Proposal for local school district

Elementary School Design

INTEGRATED PROJECT DELIVERY / BUILDING INFORMATION MODELING STUDIO - SPRING 2011

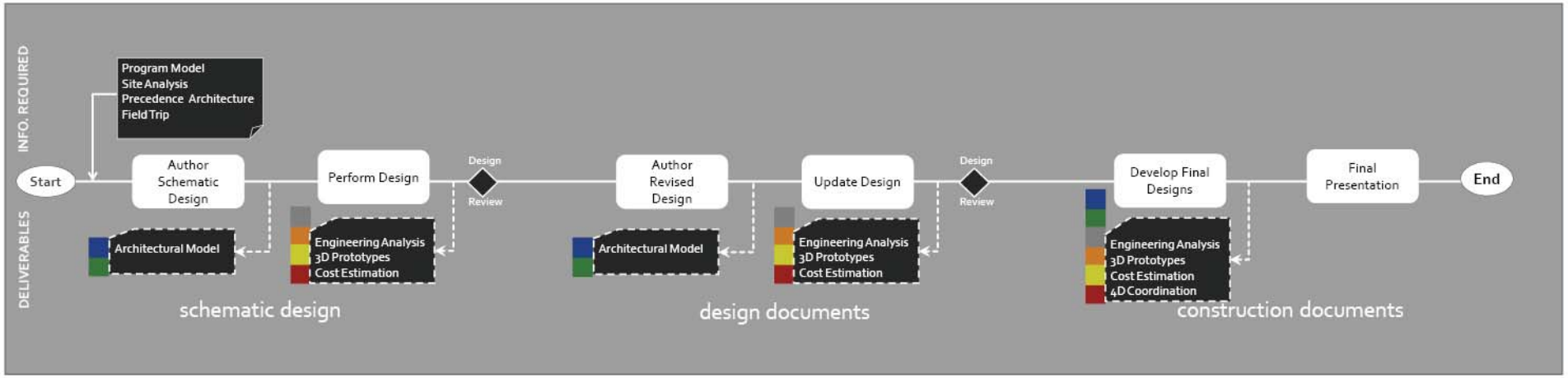
Team Members

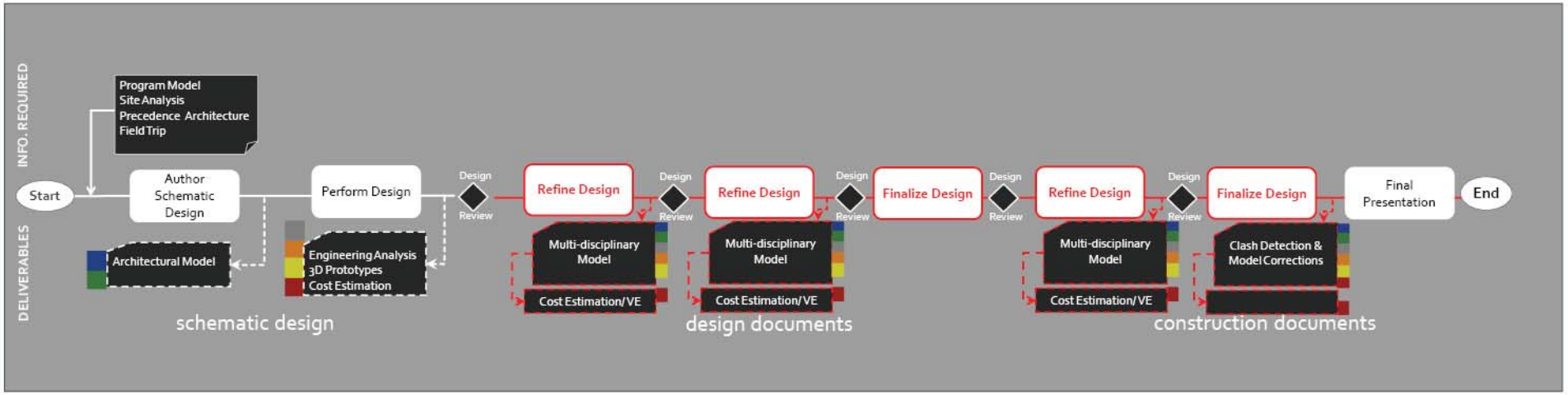
Architecture
Landscape Architecture
Structural Engineer
Mechanical Engineer
Lighting/Electrical Engineer
Construction Manager

Submitted

May 13, 2011

Contents





BIM Execution Plan

Living Document

The BIM Execution Planning Guide was utilized as a basepoint and group organizational tool for this studio. The team was able to identify goals, establish an execution process and information exchanges, and, finally, define a supportive infra-structure. This section shows the treatment of the BIM ex plan as a living document, constantly being improved.

Process Maps

The above diagrams show the initial process our team expected to follow throughout the semester. Here the design process is strict and linear, which hinders collaboration and iterations. After a semester of working together our new process map, shown directly above, has been revised to showcase consistent value engineering, as well as, multiple design iterations.

Mission Statement

The team was dedicated to delivering efficient, sustainable designs that maximize project value and minimize extraneous project expenditures. We strive to work cooperatively with owners and subcontractors alike in an effort to eliminate the traditionally adversarial atmosphere associated with the building construction process.

Major BIM goals/objectives

X	DESIGN	X	CONSTRUCT
X	DESIGN AUTHORING	M	SITE UTILIZATION PLANNING
X	DESIGN REVIEW		CONSTRUCTION SYSTEM DESIGN
X	3D COORDINATION	X	3D COORDINATION
M	STRUCTURAL ANALYSIS		DIGITAL FABRICATION
M	LIGHTING ANALYSIS		
M	ENERGY ANALYSIS		
M	MECHANICAL ANALYSIS		
	OTHER ANALYSIS		
M	SUSTAINABILITY (LEED) EVALUATION		
	CODE VALIDATION		
X	PHASE PLANNING (4D MODELING)	X	(4D MODELING)
X	COST ESTIMATION	X	COST ESTIMATION
	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

above: Our first step was to evaluate the list of BIM goals in the planning guide and decide which ones pertained to our unique studio project.

PRIORITY HIGH/MED/LOW	GOAL DESCRIPTION	POTENTIAL BIM USES
High	Maximize efficiency of design & coordination process	3D Coordination, Design Authoring
High	Minimize clashes both in frequency and severity on-site	3D Coordination, Design Reviews
High	Turnover the project on-time and at least on-budget	Cost Estimation
HIgh	Perform design reviews in a virtual environment	Design Review
High	Utilize analytical programs to design a sustainable, energy efficient project.	Sustainability, Struct., Mech., Lighting Analysis
Medium	Utilize integrated multi-disciplinary software to learn capabilities	Design Authoring
Medium	To evaluate constructability and verify the feasibility of an aggressive schedule	4D Modeling, Design Reviews
Medium	Improve communication between all disciplines	3D Coordination

above: After choosing specific goals that fit our project we developed a hierarchy.

Sustainablitiy

MATERIAL	SUPPLIER	LOCATION	DISTANCE	METHOD	FUEL ECONOMY	TYPE OF FUEL	EMISSIONS	FOOTPRINT	# OF TRUCKS	TOTAL FOOTPRINT
Steel Deck	Vulcraft	Chemung, NY	140 MILES	Tractor Trailer	8 MPG	DIESEL	22.2 LBS/GAL	777 LBS		
Joists	Vulcraft	Chemung, NY	140 MILES	Tractor Trailer	8 MPG	DIESEL	22.2 LBS/GAL	777 LBS		
W-Shapes	Western PA	Pittsburgh, PA	148 MILES	Tractor Trailer	8 MPG	DIESEL	22.2 LBS/GAL	777 LBS		
Masonry	Centre Hall Masonry Supply	Centre Hall, PA	15 MILES	Tractor Trailer	8 MPG	DIESEL	22.2 LBS/GAL	777 LBS		
Metal Studs	Dietrich Industries	Blairsville, PA	103 MILES	Tractor Trailer	8 MPG	DIESEL	22.2 LBS/GAL	777 LBS		

Material	Embodied Energy	CO_2 emissions/lb.	Strength-to-Weight Ratio
Steel	High	1.50 lb/lb	1:10
Concrete	Med	1.00 lb/lb	1:40
Masonry	Med	~1.00 lb/lb	Low
Wood	Low	0.7 lb/lb	Low

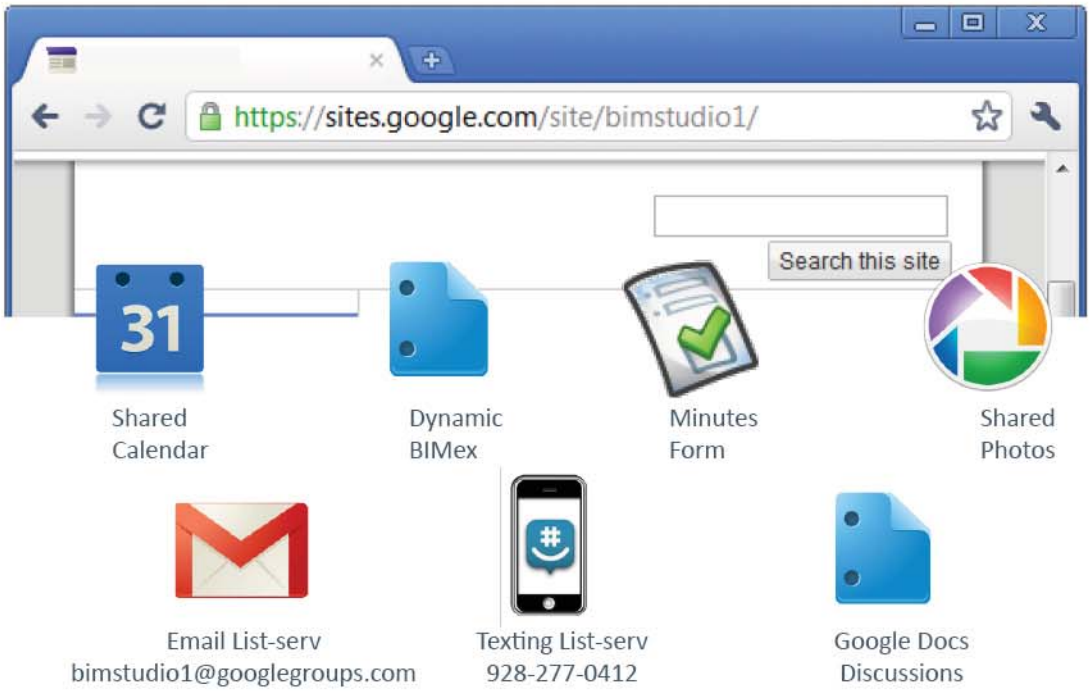
RANK	TOUCHSTONES
1	Supports learning program
2	Highly adaptable & flexible spaces
3	Energy efficiency
4	Daylighting
5	Adequate teacher space
6	Building & landscape
7	LEED Gold or Platinum
8	Adequate & appropriate storage/display
9	Thermal comfort
10	Indoor air quality & operable windows

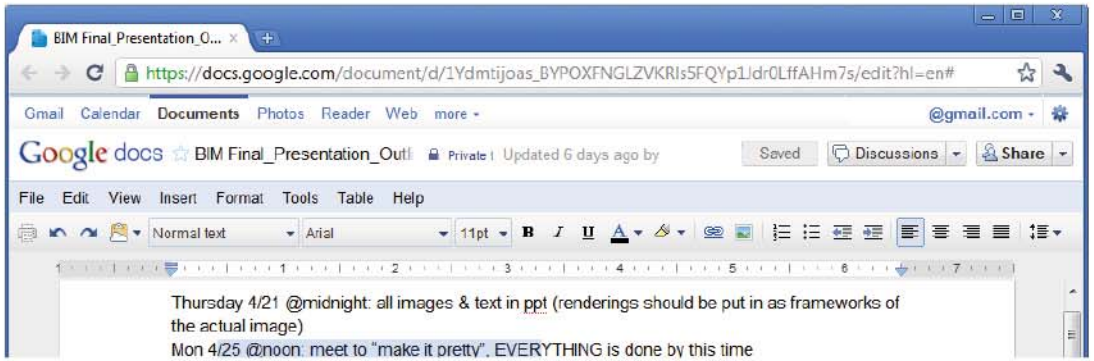
High embodied energy, CO2 emissions
Efficiency of design = Essential
Maintain modularity & linearity in curvilinear design
Use local manufacturer/fabricator
LEED material tracking

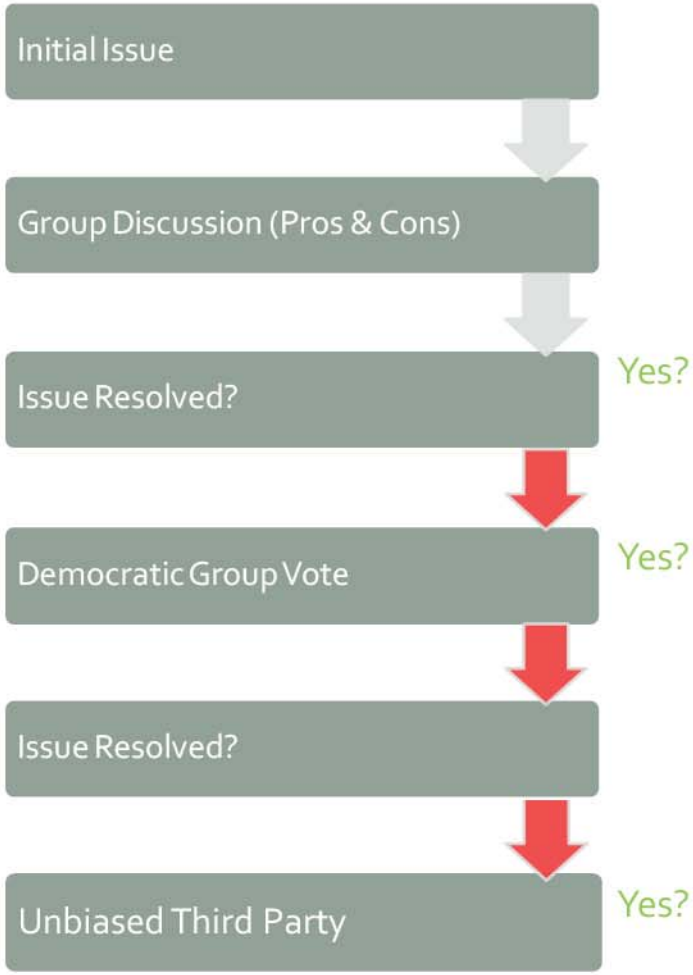
Located local material suppliers
Tonnage Calculations
Carbon Footprint Calculations

MON	TUES	WED	THU	FRI
11-2	5-7	5-8	5-7 7-9	

ICON Lab | 307 Sackett | SCDC Lab

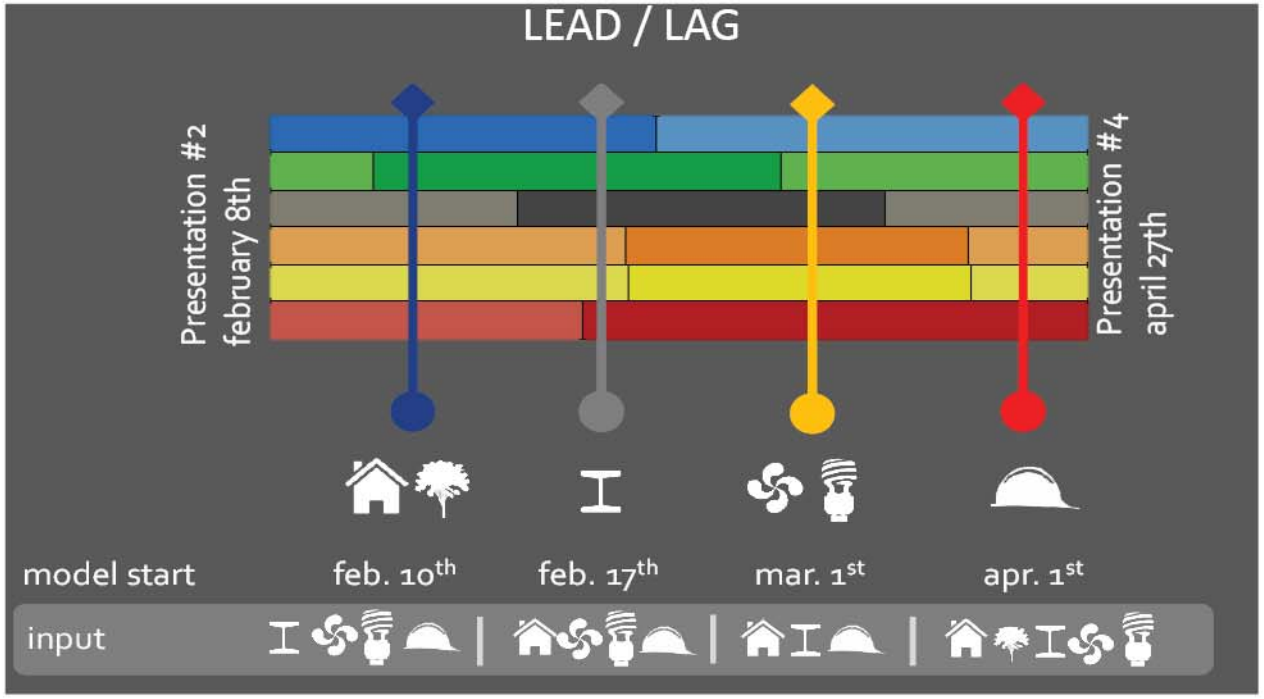






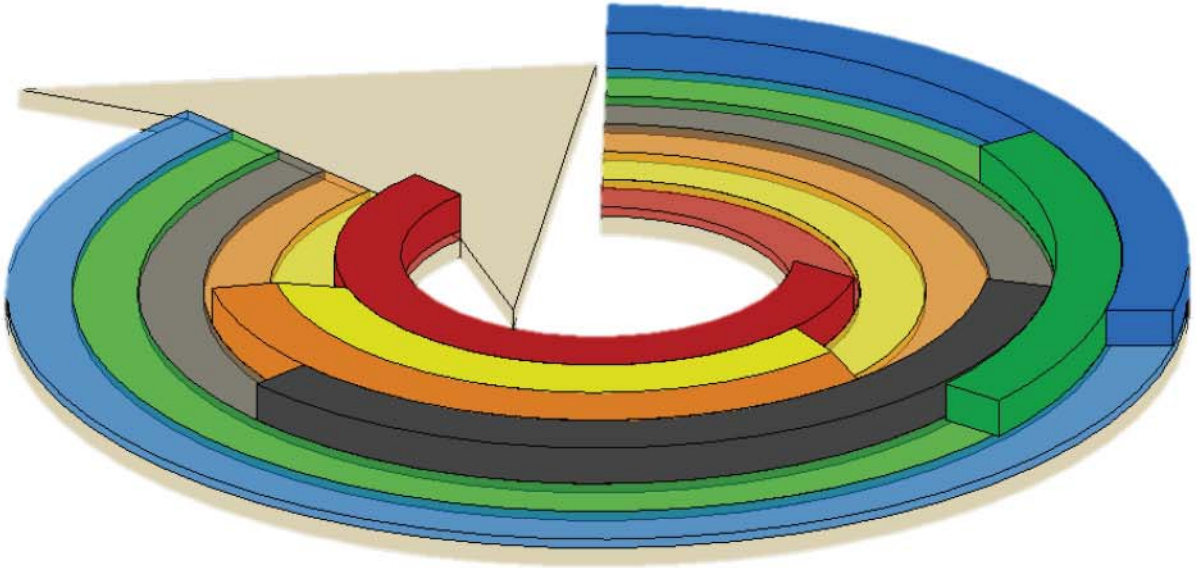
Communication

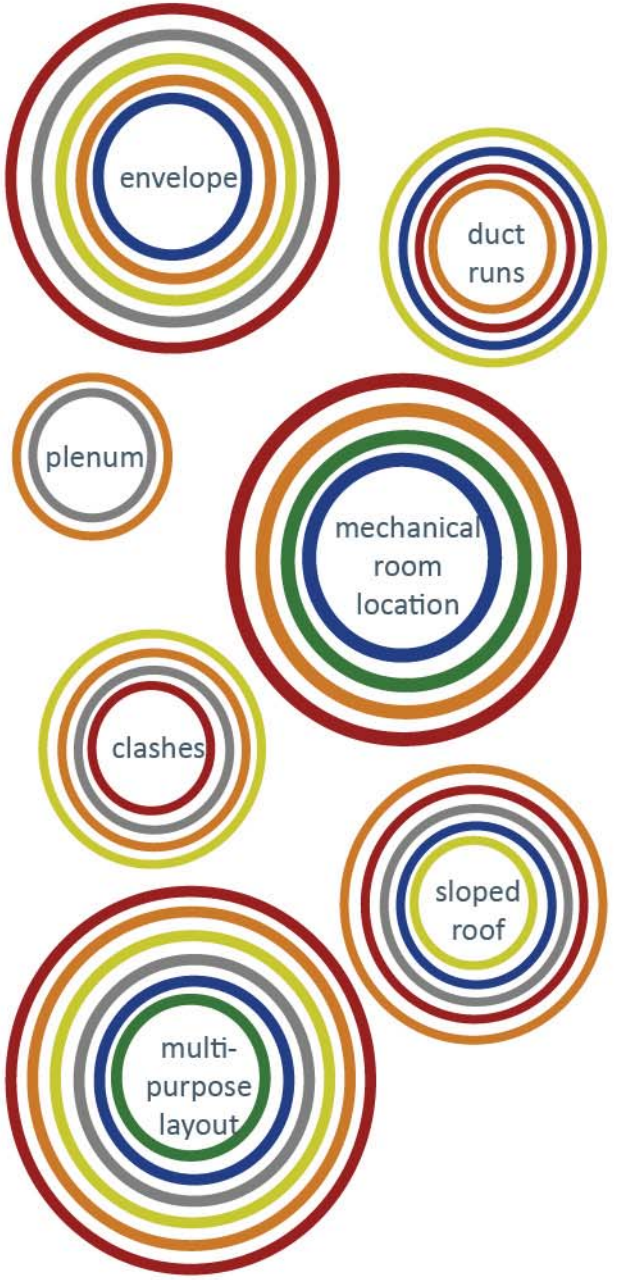
In an effort to increase efficiency within the group we created a network of information and guidelines. The above graphics describe meeting locations, means of communication, and conflict resolution. While it was essential to setup this network, the team was able to conduct much of the communication, face-to-face, during required studio times.



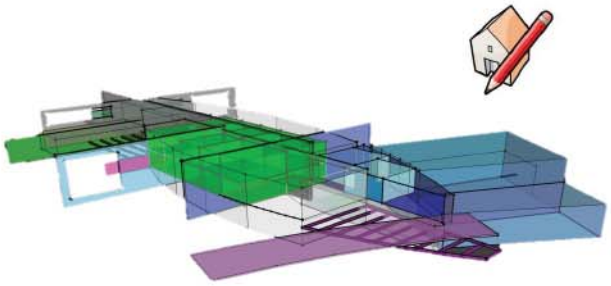
above: Our initial plan to make the deadlines had each discipline working in an assembly line.

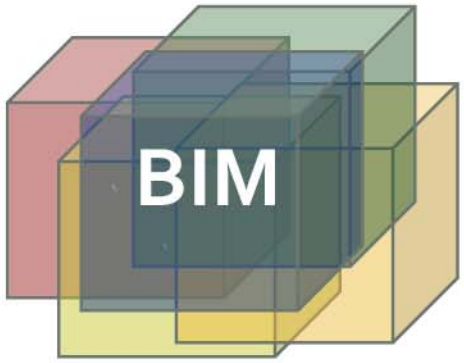
below: In a second iteration we pushed a cyclic process with more rapid turnovers.

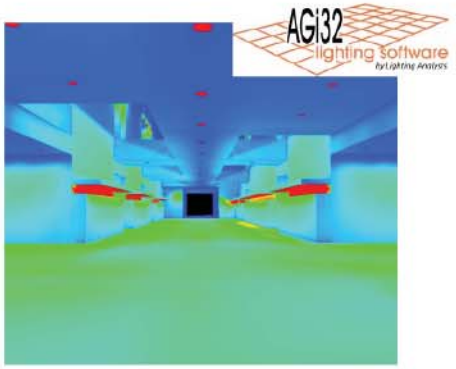


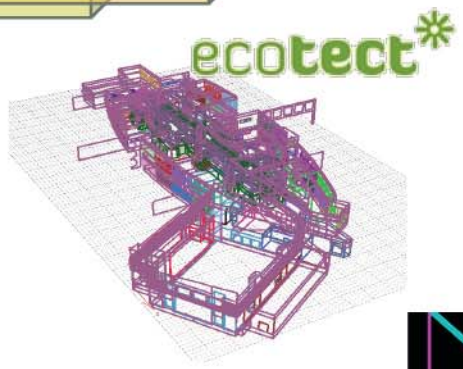


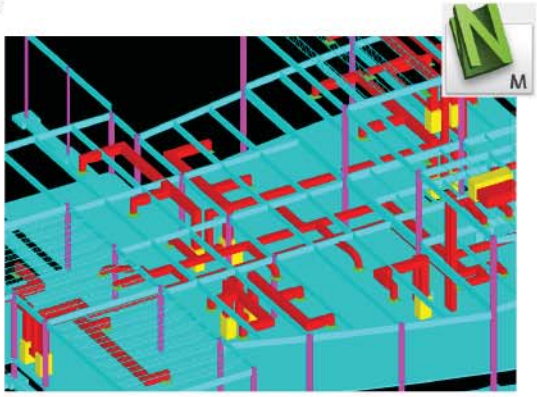
above: Finally, our decision making shows a ripple pattern; where one discipline would raise a concern that would move through the group and potentially start related discussions.

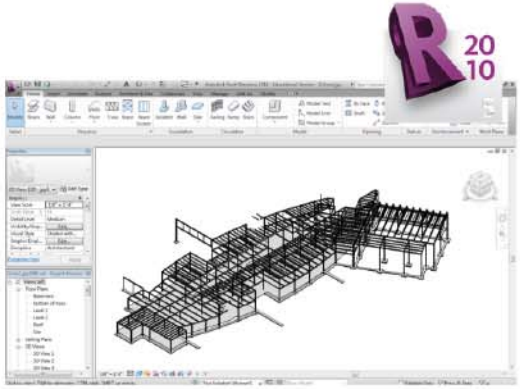




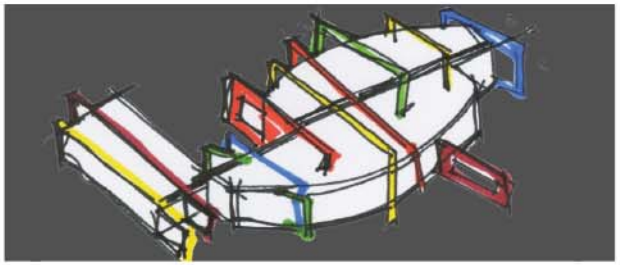


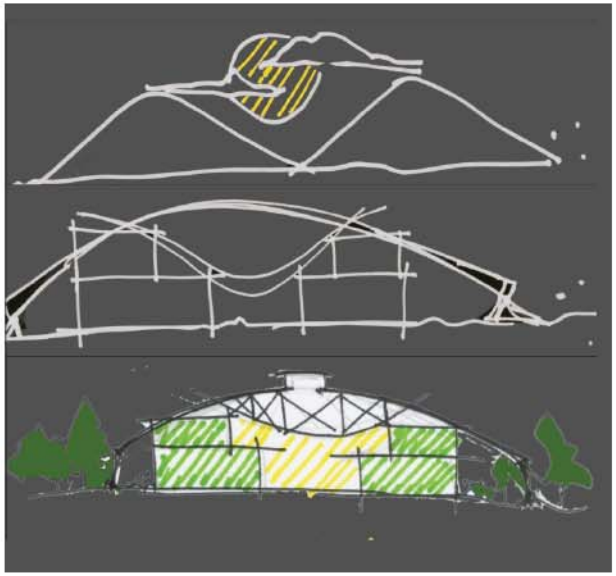


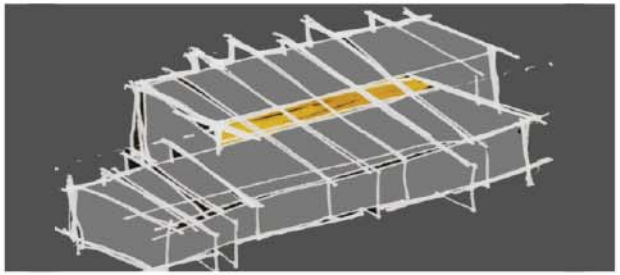


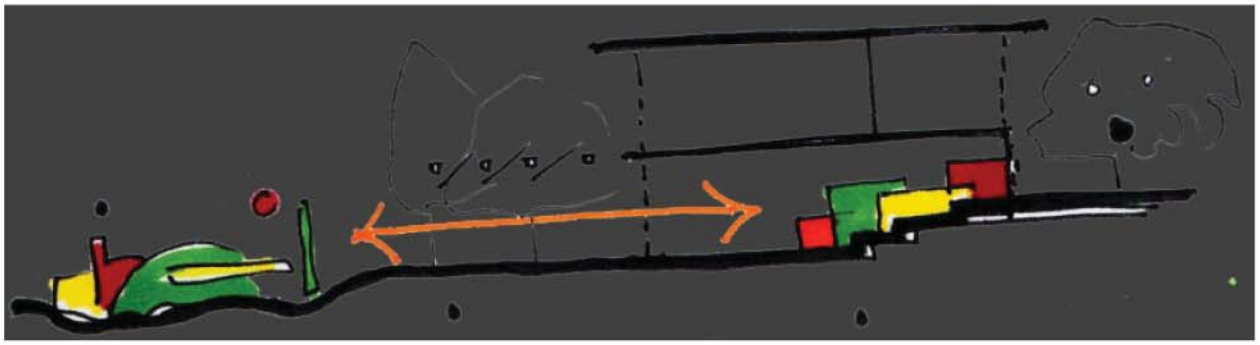


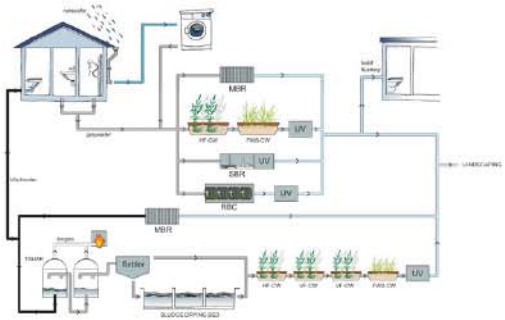
above: BIM does not equal Revit, above are the programs used by the team during the semester.











Conceptual Design

Xylophone

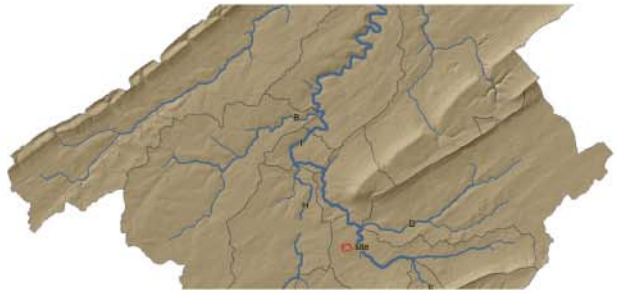
School design should focus on the kids and facilitate enjoyable and meaningful experiences, such as, playing a xylophone during music class. This concept experiments with the colorful and playful character of a xylophone by incorporating colorful lines or frames that connect the various program elements. The colorful frames embrace the whole building and work aesthetically and structurally, while creating playful elements connecting the playgrounds to the school.

