TECHNICAL REPORT 2

UNIVERSITY BUILDING
UNIVERSITY, MID ATLANTIC REGION, UNITED STATES

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EXECUTIVE SUMMARY

Project Schedule

The University Engineering Building (UEB) project began construction on January 13th, 2013 and currently has an expected completion date early January 2015, consisting of 517 total work days. The project schedule was divided into seven main phases (with corresponding durations):

- Sitework/Site Utilities – 165 days
- Building Caissons/Foundations – 176 days
- Building Structure – 69 days
- Building Roof & Exterior Enclosure – 134 days
- Building Interior Rough-Ins & Finishes – 274 days
- Building Systems Start-Up Testing & Commissioning – 100 days
- Finish Sitework – 83 days

These divisions were sub-divided even further based on construction phases, office space or laboratory space, building levels and by trade.

Site Layout Plans

To examine the construction phases of the UEB and to analyze Massaro's site layout, four different site layout plans were created, highlighting four main phases of construction. Those phases are as follows:

- Excavation Phase
- Superstructure Phase
- MEP Rough-In Phase
- Finishes Phase

Full size site layout plans are provided in Appendix B.

General Conditions Estimate

A general conditions estimate was created for the University Engineering Building based a total construction duration of twenty-four months. Line items included were based off the items included in Massaro's general conditions estimate, with the only missing items being personnel salaries for the Vice President of Operations, Director of Construction and Senior Project Manager, overseeing the project. These costs were assumed to be part of office overhead costs, thus not included in general conditions. Being unable to obtain the actual general conditions cost from Massaro, due to the project being a hard bid and Massaro wanting to keep that information private, the assumption was made that their general conditions were 6% of the total construction costs.

My total general conditions estimated was $1.6 million, while the 6% of construction costs was $1.96 million, leaving a difference of $350,000.

Structural Systems Estimate

To gain a better understanding of the UEB's structural system, a detailed estimate was performed highlighting five key areas of analysis: caissons, concrete, concrete reinforcement, structural steel and formwork.

The final cost breakdown is as follows:

- Concrete = $630,000
- Reinforcement = $111,000
- Structural Steel = $994,000
- Formwork = $301,000
- Metal Decking = $138,000

Actual structural system costs, provided by Massaro, totaled $2.3 million. My structural system estimate, after taking into account miscellaneous steel, tax and location, totaled $2.4 million, with the differences due to cost assumptions in RS Means and only being provided a rough contract cost by Massaro.

MEP Assemblies Estimate

The assemblies estimate was broken into two main systems: electrical and mechanical/plumbing, since the mechanical and plumbing is performed by the same subcontractor, thus there being only one contract for both trades.

The electrical estimate took into account items such as switchgears, panelboards, receptacles, lighting fixtures, generators, feeders and motors. The actual electrical contract value is $3.4 million, with the assemblies estimate coming in at $3.1 million, a difference of just over 10%.

The mechanical and plumbing estimate was the more difficult of the two, due to RS Means inability to provide costs for highly customized equipment. Costs for the air-handling units, duct work and lab equipment were provided by Massaro as a means to have a more accurate estimate. Other items included in the estimate are: water closets, lavatory systems, water cooler systems, roof drain systems, water heaters, etc. The actual mechanical and plumbing contract value is $11 million, with the assemblies estimate coming in at $10 million, falling just under a difference of 10%.

Constructability Challenges

Three different constructability challenges are discussed in this report, with two having already occurred and the third being anticipated in the coming months. The first constructability challenge deals with the coordination issues with installing the mezzanine air-handling units in the building during the steel erection phase because of the AHU's size. The second constructability challenge involves excavation and dewatering issues the project team encountered. The main issue was an underground spring not found during the geo-technical report and along with disruptive weather caused delays and issues with foundation work. The third constructability challenge is currently being analyzed by the project team dealing with the building enclosure during the winter months.

BIM Use Evaluation

A BIM use evaluation was performed based on uses outline by Massaro. Those uses included creation of a 3D model of the steel and MEP systems, used mainly for coordination between trades prior to construction beginning on those systems, the creation of a 4D model to track construction progress and utilizing both for quality control purposes.

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UEB SCHEDULE

What makes the University Engineering Building unique in terms of scheduling is at its basic components, the building is really two smaller buildings joined by a connecting corridor. This idea was used heavily by Massaro Construction when creating the schedule and in-turn, my detailed project schedule. The UEB is broken into two main phases, the Office space and the Laboratory Space and one sub-phase, Level 0 and the Mezzanine. The original project schedule began in January 2013 and had a substantial completion date of November 2014, but due to delays early in the construction phase, the current completion date is set for January 2015. This new completion date is reflected in my project schedule to better reflect the current status of the project. Please see Appendix for complete schedule.

Sitework

Notice to proceed was given on January 14th, 2013, almost one year to the day that the donation to fund the project was presented to the University. Site mobilization and prep work was completed by the end of February 2013, with excavation work beginning in early February. This is the first instance where the phasing of activities based on Office and Lab space, where excavation for the Lab space began first. This was done first because Level 0 and the Mezzanine occupy more of the lab wing of the building below grade, second this area is located closet to neighboring buildings, in this instance the Soils/Plants Building and as stated below in this report, excavation was difficult as to not affect the Soils Building in any possible way. By far, the longest activity to complete was construct soldier pile retaining wall which was caused by many weather delays that affected portions of the foundation work, which will be discussed further in this report.

Figure 1: Site Excavation (Courtesy of Owner)

Foundations

This phase of construction was again split into the Office and Lab spaces. The lab foundations were started first due to the west foundation wall separates the Lab foundation from the Office foundation, which the Office foundation walls tie into, also the Lab walls are deeper into the ground at twenty-four feet below grade, compared to ten feet for the Office. The foundation phase was the main cause for project delays and caused all other phases to shift later, pushing the completion date back of the final building.

Structure

In order to keep the structural phase on pace with the project schedule the initial delivery of steel had to be met. The steel sequences were broken down into levels and sections consisting of 23 total sequences. The Laboratory space consists of sequences 1-17 which are broken into 3 different activities, each covering roughly one floor. The lab structure is being placed first due to the coordination issues with the air-handling units going in both the mezzanine and the penthouse, with the office following suit as the last portion of sequences for the lab are being erected. Metal decking and concrete slabs are sequenced to mimic the steel erection sequencing; also the activities are set during the same time as steel erection to keep pace with the schedule.

Exterior Enclosure & Roof

In the coming months work will begin on the building façade, marking a critical piece of the schedule where the building must be enclosed in order to begin the rough-in phase due to required temperature and environment settings for mechanical equipment. Both of the main phases follow the same sequence of activities to construct the enclosure system with a two week difference between the start of the lab space and the start of the office space.

Interior Rough-In & Finishes

By far the most detailed and intensive phase of the project schedule is for saved for the interior rough-ins and finishes. In order to gain a better perspective on the flow of work and the amount of work, I broke down the activities into sections by floor and then by trade. The Mechanical Level 0 and Mezzanine activities are shown in greater detail, but Levels 1 – Penthouse follow the same activities with some slight variations. Examples of the trade by trade breakdown can be seen in the following figure.

Mechanical Level 0 & Mezzanine		274	13-Nov-13	03-Dec-14
Lab - Mechanical Level		253	13-Nov-13	04-Nov-14
Mechanical & Plumbing Trade		224	18-Nov-13	29-Sep-14
A1810	Install Duct Risers	10	18-Nov-13	02-Dec-13
A1820	R-I Storm	25	25-Nov-13	31-Dec-13
A1830	R-I Water Supply & Return	34	25-Nov-13	13-Jan-14
A1840	R-I Cast Iron & PVC Sanitary	29	03-Dec-13	13-Jan-14
A1850	HVAC Piping Equipment	32	05-Dec-13	20-Jan-14
A1860	Install Duct Mains	41	25-Nov-13	22-Jan-14
A1870	Install Branch Ducts	51	17-Dec-13	26-Feb-14
A1880	Install HVAC Equipment	29	23-Jan-14	04-Mar-14
A1890	R-I Lab Waste/Vent	19	16-Dec-13	10-Jan-14
A1900	R-I & Test In-Wall Plumbing	50	02-Jan-14	12-Mar-14
A1910	R-I Water, Vacuum, Air	35	13-Jan-14	28-Feb-14
A1920	Install GRD's	34	03-Jun-14	18-Jul-14
A1930	Plumbing Equipment/Fixtures	61	07-Jul-14	29-Sep-14
Electrical Trade		245	18-Nov-13	28-Oct-14
A1940	Layout & Top Track	8	18-Nov-13	27-Nov-13
A1950	R-I Power Distribution	35	03-Dec-13	21-Jan-14
A1960	R-I Electric Room	35	23-Dec-13	10-Feb-14
A1970	O/H Branch R-I Power	41	23-Dec-13	18-Feb-14
A1980	R-I In-Wall Branch	43	07-Jan-14	06-Mar-14
A1990	O/H Branch R-I Systems	30	22-Jan-14	04-Mar-14
A2000	Electrical Lighting/Trim-Out	40	22-May-14	16-Jul-14
A2010	Systems Trim-Out	67	17-Jul-14	17-Oct-14
A2020	Branch Trim-Out	74	17-Jul-14	28-Oct-14
Fire Suppression Trade		152	13-Nov-13	16-Jun-14
A2030	Spray Fireproofing	8	13-Nov-13	22-Nov-13
A2040	O/H Sprinkler R-I	50	02-Jan-14	12-Mar-14
A2050	Sprinkler Trim	10	03-Jun-14	16-Jun-14

Figure 2: Trade Rough-In Activities Breakdown

See Appendix A for Complete Schedule

Under the Mechanical Level 0 and Mezzanine section of the schedule falls the clean room and its associated activities. Failure to complete all necessary activities, Mechanical, Electircal, Plumbing (MEP) rough-in and building enclosure, would delay the installation of the clean room, thus affecting testing and commissioning since the final clean for the clean room occurs in December 2014, around the time final systems commissioning begins. This alone could put turning the building to the Owner by January 2015 in jeopardy.

Once work begins on the above grade levels, 1 – Penthouse, the activities become more straightforward and repeat on each floor, except for the penthouse, which doesn't require as much work to make the space functional and habitable for daily occupants. The flow of work, like on the other phases of the building, moves from the laboratory wing to the office wing and ascending each floor, as shown in figure 3 below.

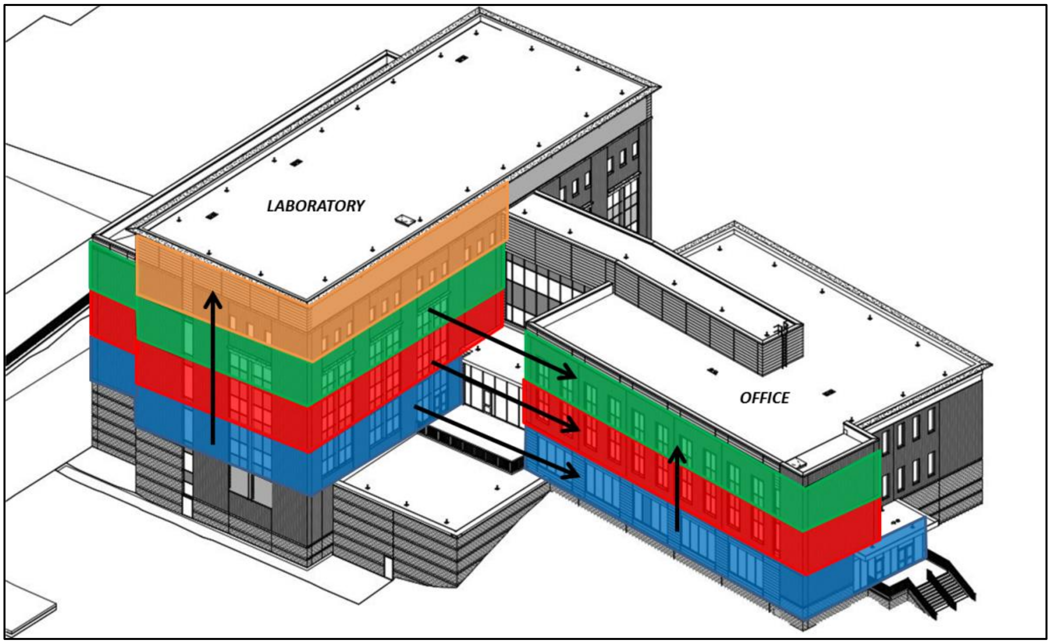


Figure 3: Interior Work Flow, Levels 1 – Penthouse (Courtesy of Stantec)

Systems Start-Up Testing & Commissioning

Aside from interior rough-in and finishes, the final key phase necessary to turn over a functional University Engineering Building is successful system start-up testing and commissioning. Since this is a research facility the MEP systems must function properly or the research being conducted could be wasted and grant monies revoked as a result.

Finish Sitework

The final piece of the UEB schedule is the completion of the sitework. This mainly consists of landscaping, roadway paving and sidewalk placements. This will occur prior to substantial completion but will not affect turn-over of the completed building, aside from life safety issues, such as walkways.

