridors are dimmed to 80% light output. The horizontal illuminance on the floor exceeds the recommended illuminance in order to increase the illuminance to vertical surfaces in the corridors. Illuminating the walls in the corridors is important, to showcase the artwork and bulletins typically mounted to the walls in the corridors.

Application	$E_{horizontal}$ (fc.)		$E_{vertical}$ (fc.)		$E_{avg.}/E_{min}$	
Independent passageways	5*	**7.48**	3*	**2.67**	4:1*	**3.8:1**
Building Entries	10*	**7.21**	--	**--**	4:1*	**5.41:1**

Table 20: Transitional spaces illuminance levels

*As recommended by IESNA Lighting Handbook 9th Edition

A E I Team 10-2013

SECTION 3: DRAWINGS

The following drawings are included in the submission:

E-101 – FIRST FLOOR ELECTRICAL PLAN

E-400 – POWER DISTRIBUTION ONE LINE DIAGRAM

L-101 – FIRST FLOOR LIGHTING PLAN

L-301 – EXTERIOR PERSPECTIVES

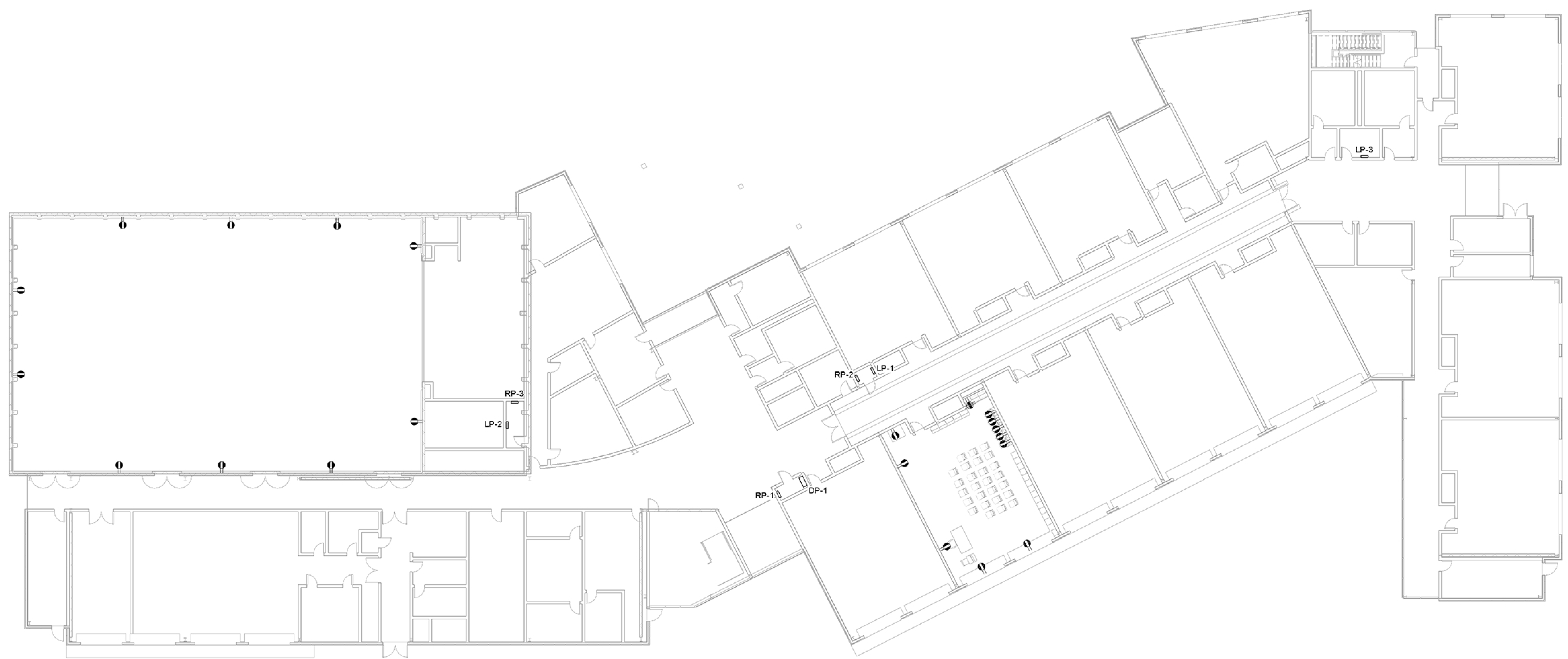
L-302 – POOL DETAILS

L-303 – MULTIPURPOSE ROOM DETAILS

L-304 – CLASSROOM DETAILS

L-305 – CORRIDOR DETAILS

L-400 – SCHEDULES



1 FIRST FLOOR ELECTRICAL PLAN
1/16" = 1'-0"

AEI TEAM
10 - 2013

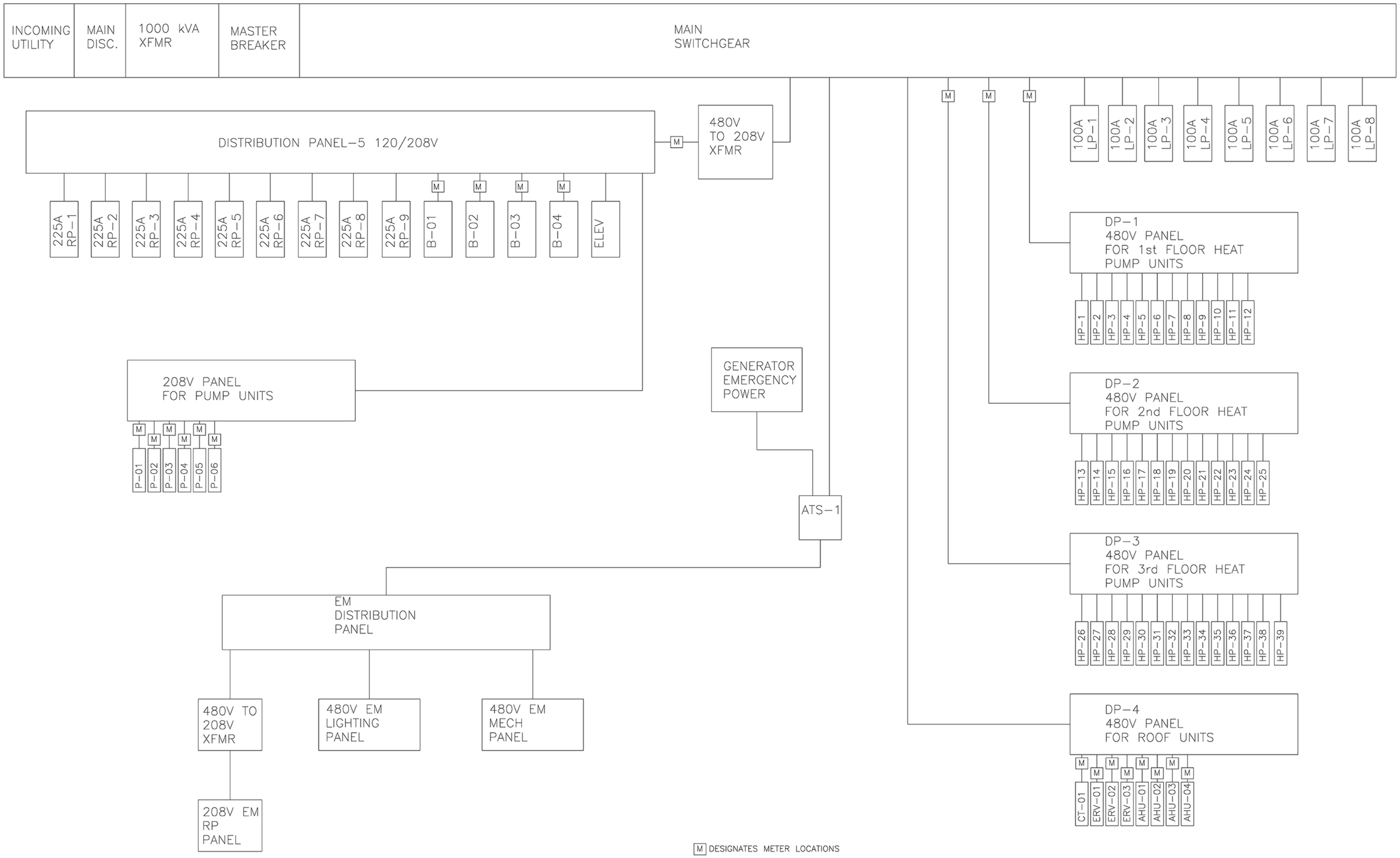
READING
ELEMENTARY SCHOOL

FIRST FLOOR
ELECTRICAL PLAN

Date 02.22.2013

E-101

Scale 1/16" = 1'-0"



AEI TEAM
10 - 2013

READING
ELEMENTARY SCHOOL

POWER DISTRIBUTION
ONE LINE DIAGRAM

Date 02.22.2013

E-400

Scale

FIRST FLOOR LIGHTING PLAN
1/16" = 1'-0"

