

THE DUFFY SCHOOL ADDITION & RENOVATION



**Rendering of building supplied by Gary Gardner with Owner Permission

PENN STATE AE
SENIOR CAPSTONE
PROJECT

JEREMY DRUMMOND
CONSTRUCTION OPTION

ADVISOR: ANUMBA

APRIL 14TH, 2014



PRESENTATION OUTLINE:

I. INTRODUCTION

II. PROJECT OVERVIEW

III. ANALYSIS #1: ROOFTOP SOLAR PANELS

IV. ANALYSIS #2: HISTORICAL REQUIREMENTS

V. ANALYSIS #3: PREFAB EXTERIOR WALLS

VI. FINAL RECOMMENDATIONS

VII. ACKNOWLEDGEMENTS

PROJECT OVERVIEW



Googlemaps.com

ANALYSIS 1 | ROOFTOP SOLAR PANELS



<http://www.solar.exclus.com/solar-equipment/solar-panels/>

ANALYSIS 3 | PREFABRICATED EXTERIOR WALL PANELS



<http://cptmfg.com/portfolio/pew-s.php>

ANALYSIS 2 | HISTORICAL REQUIREMENTS



Taken by Jeremy Drummond

PROJECT BACKGROUND



PRESENTATION OUTLINE:

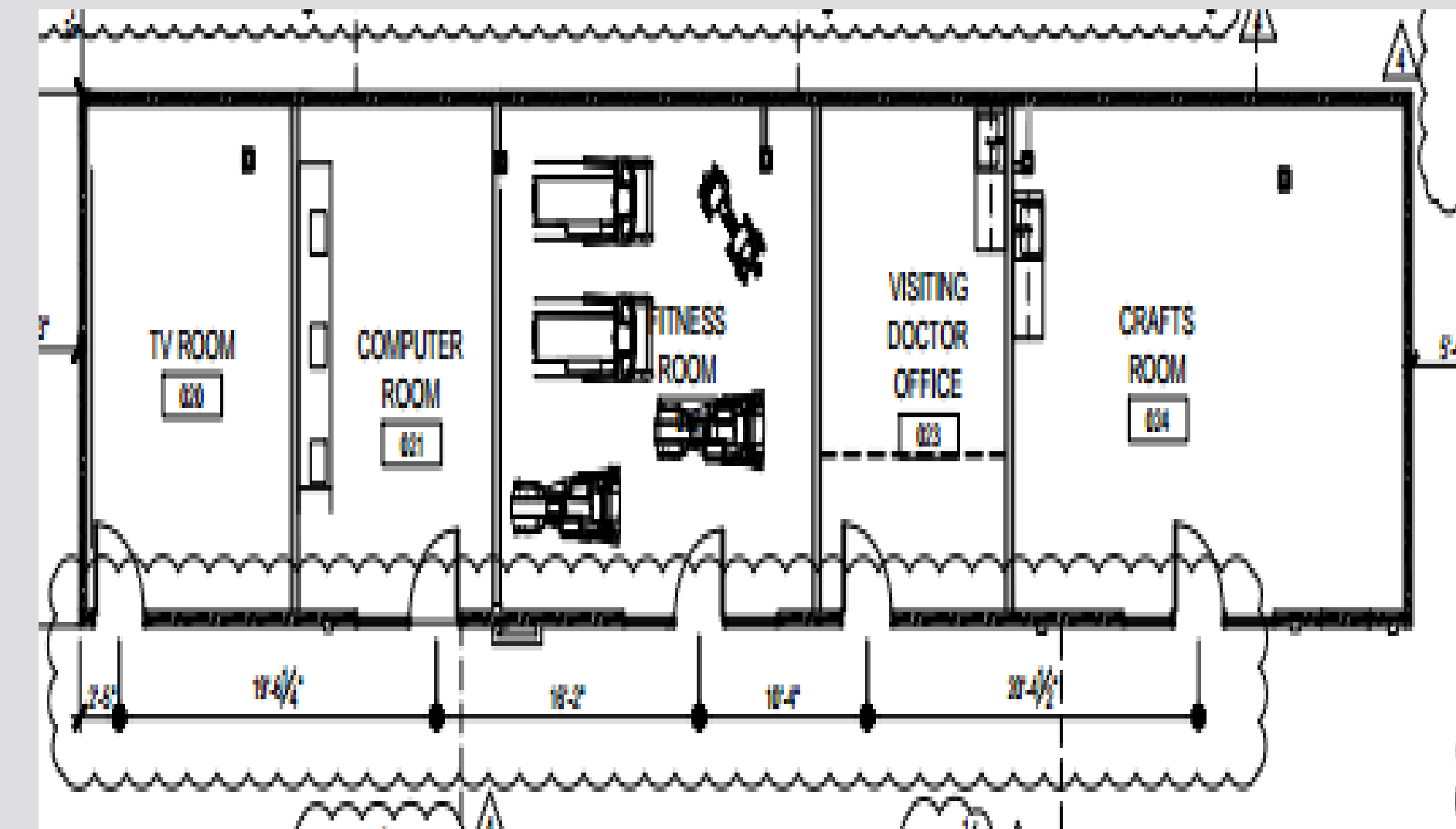
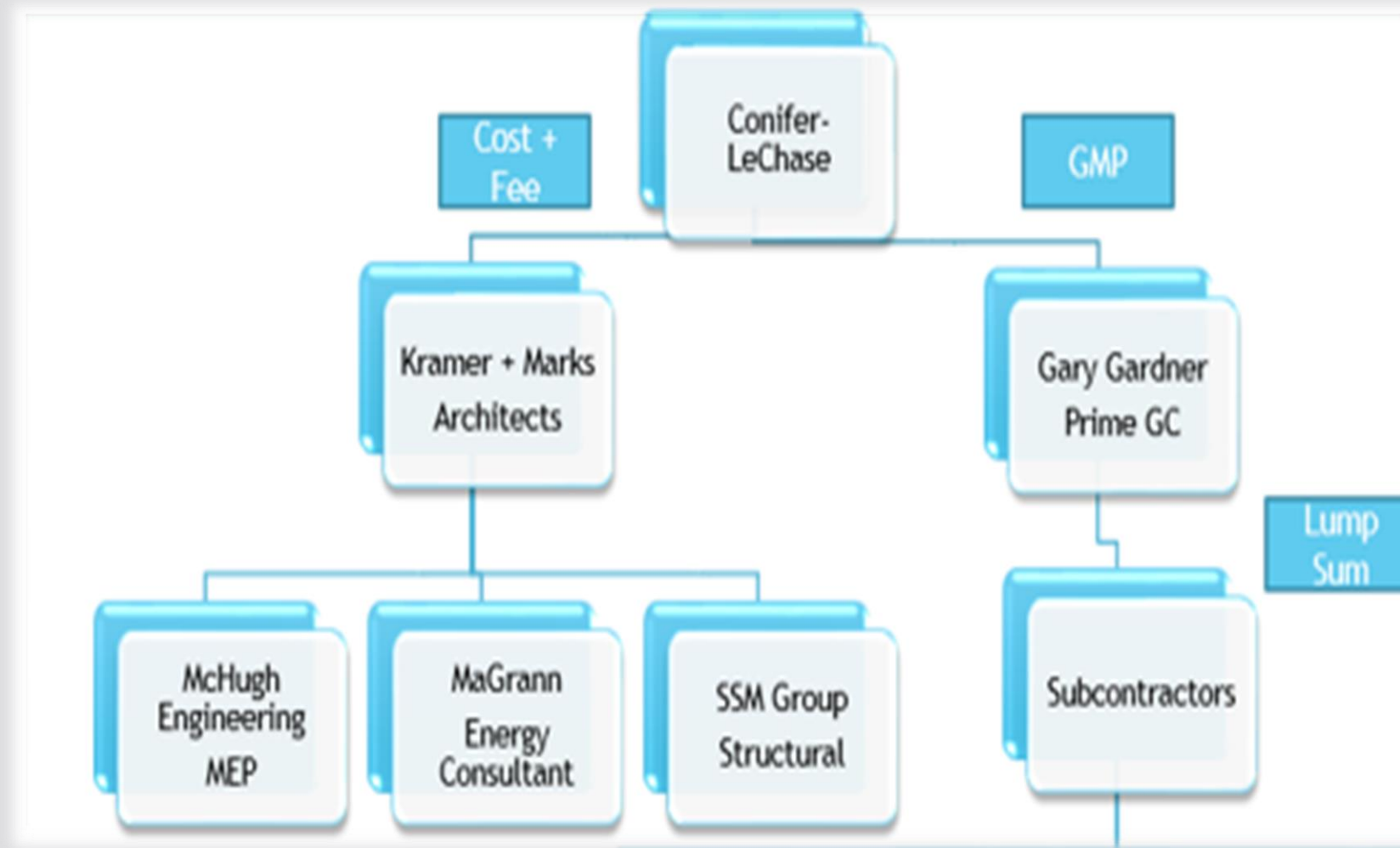
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■ Building History:

- Marcella. L Duffy School 1870
- Expansion 1950
- Closed 2008

■ Building Use:

- Affordable Senior Citizen Apartments
- 53 New Units
- Gym, Entertainment Center, Library, Doctors Office, Kitchen, Etc.





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PROBLEM IDENTIFICATION

COMPONENTS

FEASIBILITY ANALYSIS

ELECTRICAL BREADTH

IMPLEMENTATION & RECOMMENDATION

IV. ANALYSIS #2: HISTORICAL REQUIREMENTS

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Analysis #1

Implementing Rooftop Solar Panels



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■ **Problem Identification:**

- Affordable Apartments
- Apartment Amenities
- Payment Method?



<http://www.solar.exclus.com/solar-equipment/solar-panels/>

■ **Proposed Solution:**

- Rooftop Solar Panels

■ **Research Goal:**

- Different types of photovoltaic systems
- Sunlight Properties
- Cost vs. Schedule

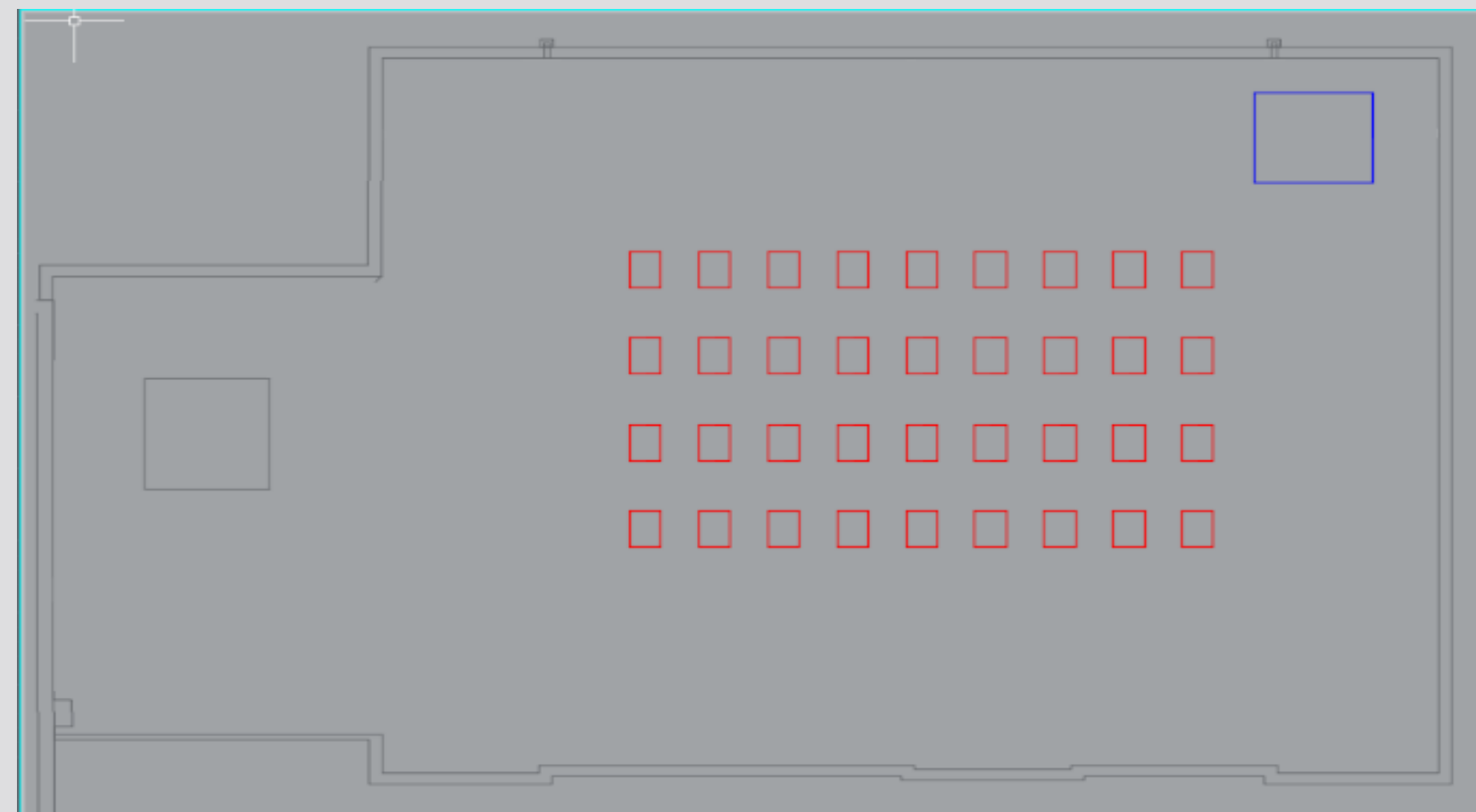


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■ System:

- Grid-tied system
- 4 rows of 9 panels (36 panels)
- SunPower X21- 345 Panel
- UltraLITE Model ELU14000
Centralized Inverter
- IronRidge XR1000



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■ Placement:

- New Addition
- EPDM Roof
- Inverter Location
- AC panel and utility tie in
located in RM

FEASIBILITY ANALYSIS



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■ **Schedule:**

- Installation Process
- Longest Task
- Total- 18.5 Days

■ **Cost:**

- Prices
- Installation
- Total- \$69,270

Solar Panel Installation				
Item	Qty.	Unit	Hours	Total
Mount	36	Ea.	1.25	45
Rack	4	Per 9 Mounts	0.75	3
Solar Panels	36	Ea.	1	36
Inverter	1	Ea.	4	4
Circuit Breaker	1	Ea.	1.5	1.5
#12 AWG	20	LF	0.5	10
#8 AWG	6	LF	0.5	3
3/4" Conduit	1153	LF	0.03	34.6
1/2" Conduit	42	LF	0.25	10.5
				147.6

Solar Panel Cost				
Item	Cost	Qty.	Unit	Total Cost
Mount	\$0.11	12420	Watt	\$1,366.20
Rack	\$322.54	4	Ea.	\$1,290.16
Solar Panels	\$426.25	36	Ea.	\$15,345.00
Inverter	\$5,153.88	1	Ea.	\$5,153.88
Circuit Breaker	\$912.05	1	Ea.	\$912.05
#12 AWG	\$47.69	20	LF	\$953.80
#8 AWG	\$89.23	6	LF	\$535.38
3/4" Conduit	\$3.57	1153	LF	\$4,116.21
1/2" Conduit	\$2.44	42	LF	\$102.48
Solar Panel Installation	\$3.18	12420	Watt	\$39,495.60
				\$69,270.76

ELECTRICAL BREADTH



PRESENTATION OUTLINE:

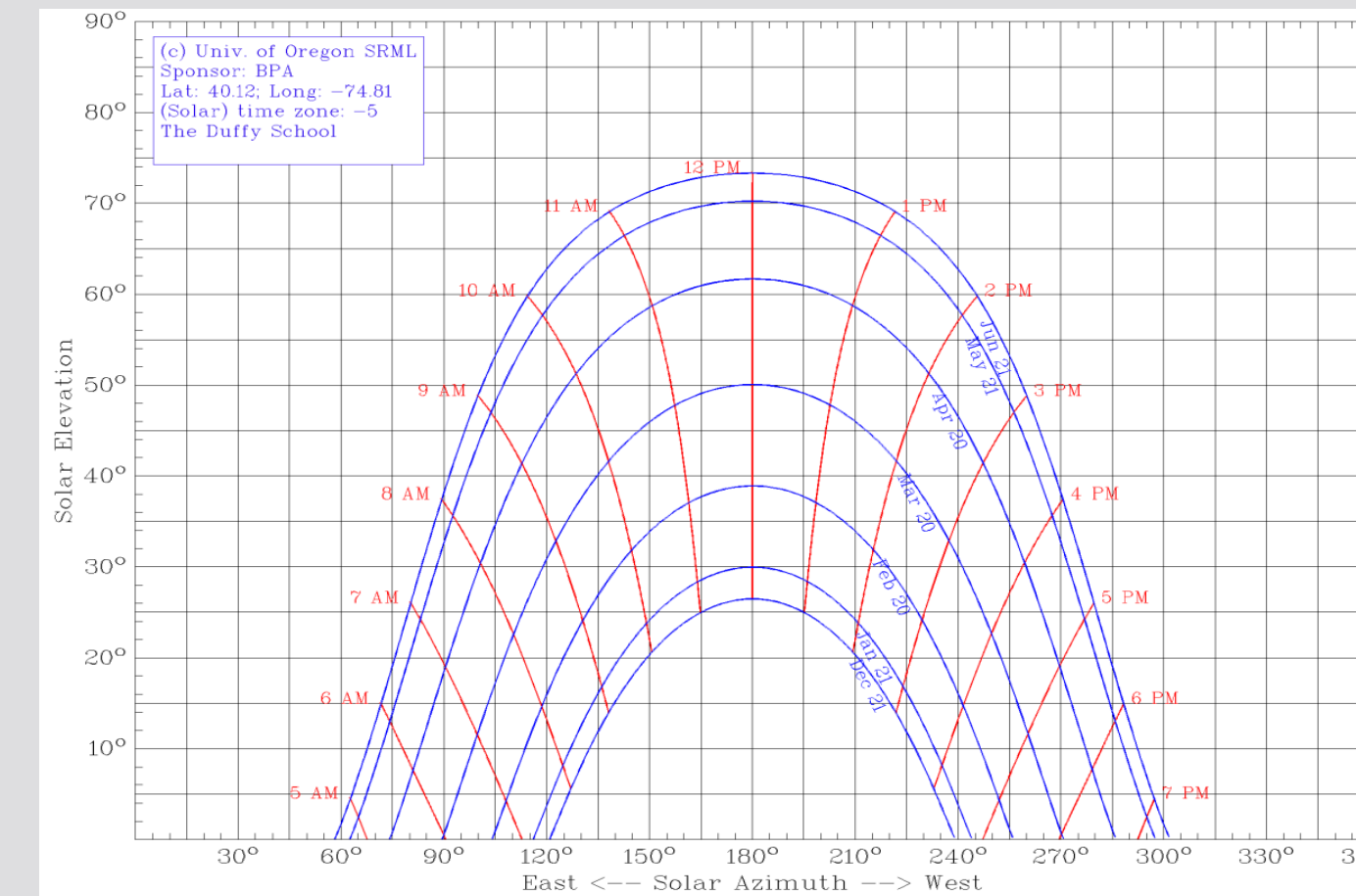
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■ Power Usage:

- Receptacles
- Lighting
- Dryer
- Washer
- Refrigerator
- Fireplace
- Exercise Equipment

Power Usage						
Equipment	Amount	Watts	HRs	kWh/Day	kWh/Month	kWh/Year
TV Room RCPT	2	360	8	5.76	172.8	2073.6
Gym TV RCPT	1	360	6	2.16	64.8	777.6
Comm Room RCPT	6	1260	8	60.48	1814.4	21772.8
Comm RM FI RCPT	2	720	8	11.52	345.6	4147.2
Computer RM RCPT	7	180	4	5.04	151.2	1814.4
Comm RM Kitchen RCPT	2	180	4	1.44	43.2	518.4
Craft RM RCPT	2	1260	4	10.08	302.4	3628.8
Doctors RCPT	1	900	8	7.2	216	2592
Fitness RCPT	1	1080	4	4.32	129.6	1555.2
Comm RM LTG	2	1500	12	36	1080	12960
Dryer	4	5600	8	179.2	5376	64512
Dishwasher	1	1200	2	2.4	72	864
Washer	4	1200	8	38.4	1152	13824
Fridge	1	900	24	21.6	648	7776
Fireplace	1	500	4	2	60	720
Trash Compactor	1	2500	8	20	600	7200
Treadmill	6	1200	8	57.6	1728	20736
Total	44	20900	128	465.2	13956	167472

