

***Jeremy Feath***  
*Construction Option*



(Courtesy of Owner)

***University Engineering Building***  
*Mid-Atlantic University, United States*



**Jeremy Feath**  
*Construction Option*

# Project Overview

**University Engineering Building**  
*Mid-Atlantic University, United States*

## Project Overview

**Analysis 1: Clean Room Coordination**  
*Background*  
*Project Organization Results*  
*Coordination Results*

**Analysis 2: Roof System Redesign**  
*Background*  
*Schedule Results*  
*Cost Comparison*  
*Structural Breadth*

**Analysis 3: Underground Spring**  
*Background*  
*Results*  
*Mechanical Breadth*

**Analysis 4: FM Information Delivery**  
*Final Recommendations*  
*Acknowledgements*

**Location:** *Mid-Atlantic, United States*

**Size:** *95,000 SF*

**Project Cost:** *\$43 million*

**Delivery Method:** *Design-Bid-Build*

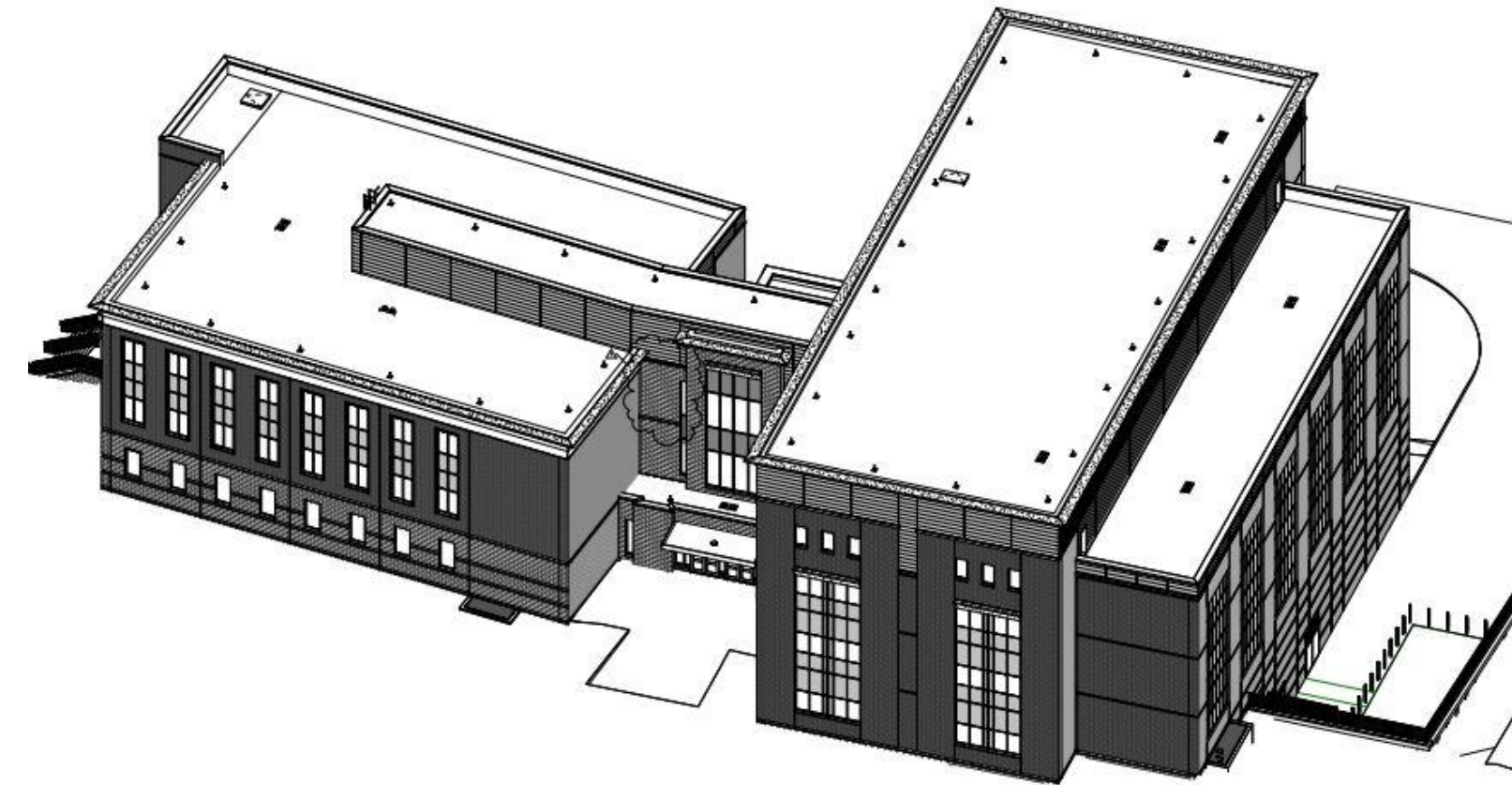
**Project Duration:** *Jan. 2013 – Jan. 2015*



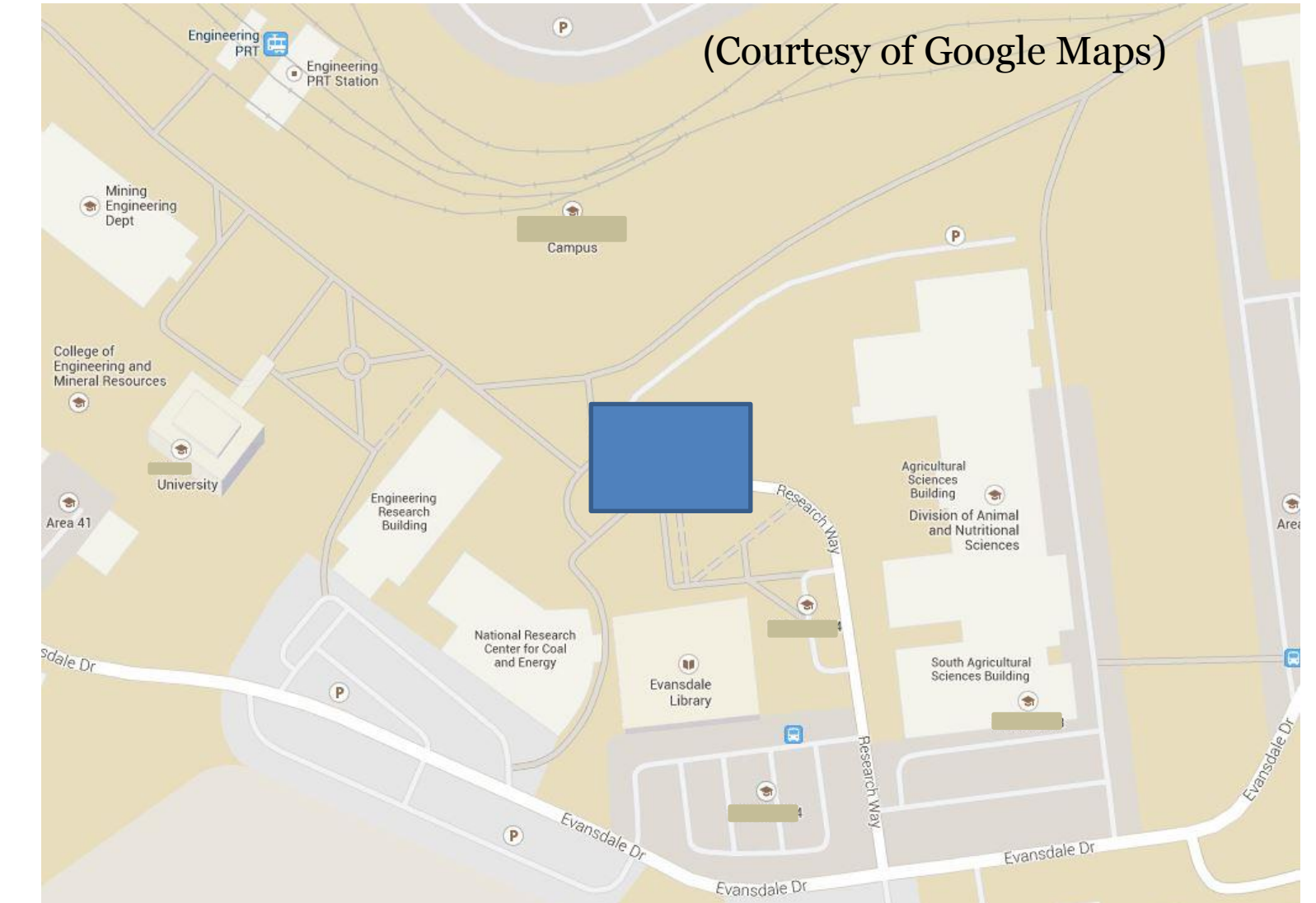
**Owner:** *Mid-Atlantic University*

**Design Architect:** *Stantec Arch. Inc.*

**General Contractor:** *Massaro Const.*



(Courtesy of Stantec)



(Courtesy of Google Maps)



*Jeremy Feath*  
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*Mechanical Breadth*

### *Analysis 4: FM Information Delivery*

### *Final Recommendations*

### *Acknowledgements*

## **Analysis 1: Clean Room Coordination**

- *Reorganize project organization chart, along with creating and analyzing Clean Room coordination schedule & process*

## **Analysis 2: Roof System Redesign**

- *Propose a feasible alternative to the Fully-Adhered TPO roof system*



(Courtesy of Jeremy Feath)

## **Analysis 3: Underground Spring**

- *Propose an alternative to the permanent sump pump to manage the underground spring located underneath the UEB's foundation*

## **Analysis 4: FM Information Delivery**

- *Research and study the methods of information delivery from CM to FM and utilizing that information to manage facilities*



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# Analysis 1

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## **Analysis 1: Clean Room Coordination**



# Analysis 1

## Clean Room Coordination

# Background

## University Engineering Building

### Mid-Atlantic University, United States

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Structural Breadth

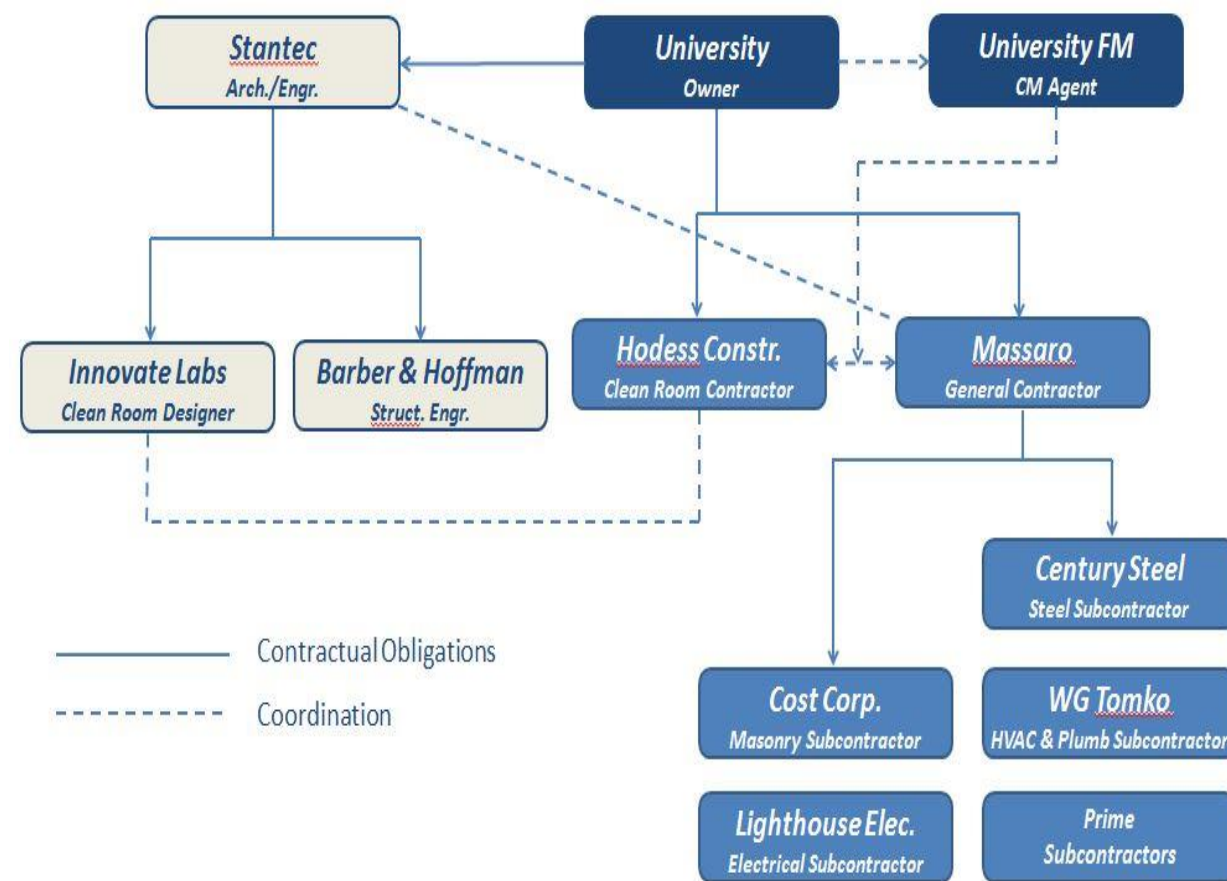
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Mechanical Breadth