AEI TEAM
10 - 2013

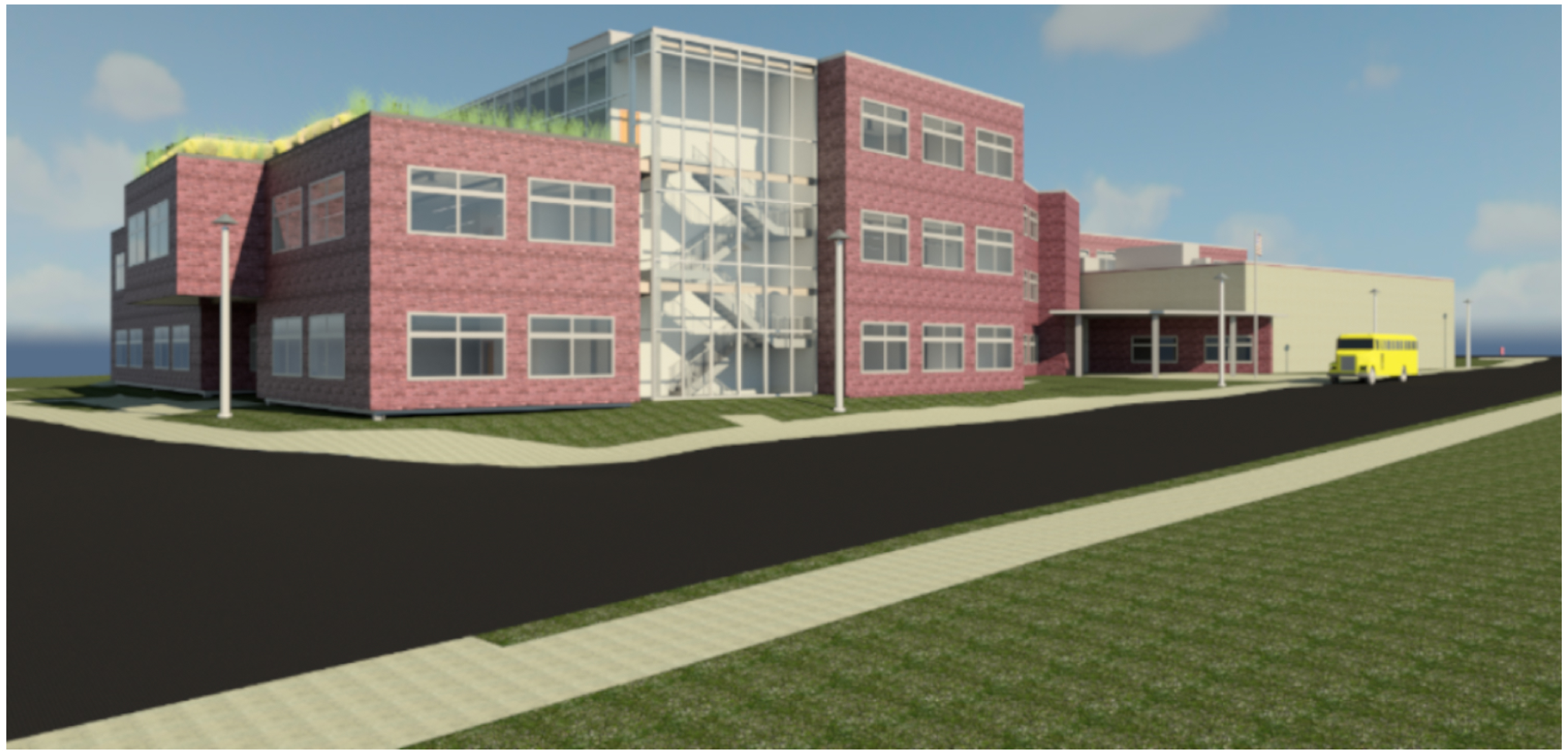
READING
ELEMENTARY SCHOOL

FIRST FLOOR
LIGHTING PLAN

Date 02.22.2013

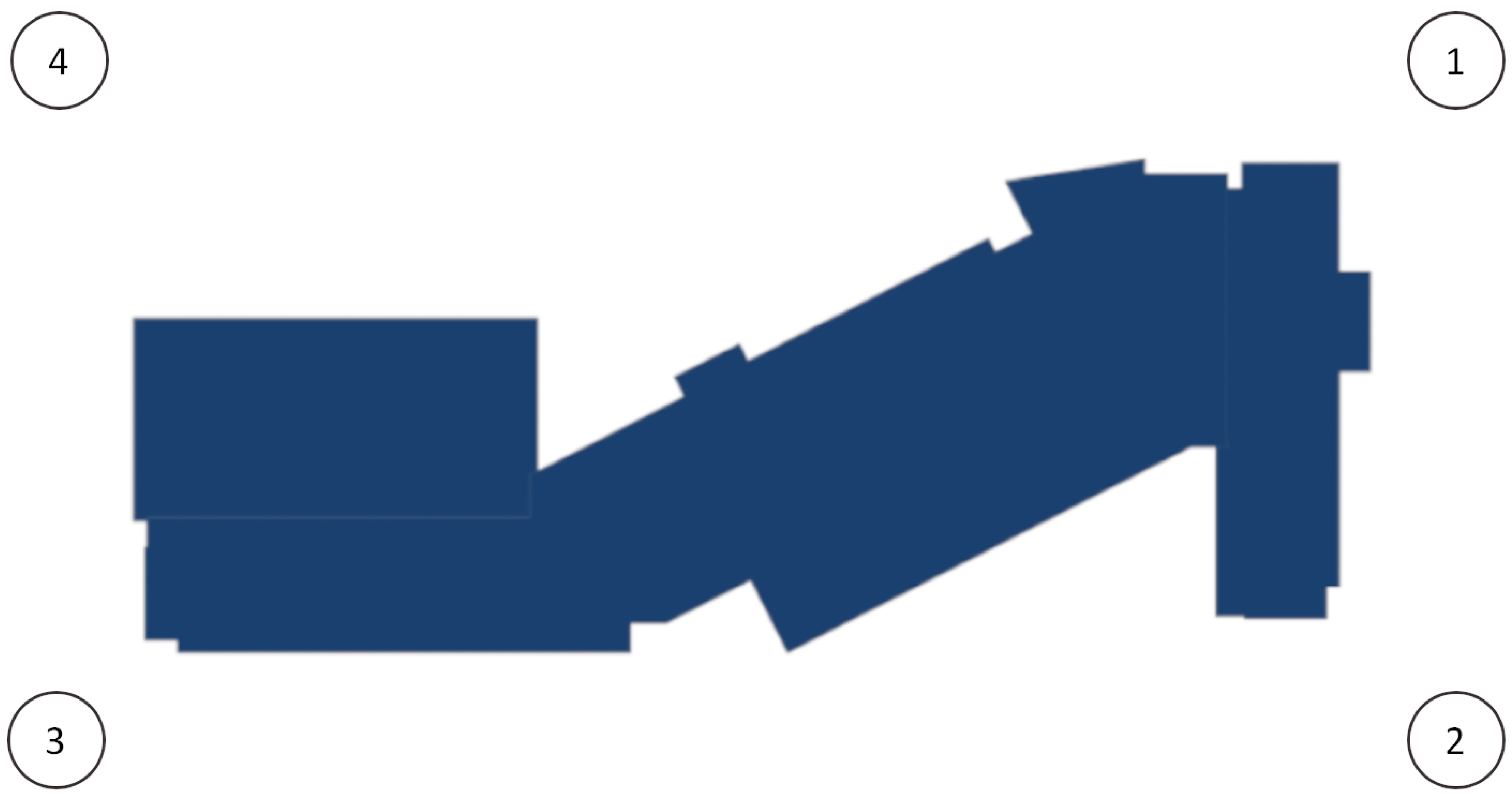
L-101

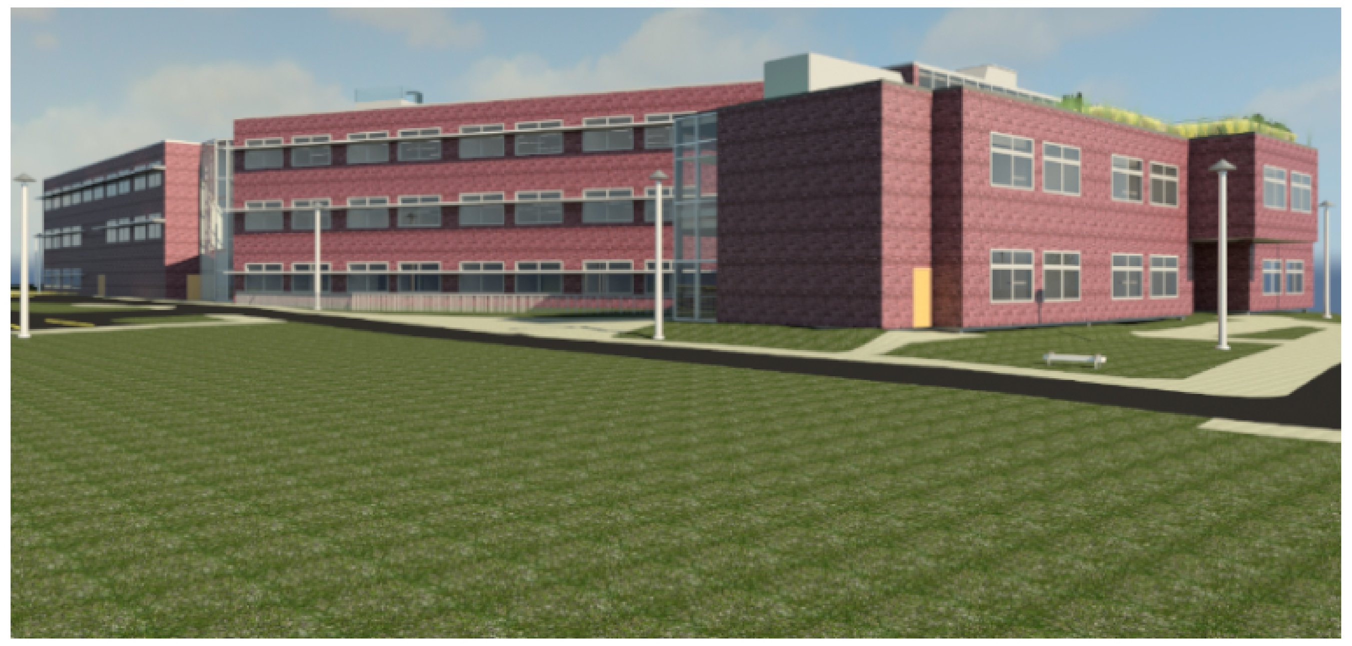
Scale 1/16" = 1'-0"



1: Northeast exterior perspective

Looking toward Reading Elementary School from its northeast corner, one can see the green roof above the east wing classrooms, as wel as the glazing-encased staircase that reaches up to the third floor classrooms. Looking further down Park Stret, the school's main covered entrance can be seen against the eastern wall of one of the school's most unique spaces, the multipurpose room/shelter.