Valley

In the secondary idea, see upper right, a central collective space within the building embraces the children much like a valley is embraced by its surrounding mountains. Both concepts seek to respond to and work with the environment.

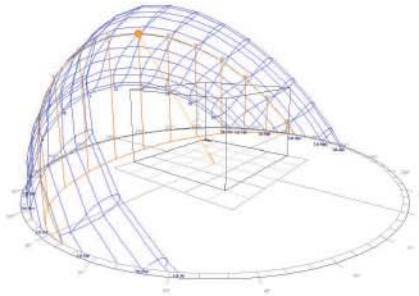
above left: The architect's concept sketches show an architectural vocabularly that is fun, colorful and inclusive of nature.

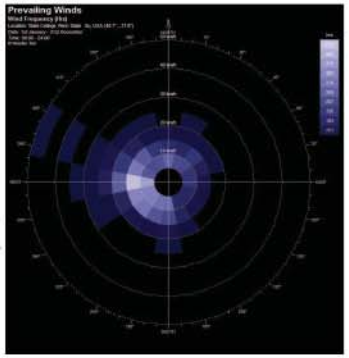
below: These concepts were developed within a pristine local watershed; using ecologically responsible systems, such as, the comprehensive water recycling shown in the above diagram.

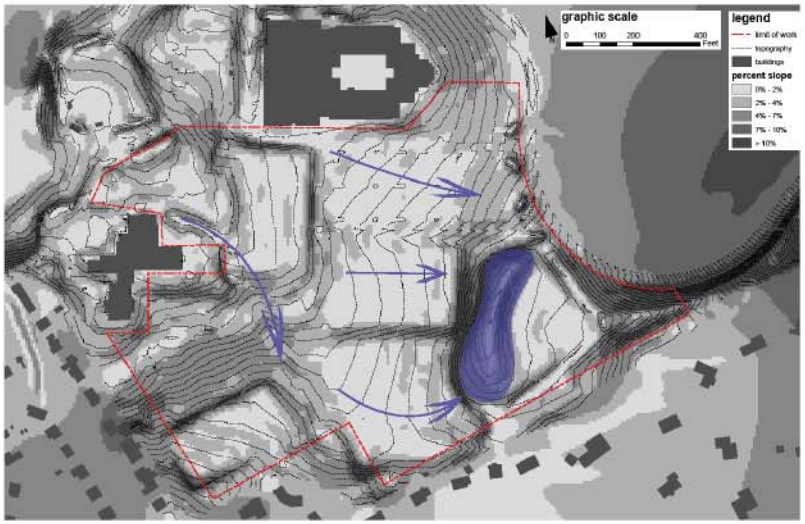


above: The site is surrounded by walkable neighborhoods.

below: Site inventory and analysis showing sun path, wind, topography and hydrology.

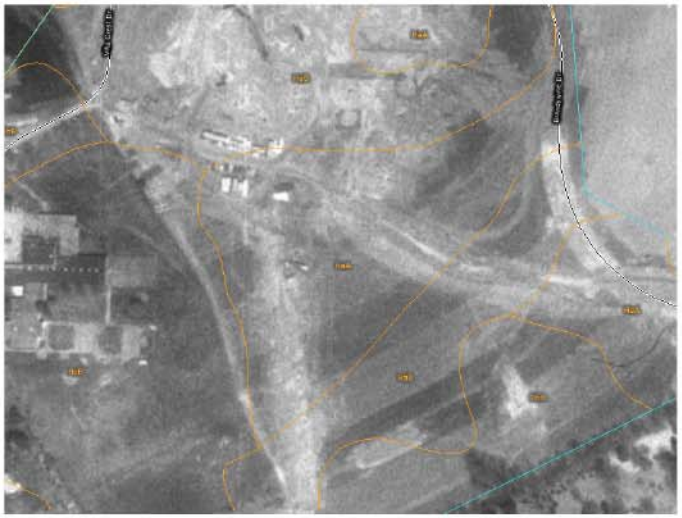






Construction Management Concerns

Utility tie-ins: Deliveries - 450', Sewage - 430', Electric - 450', Water - 950', Gas - 450'
Construction equipment will be prohibited from infiltration zone to accomodate systems.



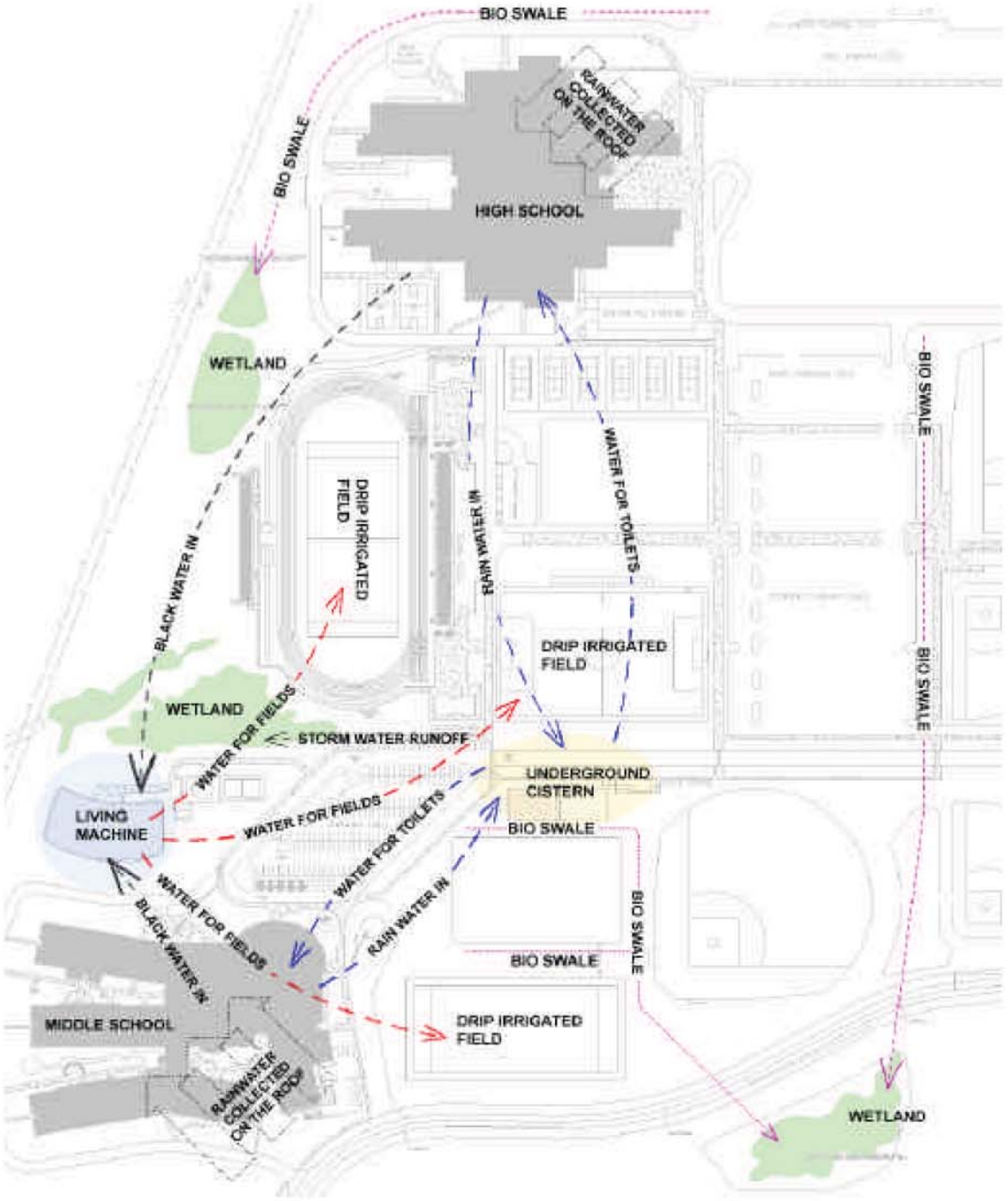
Geotechnical report

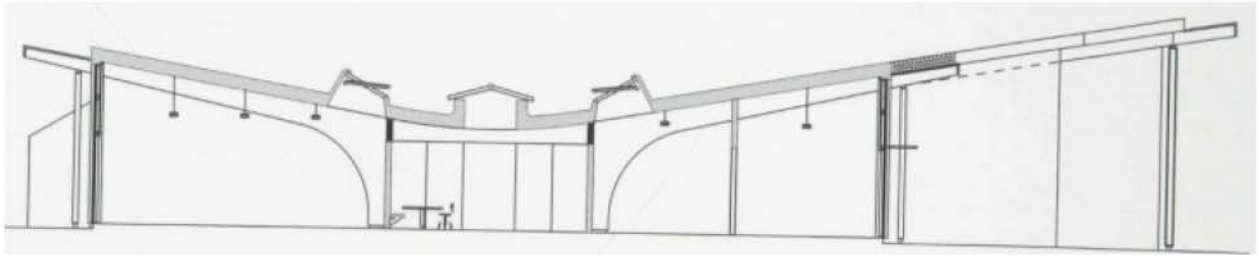
Cohesive soil on site includes clay, silt and gravel. The boring plan shows bedrock 3' – 50' below grade, causing small areas of earth that are difficult to excavate. The regional Karst topography raises the potential for sinkholes.

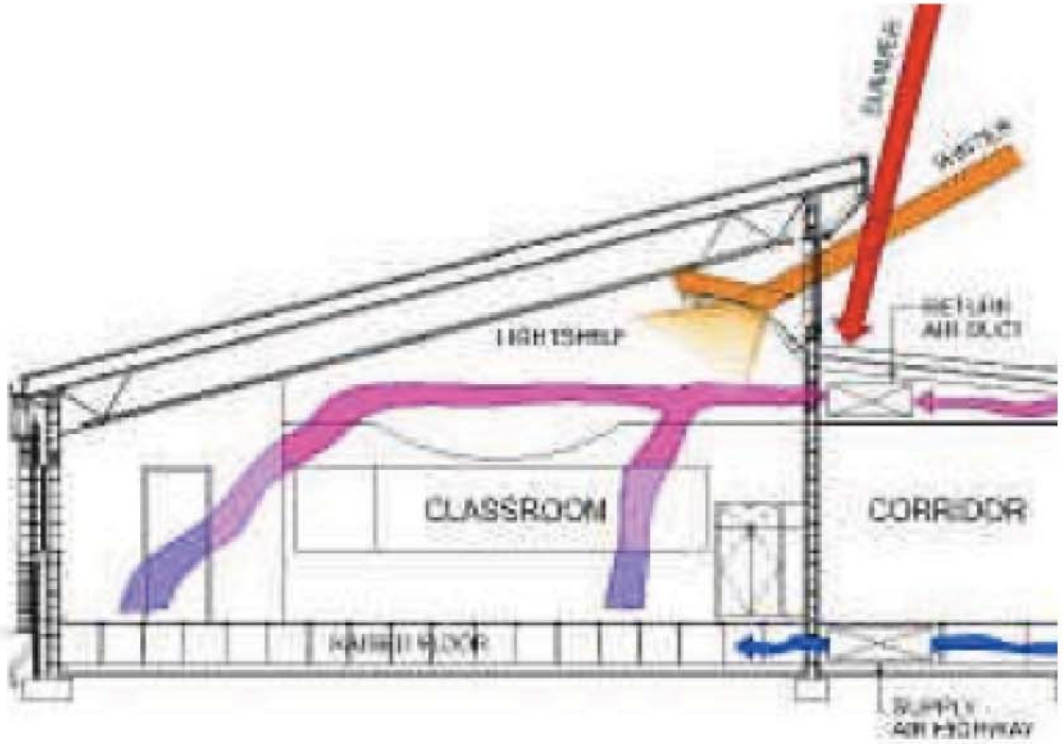
Recommended foundations:
Shallow continuous wall foundation & spread footings.

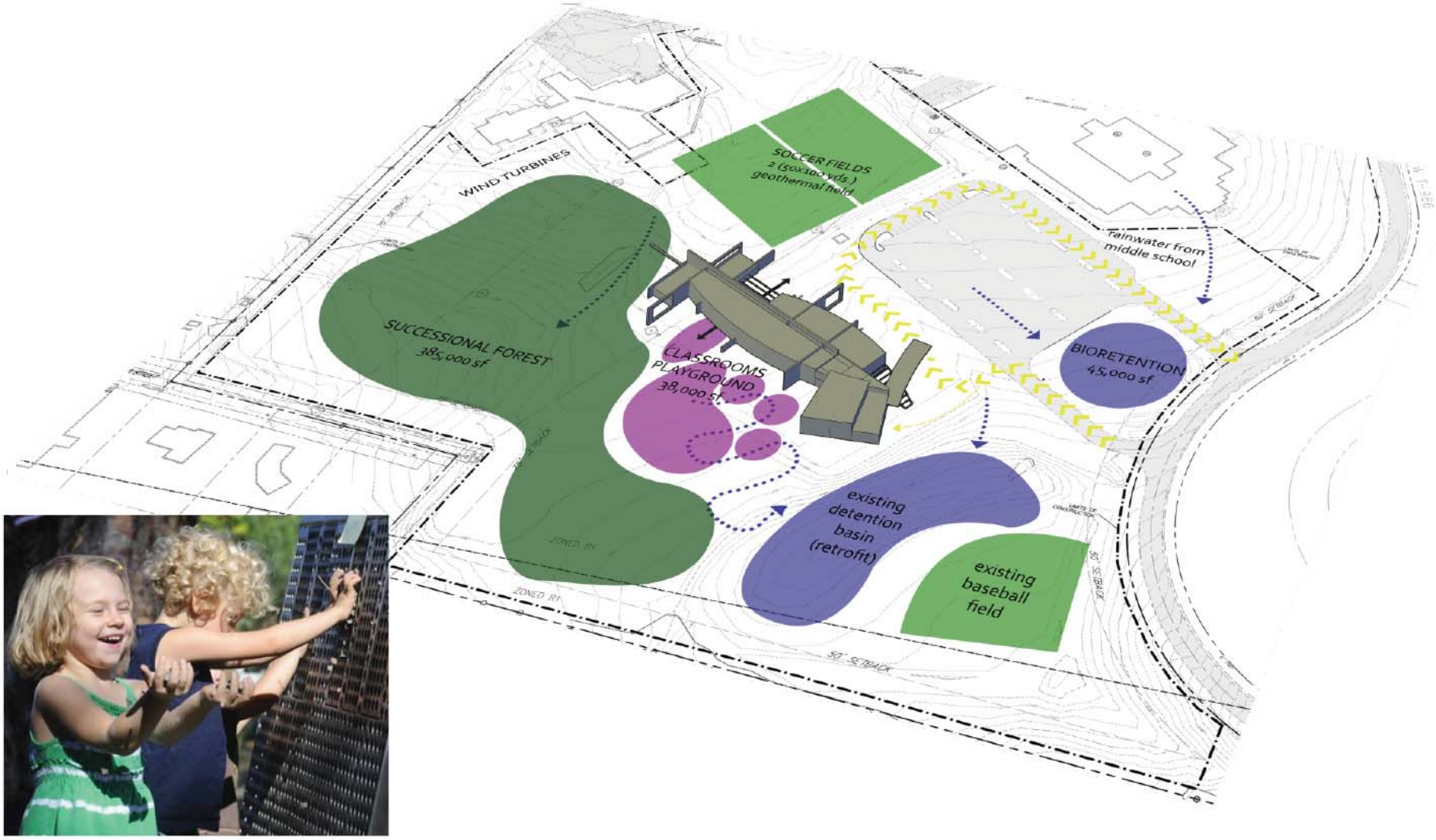
Team Precedent

North Guilford Middle School, in North Carolina, went well beyond the LEED Platinum they earned. The diagram, on the right, shows their comprehensive system for cleansing stormwater and blackwater on the entire campus. The various green solutions employed were strongly tied to the students' curriculum. This allowed the students to gain a better understanding of the building's mechanical system in an environment conducive to learning, due to the innovative daylighting solutions throughout the building.





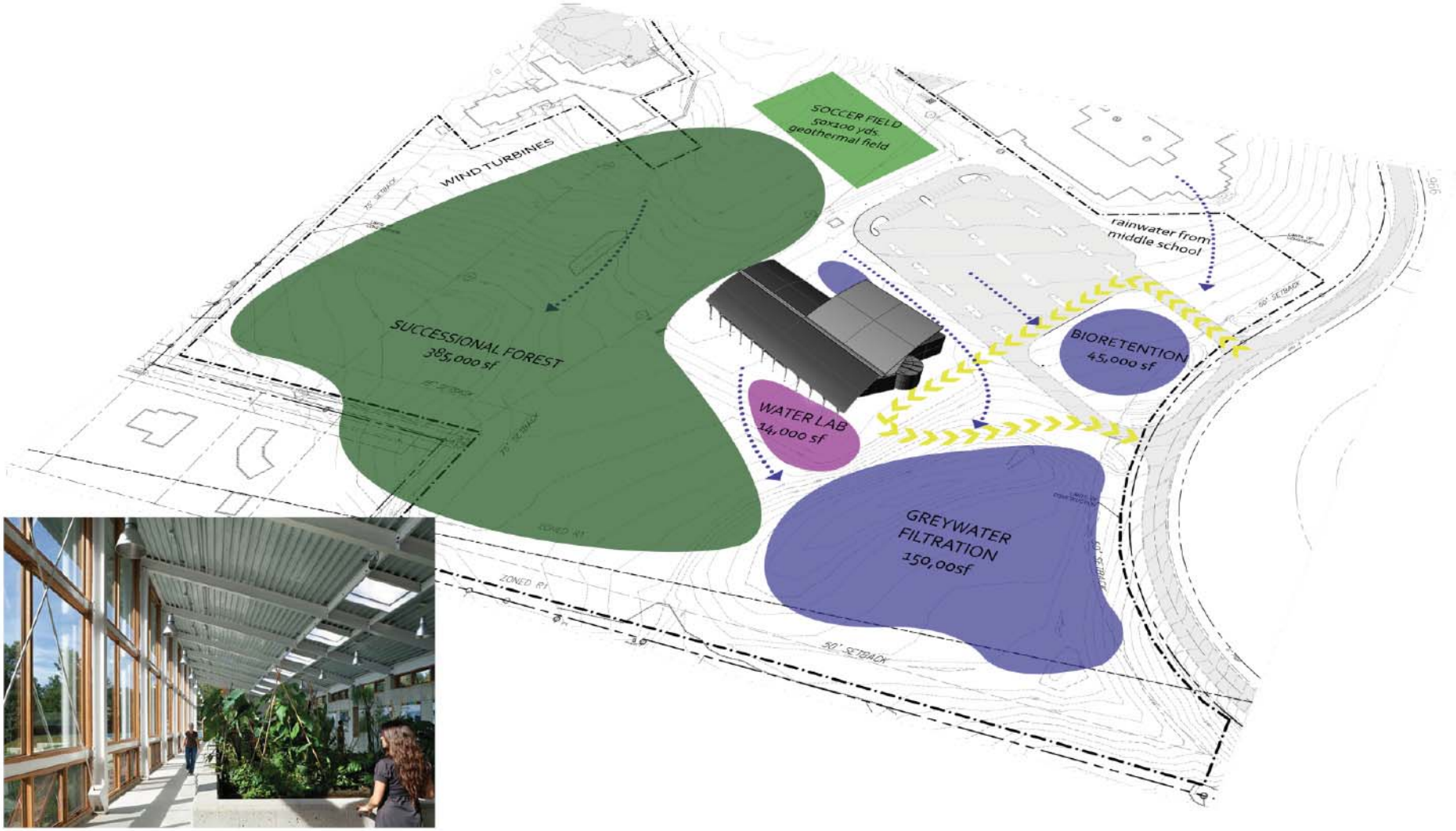

LIGHTSHELF
CLASSROOM
CORRIDOR



Landscape Concept 1

Integration of building and landscape is a major focus of this concept, the boundary between the two blurred. The colorful frames define smaller play spaces and work as play structures. To emphasize the musical inspiration of the architecture various outdoor spaces will be created to encourage experimental play, as seen above.

	Concept 1
Pros	Central energy shaft
	Formal variety
	Strong connection between inside & outside
	Maintain existing site facilities
	Creative & engaging outdoor educational spaces
	Building as teaching tool through exposed mechanical systems
	Day lighting from corridor and central shaft
Cons	More external surface area increases mechanical loads
	Weak connection of music room, music garden & stage
	More sports fields and playgrounds
	Increased square footage of pavement

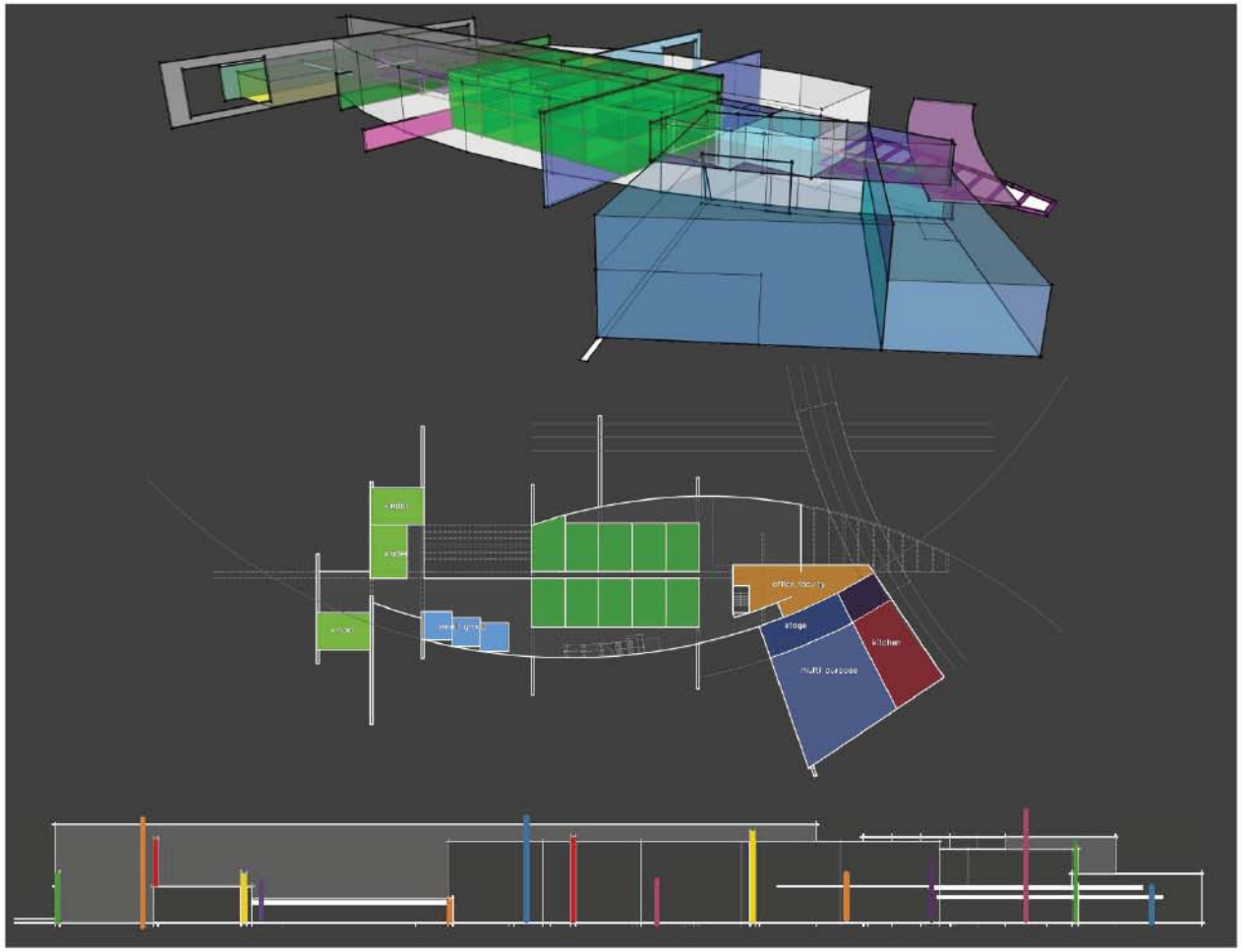


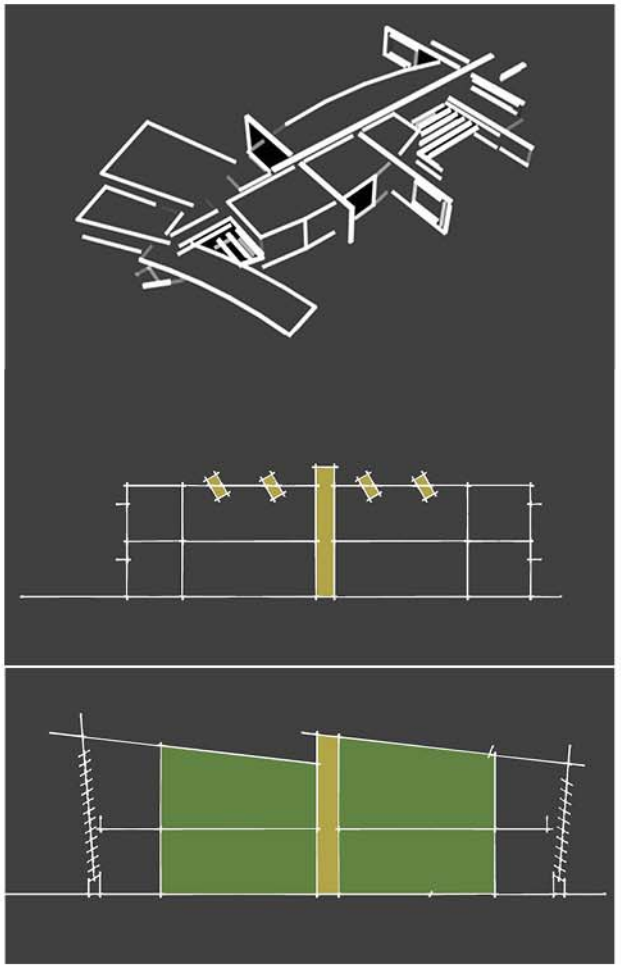
Landscape Concept 2

With the inspiration of a valley, this concept lends itself to teaching the kids about their place in the ecosystem and has a more naturalistic design vocabulary. The site would read more as a natural area where kids will learn through play rather than consciously studying the science behind the trees, animals, etc.

	Concept 2
Pros	Dense form
	One central indoor area
	Single structured roof
	Decreased areas of low infiltration (pavement & sports fields)
	Highly visible entrance

Cons	Ramp as main access for children
	Exploit Topography change for Mechanical Room
	Less connection between indoor and outdoor spaces
	Less dynamic form
	Less transparent
	Complex structure





Schematic Design

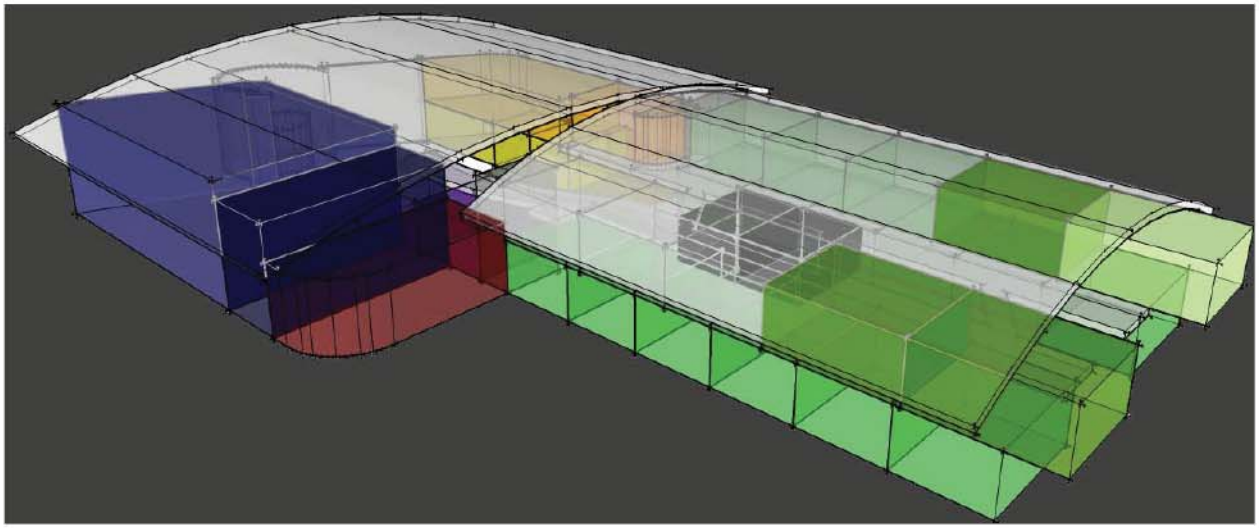
Form

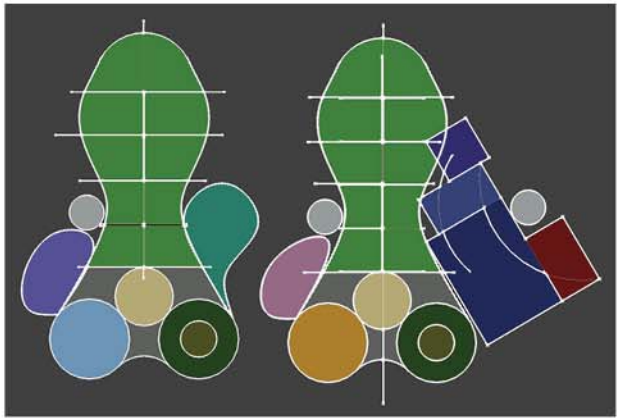
The two previous concepts of a xylophone and valley were merged in our schematic design.

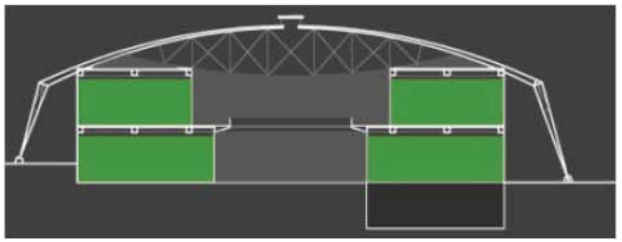
In the valley concept, the central atrium provided an opportunity for flexible usage of space, but lacked the more dynamic form of the xylophone concept. In addition, the xylophone concept had more interaction with the landscape. The resulting design focused around the central atrium with classrooms and a central thermal shaft, creating a structural core. The mechanical ducts branch out from here into all of the spaces, while allowing light to penetrate. The space's openness facilitates its use as an educational tool. More public functions, such as the multipurpose room, kitchen and specialized classrooms branch off this integrated central core.

Functional Layout

In both conceptual design options, classrooms are oriented in an east-west axis to benefit from southern light. Two separate entrances prevent car and bus circulation from mixing and allowing the school to be used for a variety of uses. The main enterance accomodates parent drop off, after school activities and community events. The defined entrance welcomes people into the school's more public spaces including the multi-purpose room, kitchen and administrative offices.

