CARDEROCK SPRINGS ELEMENTARY SCHOOL

Bethesda, Maryland

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Presentation Outline

I. Project Overview
II. BIM 3D MEP Coordination
III. Relocation of Underground Storm Water Retention System (UGS)
IV. Solar Panel Analysis
V. Structural Analysis
VI. Conclusions
VII. Questions & Answers

Project Overview

❖ Location: Bethesda, Maryland

❖ Owner: Montgomery County Public Schools

❖ CM @ Risk: Hess Construction + Engineering Services

❖ Goal: Modernize Carderock Springs Elementary School

❖ New Building is 80,121 ft^2

Total Project Cost and Square Foot Cost		
Building Systems	Cost	Cost/SF
General Conditions	$1,665,420	$20.79
Site Work	$3,412,850	$42.60
Concrete	$1,044,350	$13.03
Masonry	$1,974,625	$24.65
Structural	$1,952,070	$24.36
Moisture Protection	$669,000	$8.35
Carpentry	$310,600	$3.88
Openings	$1,758,436	$21.95
Finishes	$871,828	$10.88
Specialties	$221,025	$2.76
Equipment	$236,390	$2.95
Furnishings	$101,000	$1.26
Elevator	$95,000	$1.19
Mechanical	$3,894,487	$48.61
Electrical	$1,303,550	$16.27
Allowances	$975,036	$12.17
Total	**$21,304,667**	**$265.91**

Project Overview

❖ COST AND SCHEDULE

- Approximate cost = $21.3 Million GMP
- Construction Schedule is 20.5 Months
  - Demolition Started October 2008
- Owner Receives Building July 7, 2010
  - Must complete for start of school year

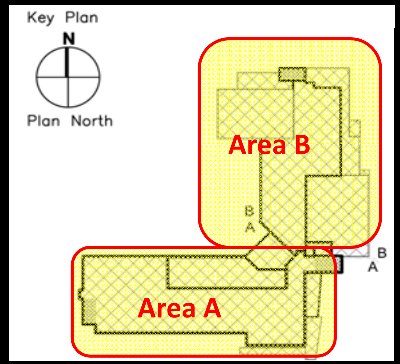
SCHEDULE SUMMARY

Activity Name	Original Duration	Start	Finish
Carderock Springs Elen	832	01-May-07	07-Jul-10
HIRE ARCHITECT	0	01-May-07	
SCHEMATIC DESIGN	134	14-May-07	15-Nov-07
DESIGN DEVELOPMENT	81	01-Nov-07	21-Feb-08
CONSTRUCTION DOCS	114	22-Feb-08	30-Jul-08
BID DAY	0	07-Oct-08	
PROCUREMENT	203	08-Oct-08	17-Jul-09
DEMOLITION	80	08-Oct-08	27-Jan-09
EXCAVATION/UTILITIES	187	20-Nov-08	07-Aug-09
SUBSTRUCTURE A	69	09-Mar-09	11-Jun-09
GEOTHERMAL WELLS	129	26-Mar-09	22-Sep-09
SUBSTRUCTURE B	85	10-Apr-09	06-Aug-09
SUPERSTRUCTURE A	30	12-Jun-09	23-Jul-09
SUPERSTRUCTURE B	41	17-Jul-09	11-Sep-09
DECKING & SOD A	31	17-Jul-09	28-Aug-09
DECKING & SOD B	34	20-Aug-09	06-Oct-09
ENCLOSURE	144	25-Aug-09	12-Mar-10
ROUGH INS A	115	08-Sep-09	15-Feb-10
ROUGH INS B	109	23-Oct-09*	24-Mar-10
FINISHES A	127	11-Nov-09*	06-May-10
FINISHES B	85	27-Jan-10*	25-May-10
WATERTIGHT	0		12-Mar-10
FINAL PAVE/LANDSCAPE	38	01-Apr-10*	24-May-10
FINAL INSPECTIONS/START-UP	21	04-May-10*	01-Jun-10
PUNCHLIST A	22	07-May-10*	07-Jun-10
PUNCHLIST B	22	24-May-10*	22-Jun-10
GAS OFF PERIOD	11	23-Jun-10*	07-Jul-10
TURNOVER BUILDING	0		07-Jul-10