2: Southeast exterior perspective

Seen above is the east classroom wing with green roof above, as well as the main classroom wing.

3: Southwest exterior perspective

The exterior lightshelves on the classroom windows can be easily viewed from the southwest corner of the building.

4: Northeast exterior perspective

AEI TEAM
10-2013

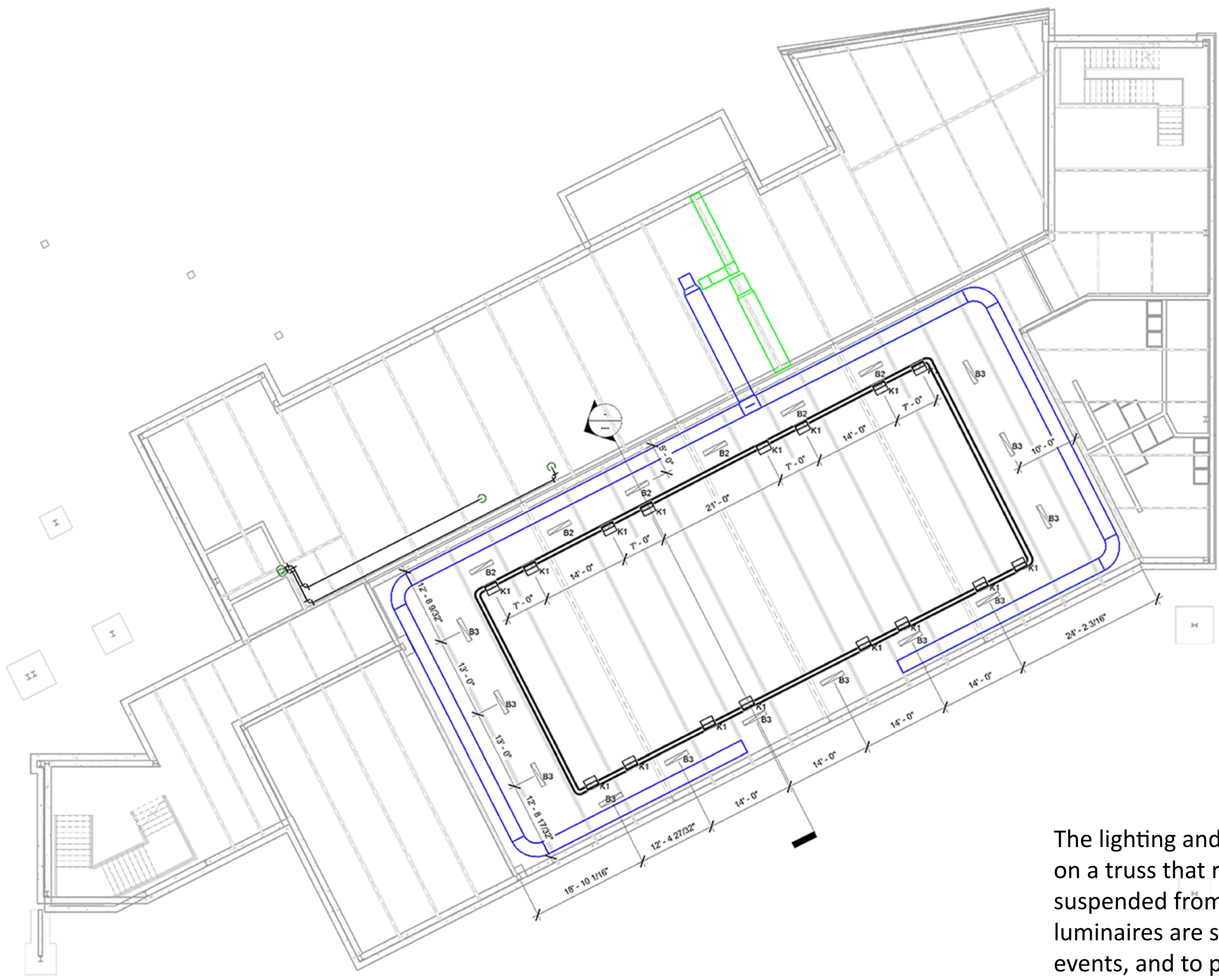
READING ELEMENTARY SCHOOL

EXTERIOR PERSPECTIVES

Date 02.22.2013

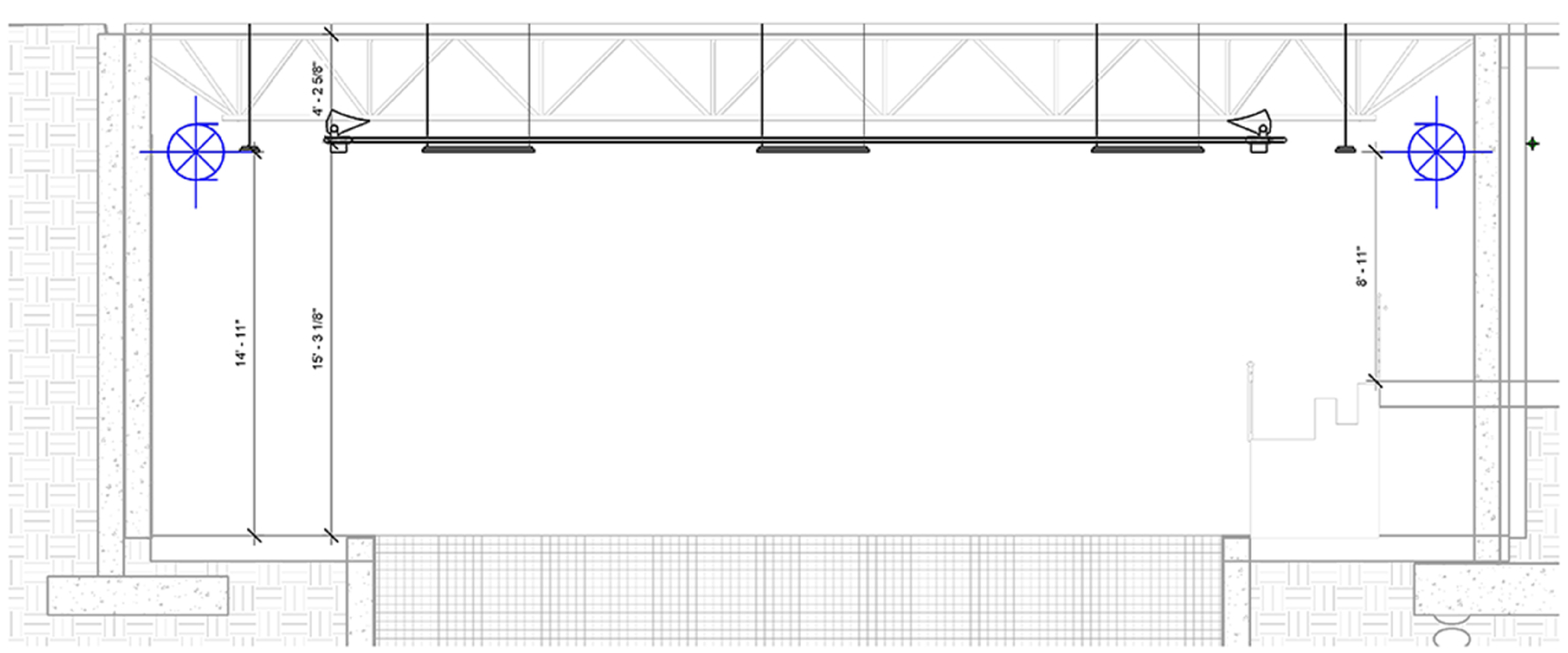
L-301

Scale

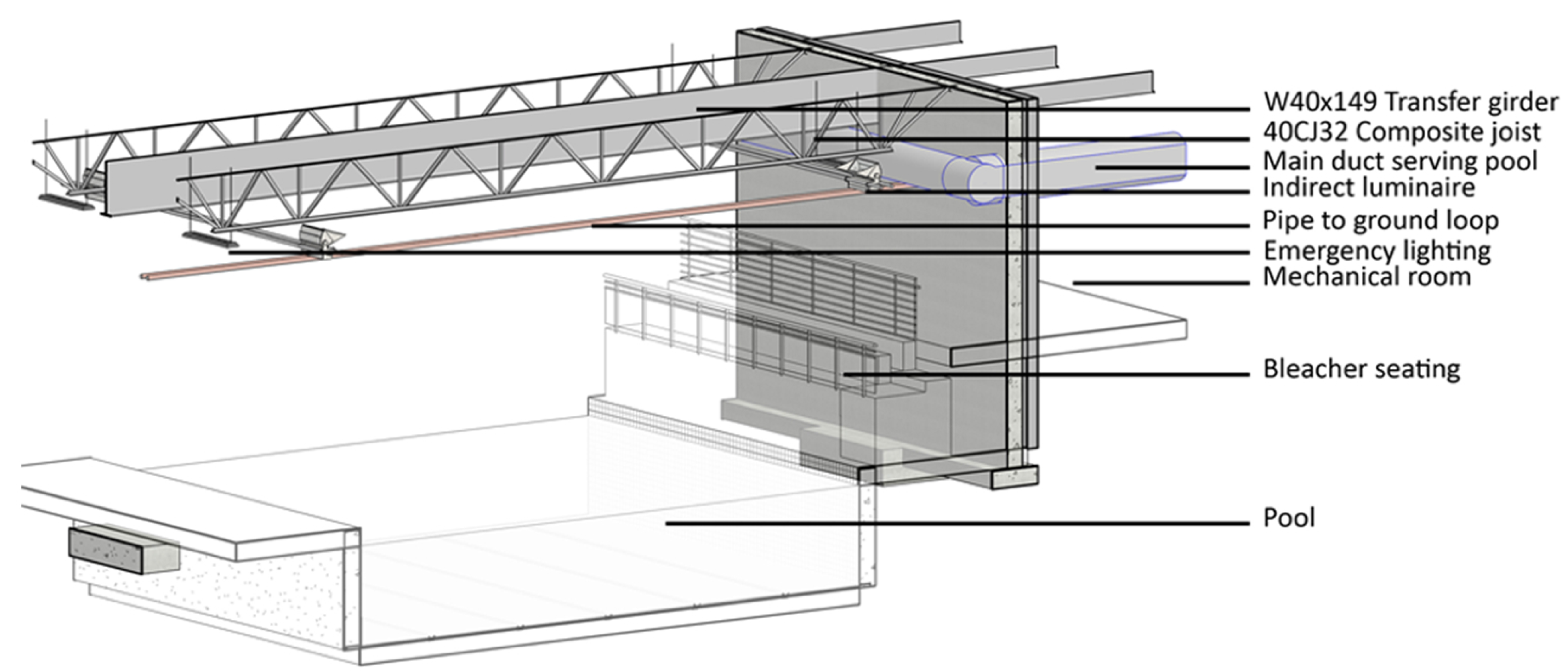


1 Pool Lighting Plan
3/32" = 1'-0"

The lighting and electrical design in the pool utilizes an indirect metal halide luminaire that is mounted on a truss that runs around the perimeter of the pool area. Additional linear fluorescent luminaires are suspended from the ceiling, and located above the pool deck and viewing stands. The suspended luminaires are specified to increase illumination levels along the end lanes for competitive swimming events, and to provide emergency lighting. The restrike time for the indirect metal halide luminaires, requires an additional light source in the pool for emergency