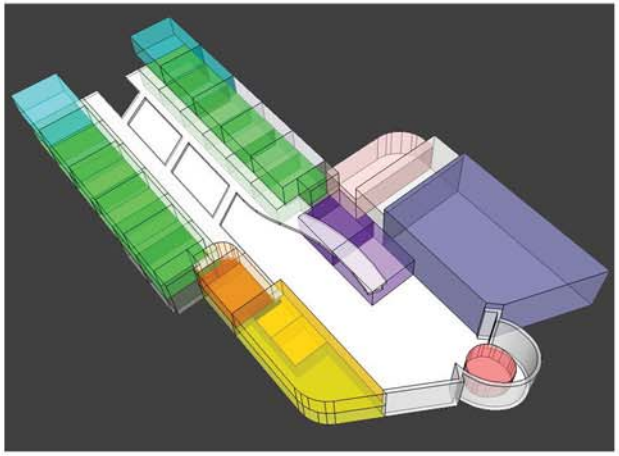


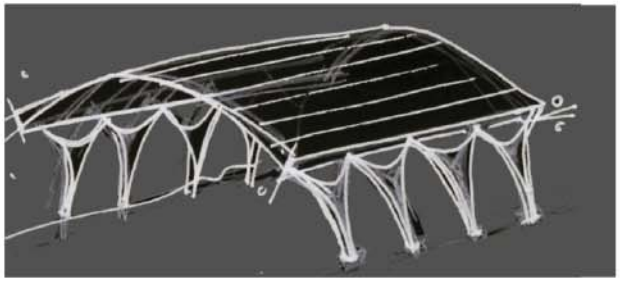




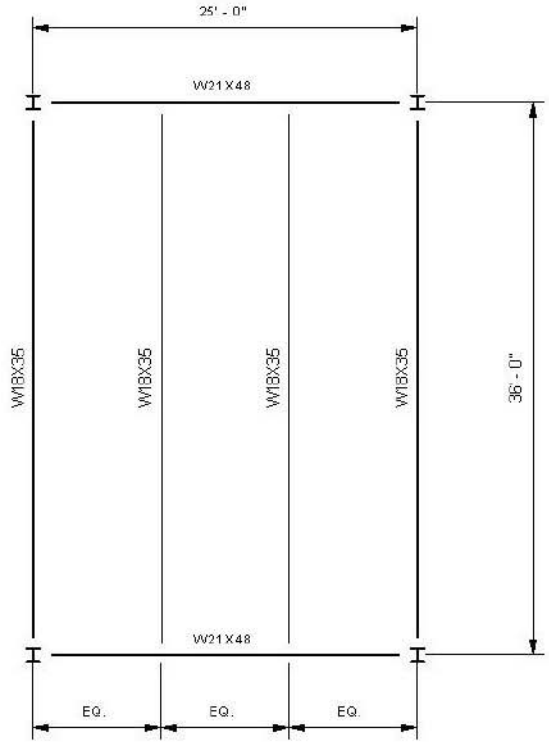
Integrated Concept Statement

The elementary school is designed with a playful **aesthetic** that supports a **feeling** of community and learning. Thus, enhancing the traditional learning facility with an **outdoor experience;** by providing **stable** and **flexible** spaces that allow occupants to learn in a **comfortable** and **healthy** environment. This promotes **efficiency** through **visibly** changing the **mood** of traditional learning, yet is accomplished at an appropriate **cost** through integrated design **implementation**.





above & below: typical classroom structural layout



Four main structural systems

Steel: reusable, high strength to weight ratio, quick to erect, but additional fireprotection needed

Concrete: high compressive strength, fire resistant, lower floor to floor height, but longer erection time

Masonry: passive solar applications, fire resistant, but low strength to weight ratio

Wood: low embodied energy, reusable, cheap construction cost, but lower material strength

LRFD Analysis

+ 25'-0" x 36'-0" bays
+ W 18's, equally spaced infill beams
+ W21's for girders
+ W10/W12's for columns
+ Assumed 15'-0" floor to floor

Occupancy of Use	Uniform LL (psf)
Lobbies	100
Gymnasiums	100
Classrooms	40
Corridors (1st Floor)	100
Corridors (Above)	80
Reading Rooms	60
Stack Rooms	150
Snow Load*	30

Lateral Force(s)	Location-Specific Data
Wind*	V= 90 mph
Seismic *	$S_{0.2}$ = 0.18g
Seismic *	$S_{1.0}$ = 0.06g

SCHEDULE	TIMES	PERCENT LOAD
School (Weekdays Year-Round)	6am-8am 8am-4pm 4pm-6pm	40 100 40

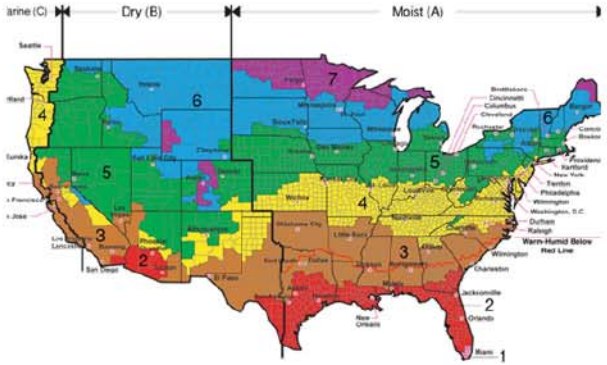
Mechanical Systems Comparison

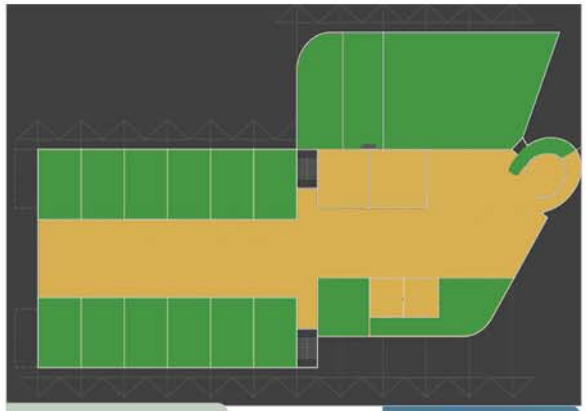
LOCAL	CENTRAL
+ Ability to respond quickly to individual rooms	+ Equipment contained within own space
+ Allows greater control over the room	+ Maintenance can be carried out without disrupting activities
+ Small foot print	
- Noise or by-products go right into room	- Breakdown paralyzes entire school
EX: unit ventilators	EX: heat pumps, fan/evaporator coils

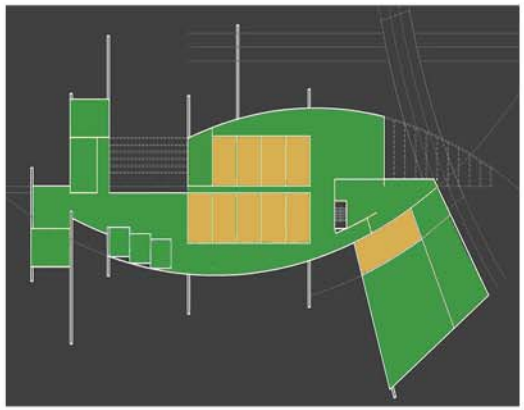
RECOMMENDED FOR	RECOMMENDED FOR
Classrooms, Lounge	Corridors, Multi-purpose, Bathroom, Office, Library

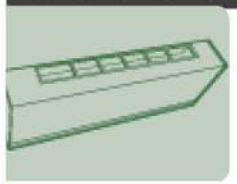
SET-POINT	HEAT AT	COOL AT
Occupied	70 °F	75 °F
Unoccupied	60 °F	85 °F
Holiday	50 °F	85 °F

Climatic Regions









	CONCEPT#1	CONCEPT#2	
EXTERNAL	Kindergarten, Small Group Study, Corridors, Office, Multipurpose, Kitchen	Classrooms, Kitchen, Stage, Multipurpose, Nurse, Office	EXTERNAL
INTERNAL	Classrooms, Stage	Corridors, Music, Faculty Lounge	INTERNAL

UNIT VENTILATORS	CHILLED BEAM	VARIABLE AIR VOLUME (VAV)
Uses a fan to blow air across a coil, thus conditioning the space which it is serving	Uses water to remove heat from room, chilled water closer to space	Fan capacity controls ventilation of multiple rooms from one area through ducts
+ Heats, cools & ventilates + Durable cabinet design + Cost-effective	+ Minimizes energy required by fans	+ Great reliablility + Flexible + Cost-effective
- Source of noise	- Level of humidity control required due to potential water damage - High cost	- Considerable space requirements (Up to 18" above ceiling)

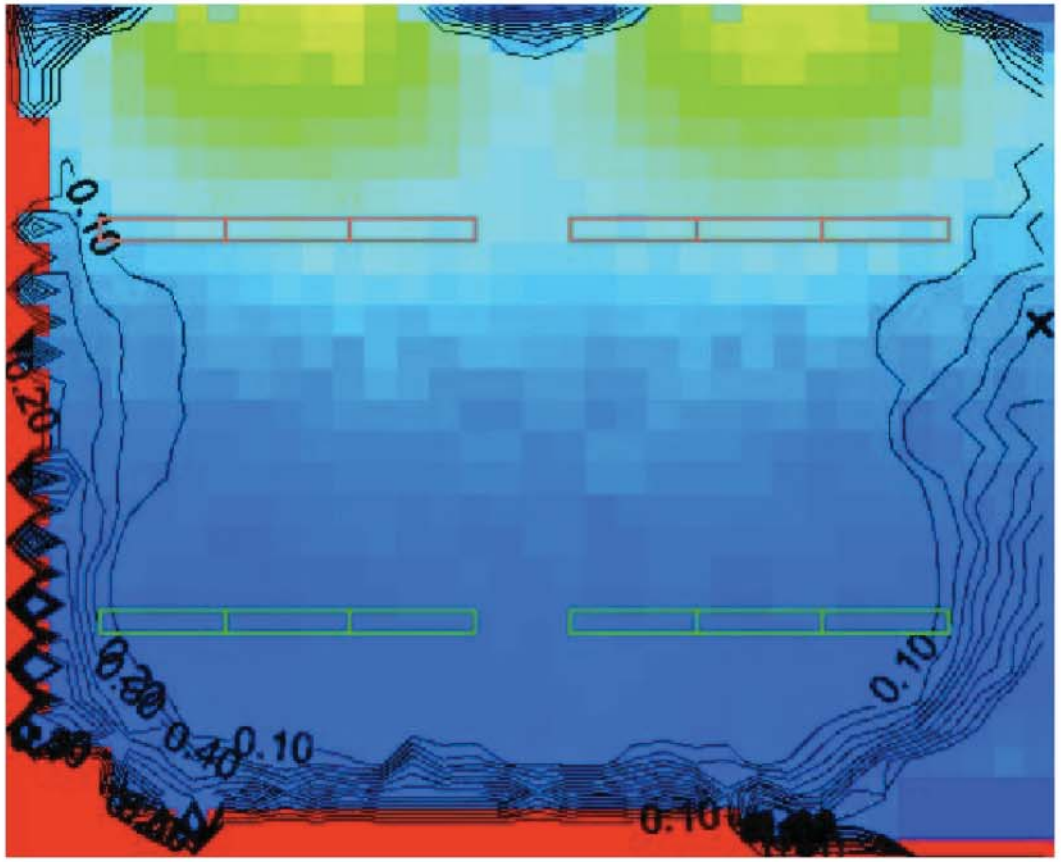
Functional Layout

Passive low-energy approach to ventilation = windows (give building occupants control over outdoor air)
Pollutant sources: odors, irritants, toxic, biological, radon

INDOOR AIR QUALITY RECOMMENDATIONS
Locate air intakes above pollution
Zone equipment such as copier near intakes
Dirty vs. clean areas: change pressure

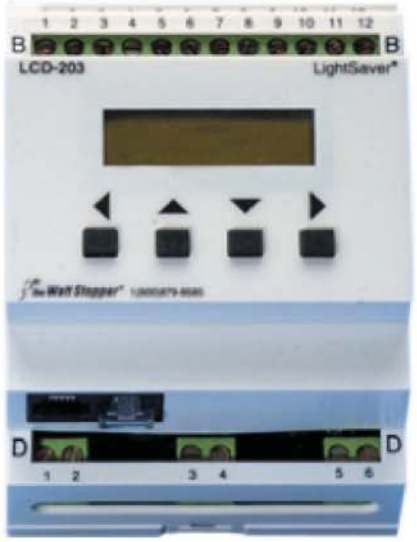
AREAS OF CONCERN
Sickroom, Art Classroom, Kitchen

ASHRAE	Summer Design Condition Cooling 0.4%	Winter Design Condition Heating 99.6%
Outside Air Dry Bulb (°F)	88.5	4.7
Outside Air Wet Bulb (°F)	72.0	--
Indoor Comfort Area (°F)	75 DB, 50% RH	75 DB, 50% RH



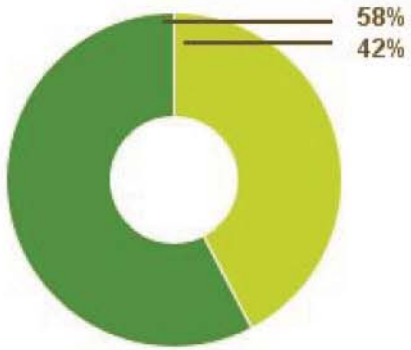
Strategies for reducing HVAC cooling load

+ Selection of low emissivity, spectrally selective glass
+ Window assemblies with low U-values
+ Tinted or electrochromic windows
+ Photosensors
+ Occupancy sensors
+ Timers

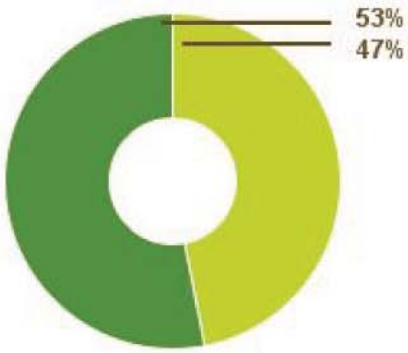


CATEGORY	LIGHTING PD (W/ft²)	EQUIPMENT PD (W/ft²)
Classrooms (age 9+)	1.4	1.0
Classrooms (age 5-8)	1.4	1.0
Music/Theater/Dance	1.3	1.0
Libraries	1.4	1.0
Art Classroom	1.4	1.0
Office Space	1.1	1.5
Sickroom	1.1	1.5
Restrooms	0.9	0.3
Break Room	1.2	0.5
Mechanical	1.5	0.3
Corridors	0.5	0.3
Kitchen	1.2	1.5
Multipurpose Assembly	1.3	1.0

Annual Energy Use/Cost

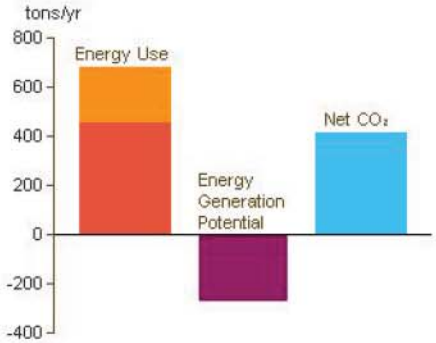


Electricity	42%	$76,952	804,940 kWh
Fuel	58%	$52,830	37,414 Therms
		$129,782	

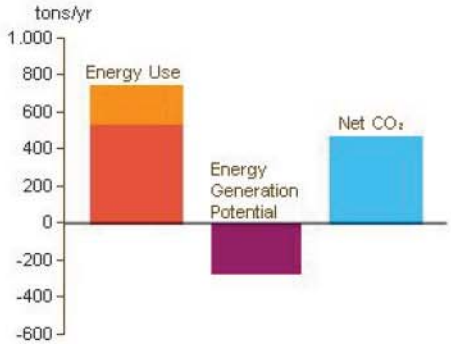


Electricity	47%	$88,711	927,935 kWh
Fuel	53%	$50,504	35,767 Therms
		$139,214	

Annual Carbon Emissions



	(tons/yr)
Electricity Consumption	463
Fuel Consumption	217
Roof PV Potential (High Efficiency)	-265
Single 15' Wind Turbine Potential	0
Net CO_2	415



	(tons/yr)
Electricity Consumption	533
Fuel Consumption	207
Roof PV Potential (High Efficiency)	-273
Single 15' Wind Turbine Potential	0
Net CO_2	467

Life Cycle Energy Use/Cost

Life Cycle Electricity Use:	24,148,209 kWh
Life Cycle Fuel Use:	1,122,441 Therms
Life Cycle Energy Cost:	$1,767,629

*30-year life and 6.1% discount rate for costs

Renewable Energy Potential

Roof Mounted PV System (Low efficiency):	154,027 kWh/yr
Roof Mounted PV System (Medium efficiency):	308,054 kWh/yr
Roof Mounted PV System (High efficiency):	462,081 kWh/yr
Single 15' Wind Turbine Potential:	1,220 kWh/yr

*PV efficiencies are assumed to be 5%, 10% and 15% for low, medium and high efficiency systems

Life Cycle Energy Use/Cost

Life Cycle Electricity Use:	27,838,065 kWh
Life Cycle Fuel Use:	1,073,025 Therms
Life Cycle Energy Cost:	$1,896,099

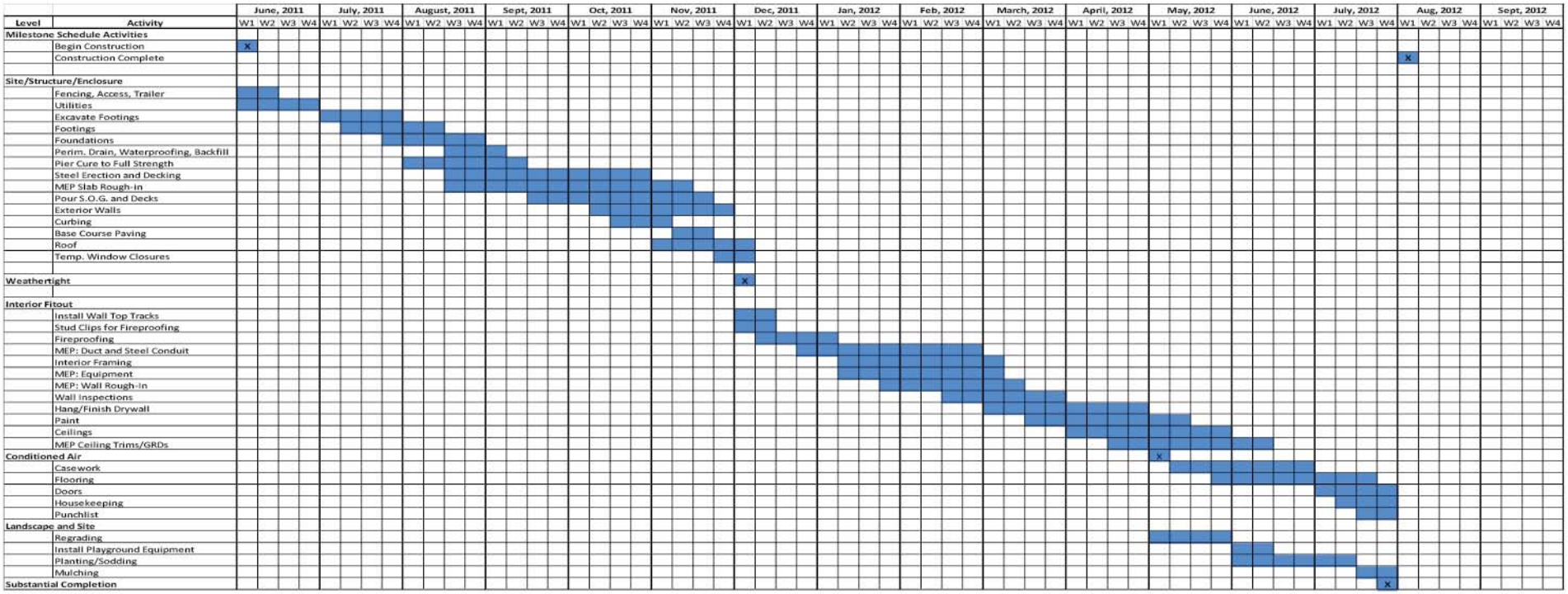
*30-year life and 6.1% discount rate for costs

Renewable Energy Potential

Roof Mounted PV System (Low efficiency):	158,653 kWh/yr
Roof Mounted PV System (Medium efficiency):	317,305 kWh/yr
Roof Mounted PV System (High efficiency):	475,958 kWh/yr
Single 15' Wind Turbine Potential:	1,220 kWh/yr

*PV efficiencies are assumed to be 5%, 10% and 15% for low, medium and high efficiency systems

Concept 1 Preliminary Schedule



Category	Complex Building	Modular Building
Net Area	36,920 SF	36,920 SF
Gross Area	58,333 SF	58,333 SF
R.S. Means Value for School	$7,291,625	$7,291,625
Size Multiplier	0.98	0.98
Location (Williamsport)	0.872	0.872
Complexity Markup	15%	0%
General Conditions Markup	10 Weeks - $25,000	$0.00
Total Price	$7,190,800	$6,231,132
Cost per Student	$17,977	$15,577
Schedule Duration	68 Weeks	57 Weeks

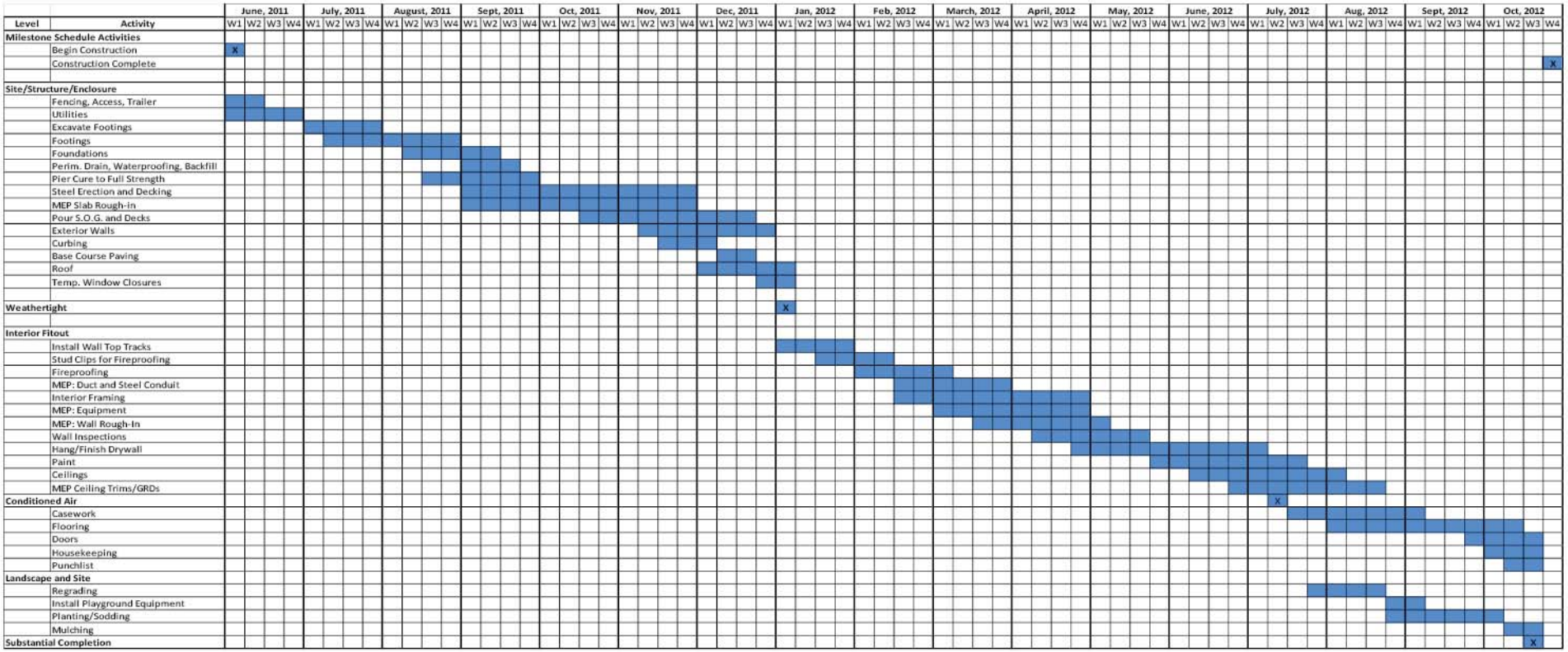
R.S. Means S.F. Costs for 2011

+ Median Price of $125/S.F.

Complex Design: $18,000 per pupil

Modular Design: $15,500 per pupil

Concept 2 Preliminary Schedule



Level	Activity	June, 2011				July, 2011				August, 2011				Sept, 2011				Oct, 2011				Nov, 2011				Dec, 2011				Jan, 2012				Feb, 2012				March, 2012				April, 2012				May, 2012				June, 2012				July, 2012				Aug, 2012				Sept, 2012				Oct, 2012			
		W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
Milestone Schedule Activities																																																														
	Begin Construction	X																																																														
	Construction Complete																																																													X
Site/Structure/Enclosure																																																														
	Fencing, Access, Trailer																																																													
	Utilities																																																													
	Excavate Footings																																																													
	Footings																																																													
	Foundations																																																													
	Perim. Drain, Waterproofing, Backfill																																																													
	Pier Cure to Full Strength																																																													
	Steel Erection and Decking																																																													
	MEP Slab Rough-in																																																													
	Pour S.O.G. and Decks																																																													
	Exterior Walls																																																													
	Curbing																																																													
	Base Course Paving																																																													
	Roof																																																													
	Temp. Window Closures																																																													
Weathertight																																		X																												
Interior Fitout																																																													
	Install Wall Top Tracks																																																												
	Stud Clips for Fireproofing																																																												
	Fireproofing																																																													
	MEP: Duct and Steel Conduit																																																												
	Interior Framing																																																													
	MEP: Equipment																																																												
	MEP: Wall Rough-In																																																												
	Wall Inspections																																																												
	Hang/Finish Drywall																																																											
	Paint																																																												
	Ceilings																																																											
	MEP Ceiling Trims/GRDs																																																										
Conditioned Air																																																												
	Casework																																																											
	Flooring																																																										
	Doors																																																										
	Housekeeping																																																										
	Punchlist																																																										
Landscape and Site																																																											
	Regrading																																																										
	Install Playground Equipment																																																										
	Planting/Sodding																																																										
	Mulching																																																										
Substantial Completion																																																											X

Constructability

+ Building locations
+ Existing bedrock spikes
+ Access to utilities
+ Minimize temporary roads
+ Zoning/Township lines
+ Design
+ Curvilinear vs. Modular
+ Long term
+ Consolidate parking lots

ARCHITECT

DESIGN ELEMENTS	EFFECT ON OTHER DISCIPLINES
CURVILINEAR WALLS	Construction Time
	Cost
	Structural Layout
DENSE FORM	Mechanical System Load
	Day Light Infiltration
ORIENTATION	Energy saved and wasted
	Artificial Lighting Requirement
	Connection with Outdoor grounds
LINEAR LAYOUT	Iterative Grid
	Most spaces have North or South light
	Visual Connection with Landscape
MECH ROOM LOCATION	Amount of Plumbing and Energy Waste through Distribution

LANDSCAPE ARCHITECT

DESIGN ELEMENTS	EFFECT ON OTHER DISCIPLINES
GREYWATER FILTRATION	Interior building systems connecting to exterior, installation
LANDFORM	Extreme grade changes increase construction costs
BUILDING ORIENTATION	Energy efficiency of building
RENEWABLE E GENERATION	Impact needed energy loads & site utilization

STRUCTURAL ENGINEER

DESIGN ELEMENTS	EFFECT ON OTHER DISCIPLINES
STEEL	Lead times on steel fabrication
	Site Utilization - Staging Area
	Site Utilization - Crane Placement
	Floor to floor heights
	Larger bays/open design capabilities
CONCRETE	Cure time schedule delays
	Floor to floor heights

MECHANICAL ENGINEER

DESIGN ELEMENTS	EFFECT ON OTHER DISCIPLINES
SPACE	Floor to floor heights to fit ductwork
AIR QUALITY	Covering ductwork during construction
ENERGY	Appropriate lighting & electrical loads in order to create model
COMFORT	Keep infiltration in mind when selecting materials
	Mindful of external spaces & additional thermal load

LIGHTING/ELECTRICAL ENGINEER

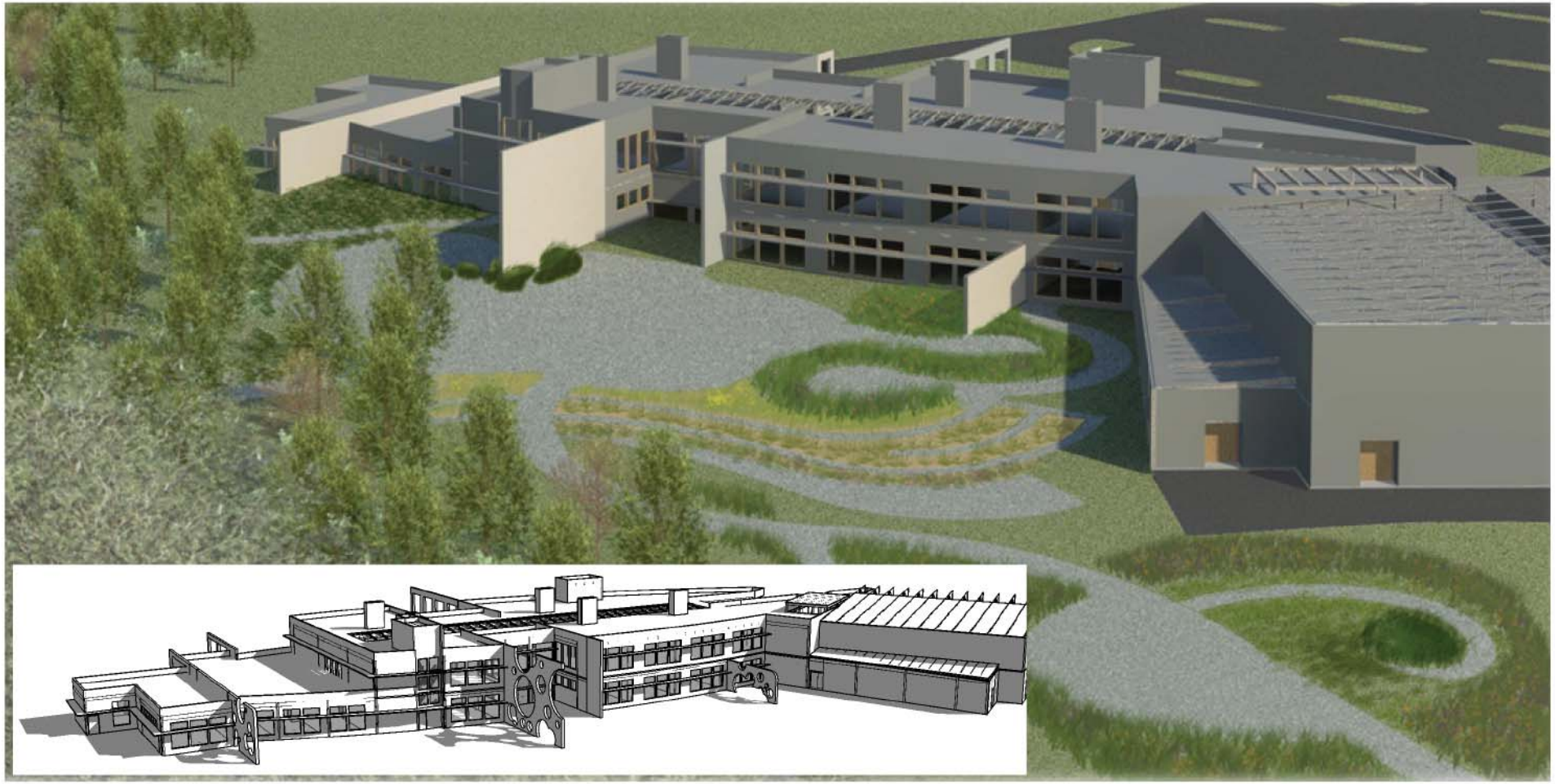
DESIGN ELEMENTS	EFFECT ON OTHER DISCIPLINES
SPACE	Integrated lighting techniques
	Support locations for large scale multipurpose room lighting
DAYLIGHT	Daylighting penetration
	Solar heat gain
	Building orientation

CONSTRUCTION MANAGER

DESIGN ELEMENTS	EFFECT ON OTHER DISCIPLINES
SITE LAYOUT	Interference/Compatibility with Landscape
	Material Laydown and Storage Areas
MEANS/METHODS	Workforce Availability
	Equipment/Machinery Availability
LEED DOCUMENTATION	Larger bays/open design capabilities

Examples of Integration

Throughout the semester, our team was committed to true integration. Above are a series of charts that show various design elements that required input from other disciplines. The colored logos represent the other disciplines consulted.