Project Overview

❖ BUILDING SYSTEMS

- Steel Superstructure
- Shallow Footing Substructure (strip and pier footings)
- 2-3 Stories
- Geothermal heating & cooling
  - 120 Wells @ 520’ Deep
- Primarily Masonry Façade w/ CMU backup
- Attempting LEED Silver Certification



Geothermal Drilling and Trenching

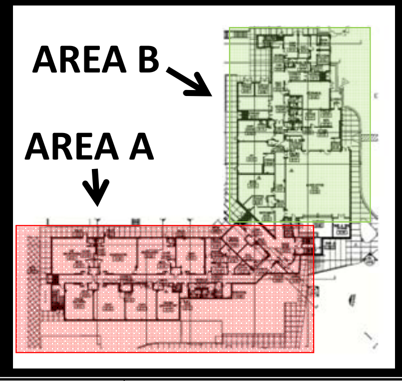
Analysis 1 – BIM 3D MEP Coordination

❖ Goals of Analysis

1. Review Carderock's 2D Coordination Process
2. Overview of General Plan for Implementation of 3D MEP Coordination @ Carderock
3. Assess Potential Advantages/Disadvantages of 3D MEP Coordination Process

❖ What is BIM and 3D MEP Coordination?

- "Process in which Clash Detection software is utilized during the coordination process to determine field conflicts by comparing 3D models of building systems." – PSU CIC
- "The goal is to eliminate the major system conflicts prior to installation." – PSU CIC

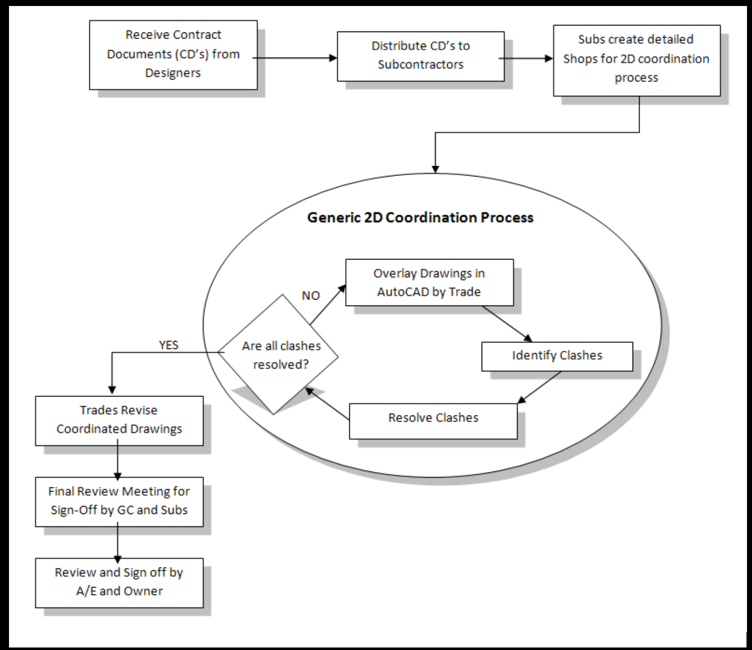


Area	Components of the Area		
Area 'A'	A Lower Level	A Main Level	A Upper Level
Area 'B'	B Lower Level	B Main Level	
Gym	One Logical Area		
Multipurpose Room	One Logical Area		