lighting. The truss mounted luminaires are spaced between the structural trusses and girders. An indirect luminaire was chosen for the primary lighting in the pool because it reduces veiling reflections off the water surface, providing a safe environment for swimmers, viewers and lifeguards.



2 Pool Lighting Section
1/4" = 1'-0"



AEI TEAM
10-2013

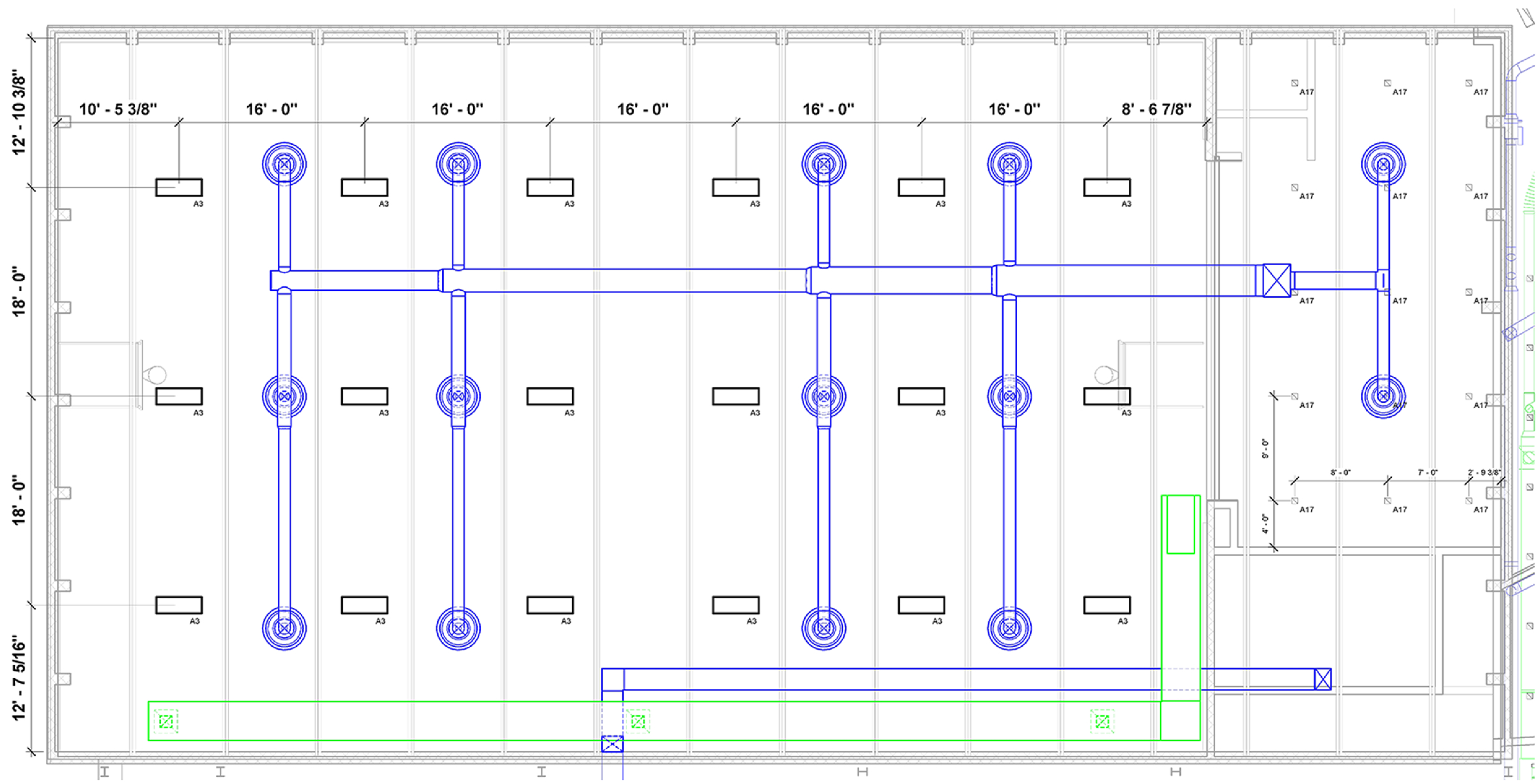
READING ELEMENTARY SCHOOL

POOL DETAILS

Date 02.22.2013

L-302

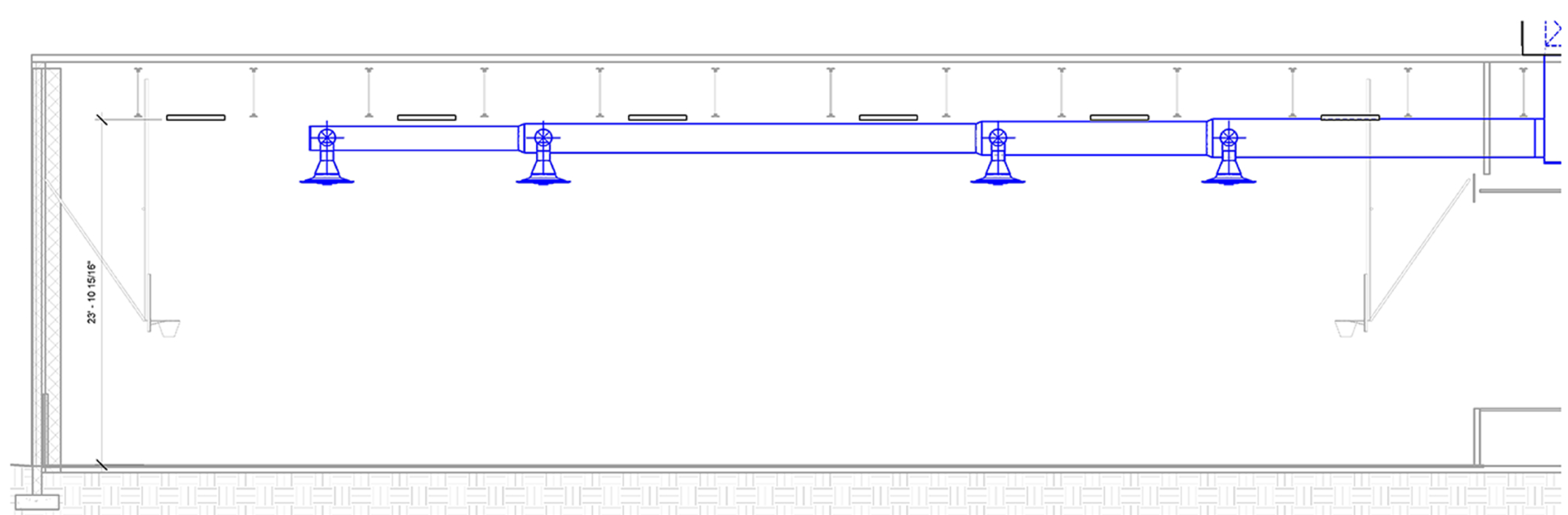
Scale As indicated



1 MULTIPURPOSE
3/16" = 1'-0"

The lighting in the multipurpose space is intended to provide the public, students, and instructors with a flexible design. Because the multipurpose space will be used for many different purposes by numerous different groups and organizations. The layout is spaced evenly between the mechanical diffusers and the structural trusses. The evenly spaced luminaires provide uniformity.

The multipurpose space is also designed to function as a community shelter. The mechanical and lighting equipment in the multipurpose space are provided power from the dual-fuel generator located in the basement.