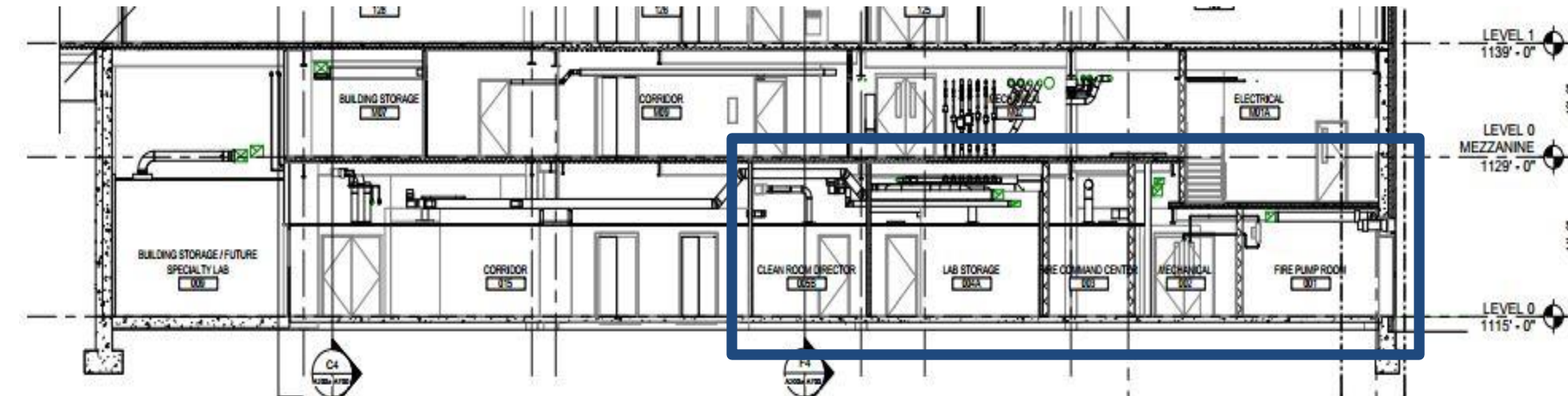
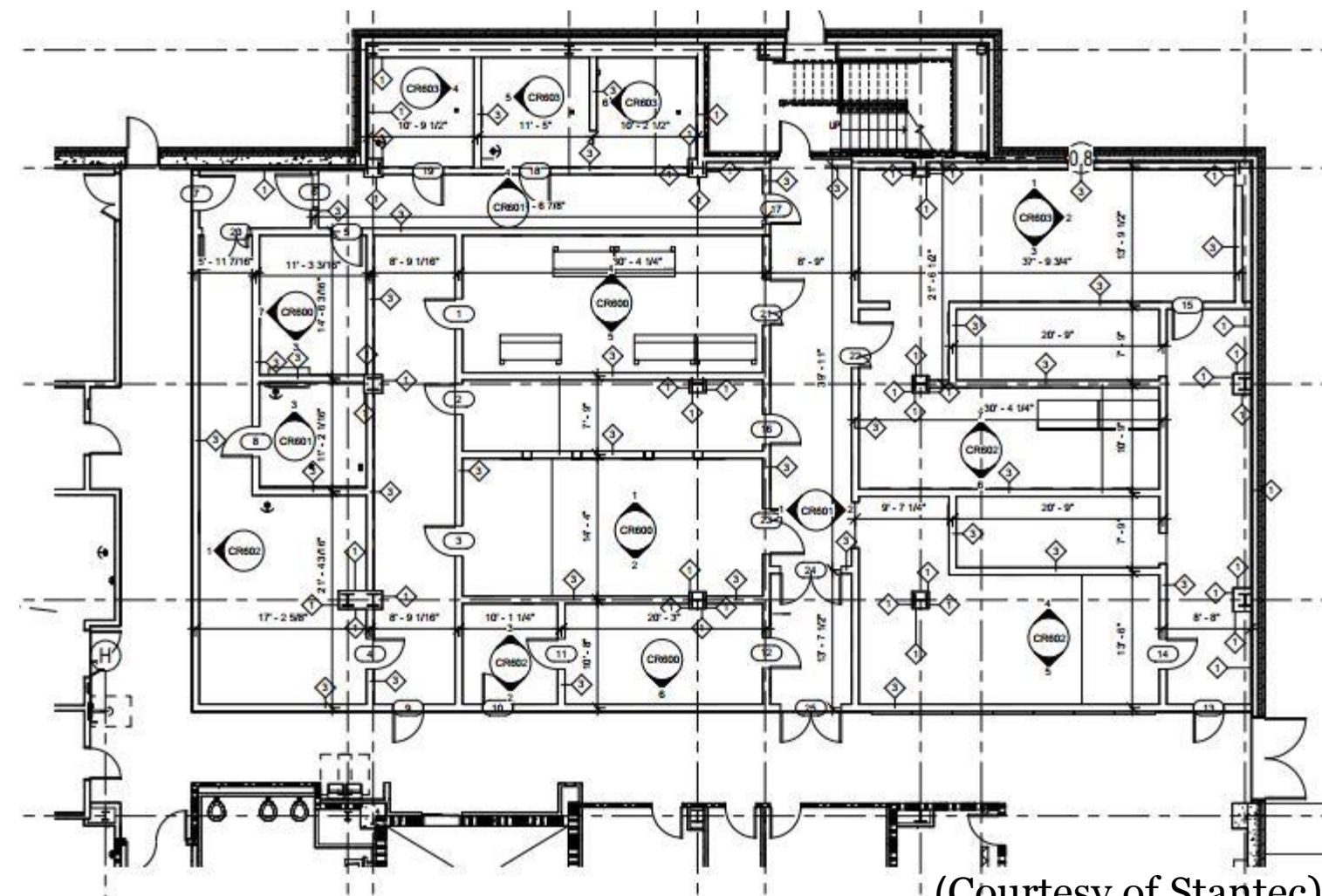
#### Analysis 4: FM Information Delivery

#### Final Recommendations

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#### Problem Identification:

- Both Massaro and Hodess have separate contracts w/ the Owner
- Coordination for the Clean Room is extremely intensive
  - Scopes of Work
  - Constructability



# Analysis 1 Clean Room Coordination

# Project Organization

University Engineering Building  
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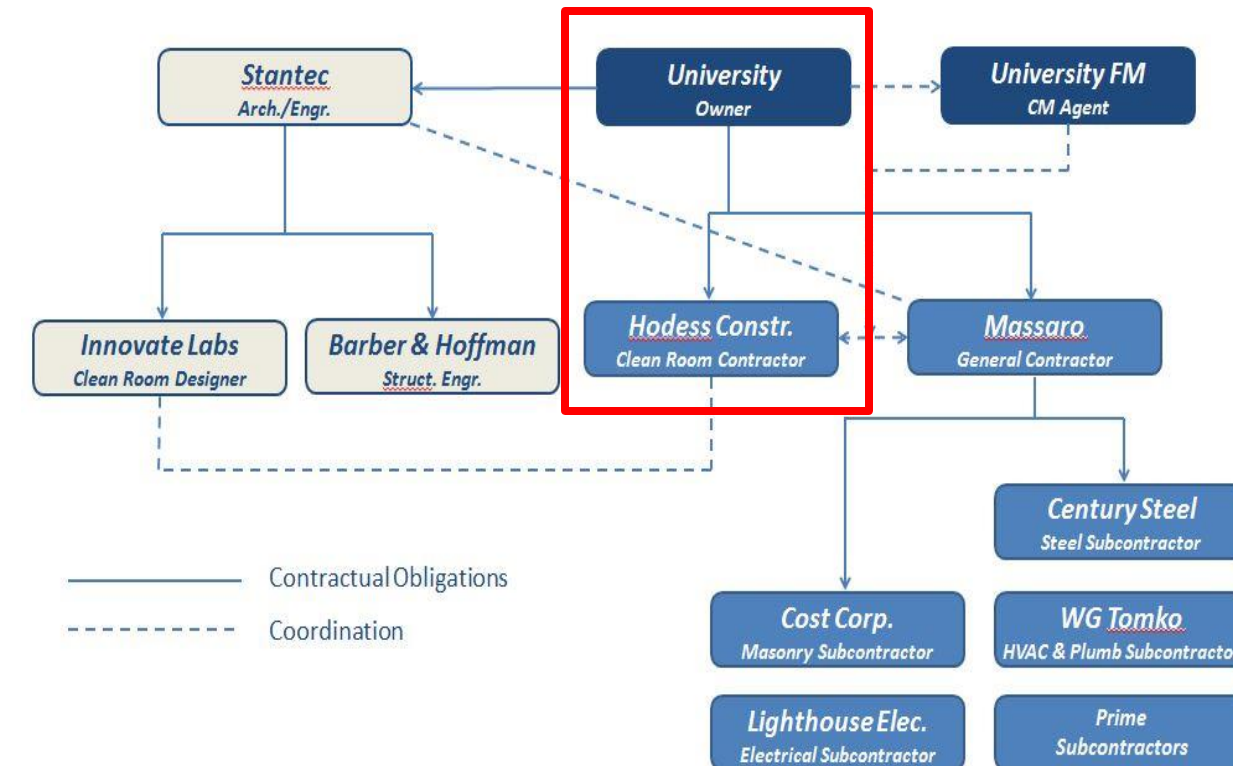
### Analysis 3: Underground Spring

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### Analysis 4: FM Information Delivery

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### Original Contractual Obligations:

- Hodess used for Design Coordination, contracted to Owner at time
- Massaro chosen as General Contractor, contracted to Owner
- Owner unsuccessfully attempted to transfer Hodess' contract to Massaro

Original Design-Bid-Build  
Hodess contract w/ Owner

(Courtesy of Jeremy Feath)



# Analysis 1

## Clean Room Coordination

# Project Organization

# University Engineering Building

## Mid-Atlantic University, United States

**Project Overview**

**Analysis 1: Clean Room Coordination**  
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 Coordination Results

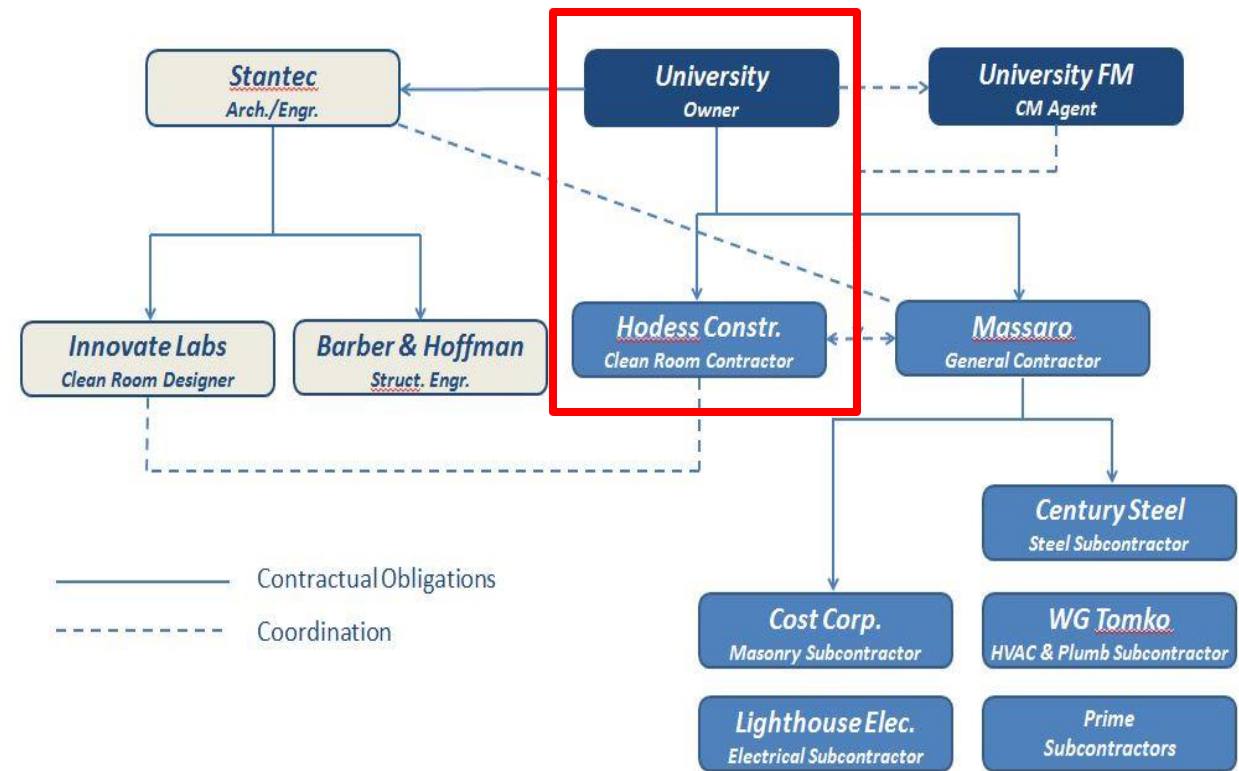
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**Original Design-Bid-Build**  
 Hodess contract w/ Owner

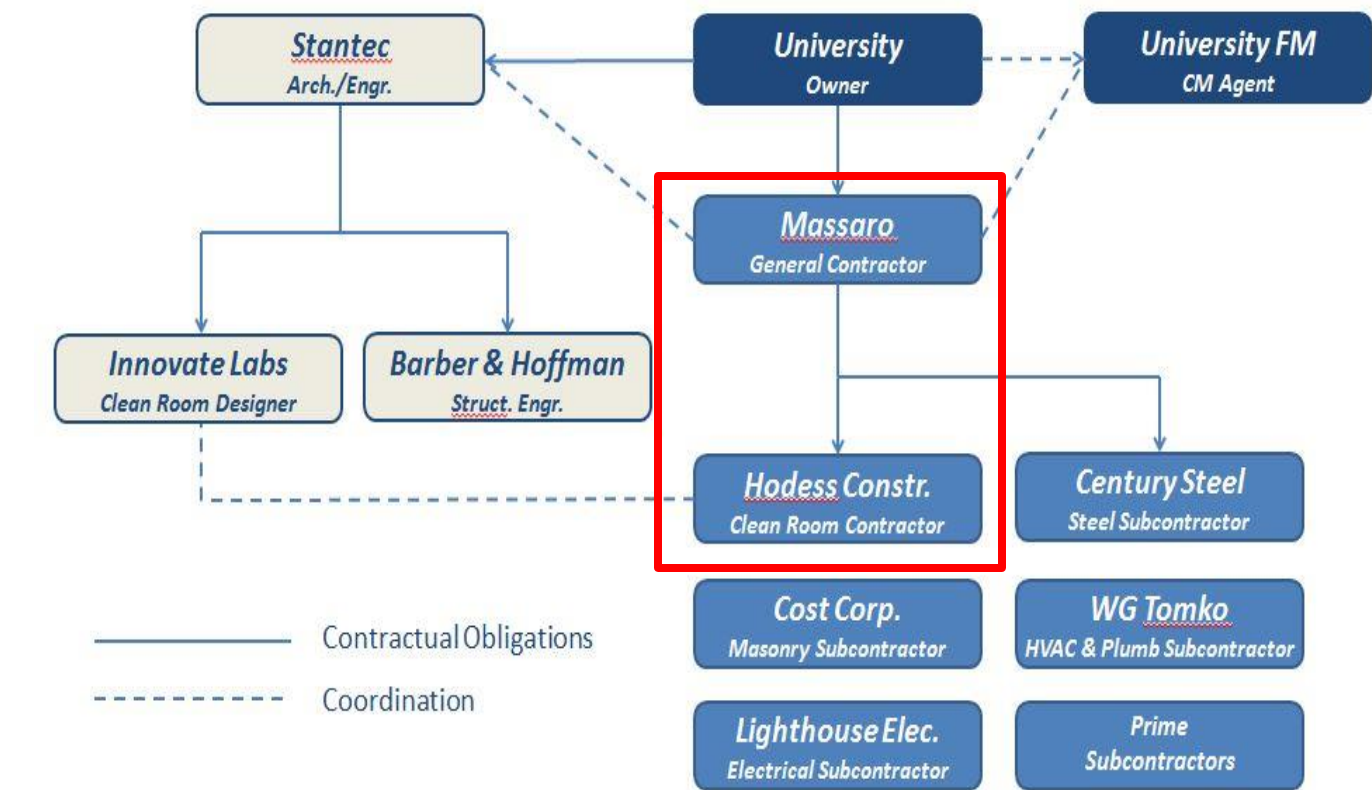
### Original Contractual Obligations:

- Hodess used for Design Coordination, contracted to Owner at time
- Massaro chosen as General Contractor, contracted to Owner
- Owner unsuccessfully attempted to transfer Hodess' contract to Massaro

### New Contractual Obligations:

- Hodess has preconstruction contract with Owner
- Massaro awarded bid, contract with the Owner
- Hodess now acts as a subcontractor, construction contract with Massaro

(Courtesy of Jeremy Feath)



**New Design-Bid-Build**  
 Hodess contract w/ Massaro

(Courtesy of Jeremy Feath)



# Analysis 1

## Clean Room Coordination

# Clean Room Coordination

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Mid-Atlantic University, United States

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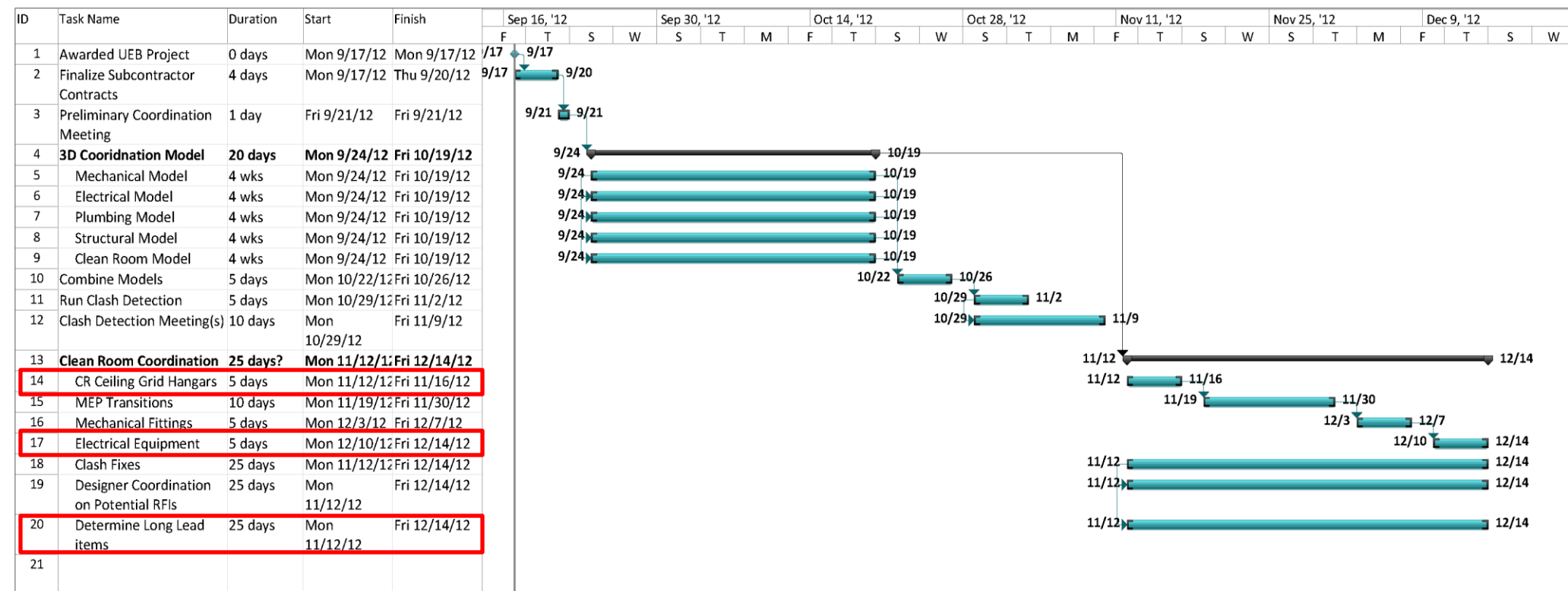
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(Courtesy of Jeremy Feath)

### Problem Areas:

- Clean Room Light Fixtures
- Mezzanine AHUs
- Clean Room Ceiling Grid



(Courtesy of Stantec)

(Courtesy of Jeremy Feath)



(Courtesy of Jeremy Feath)







# Analysis 1

## Clean Room Coordination

# Clean Room Coordination

University Engineering Building  
Mid-Atlantic University, United States

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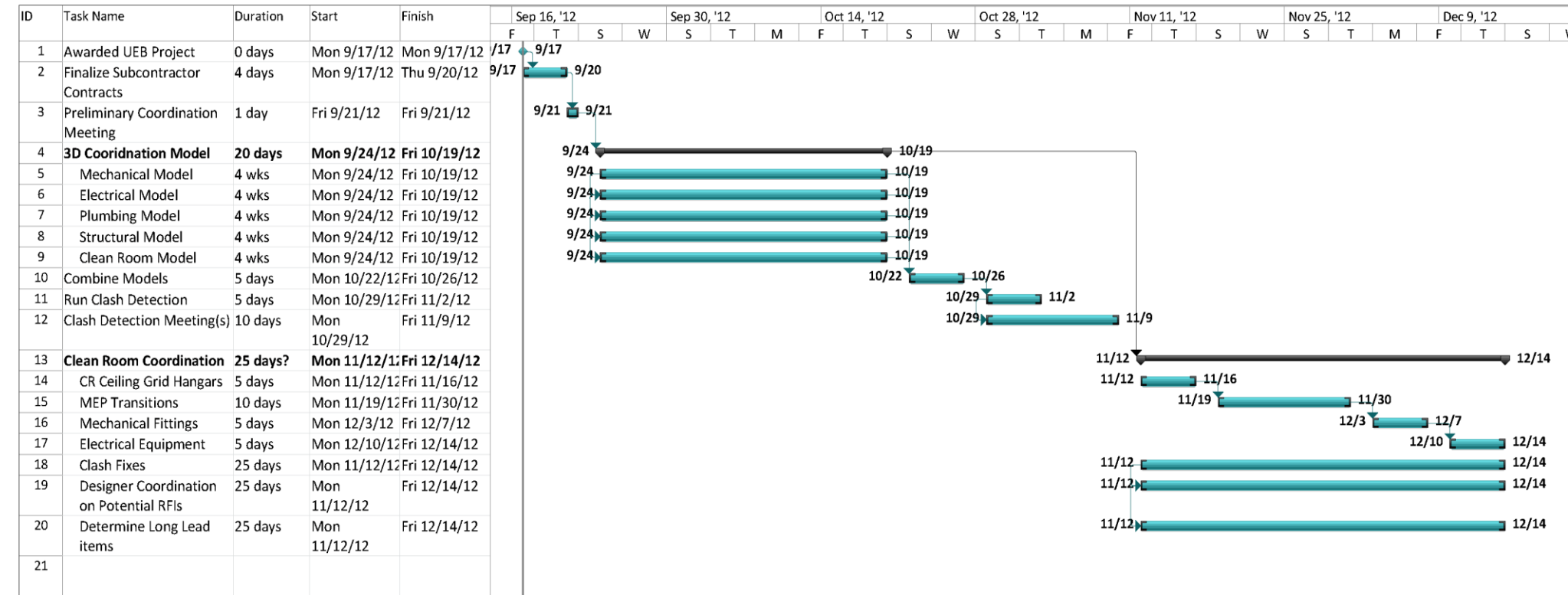
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(Courtesy of Jeremy Feath)

### Problem Areas:

- Clean Room Light Fixtures
- Mezzanine AHUs
- Clean Room Ceiling Grid

### Tools:

- 3D Model Coordination
- Hodess Precon experience
- Early Problem Identification

### Savings:

- Less RFIs, COs
- Fewer Constructability Problems
- Potential Schedule Savings



(Courtesy of Stantec)

(Courtesy of Jeremy Feath)



(Courtesy of Jeremy Feath)





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# **Analysis 2**

***University Engineering Building***  
*Mid-Atlantic University, United States*

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*Analysis 3: Underground Spring*

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## ***Analysis 2: Roof System Redesign***



# Analysis 2

## Roof System Redesign

# Background

University Engineering Building  
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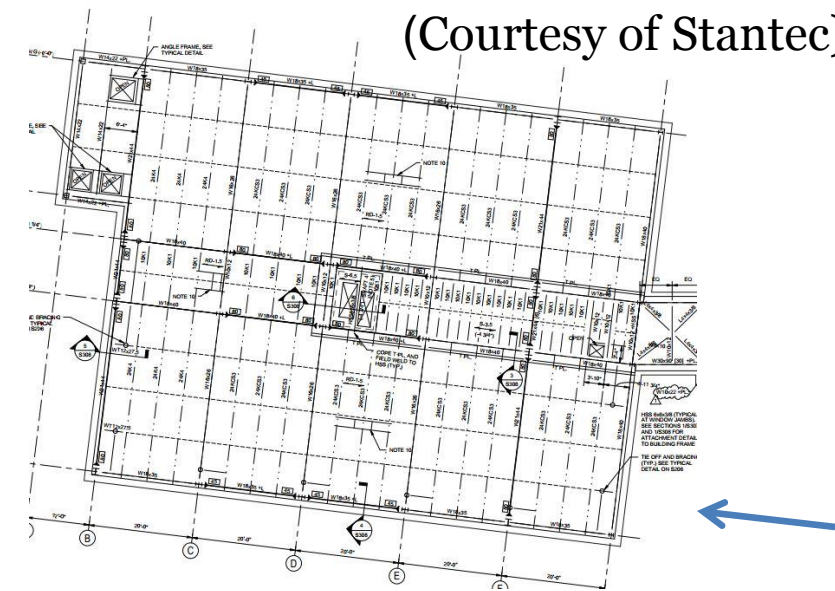
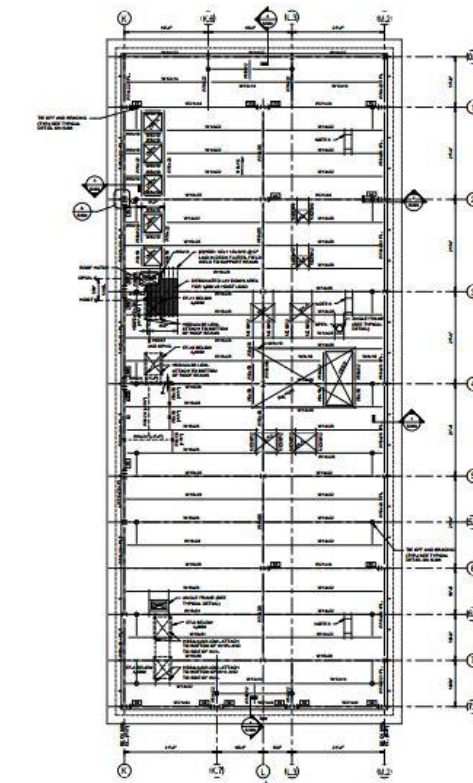
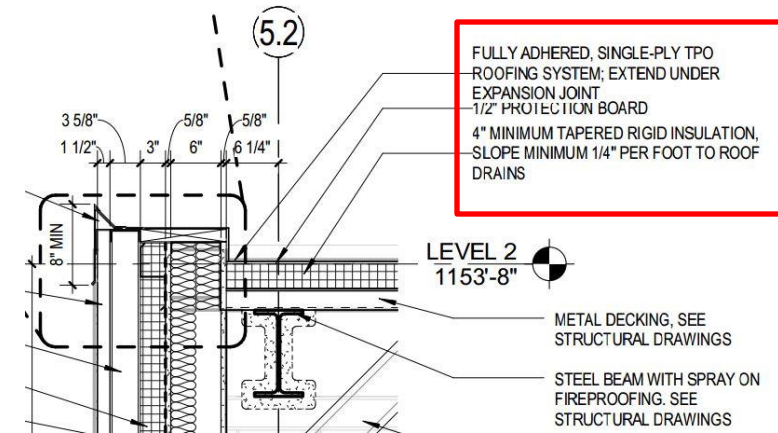
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(Courtesy of Stantec)

Lab Roof: 14,000 SF

Office Roof: 10,000 SF



# Analysis 2 Roof System Redesign

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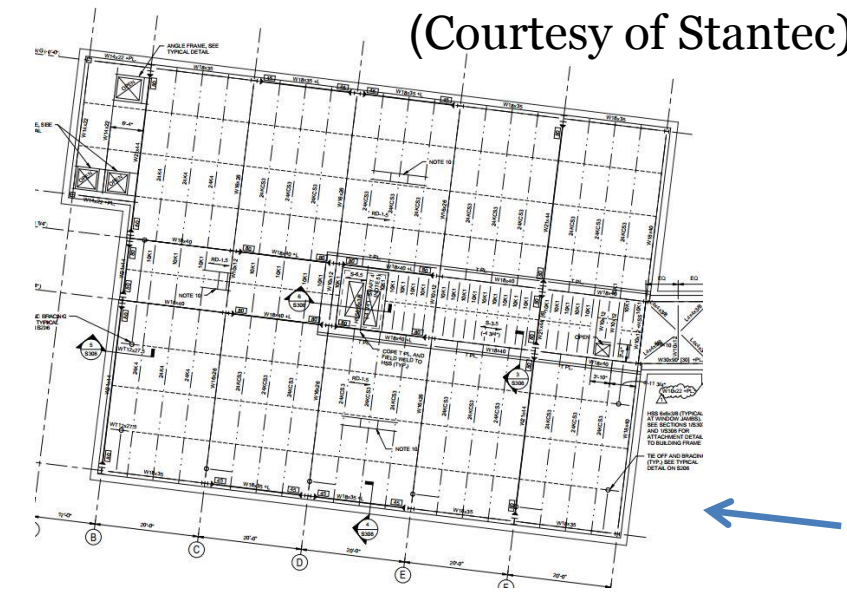
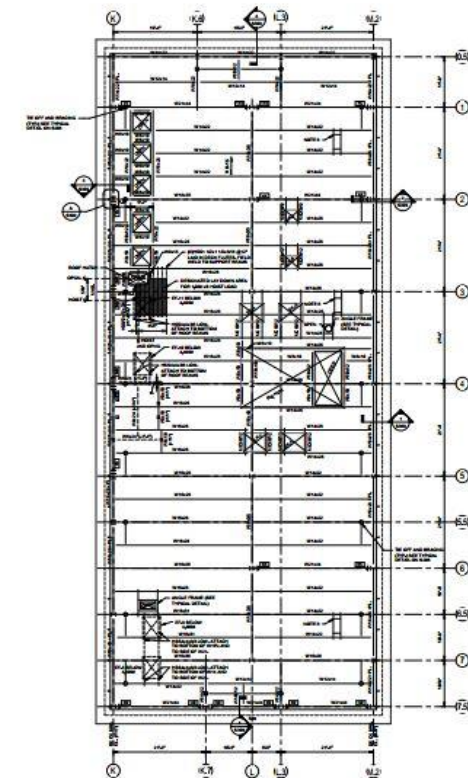
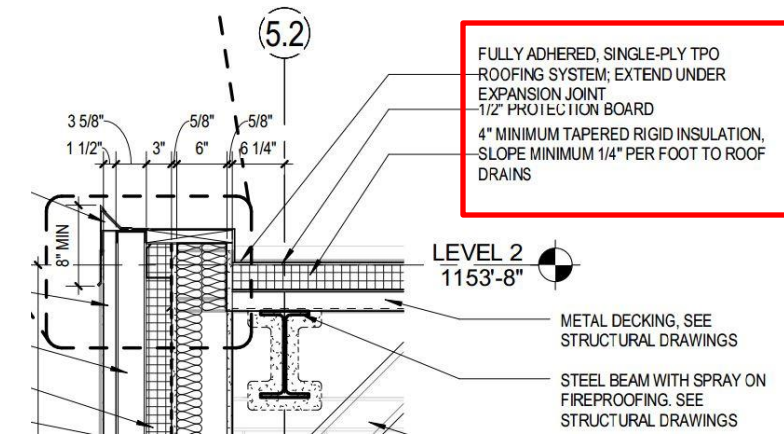
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(Courtesy of Stantec)