SITE LAYOUT PLANS

The site for the UEB project is unique in that it is centrally located in the middle of a string of buildings on the University's campus. Most of the neighboring buildings, not shown on the layout plans, are for the different science and engineering fields offered at the university, making the location of the UEB a logical choice. Located to the north of the building footprint is a road, now used for construction only access consisting of one entrance and exit and one-way travel. Originally near the Plant/Soils Building was a parking lot for faculty, which now functions as on-site parking and the location of the job trailers for Massaro Construction. Site layout plans were created for four main phases of construction, excavation, superstructure, MEP rough-in and finishes.

Excavation Phase

The excavation for the UEB project was based off the findings of the geo=technical report that was conducted by NGE Environmental & Geotechnical Engineering Solutions. Their findings determined that soil and bedrock conditions varied between the eight soil bores taken on the job-site, also there were concerns associated with the discovery of expansive pyritic material. The foundation recommendation made was for a deep foundation system, with drilled caissons chosen. This information determined how deep excavation needed to be in order for the caissons to be at the proper depth. One issue that the geo-tech report did not uncover was the existence of an underground spring that was later discovered during excavation. The exact location of the spring and its limits are currently unknown but it was located in the region of the lab wing (east wing) of the building.

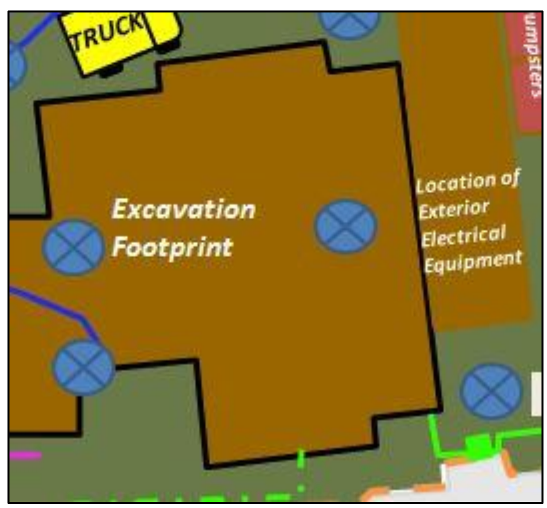


Figure 4: Underground Spring Location

Items that I felt were useful in understanding the job-site were the inclusion of the test bore locations, which helped in understanding the issue with the underground spring on site. Also the inclusion of existing utilities presented difficulties that could have arisen during excavation.

Superstructure Phase

The UEB's steel erection phase includes some features that allow one to better understand the methods used in construction and planning. First, an 80-ton crawler crane is currently being used for steel erection. The crane is able to travel around the entire project, hence the dashed yellow oval, which depicts the relative path the crane can make around the building. Next, are the blocks that designate air-handling units. A total of six air-handling units are located in the mezzanine, but due to their size, they had to be installed during steel erection, otherwise the units would not fit into the building at any other point during construction. This situation is described and analyzed in more detail in the constructability challenges portion of this report. Another key feature during this phase of construction are the black dashed lines which represent the sequencing of steel, which can be seen in the project schedule. The sequencing can be confusing at first, but after studying the building and consulting with Massaro, the sequencing they chose lent itself best for efficient work flow and phasing between the two main building wings.

During particular crane picks, mainly on the east side of the building, the issue of swing radius comes into effect for the neighboring Plant/Soils Building. The swing radius of the crane intersects with the building, so the University notifies building personnel in the Plant/Soils Building on the days of picks that affect them that portions of the building can not be occupied throughout the duration of the steel erection.

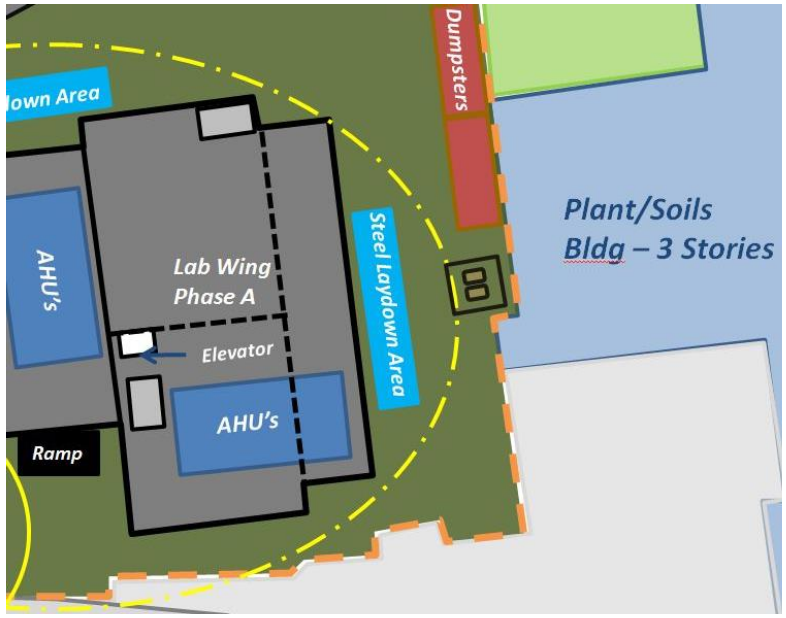


Figure 5: Crane Swing Radius Clashes

MEP Rough-In Phase

-The key addition during the MEP rough-in phase is the installation of the clean room, located on level 0 of the UEB. I feel that it's necessary to show the location of the clean room on the site layout plan because; the coordination for that space is extremely important and is such an integral part of the building that it needs to be displayed along with all the other spaces and items. The crane will be removed from the site once the penthouse air-handling units are set and installed. Technically this falls towards the end of the superstructure phase, but leaving the crane on the layout plan portrays the difficulty involved with equipment installation. Ramps are installed at the main building entrances as a means of easily transporting equipment and larger materials into the building for installation and rough-in. The elevator bay includes both maintenance and occupant elevators, allowing for easy transport of materials between levels.

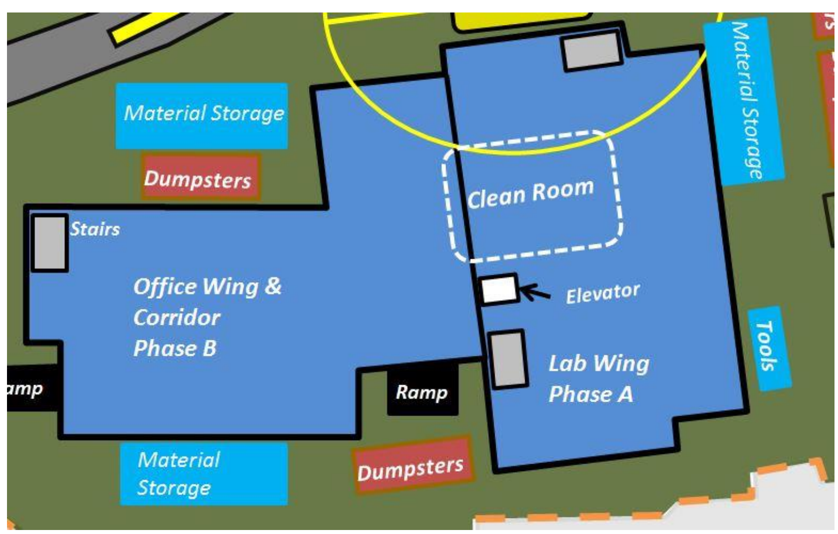


Figure 6: Clean Room Location

Finishes Phase

Once the UEB reaches the finishes phase, all major equipment will be off site, besides trucks for deliveries of materials. Since more trades will be on-site during this phase and the previous phase, space on the job perimeter has be allocated for subcontractor office trailers or material storage trailers, whichever is needed by the individual contractors. More dumpsters have been brought on site, as a means to maintain cleanliness and for recycling purposes.

GENERAL CONDITIONS ESTIMATE

An analysis of the general conditions used on the University Engineering Building yielded a cost of $1.6 million. These costs were determined using RS Means general conditions estimate information and items and durations provided by Massaro. The items included are the items Massaro has included in their general conditions estimate. When comparing this information to the staffing plan, shown in figure 7, there is one key difference, which is not including the salaries of the Project Executive, Director of Construction and Vice President of Operations in general conditions. I feel the reason for not including these members of the project team, is that they are included office overhead costs because they handle multiple projects at any given time. The rest of the project team works solely on the UEB project.

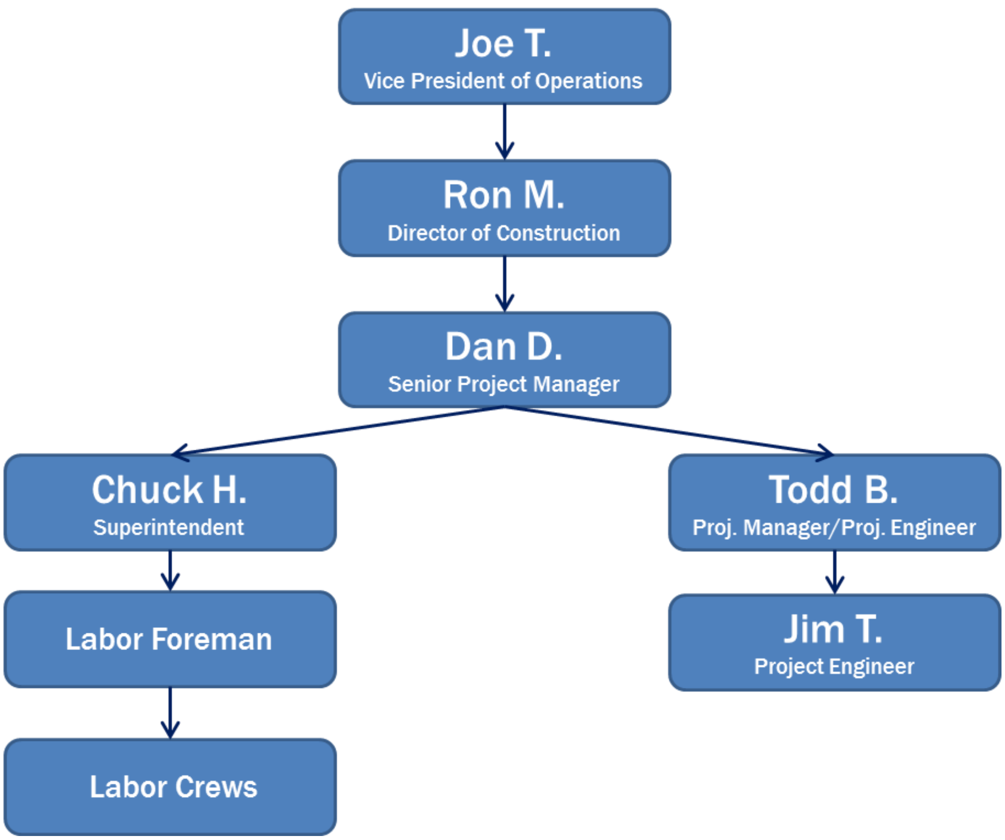


Figure 7: Massaro Staffing Plan (Courtesy of Massaro)

Comparing my general conditions cost to Massaro's is difficult because I was unable to obtain their total cost because of the project being a hard bid. In order to make a comparison, I used the assumption that general conditions is roughly 6% of construction costs. The total construction cost for UEB is $32.7 million, making general conditions roughly $1.96 million. A breakdown of the difference between the two estimates and a percent difference can be seen in figure 8 and in the total general conditions estimate located in Appendix C.

TOTAL			$1,610,845.00
TOTAL CONSTRUCTION COSTS * 6%			$1,962,000.00
COST DIFFERENCE			$351,155.00
% DIFFERENCE			17.90

Figure 8: General Conditions Comparison

I feel the differences between costs come down to salary and insurance and bond costs. RS Means includes average costs and assumptions for salaries, which could be lower than what the project team members salaries are for Massaro; as for what those costs are, I am not privileged to that information. Also bonds and builders risk insurance were assumed to be certain percentages, 0.5% and 0.24% respectively, of the total project cost, but those costs vary depending on owners and contractors. Also the line item B & O Tax is an exclusive tax paid in very few states, with the state where the university is located being one of them.

Durations for monthly costs were assumed to be twenty-four months, based on the project schedule, with certain items such as temporary heat lasting only ten months for the winter months for both years of construction. Other items were listed as lump sum costs, such as signage, bond and insurance and tools and testing, which are one-time costs. Testing is considered a one-time expense because they are paid for as needed, so enough is allotted to cover these expenses.

STRUCTURAL SYSTEMS ESTIMATE

To create a detailed estimate of the UEB's structural system, certain assumptions were made in order to take advantage of the similar aspects of the building. Structural steel, metal decking and slab on decks were taken off for one floor of the office space, one floor of laboratory space and the penthouse level, with the office and lab takeoffs multiplied by three for levels 1-3. The foundation system included a takeoff of the caissons, retaining wall and slab on grades. All quantities were gathered using Autodesk Quantity Takeoff software. A final assumption was made of miscellaneous totaling 8% of the subtotal. The actual structural system cost for the University Engineering Building provided by Massaro was $2.3 million and the total estimate cost came in at $2.4 million.

Caissons

The caisson system for the UEB required a complete takeoff, due to there being six different caisson types, ranging in diameters from 30" – 60" and a wide variety of heights. The tables provided in the appendix break down into caisson lengths, rebar, both length and weight, and finally concrete. A drilled shaft schedule was provided on drawing S100, the caisson plan, and provided here as a means of understanding the information on the caisson types.