2 MULTIPURPOSE SECTION
3/16" = 1'-0"

AEI TEAM
10 - 2013

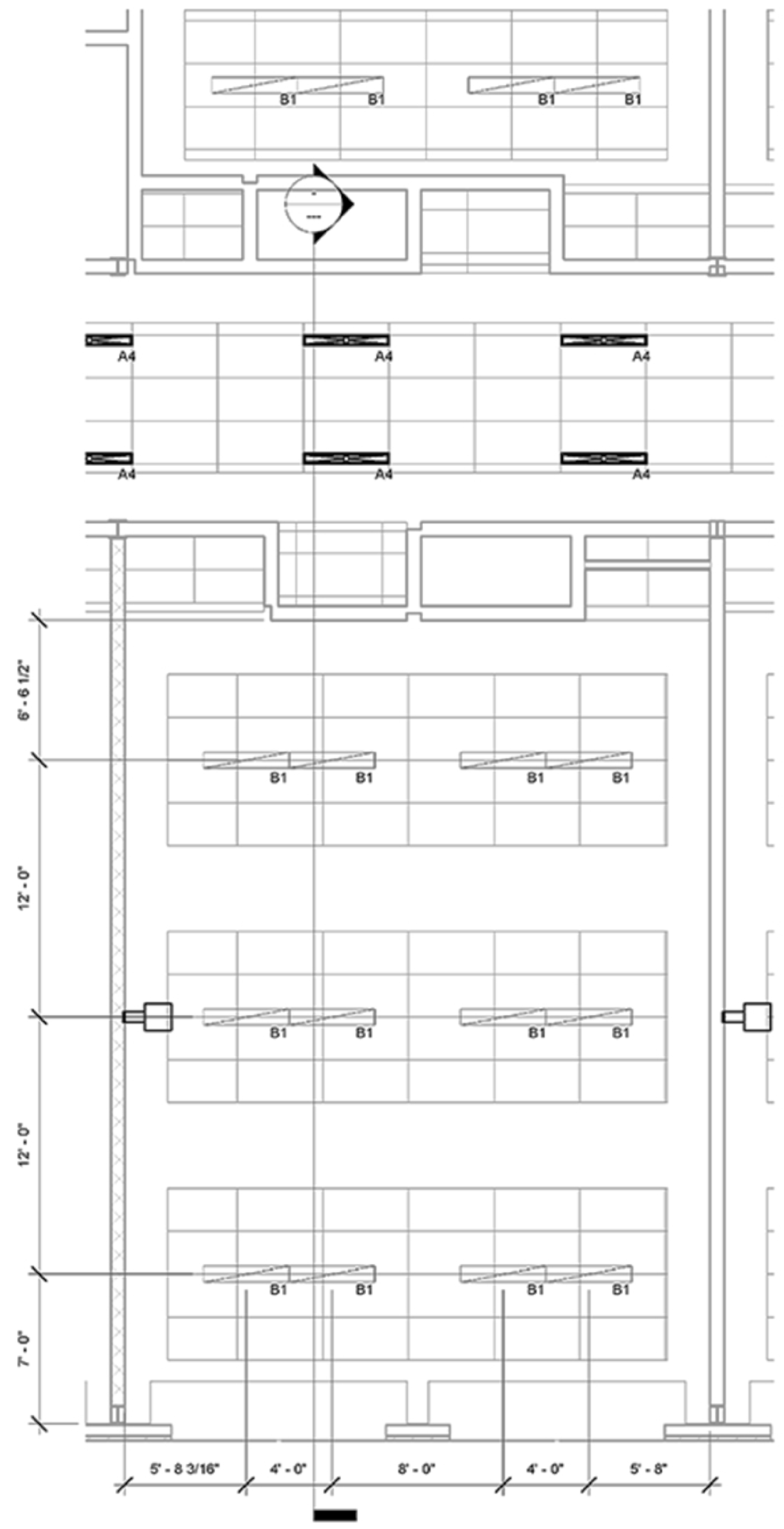
READING
ELEMENTARY SCHOOL

MULTIPURPOSE
ROOM DETAILS

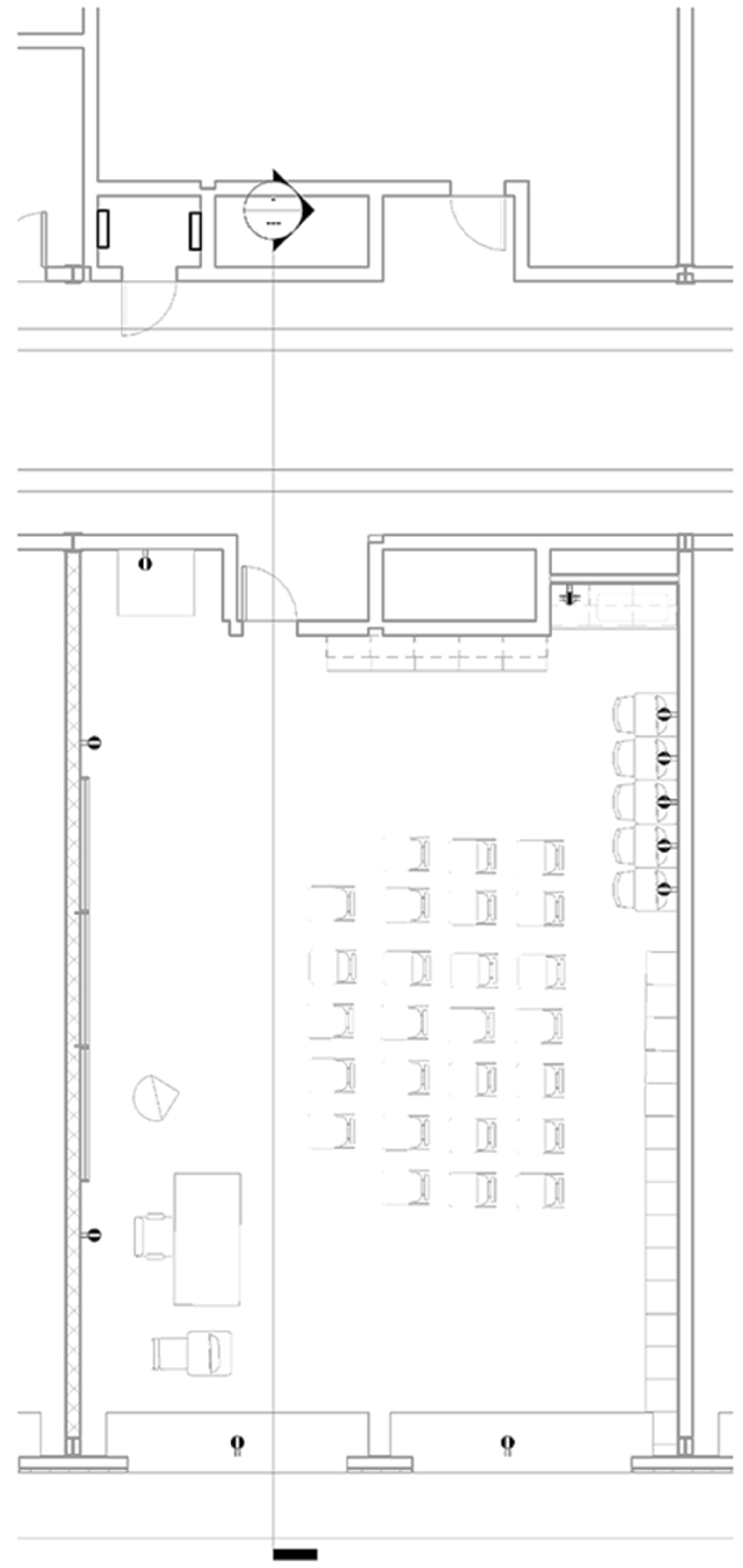
Date 02.22.2013

L-303

Scale 3/16" = 1'-0"