Analysis 1 – BIM 3D MEP Coordination

❖ 2D Coordination Process @ Carderock

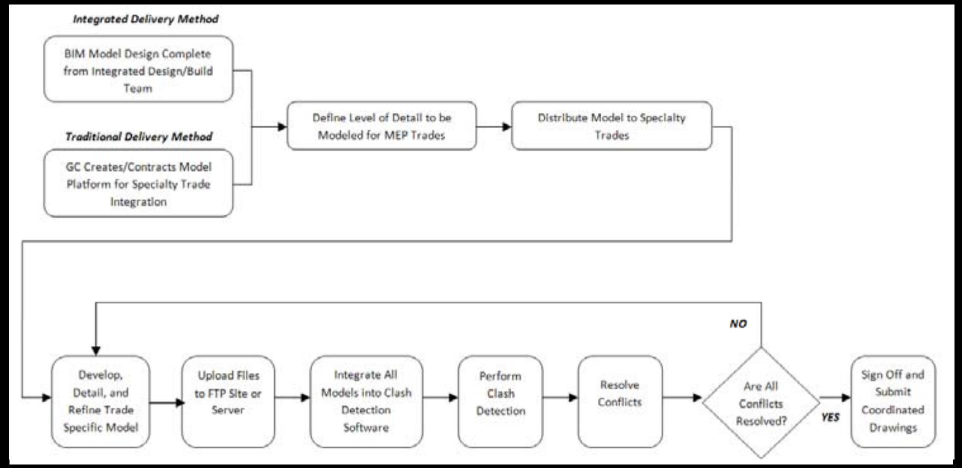
- Separated by Area and Floor Level
- Meeting for each separate area
- Coordination through Intuition and Experience
- 3-4 Weeks Coordination Cycle per Area
- Project Manager noted majority of time spent on Change Order Management
- Change Order Process Approximately 1-2 months



Analysis 1 – BIM 3D MEP Coordination

❖ 3D MEP Coordination Process w/ CM @ Risk Delivery

- Prequalify Contractors based on capabilities
- CM Creates Contract Specific 3D Modeling Requirements
  - Must define who will model, what to model, level of detail, and software compatibility requirements
  - Contractors: Create Models, Upload to FTP,
  - CM: Integrate Model, Run Clash Detection, Distribute Reports
  - Meetings to crease solutions to conflicts



Analysis 1 – BIM 3D MEP Coordination

❖ 3D MEP Considerations if Implemented @ Carderock

- What trades?
- What are the trades capabilities?
- When to start coordination process?

❖ Trades

- Steel
- Mechanical/HVAC
- Plumbing
- Electrical
- Fire Protection

Analysis 1 – BIM 3D MEP Coordination

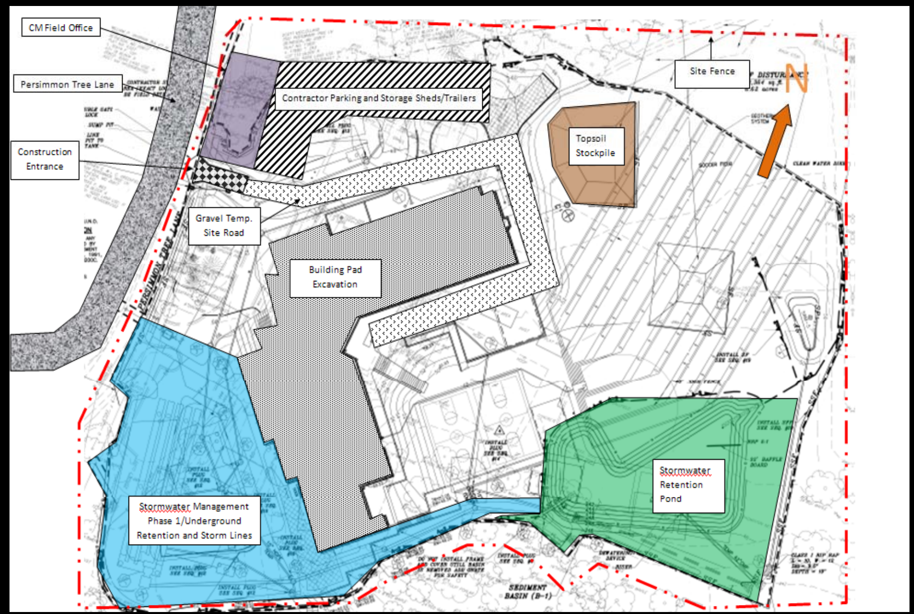
❖ Potential Advantages of 3D MEP Coordination
- Decrease Change Orders & cost increases
- Decrease amount of RFI's
- Increase Potential for Prefabrication
- Increase Overall Productivity
- Decrease Schedule
- Automated Process