Lab Roof: 14,000 SF

Office Roof: 10,000 SF

## Original Project Schedule

Building Roof & Exterior Enclosure		133	133		11-Nov-13	19-May-14
Lab		133	133		11-Nov-13	19-May-14
Lab - Roof		61	61		12-Dec-13	10-Mar-14
Lab-30000	Roof Blocking - Lab Roof	5	5	0%	12-Dec-13	18-Dec-13
Lab-30010	Roof Drains - Lab Roof	4	4	0%	13-Dec-13	18-Dec-13
Lab-30020	Roofing System - Lab Roof	15	15	0%	11-Feb-14	03-Mar-14
Lab-30030	Lightning Protection - Lab Roof	5	5	0%	04-Mar-14	10-Mar-14
Lab-30035	Install Roof Crane	5	5	0%	04-Mar-14	10-Mar-14

Lab Roof Activities – Total Duration: 61 days

Office		101	101		25-Nov-13	17-Apr-14
Office - Roof		30	30		07-Jan-14	17-Feb-14
Off-30000	Roof Blocking - Office Roof	5	5	0%	07-Jan-14	13-Jan-14
Off-30010	Roof Drains - Office Roof	4	4	0%	08-Jan-14	13-Jan-14
Off-30020	Roofing System - Office Roof	20	20	0%	14-Jan-14	10-Feb-14
Off-30030	Lightning Protection - Office Roof	5	5	0%	11-Feb-14	17-Feb-14

Office Roof Activities – Total Duration: 30 days

(Courtesy of Massaro)



# Analysis 2 Roof System Redesign

# Background

University Engineering Building  
Mid-Atlantic University, United States

**Project Overview**

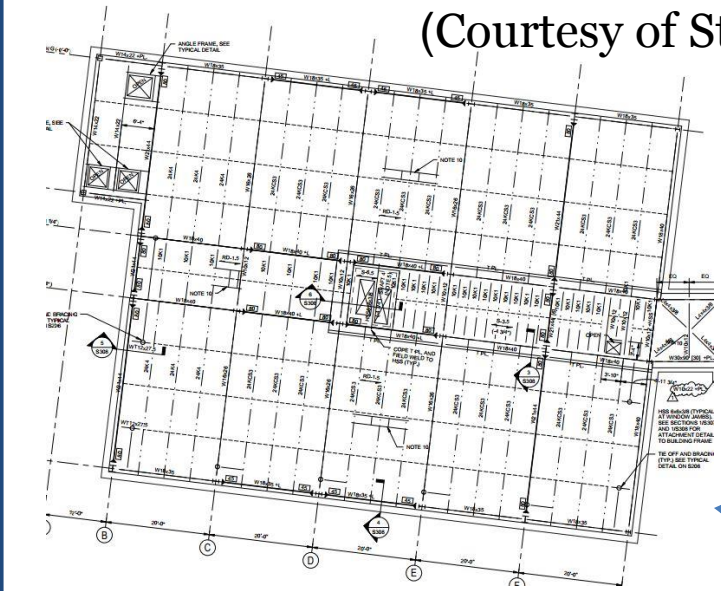
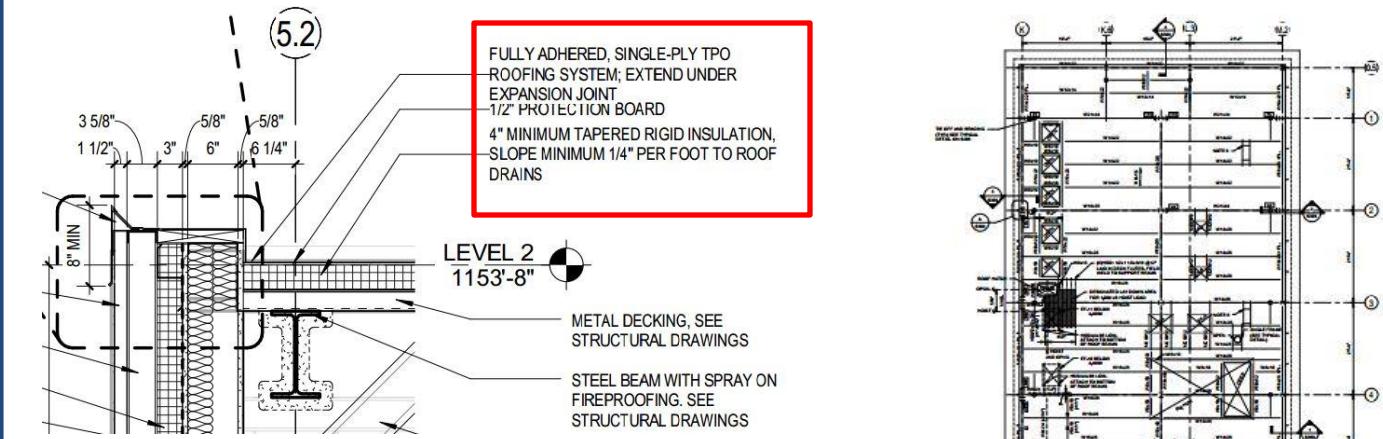
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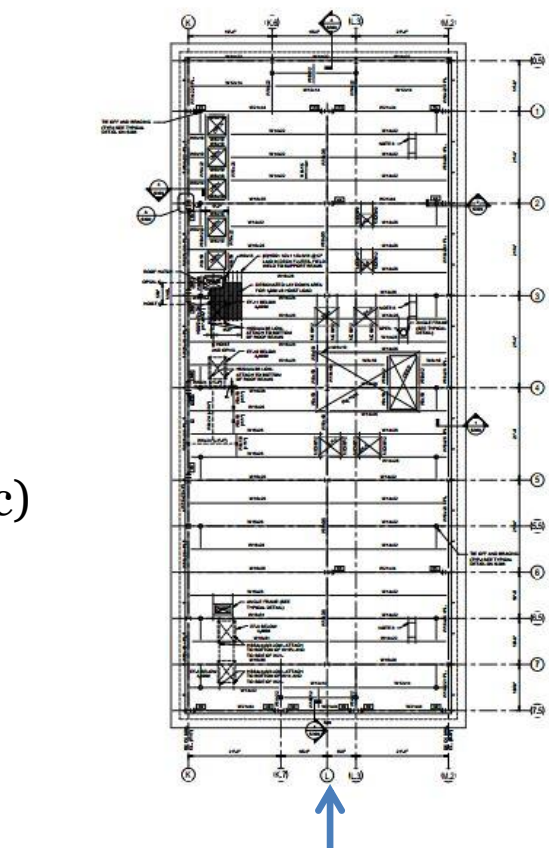
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Acknowledgements



(Courtesy of Stantec)



Lab Roof: 14,000 SF  
Office Roof: 10,000 SF

## Original Project Schedule

Building Roof & Exterior Enclosure		133	133		11-Nov-13	19-May-14
Lab		133	133		11-Nov-13	19-May-14
Lab - Roof		61	61		12-Dec-13	10-Mar-14
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Lab-30010	Roof Drains - Lab Roof	4	4	0%	13-Dec-13	18-Dec-13
Lab-30020	Roofing System - Lab Roof	15	15	0%	11-Feb-14	03-Mar-14
Lab-30030	Lightning Protection - Lab Roof	5	5	0%	04-Mar-14	10-Mar-14
Lab-30035	Install Roof Crane	5	5	0%	04-Mar-14	10-Mar-14

Lab Roof Activities – Total Duration: 61 days

Office		101	101		25-Nov-13	17-Apr-14
Office - Roof		30	30		07-Jan-14	17-Feb-14
Off-30000	Roof Blocking - Office Roof	5	5	0%	07-Jan-14	13-Jan-14
Off-30010	Roof Drains - Office Roof	4	4	0%	08-Jan-14	13-Jan-14
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Off-30030	Lightning Protection - Office Roof	5	5	0%	11-Feb-14	17-Feb-14

Office Roof Activities – Total Duration: 30 days

(Courtesy of Massaro)

## Roof System Problems:

- Cold-Weather Constructability Difficult
- Increased General Conditions Costs
- Delayed Interior Work (Fireproofing, MEP Rough-Ins)



(Courtesy of Jeremy Feath)



(Courtesy of Jeremy Feath)



## Analysis 2

### Roof System Redesign

# Background

## University Engineering Building

### Mid-Atlantic University, United States

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### Proposed Solution:

## Firestone TPO InvisiWeld System

**Improved Cold-Weather  
Constructability**

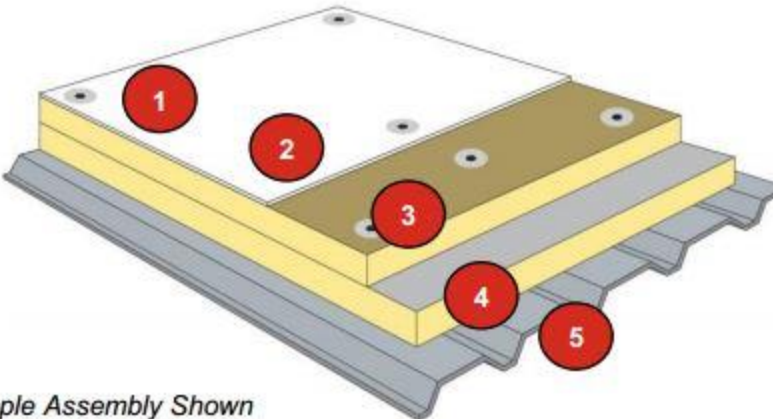
**Meets Owner Approval &  
Contractor Experience**



### UltraPly™ TPO InvisiWeld™ System

#### Various Decks

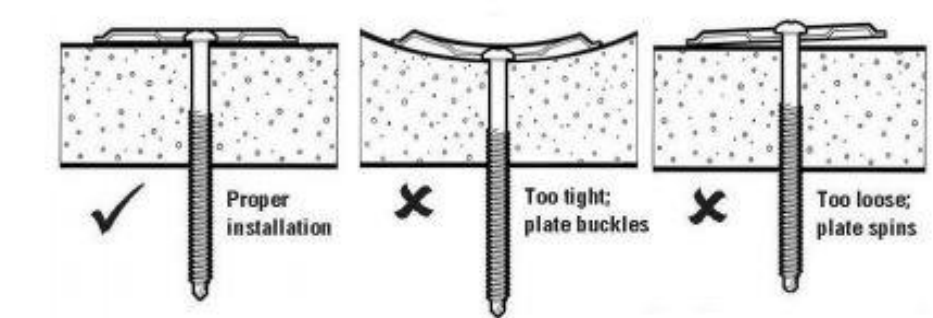
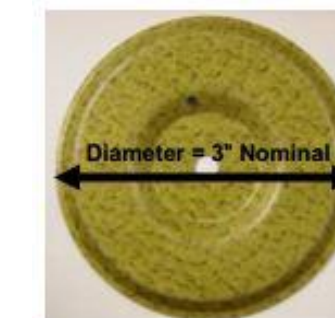
5, 10, 15, 20 Year  
Red Shield™  
Warranty



1. Firestone UltraPly™ TPO Membrane
2. InvisiWeld™ System Attachment
3. Mechanically Attached or Adhered Cover Board (Optional)
4. Mechanically Attached Insulation
5. Steel, Structural Concrete, Wood or Metal Building Recover

Sample Assembly Shown

(Courtesy of Firestone Building Products)



(Courtesy of Firestone Building Products)



## Analysis 2

### Roof System Redesign

# Schedule Results

*University Engineering Building*  
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***InvisiWeld Plate Weld Durations***

Location	Area (SF)	4'x8' Board (SF)	# Boards	Avg. # of Plates	Total Plates	# Plates/Hr.	Total Hrs.	Total Days
Lab	14000	32	437.5	14	6125	300	20.42	2.55
Office	10000	32	312.5	14	4375	300	14.58	1.82

***Note: 300 plates/hr. based on Firestone literature***

***Roof System Duration Comparison***

Roof System	Lab Duration	Office Duration	Total Duration
Fully-Adhered TPO	61	30	61
InvisiWeld	35	25	40
Built-Up Roof	51	47	65

(All Courtesy of Jeremy Feath)



# Analysis 2 Roof System Redesign

# Schedule Results

# University Engineering Building Mid-Atlantic University, United States

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**InvisiWeld Plate Weld Durations**

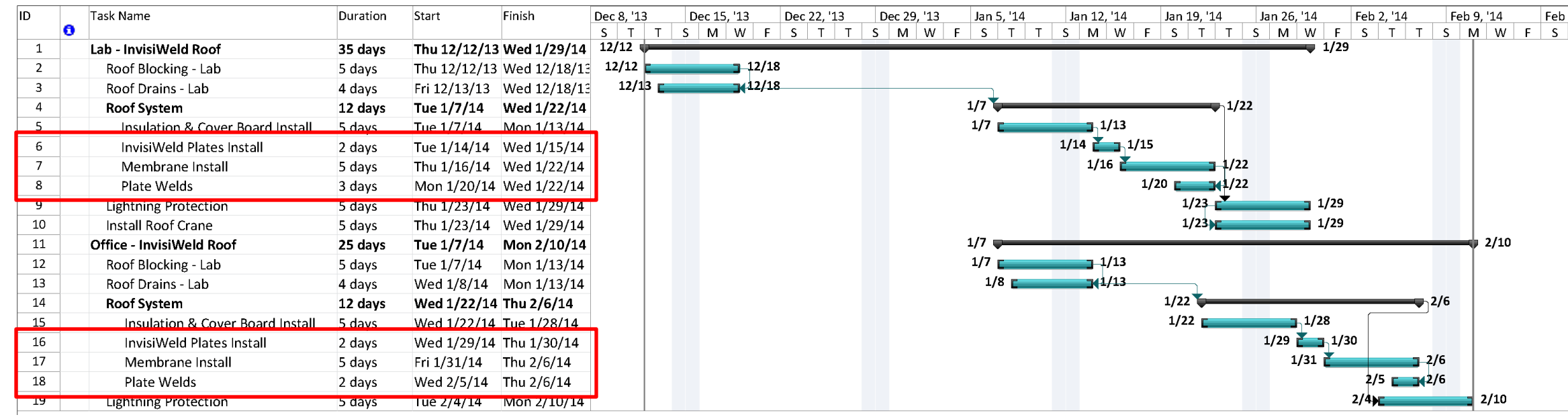
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**InvisiWeld Construction Schedule**