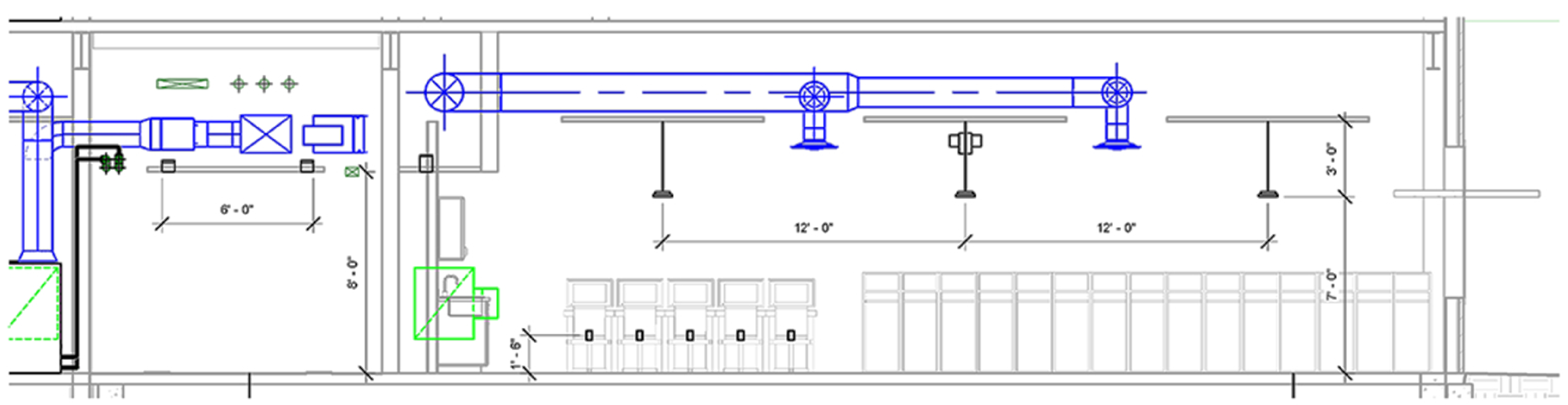


1 TYPICAL CLASSROOM RCP
3/16" = 1'-0"

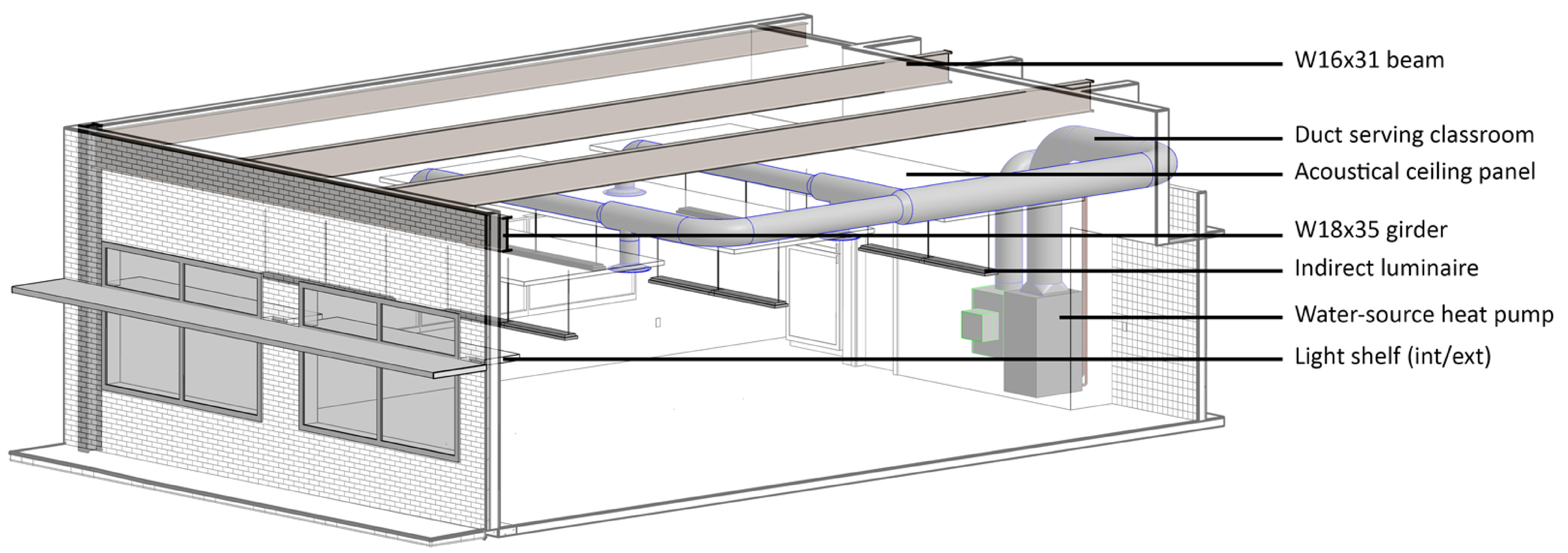


2 CLASSROOM RECEPTACLE LAYOUT
3/16" = 1'-0"

The classroom design exposes the different systems of the building. The design is intended to help teachers incorporate the building as a teaching tool through a school curriculum. Indirect linear fluorescent luminaires illuminate ceiling panels above, creating a bright learning environment. Daylight is provided through two 10'-0" x 6'-0" windows in each classroom. The amount of daylight entering the classrooms is controlled by exterior and interior light shelves, in addition to manual shades inside the classroom.