❖ Potential Disadvantages and Resistance to 3D MEP Coordination
- Learning Curve
- Team Commitment
- Cost of Initial Investment
- Lack of Resources

Analysis 2 – Relocation of UGS

❖ Background of Analysis

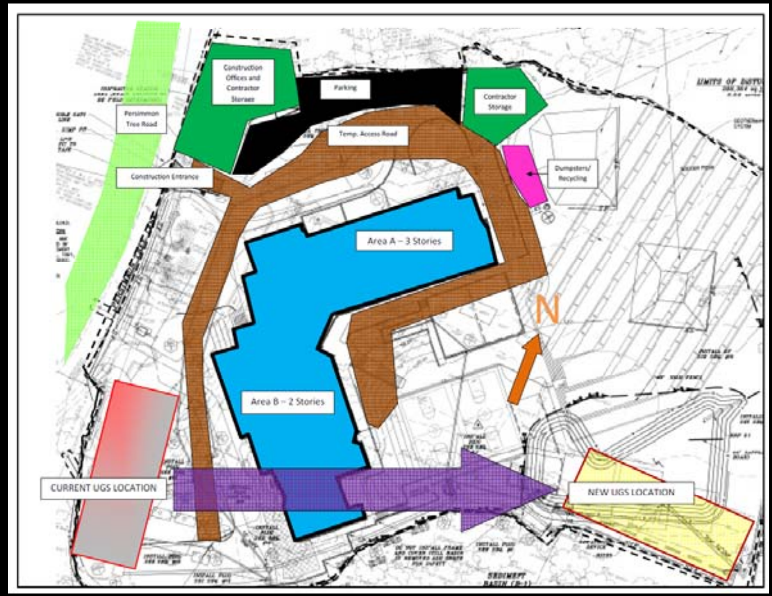
- Superintendent identified current location restricting to site Utilization in Area B
- Potential for Schedule Acceleration
- Potential for More Parking and on-site Material Storage



Analysis 2 – Relocation of UGS

❖ New Location Site Analysis

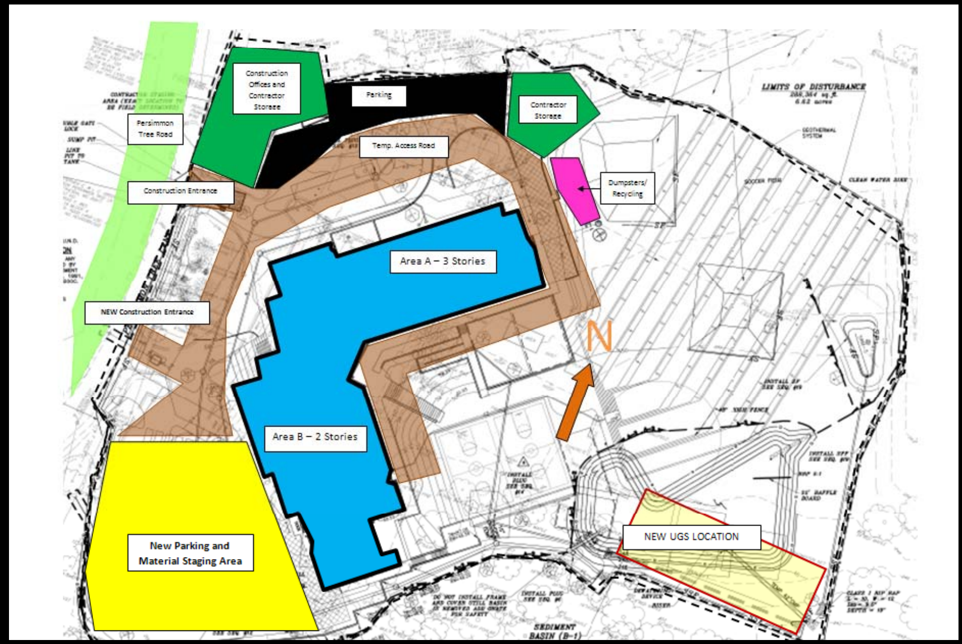
- Current Location at High Site Elevation
    - Requires Deeper Elevation for Correct Inverts
    - Excavation was approx 25'-30' deep
- New Location would require only 10' excavation