(All Courtesy of Jeremy Feath)





# Analysis 2

## Roof System Redesign

# Cost Comparison

University Engineering Building  
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**Analysis 4: FM Information Delivery**

**Final Recommendations**

**Acknowledgements**

Fully Adhered TPO Membrane Roof Estimate				
Material	Quantity	Unit	Cost/Unit	Total Cost
TPO Membrane (80 mil)	24000	SF	\$1.03	\$24,720.00
Multipurpose Adhesives	40	600 SF	\$145.00	\$5,800.00
Expansion Joint	800	LF	\$2.00	\$1,600.00
1/2" Protection Board	24000	SF	\$0.53	\$12,720.00
(2) 2" Rigid Insulation	24000	SF	\$0.65	\$15,600.00
Single-Ply Memb. Sealants	100	1 gal. Pail	\$75.00	\$7,500.00
Sealant Primers	100	1 gal. Pail	\$67.00	\$6,700.00
Sheet Flashing	24	100 SF	\$251.00	\$6,024.00
Bonding Adhesive	54	450 SF Pail	\$145.00	\$7,830.00
Fasteners	25	5" HD 1000/Pail	\$190.00	\$4,750.00
Metal Termination Bar	80	10 LF	\$7.00	\$560.00
<b>Total</b>				<b>\$93,804.00</b>

Original General Conditions Estimate			
TOTAL			\$1,610,845.00
TOTAL CONSTRUCTION COSTS * 6%			\$1,962,000.00
COST DIFFERENCE			\$351,155.00
% DIFFERENCE			17.90

Revised General Conditions Estimate			
TOTAL			\$1,618,545.00
TOTAL CONSTRUCTION COSTS * 6%			\$1,962,000.00
COST DIFFERENCE			\$343,455.00
% DIFFERENCE			17.51

**Fully-Adhered TPO System**  
**General Conditions Increase - \$7,700**

**Increase in Temporary Heating & Enclosure:**

- **Protect Penthouse Equipment & Stored Materials**
- **Enable interior rough-in work to continue**

**Note: The increase in GC does not occur for BUR or InvisiWeld**



# Analysis 2

## Roof System Redesign

# Cost Comparison

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Fasteners	25	5" HD 1000/Pail	\$190.00	\$4,750.00
Metal Termination Bar	80	10 LF	\$7.00	\$560.00
<b>Total</b>				<b>\$93,804.00</b>

Traditional Built-Up Roof				
Material	Quantity	Unit	Cost/Unit	Total Cost
Ply VI Membrane (4 Layers)	96000	SF (1 - Layer)	\$0.85	\$81,600.00
Asphalt	30	ton	\$820.00	\$24,600.00
(2) 2" Rigid Insulation	24000	SF	\$0.65	\$15,600.00
Cover Board	24000	SF	\$0.53	\$12,720.00
<b>Total</b>				<b>\$134,520.00</b>

Labor Cost Estimate				
Roof Type	Duration (days)	Hourly Rate	Daily Rate	Total Cost
Fully-Adhered TPO	61	\$100.00	\$800.00	\$48,800.00
Built-Up Roof	65	\$100.00	\$800.00	\$52,000.00
InvisiWeld TPO	40	\$100.00	\$800.00	\$32,000.00

(All Courtesy of Jeremy Feath)



# Analysis 2

## Roof System Redesign

# Cost Comparison

# University Engineering Building

## Mid-Atlantic University, United States

### Project Overview

#### Analysis 1: Clean Room Coordination

- Background
- Project Organization Results
- Coordination Results

#### Analysis 2: Roof System Redesign

- Background
- Schedule Results
- Cost Comparison
- Structural Breadth

#### Analysis 3: Underground Spring

- Background
- Results
- Mechanical Breadth

#### Analysis 4: FM Information Delivery

#### Final Recommendations

#### Acknowledgements

Fully Adhered TPO Membrane Roof Estimate				
Material	Quantity	Unit	Cost/Unit	Total Cost
TPO Membrane (80 mil)	24000	SF	\$1.03	\$24,720.00
Multipurpose Adhesives	40	600 SF	\$145.00	\$5,800.00
Expansion Joint	800	LF	\$2.00	\$1,600.00
1/2" Protection Board	24000	SF	\$0.53	\$12,720.00
(2) 2" Rigid Insulation	24000	SF	\$0.65	\$15,600.00
Single-Ply Memb. Sealants	100	1 gal. Pail	\$75.00	\$7,500.00
Sealant Primers	100	1 gal. Pail	\$67.00	\$6,700.00
Sheet Flashing	24	100 SF	\$251.00	\$6,024.00
Bonding Adhesive	54	450 SF Pail	\$145.00	\$7,830.00
Fasteners	25	5" HD 1000/Pail	\$190.00	\$4,750.00
Metal Termination Bar	80	10 LF	\$7.00	\$560.00
<b>Total</b>				<b>\$93,804.00</b>

Traditional Built-Up Roof				
Material	Quantity	Unit	Cost/Unit	Total Cost
Ply VI Membrane (4 Layers)	96000	SF (1 - Layer)	\$0.85	\$81,600.00
Asphalt	30	ton	\$820.00	\$24,600.00
(2) 2" Rigid Insulation	24000	SF	\$0.65	\$15,600.00
Cover Board	24000	SF	\$0.53	\$12,720.00
<b>Total</b>				<b>\$134,520.00</b>

Labor Cost Estimate				
Roof Type	Duration (days)	Hourly Rate	Daily Rate	Total Cost
Fully-Adhered TPO	61	\$100.00	\$800.00	\$48,800.00
Built-Up Roof	65	\$100.00	\$800.00	\$52,000.00
InvisiWeld TPO	40	\$100.00	\$800.00	\$32,000.00

InvisiWeld TPO Membrane Roof				
Material	Quantity	Unit	Cost/Unit	Total Cost
TPO Membrane (80 mil)	24000	SF	\$1.03	\$24,720.00
Expansion Joint	800	LF	\$2.00	\$1,600.00
1/2" Protection Board	24000	SF	\$0.53	\$12,720.00
(2) 2" Rigid Insulation	24000	SF	\$0.65	\$15,600.00
Single-Ply Memb. Sealants	100	1 gal. Pail	\$75.00	\$7,500.00
Sealant Primers	100	1 gal. Pail	\$67.00	\$6,700.00
Sheet Flashing	24	100 SF	\$251.00	\$6,024.00
Fasteners	25	5" HD 1000/Pail	\$190.00	\$4,750.00
InvisiWeld Plates	21	500 Pail	\$90.00	\$1,890.00
InvisiWeld Machine	1	EA	\$7,500.00	\$7,500.00
T-Patches	5250	EA	\$0.44	\$2,310.00
Pipe Boots	10	EA	\$23.00	\$230.00
<b>Total</b>				<b>\$91,544.00</b>

**Total Cost Savings:**

**\$26,760.00**

(All Courtesy of Jeremy Feath)



# Analysis 2 Roof System Redesign

# Roof Deck Study

# University Engineering Building Mid-Atlantic University, United States

## Project Overview

- Analysis 1: Clean Room Coordination
  - Background
  - Project Organization Results
  - Coordination Results

- Analysis 2: Roof System Redesign
  - Background
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- Analysis 3: Underground Spring
  - Background
  - Results
  - Mechanical Breadth

- Analysis 4: FM Information Delivery

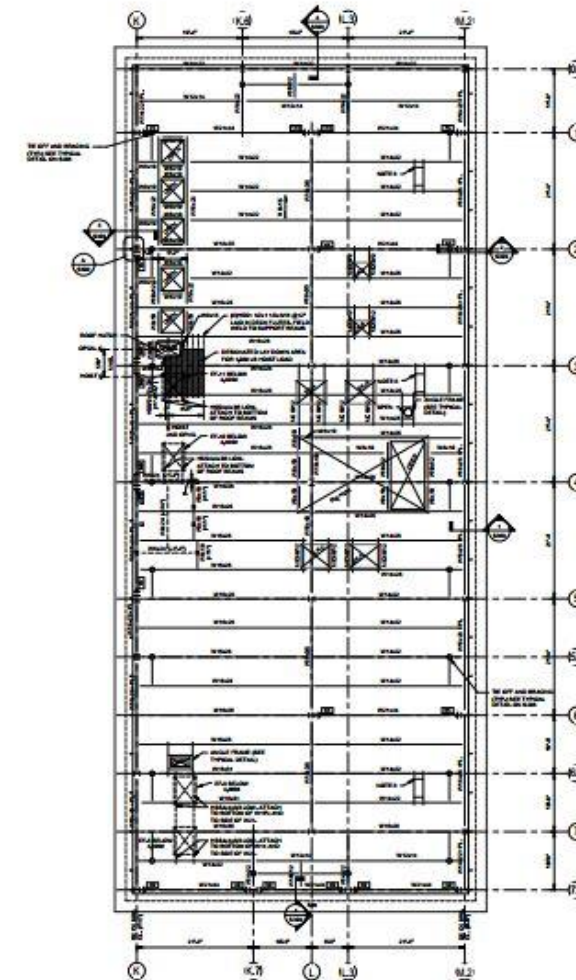
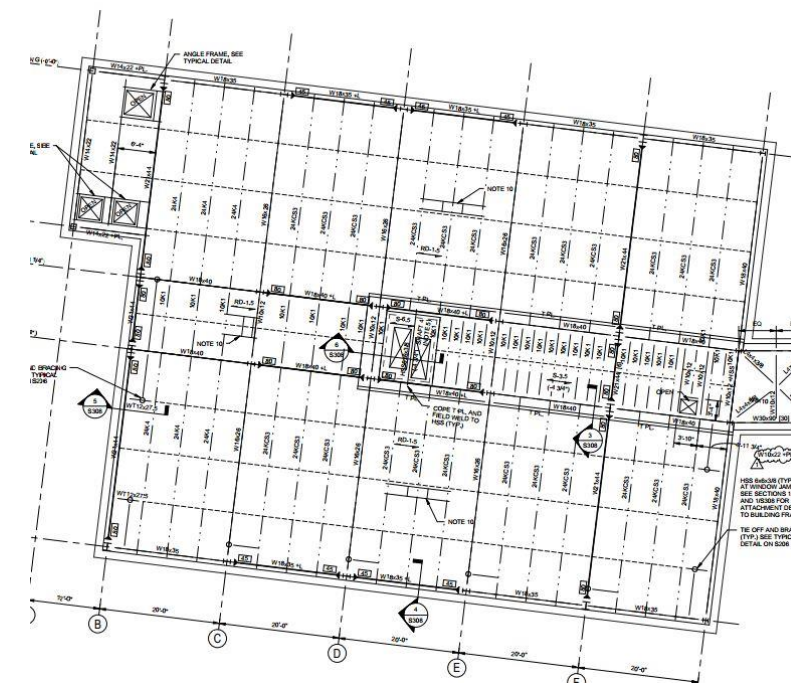
## Final Recommendations

## Acknowledgements

### Purpose:

- To study the affect increased roof load has on metal decking

Original Deck: 1-1/2", 20 gauge



(Courtesy of Stantec)

(Courtesy of Vulcraft)

**1.5 B, BI, BA, BIA, BSV**

Maximum Sheet Length 42'-0"  
Extra charge for lengths under 6'-0"  
ICC ESR-3415  
FM Global Approved<sup>2</sup>

**SECTION PROPERTIES**

Deck Type	Design Thickness (in)	W (psf)	Section Properties				I <sub>x</sub> (in <sup>4</sup> )	I <sub>y</sub> (in <sup>4</sup> )	S <sub>x</sub> (in <sup>3</sup> )	S <sub>y</sub> (in <sup>3</sup> )
			L <sub>1</sub> (in)	L <sub>2</sub> (in)	L <sub>3</sub> (in)	L <sub>4</sub> (in)				
B24	0.0239	1.48	6.107	6.120	6.135	6.131	2634	60		
B22	0.0206	1.75	6.155	6.165	6.185	6.182	1918	33		
B20	0.0158	2.14	6.201	6.234	6.222	6.247	2193	33		
B18	0.0419	2.49	6.246	6.277	6.260	6.289	2546	33		
B16	0.0474	2.82	6.289	6.318	6.295	6.327	2870	33		
B15	0.0598	3.54	6.372	6.409	6.372	6.411	3576	33		

**ACOUSTICAL INFORMATION**

Deck Type	TL <sub>1</sub> (dB)	TL <sub>2</sub> (dB)	TL <sub>3</sub> (dB)	TL <sub>4</sub> (dB)	TL <sub>5</sub> (dB)	TL <sub>6</sub> (dB)	TL <sub>7</sub> (dB)	TL <sub>8</sub> (dB)	TL <sub>9</sub> (dB)	TL <sub>10</sub> (dB)
1.5B, 1.5BIA	11	18	66	1.02	0.61	0.33	0.60			

**VERTICAL LOADS FOR TYPE 1.5B**

No. of Spans	Deck Type	Max. SCL Cover Span	Allowable Total (PSF) <sup>1</sup> Load Capacity Reduction of 1.00 or 1 psf (PSF)												
			5'-0"	6'-0"	8'-0"	10'-0"	12'-0"	14'-0"	16'-0"	18'-0"	20'-0"	24'-0"			
1	B24	4-8	189/195	192/195	197/195	202/195	207/195	212/195	217/195	222/195	227/195	232/195	237/195	242/195	247/195
	B22	6-7	189/195	192/195	197/195	202/195	207/195	212/195	217/195	222/195	227/195	232/195	237/195	242/195	247/195
	B18	7-1	189/195	192/195	197/195	202/195	207/195	212/195	217/195	222/195	227/195	232/195	237/195	242/195	247/195
2	B24	9-10	124/113	103/113	86/113	74/113	64/113	56/113	49/113	43/113	38/113	33/113	29/113	25/113	21/113
	B22	8-5	189/195	192/195	197/195	202/195	207/195	212/195	217/195	222/195	227/195	232/195	237/195	242/195	247/195
	B18	8-5	189/195	192/195	197/195	202/195	207/195	212/195	217/195	222/195	227/195	232/195	237/195	242/195	247/195
3	B24	12-13	104/113	103/113	102/113	101/113	100/113	99/113	98/113	97/113	96/113	95/113	94/113	93/113	92/113
	B22	7-9	189/195	192/195	197/195	202/195	207/195	212/195	217/195	222/195	227/195	232/195	237/195	242/195	247/195
	B18	8-1	210/209	174/211	147/211	128/211	108/211	95/211	83/211	74/211	66/211	59/211	54/211	50/211	47/211

**ACOUSTICAL INFORMATION**

Type B (wide rib) deck provides excellent structural load carrying capacity per pound of steel utilized, and its restable design eliminates the need for fire-act ends.