■ Shading:



ELECTRICAL BREADTH



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■ **Payback Period:**

- Total Cost- \$69,270
- 36 Panels
- 60480 kWh per day Output
- Electrical Rate- \$0.12

ANNUAL PRODUCTION

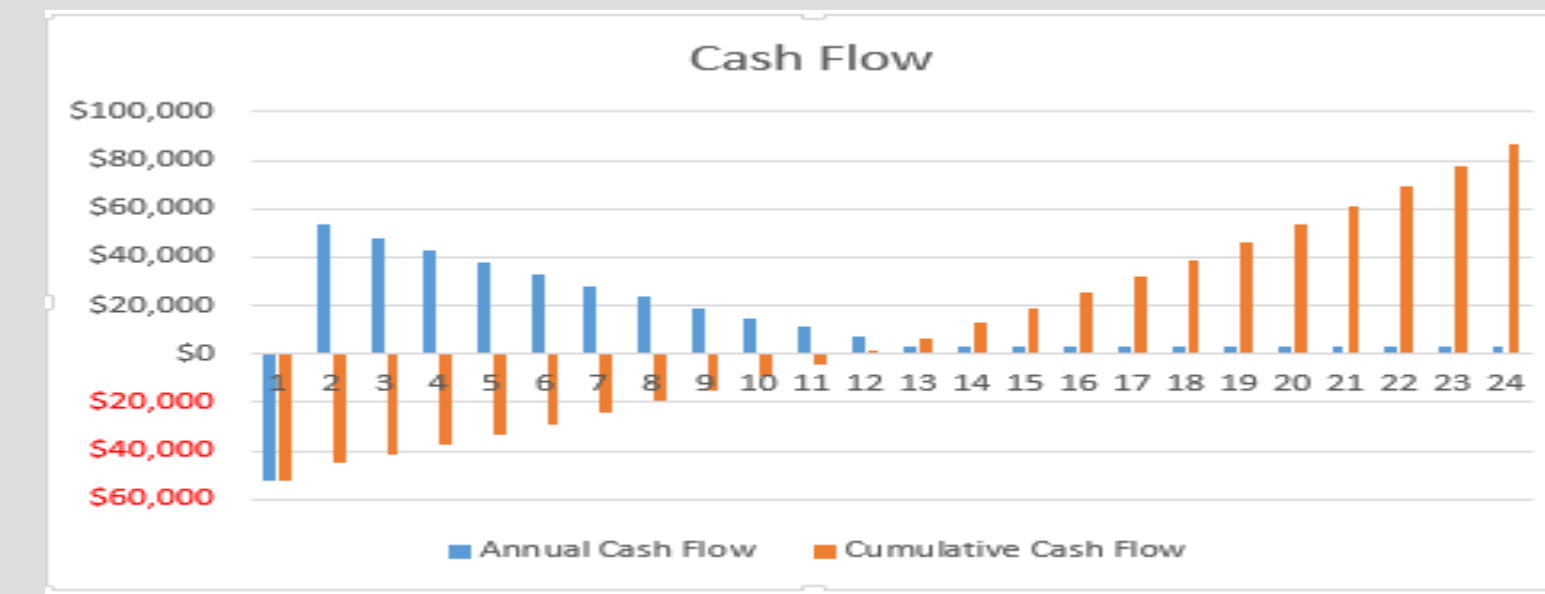
Number of Panels	36
STC Rating in Watts Per Panel	350
Total watts per hour assuming optimum conditions	12,600
Performance under real world solar conditions	80%
Adjusted watts per hour assuming real conditions	10,080
Average hours of sunlight per day	6.0
Estimated kilowatt hours per day output	60,480
Estimated kilowatt hours per year	22,075
Florence , NJ electric rate	\$0.12
Estimated Income (Year 1)	\$3,559
Electrical Rate Annual Inflation Assumption	4.0%
Combined State and Federal Income Tax Bracket	30%

REVENUES AND EXPENSES

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
Initial System Cost & Salvage Value	-\$52,371												
Electricity Sales		\$3,559	\$3,701	\$3,849	\$4,003	\$4,164	\$4,330	\$4,503	\$4,683	\$4,871	\$5,066	\$5,268	\$5,479
Cumulative Electricity Sales		\$3,559	\$7,260	\$11,110	\$15,113	\$19,277	\$23,607	\$28,110	\$32,793	\$37,664	\$42,730	\$47,998	\$53,477
Simple Payback (Personal) {Year cash flow turns positive}:		-\$48,812	-\$45,110	-\$41,261	-\$37,258	-\$33,094	-\$28,764	-\$24,261	-\$19,577	-\$14,707	-\$9,641	-\$4,373	\$1,106

■ **Payback Period:**

- Annual Energy Value- \$3,559
- Annual System Output-
- 11 Years



SOLAR PANEL IMPLEMENTATION



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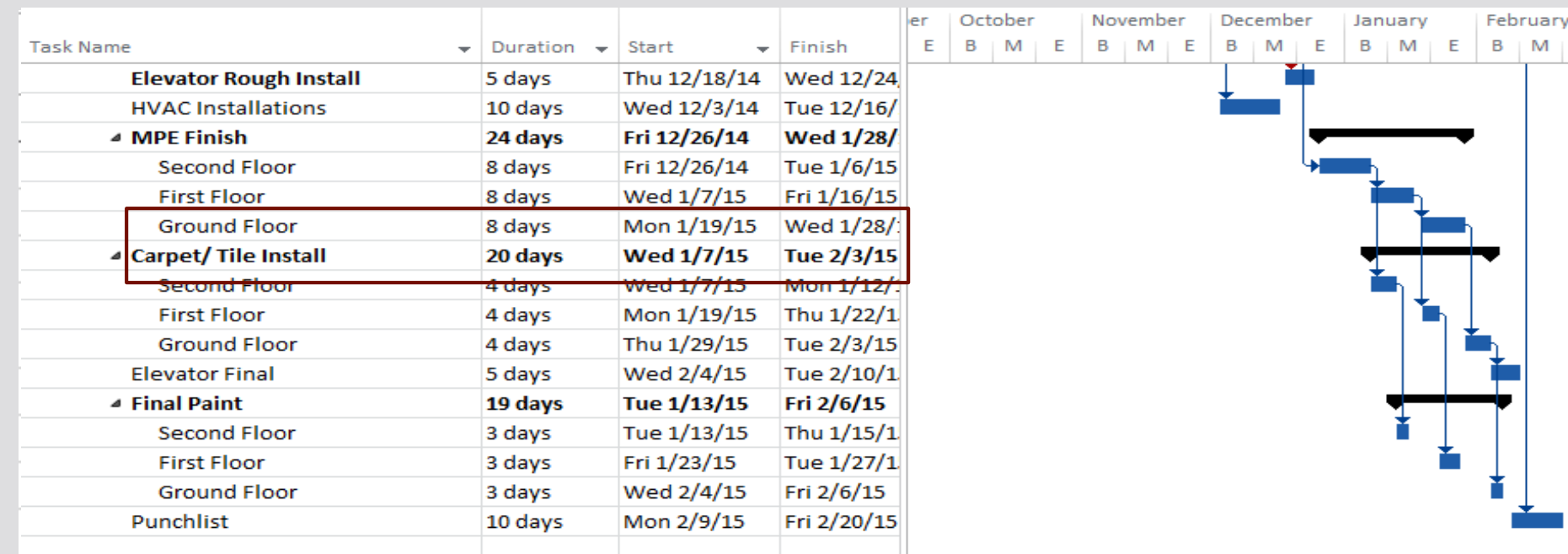
■ Schedule Impact:

■ 18.5 Days

■ Cost Impact:

■ \$69,270

■ Schedule Implications:



- Design Phase: Implement Early
 - Design-Review meetings between project participants & end users
 - Changes can be costly to implement later in the project lifecycle
- Construction Phase: During interior finishes

■ Recommendation:

- Implement Rooftop Solar Panels

■ Potential Value Added:

- Occupant Satisfaction
- Profit after 11 years
- NJ Green Checklist



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CURRENT VS. PREFABRICATED FAÇADE

PANEL DESIGN

MECHANICAL BREADTH ANALYSIS

PANEL IMPLEMENTATION

CONCLUSION & RECOMMENDATIONS

V. ANALYSIS #3: PREFAB EXTERIOR WALLS

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Analysis #2
Historical Requirements

REQUIREMENTS



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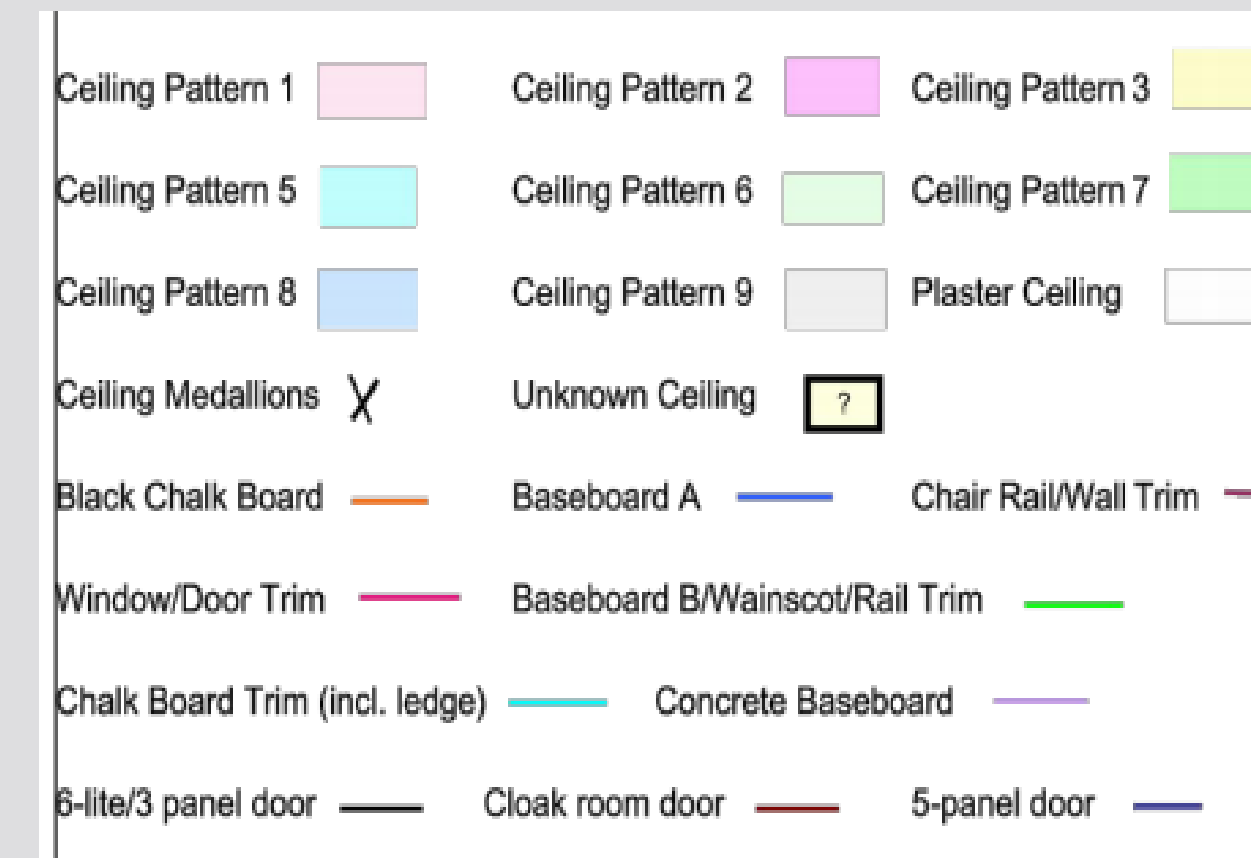
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■ Requirements:

- Chalkboards
- Trim
- Tin Ceilings
- Border
- Panels



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HISTORICAL CONSULTANT



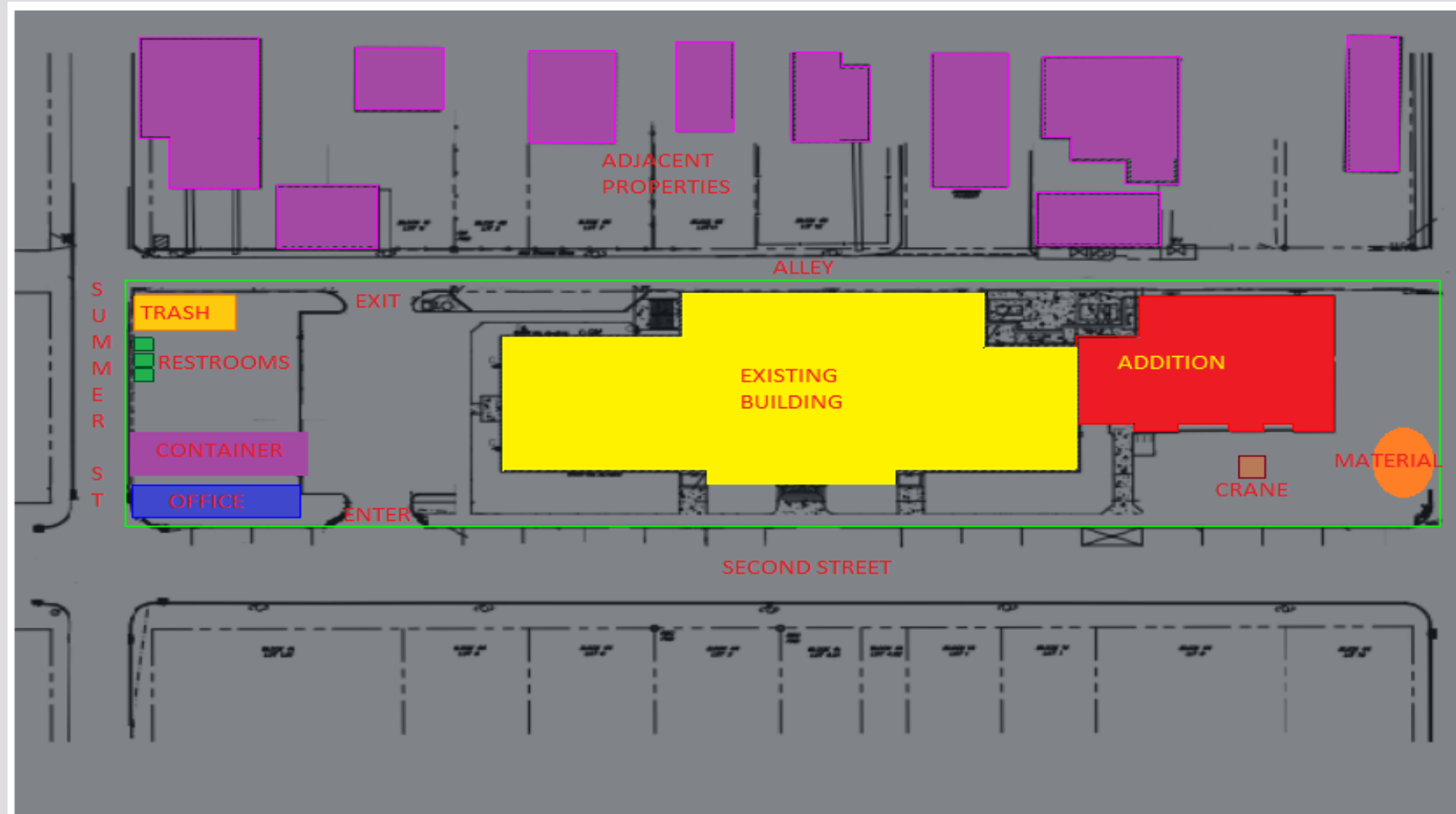
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■ Consultant:

- Keystone Preservation Group
- Location
- Previous Projects
- Cost???

Keystone Preservation Group



Created by Jeremy Drummond

■ Issue #1:

- Current Storage
- Item Movement
- On-Site Containers



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HISTORICAL CONSULTANT



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Issue #2:

- Window Procurement
- Schedule Delays
- Consultant



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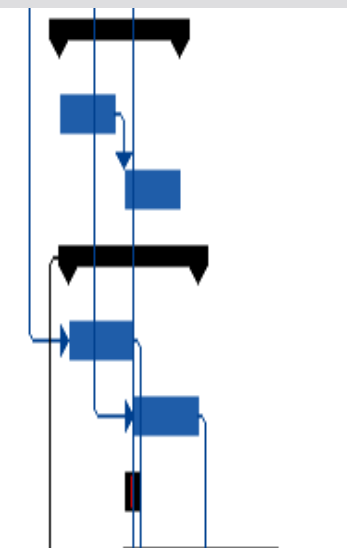
Provided by Keystone Preservation Group

Issue #3:

- Installation Issues
- Labeling
- Consultant

Historic Window Installations	20 days	Mon 12/1/14	Fri 12/26/14
South Elevation	10 days	Mon 12/1/14	Fri 12/12/14
North Elevation	10 days	Mon 12/15/14	Fri 12/26/14
Historic Trim/ Tin Ceilings	20 days	Wed 12/3/14	Tue 12/30/14
Second Floor	10 days	Wed 12/3/14	Tue 12/16/14
First Floor	10 days	Wed 12/17/14	Tue 12/30/14
Permanant Power	3 days	Mon 12/15/14	Wed 12/17/14

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IMPLEMENTATION



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■ **Schedule Impact:**

- 27 Days

■ **Cost Impact:**

- +\$2,000

Comparison Summary		
Item	Consultant Firm	No Firm
Fee	\$35,000	X
General Conditions	X	\$37,000
Schedule	Save 27 Days	X
Total	\$35,000	\$37,000
	Save \$2,000	

Architectural Breadth

■ **Final Conclusions:**

- On-Site Storage Container
- Material Procurement
- Labeling

■ **Recommendation:**

- Recommend hiring The Keystone Preservation Group to do historical consulting for The Duffy School.



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CURRENT VS. PREFABRICATED FAÇADE

PANEL DESIGN

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Analysis #3

Prefabricated Exterior Wall Panels

FAÇADE COMPARISON



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Opportunity Identification:

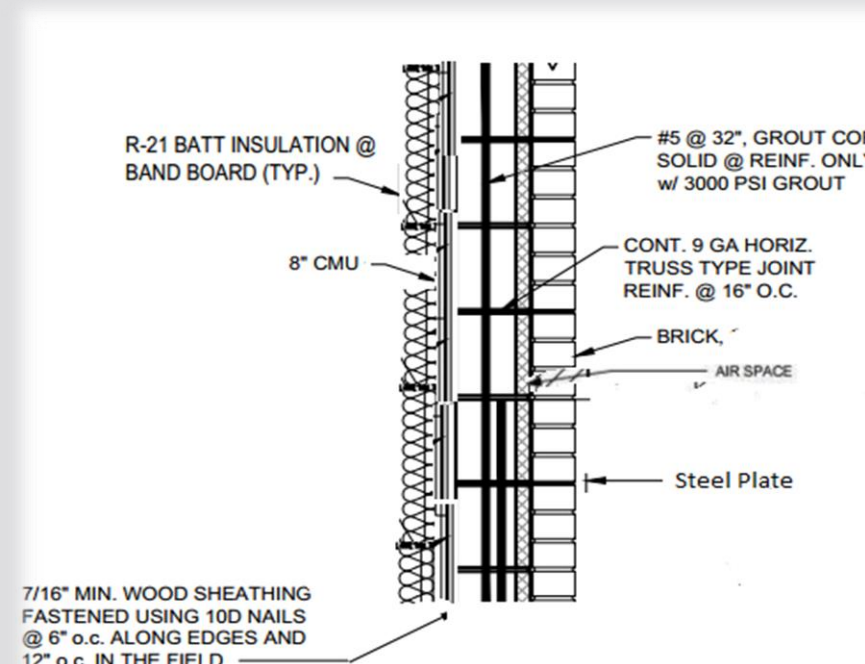
- Time & Labor Intensive
- Site Congestion
- Weather Delays
- Critical Path