DRILLED SHAFT SCHEDULE			
Mark	D	Vertical	Ties
30" Ø	30"	(6) #7	#3 @ 14"
36" Ø	36"	(7) #8	#3 @ 16"
42" Ø	42"	(7) #9	#4 @ 18"
48" Ø	48"	(7) #10	#4 @ 18"
54" Ø	54"	(9) #10	#4 @ 18"
60" Ø	60"	(9) #11	#4 @ 18"

Table 1: Caisson Schedule (Courtesy of Stantec)

Assumptions made for this estimate include:

- Tie Length = (Ø – 6") * (# of bars)(π)
- Vertical Length = (# of bars)(length)
- Concrete is 4,000 psi, per structural general notes

The final takeoffs calculated used in the cost estimate breakdown as follows:

- Caisson Concrete = 14,286 CF
- Caisson Rebar = #3 - #11 bar totaling 19.79 tons

Concrete

The concrete takeoff was broken down into four main categories to account for the different concrete uses on the UEB. Retaining wall concrete was sub-divided into office and laboratory space, yielding the results located in Appendix D.

An assumption was made to include the wall separating the office and lab spaces with the laboratory wall length, due to the fact that it reaches the same height as the rest of the lab retaining wall and the office walls connect to the dividing wall. Also the retaining wall concrete was 5,000 psi, since in the structural general notes, it was called out that the retaining wall is located at the freeze-thaw threshold warranting the increase in psi.

The following are takeoffs for the retaining wall concrete:

- Office = 275.46 CY
- Laboratory = 840 CY
- Total (Rounded) = 1116 CY

Another piece of the foundation system includes the grade beam system that runs underneath the retaining walls. Four different types of grade beams were used, ranging in widths but all keeping a constant two foot depth. Like the caissons and the rest of the concrete, aside from retaining walls, on the project, 4,000 psi concrete was used, with a table providing takeoff values, located in Appendix D.

The following are results from the grade beam takeoff:

- GB2424 = 0.89 CY
- GB3024 = 153.70 CY
- GB3624 = 22.22 CY
- GB4824 = 8.89 CY
- Total = 185.70 CY

Slabs on Grade are only located in the laboratory space, because of a crawl space located below level 1 of the office wing. Slabs range from 4” to 12”, with a majority of the area being either 6” or 8” slabs, also the concrete is, again, 4,000 psi.

This takeoff was straightforward and produced the following results:

- 4” Slab = 6.84 CY
- 6” Slab = 121.17 CY

- 8” Slab = 158.58 CY
- 12” Slab = 51.35 CY

The slabs on deck began the process of performing a takeoff on one floor and multiplying it by three to account for the other floors, which are exactly the same layout and material-wise. A separate takeoff was performed on the penthouse since it uses only one type of slab thickness for the entire floor. The difference between the S-5.5 deck and S-5.5A deck is that the S-5.5A deck uses an electrified cellular deck with 20 gage ribs and 20 gage bottom cover plate, but other than that fact, the concrete thickness and reinforcement is exactly the same. The 6” concrete slab is only located on the penthouse level in specified areas near the locations of air-handling units.

The one level breakdown is as follows:

- S-5.5 = 96.46 CY
- S-5.5A = 2.3 CY
- S-6.5 (Penthouse) = 4.6 CY
- S-8 (One Level & Penthouse) = 170.5 CY
- 6” Conc. Slab (Penthouse) = 6.6 CY

The total slab on deck concrete amount, after taking into account the remaining levels, came in at 755 CY.

The final area of concrete use in the building is reinforced concrete curbs that are located exclusively on the penthouse. The curbs are reinforced and used as pads to elevate the air-handling units off of the floor for vibration purposes. The 12” x 10” curb is used to supported the units, while the 7” x 12” curb runs the perimeter of the penthouse.

The concrete quantities for the reinforced curbs are as follows:

- 12” x 10” = 12.3 CY
- 7” x 12” = 9.3 CY

<u>Concrete Reinforcement</u>

Three main forms of reinforcement are used on the UEB project and those are: rebar, welded-wire reinforcement and metal decking.

The retaining walls features four different types of rebar used to reinforce the structure. Those descriptions were taken from the retaining wall detail shown in figure 9.

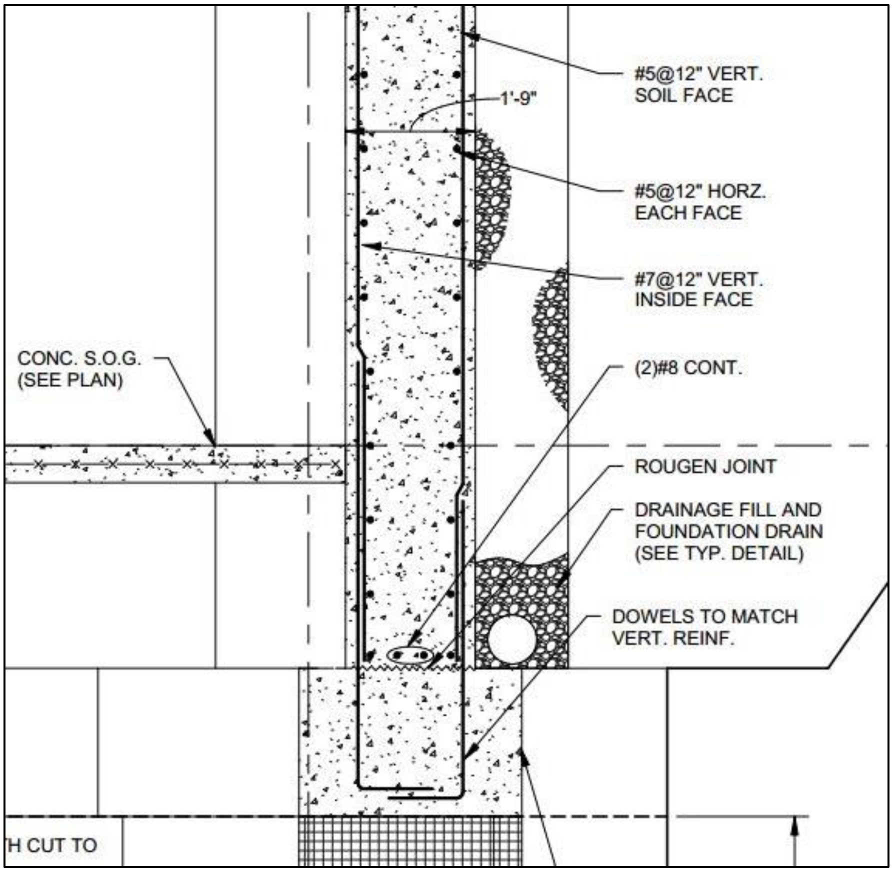


Figure 9: Retaining Wall Detail (Courtesy of Stantec)

Lengths, where they apply, were carried over from the concrete takeoffs in order to get the correct number of rebar and the correct weight of rebar.

The breakdown of retaining wall rebar is:

- #7 @ 12” Vert. Inside Face = 17.59 tons
- #5 @ 12” Vert. Soil Face = 8.98 tons
- #5 @ 12” Horiz. Each Face = 4.60 tons
- (2) #8 Cont. Length = 0.64 tons

The grade beams utilized a rebar system where bars ran the entire length of the beams on each side and were connected via stirrups that were spaced throughout the length of the grade beam. The following table and figure provide the information on the rebar breakdowns for the different types of grade beams.

Grade Beam Schedule							
Mark	Width (ft.)	Depth (ft.)	Top Bars	Bottom Bars	Side Bars (Each Face)	Closed Stirrups	
GB2424	2	2	(4) #8	(4) #8		#4 @ 12"	2 Legs
GB3024	2.5	2	(4) #7	(4) #7	(2) #7	#4 @ 12"	2 Legs
GB3624	3	2	(5) #9	(5) #9	(3) #9	#4 @ 12"	3 Legs
GB4824	4	2	(6) #8	(6) #8	(2) #8	#4 @ 12"	4 Legs

Table 2: Grade Beam Schedule (Courtesy of Stantec)

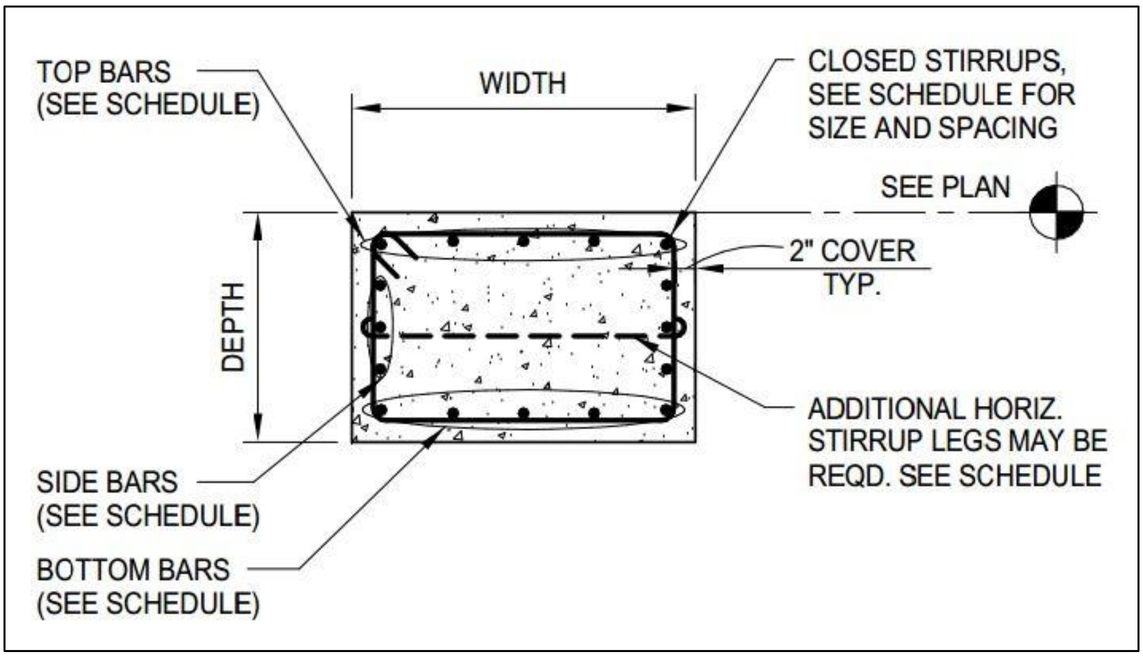


Figure 10: Grade Beam Rebar Detail (Courtesy of Stantec)

All of this information led to these grade beam rebar quantities:

- #4 Stirrup = 2.97 tons
- #7 = 8.48 tons
- #8 = 0.62 tons
- #9 = 2.21 tons

The final use of rebar occurs in the reinforced concrete curbs on the penthouse level. Figure 11 is a detail of the curbs to better explain the use of rebar. A note for this takeoff, is that the dowels pictured in the detail were not taken into account for the estimate, only the rebars.

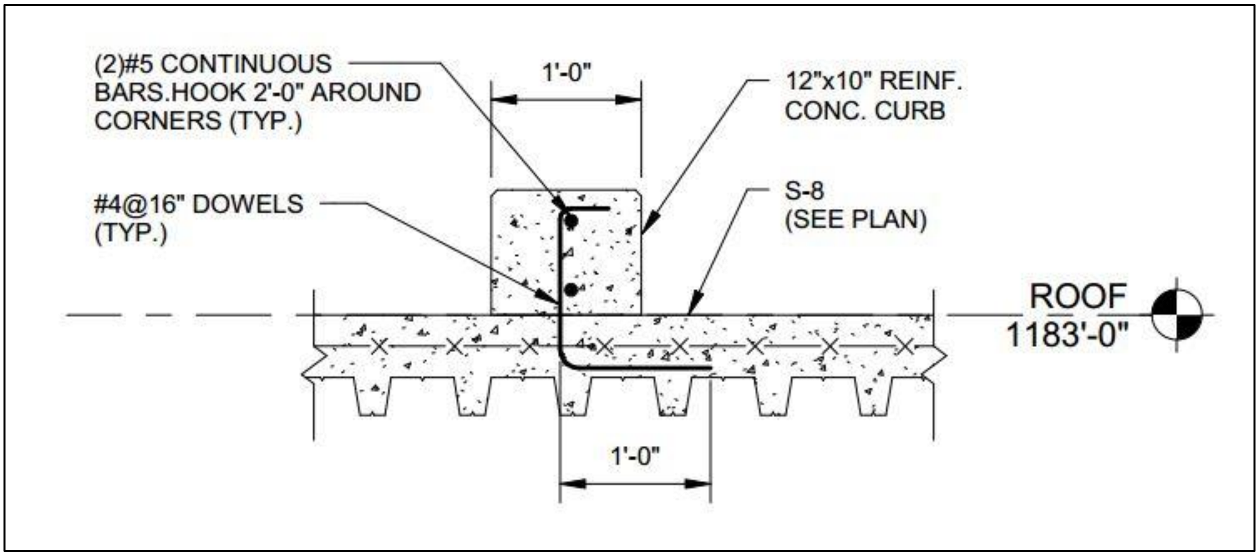


Figure 11: Typcial Equipment Curb Detail (Courtesy of Stantec)

The final quantities for rebar in the curbs are:

- 12” x 10” = 0.414 tons
- 7” x 12” = 0.449 tons

All of the concrete slabs are reinforced by welded-wire reinforcement, with all the slabs on grade and all the slabs on deck, except for S-8, using 6x6 W2.9 x W2.9 WWR. The slabs on deck quantities were gathered using the one level system, exactly the same as concrete takeoffs.