Analysis 2 – Relocation of UGS

❖ Results of New Location

- Save about $5,000 in excavation Costs
- Better Site Utilization Close to Area B
- Ability to Create Additional Parking



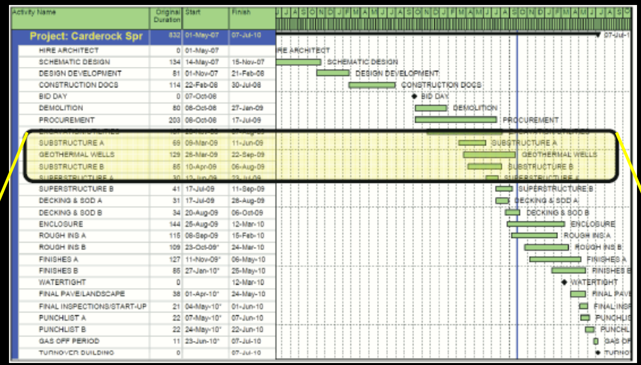
Analysis 2 – Relocation of UGS

❖ Schedule Acceleration Analysis

- By moving UGS, work on Substructure B can begin simultaneously with Substructure A
    - Saves about 20-30 Work Days on Critical Path
    - General Conditions Savings of about $94,000
    - Reduces schedule by about 9.1%

❖ Management Considerations

- Addition of an Assistant Superintendent
- Materials Procurement & Supply Chain
- Additional Crews Needed
- Quality Control and Concrete Testing



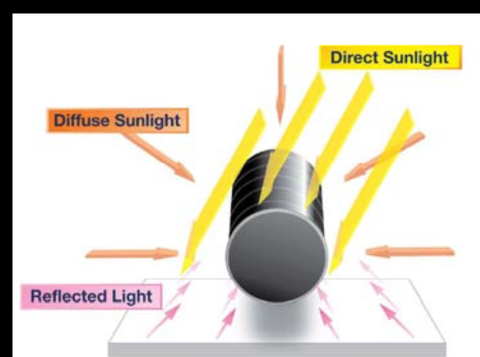
Analysis 2 – Relocation of UGS

❖ Summary of UGS Relocation

- More room for materials and parking
- Opportunity to Decrease Schedule by 9.1% or 20-30 Days
- More Supervision Needed for Quality Control & Coordination

Analysis 3 – Addition of Solar Panels (Elec. Breadth)

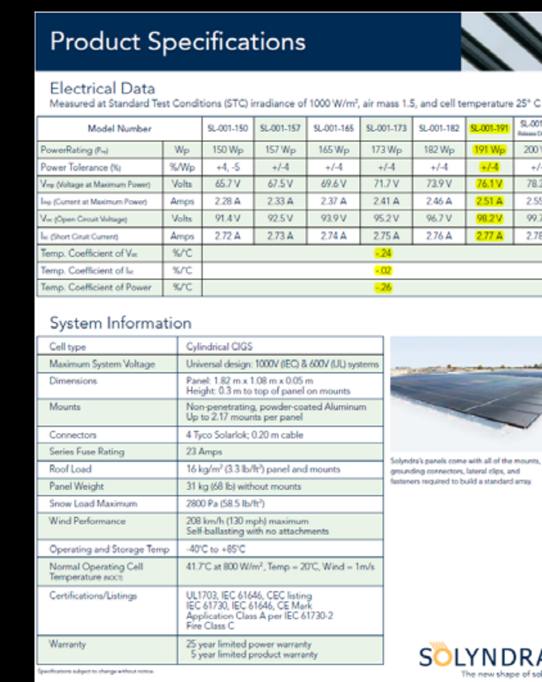
- Background of Analysis
  - Carderock striving to achieve LEED Silver from USGBC
  - MCPS District dedicated to Sustainable Buildings
  - Offset electrical Consumption
    - Energy Prices are on the Rise
- Goals of Analysis
  - Maximize Solar Energy Generation with available Roof Space