Design Development

After evaluation of the schematic alternatives, a building was created with a central atrium as the collective space to resemble the valley concept. Curvilinear shapes and colorful walls across the building were kept from the xylophone concept.

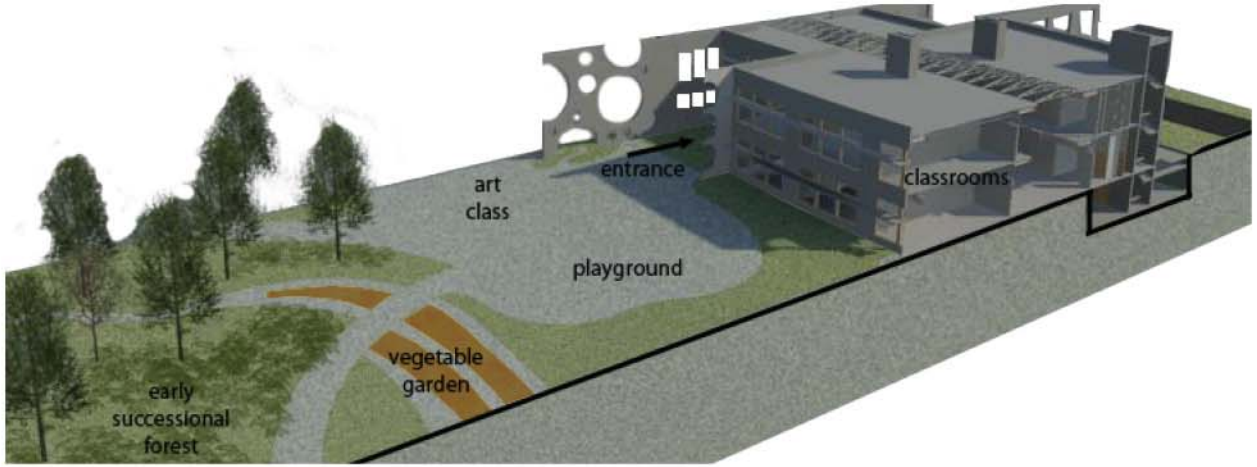
On the north side of the building, the colorful walls extend beyond the structural shear walls as an aesthetic gate for the bus drop off. While on the southern side the walls provide a connection between architecture and landscape.

Interdisciplinary inputs

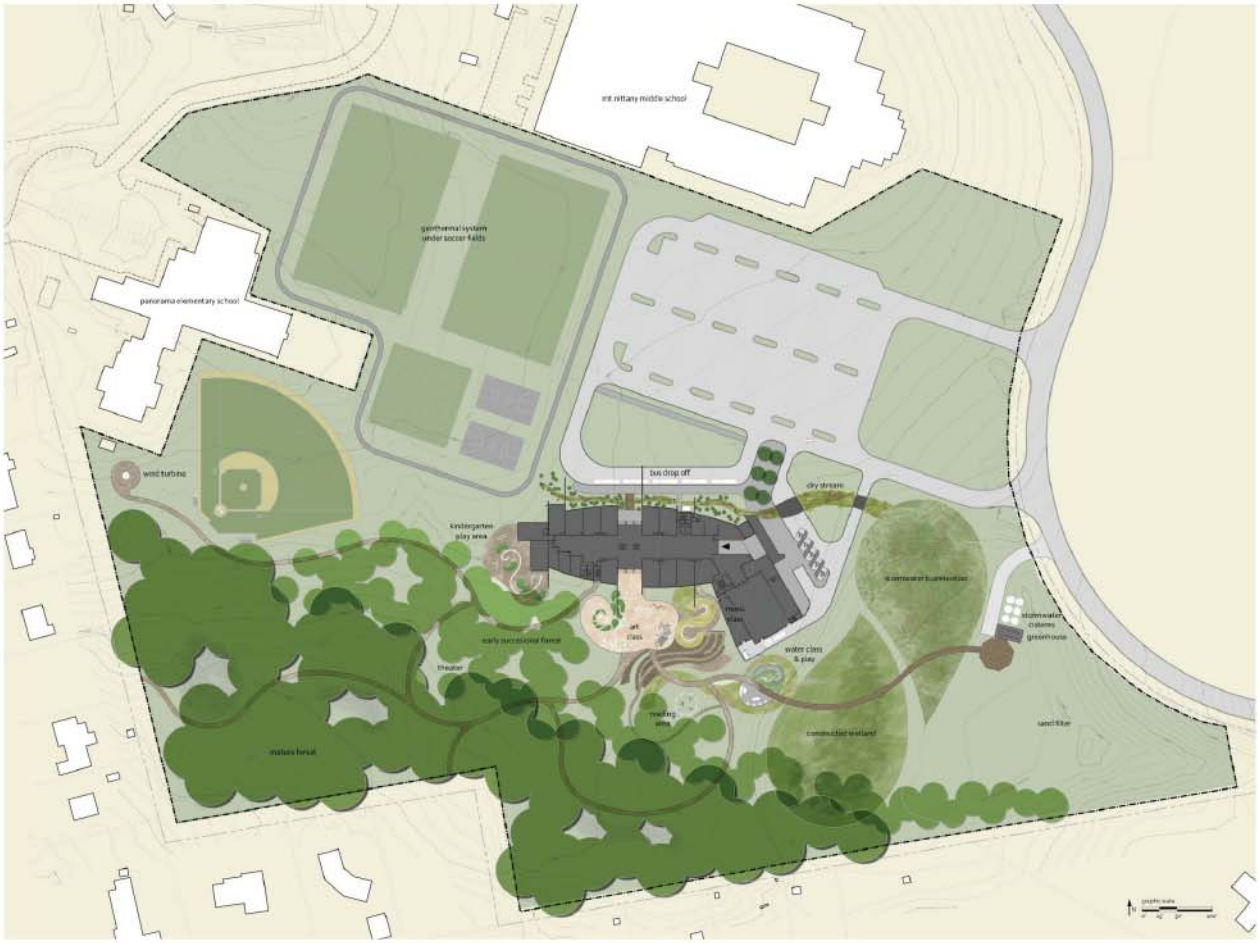
In this stage, functional layout of the building was finalized based on the lighting and mechanical considerations. The classrooms face north and south to maximize the amount of light infiltration into classes and corridors. Mechanical considerations required a minimum percentage of openings on the southern and western sides to keep the heat out, especially in this design layout that the excess of exposed surfaces could significantly increase the mechanical loads. Thermal chimneys are used as secondary ventilation tool.

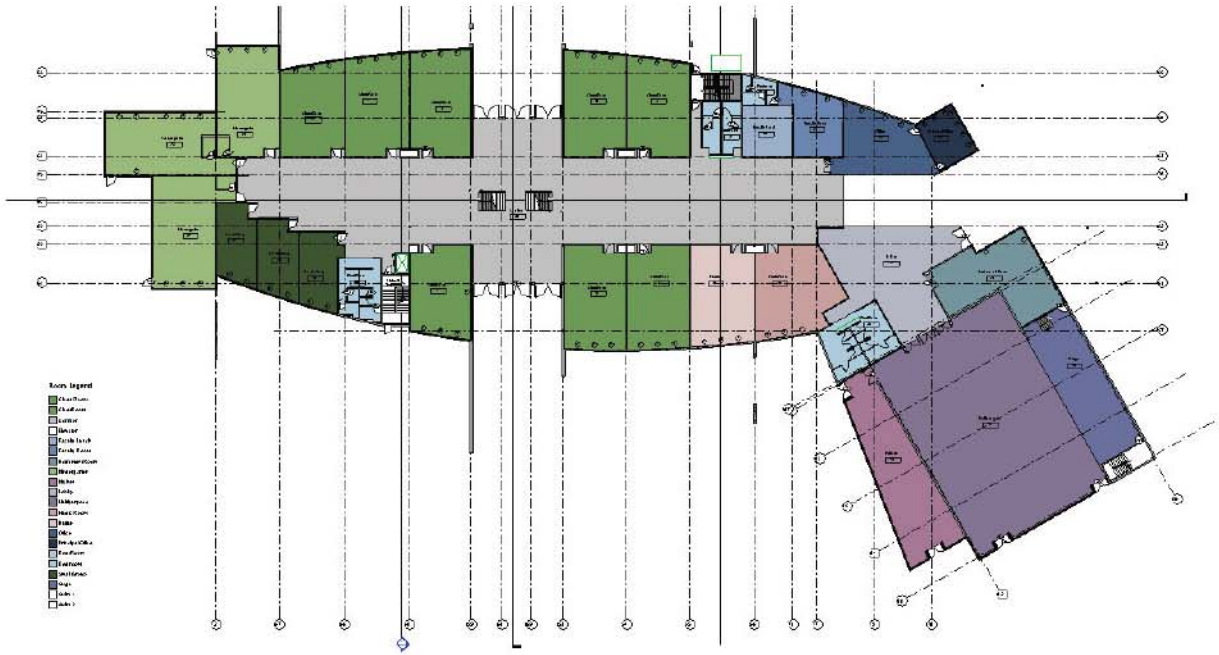
Curvilinear exterior walls asked for a more inventive structural design while their added cost and construction time was a major concern for construction manager.

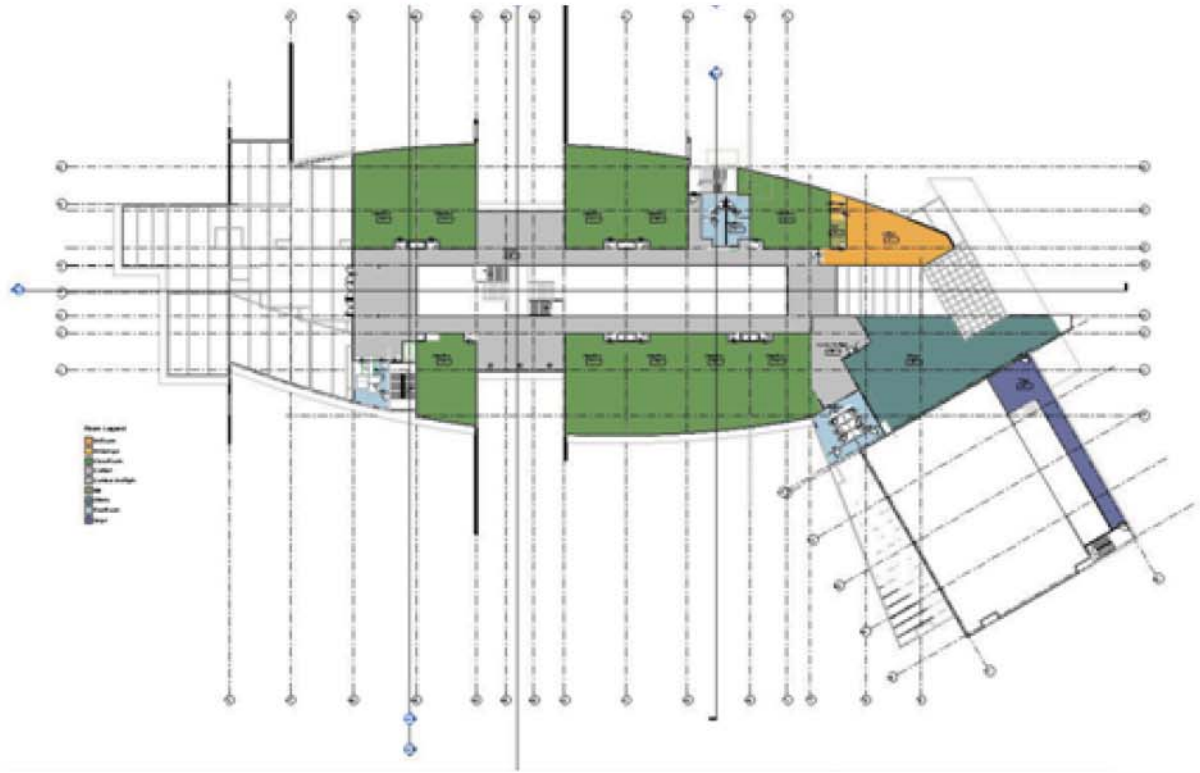
Floor to floor height was changed several times to provide enough space for MEP and structural systems while they were being decided.



During this stage the two landscape concepts were combined and the zones of play were detailed with thematic gardens. The school's entrance, parking lot, and sports will all be highly visible and are therefore a great location for stormwater and grey/blackwater filtration to ensure all visitors are aware of their impact on the environment. The area behind the school is more sheltered and will accomodate a variety of gardens, playgrounds, and outdoor classrooms to stimulate the children through play and first hand observation.

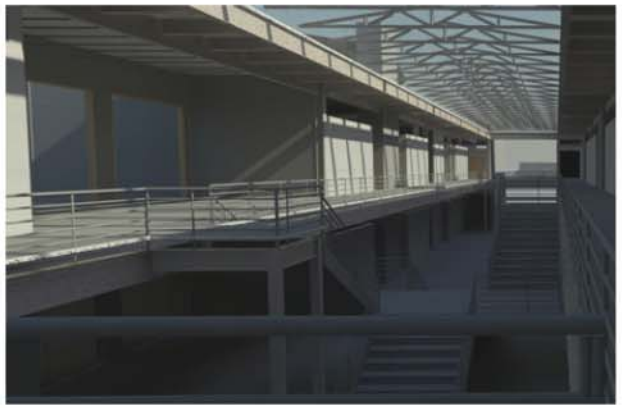


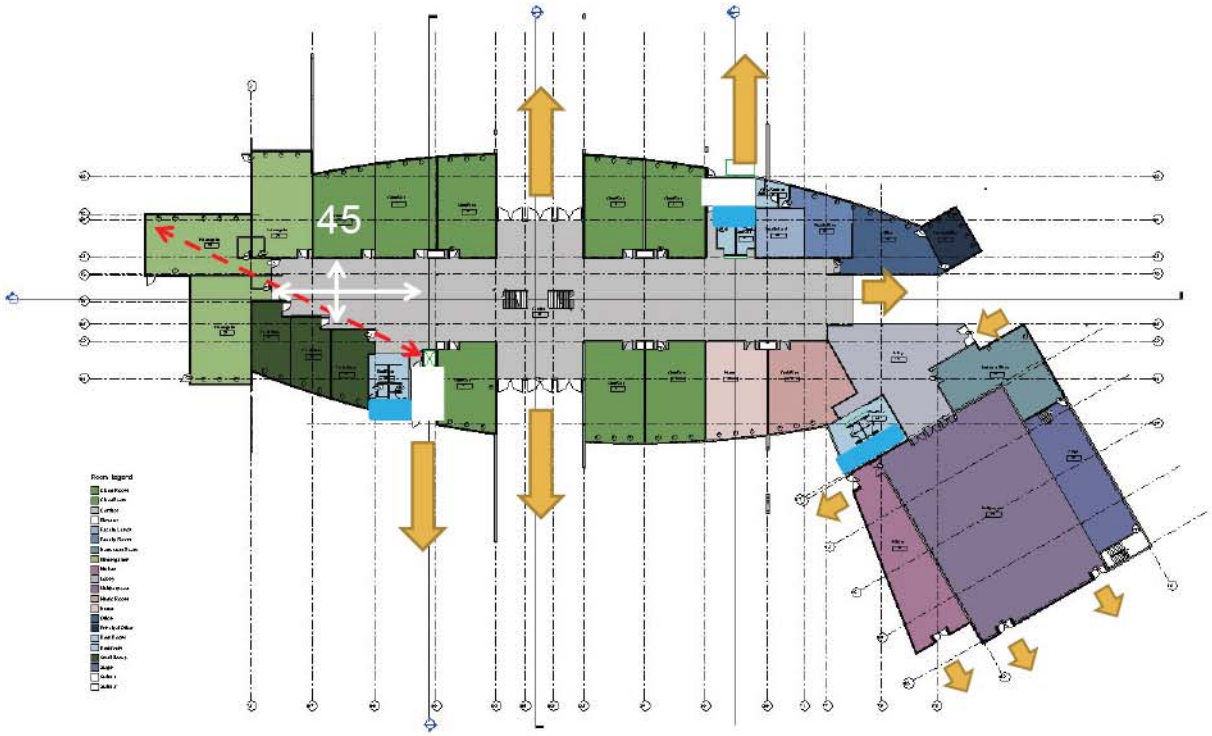




Room Legend

- Class Room
- ClassRoom
- Corridor
- Elevator
- Faculty Lunch
- Faculty Room
- Instrument Room
- Kindergarten
- Kitchen
- Lobby
- Multipurpose
- Music Room
- Nurse
- Office
- Principal Office
- Rest Room
- Restroom
- Small Group
- Stage
- Stairs 1
- Stairs 2
- Art Room
- Art Storage
- Class Room
- Corridor
- Corridor 2nd Right
- Library
- Rest Room
- Stage



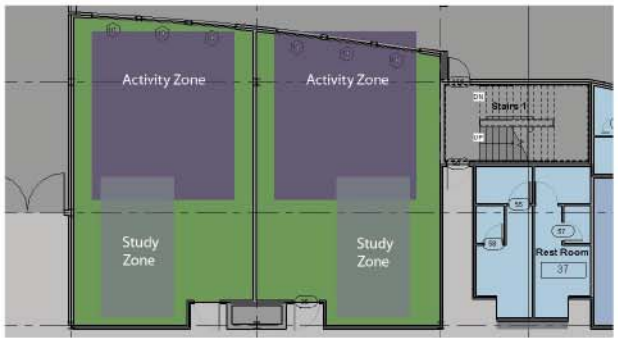


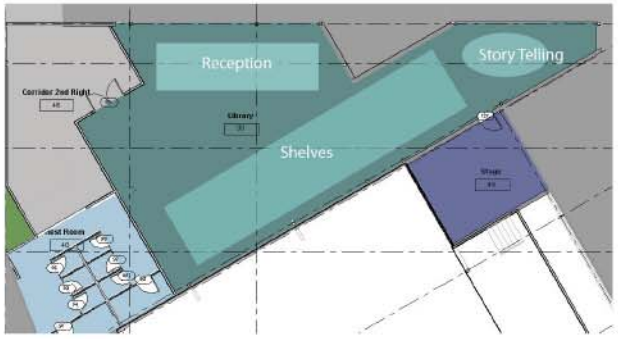
Type IIA building Construction
Type E education Occupancy

+ Fully sprinkled
+ 2 hour rated stairwells, due to open atrium

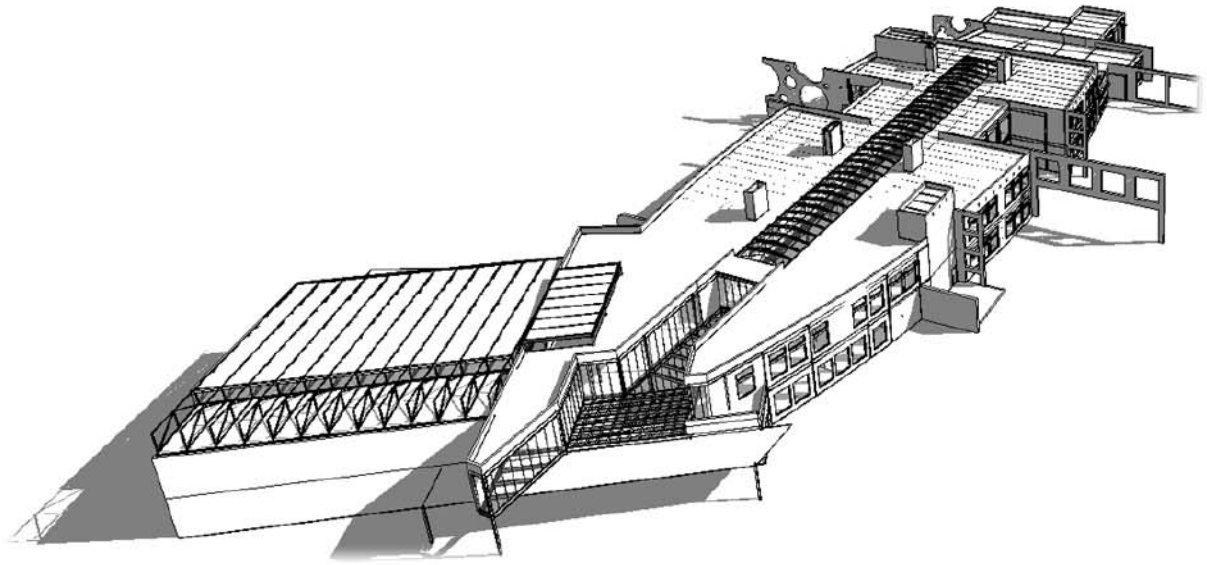
+ ADA compliant restrooms
+ No ramps, elevator access to 2nd floor

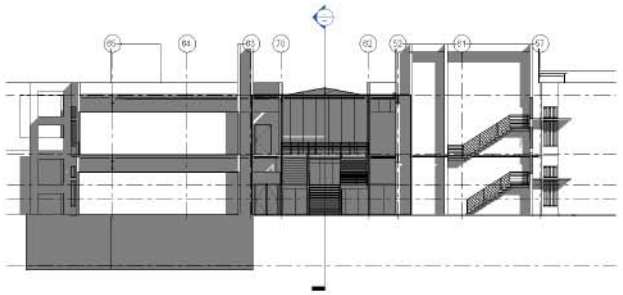
Calculated and considered in the design:
+ Means of egress
+ Travel distances
+ Width of Egress
+ Dead ends
+ Number of exits

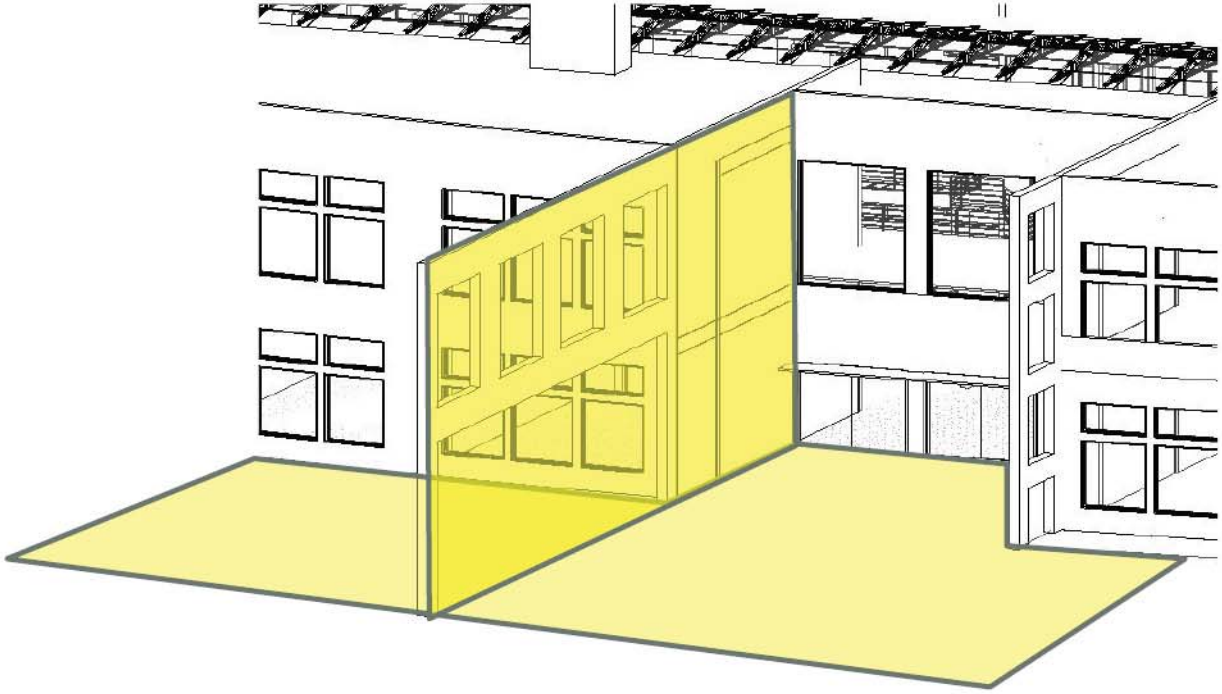




As Designed	58,185 SF
By Program	58,333 SF
Percentage Over	~ 0 %

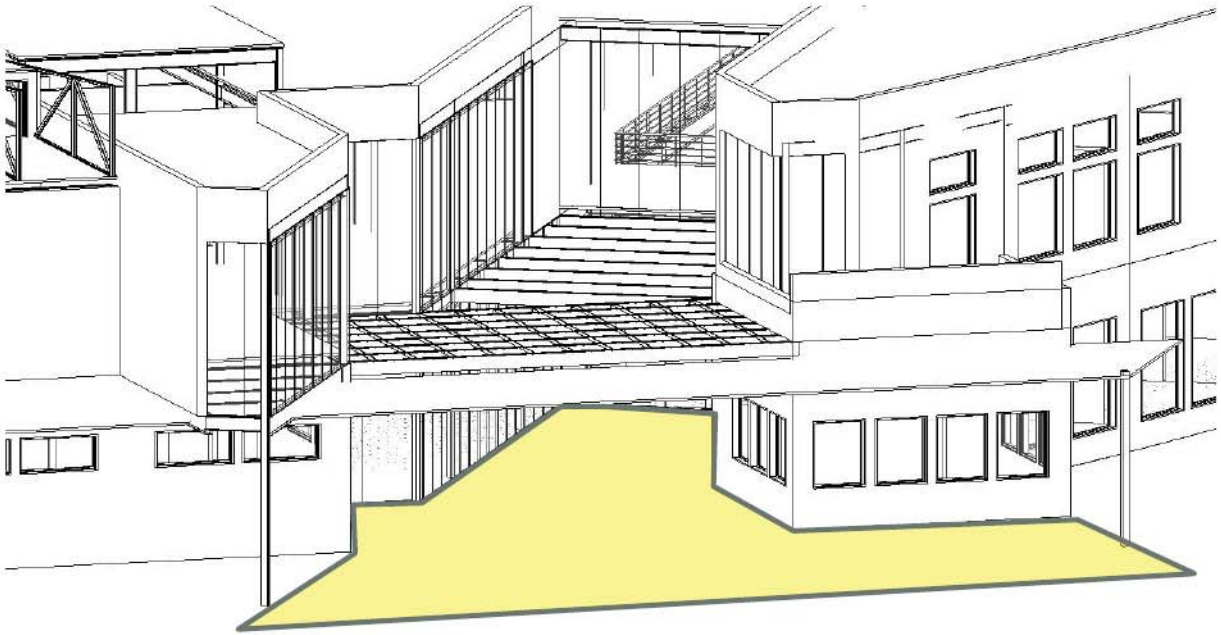






Exterior Lighting

+ Wash exterior entrance
+ Low profile fixtures under trellis
+ LED



3 fc on parking lots
1 fc on paths

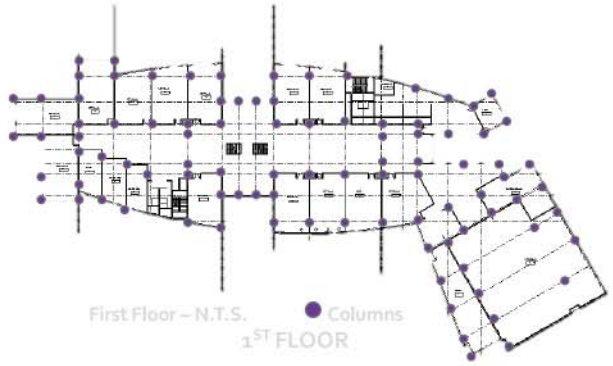
Preliminary Structural Design

Architectural Requests:
+ Large, open volumes
+ Cantilevered floor slabs
+ Flexibility in spaces

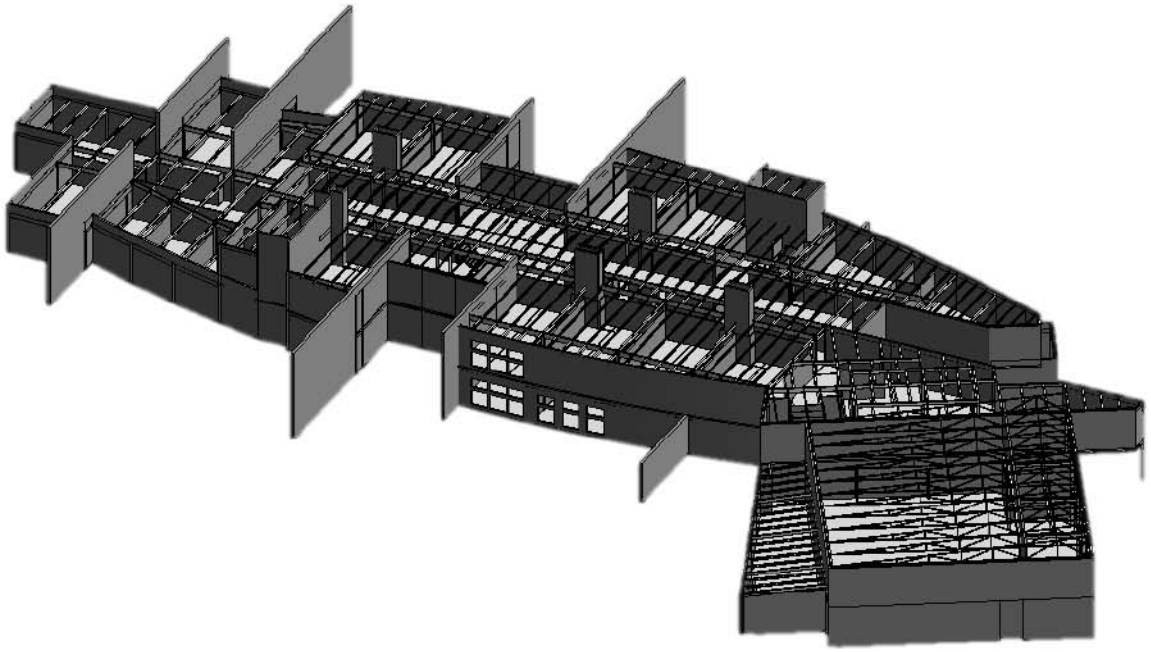
Daylighting Requests:
+ Smaller structural members