The slab on grade breakdown: (Note: All use 6x6 W2.9 x W2.9 WWR)

- 4” Slab = 6 CSF
- 6” Slab = 66 CSF
- 8” Slab = 65 CSF
- 12” Slab = 14 CSF

The slab on deck one level breakdown: (Note: S-8 uses 6x6 W4.0 x W4.0 WWR)

- S-5.5 = 90 CSF
- S-5.5A = 3 CSF
- S-6.5 = 4 CSF
- S-8 = 82 CSF

The total amount of squares for all three levels plus the penthouse was calculated to be 624 CSF.

Metal Decking acts mainly as support mechanism and was used exclusively for the slabs on deck. Four different types of metal decking were used, but I combined S-5.5 deck with the S-5.5A deck for cost and quantity, this is one area would costs would be different, but it would not greatly affect the total structural system estimate.

Those quantities are as follows for one level:

- 2”, 20 gage, Galvanized = 9139.3 SF
- 2.5”, 20 gage, Galvanized = 369.4 SF
- 3”, 20 gage, Galvanized = 8196.25 SF

The total for all three levels plus the penthouse is 52,376 SF.

Structural Steel

The final category included in the structural system takeoff for the UEB is steel beams and columns. Beam quantities were gathered by getting lengths of the beams on level 1 and taking those totals and multiplying them by 3 to include all three levels. When gathering column quantities, the column schedule was used to get the linear footage of the columns over the span of the entire building. RS Means does not include all beam and column sizes that were used on the UEB so the next closest size was used to get similar cost information.

Formwork

Formwork takeoffs were done for foundation and slab work. Concrete thicknesses were used where necessary and yielded a foundation total of 39,434 SFCA and slab total of 2577 SFCA.

Conclusion

All of the takeoffs were complied into one cost estimate, where tax and location factor were used to gain a more accurate cost estimate. The total I calculated came in roughly $100,000 higher than Massaro’s cost, but I attribute this to adjusting costs in RS Means to fit into a specific item. Some beam and column sizes were generously sized up which adds much more cost on top the other items included. Also the percentage used for miscellaneous steel was assumed based on averages for most projects of similar scope and size. Also the difference between the two could be negligible because the number Massaro provided was a rough contract value and not exact.

MEP ASSEMBLIES ESTIMATE

Electrical Estimate

The electrical assemblies estimate for the University Engineering Building was broken into main equipment, including: switchgear, panelboards, receptacles, lighting fixtures, generators, feeders and motors. The costs were calculated using RS Means Assemblies Estimate Guide, which included costs based on numbers of items per given SF. Receptacles and light fixtures fell into this category, where light fixtures were assumed to be all fluorescent and both were broken into building spaces due to different power needs in those given areas. The single line diagram drawing was heavily used to get totals for the different pieces of equipment. After tax and location factor the total electrical estimate came in at just over $3.1 million and when comparing this to the actual cost of $3.4 million, the percent difference was 10.7%, within the expected error of an assemblies estimate. Reasons that my estimate would be lower than the actual cost is due to the generalization of RS Means equipment and cost information. Especially for a lab building, many of the items such as a 4000 A switchgear is not included so the cost was interpolated based on provided costs for smaller switchgears. The full estimate breakdown can be viewed in the appendix.

SUBTOTAL							$3,036,984.80
TAX (8%)							$242,958.78
TOTAL (INCLUDES LOCATION - 0.95)							$3,128,094.34
ACTUAL							$3,400,000.00

Table 3: Electrical Assemblies Estimate

Mechanical & Plumbing Estimate

This was the most difficult estimate to compile because of the complexity of the systems, especially the mechanical. Laboratory spaces are not included in equipment listings within RS Means which accounts for grossly underestimating the system's value. Air-handling unit, duct work and lab equipment costs were provided by Massaro to aid in finding a cost that is close to the contract value of $11 million. Two of the largest air-handling units alone cost $145,000 each, which is something that RS Means would never be able to account for. Lab equipment was given as a total cost, due to the University not wanting specific items and their associated costs being released. The duct work was also rough costs given to help me better understand the complexity of the system and the sheer volume of work and material included. The percent difference between my calculated total and actual cost provided by Massaro was 9% which falls within the expected error of 10%.

TOTAL							$9,713,796.71
TAX (8%)							$777,103.74
TOTAL (INCLUDES LOCATION - 0.95)							$10,005,210.61
ACTUAL							$11,000,000.00

Table 4: Mechanical & Plumbing Assemblies Estimate

CONSTRUCTABILITY CHALLENGES

Air-Handling Units

The main constructability challenge currently being faced by the project team involves the Mezzanine and Penthouse levels air-handling units. The challenge at hand is coordinating placement of the air-handling units inside the building because once the structural phase is completed, it is physically impossible to move the units into the Mezzanine space. Figure 12 is an enlarged mechanical plan of the mezzanine space and as you can see, the units are large and unwieldy and occupy most of the room's space.

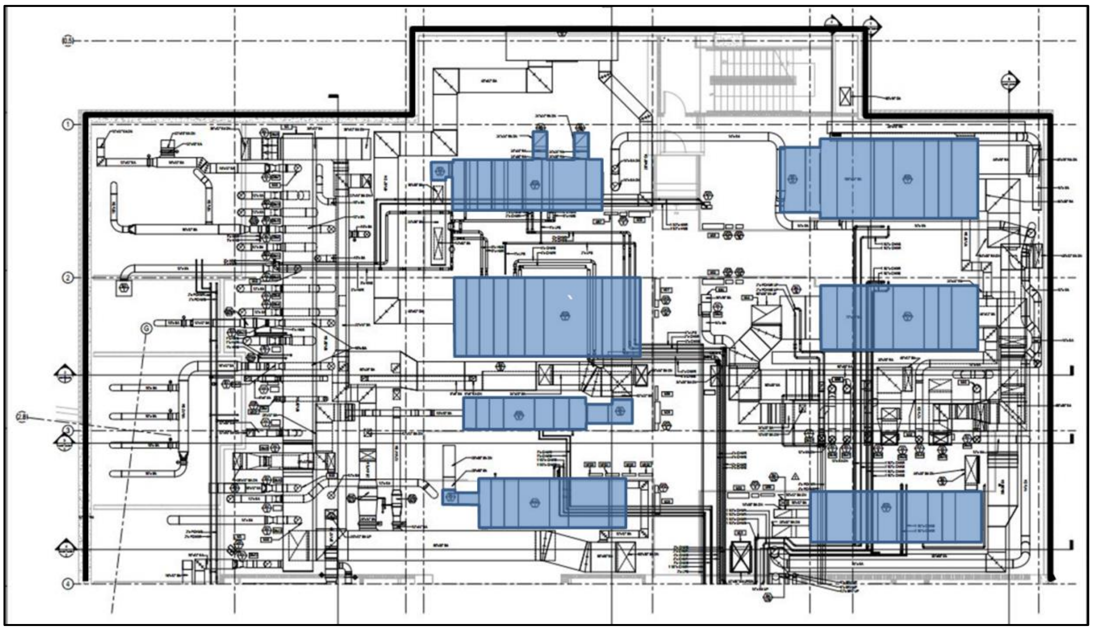


Figure 12: Enlarged Mezzanine Mechanical Plan (Courtesty of Stantec)

To provide a perspective on the size of these units, the smallest (AHU-5) measures a width of 4'-6", length of 17'-0" and height of 5'-0", while the largest (AHU-1) specs are a width of 12'-10", length of 35'-0" and a height of 10'-6", with the rest falling within those ranges.

The final solution required an analysis of multiple key factors to coordinate design, fabrication, testing, delivery and finally installation. Due to the size of these units, it was determined the only possible solution to placing them within the building would be to do so during the structural steel erection phase. Due to this expedition, the units were finalized early in the construction phase with all necessary RFI's sent and answered by the Mechanical Engineer. This also needed to be done early because the AHU's are long lead items, with each being unique and a custom build. One problem that did arise was the Mechanical Engineer wanted all the units tested in-house at the manufacturer in Canada, which would have caused delays in the schedule by pushing back the structural steel erection. A compromise was made that field testing would be performed in lieu of factory testing, the field testing occurring after building enclosure and prior to commissioning. The next main factor that affected the placement of the air-handling units was at what exact point during steel erection the units should be placed in the mezzanine level and at what point is there enough structure in place to set the units. This was solved over the course of many meetings between the Project Manager and the Structural Engineer. The consensus reached was the units needed to be placed before the all of the mezzanine steel was set, at that point, there would not be openings large enough to fit the units. Also due to concerns of the Mechanical Engineer, each unit was inspected prior to being set, so that any damage was caught early. The final area of analysis was work flow involving, welders and steel workers. The locations of the AHU's were completed prior to delivery so that the laborers could move to different areas to continue working without being affected by setting of the units and vice versa.

This problem will again be faced when the point in the scheduled is reached to set the Penthouse air-handling units. The coordination needed for this activity involves having all slabs on deck below the penthouse level poured and cured so that the penthouse level slab can be poured. The penthouse level slab and reinforced concrete curbs must be placed and cured so they reach the correct strength in order for the units to be set. The other issue is that those units must be placed through the roof of the penthouse via the 80-ton crawler crane used for steel erection, meaning that steel can not be completed until after the units are set. The following figure highlights the area of the building where the penthouse is located.

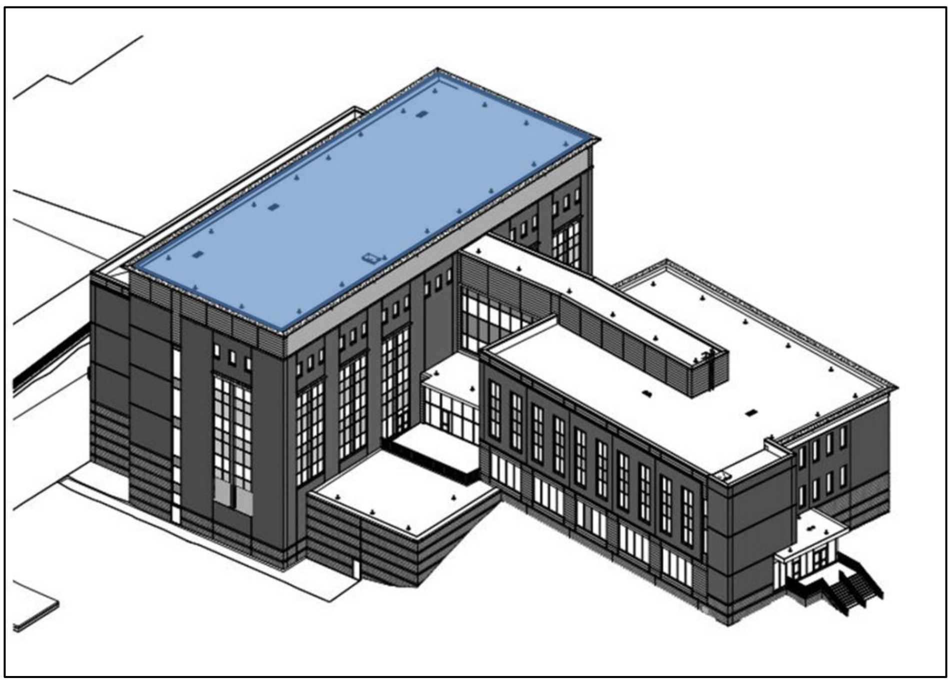


Figure 13: Building Perspective w/ Penthouse Highlighted

The penthouse air-handling units were already delivered to the job-site where they have been stored wrapped in shrink-wrap to protect against weathering at the recommendation of the mechanical engineer. The mezzanine level units are sealed off with tarps and wood covering to protect them until the building is enclosed to an acceptable degree.

Excavation/Dewatering

Unforeseen problems with problems with weather and other factors during the excavation phase, caused the project team to adapt in order to avoid delays in the schedule. The first issue with excavation was the University Engineering Building's close proximity to the Plants/Soils Building (P/SB) located on the east side of the UEB. The east wing of the UEB houses all of the laboratory space including the 0 and Mezzanine levels, which are at the furthest points of excavation, 24' below grade. As shown in figure 14, the distance between the UEB and the P/SB is only 10'-8", with soldier and lag pile excavation support used for the retaining wall on the UEB.