Analysis 3 – Addition of Solar Panels

❖ Product Selection

- Solyndra SL-001-191 Solar Panel
  - Cylindrical In Shape – Collects Direct, Indirect, and Reflected Light
  - Takes Advantage of the white “cool roof” @ Carderock
  - Requires little structural considerations – no protrusions through roof
  - Weighs 68lb making installations easier



Product Specifications

Electrical Data

Measured at Standard Test Conditions (STC) irradiance of 1000 W/m², air mass 1.5, and cell temperature 25° C

Model Number		SL-001-150	SL-001-157	SL-001-165	SL-001-173	SL-001-182	SL-001-191	SL-001-200
PowerRating (P_{m})	Wp	150 Wp	157 Wp	165 Wp	173 Wp	182 Wp	191 Wp	200 Wp
Power Tolerance (%)	%/Wp	+4, -5	+/-4	+/-4	+/-4	+/-4	+/-4	+/-4
V_{mp} (Voltage at Maximum Power)	Volts	65.7 V	67.5 V	69.6 V	71.7 V	73.9 V	76.1 V	78.3 V
I_{mp} (Current at Maximum Power)	Amps	2.28 A	2.33 A	2.37 A	2.41 A	2.46 A	2.51 A	2.55 A
V_{oc} (Open Circuit Voltage)	Volts	91.4 V	92.5 V	93.9 V	95.2 V	96.7 V	98.2 V	99.7 V
I_{sc} (Short Circuit Current)	Amps	2.72 A	2.73 A	2.74 A	2.75 A	2.76 A	2.77 A	2.78 A
Temp. Coefficient of V_{oc}	%/°C	-.24						
Temp. Coefficient of I_{sc}	%/°C	-.02						
Temp. Coefficient of Power	%/°C	-.26						

System Information

Cell type	Cylindrical CIGS
Maximum System Voltage	Universal design: 1000V (IEC) & 600V (UL) systems
Dimensions	Panel: 1.82 m x 1.08 m x 0.05 m Height: 0.3 m to top of panel on mounts
Mounts	Non-penetrating, powder-coated Aluminum Up to 2.17 mounts per panel
Connectors	4 Tyco Solarlok; 0.20 m cable
Series Fuse Rating	23 Amps
Roof Load	16 kg/m² (3.3 lb/ft²) panel and mounts
Panel Weight	31 kg (68 lb) without mounts
Snow Load Maximum	2800 Pa (58.5 lb/ft²)
Wind Performance	208 km/h (130 mph) maximum Self-ballasting with no attachments
Operating and Storage Temp	-40°C to +85°C
Normal Operating Cell Temperature (NOCT)	41.7°C at 800 W/m², Temp = 20°C, Wind = 1m/s
Certifications/Listings	UL1703, IEC 61646, CEC listing IEC 61730, IEC 61646, CE Mark Application Class A per IEC 61730-2 Fire Class C
Warranty	25 year limited power warranty 5 year limited product warranty

Solyndra's panels come with all of the mounts, grounding connectors, lateral clips, and fasteners required to build a standard array.

Specifications subject to change without notice.

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Analysis 3 – Addition of Solar Panels

❖ LEED Design Considerations

- Potentially Can add 2-7 credits in "Optimizing Energy Performance"
- Possibly can push rating to LEED Gold

?