1" or more rigid insulation is required for Type B deck.

Acoustical deck (Type BA, BIA) is particularly suitable in structures such as auditoriums, schools, and theaters where sound control is desirable. Acoustic perforations are located in the vertical webs where the load carrying properties are negligibly affected (less than 5%).

Inert, non-organic glass fiber sound absorbing batts are placed in the ribs operating to absorb up to 65% of the sound striking the deck. Batt is field installed and may require separation.

**Notes:**  
1. Minimum interior bearing length required is 1.50 inches. Minimum interior bearing length required is 3.00 inches.  
2. FM Global approved numbers and spans available on page 21.

(Courtesy of Vulcraft)

### TPO vs. Garden Roof

Lab Roof Calculations | University Engineering Building | Jeremy Feath

Built-Up + TPO Roofs:

$W_{TL} = 2 \times 8 + 30 + 30 + 30 = 100 \text{ psf}$  @ 5'-4" span, 3 or more

Try 1.5B Vulcraft Roof Deck

- For max construction span, need B24  $\rightarrow 5'-10"$  (Table)  $\geq 5'-4"$  (Given)  $\therefore$  OK
- $W_{TL}$  for strength, B24 carries 128 psf  $> 100 \text{ psf}$  (Given)  $\therefore$  Condition does not Control
- Max load for  $\frac{1}{240}$ , B24 carries 90 psf for  $\frac{1}{240}$ ,  $90 \times \frac{240}{180} = 120 \text{ psf} > 100 \text{ psf}$
- $\therefore$  Condition does not Control

**Use B24 Deck**

Garden Roof:

$W_{TL} = 2 \times 4 + 100 + 30 + 30 = 166 \text{ psf}$  @ 5'-4" span, 3 or more

Try 1.5B Vulcraft Roof Deck

- For max construction span, need B18  $\rightarrow 9'-1"$  (Table)  $\geq 5'-4"$  (Given)  $\therefore$  OK
- $W_{TL}$  for strength, B18 carries 174 psf  $> 166 \text{ psf}$  (Given)  $\therefore$  Condition does not Control
- Max load for  $\frac{1}{240}$ , B18 carries 217 psf for  $\frac{1}{240}$ ,  $217 \times \frac{240}{180} = 289 > 166 \text{ psf}$
- $\therefore$  Condition does not control

**Use B18 Deck**

(Courtesy of Jeremy Feath)

Office Roof Calculations | University Engineering Building | Jeremy Feath

Built-Up Roof + TPO Roof:

$W_{TL} = 2 \times 8 + 30 + 10 + 30 + 80 \text{ psf}$  @ 5'-0" span, 3 or more

Try 1.5B Vulcraft Roof Deck

- For max construction span, need B24  $\rightarrow 5'-10"$  (Table)  $\geq 5'-0"$  (Given)  $\therefore$  OK
- $W_{TL}$  for strength, B24 carries 154 psf  $> 80 \text{ psf}$  (Given)  $\therefore$  Condition does not Control
- Max load for  $\frac{1}{240}$ , B24 carries 120 psf,  $120 \times \frac{240}{180} = 160 \text{ psf} > 80 \text{ psf}$
- $\therefore$  Condition does not control

**Use B24 Deck**

Garden Roof:

$W_{TL} = 2 \times 4 + 100 + 10 + 30 = 146 \text{ psf}$  @ 5'-0" span, 3 or more

Try 1.5B Vulcraft Roof Deck

- For max construction span, need B24  $\rightarrow 5'-10"$  (Table)  $\geq 5'-0"$  (Given)  $\therefore$  OK
- $W_{TL}$  for strength, B24 carries 154 psf  $> 146 \text{ psf}$  (Given)  $\therefore$  Condition does not Control
- Max load for  $\frac{1}{240}$ , B24 carries 120 psf,  $120 \times \frac{240}{180} = 160 \text{ psf} > 146 \text{ psf}$
- $\therefore$  Condition does not control

**Use B24 Deck**

(Courtesy of Jeremy Feath)



***Jeremy Feath***  
*Construction Option*

# **Analysis 3**

***University Engineering Building***  
*Mid-Atlantic University, United States*

***Project Overview***

***Analysis 1: Clean Room  
Coordination***

*Background*  
*Project Organization Results*  
*Coordination Results*

***Analysis 2: Roof System Redesign***

*Background*  
*Schedule Results*  
*Cost Comparison*  
*Structural Breadth*

***Analysis 3: Underground Spring***

*Background*  
*Results*  
*Mechanical Breadth*

***Analysis 4: FM Information Delivery***

***Final Recommendations***

***Acknowledgements***

## ***Analysis 3: Underground Spring***



# Analysis 3

## Underground Spring

# Background

University Engineering Building  
Mid-Atlantic University, United States

### Project Overview

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Analysis 4: FM Information Delivery

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### Problems:

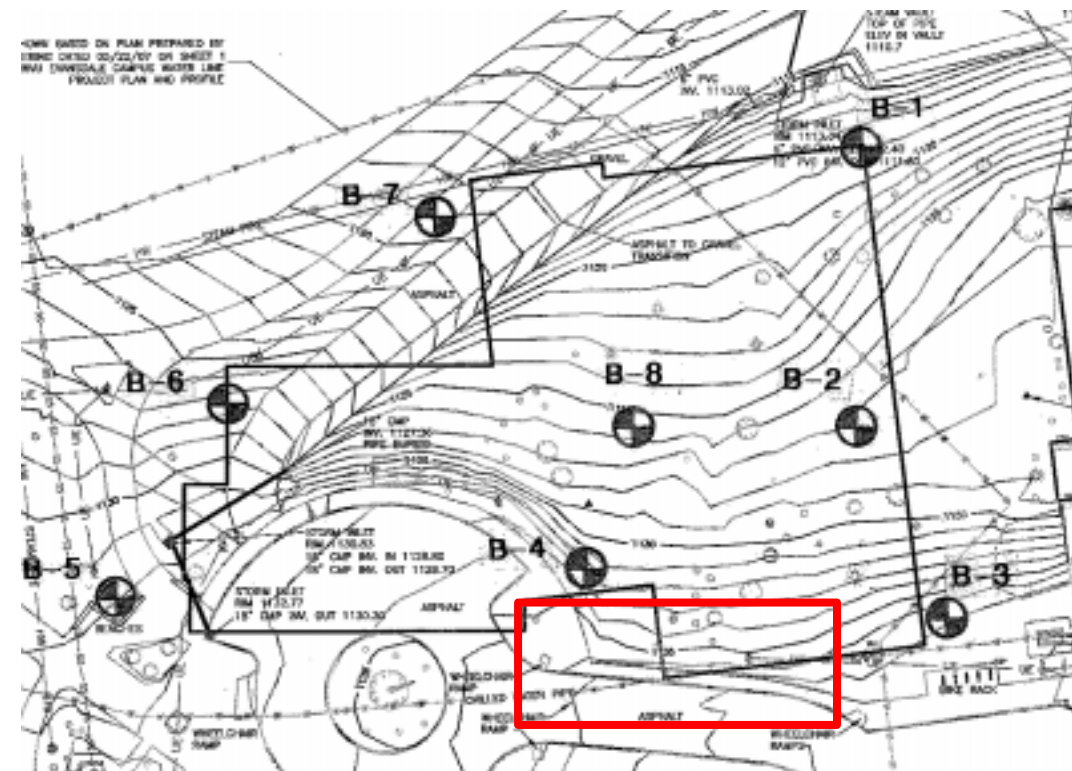
- Spring & Rain delayed construction during Excavation & Foundations
- Spring was NOT discovered during GeoTech Investigation



(Courtesy of Jeremy Feath)

### Proposed Solution:

- Addition of Waterproofing Membrane to Lab Foundation Wall w/ Sump Pump backup



(Courtesy of Stantec)



# Analysis 3 Underground Spring

# Background

University Engineering Building  
Mid-Atlantic University, United States

**Project Overview**

**Analysis 1: Clean Room Coordination**  
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**Analysis 4: FM Information Delivery**

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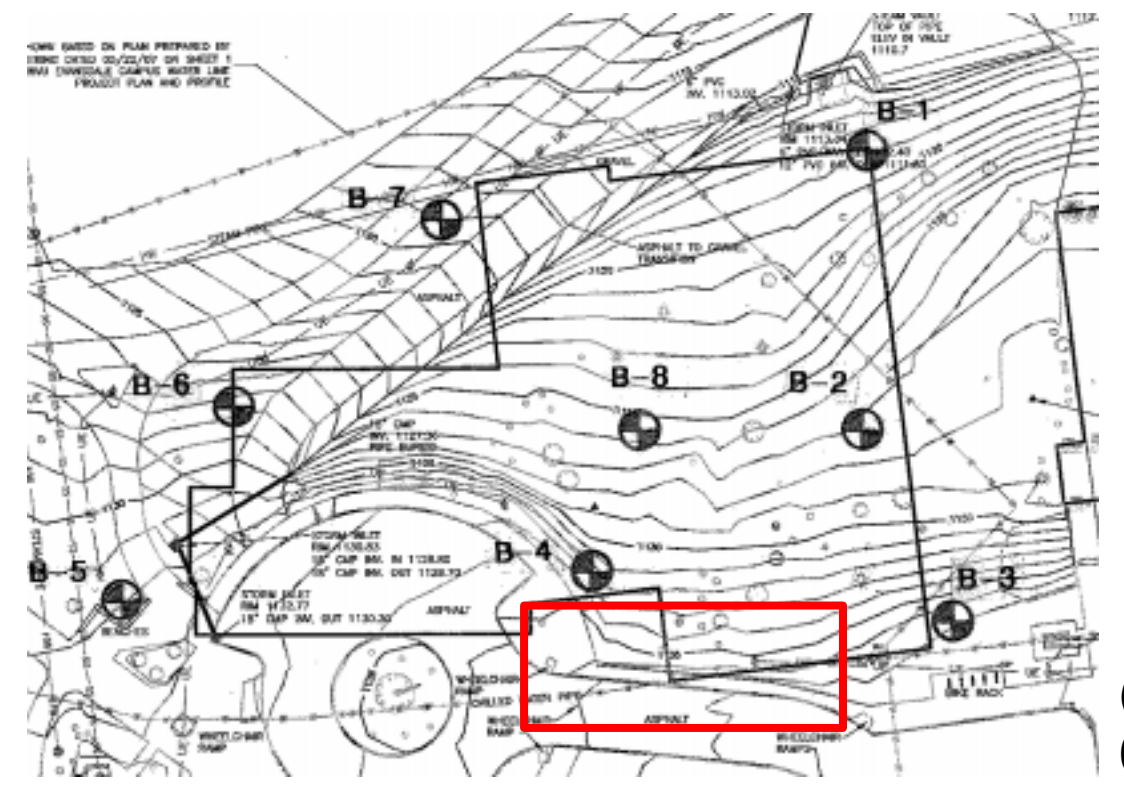
## Problems:

- Spring & Rain delayed construction during Excavation & Foundations
- Spring was NOT discovered during GeoTech Investigation

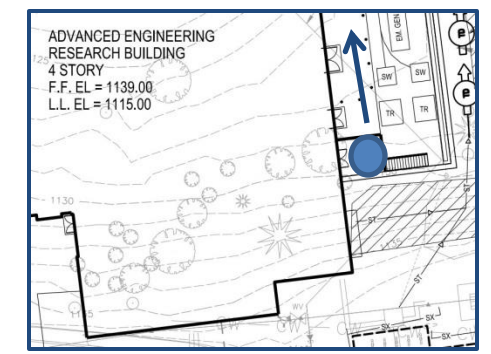
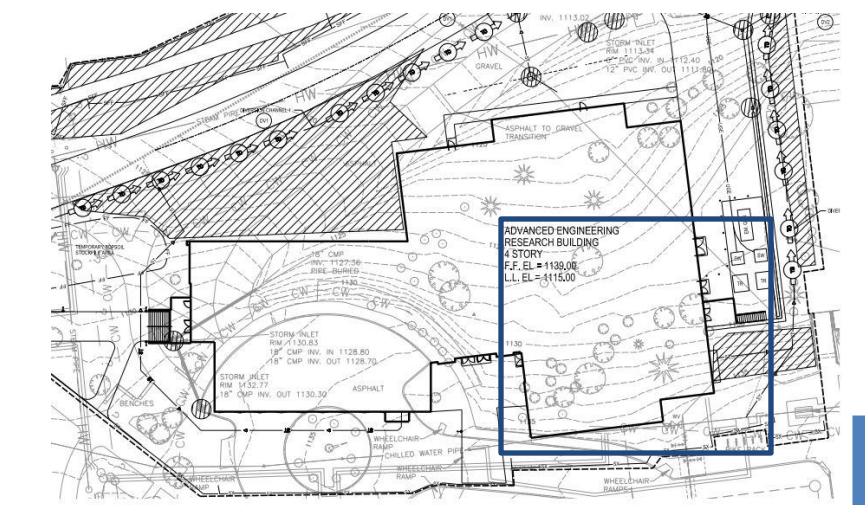


## Proposed Solution:

- Addition of Waterproofing Membrane to Lab Foundation Wall w/ Sump Pump backup



## Project Team Solution – Permanent Sump Pump



Sump Pump System Estimate

Material	Quantity	Unit	Cost per Unit	Total Cost
Sump Pump (Temporary)	1	EA	\$120.00	\$120.00
Sump Pump (Permanent)	1	EA	\$215.00	\$215.00
2" PVC	160	LF	\$12.09	\$1,934.40
Check Valve	1	EA	\$37.25	\$37.25
90° Elbow	1	EA	\$46.86	\$46.86
45° Elbow	3	EA	\$36.48	\$109.44
<b>Total</b>				<b>\$2,462.95</b>

(Const. DWGs Courtesy of Stantec)  
(Photos & Table Courtesy of Jeremy Feath)



# Analysis 3 Underground Spring

# Results

University Engineering Building  
Mid-Atlantic University, United States

## Project Overview

Analysis 1: Clean Room  
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Analysis 4: FM Information Delivery