Construction Requests:
+ Available material
+ Aggressive schedule

Sustainability Responsibilities:
+ Renewable material
+ Local manufacturers



+ Linear interior column layout with isolated column pads
+ Less exterior columns due to cantilevers
+ Open interior atrium
+ Focus on flexibility and open
+ strip footings

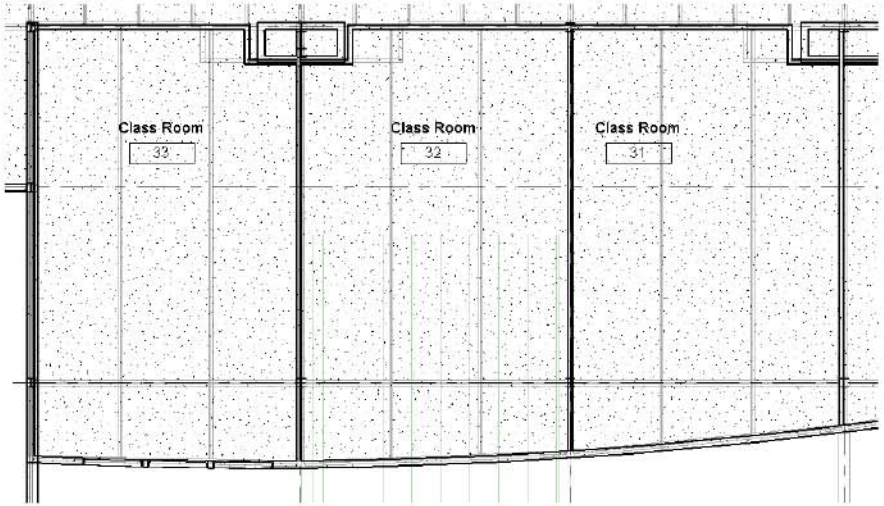


Material	Advantages	Disadvantages
~~Concrete~~	~~High Compressive Strength~~	~~Low Tensile Strength~~
	Fire Resistant	~~Formwork & Shoring~~
	Low Maintainence	Low Strength to Weight Ratio
	~~Lower Floor to Floor Height~~	~~Longer Time To Erect~~
Steel ✓	High Strength-to-Weight Ratio ✓	Corrosive Material
	Quick to Erect ✓	Additional Fireprotection needed
	Good in Tension and Compression ✓	Availability can be limited
	Reusable Material ✓	
Masonry ✓	High Compressive Strength ✓	Low Tensile Strength
	Fire Resistant	Degradation of Material
	Passive Solar Applications ✓	Low Strength to Weight Ratio
~~Wood~~	Cheap Construction Cost	~~Degradation of Material~~
code issue?	Low Embodied Energy	~~Lower Material Strength~~
	Fire Resistant	Non-uniform Stresses
	Reusable, Efficient Material	

Classroom Structural Impact

Cantilevered beam system dictates:

- Ceiling height
- MEP plenum
- Daylighting opportunities

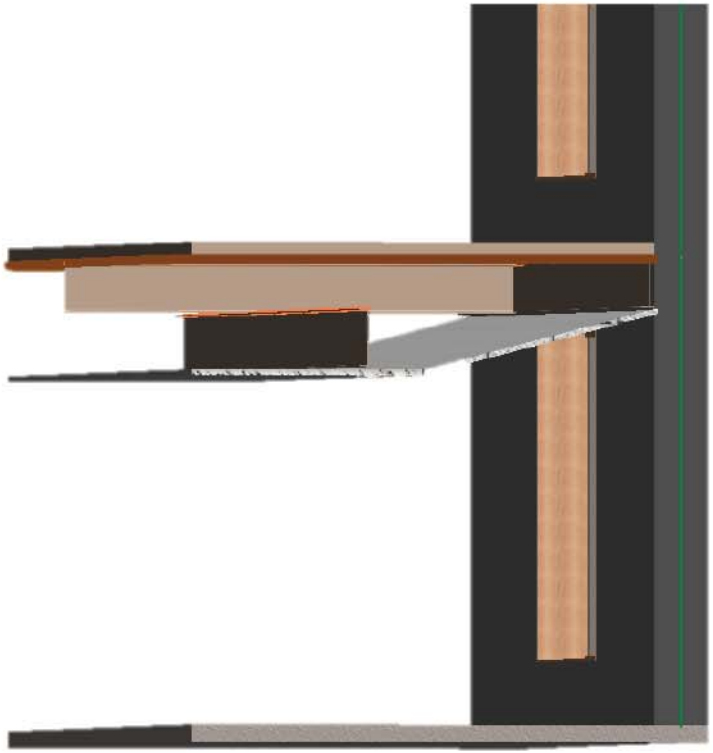


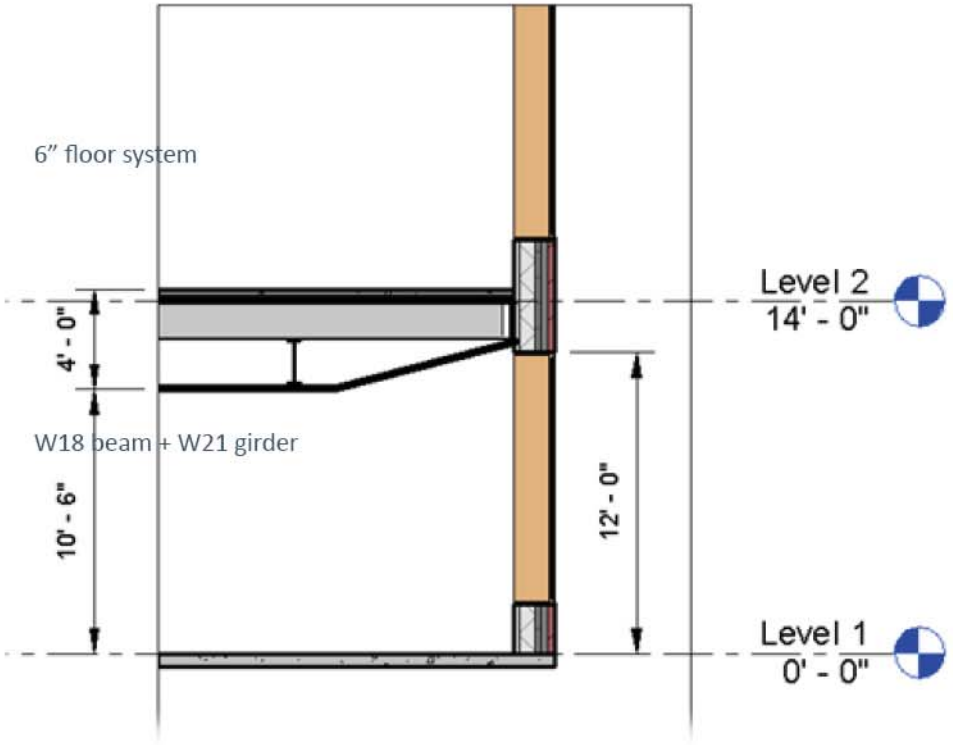
Architectural integration

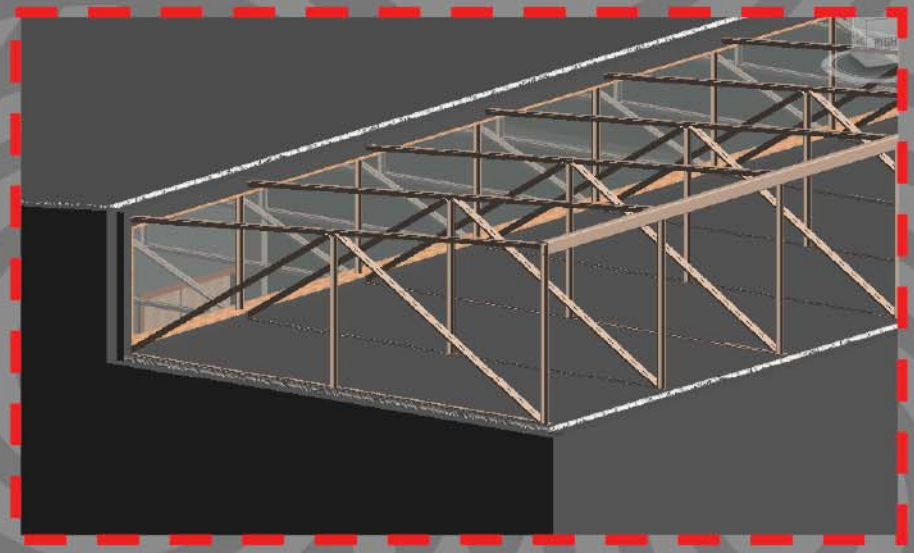
+ Cantilevers allow for open atrium with floating corridors
+ Aesthetically pleasing truss systems in key elements
+ Seamless curvilinear transitions
+ Daylighting opportunities
+ Sloped members flow with architecture

Daylighting integration:

+ Cantilevered classroom section allows for maximum daylighting opportunities



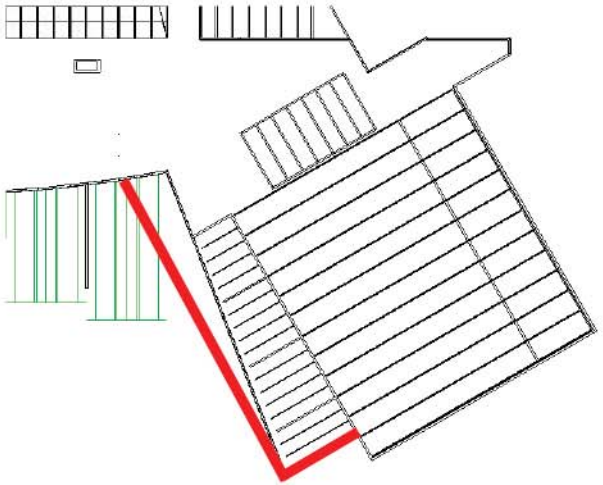




INTEGRATED INPUT: sloped roof

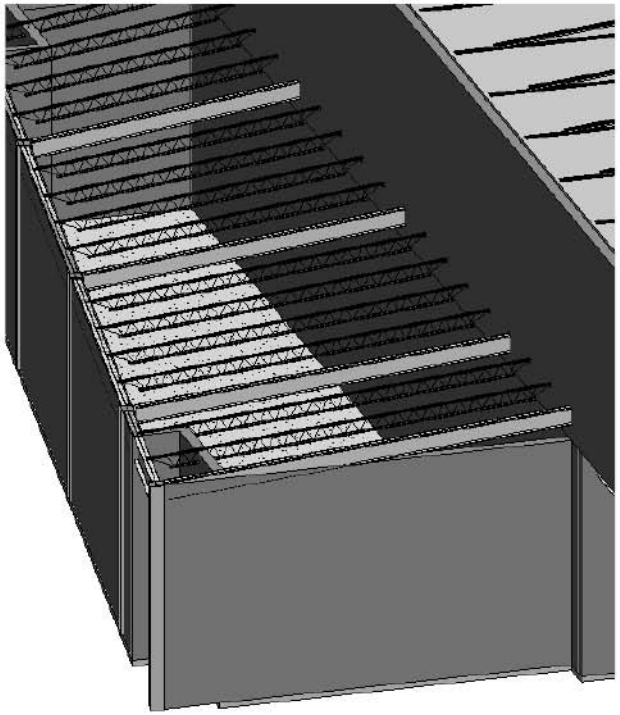
- Aesthetically desired
- Structurally feasible
- Minimal additional load
- Daylighting acheived
- Constructable & cost effective

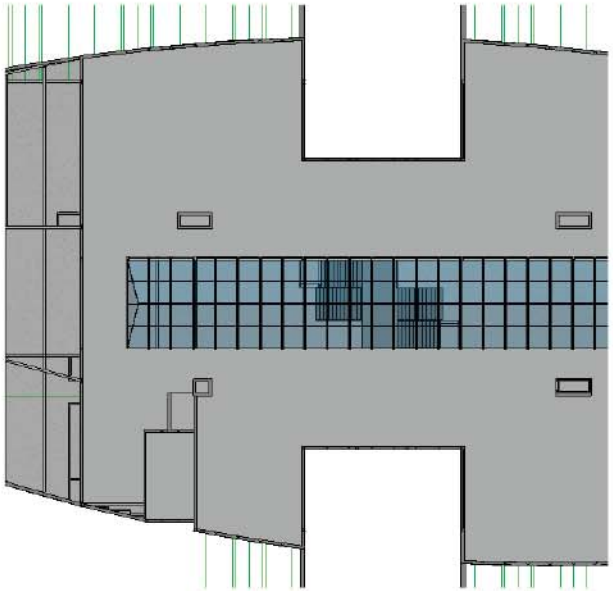
Constructability Issues



Kitchen Joists

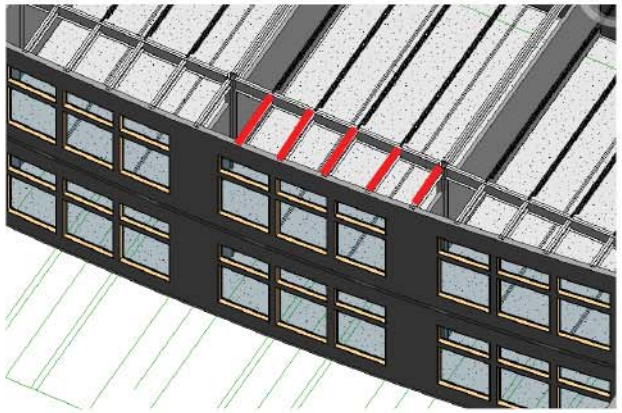
Square corners will allow for repetitive members



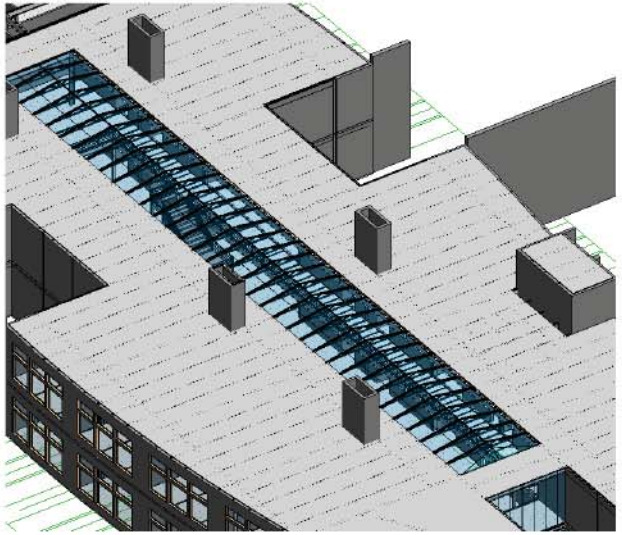


Curvilinear strip footings

The footings will require careful layout and time intensive excavation. The curves then restrict structural continuity, thus demanding expensive fabrication and non-repetitive erection. While the cantilevered beams will require labor intensive moment connections.

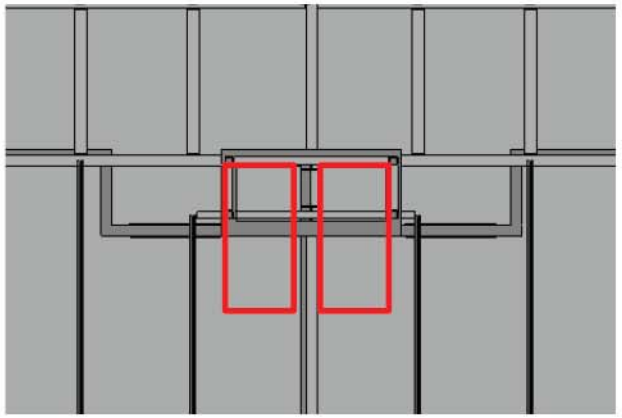


Structural Continuity



Atrium System

Truss and glass system over atrium will require accurate details and labor intensive flashing.



Thermal Chimneys

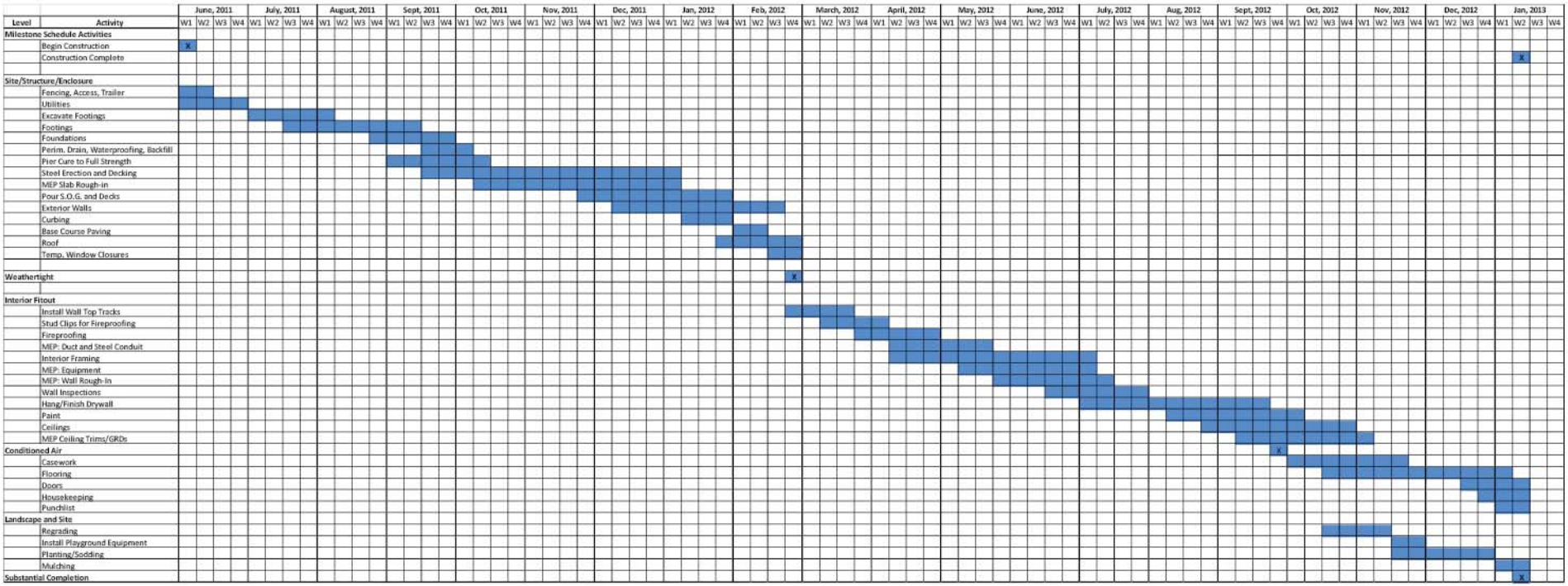
Current alignment interferes with floor joists, resulting in moment connections within the chimney itself. A realignment would allow for increased ventilation and avoid structural interference.

UTILITY	COST($)/UNIT
Purchased steam	9.85/1000lbm
Purchased chilled water	0.22/ton-hr
Electric consumption	0.07517/kWh
Electric on peak	1.09/kW
Water	3.32/1000 gallons

Updated Project Schedule

Schedule Reflects Lengthened Durations For:
Foundations
Truss Erection
Extensive Moment Welding
Exterior Walls
Hang Drywall
Flooring

Schedule Milestones:
Watertight – 9 Months
Conditioned Air – 16 Months
Substantial Completion – 19.5 Months



Project GC Costs					
Item	**Cost**	**Unit**	**Quantity**	**Duration**	**Total Cost**
Security					
Fencing	$7.13	LF	3151		$22,466.63
Signage	$26.50	SF	80		$2,120.00
Temporary Structures					
CM/GC Offices (50'x12')	$360.00	Month	1	19.5	$7,020.00
Subcontractor Offices (32'x8')	$193.00	Month	Provided By Others		$0.00
Workforce Pathways (Gravel - 4" Deep)	$6.88	SY	1610		$11,076.80
Utilities					
Power	$1,485.00	Month		19.5	$28,957.50
Temporary Lighting	$29.30	Month		19.5	$571.35
Water	$62.00	Month		19.5	$1,209.00
Heat	$1,200.00	Week		26	$31,200.00
Office Equip./Supplies	$286.00	Month		19.5	$5,577.00
Winter Protection	$1.14	SF		33000	$37,620.00
Telephone Bill	$81.00	Month		19.5	$1,579.50
Office Lights/HVAC	$152.00	Month		19.5	$2,964.00
Traffic/Materials Control					
Roads (Gravel - 4" Deep)	$6.88	SY	INC. ABOVE		
Storage Boxes (20x8)	$71.50	Month	5	19.5	$6,971.25
Housekeeping					
Dumpsters	$550.00	EACH	3	19.5	$32,175.00
Personnel					
Construction Staff	$8,295.00	$/Week	1	78	$647,010.00
				Total	**$838,518.03**
			Location Multiplier	**87.2%**	**$731,187.72**
			Grand Total	**$731,187.72**	

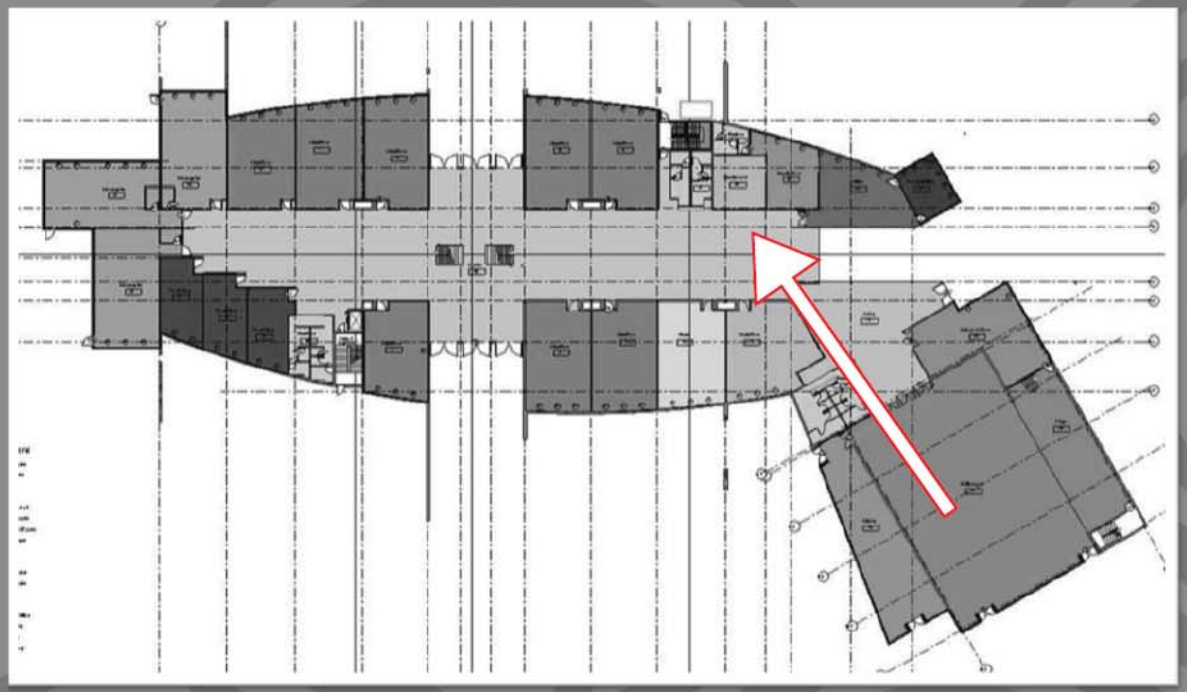
Estimate Breakdown	
Discipline	**Cost**
Concrete	$1,434,608.41
Masonry	$753,169.41
Structural Steel	$2,565,558.04
General Trades	$3,419,150.04
Roofing	$96,118.76
Windows	$1,338,967.85
Kitchen Equipment	$38,256.22
Built-In Casework	$669,483.92
Plumbing	$1,549,377.08
Fire Protection	$323,265.09
Mechanical	$2,610,987.31
Electrical	$1,147,686.73
General Conditions	$731,187.72
Landscaping	$387,555.03
Total	$17,065,372
CM Fee	$511,961
Total Cost	**$17,577,333**

Base Estimate	
Design Area	58,000
Price Per SF	$201.45
Perimeter Adjustment	($7.13)
Story Height Adjustment	($1.40)
Adjusted Price Per SF	$192.92
100 S.F. Basement Addition	$2,430.00
R.S. Means Value for School	$11,191,790
Size Multiplier	0.98
Location	0.872
Total Price	**$9,564,056**

Estimated costs

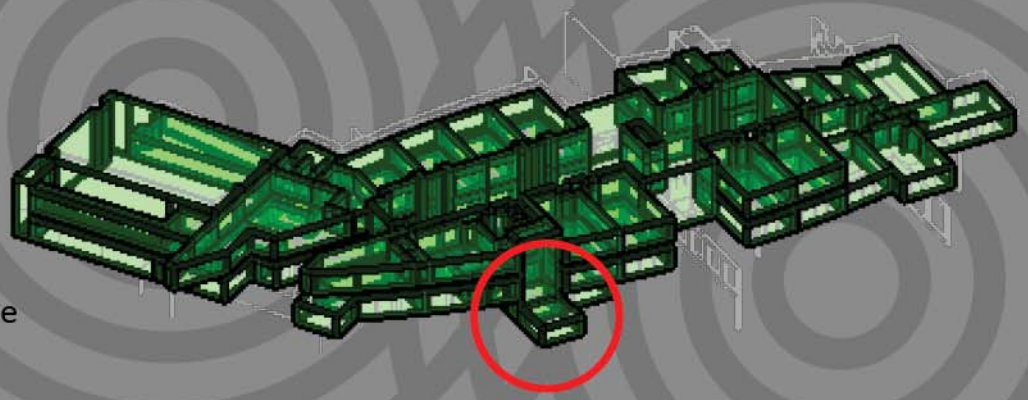
The above chart shows the base estimate, which was then broken down and adjusted in the chart below. The final estimated project cost is $17, 577,333 (left); which includes general conditions (far left), landscaping, and CM fee.

Estimate Breakdown					
Discipline	**% Total**	**Base Price**	**Multiplier**	**Justification**	**Adjusted Price**
Concrete	10.00%	$956,406	1.5	Non-Linear Strip Footings/Extensive Spread Footings	$1,434,608
Masonry	6.30%	$602,536	1.25	Non-Linear Exterior Walls	$753,169
Structural Steel	10.73%	$1,026,223	2.5	Non-Repetitive Members/Moment Connections	$2,565,558
General Trades	14.30%	$1,367,660	2.5	Custom Cutting of All Exterior Wall Finishes	$3,419,150
Roofing	0.67%	$64,079	1.5	Custom Cutting @ Non-Linear Walls/Thermal Chimney Penetrations	$96,119
Windows	7.00%	$669,484	2	Oversized Lintels to Support Long Windows on Exterior Wall	$1,338,968
Kitchen Equipment	0.40%	$38,256	1		$38,256
Built-In Casework	7.00%	$669,484	1		$669,484
Plumbing	10.80%	$1,032,918	1.5	Allowance for Complex Bioretention System	$1,549,377
Fire Protection	2.60%	$248,665	1.3	Non-typical Fire Piping Throughout Classrooms	$323,265
Mechanical	18.20%	$1,740,658	1.5	Allowance for Geothermal Wells and Zone Heat Pumps	$2,610,987
Electrical	12.00%	$1,147,687	1		$1,147,687
Total Price	100%	$9,564,056			**$15,946,629**



INTEGRATED INPUT: mechanical room location

- Aesthetically desired
- Works well with topography
- Longer duct runs increase air travel distance
- Room for installation & maintenance
  Longer duct runs = higher cost



Final Design

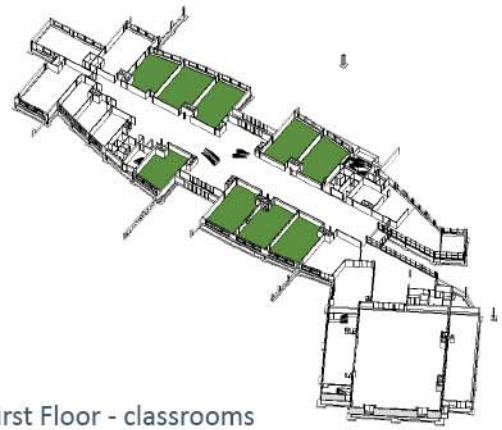
During this stage, the finalized functional plan was detailed; causing multiple revisions to the atrium's cross section. The corridor was pushed to the center with bridges connecting to the classes on the second floor. Pitched trusses were replaced with curved ones, and then covered with a translusent material to increase light penetration without overheating the building interior.

Facade material was finalized; utilizing a combination of modern bricks and precast concrete finish with a core of CMU blocks on metal studs.

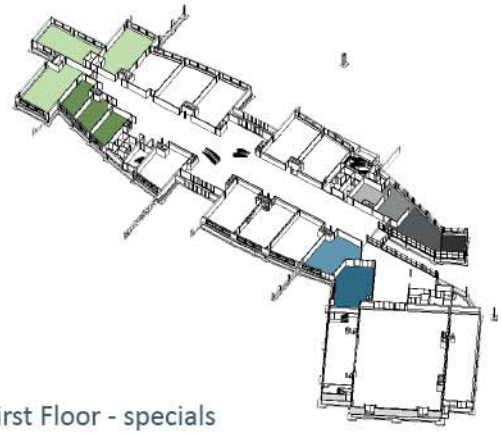
All classrooms include double glazed and wooden framed windows; which are fixed on the upper and operable lower windows.

On the roof, air handler units are covered with metal screens.

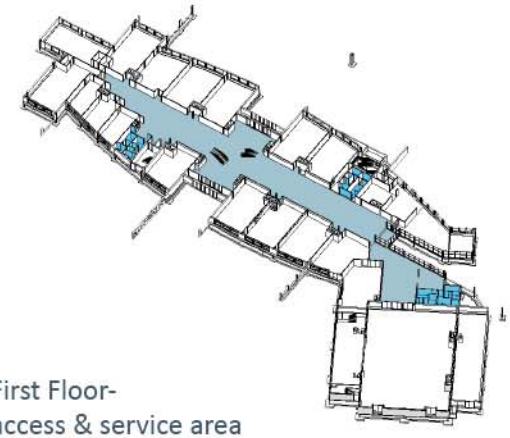
The theater area was greatly detailed, with a curtain wall seperating the indoor and outdoor stage. This strengthened the connection between the multipurpose room and music garden.