❖ Design

- Determine Available Roof Space
- Amount of Panels Used is 990 Panels
  - 660 Panels on A
  - 330 Between B & Gym
- Three Arrays of 330 Panels will be used
  - PVPowered 75 kW inverter for each array
  - 66 Parallel Strings of 5 Panels
- Amtec Solar Combiner Used to group strings together
  - Max Load = 36 strings @ 540 A
  - 2 Combiners Per Array of 330 Panels
- #2 AWG Conductor used to carry load to Electrical Room
  - Rating of 106.6A
  - Carried in ½" EMT

- National Center for Education Statistics study in 1998 reported that a public educational facility stands for 42 Years

Analysis 3 – Addition of Solar Panels

- Output and Payback

ENERGY OUTPUT AND COST DATA

Month	Days in Month	Insolation Value	Energy Rates	Panel Output PTC (W)	Adj. for Roof Reflectivity	Adj. for Inverter Efficiency	Number of Panels	Energy Output (kWh)	Energy Cost Savings
January	31	1.87	$0.137	180	0.95	0.96	990	9,814	$1,344
February	28	2.61	$0.137	180	0.95	0.96	990	12,372	$1,695
March	31	3.58	$0.137	180	0.95	0.96	990	18,788	$2,574
April	30	4.61	$0.137	180	0.95	0.96	990	23,413	$3,208
May	31	5.27	$0.137	180	0.95	0.96	990	27,657	$3,789
June	30	5.75	$0.137	180	0.95	0.96	990	29,203	$4,001
July	31	5.65	$0.137	180	0.95	0.96	990	29,651	$4,062
August	31	5.08	$0.137	180	0.95	0.96	990	26,660	$3,652
September	30	4.11	$0.137	180	0.95	0.96	990	20,873	$2,860
October	31	3.14	$0.137	180	0.95	0.96	990	16,479	$2,258
November	30	2.10	$0.137	180	0.95	0.96	990	10,665	$1,461
December	31	1.64	$0.137	180	0.95	0.96	990	8,607	$1,179
							Totals:	234,181	$32,083

COST AND PAYBACK

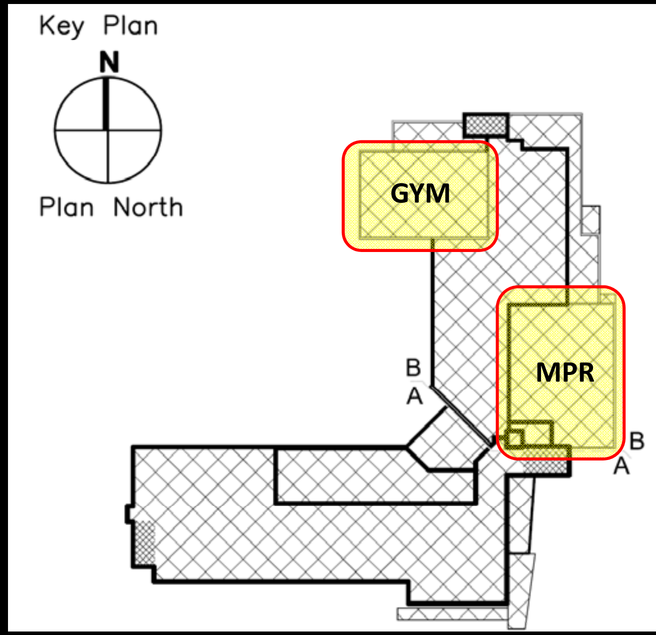
Cost/W (Installed)	Total Output STC (W)	Additional Project Cost	Federal Gov. Tax Incentive (30%)	Adjusted Cost	Yearly Savings	Payback (Years)
$7.00	187,180	$1,310,260	$393,078	$917,182	$32,083	28.6
$6.00	187,180	$1,123,080	$336,924	$786,156	$32,083	24.5
$5.00	187,180	$935,900	$280,770	$655,130	$32,083	20.4

- Recommendation & Conclusions
  - Approx. $32,000 saved annually on energy Costs
  - Simple Payback between 21-29 Years less than Building lifetime of 42 Years
  - Feasible if Budget Allows Initial Investment