Final Recommendations

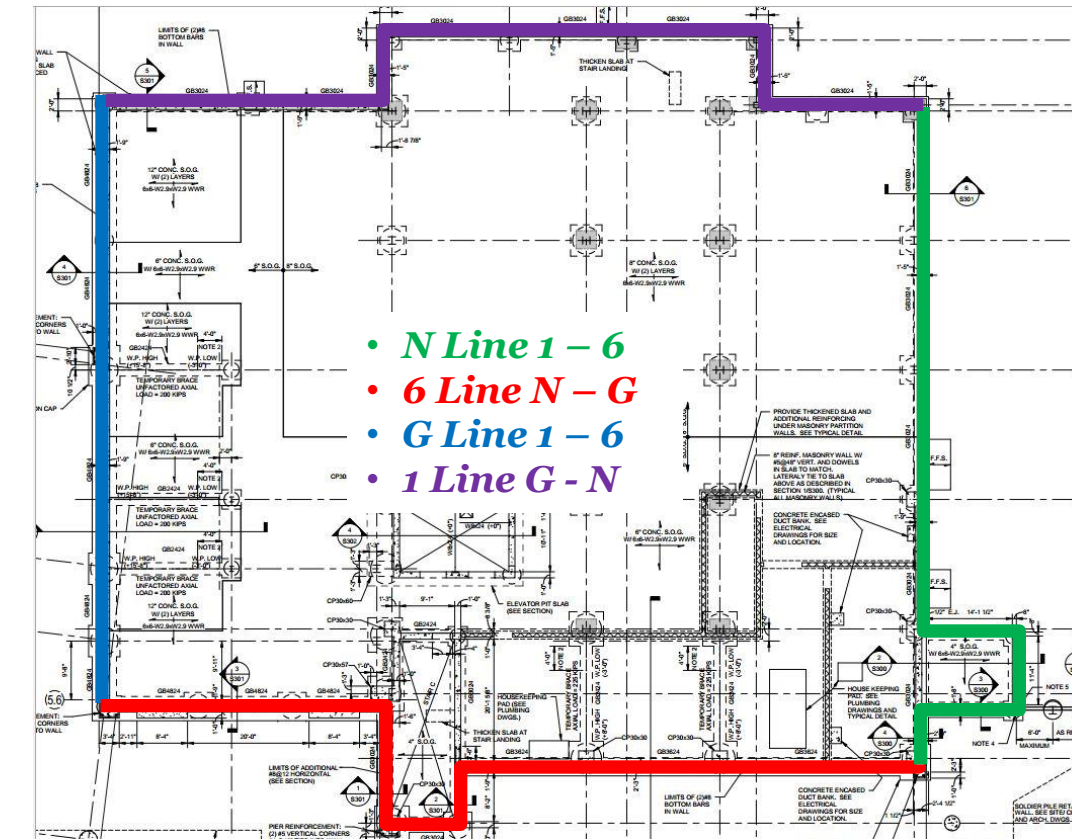
Acknowledgements

## Underground Spring Solution:

### Tamko TW-60 Waterproofing Membrane



(Courtesy of Tamko)



(Const. DWGs Courtesy of Stantec)  
(Photos & Table Courtesy of Jeremy Feath)





# Analysis 3 Underground Spring

# Results

# University Engineering Building Mid-Atlantic University, United States

## Project Overview

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Analysis 4: FM Information Delivery

Final Recommendations

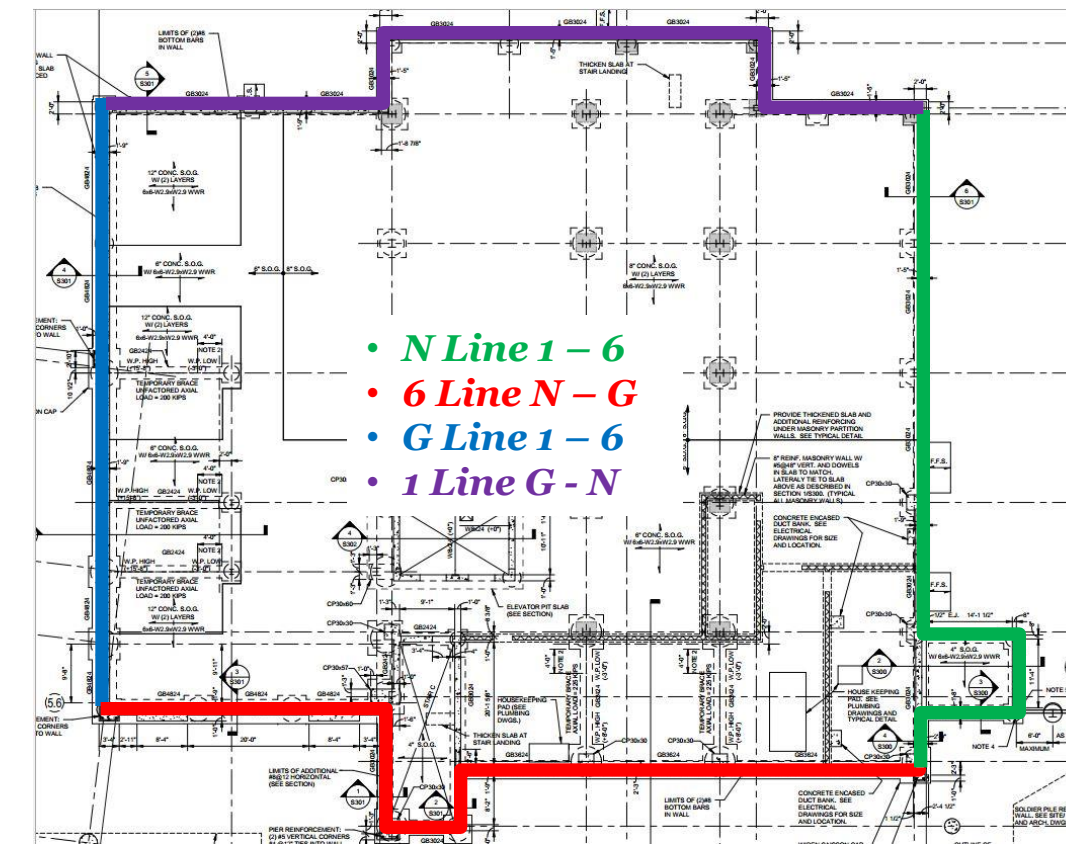
Acknowledgements

## Underground Spring Solution:

### Tamko TW-60 Waterproofing Membrane



(Courtesy of Tamko)



## Cost Estimate Impact

### Tamko TW-60 Material Foundation Wall Costs

Level 0 & Mezzanine (Lab)	Roll Width (in.)	Roll Size	Area Coverage	Wall Area	# Rolls Needed	Cost per Roll	Total Cost
N Line 1 - 6	39.375	39.375" x 61'	200	3404.88	18	\$292.00	\$5,256.00
6 Line N - G	39.375	39.375" x 61'	200	4173.36	21	\$292.00	\$6,132.00
G Line 1 - 6	39.375	39.375" x 61'	200	2496.96	13	\$292.00	\$3,796.00
1 Line G - N	39.375	39.375" x 61'	200	2210.18	12	\$292.00	\$3,504.00
<b>Total</b>							<b>\$18,688.00</b>

**Note: Labor Costs do NOT change**

**Total System Cost - \$21,151.00**

(Const. DWGs Courtesy of Stantec)  
(Table s Courtesy of Jeremy Feath)

### Sump Pump System Estimate

Material	Quantity	Unit	Cost per Unit	Total Cost
Sump Pump (Temporary)	1	EA	\$120.00	\$120.00
Sump Pump (Permanent)	1	EA	\$215.00	\$215.00
2" PVC	160	LF	\$12.09	\$1,934.40
Check Valve	1	EA	\$37.25	\$37.25
90° Elbow	1	EA	\$46.86	\$46.86
45° Elbow	3	EA	\$36.48	\$109.44
<b>Total</b>				<b>\$2,462.95</b>

- Cost difference made up from Roof System change
- System is necessary to combat the Spring in combination with heavy rainfall



# Analysis 3 Underground Spring

# Results

# University Engineering Building Mid-Atlantic University, United States

## Project Overview

### Analysis 1: Clean Room Coordination

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- Coordination Results

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### Analysis 3: Underground Spring

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### Analysis 4: FM Information Delivery

### Final Recommendations

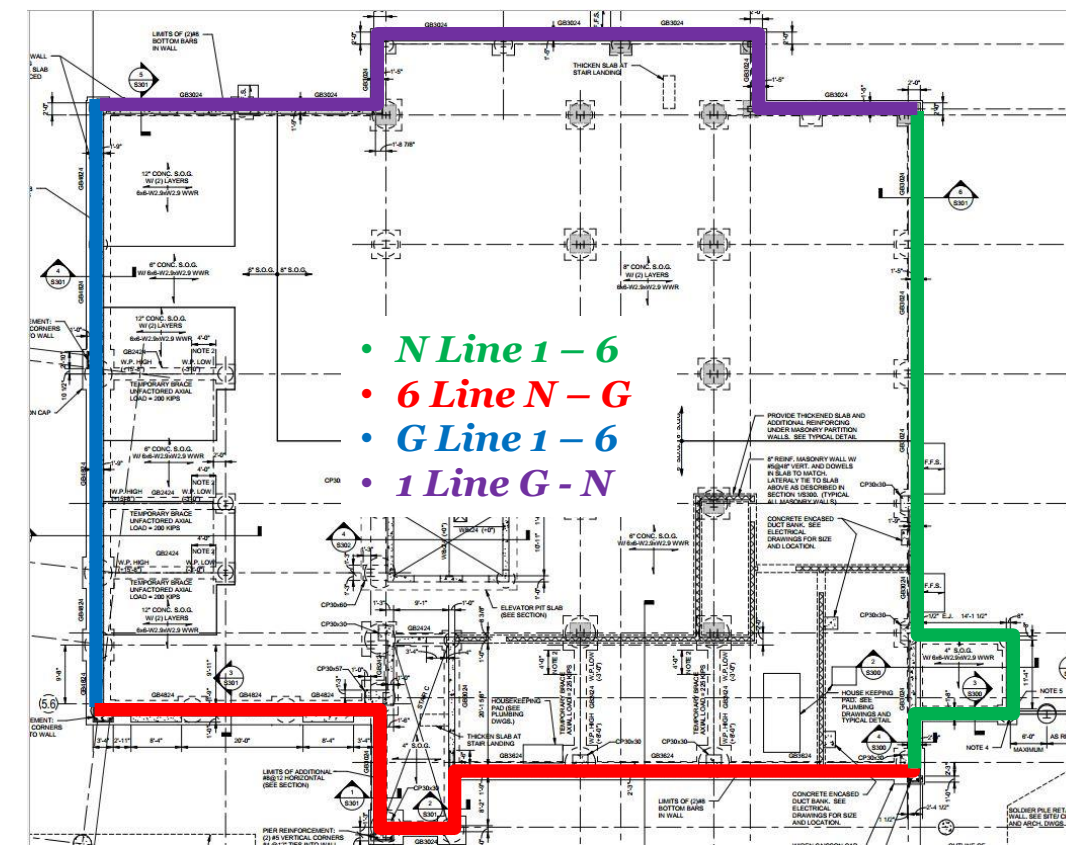
### Acknowledgements

## Underground Spring Solution:

## Tamko TW-60 Waterproofing Membrane



(Courtesy of Tamko)



## Schedule Impact

### Foundation Waterproofing Membrane Durations

Level 0 & Mezzanine (Lab)	LF Coverage	Wall Height	Daily Output (LF)	Daily Output (SF)	Coverage Area	Duration
N Line 1 - 6	141.87	24	80	1920	3404.88	1.77
6 Line N - G	173.89	24	80	1920	4173.36	2.17
G Line 1 - 6	104.04	24	80	1920	2496.96	1.30
1 Line G - N	157.87	14	80	1120	2210.18	1.97
<b>Total</b>						<b>7.22</b>

**Total Schedule Change = +4 days**

*Roughly 1 extra day per Wall section*

(Const. DWGs Courtesy of Stantec)  
(Table & Schedule Courtesy of Jeremy Feath)

9	N Line 1 - 6	27 days	Tue 4/2/13	Wed 5/8/13
10	Bituminus Seal	1 day	Tue 4/2/13	Tue 4/2/13
11	Excavate Grade Beam	2 days	Tue 4/2/13	Wed 4/3/13
12	Place Geo-Foam	1 day	Wed 4/3/13	Wed 4/3/13
13	FRP Grade Beams	4 days	Thu 4/4/13	Tue 4/9/13
14	FRP Walls N Line 1 - 3	2 days	Fri 5/3/13	Mon 5/6/13
15	Install Sheet Waterproofing N Line 1 - 3	1 day	Tue 5/7/13	Tue 5/7/13
16	FRP Walls N Line 3 - 6	2 days	Mon 5/6/13	Tue 5/7/13
17	Install Sheet Waterproofing N Line 3 - 6	1 day	Wed 5/8/13	Wed 5/8/13

- Each Wall section follows same pattern
- Duration from Table, broken down based on # of pours for the Wall section
- Schedule increase acceptable, work can be completed around steel erection



# Analysis 3 Underground Spring

# Sizing of a Sump Pump

# University Engineering Building Mid-Atlantic University, United States

## Project Overview

**Analysis 1: Clean Room Coordination**  
Background  
Project Organization Results  
Coordination Results

**Analysis 2: Roof System Redesign**  
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Cost Comparison  
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**Analysis 3: Underground Spring**  
Background  
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Mechanical Breadth

**Analysis 4: FM Information Delivery**

**Final Recommendations**

**Acknowledgements**

## Technical Data:

- System Capacity = 30 GPM
- Total Dynamic Head = 14'
  - Static Head = 10'
  - Friction Head = 3.27'

$$\frac{(Actual + Equivalent)(Friction Loss)}{100}$$

$$\frac{(150 + 30.8)(1.81)}{100} = 3.27$$

### SUMP PUMPS

#### HP33/HP50

Ideal for applications with small diameter sump pits



Typical Application	Basement sumps, dewatering, light effluent, water transfer
Capacities	up to 62 GPM (235 LPM)
Heads	up to 32 ft. (9.8 m)
Electrical	1/3 HP, 115V, 1ø, 9.8A, 60Hz; 1/2 HP, 115V, 1ø, 12A, 60Hz
Motor	1/3 or 1/2 HP shaded pole with thermal overload, 1550 RPM
Continuous Liquid Temperature	130°F (54°C)
Minimum Recommended Sump Diameter	10" (25.4 cm)
Automatic Operation	2-Pole float switch
Materials of Construction	Cast iron
Impeller	Thermoplastic, vortex type
Discharge Size	1-1/2" NPT (38.1 mm)
Solids Handling	1/2" (12.7 mm)
Power Cord	10' or 20', 16/3, SJTW-A, SJTW

#### Superior Features

- 2-pole switch design permits water fit in sump pits as small as 10" in diameter
- Oil-filled motor for maximum heat dissipation
- Thermal overload protection, shaded pole motor with no starting switch or relay
- Carbon/ceramic seal protects motor against water leakage
- Lubricated ball bearings and shaft seal for longer service life
- Easy field-serviceable pump, intake screen volute base, switch and power cord
- Anti-arc hole in base reduces labor