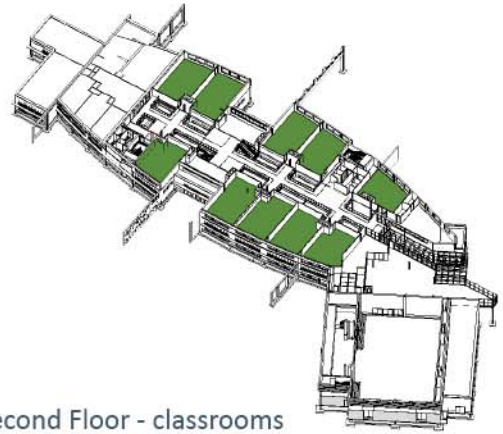
First Floor - classrooms



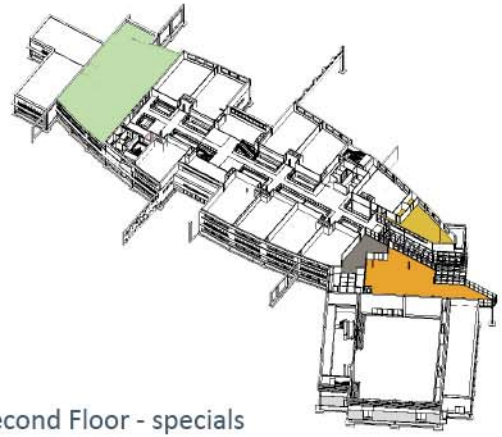
First Floor - specials



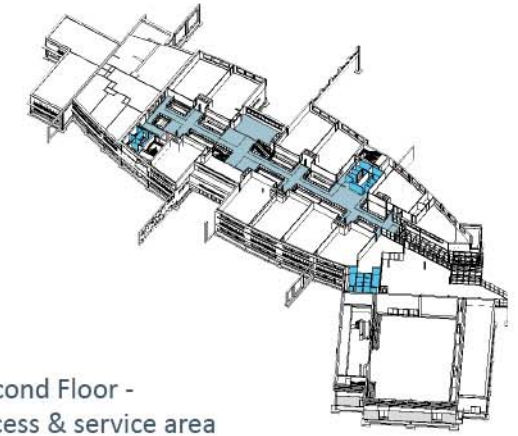
First Floor-
access & service area



Second Floor - classrooms

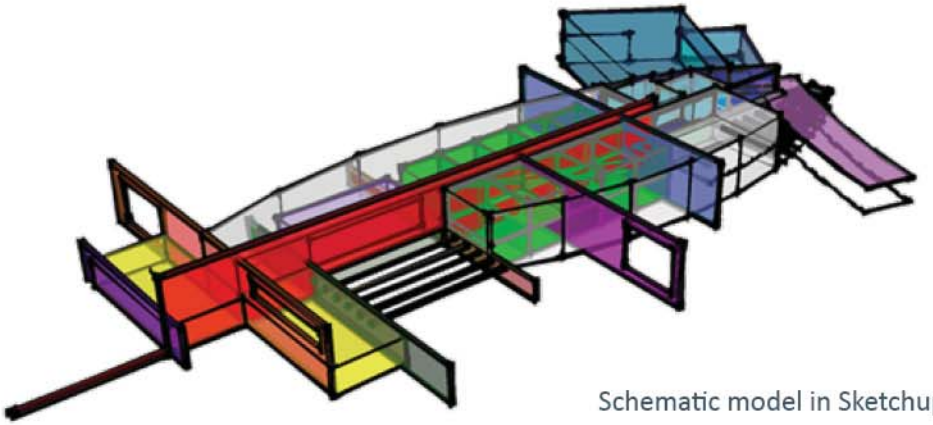


Second Floor - specials

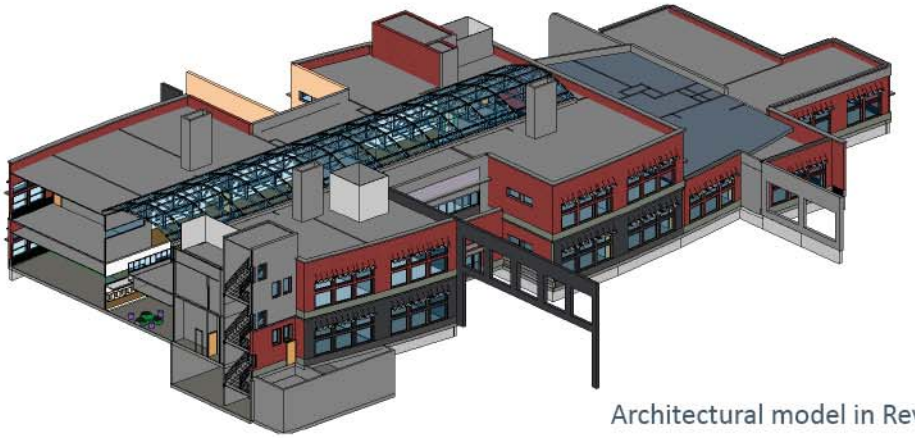


Second Floor -
access & service area

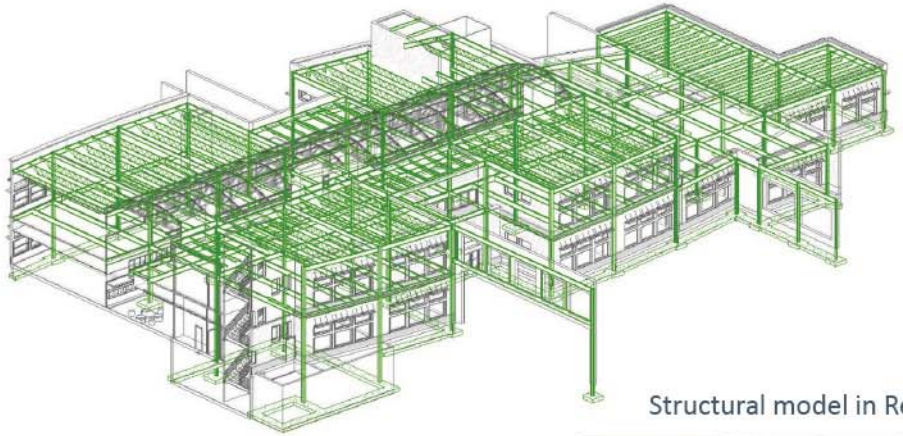
First Floor -
multipurpose & kitchen



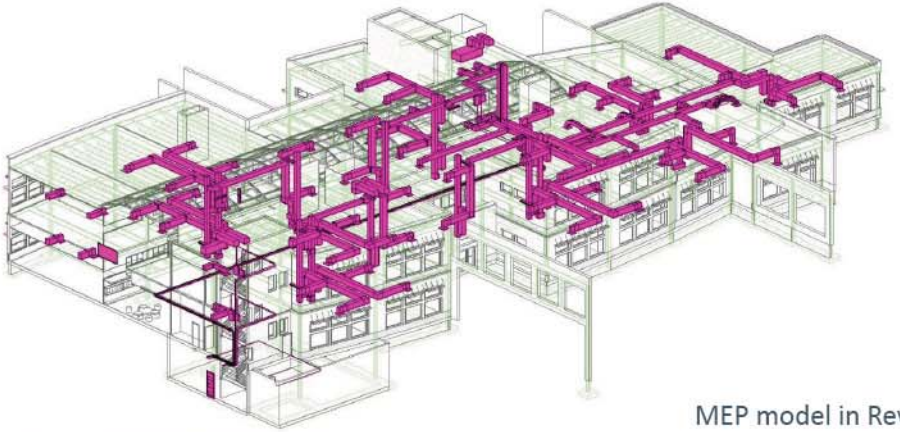
Schematic model in Sketchup



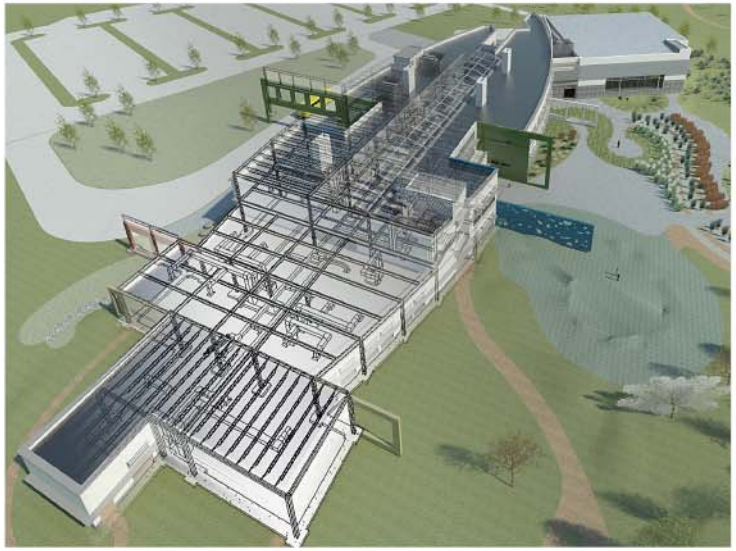
Architectural model in Revit



Structural model in Revit



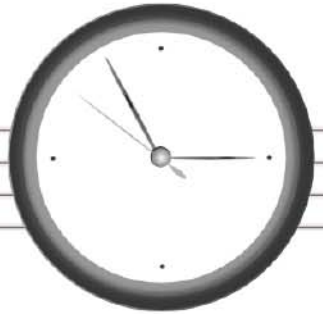
MEP model in Revit



Final model rendered in Revit & Photoshop


GRAPHIC SCALE
0' 25' 50' 100' 200'

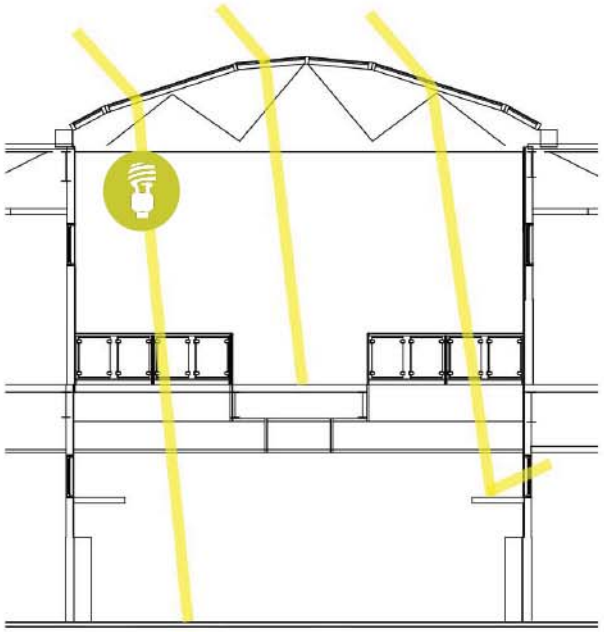
8am	8:15am	9am		11am	12pm	1pm
bus loop	atrium	classroom		lunch	recess	specials



8:00am

bus loop

As the busses drop off the children they will move through one of the many colorful walls extending beyond the building. These walls are structural and aesthetic as they enhance the children's understanding of the connection between building and landscape. The solids and voids created by the walls position in the landscape provide valuable visual relief to the facade, as well as, aiding in the organization of the vehicle and pedestrian circulation on site.



8:15am
atrium

As the children first enter the building they experience the openess of the atrium before being directed to individual classrooms by their teachers. The central atrium space provides playful furnishings and various sized meeting areas. While both floors have cubby spaces along the walls for the children to keep their belongings during class.

8:15am
atrium

On the second floor, sunlight pours in through the glazed roof and filters down to the first floor in between the path bridges.

Abundant open instruction spaces can be used by the teachers and their students for special activities.

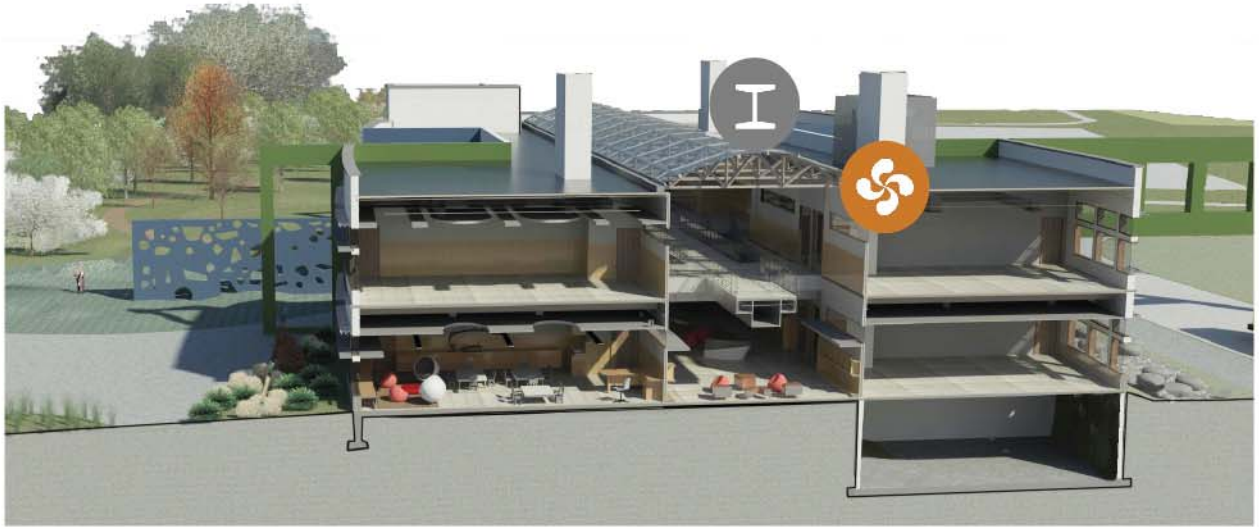
9:00am
classroom

Each classroom offers three zones (study, play and the teacher's desk) the layout of which is based on lighting quality and functional necessities.

In the play zone children can sit on the floor or in bean bags to enjoy the sunlight while they study.

The drop ceiling in the classroom has four openings to reveal the structural and mechanical systems for educational purposes.

Each class has an individual heat pump and supply/return equipment.



11:00am

lunch

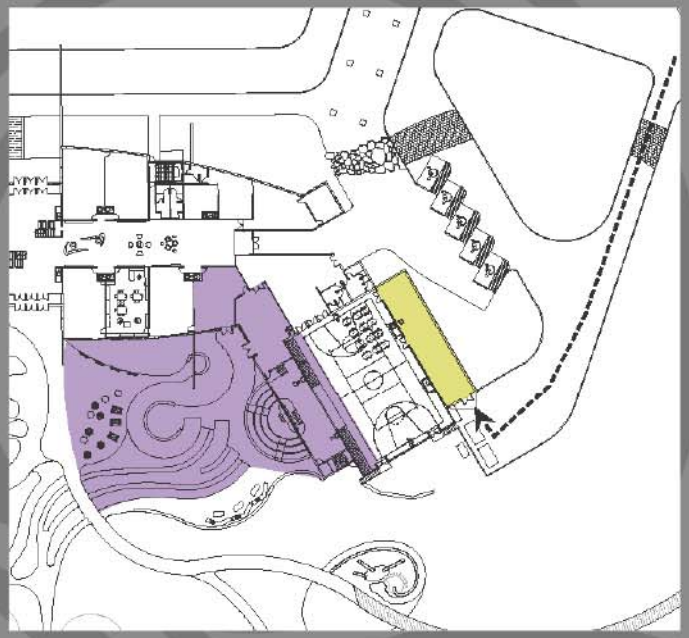
gym

The multipurpose room will be used during the school day as the gym and lunch room and after school it will serve as a community destination.

Light is provided from sloped openings above the roof trusses from the north eastern side. All the structural and mechanical systems are exposed.

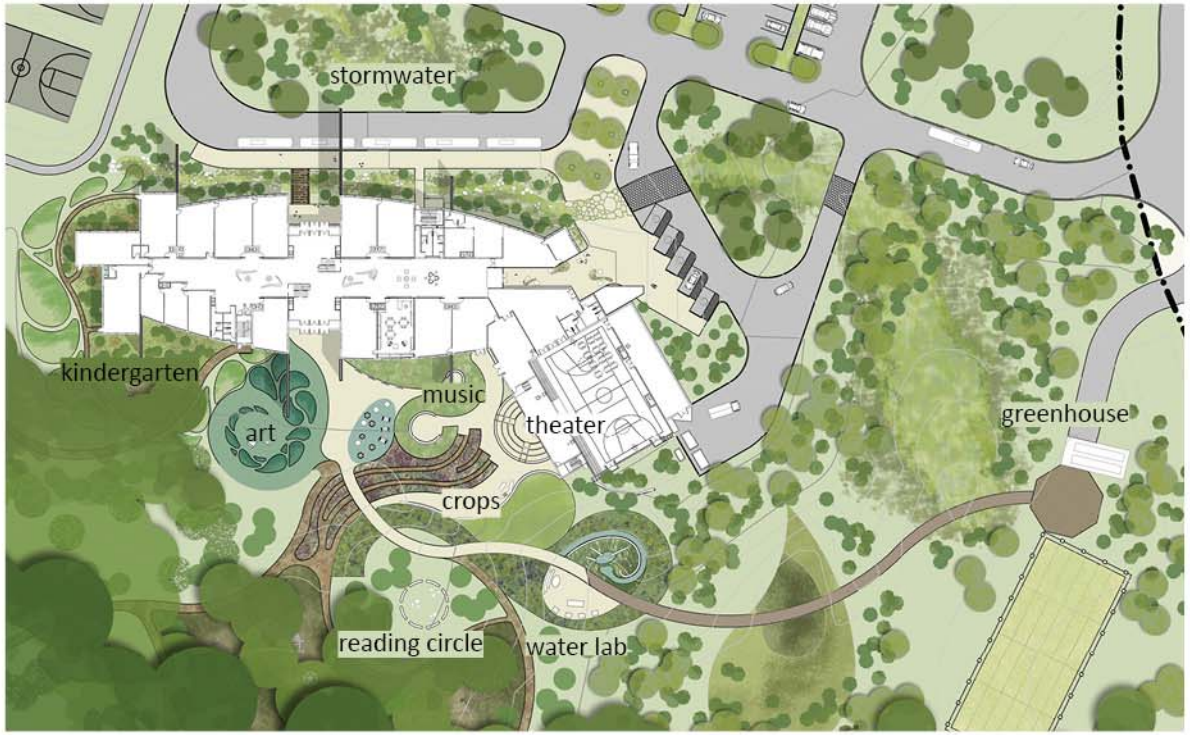
Stage is designed in the western part to work with the recess part via double sided stage.

Stage storage and equipment area are designed on its second floor which is accessible from the staircase beside it.



INTEGRATED INPUT: multipurpose layout

- Concern for how design is impacted
- Suggestion to switch kitchen with stage to increase interaction with building
- Standardizes truss lengths
- Kitchen exhaust will not empty on playground
  Bathrooms not stacked
- Prevents daylighting glare for audience
- Shortens truck delivery route

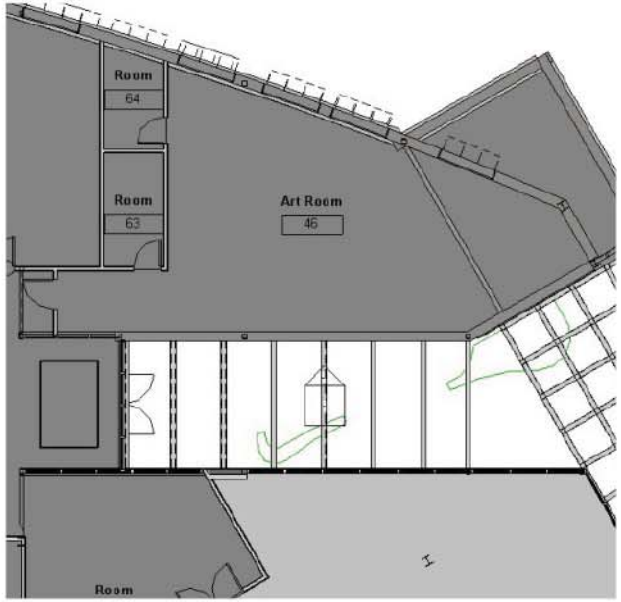

stormwater
kindergarten
art
music
theater
crops
greenhouse
reading circle
water lab

12:00pm
recess

During recess, children can play in a variety of open spaces behind the school, with the supervision of their teachers. The music garden, shown on facing page, will include a variety of abstract and structured instruments for the children to experiment with. As you move away from the school the opportunities for play are still present, but perhaps hidden under rocks and logs in the woodland. The woodland area creates its own set of opportunities and constraints for play; due to the increased area and difficulty of monitoring children undergrowth will be minimized. In addition it is more likely that younger children will be kept in small groups while older children will be allowed to explore the landscape for themselves.

Colorful **fins** are designed based on the xylophone concept as:

+ extensions of the shear walls
+ frames/porous walls that embrace the building
+ connection to the landscape
+ playful walls for the children
+ monumental features



1:00pm
specials

Art room

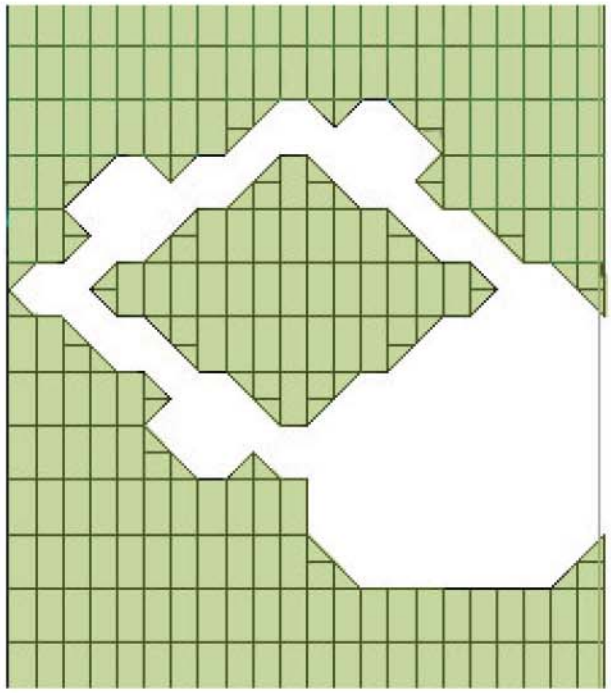
The art room, shown above, will require specialized mechanical systems to accomodate the kiln. Other areas of concern include the nurse's office and kitchen areas. In these areas it will be necessary to change air pressure by supplying less air to the space, as well as, locating air intakes above pollution centers.

Library

Above, a cantilevered curved form with glazed surfaces invites people into the main entrance area. Inside the library this glazing allows soft northern light to fill the space; creating a special experience

Green roof

Located above the one storey section of the building, on the west side. The roof above the small group instruction rooms and kindergarten area needed to be designed differently due to the added structural load and green roof's depth. The plants will be maintained in a series of trays allowing for future expansion and experimentation.

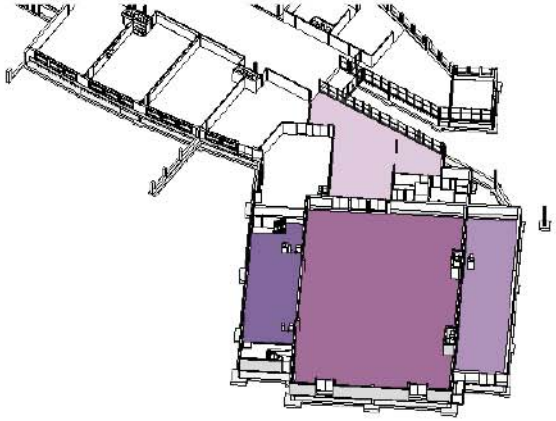


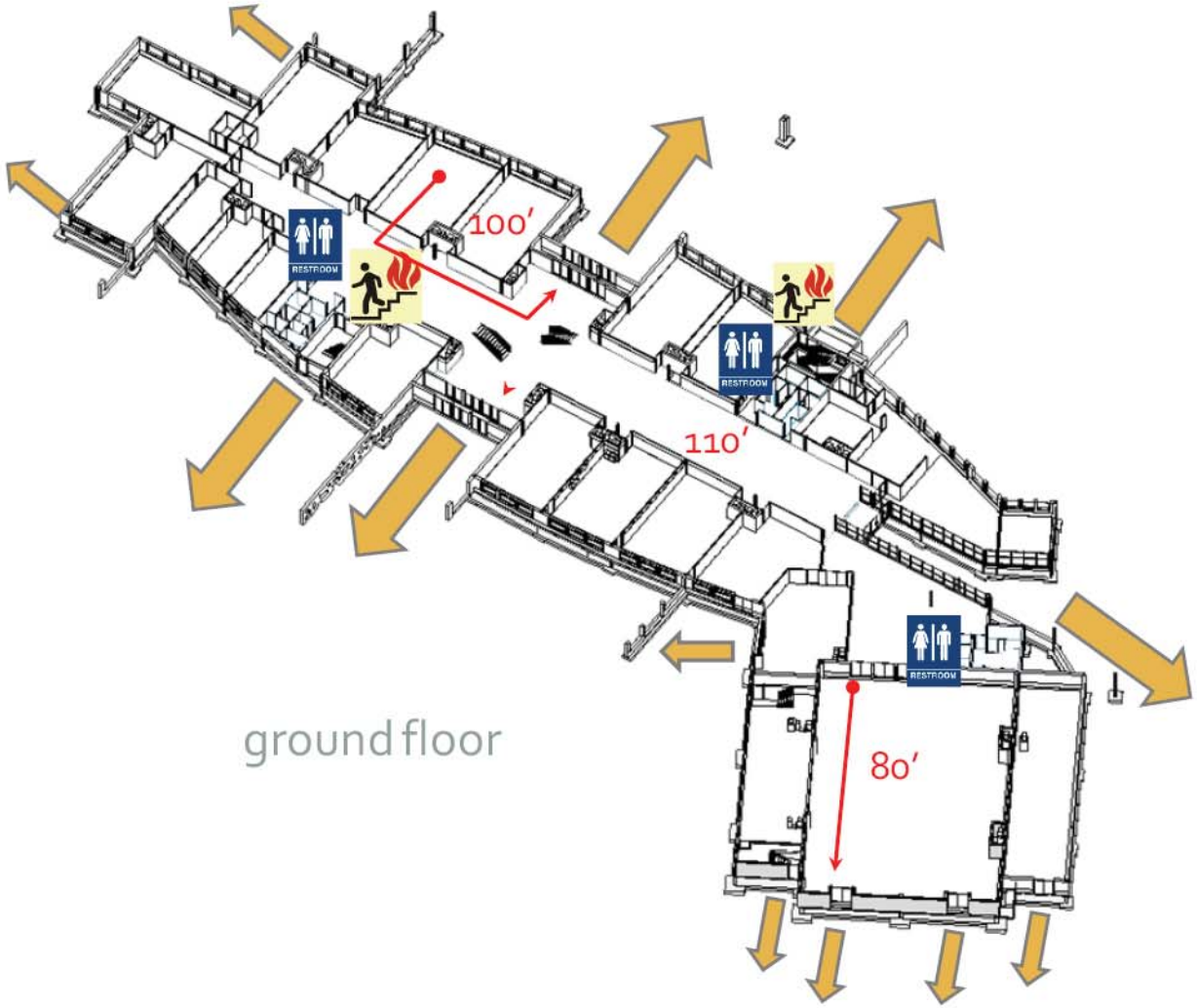
end of the day

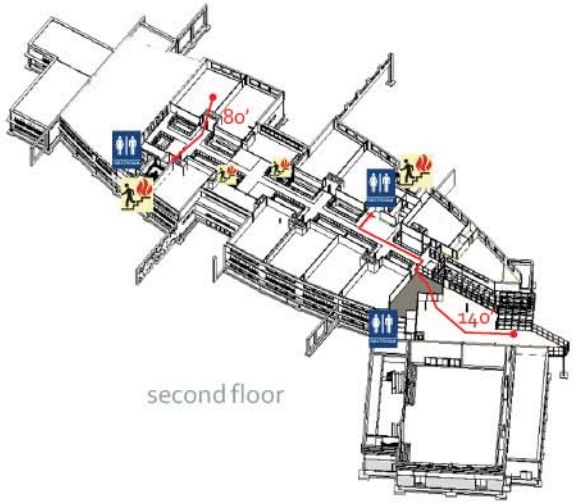
pick up
office access
special events

At the end of the school day, parents can pick up their children at this entrance.

In addition this entrance leads to a lobby that is connected to restrooms, the multipurpose room, instrument room, and the office. Thus allowing the space to be used after school hours both for school and community sponsored events.







After the atrium was redesigned the 2nd floor corridor needed to be reevaluated for travel distances and width of egress. Sprinklers are required under the atrium trusses but water curtains are not necessary for the openings between the bridges.