3 CLASSROOM AND CORRIDOR SECTION
1/4" = 1'-0"



AEI TEAM
10 - 2013

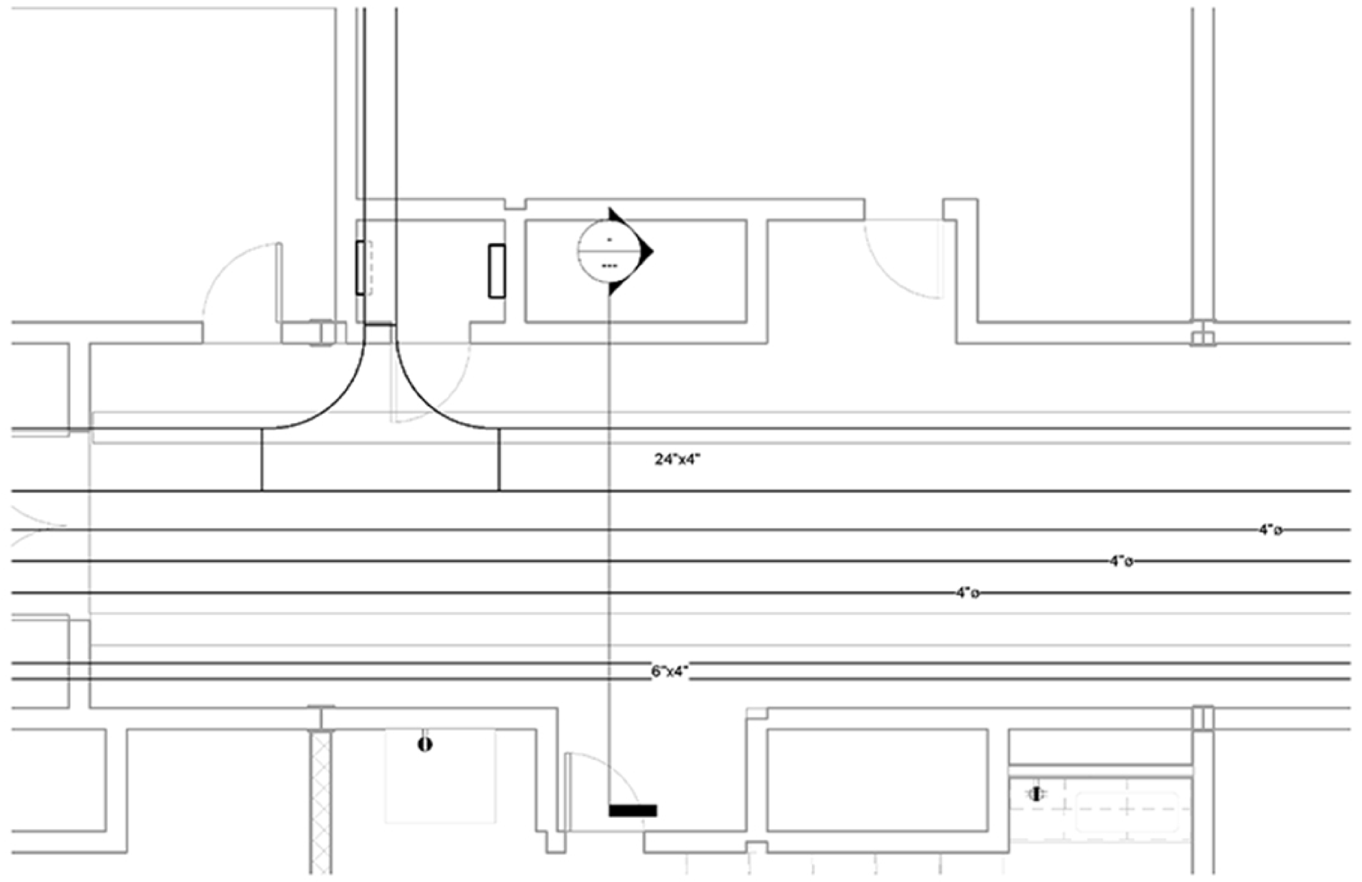
READING
ELEMENTARY SCHOOL

CLASSROOM DETAILS

Date 02.22.2013

L-304

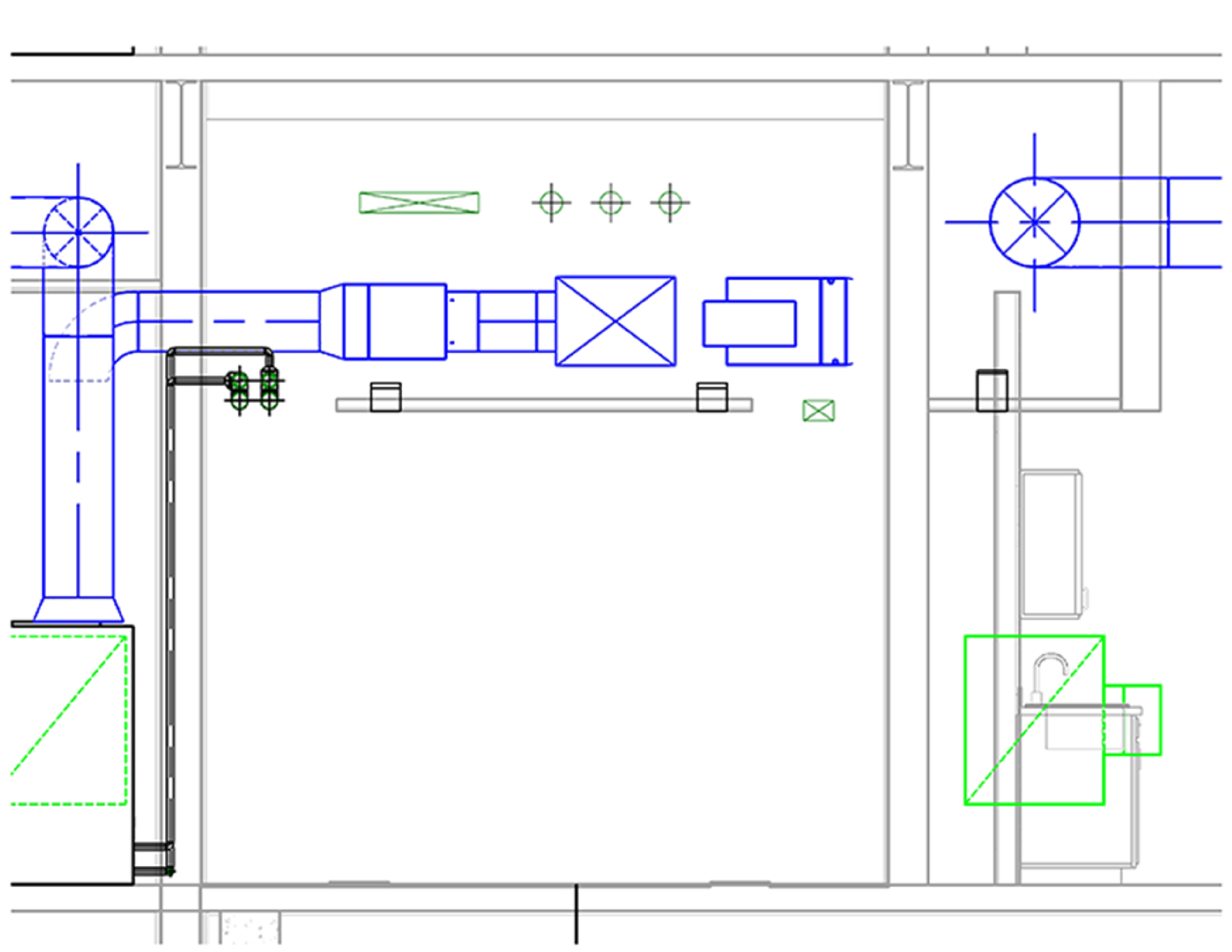
Scale As indicated



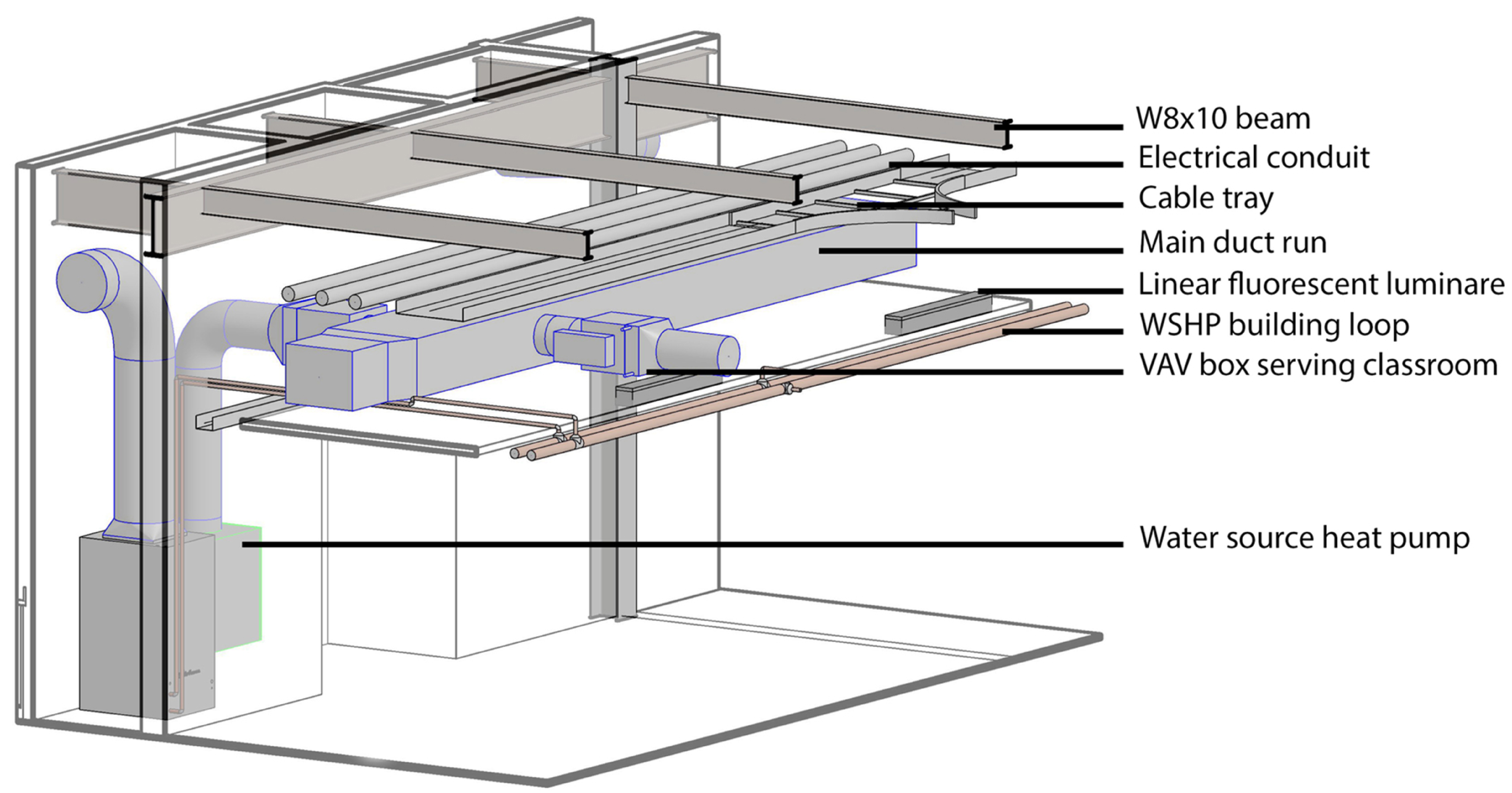
1 TYPICAL CORRIDOR DETAIL
1/4" = 1'-0"

The corridor is illuminated with linear fluorescent luminaires. The luminaires selected provide illumination to the corridor walls, to highlight the student's artwork and bulletin boards that are anticipated to be showcased in the corridors.

Colored building systems provide an opportunity to integrate the building into a curriculum focused on the building as a teaching tool. Pipes and cable trays run along the edges of the corridors, where they are exposed next to the suspended ceiling grid.



2 TYPICAL CORRIDOR SECTION
1/2" = 1'-0"



AEI TEAM
10 - 2013

READING ELEMENTARY SCHOOL

CORRIDOR DETAILS

Date 02.22.2013

L-305

Scale As indicated

Electrical Loads for Mechanical Equipment					
Tag	**Location of Unit**	**Volt**	**Phase**	**FLA**	**KVA**
B-01	Mech Rm	120	1	7.3	**0.876**
B-02	Mech Rm	120	1	7.3	**0.876**
B-03	Mech Rm	120	1	15	**1.8**
B-04	Mech Rm	120	1	7.3	**0.876**
ERV-01	Roof (above stage)	480	3	79.1	**37.968**
ERV-02	Roof (center)	480	3	54	**25.92**
ERV-03	Green Roof	480	3	15.2	**7.296**
AHU-01	Roof (center)	480	3	92.1	**44.208**
AHU-02	Roof (above restrooms)	480	3	54.2	**26.016**
AHU-03	Roof (above stage)	480	3	29.6	**14.208**
AHU-04	Mech Rm	480	3	71	**34.08**
CT-01	Roof (center)	480	3	28	**13.44**
P-01	Mech Rm	208	3	46.2	**9.6096**
P-02	Mech Rm	208	3	46.2	**9.6096**
P-03	Mech Rm	208	3	16.7	**3.4736**
P-04	Mech Rm	208	3	16.7	**3.4736**
P-05	Mech Rm	208	3	16.7	**3.4736**
P-06	Mech Rm	208	3	16.7	**3.4736**
HP 1-39	Classrooms	480	3	4.5	**2.16**

The electrical loads for mechanical equipment was considered when determining the amount of panelboards, and the locations of the panelboards. A sample panelboard is provided to show the intended organization of circuits by room, to allow for convenient retrofit procedures in the future. A lighting schedule is provided with the luminaires, and lamp types proposed in this project.

VOLTAGE: 277 / 480	**3 PHASE**	**4 WIRE**	**TOTAL WATTS L1**	8,809	**DESIGNATION** XXXXXXX
MAIN BREAKER:	**FRAME:**	**TRIP:**	**TOTAL WATTS L2**	7,047	1 OF 3 TUBS
MAIN BUS:	**MOUNTING:**		**TOTAL WATTS L3**	5,285	**LOCATION:** FLOOR - 1
NOTE:			**TOTAL WATTS**	21,141	

LOAD	DIRECTORY	WATTS LOAD L1	WATTS LOAD L2	WATTS LOAD L3	CKT.	AMPS	L1 Y	L2 Y	L3 Y	AMPS	CKT.	WATTS LOAD L1	WATTS LOAD L2	WATTS LOAD L3	DIRECTORY	LOAD
L	RM 145	1,762			1	20	•			20	2	1,762			RM 160	L
L	RM 144		1,762		3	20		•		20	4		1,762		RM 159	L
L	RM 143			1,762	5	20			•	20	6			1,762	RM 155	L
L	RM 142	1,762			7	20	•			20	8	1,762			RM 140	L
L	RM 141		1,762		9	20		•		20	10		1,762		RM 136	L
					11	20			•	20	12			1,762	RM 135	L
					13	20	•			20	14	1,762			RM 134	L
					15	20		•		20	16					
					17	20			•	20	18					
					19	20	•			20	20					
					21	20		•		20	22					
					23	20			•	20	24					
					25	20	•			20	26					
					27	20		•		20	28					
					29	20			•	20	30					
					31	20	•			20	32					
					33	20		•		20	34					
					35	20			•	20	36					
					37	20	•			20	38					
					39	20		•		20	40					
					41	20			•	20	42					
	SUBTOTAL	3,523	3,523	1,762								5,285	3,523	3,523	SUBTOTAL	