Analysis 4 – Structural Change

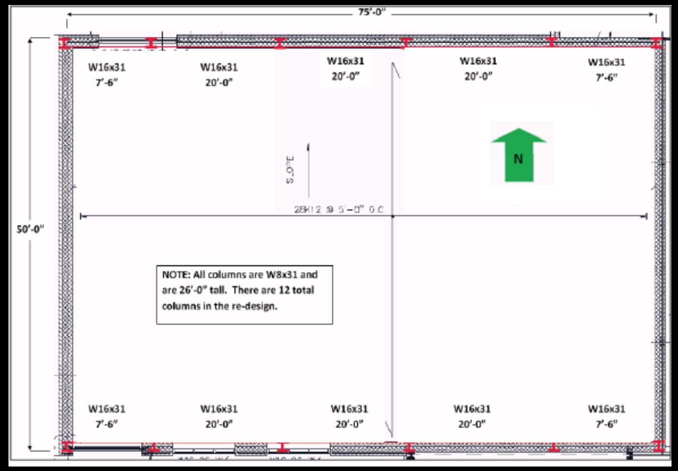
❖ Background of Analysis
- Gym and Multipurpose Room have Load Bearing Concrete Masonry Unit Walls
  - Steel truss rest on the walls
- Multiple Contractors Rely on Each Other

❖ Goals of Analysis
- Change system to Steel columns and beams
- Minimize Risks to Critical Path
- Increase Constructability

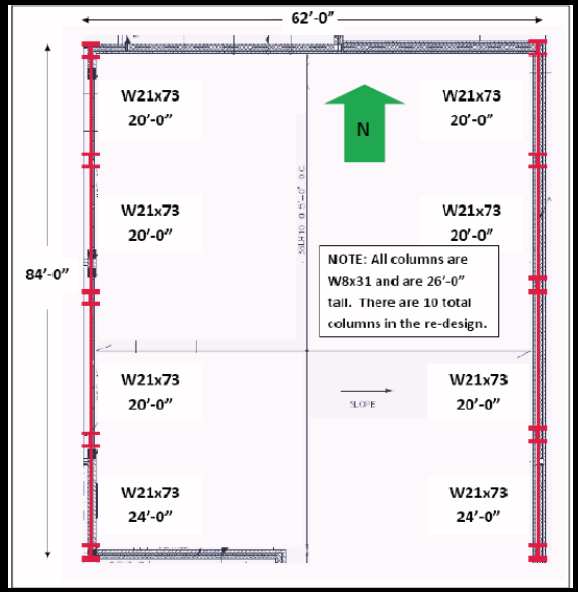


Analysis 4 – Structural Change

- ❖ Design & Layout
  - Load and Resistance Factored Design (LRFD)



❖ GYM



❖ Multipurpose Room

Analysis 4 – Structural Change

- Cost and Schedule Analysis

Room	Original			Redesign				Percent Difference	Total Savings
				Masonry		Steel	General Cond.		
	Material	Labor	General Cond.	Material	Labor	Mat. + Install			
Gym	$30,550	$57,200	$52,860	$18,135	$41,548	$20,187	$21,144	50.28%	$39,596
MPR	$45,947	$86,029	x x x x x	$26,021	$61,485	$28,647	x x x x x	12.75%	$15,824
Totals	*$76,497*	*$143,229*	*$52,860*	*$44,156*	*$103,033*	*$48,834*	*$21,144*	*22.63%*	*$55,420*

Notes: Multipurpose room not on the Critical Path, therefore no G.C. savings

General Conditions derived from actual budget in General Conditions Estimate section of report

Room	Original Duration	New Duration	Work Days Saved
Gym	20	8	**12**
MPR	10	6	**4**

Note: Only Gym on the Critical Path

Original Project Finish: July 7,2010

New Project Finish: June 21, 2010

CONCLUSIONS

❖ BIM 3D MEP COORDINATION
- Decrease Change Orders
- Increase Productivity

❖ RELOCATE UNDERGROUND STORM RETENTION SYSTEM
- Save 20-30 Days on Critical Path
- $94,000 General Conditions Savings

❖ ADDITION OF SOLAR PHOTOVOLTAIC PANELS
- Offsets $32,000 on Energy Bill Annually

❖ CHANGE STRUCTURAL SYSTEM IN GYM & MPR
- Saves $55,000
- Decrease Schedule by 12 days

Questions

Acknowledgements

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