Research Goals:

- Identify alternative panel
- Reduce schedule & cost
- Reduce site congestion & trade coordination on site

Original Façade:

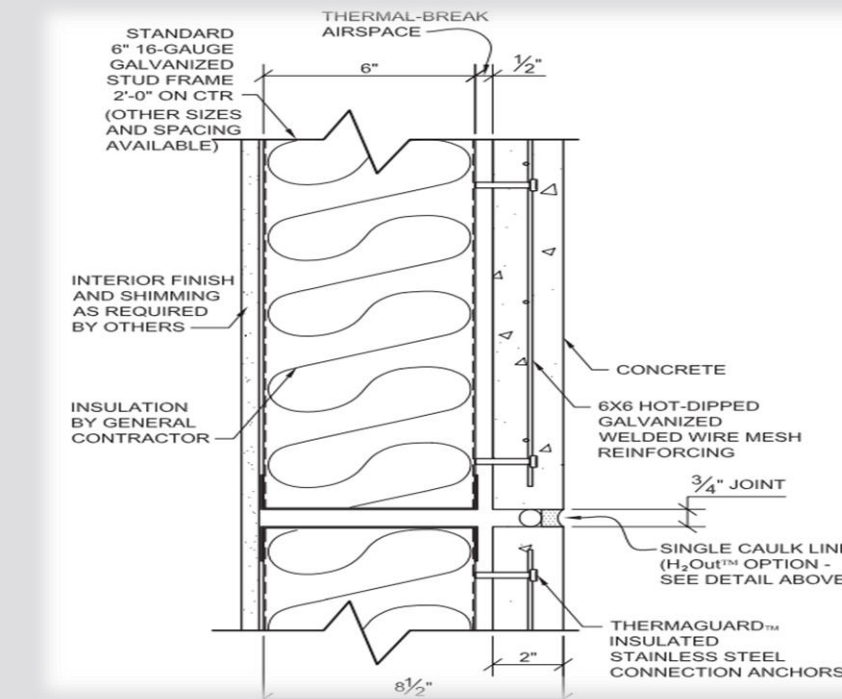
- 3.5" Brick on Wood Stud
- Cost
- Schedule



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Proposed Façade:

- 9" Insulated Precast Panel
- Embedded Thin Brick
- Cost = \$32/SF
- Erection = 8 panels/ day



Slenderwall.com

PANEL DESIGN

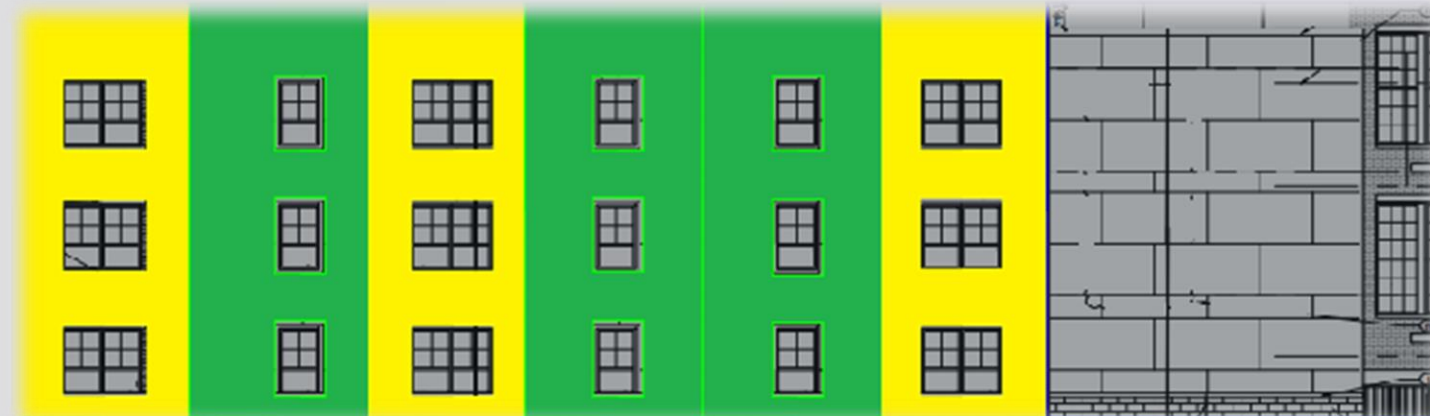


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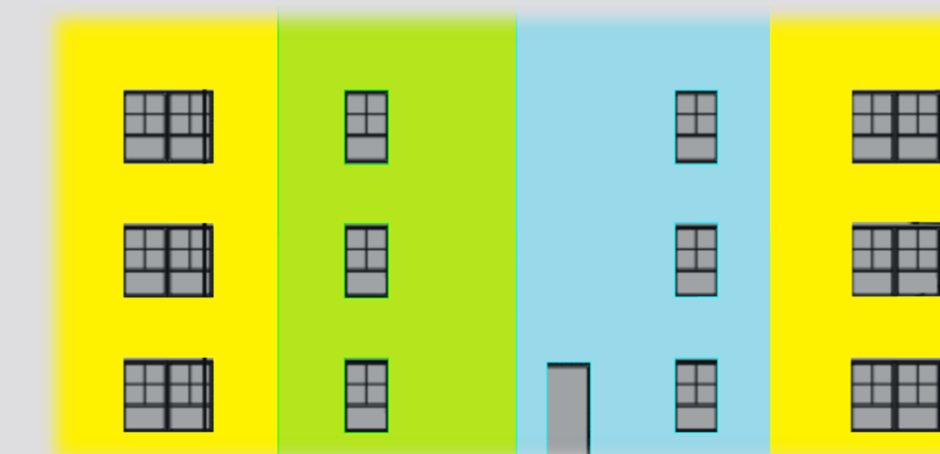
Panel Design:

- Consistency & Transportation
- Span Building Height
- Maximum width 12'
- Total 16 precast panels
 - 4 different panel types



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North



Created by Jeremy Drummond

East



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South

Panel Installation Durations			
Elevation	Panel QTY.	Duration	Adjusted Duration
South	6	.75 Days	1 Day
North	6	.75 Days	1 Day
East	4	.5 Days	.75 Days
Total	16	2 Days	2.75 Days

PANEL IMPLEMENTATION



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Cost Implications:

Cost Comparison Summary

Item	Prefabricated Panels Total Cost	Traditional Brick Total Cost
Cost of Assembly	\$327,350	\$233,984
General Conditions Cost	\$466,630	\$487,156
Total	\$793,980	\$721,140

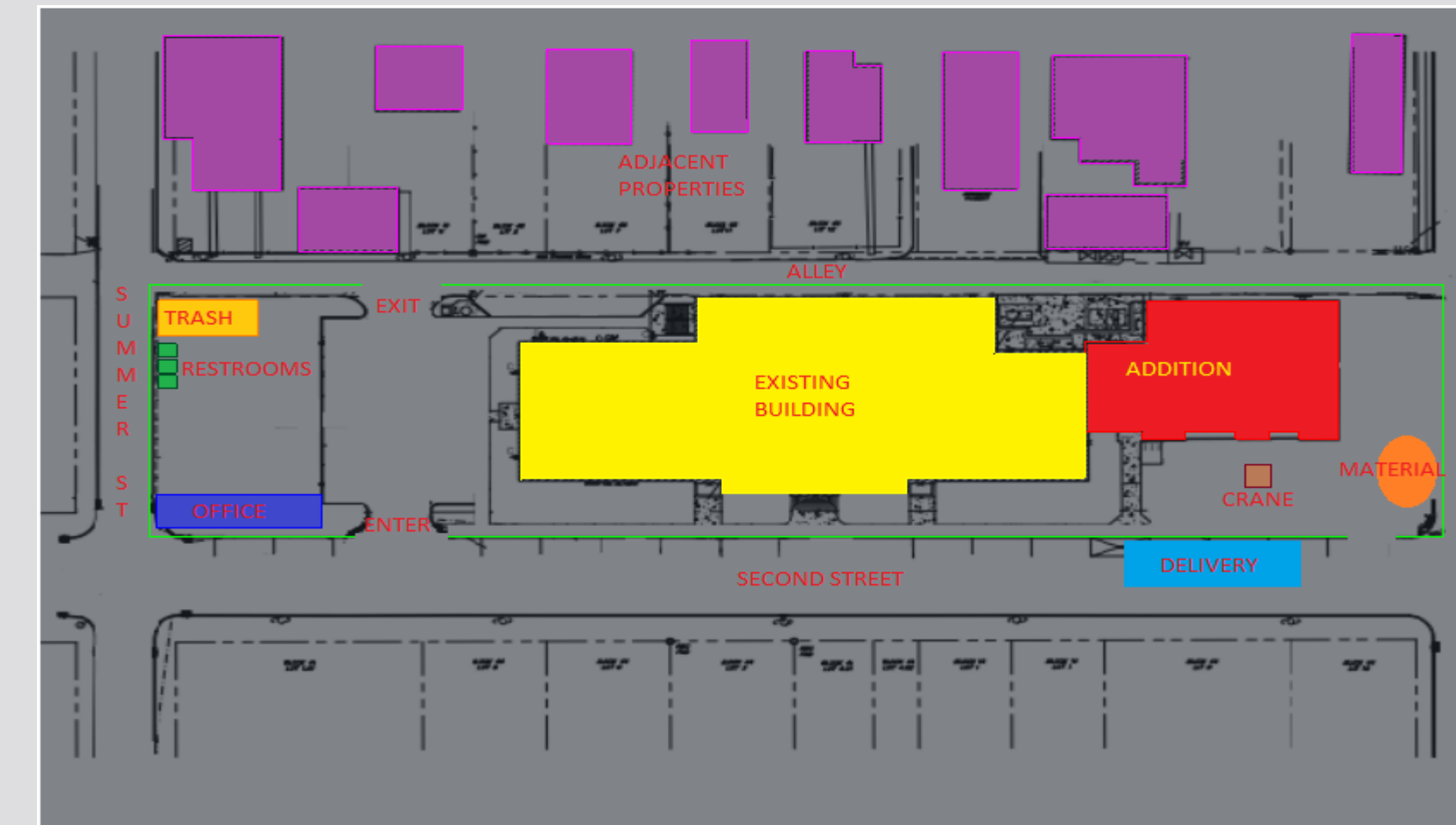
Difference

+ \$72,840

Building Enclosure Construction Cost Comparison

Material	Total (SF)	Prefabricated Panels		Traditional Brick	
		Cost/SF	Total	Cost/SF	Total
Exterior Face Wall	6,200	\$32.00	\$198,400	\$10.47	\$64,914
Interior Components	6,200	\$18.73	\$116,126	\$18.73	\$116,126
Insulation	6,200	\$1.65	\$10,230	\$2.89	\$17,918
Caulking	1,190	\$2.18	\$2,594.20	x	X
Transportation	x	Included	Included	x	X
Erection Equipment	x	Included	Included	x	\$35,026
Total		\$54.56	\$327,350	\$32.09	\$233,984

Site Layout:



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PANEL IMPLEMENTATION



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Cost Implications:

- Implement = Additional \$6/SF
- Interior Components Same
 - Vapor Barrier, Sheathing & Backup
- General Conditions Savings
 - 15 Days = \$20,526

▲ New Building	173 days	Wed 6/25/14	Fri 2/20/15	
▲ Building Frame	82 days?	Wed 6/25/14	Thu 10/16/14	
Ground Floor	10 days	Tue 11/4/14	Mon 11/17/14	
First Floor	15 days	Wed 11/12/14	Tue 12/2/14	
Second Floor	9 days	Tue 12/2/14	Fri 12/12/14	
Brick Install	3 days	Mon 12/15/14	Wed 12/17/14	
Window and Door Installation	10 days	Mon 12/22/14	Fri 1/2/15	
Exterior Finishes	25 days	Mon 1/5/15	Fri 2/6/15	
Permanent Power	3 days	Thu 12/18/14	Mon 12/22/14	

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Final Conclusions:

- 16 Architectural Precast Panels
- Schedule Reduction = 15 Days
- Implementation Cost = \$72,840

Recommendation:

- Not in owner's best interest to pursue
 - Increased cost and planning for implementation outweigh savings in schedule and building performance

CONCLUSIONS



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- V. ANALYSIS #3: REVALUATING COMP. SLAB
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ANALYSIS 1 | ROOFTOP SOLAR PANELS

- Implement Rooftop Solar Panels
 - Save Cost
 - Help Occupants

ANALYSIS 2 | HISTORICAL REQUIREMENTS

- Would hire an historical consultant firm
 - Reduced Schedule & Planning
 - Increased upfront Cost

ANALYSIS 3 | PREFAB EXTERIOR WALLS

- Would not recommend the prefabrication of the building's facade
 - Increased Cost & Planning
 - Reduced Schedule

ACKNOWLEDGEMENTS



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Architectural Engineering Faculty:

Dr. Chimay Anumba (Advisor)



Special Thanks to:

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Questions & Comments



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