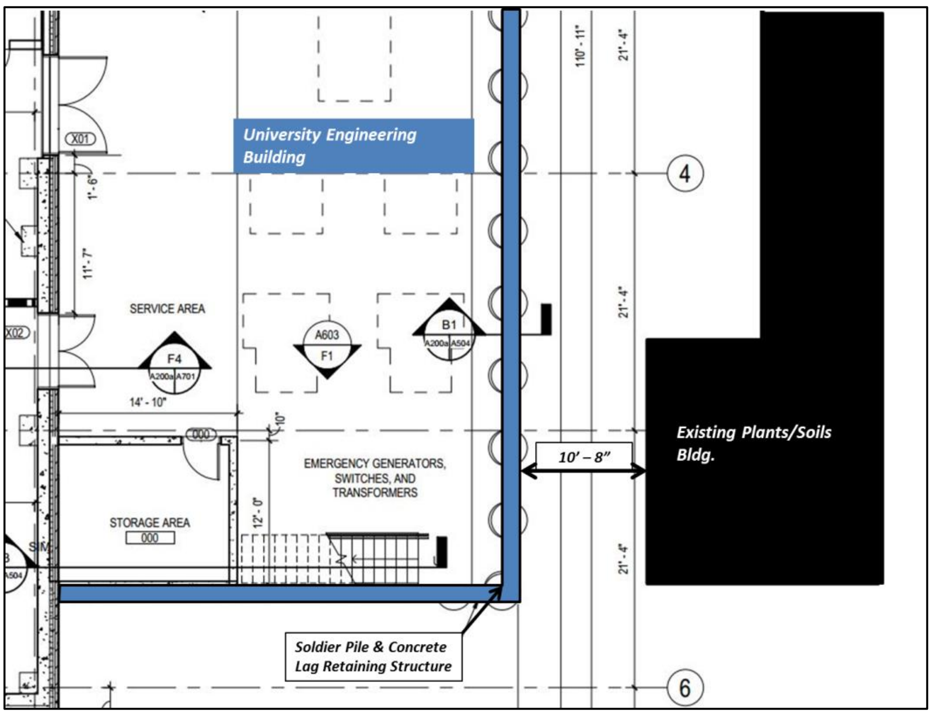


Figure 14: Building Proximity Detail (Courtesy of Stantec)

Limits on layback were put in place to protect the integrity of the P/SB foundation, along with not disturbing critical research taking place. Another issue concerning excavation, is one-way traffic through the job-site. Work was sequenced to accommodate incoming and outgoing trucks to allow a more fluid pace of bringing trucks in, filling them and getting them out without delaying the excavators. Areas of the site were phased to allow work on the foundations to begin while excavation was still going on. One specific area this affected was the foundation wall that runs along marker G, highlighted in figure 15, where the wall on the lab portion of the building had to be placed and cured prior to the office walls being connected.

Once the excavation was complete, weather and dewatering began affecting the pace of construction. A previously unknown underground spring was discovered to run underneath part of the site, causing water to fill the excavated area and affect foundation work. Also around this time, the University received a large amount of rain over a period of a few weeks, adding to the amount of surface water in the excavated site. The surface water delayed concrete pours on multiple days because the geo-foam layer, located underneath the grade beams was forced upwards by the water, thus affecting rebar cages and formwork that was laid out for pours occurring on those specified days and in turn delaying the project schedule in the process. Massaro began inspections on the days of concrete pours to ensure all rebar, formwork and geo-foam was in the correct locations and not moved by any surface water prior to the pours. The weight of the concrete afterwards was enough to resist all surface water in given locations. Massaro's solution to removing the excess water involved the addition of a sump pit and well, with both becoming permanent for use in the completed UEB.

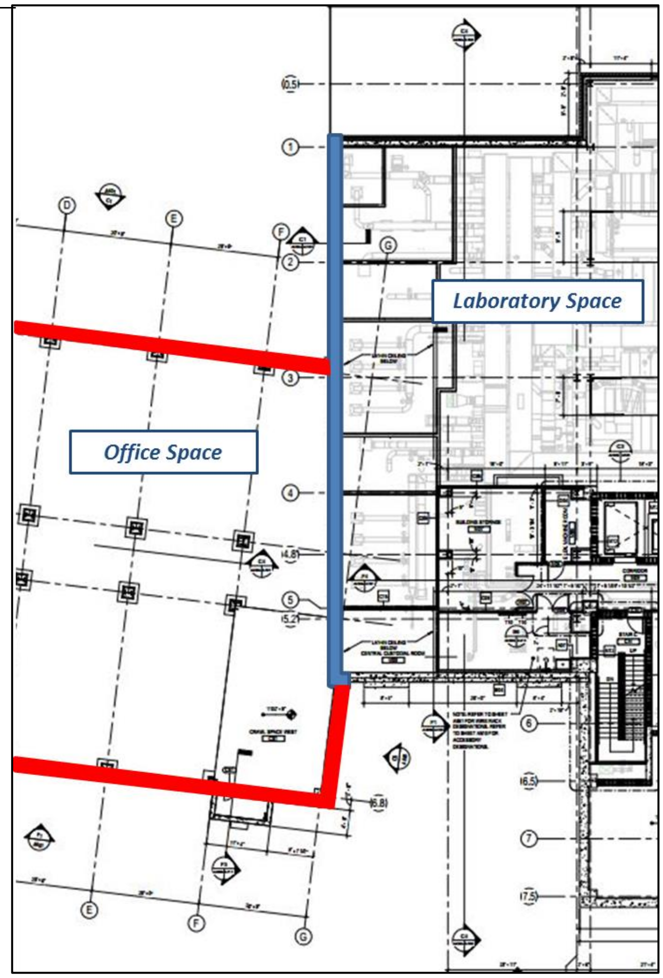


Figure 15: Foundation Wall Line G (Courtesy of Stantec)

Façade/Enclosure

According to the Project Manager of Massaro, Todd B., the next foreseeable constructability challenge regards the UEB enclosure. Currently, the exterior façade is scheduled to begin early in December of this year, causing various issues involving temperature maintenance. Building enclosure is a key milestone that must be completed on time because until enclosure reaches an acceptable level, interior work can't begin and interior rough-in and finishes occupies over half of the activities on the project schedule. The most important set of activities affected by the building enclosure involve the installation of the clean room, as this process must follow strict guidelines, such as interior temperature, debris and materials, in order for the room to retain its proper rating once it's installed and completed. Another aspect involving the façade is the masonry work that will be going on during the winter months. All possible scenarios are currently being weighed by the project team, but as of October 7th, 2013 the proposed solutions for façade construction include: erecting temporary enclosures for the masons to work in, providing portable, temporary heat to maintain proper temperatures for curing and mortar workability and finally, analyzing which areas of the building could expedite the project schedule and allow the masonry to be completed at a faster pace. The following figure 16 displays a possible solution for temporary enclosure, by using a tent like structure that sets on the building and can be made to a height requested by the masons or chosen by Massaro. Temporary heating will most likely be propane or electric heaters that tap into the temporary electricity or a combination of the two.

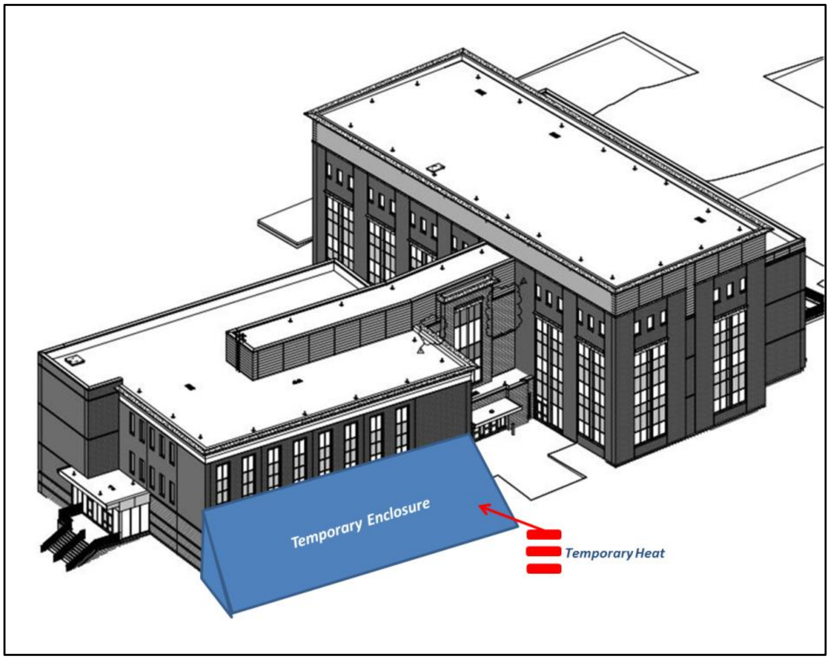


Figure 16: Temporary Enclosure Detail (Courtesy of Stantec)

Two things Massaro will have to monitor; first is the schedule, so that erecting temporary enclosures doesn't delay other activities, second is general conditions costs, where the added materials for temporary enclosures and increased utility costs and propane costs will add to the monthly gc costs. Also, the labor required to erect the enclosures will have to be taken into account, whether it's during straight time or overtime in order to not affect the schedule.

BIM USE EVALUATION

For a building containing predominately laboratory space and a clean room, such the University Engineering Building (UEB), utilizing BIM is does not only greatly aid with modeling these complex systems, but allows for design challenges to be solved prior to construction. The 3D model created only features structural steel, foundations and mechanical, electrical, plumbing and fire suppression systems as Massaro only wanted to coordinate these systems, being that they are the most crucial to the success of the project.

Massaro has decided to implement BIM on the UEB project for three main reasons. The first reason is for coordination between the mechanical, electrical, plumbing and fire suppression trades. Since the UEB is comprised mostly of lab space, these systems become very complicated and require exact planning and coordination in order to avoid on-site clashes and problems. Each trade created a working 3D model of their respective systems and Massaro's Project Manager was tasked with creating one master 3D model. These models are currently being used to run clash detection in order catch and solve any clashes on paper before they become issues on-site. With delays already occurring and pushing back the project schedule, utilizing BIM in this manner will save time later during construction.

The second reason for the decision to implement BIM on the UEB project was to create a 4D model in order to track the progress of the MEP rough-in phases and to better manage and adjust the project schedule. The project manager is heading the creation of the 4D model currently and along with the superintendent and subcontractor foremen will manage the pace at which work is completed and which activities are scheduled to be worked on during given dates.

The third and final reason Massaro chose to implement BIM on this project was for quality control purposes. The systems in this building must be installed according exactly to the drawings due to complicated materials occupying spaces with very little room for error. Coordination meetings have been held and will continue to be held as rough-in draws closer between Massaro's team and the foremen from the key subcontractors to go over questions, concerns and to present as much information as needed to ensure the subcontractors know exactly how to install all material. Early meetings dealt with issues such as subcontractor order and designating who installs their equipment first, basing it off criteria such as largest equipment and height of the equipment (highest to lowest from the floor). In order to keep the necessary subcontractors informed, they have been given access to the model for use on the field and if a subcontractor needs information from the model but doesn't have access to it, Massaro will provide them with information needed.

The University Engineering Building is currently in the structural phase, pre-rough-in work has started, including the installation of pipe and duct hangars to allow for a smooth transition to MEP rough-in. The 3D model is complete and final touches are being added to ensure nothing has been passed over or missed. At this time, there are no plans to turn this model over to the owner, since it was Massaro and the MEP subcontractors who decided on their own that a 3D model was necessary to ensure quality of the completed project.

BIM implementation was based on the sole need for it, realized by Massaro and the MEP subcontractors, but utilizing BIM earlier in the project and expanding its uses would have been a benefit to all members of the project team. Even with the project being a design-bid-build delivery method 3D models could have still been created during the preconstruction phase for use once construction began. My proposed use of BIM entails 5 main reasons, both similar and different to Massaro's use, to aid all members of the project team both during construction and after the building has been completed and turned over to the University.

My first use of BIM would utilize the model along with the costs estimate to track money spent as progress is achieved on the UEB. Benefits of using a 5D model include the following: easily track construction costs with work completed via the schedule, spot problem areas for cost overruns and easily manage the budget, track general conditions costs to better monies spent by Massaro and provide accurate payment requisitions to the University. This use also includes the second use that both myself and Massaro implemented, the 4D schedule. Linking the schedule to the 3D model allows to better manage work being done on the job-site. Delays can re-worked with other activities to make back time and accelerate the project schedule.

My third use of BIM on the UEB project would be for clash detection/MEP coordination, the main use of implementation by Massaro. Due to the University Engineering Building's complex MEP systems, coordination is needed to ensure all equipment and material is installed correctly and any possible problems are avoided on-site due to the importance of completing the rough-in phase. This is one area where I agree with Massaro plan and implementation of BIM, but they could also have taken it further to all phases on construction, which leads to my next use of BIM on the UEB.