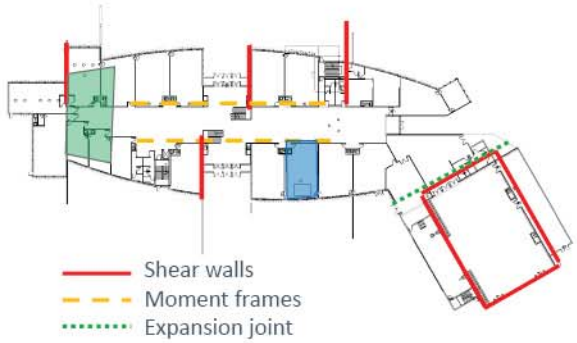
Type IIA building Construction
Type E education Occupancy

+ Fully sprinkled
+ 2 hour rated stairwells, due to open atrium

+ ADA compliant restrooms
+ No ramps, elevator access to 2nd floor

Calculated and considered in the design:
+ Means of egress
+ Travel distances
+ Width of Egress
+ Dead ends
+ Number of exits

Lateral System Overview



System Layout

+ Steel, no exterior bearing walls
+ Shallow strip foundations
+ Composite Design on 1st floor
+ Non-composite Design for roof (K-Joists)
+ Deep truss system for multipurpose
+ Flexible, adaptable, open spaces capable of future expansion
+ Open atrium with minimal columns

Typical Classroom:

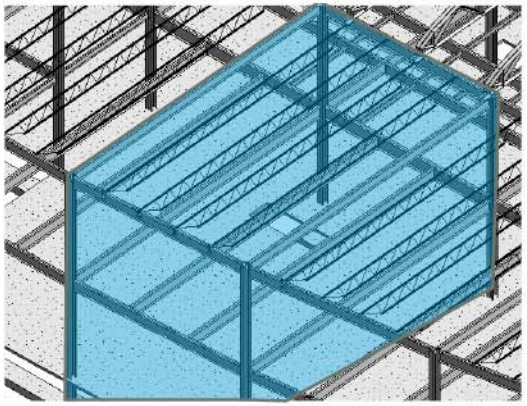
40’ x 25’ bay

W18x35 beams & girders

Composite Beam Design

W10x33 columns

24K9 roof joists



Design Loads

Occupancy	Design Loads
Atrium (ground floor)	100 psf
Atrium (above grnd. flr.)	80 psf
Classroom	40 psf
Library (Reading Rooms)	60 psf
Library (Stack Rooms)	150 psf
Exterior Walls	25 psf
Snow Load	30 psf

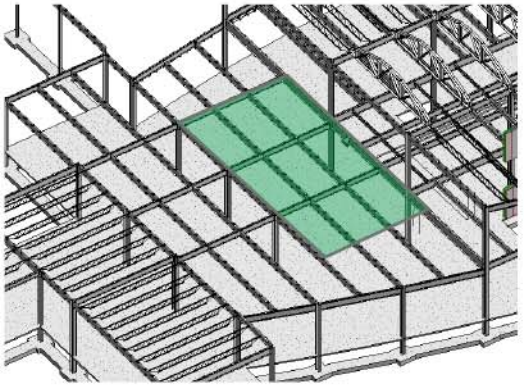
Green Roof:

Various Bay Sizes

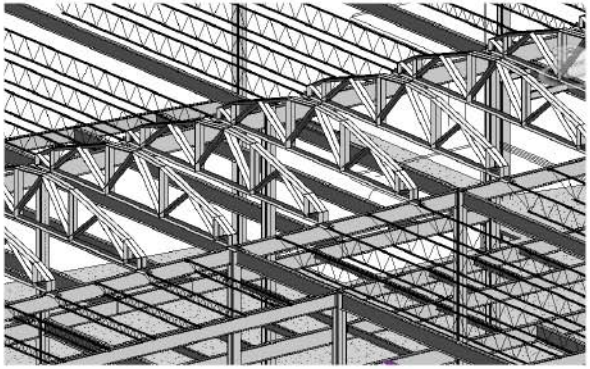
W16x26 beams & girders

Composite Beam Design

W10x33 columns



Composite Design



Inputs:

Loads:

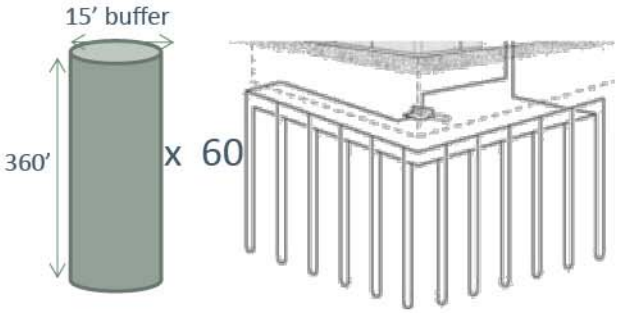
Dead	50	psf	Steel Deck & Concrete Topping	*2 1/2 topping thk. - 3VLI Composite Deck - UL Des. #B90	
	10	psf	Superimposed Dead Load		
	5	psf	SW Allowance		
	65	psf	Total Dead Load		
Live	49.96	psf	Total Live Load		
	80	psf	Code Mandated		
Live Load Reduction					
A_T	331.38	ft^2		Span	40.1667 ft
K_{LL}	2			Beam Spacing	8.25 ft
$K_{LL}A_T$	662.76	ft^2	OK		
L_o	49.96	psf			
	80	psf			

Factored Loads:

DL Factor	1.2
LL Factor	1.6

w_u	157.9	psf
M_u	262.8	k-ft

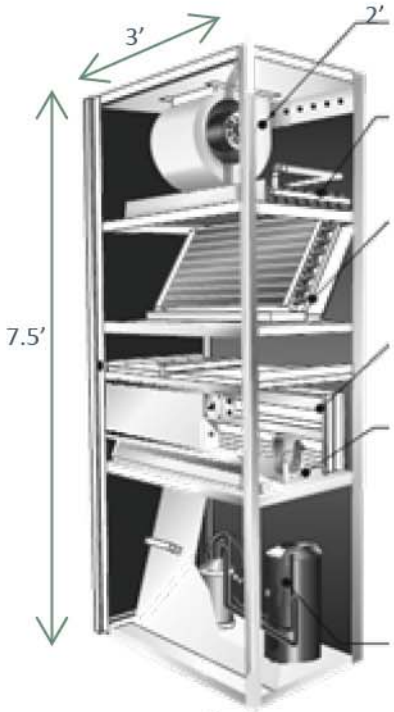
GEOTHERMAL GROUND SOURCE



soccer fields

mechanical room

LOCAL HEAT PUMPS



x 42

each classroom

DEDICATED OUTDOOR AIR SYSTEM

roof

ENERGY

Energy efficiency was the 3rd most important touchstone to the school board. Thus, interdisciplinary efforts in making the most efficient design was a goal throughout the entire semester. The final energy analysis was performed within Trane TRACE.

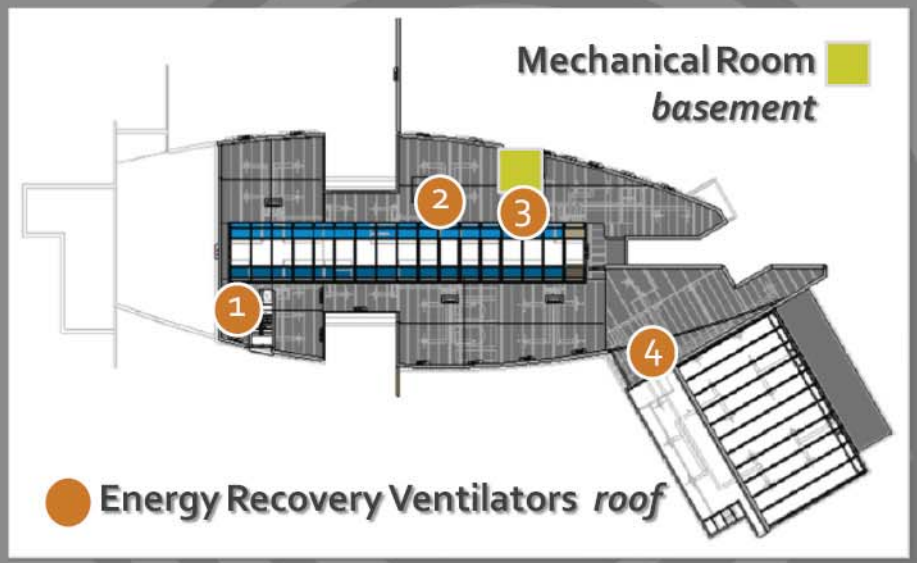
EQUIPMENT CONSUMPTION

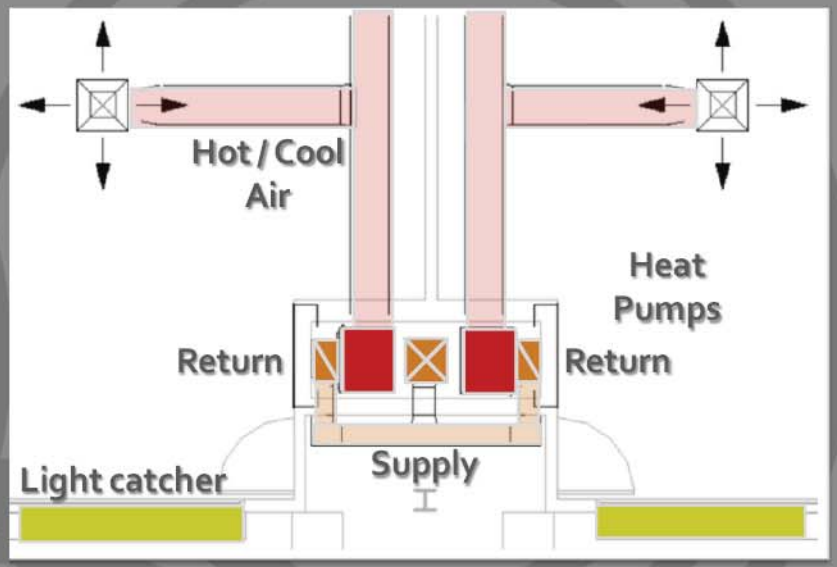
The equipment consumption revealed that the heating consumption was much lower than expected. Through a further TRACE analysis we were led to believe that the local heat pumps heating was lumped into the cooling load.

- \+ Less fan energy
- \+ Increased energy performance
- \+ Small mechanical room
- \+ Soils feasible for bore holes

- \+ Ability to respond quickly to individual rooms
- \+ Teachers have control over the room
- \+ Less conditioned air duct runs
- \+ Higher costs

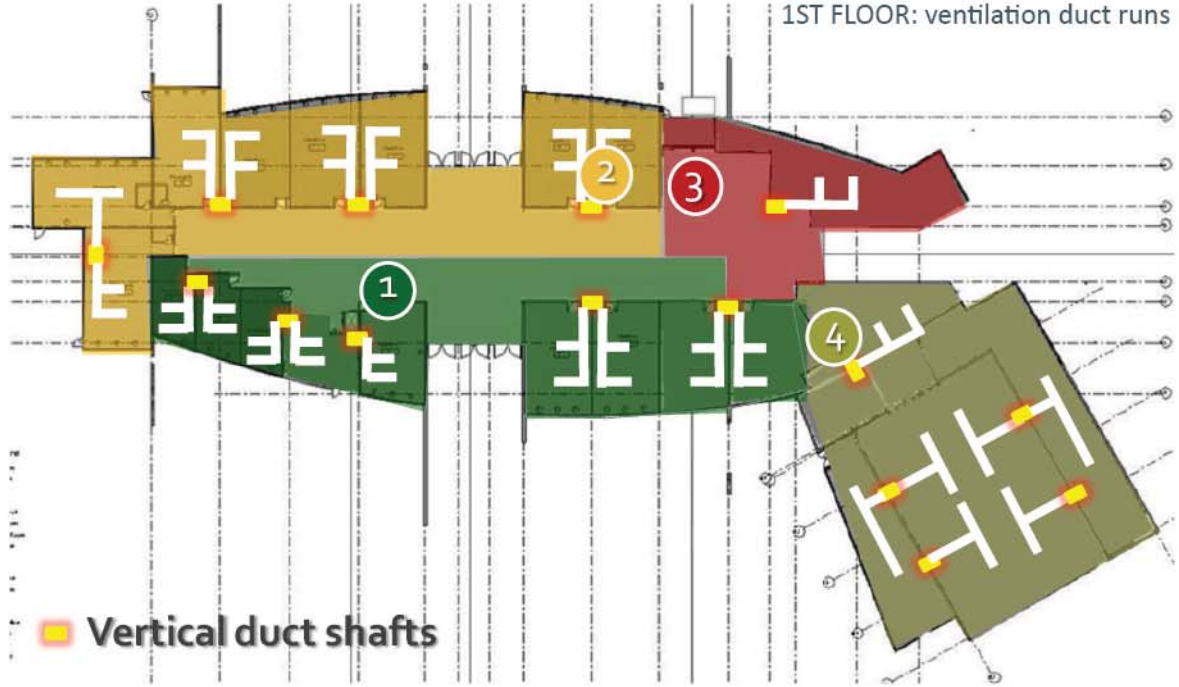
- \+ Conserves energy
- \+ Indoor air quality
- \+ Radiant loads directly increased comfort
- \+ Aesthetically covered by screens on roof



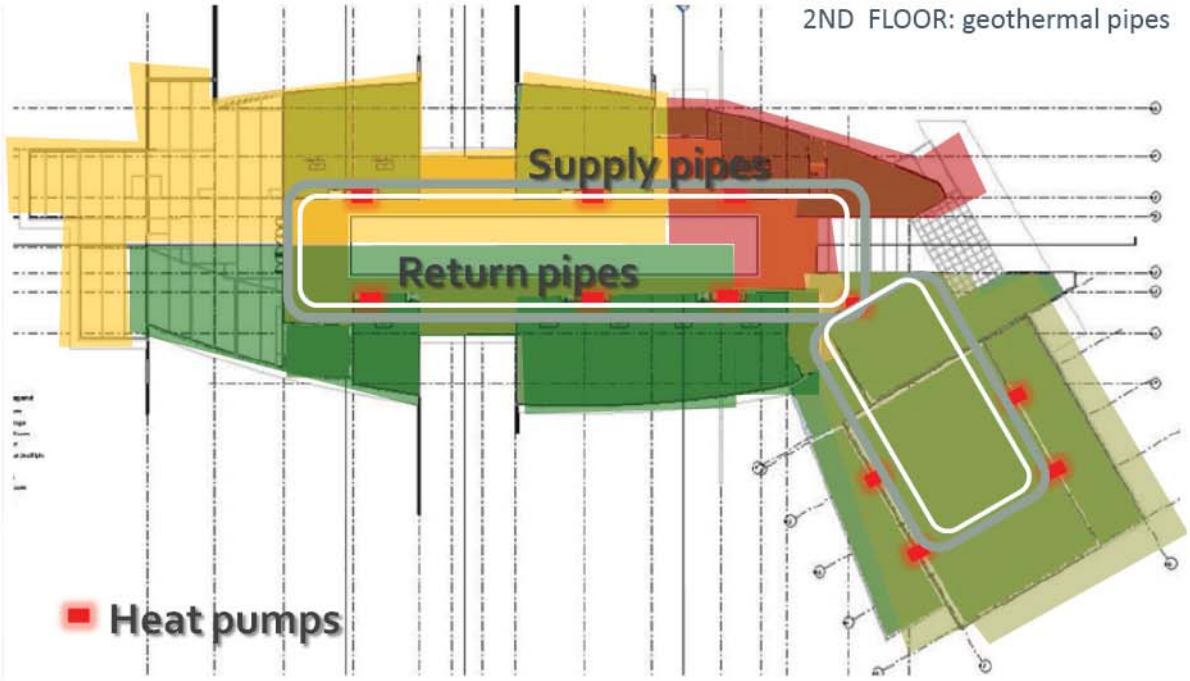


INTEGRATED INPUT: duct runs

- No exposed duct work in atrium
- Duct runs from basement mechanical room would be long & large
- Light shelves along atrium wall restricts horizontal runs
- Long duct runs very expensive

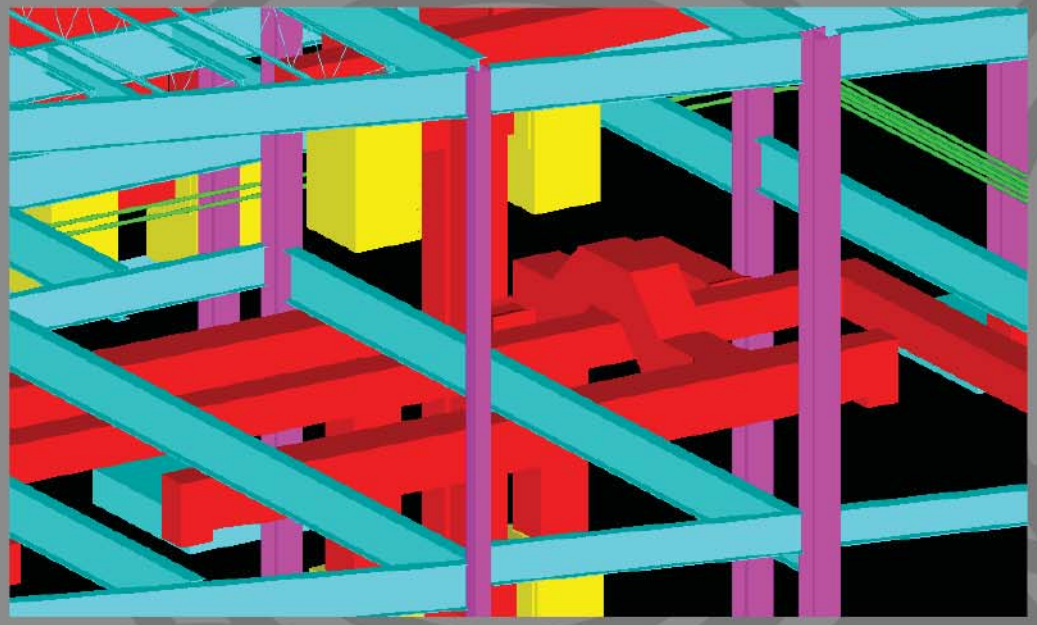


	SPACES	
1	Classrooms Atrium Corridors	1
2	Classrooms Atrium Corridors Art	2
3	Office	3
4	Multipurpose Music Library	4



Monthly Consumption

The monthly consumption curve was simply based upon our kBTU/ month. The percentage increase and decrease from our valley design is based off of the kBTU/sqft/yr standards from ASHRAE. Through a year's time, our design consumes about 36% less kBTU/sqft/yr compared to the typical school design ASHRAE standard. Our design could be further improved by reducing the amount of glass in the facade, as well as, more progressive architectural features.

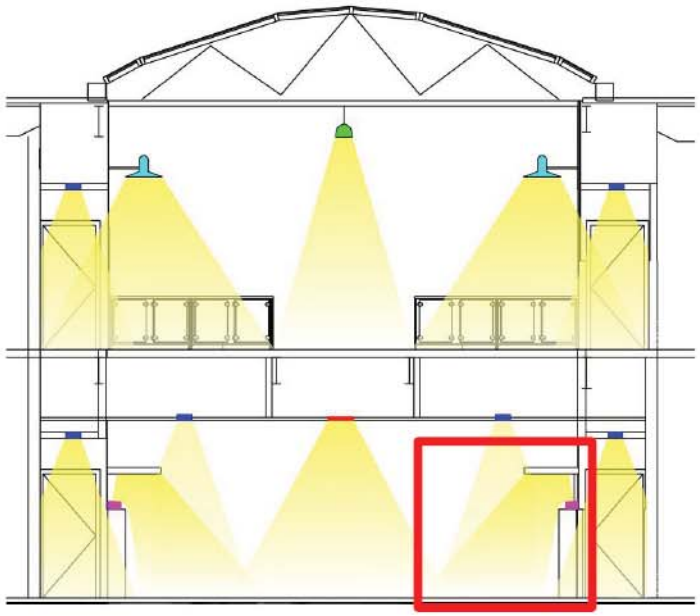


Value Engineering

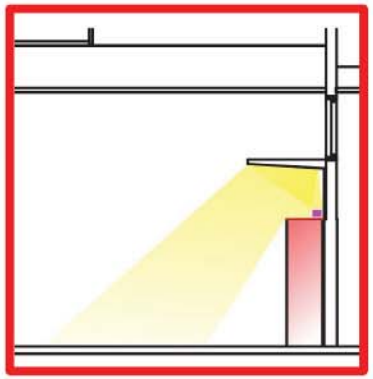
- utilizes plenum space
- minimizes custom duct fittings around steel
- allows efficient runs
  - minimizes material and labor
  - minimizes air flow noise
- maintains design air pressure
- maximizes fan efficiencies

INTEGRATED INPUT: plenum

- Provides increased vertical space and presence
- Allows larger windows for views of landscape
- Beam designed to provide largest possible plenum
- Mechanical systems condensed between beams
- Higher ceiling heights allow deeper light penetration



Atrium LIghting

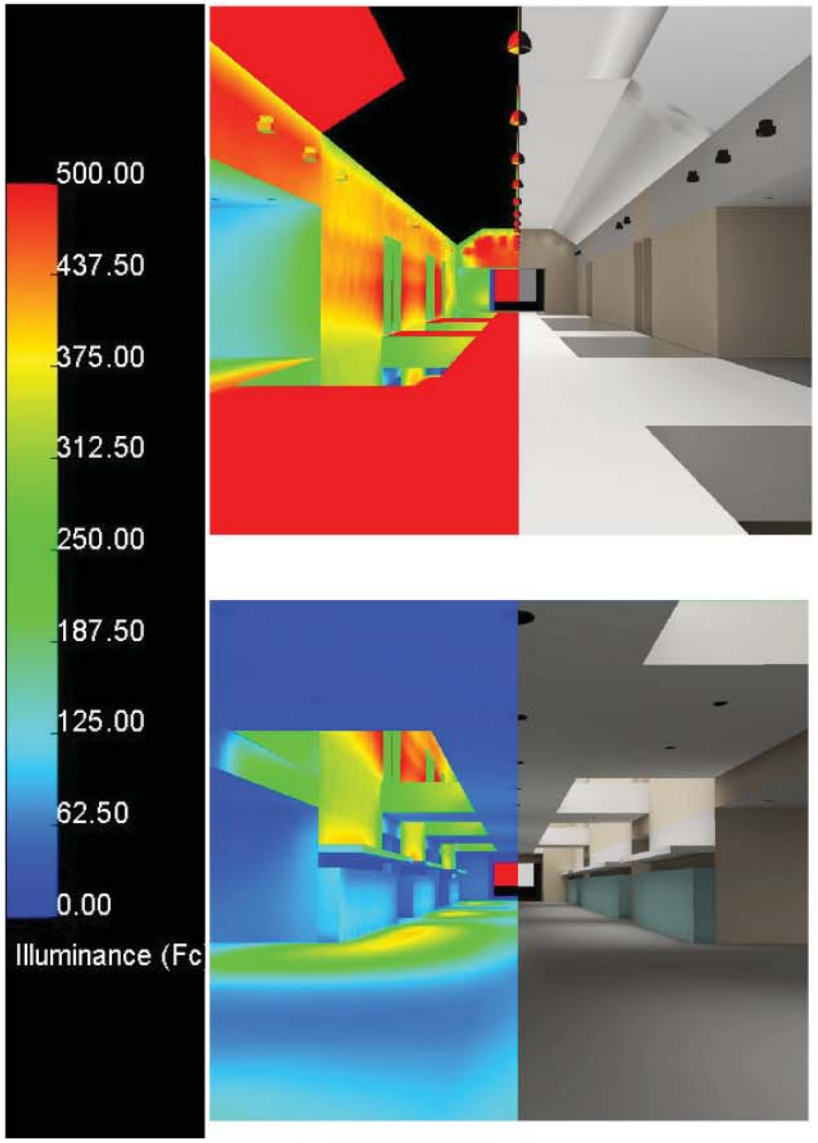


Up-lighting daylight shelves to bring down the scale of the atrium

Fluorescent sources
High efficacy
Relatively expensive

A cellular polycarbonate material was selected for the atrium roof for its thermal properties and for its ability to transmit diffuse light. The majority of the daylight in the classroom was provided by windows in the exterior envelope.

For the northern classrooms, large windows took advantage of even light. For the south classroom, fins and light shelves were used to maximize the amount of light in the space while minimizing the penetration of direct sunlight.



IESNA recommendation: 10 fc

Overcast Day
1st Floor: 56.5 fc
2nd Floor: 413.7 fc

Electric Lighting
1st Floor: 10.5fc
2nd Floor: 10fc

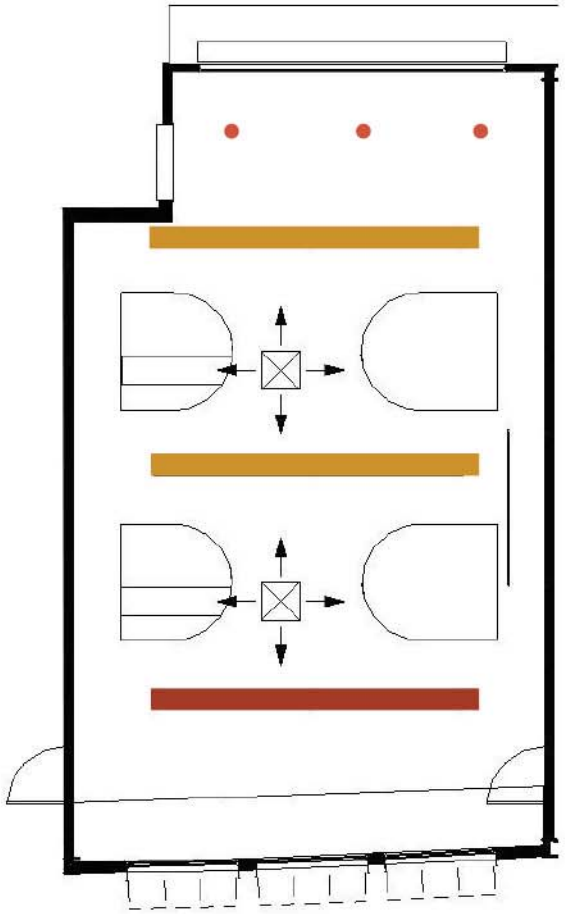
Classroom Lighting

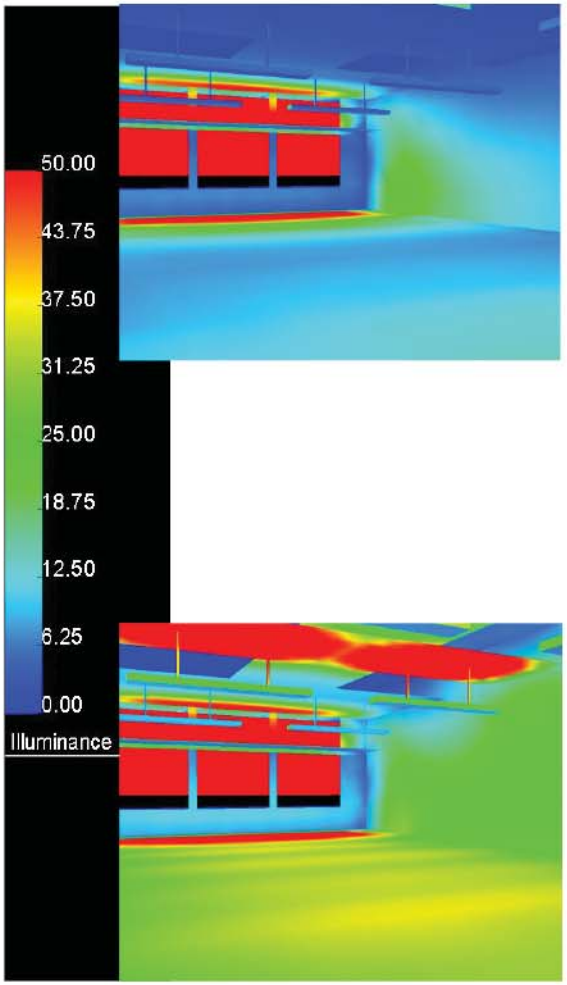
The main objective for the final design was to get more daylight into the classrooms. The 2nd floor corridors, instead of being cantilevered out into the atrium, were moved to the center of the atrium and formed a corridor bridge system. This allowed light to penetrate down to the 1st floor. Interior windows between the 1st floor classrooms and atrium allowed more light into the classrooms, providing more even illumination.

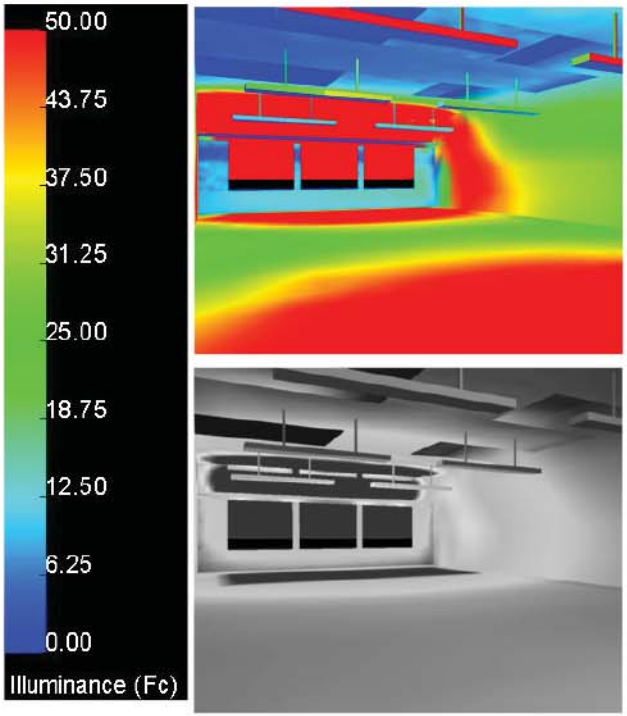
Challenge: coordinating to produce workable ceiling plan

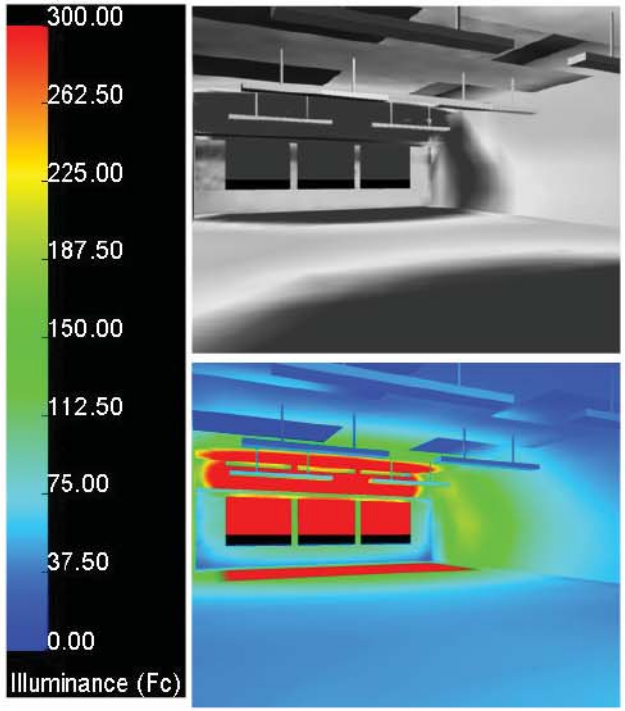
IESNA recommends:
classrooms: 30.0 fc

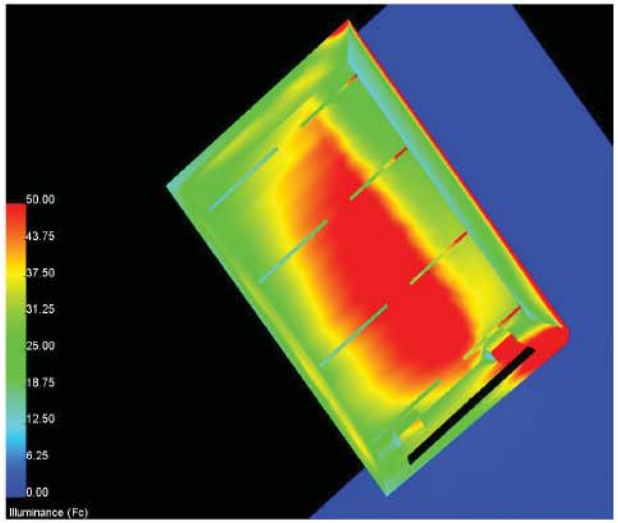
Overcast: 19.9 fc
Electric: 27.5 fc
Overcast with electric dimmed:
37.6 fc

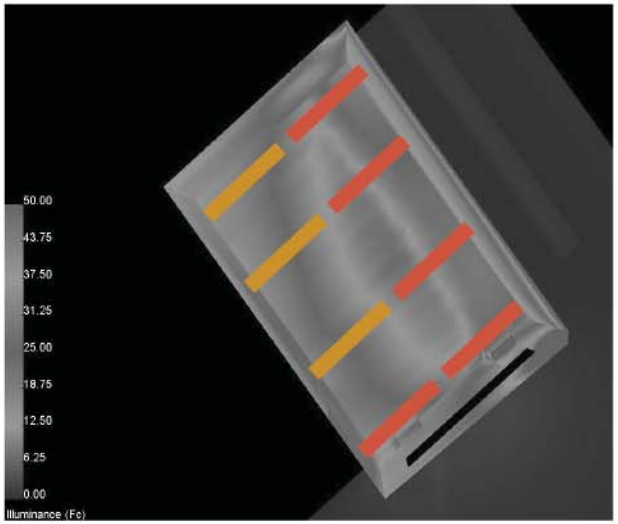


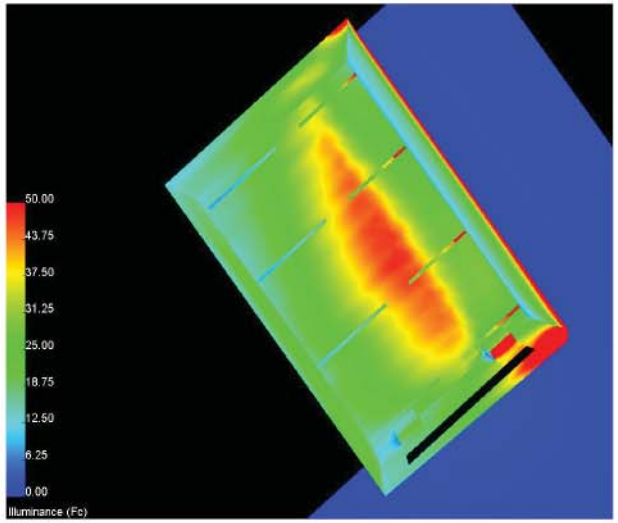












Space	Allowable W/SF	Design W/SF
Classrooms	1.4	0.84
Multipurpose	1.4	2.98
Atrium	0.6	0.63

Multipurpose Lighting

To complement northern clerestories, in the multipurpose room, fixtures with three linear fluorescent sources were used for the flexibility of photo sensor switching.