#### Performance



#### HTS33A1

Submersible sump pump designed for high temperatures up to 194°F



Typical Application	Boiler blow-down, condensate pits and hot water transfer
Capacities	up to 45 GPM (170 LPM)
Heads	up to 21 ft. (6.4 m)
Electrical	115V, 1ø, 12.0 FLA, 60Hz
Motor	1/3 HP shaded pole with thermal overload, 1550 RPM
Continuous Liquid Temperature	194°F (90°C) with switch; 200°F (93°C) manual
Minimum Recommended Sump Diameter	18" (457.2 mm)
Automatic Operation	Wide-angle float switch (manual available)
Materials of Construction	Cast iron
Impeller	Cast iron
Discharge Size	1-1/2" NPT (38.1 mm)
Solids Handling	3/4" (19.1 mm)
Power Cord	20', 16/3, SJOOW-A/SJOW

#### Superior Features


- Easily field serviceable
- Oil-filled motor for bearing lubrication and maximum heat dissipation
- Thermal overload protection, shaded pole motor with no starting switch or relay
- Heavy cast-iron motor housing for cooler motor which extends the life
- Maintenance-free operation
- Wide-angle, mercury-free, high-temperature mechanical float switch
- Automatic piggyback models available but can be operated manually by plugging directly into outlet
- Cast-iron volute impeller and volute passes 3/4" solids

#### Performance



### HP33/HP50

Ideal for applications with small diameter sump pits



Typical Application: Basement sumps, dewatering, light effluent, water transfer

Capacities: up to 62 GPM (235 LPM)

Heads: up to 32 ft. (9.8 m)

Electrical: 1/3 HP, 115V, 1ø, 9.8A, 60Hz; 1/2 HP, 115V, 1ø, 12A, 60Hz

Motor: 1/3 or 1/2 HP shaded pole with thermal overload, 1550 RPM

Continuous Liquid Temperature: 130°F (54°C)

Minimum Recommended Sump Diameter: 10" (25.4 cm)

Automatic Operation: 2-Pole float switch

Materials of Construction: Cast iron

Impeller: Thermoplastic, vortex type

Discharge Size: 1-1/2" NPT (38.1 mm)

Solids Handling: 1/2" (12.7 mm)

Power Cord: 10' or 20', 16/3, SJTW-A, SJTW

### HTS33A1

Submersible sump pump designed for high temperatures up to 194°F



Typical Application: Boiler blow-down, condensate pits and hot water transfer

Capacities: up to 45 GPM (170 LPM)

Heads: up to 21 ft. (6.4 m)

Electrical: 115V, 1ø, 12.0 FLA, 60Hz

Motor: 1/3 HP shaded pole with thermal overload, 1550 RPM

Continuous Liquid Temperature: 194°F (90°C) with switch; 200°F (93°C) manual

Minimum Recommended Sump Diameter: 18" (457.2 mm)

Automatic Operation: Wide-angle float switch (manual available)

Materials of Construction: Cast iron

Impeller: Cast iron

Discharge Size: 1-1/2" NPT (38.1 mm)

Solids Handling: 3/4" (19.1 mm)

Power Cord: 20', 16/3, SJOOW-A/SJOW

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION				FEEDER INFORMATION					
	VOLTAGE	PHASE	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	NOTES	LOAD WATTS	LOCATION/ITEM
PLN-GB7	208/120V	3	MAIN/MLO		200A		MAIN BREAKER - 150A		FROM	DPLN-GB		TYPE	NORMAL	
RECESSED	GROUND FLOOR		WIRE		AIC RATING		10,000		SIZE	SEE RISER ON E601				
LOCATION/ITEM	LOAD WATTS	NOTES	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	NOTES	LOAD WATTS	LOCATION/ITEM
RCPT LAB 009	540		#12	3/4"	20A-1P	1	A---	2	20A-1P	3/4"	#12		540	RCPT LAB 011
RCPT LAB 009	540		#12	3/4"	20A-1P	3	--B--	4	20A-1P	3/4"	#12		540	RCPT LAB 011
RCPT LAB 009	540		#12	3/4"	20A-1P	5	----C	6	20A-1P	3/4"	#12		540	RCPT LAB 011
RCPT LAB 009	540		#12	3/4"	20A-1P	7	A---	8	20A-1P	3/4"	#12		540	RCPT LAB 011
RCPT LAB 009	540		#12	3/4"	20A-1P	9	----B	10	20A-1P	3/4"	#12		540	RCPT LAB 011
RCPT LAB 009	1000		#10	3/4"	30A-1P	11	----C	12	30A-1P	3/4"	#10		1000	RCPT LAB 011
RCPT LAB 009	1000		#10	3/4"	30A-1P	13	A---	14	30A-1P	3/4"	#10		1000	RCPT LAB 011
SPC RCPT LAB 009	1200		#10	3/4"	30A-2P	15	--B--	16	30A-2P	3/4"	#10		1200	SPC RCPT LAB 011
	1200					17	----C	18					1200	
SPC RCPT LAB 009	1200		#10	3/4"	30A-2P	19	A---	20	30A-2P	3/4"	#10		1200	SPC RCPT LAB 011
	1200					21	--B--	22					1200	
FUME HOOD 000H	400		#12	3/4"	20A-1P	23	----C	24	20A-1P	3/4"	#12		400	EM SHWR
FUME HOOD 000H	400		#12	3/4"	20A-1P	25	A---	26	20A-1P					SPARE
RCPT LAB 000H	540		#12	3/4"	20A-1P	27	--B--	28	20A-1P					SPARE
RCPT LAB 000H	540		#12	3/4"	20A-1P	29	----C	30	20A-1P					SPARE
RCPT LAB 000H	540		#12	3/4"	20A-1P	31	A---	32	20A-1P					SPARE
SPARE					20A-1P	33	--B--	34	20A-1P					SPARE
SPARE					20A-1P	35	----C	36	20A-1P					SPARE
SPARE					20A-1P	37	A---	38	20A-1P					SPARE
SPARE					20A-1P	39	--B--	40	20A-1P					SPARE
SPARE					20A-1P	41	----C	42	20A-1P					SPARE

NOTES:

- Level o Panelboards have the capacity to handle the additional load of a sump pump

(Const. DWGs Courtesy of Stantec)  
(Equation Courtesy of Jeremy Feath)  
(Literature Courtesy of Hydromatic)



# Analysis 4 CM to FM Information Delivery

# Summary

## University Engineering Building Mid-Atlantic University, United States

### Project Overview

**Analysis 1: Clean Room  
Coordination**  
Background  
Project Organization Results  
Coordination Results

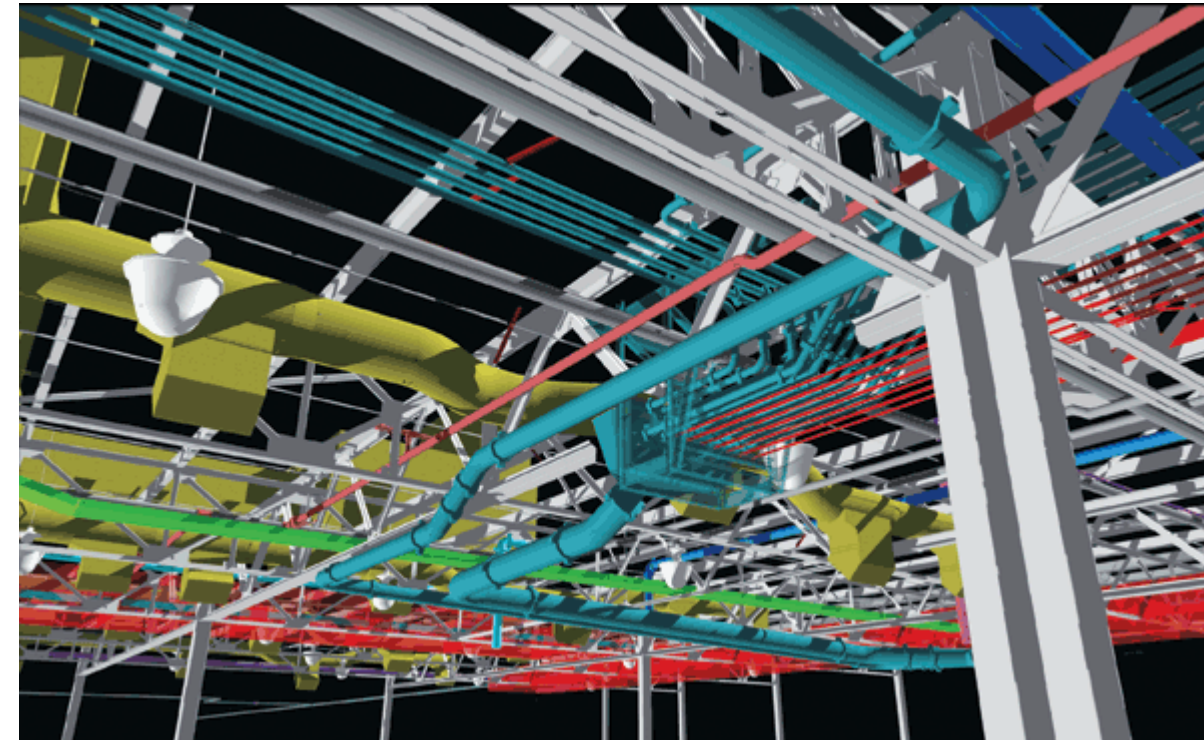
**Analysis 2: Roof System Redesign**  
Background  
Schedule Results  
Cost Comparison  
Structural Breadth

**Analysis 3: Underground Spring**  
Background  
Results  
Mechanical Breadth

**Analysis 4: FM Information Delivery**

Final Recommendations

Acknowledgements



### Understanding the impact and value of enterprise asset management

*Implementing IBM Maximo Asset Management to enable your smarter physical infrastructure*

### Key Takeaways:

- *Necessary to weed out critical information from excess*
- *It's not always the information itself, but the means of using that information for O&M*



*Jeremy Feath  
Construction Option*

# Final Recommendations

*University Engineering Building  
Mid-Atlantic University, United States*

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*Analysis 4: FM Information Delivery*

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### **Analysis 1: Clean Room Coordination:**

- Reorganize project team chart to reflect new contractual obligations for Hodess
- Creation of Coordination Schedule to maximize early coordination for the Clean Room
- **Recommendation: PROCEED**

### **Analysis 2: Roof System Redesign:**

- Replace Fully-Adhered TPO with InvisiWeld TPO system.
- Saves 20+ working days on schedule
- Saves \$27,000 in costs
- **Recommendation: PROCEED**



(Courtesy of Owner)

### **Analysis 3: Underground Spring:**

- Add Waterproofing Membrane in addition to the sump pump solution of the project team.
- Schedule Impact is negligible
- Cost Impact, while substantial, can be offset by Roof savings
- **Recommendation: PROCEED**

### **Analysis 4: CM – FM Information Delivery:**

- Outline created to help Owners/FM incorporate technologies
- Means of using information more important than information at times
- **Recommendation: PROCEED**



*Jeremy Feath*  
*Construction Option*

# Acknowledgements

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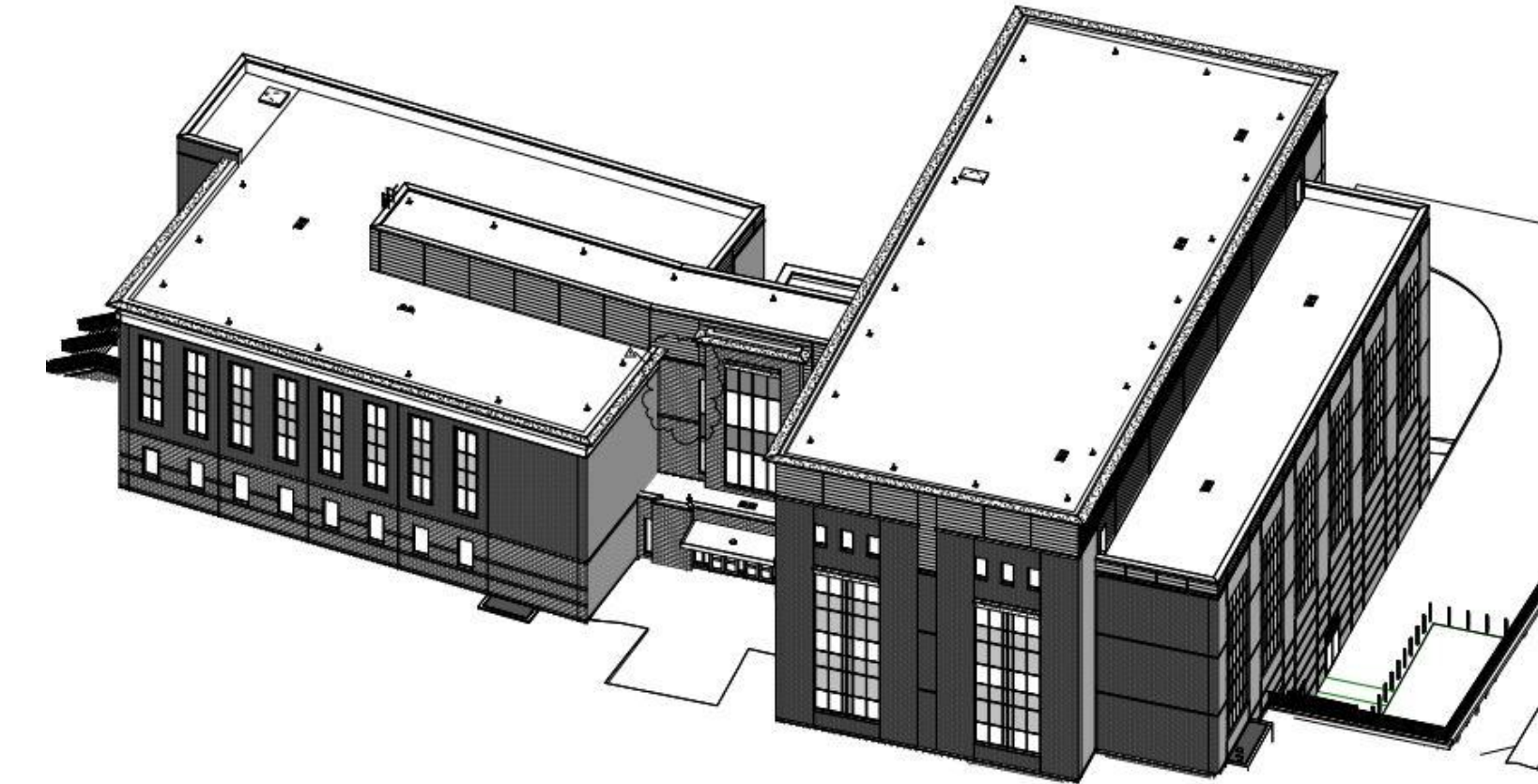
*Todd Bookwalter*

*Bud Curry*

*The University Project Team*

*Massaro Project Team*

*Friends & Family*



(Courtesy of Stantec)



# Jeremy Feath Construction Option

# Questions

# University Engineering Building Mid-Atlantic University, United States

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