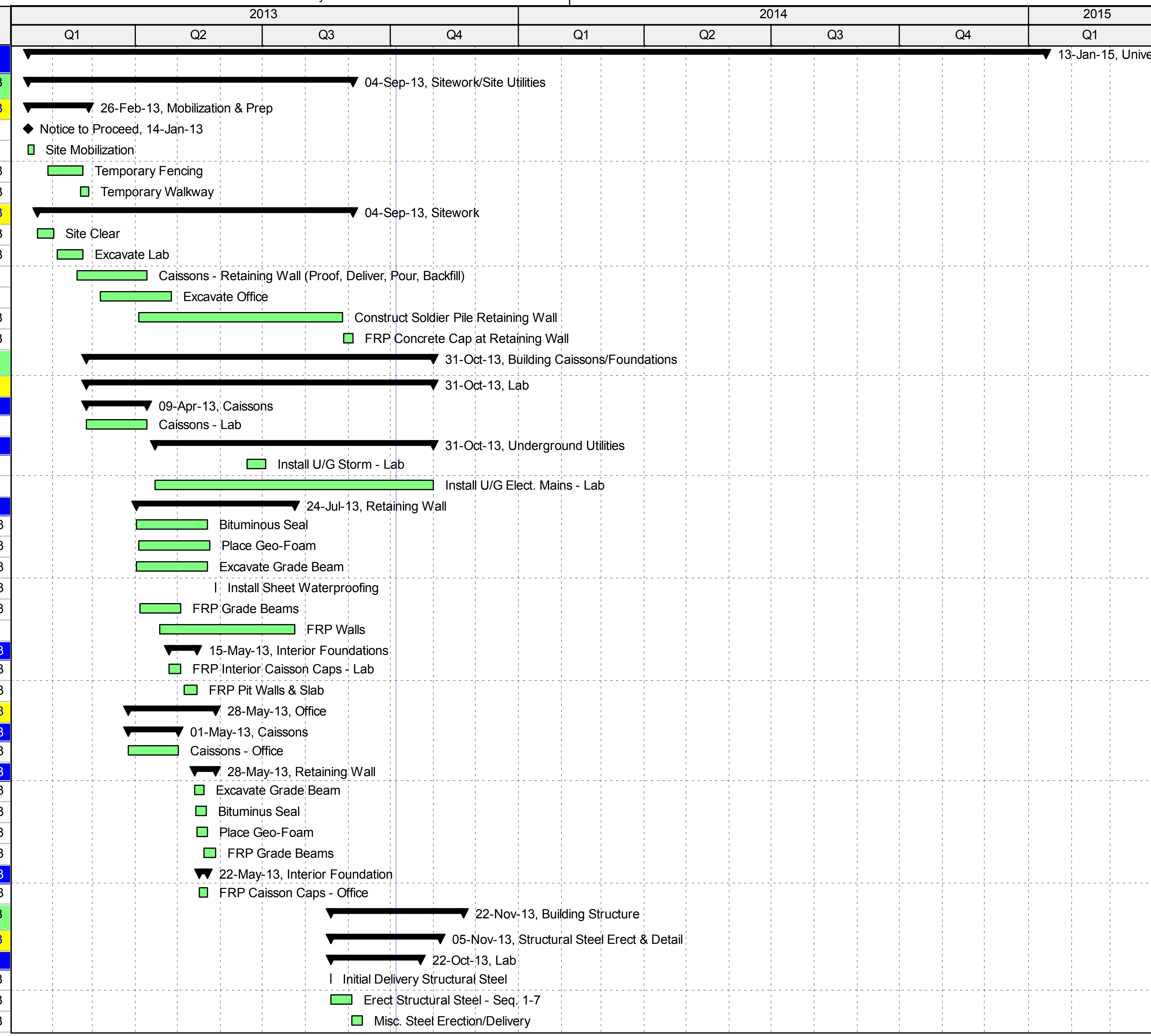
The fourth use of BIM is again another use of Massaro's, quality control. Assuring clashes are avoided prior to the rough-in phase is the first step in the highest quality product, but transitioning the model to the field and placing it in the hands of the laborers who will be performing is the second step in ensuring the quality expected by the owner. I agree with Massaro again where the foremen for the subcontractors need to be included in BIM meetings to study the model, ask questions, present any suggestions that could benefit the model and the construction process for not just MEP rough-in but all phases of construction. Understandably, not all subcontractors have the tools and means to implement BIM, but as Massaro is already doing, they will offer meetings to discuss issues and show subcontractors the model to answer all questions and to help ensure quality.

My final use of BIM on the University Engineering Building project is beneficial to the owner, where Massaro will turn over the model upon completion of the building and it will then be used a facility management tool for maintenance, upkeep and any future renovation work on the building. BIM doesn't end with the completion of the project but continues with the building's life cycle. Having a full building model, the University is in a better position to handle all maintenance issues with the UEB. This again ties into the complexity of the MEP systems and how facility managers can use the model to analyze the best methods for repairs and any possible equipment replacements. Most of the piping and ductwork is very tight fitting in spaces and the model shows its benefit in displaying the easiest method of access and the locations of all entrance panels to units. Also information about the equipment, especially the air-handling units, can be stored on the model and by highlighting a specific piece of equipment, all of its information can be displayed along with maintenance requirements.

For a project where the owner did not directly request the use of BIM on the project, Massaro took the incentive to utilize BIM for MEP coordination. They are using it in the most beneficial way at this point in the construction process, but had they decided to implement it earlier during preconstruction, the uses I outlined above would have been beneficial compliments to the uses they have already outlined.

Appendix A – Detailed Project Schedule

Activity ID	Activity Name	Original Duration	Start	Finish
University Engineering Building		517	14-Jan-13	13-Jan-15
Sitework/Site Utilities		165	14-Jan-13	04-Sep-13
Mobilization & Prep		32	14-Jan-13	26-Feb-13
A0100	Notice to Proceed	0	14-Jan-13	
A1000	Site Mobilization	5	14-Jan-13	18-Jan-13
A1010	Temporary Fencing	20	28-Jan-13	22-Feb-13
A1020	Temporary Walkway	4	21-Feb-13	26-Feb-13
Sitework		160	21-Jan-13	04-Sep-13
A1030	Site Clear	10	21-Jan-13	01-Feb-13
A1040	Excavate Lab	15	04-Feb-13	22-Feb-13
A1050	Caissons - Retaining Wall (Proof, Deliver, F	37	18-Feb-13	09-Apr-13
A1060	Excavate Office	37	07-Mar-13	26-Apr-13
A1070	Construct Soldier Pile Retaining Wall	103	03-Apr-13	27-Aug-13
A1080	FRP Concrete Cap at Retaining Wall	5	28-Aug-13	04-Sep-13
Building Caissons/Foundations		176	25-Feb-13	31-Oct-13
Lab		176	25-Feb-13	31-Oct-13
Caissons		32	25-Feb-13	09-Apr-13
A1090	Caissons - Lab	32	25-Feb-13	09-Apr-13
Underground Utilities		141	15-Apr-13	31-Oct-13
A1100	Install U/G Storm - Lab	10	20-Jun-13	03-Jul-13
A1110	Install U/G Elect. Mains - Lab	141	15-Apr-13	31-Oct-13
Retaining Wall		80	02-Apr-13	24-Jul-13
A1120	Bituminous Seal	37	02-Apr-13	22-May-13
A1130	Place Geo-Foam	38	03-Apr-13	24-May-13
A1140	Excavate Grade Beam	37	02-Apr-13	22-May-13
A1150	Install Sheet Waterproofing	1	28-May-13	28-May-13
A1160	FRP Grade Beams	22	04-Apr-13	03-May-13
A1170	FRP Walls	68	18-Apr-13	24-Jul-13
Interior Foundations		15	25-Apr-13	15-May-13
A1180	FRP Interior Caisson Caps - Lab	7	25-Apr-13	03-May-13
A1190	FRP Pit Walls & Slab	8	06-May-13	15-May-13
Office		44	27-Mar-13	28-May-13
Caissons		26	27-Mar-13	01-May-13
A1200	Caissons - Office	26	27-Mar-13	01-May-13
Retaining Wall		11	13-May-13	28-May-13
A1210	Excavate Grade Beam	6	13-May-13	20-May-13
A1220	Bituminus Seal	6	14-May-13	21-May-13
A1230	Place Geo-Foam	6	15-May-13	22-May-13
A1240	FRP Grade Beams	6	20-May-13	28-May-13
Interior Foundation		4	17-May-13	22-May-13
A1250	FRP Caisson Caps - Office	4	17-May-13	22-May-13
Building Structure		69	19-Aug-13	22-Nov-13
Structural Steel Erect & Detail		56	19-Aug-13	05-Nov-13
Lab		46	19-Aug-13	22-Oct-13
A1260	Initial Delivery Structural Steel	1	19-Aug-13	19-Aug-13
A1270	Erect Structural Steel - Seq. 1-7	11	19-Aug-13	03-Sep-13
A1280	Misc. Steel Erection/Delivery	6	03-Sep-13	10-Sep-13



Actual Level of Effort | Remaining Work | ◆ Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

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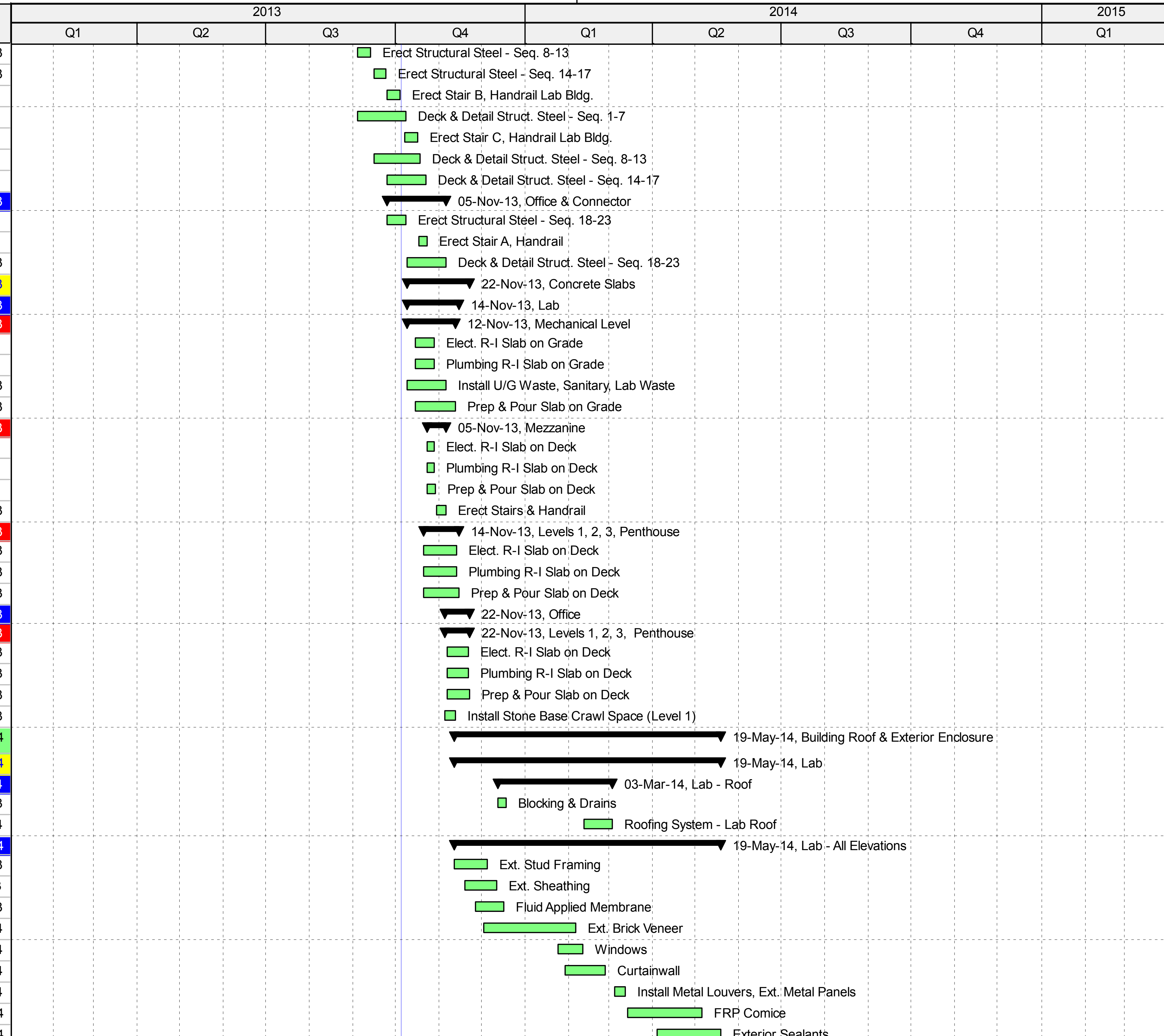
Activity ID	Activity Name	Original Duration	Start	Finish
A1290	Erect Structural Steel - Seq. 8-13	8	04-Sep-13	13-Sep-13
A1300	Erect Structural Steel - Seq. 14-17	7	16-Sep-13	24-Sep-13
A1310	Erect Stair B, Handrail Lab Bldg.	8	25-Sep-13	04-Oct-13
A1320	Deck & Detail Struct. Steel - Seq. 1-7	25	04-Sep-13	08-Oct-13
A1330	Erect Stair C, Handrail Lab Bldg.	8	07-Oct-13	16-Oct-13
A1340	Deck & Detail Struct. Steel - Seq. 8-13	25	16-Sep-13	18-Oct-13
A1350	Deck & Detail Struct. Steel - Seq. 14-17	20	25-Sep-13	22-Oct-13
Office & Connector		30	25-Sep-13	05-Nov-13
A1360	Erect Structural Steel - Seq. 18-23	10	25-Sep-13	08-Oct-13
A1370	Erect Stair A, Handrail	5	17-Oct-13	23-Oct-13
A1380	Deck & Detail Struct. Steel - Seq. 18-23	20	09-Oct-13	05-Nov-13
Concrete Slabs		33	09-Oct-13	22-Nov-13
Lab		27	09-Oct-13	14-Nov-13
Mechanical Level		25	09-Oct-13	12-Nov-13
A1390	Elect. R-I Slab on Grade	10	15-Oct-13	28-Oct-13
A1400	Plumbing R-I Slab on Grade	10	15-Oct-13	28-Oct-13
A1410	Install U/G Waste, Sanitary, Lab Waste	20	09-Oct-13	05-Nov-13
A1420	Prep & Pour Slab on Grade	21	15-Oct-13	12-Nov-13
Mezzanine		10	23-Oct-13	05-Nov-13
A1430	Elect. R-I Slab on Deck	4	23-Oct-13	28-Oct-13
A1440	Plumbing R-I Slab on Deck	4	23-Oct-13	28-Oct-13
A1450	Prep & Pour Slab on Deck	5	23-Oct-13	29-Oct-13
A1460	Erect Stairs & Handrail	5	30-Oct-13	05-Nov-13
Levels 1, 2, 3, Penthouse		19	21-Oct-13	14-Nov-13
A1470	Elect. R-I Slab on Deck	18	21-Oct-13	13-Nov-13
A1480	Plumbing R-I Slab on Deck	18	21-Oct-13	13-Nov-13
A1490	Prep & Pour Slab on Deck	19	21-Oct-13	14-Nov-13
Office		14	05-Nov-13	22-Nov-13
Levels 1, 2, 3, Penthouse		14	05-Nov-13	22-Nov-13
A1540	Elect. R-I Slab on Deck	12	06-Nov-13	21-Nov-13
A1550	Plumbing R-I Slab on Deck	12	06-Nov-13	21-Nov-13
A1560	Prep & Pour Slab on Deck	13	06-Nov-13	22-Nov-13
A1570	Install Stone Base Crawl Space (Level 1)	6	05-Nov-13	12-Nov-13
Building Roof & Exterior Enclosure		134	11-Nov-13	19-May-14
Lab		134	11-Nov-13	19-May-14
Lab - Roof		57	12-Dec-13	03-Mar-14
A1580	Blocking & Drains	5	12-Dec-13	18-Dec-13
A1590	Roofing System - Lab Roof	15	11-Feb-14	03-Mar-14
Lab - All Elevations		134	11-Nov-13	19-May-14
A1600	Ext. Stud Framing	17	11-Nov-13	04-Dec-13
A1610	Ext. Sheathing	16	19-Nov-13	11-Dec-13
A1620	Fluid Applied Membrane	14	26-Nov-13	16-Dec-13
A1630	Ext. Brick Veneer	47	02-Dec-13	05-Feb-14
A1640	Windows	12	24-Jan-14	10-Feb-14
A1650	Curtainwall	21	29-Jan-14	26-Feb-14
A1660	Install Metal Louvers, Ext. Metal Panels	6	05-Mar-14	12-Mar-14
A1670	FRP Cornice	37	14-Mar-14	05-May-14
A1680	Exterior Sealants	32	04-Apr-14	19-May-14