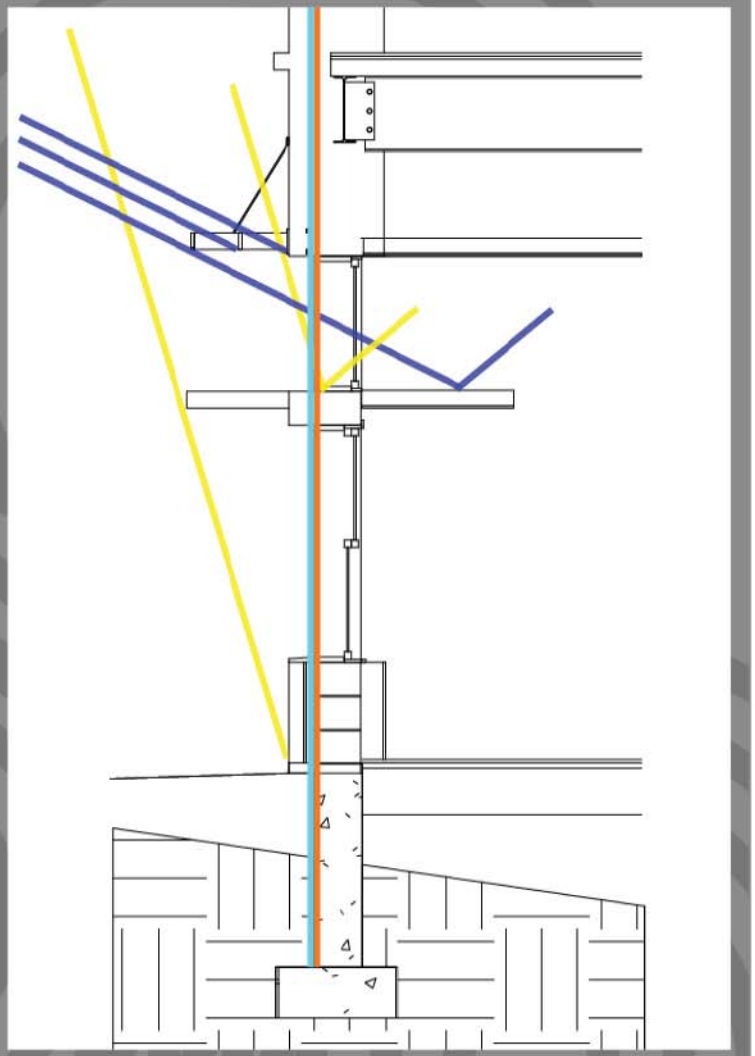
IESNA recommends:
lunch rooms: 10.0fc
sports rooms: 50.0fc

Overcast: 47.0fc

Overcast with electric dimmed: 57.3 fc

Total W/SF
Allowable: 1.2
Design: 0.97

MATERIAL	COST	THERMAL TRANSFER VALUE
5/8" GWB	$1.26/SF	R0.45
5 ½" Metal Studs w/ Fiberglass Ins.	$2.61/SF	R11.5
12" CMU.	10.23/SF	R0.39
1" Rigid Insulation	$6.56/SF	R5.0
Vapor Barrier	$0.23/SF	
Air Space		R1.26
5/8" Face Brick	$5.51/SF	R0.39



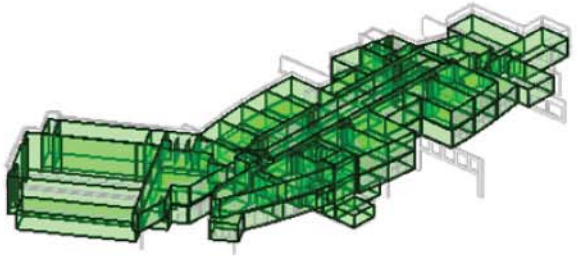
INTEGRATED INPUT: envelope

- Provides desired architectural result
- Provided column sizes to dictate masonry thickness
- Well insulated - proper moisture barrier and dew point
- Provides ample exterior lighting potential
- Standard materials and construction methods

SETUP

stages

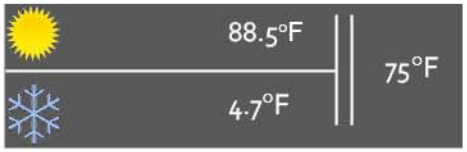
BIMex Plan



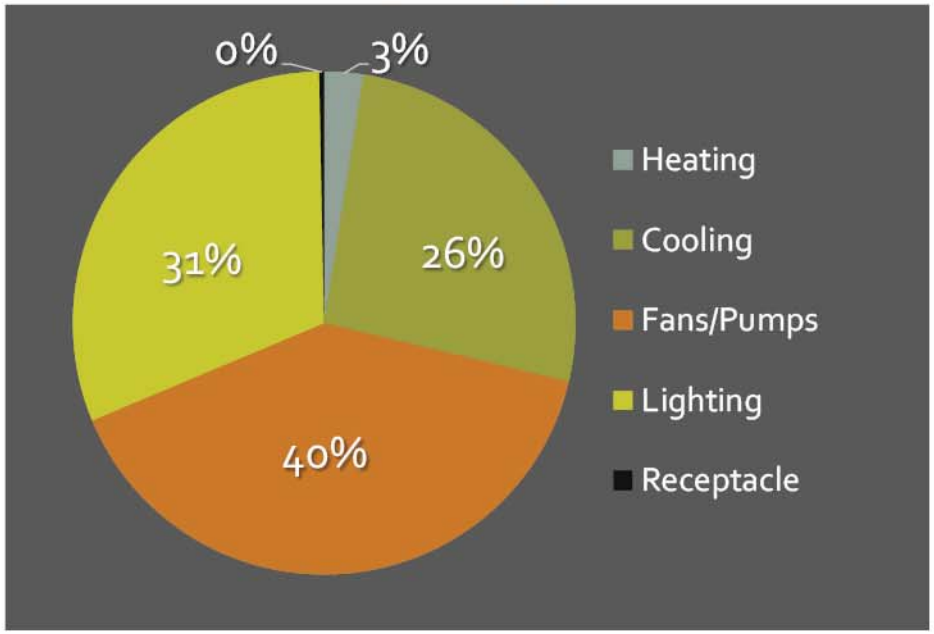
schedule

SCHEDULE	TIMES	PERCENT LOAD
School (Weekdays Year-Round)	6am-8am 8am-4pm 4pm-6pm	40 100 40

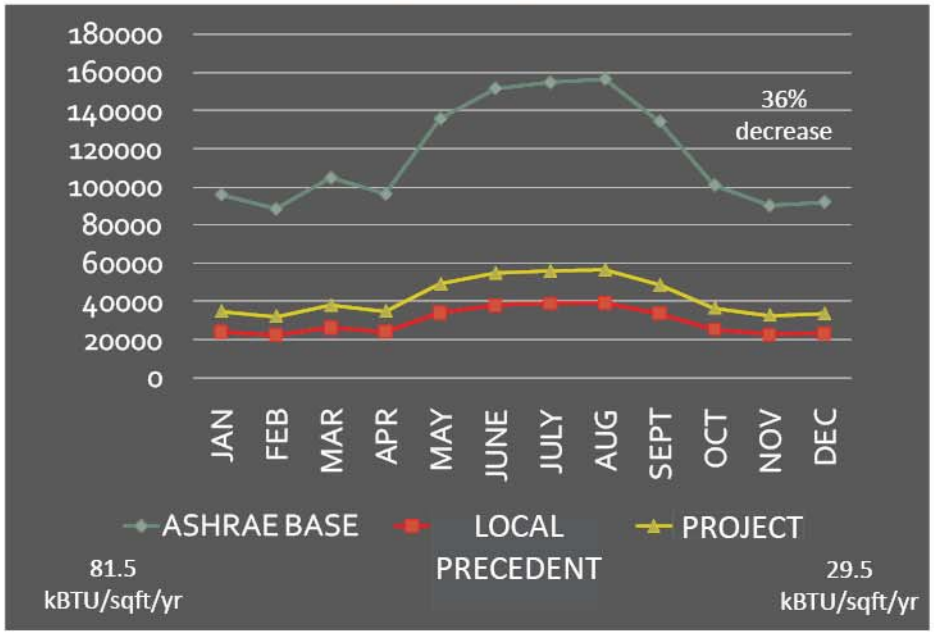
weather



EQUIPMENT CONSUMPTION
[kbtu/yr]



MONTHLY CONSUMPTION
[k BTU]



Constructability and LEED

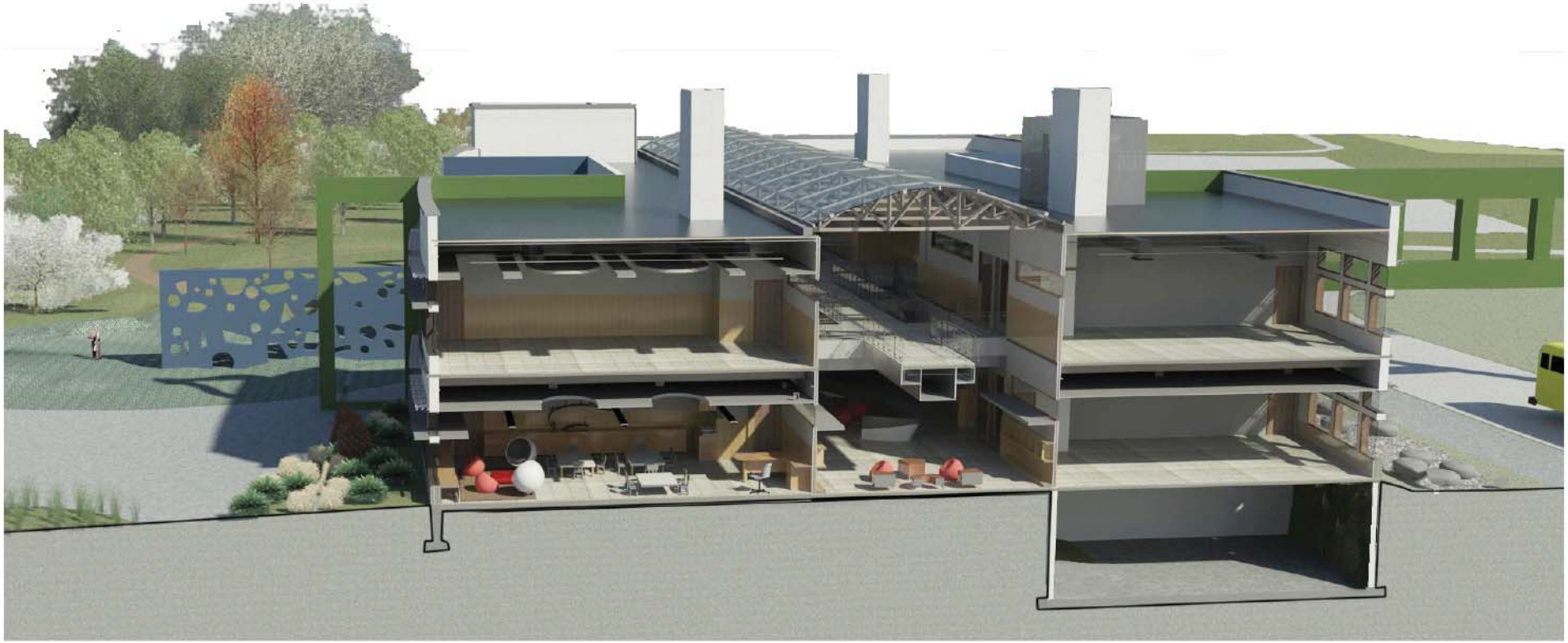
Increased accuracy will be required to execute the truss and glass system over the atrium. While other areas have been simplified; including the orginally skewed kitchen walls. Finally, realigned thermal chimneys serve only 2nd floor.

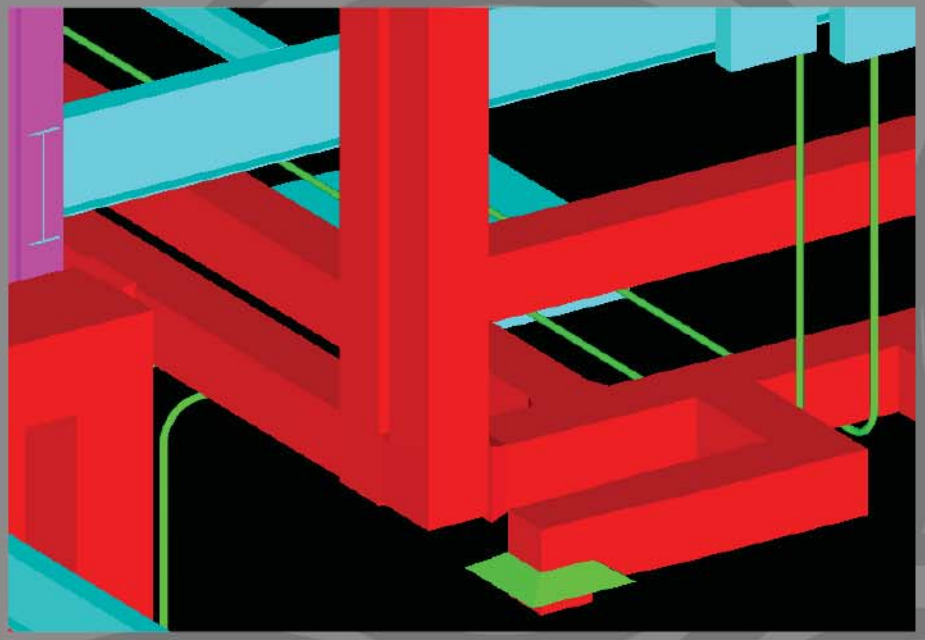
Construction Recycling Plan

Minimize field cutting
On and offsite material sorting

Construction IAQ Plan
Preserve duct condition
Establish dust control

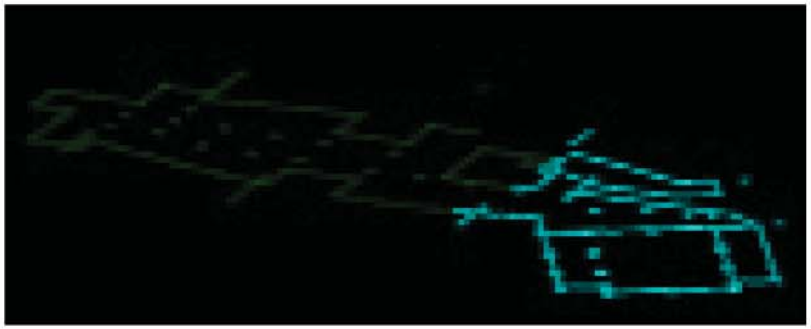
Provide LEED documentation

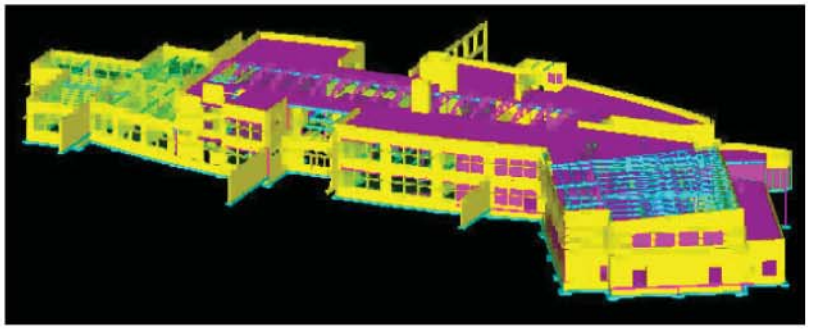


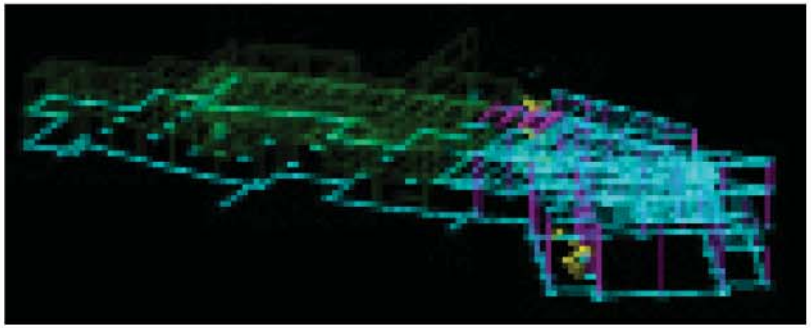


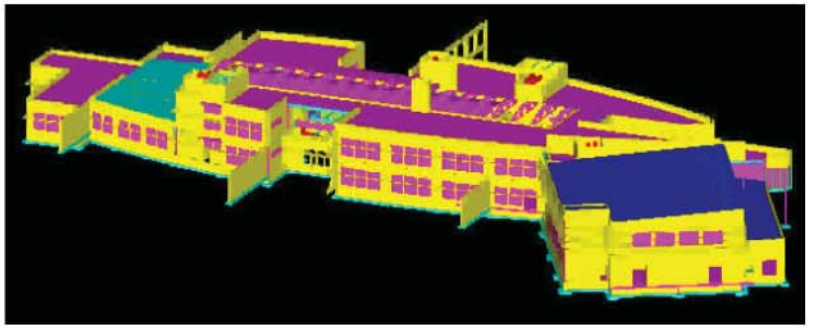
INTEGRATED INPUT: clashes

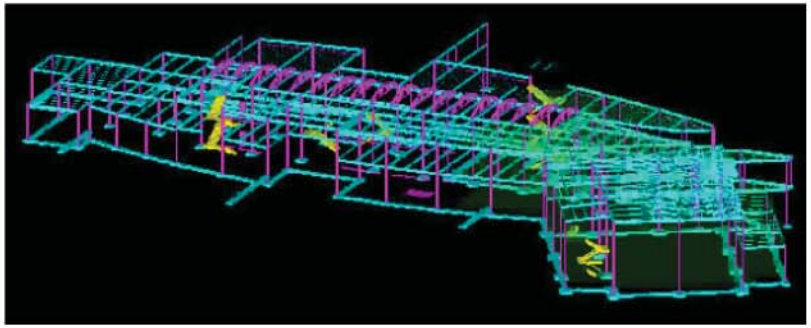
- Check architectural conflicts
- Check structural member sizing
- Check alternative duct runs
- Check alternative conduit runs
- 4D clash detection

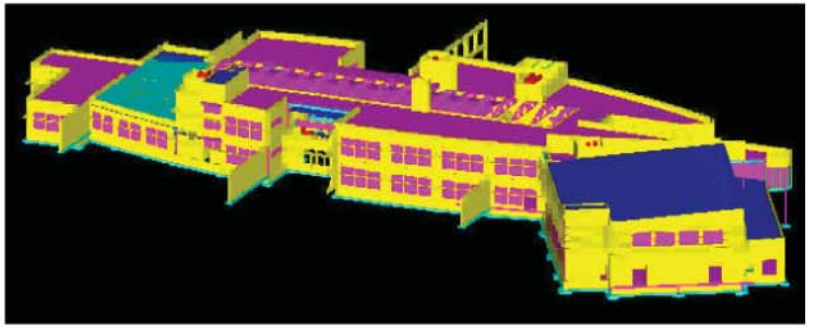


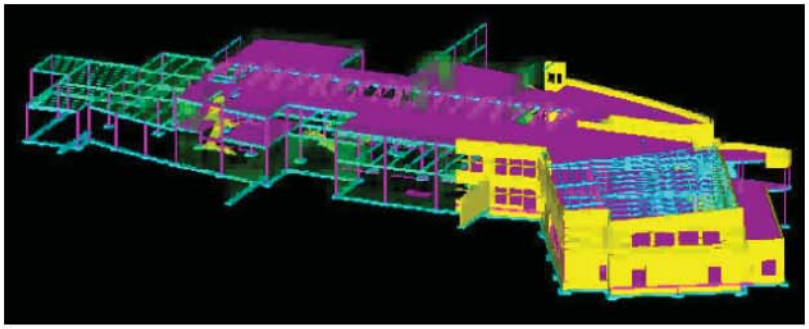






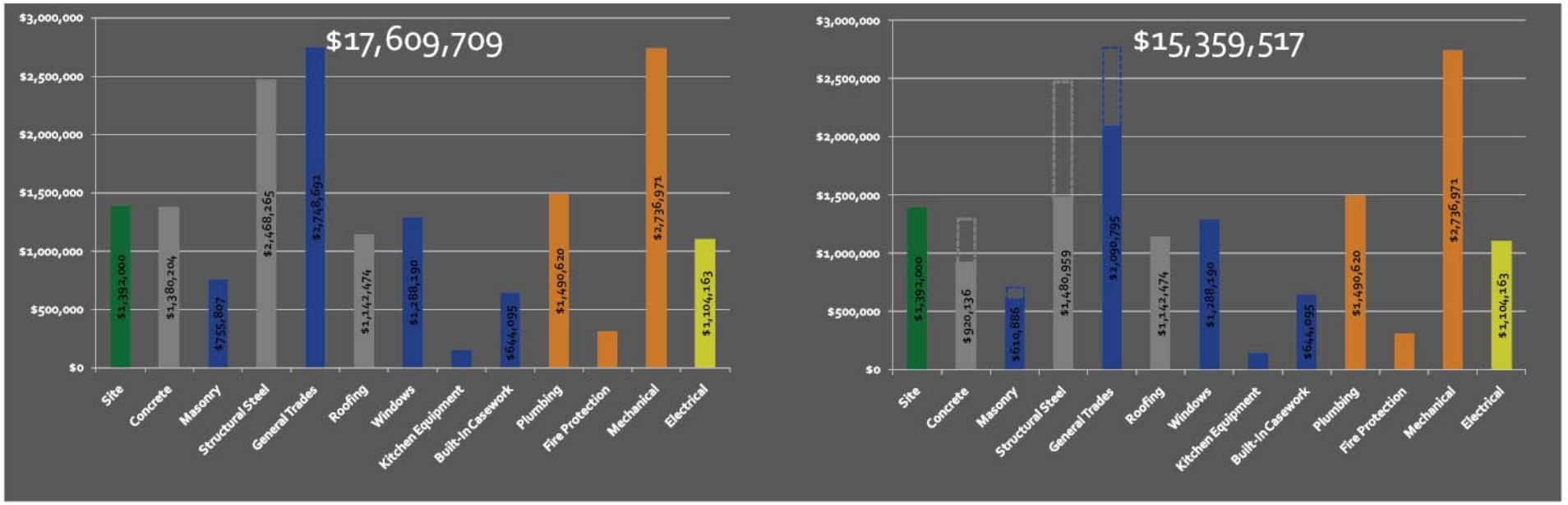






Schedule

- Start: 06/01/11
- Weathertight: 12/16/11
- Conditioned: 06/14/12
- Site: 07/12/12
- Finish: 09/12/12

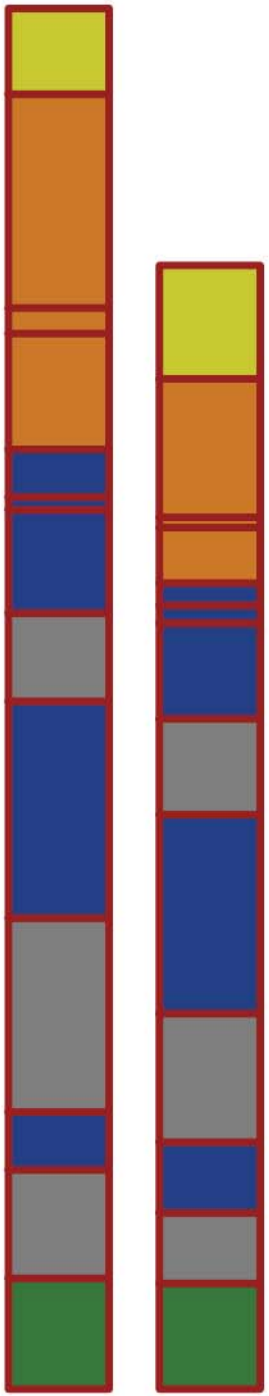


Price Per Student		
Our Cost	Base Cost	Variance
$40,544	$29,114	$11,430

The above graphics communicate the comparison of our team's design to the design for the actual elementary school being constructed.

Price Per Student		
VE Cost	Base Cost	Variance
$34,918.79	$29,114	$5,804

Our team's initial design includes: complex forms, a curvilinear foot print, a large atrium, and long structural spans; all of which contribute to increased construction costs. The above numbers show a value engineered option for the design; however, our construction manager believes these cuts will negatively impact the quality of the finished spaces and therefore should not be executed.



Cost Variance

Cost Summary		
Discipline	**Variance**	**Justification**
Site	$173,780	Increased Site Vegetation + Minimized Cut & Fill
Concrete	$577,504	Complicated Foundations
Masonry	$42,193	Less Masonry - More Windows
Structural Steel	$968,265	Moment Framing + Complicated Joists
General Trades	$446,792	Custom Cutting of Curvilinear Finishes
Roofing	$73,249	Green Roof + Atrium Flashing
Windows	$191,623	Extensive Exterior Glazing + Complicated Atrium
Kitchen Equipment	$54,778	Simple Linear Kitchen Layout
Built-In Casework	$401,275	High End Finishes
Plumbing	$853,620	Complicated Geothermal + Gray Water Systems
Fire Protection	$208,788	Increased Amount of Steel + Deluge System
Mechanical	$1,129,471	Localized Heat Pumps + Geothermal System
Electrical	$181,637	Simple Central Core Conduit Runs
Totals	**$4,745,759**	**Atypical Layout + High End Systems + Expensive Features**

left: The far left column shows our projected building site costs and the second column shows projected costs from the professional design team. Various cost elements are color coded with each discipline's logo.

above: The chart shows the numerical breakdown.

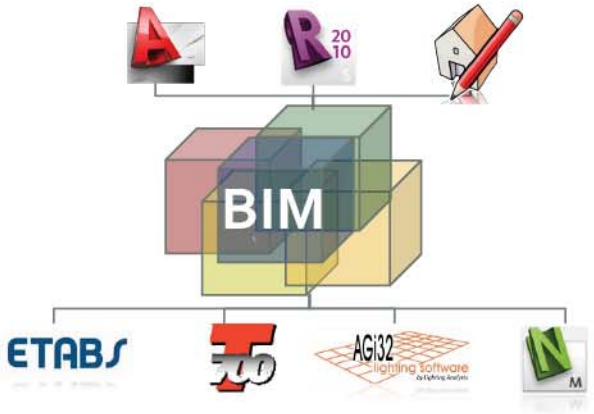
Lessons Learned

The BIM/IPD process is a **dynamic**, highly **collaborative interdisciplinary** means of creating a functional, sustainable, cost-effective product utilizing the most efficient means of **information exchange** & **conflict resolution** through **a living documentation** process, encouraging a positive **collaborative atmosphere.**

Collaborating

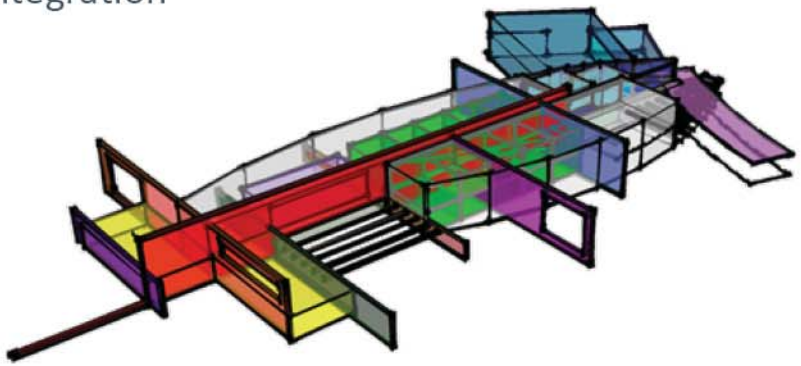
Working with people wouldn't be possible without new technologies

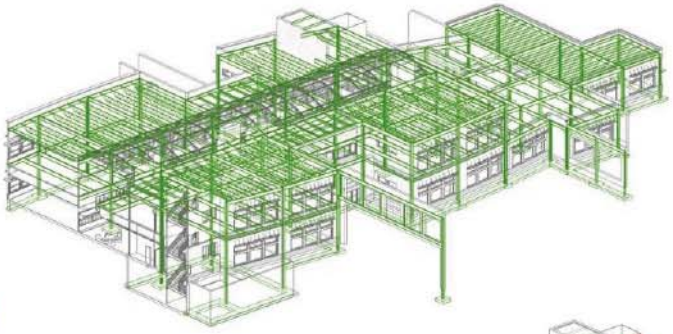
Technology

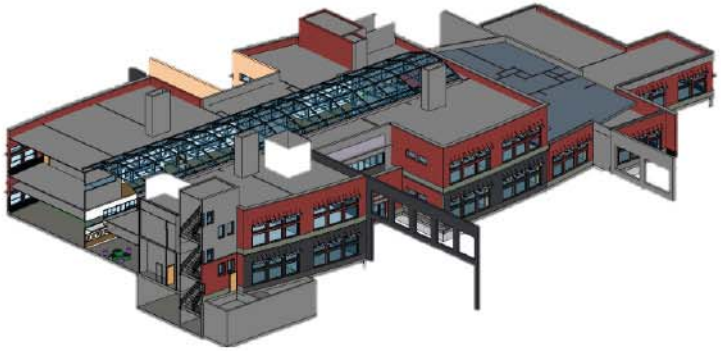


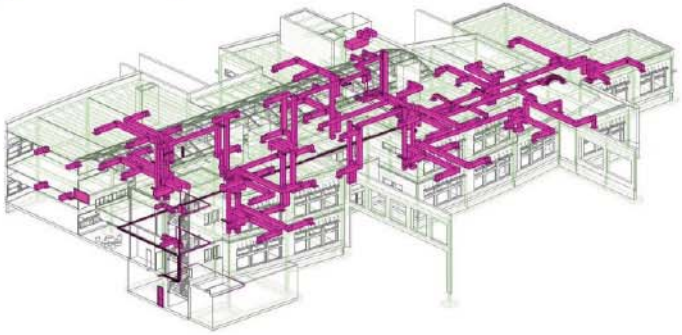
Total Time Remodeling for Software = 40hours

Integration









RESULT = best possible final product for owner