RECEPTACLE LOADS: 0 WATTS
EQUIPMENT LOADS: 0 WATTS
LIGHTING LOADS: 0 WATTS
DEMAND LOADS: 0 WATTS

Must provide "R", "E", or "L" in LOAD column to activate DEMAND LOAD and TOTAL AMPS (See Page 3) calculations

LIGHTING FIXTURE SCHEDULE

TYPE	MTG.	DESCRIPTION	LAMPING QTY	LAMPING LAMP DESIGNATION	VOLTS	MANUFACTURER	CATALOG NUMBER
A1	REC	2X4 RECESSED FLUORESCENT LUMINAIRE FOR INSTALLATION IN GRID CEILING, MAXIMUM 5 INCH DEEP STEEL HOUSING WITH FLUSH WHITE STEEL DOOR FRAME, NOMINAL 1/8 INCH EXTRUDED VIRGIN ACRYLIC LENS, BUILT-IN EARTHQUAKE CLIPS, INTEGRAL 3 LAMP DIGITAL BALLAST. OVERALL WHITE FINISH.	3	F32T8/28W/ADV841/EW/ALTO	277	LIGHTOLIER	SPS-2-G-FS-VA-3-32-277-ROVR
A2	REC	SIMILAR TO TYPE A1, EXCEPT WITH DIFFERENT LAMPING.	2	F32T8/28W/ADV841/EW/ALTO	277	LIGHTOLIER	SPS-2-G-FS-VA-2-32-277-ROVR
A3	PEND	2X4 PENDANT FLUORESCENT LUMINAIRE FOR INSTALLATATION IN UNFINISHED CEILING, MAXIMUM 4 INCH DEEP STEEL HOUSING WITH HINGE DOOR, NOMINAL 1/8 INCH PROTECTIVE CLEAR ACRYLIC LENS, SPECULAR ALUMINUM REFLECTOR, INTEGRAL 3 LAMP DIGITAL BALLAST. OVERALL WHITE FINISH.	4	F54T5/841/HO/EA/A/ALTO/49W	277	GENERAL ELECTRIC	FH5-4-4-54-0-A-ROVR-277-AP-D-E-N
A4	REC	5 INCH X 4 FOOT RECESSED FLUROESCENT LUMINAIRE FOR INSTALLATION IN GRID CEILING, MAXIMUM 6 INCH 20 GUAGE STEEL HOUSING, BOLD BAFFLE WITH PERFORATED BLADES, INTEGRAL DIGITAL BALLAST. OVERALL WHITE FINISH.	2	FP28T5/835	277	NEO-RAY	75DR-2T5-4-1EB-S722PP
A17	REC	COMPACT FLUORESCENT DOWNLIGHT WITH SQUARE APERTURE, NOMINAL 6 INCH SQUARE APERTURE X MAXIMUM 8 INCH DEEP HOUSING, HIGHLY REFLECTIVE MATTE WHITE REFLECTOR, WHITE TRIM, INTEGRAL DIGITAL BALLAST.	1	PL-T/32W/841/4P/1CT	277	GOTHAM	SQF-1/32TRT-6WR-277-ROVR
A18	REC	SIMILAR TO TYPE A17, EXCEPT WITH DIFFERENT LAMPING.	1	PL-T/26W/841/4P/1CT	277	GOTHAM	SQF-1/26TRT-6WR-277-ROVR
B1	PEND	9 INCH X 4 FOOT FLOURESCENT LUMINAIRE FOR INDIVIDUAL INSTALLATION IN UNFINISHED CEILING, ADJUSTABLE AIRCRAFT CABLE WITH STRAIGHT POWER CHORD, MAXIMUM 3 INCH DEEP ALUMINUM HOUSING, SPECULAR REFLECTOR, HIGH EFFICIENCY LOUVER, 2 LAMP INTEGRAL DIGITAL BALLAST. OVERALL WHITE FINISH.	2	F54T5/841/HO/EA/A/ALTO/49W	277	COOPER	VB-S-W-2-T5-1--D-277-A-C-120"-T2
B1	PEND	9 INCH X 4 FOOT FLOURESCENT LUMINAIRE FOR CONTINUOUS INSTALLATION IN GRID CEILING, ADJUSTABLE AIRCRAFT CABLE WITH STRAIGHT POWER CHORD, MAXIMUM 3 INCH DEEP ALUMINUM HOUSING, SPECULAR REFLECTOR, HIGH EFFICIENCY LOUVER, 1 LAMP INTEGRAL DIGITAL BALLAST. OVERALL WHITE FINISH.	1	F54T5/841/HO/EA/A/ALTO/49W	277	COOPER	VB-S-W-1-T5-1--D-277-A-C-48"-T1
B2	PEND	9 INCH X 4 FOOT FLOURESCENT LUMINAIRE FOR INDIVIDUAL INSTALLATION IN UNFINISHED CEILING, ADJUSTABLE AIRCRAFT CABLE WITH STRAIGHT POWER CHORD, MAXIMUM 3 INCH DEEP ALUMINUM HOUSING, SPECULAR REFLECTOR, HIGH EFFICIENCY LOUVER, 2 LAMP INTEGRAL DIGITAL BALLAST. OVERALL WHITE FINISH.	2	F54T5/841/HO/EA/A/ALTO/49W	277	COOPER	VB-S-W-2-T5-1--D-277-A-C-120"-T2
B3	PEND	SIMILAR TO TYPE B2, EXCEPT WITH DIFFERENT LAMPING.	3	F54T5/841/HO/EA/A/ALTO/49W	277	COOPER	VB-S-W-3-T5-1--D-277-A-C-120"-T3
K1	TRUSS	INDIRECT METAL HALIDE LUMINAIRE FOR INSTALLATION ON A CEILING TRUSS, STANDARD YOKE MOUNT FULLY ADJUSTABLE AND LOCKABLE, CAPTIVE EXTRUDED ALUMINUM DOOR WITH CONTINUOUSLY GASKETED REGRESSED LENS FOR NATATORIUM, MAXIMUM 21 INCH PROFILE, SINGLE LAMP METAL HALIDE LAMP WITH REMOTE MAGNETIC CWA BALLAST. OVERALL WHITE FINISH. SINGLE RAIL TRUSS SYSTEM JOINED CONTINUOUSLY WITH 90 DEGREE CORNER RAILS, SEMI-GLOSS FINISH FOR NATATORIUM ENVIRONMENT.	1	400W ED18 CMH	277	WINDIRECT	LUMINAIRE: XT-4-XL-MP400-277-P2-SGW-NT-STD TRUSS: STR-P2-SGW-NT-STD
M1	POLE	LED FULL CUTOFF POLE LUMINAIRE, NOMINAL 16 INCH HIGH X 22 INCH WIDE ALUMINUM FIXTURE HOOD, ADJUSTABLE PHOTOCELL TENON, HIGH TRANSMITTANCE CUSTOM MOLDED LENSES FOR TYPE I DISTRIBUTION, LEDS WITH MINIMUM CRI OF 80, 3700 MAXIMUM CANDELA AT 67.5° VERTICAL, LED LIGHT ENGINE WITH 60,000 HOUR LIFE UNTIL L70, UL LISTED FOR WET LOCATIONS, INTEGRAL LED DRIVERS. LUMINAIRE SHALL BE MOUNTED TO 20 FOOT ROUND STEPPED STEEL POLE TO WITHSTAND 110 MPH WINDS WITH A 7.6 GUST FACTOR, OVERALL PAINT FINISH TO MATCH LUMINAIRE, GFCI RECEPTACLE WITH WEATHERPROOF COVER. STRUCTURAL ENGINEER TO COORDINATE POLE BASE DETAILS.	1	3000K WHITE LED BY MANUFACTURER, MINUMUM 4500 DELIVERED LUMENS, LED TESTING TO IESNA LM-79-08 AND LM-80 TEST STANDARDS AT 25°C AMBIENT CONDITIONS.	277	SELUX	LUMINAIRE: BPL-1-1-4TL350-3000K-BK-277-PCT-DM POLE: S635-20-BK-REC
M2	POLE	SIMILAR TO TYPE M1, EXCEPT WITH TYPE IV DISTRIBUTION.	1	3000K WHITE LED BY MANUFACTURER, MINUMUM 4500 DELIVERED LUMENS, LED TESTING TO IESNA LM-79-08 AND LM-80 TEST STANDARDS AT 25°C AMBIENT CONDITIONS.	277	SELUX	LUMINAIRE: BPL-4-1-4TL350-3000K-BK-277-PCT-DM POLE: S635-20-BK-REC
M3	WALL	SIMILAR TO TYPE M1, EXCEPT WITH 10 FOOT WALL MOUNTING. STRUCTURAL ENGINEER TO COORDINATE WALL MOUNTING DETAILS.	1	3000K WHITE LED BY MANUFACTURER, MINUMUM 4500 DELIVERED LUMENS, LED TESTING TO IESNA LM-79-08 AND LM-80 TEST STANDARDS AT 25°C AMBIENT CONDITIONS.	277	SELUX	LUMINAIRE: BPL-1-1-4TL350-3000K-BK-277-PCT-DM
M4	REC	6 INCH SQUARE RECESSED LED DOWNLIGHT MOUNTED IN EXTERIOR CANOPY, MAXIMUM 6 INCH DEEP HOUSING, INTEGRAL DIGITAL BALLAST. OVERALL WHITE FINISH.		3500K WHITE LED BY MANUFACTURER, MINUMUM 4500 DELIVERED LUMENS, LED TESTING TO IESNA LM-79-08 AND LM-80 TEST STANDARDS AT 25°C AMBIENT CONDITIONS.	277	ACUITY	ECSS-35/12-6DSR-LD

AEI TEAM
10 - 2013

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SCHEDULES

Date 02.22.2013

L-400

Scale