Actual Level of Effort | Remaining Work | ◆ Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

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Activity ID	Activity Name	Original Duration	Start	Finish
Office		91	25-Nov-13	02-Apr-14
Office - Roof		25	07-Jan-14	10-Feb-14
A1690	Blocking & Drains - Office Roof	5	07-Jan-14	13-Jan-14
A1700	Roofing System - Office Roof	20	14-Jan-14	10-Feb-14
Office - All Elevations		91	25-Nov-13	02-Apr-14
A1710	Ext. Stud Framing	25	25-Nov-13	31-Dec-13
A1720	Ext. Sheathing	25	02-Dec-13	06-Jan-14
A1730	Fluid Applied Membrane	25	05-Dec-13	09-Jan-14
A1740	Ext. Brick Veneer	42	10-Dec-13	06-Feb-14
A1750	Windows	18	16-Jan-14	10-Feb-14
A1760	Curtainwall	26	16-Jan-14	20-Feb-14
A1770	Ext. Metal Panels	30	07-Feb-14	20-Mar-14
A1780	FRP Cornice	15	17-Feb-14	07-Mar-14
A1790	Exterior Sealants	28	24-Feb-14	02-Apr-14
Building Interior Rough-Ins Finishes		274	13-Nov-13	03-Dec-14
Elevators		55	05-Mar-14	20-May-14
A1800	Install Freight & Passenger Elevators - Lab	55	05-Mar-14	20-May-14
Mechanical Level 0 & Mezzanine		274	13-Nov-13	03-Dec-14
Lab - Mechanical Level		253	13-Nov-13	04-Nov-14
Mechanical & Plumbing Trade		224	18-Nov-13	29-Sep-14
A1810	Install Duct Risers	10	18-Nov-13	02-Dec-13
A1820	R-I Storm	25	25-Nov-13	31-Dec-13
A1830	R-I Water Supply & Return	34	25-Nov-13	13-Jan-14
A1840	R-I Cast Iron & PVC Sanitary	29	03-Dec-13	13-Jan-14
A1850	HVAC Piping Equipment	32	05-Dec-13	20-Jan-14
A1860	Install Duct Mains	41	25-Nov-13	22-Jan-14
A1870	Install Branch Ducts	51	17-Dec-13	26-Feb-14
A1880	Install HVAC Equipment	29	23-Jan-14	04-Mar-14
A1890	R-I Lab Waste/Vent	19	16-Dec-13	10-Jan-14
A1900	R-I & Test In-Wall Plumbing	50	02-Jan-14	12-Mar-14
A1910	R-I Water, Vacuum, Air	35	13-Jan-14	28-Feb-14
A1920	Install GRD's	34	03-Jun-14	18-Jul-14
A1930	Plumbing Equipment/Fixtures	61	07-Jul-14	29-Sep-14
Electrical Trade		245	18-Nov-13	28-Oct-14
A1940	Layout & Top Track	8	18-Nov-13	27-Nov-13
A1950	R-I Power Distribution	35	03-Dec-13	21-Jan-14
A1960	R-I Electric Room	35	23-Dec-13	10-Feb-14
A1970	O/H Branch R-I Power	41	23-Dec-13	18-Feb-14
A1980	R-I In-Wall Branch	43	07-Jan-14	06-Mar-14
A1990	O/H Branch R-I Systems	30	22-Jan-14	04-Mar-14
A2000	Electrical Lighting/Trim-Out	40	22-May-14	16-Jul-14
A2010	Systems Trim-Out	67	17-Jul-14	17-Oct-14
A2020	Branch Trim-Out	74	17-Jul-14	28-Oct-14
Fire Suppression Trade		152	13-Nov-13	16-Jun-14
A2030	Spray Fireproofing	8	13-Nov-13	22-Nov-13
A2040	O/H Sprinkler R-I	50	02-Jan-14	12-Mar-14
A2050	Sprinkler Trim	10	03-Jun-14	16-Jun-14

Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

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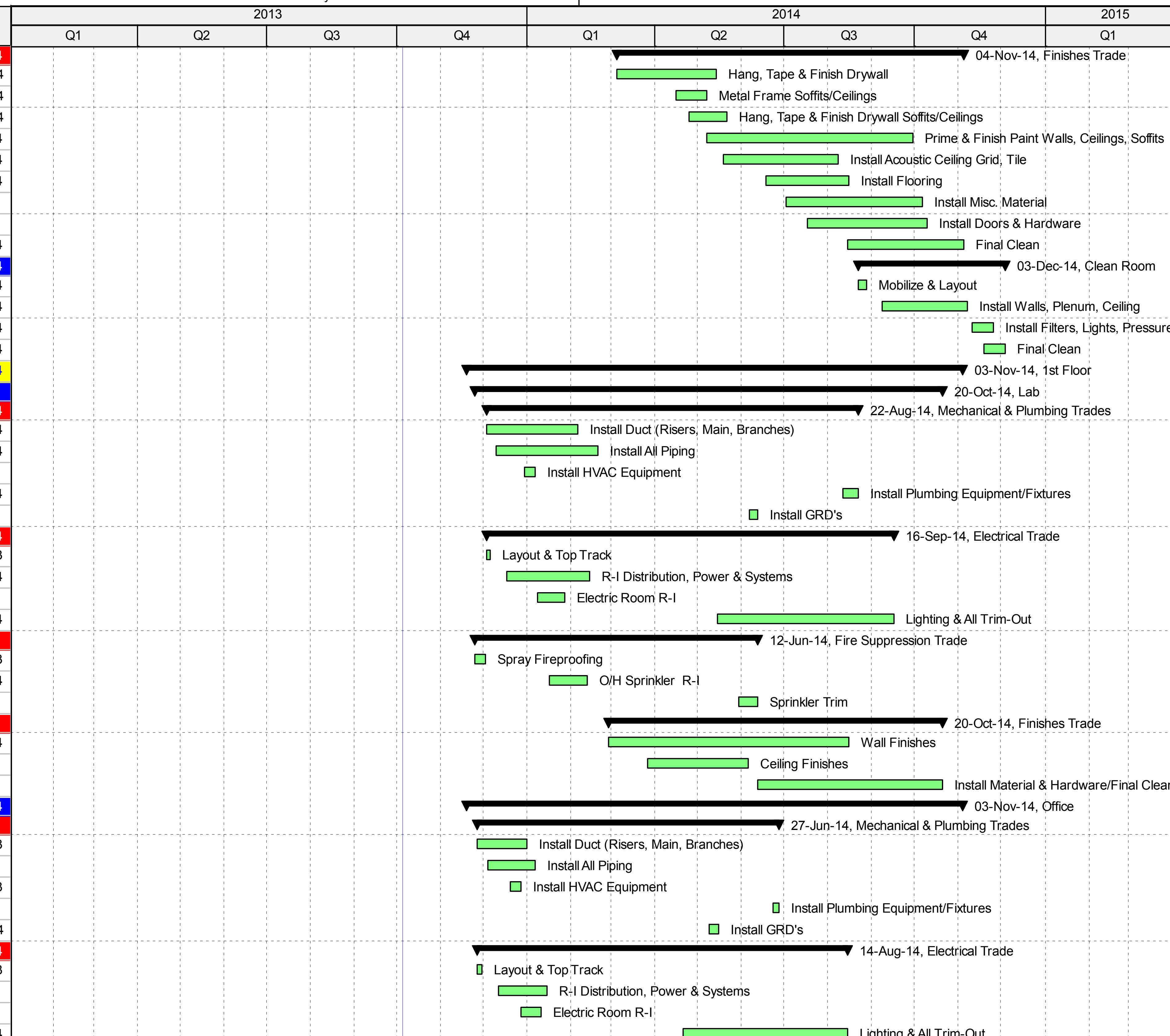
Activity ID	Activity Name	Original Duration	Start	Finish
Finishes Trade		175	05-Mar-14	04-Nov-14
A2060	Hang, Tape & Finish Drywall	51	05-Mar-14	14-May-14
A2070	Metal Frame Soffits/Ceilings	16	16-Apr-14	07-May-14
A2080	Hang, Tape & Finish Drywall Soffits/Ceilings	19	25-Apr-14	21-May-14
A2090	Prime & Finish Paint Walls, Ceilings, Soffits	104	07-May-14	29-Sep-14
A2100	Install Acoustic Ceiling Grid, Tile	60	19-May-14	08-Aug-14
A2110	Install Flooring	43	18-Jun-14	15-Aug-14
A2120	Install Misc. Material	69	02-Jul-14	06-Oct-14
A2130	Install Doors & Hardware	61	17-Jul-14	09-Oct-14
A2140	Final Clean	58	15-Aug-14	04-Nov-14
Clean Room		74	22-Aug-14	03-Dec-14
A2150	Mobilize & Layout	5	22-Aug-14	28-Aug-14
A2160	Install Walls, Plenum, Ceiling	45	08-Sep-14	07-Nov-14
A2170	Install Filters, Lights, Pressure Monitoring S	12	10-Nov-14	25-Nov-14
A2180	Final Clean	11	19-Nov-14	03-Dec-14
1st Floor		248	19-Nov-13	03-Nov-14
Lab		234	25-Nov-13	20-Oct-14
Mechanical & Plumbing Trades		188	03-Dec-13	22-Aug-14
A2190	Install Duct (Risers, Main, Branches)	46	03-Dec-13	05-Feb-14
A2200	Install All Piping	51	10-Dec-13	19-Feb-14
A2210	Install HVAC Equipment	6	30-Dec-13	06-Jan-14
A2220	Install Plumbing Equipment/Fixtures	10	11-Aug-14	22-Aug-14
A2230	Install GRD's	5	06-Jun-14	12-Jun-14
Electrical Trade		205	03-Dec-13	16-Sep-14
A2240	Layout & Top Track	3	03-Dec-13	05-Dec-13
A2250	R-I Distribution, Power & Systems	42	17-Dec-13	13-Feb-14
A2260	Electric Room R-I	14	08-Jan-14	27-Jan-14
A2270	Lighting & All Trim-Out	89	15-May-14	16-Sep-14
Fire Suppression Trade		142	25-Nov-13	12-Jun-14
A2280	Spray Fireproofing	5	25-Nov-13	02-Dec-13
A2290	O/H Sprinkler R-I	20	16-Jan-14	12-Feb-14
A2300	Sprinkler Trim	10	30-May-14	12-Jun-14
Finishes Trade		168	27-Feb-14	20-Oct-14
A2310	Wall Finishes	122	27-Feb-14	15-Aug-14
A2320	Ceiling Finishes	51	27-Mar-14	05-Jun-14
A2330	Install Material & Hardware/Final Clean	93	12-Jun-14	20-Oct-14
Office		248	19-Nov-13	03-Nov-14
Mechanical & Plumbing Trades		152	26-Nov-13	27-Jun-14
A2340	Install Duct (Risers, Main, Branches)	24	26-Nov-13	31-Dec-13
A2350	Install All Piping	23	04-Dec-13	06-Jan-14
A2360	Install HVAC Equipment	5	20-Dec-13	27-Dec-13
A2370	Install Plumbing Equipment/Fixtures	5	23-Jun-14	27-Jun-14
A2380	Install GRD's	5	09-May-14	15-May-14
Electrical Trade		186	26-Nov-13	14-Aug-14
A2390	Layout & Top Track	3	26-Nov-13	29-Nov-13
A2400	R-I Distribution, Power & Systems	24	11-Dec-13	14-Jan-14
A2410	Electric Room R-I	11	27-Dec-13	10-Jan-14
A2420	Lighting & All Trim-Out	84	21-Apr-14	14-Aug-14



Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

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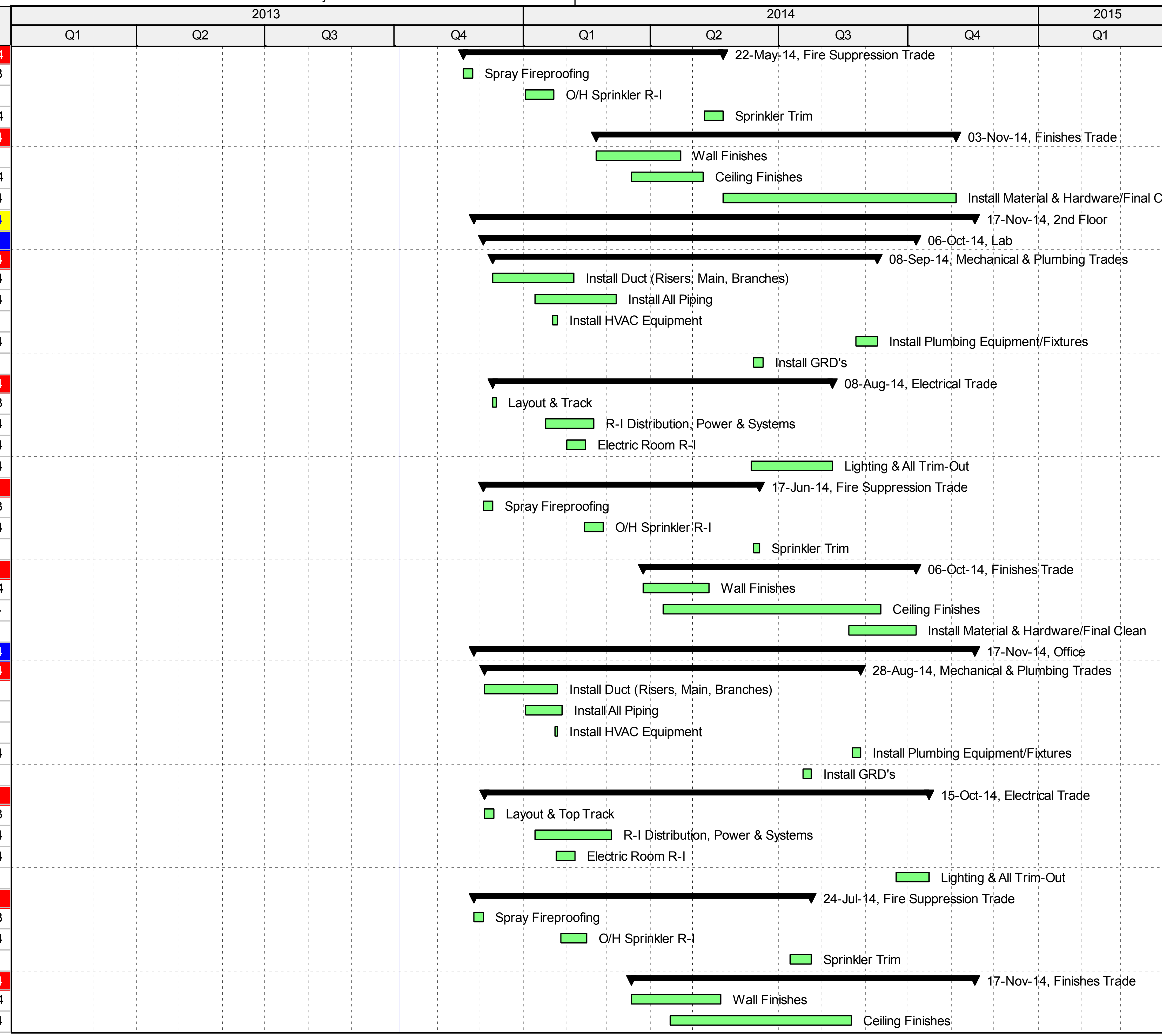
Activity ID	Activity Name	Original Duration	Start	Finish
Fire Suppression Trade		131	19-Nov-13	22-May-14
A2430	Spray Fireproofing	5	19-Nov-13	25-Nov-13
A2440	O/H Sprinkler R-I	15	02-Jan-14	22-Jan-14
A2450	Sprinkler Trim	10	09-May-14	22-May-14
Finishes Trade		182	21-Feb-14	03-Nov-14
A2460	Wall Finishes	43	21-Feb-14	22-Apr-14
A2470	Ceiling Finishes	38	18-Mar-14	08-May-14
A2480	Install Material & Hardware/Final Clean	118	22-May-14	03-Nov-14
2nd Floor		253	26-Nov-13	17-Nov-14
Lab		219	03-Dec-13	06-Oct-14
Mechanical & Plumbing Trades		194	10-Dec-13	08-Sep-14
A2490	Install Duct (Risers, Main, Branches)	41	10-Dec-13	05-Feb-14
A2500	Install All Piping	42	09-Jan-14	07-Mar-14
A2510	Install HVAC Equipment	4	21-Jan-14	24-Jan-14
A2520	Install Plumbing Equipment/Fixtures	11	25-Aug-14	08-Sep-14
A2530	Install GRD's	5	13-Jun-14	19-Jun-14
Electrical Trade		173	10-Dec-13	08-Aug-14
A2540	Layout & Track	3	10-Dec-13	12-Dec-13
A2550	R-I Distribution, Power & Systems	25	16-Jan-14	19-Feb-14
A2560	Electric Room R-I	10	31-Jan-14	13-Feb-14
A2570	Lighting & All Trim-Out	43	11-Jun-14	08-Aug-14
Fire Suppression Trade		140	03-Dec-13	17-Jun-14
A2580	Spray Fireproofing	5	03-Dec-13	09-Dec-13
A2590	O/H Sprinkler R-I	10	13-Feb-14	26-Feb-14
A2600	Sprinkler Trim	3	13-Jun-14	17-Jun-14
Finishes Trade		138	27-Mar-14	06-Oct-14
A2610	Wall Finishes	33	27-Mar-14	12-May-14
A2620	Ceiling Finishes	111	10-Apr-14	11-Sep-14
A2630	Install Material & Hardware/Final Clean	34	20-Aug-14	06-Oct-14
Office		253	26-Nov-13	17-Nov-14
Mechanical & Plumbing Trades		191	04-Dec-13	28-Aug-14
A2640	Install Duct (Risers, Main, Branches)	37	04-Dec-13	24-Jan-14
A2650	Install All Piping	19	02-Jan-14	28-Jan-14
A2660	Install HVAC Equipment	2	23-Jan-14	24-Jan-14
A2670	Install Plumbing Equipment/Fixtures	5	22-Aug-14	28-Aug-14
A2680	Install GRD's	5	18-Jul-14	24-Jul-14
Electrical Trade		225	04-Dec-13	15-Oct-14
A2690	Layout & Top Track	5	04-Dec-13	10-Dec-13
A2700	R-I Distribution, Power & Systems	39	09-Jan-14	04-Mar-14
A2710	Electric Room R-I	10	24-Jan-14	06-Feb-14
A2720	Lighting & All Trim-Out	18	22-Sep-14	15-Oct-14
Fire Suppression Trade		171	26-Nov-13	24-Jul-14
A2730	Spray Fireproofing	5	26-Nov-13	03-Dec-13
A2740	O/H Sprinkler R-I	15	27-Jan-14	14-Feb-14
A2750	Sprinkler Trim	12	09-Jul-14	24-Jul-14
Finishes Trade		175	18-Mar-14	17-Nov-14
A2760	Wall Finishes	46	18-Mar-14	20-May-14
A2770	Ceiling Finishes	93	15-Apr-14	21-Aug-14



Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

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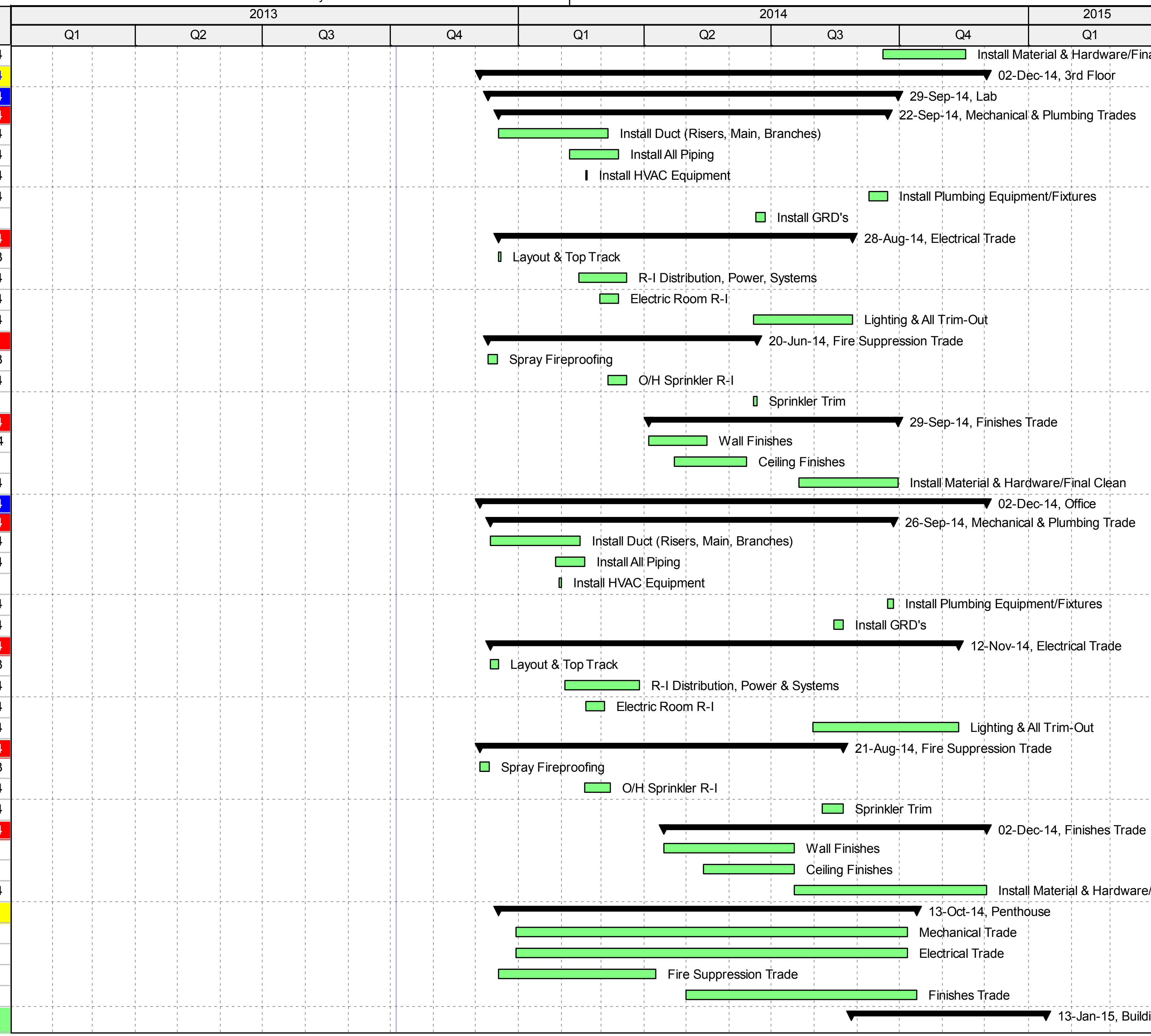
Activity ID	Activity Name	Original Duration	Start	Finish
A2780	Install Material & Hardware/Final Clean	42	19-Sep-14	17-Nov-14
3rd Floor		259	04-Dec-13	02-Dec-14
Lab		209	10-Dec-13	29-Sep-14
Mechanical & Plumbing Trades		199	17-Dec-13	22-Sep-14
A2790	Install Duct (Risers, Main, Branches)	56	17-Dec-13	05-Mar-14
A2800	Install All Piping	26	06-Feb-14	13-Mar-14
A2810	Install HVAC Equipment	1	18-Feb-14	18-Feb-14
A2820	Install Plumbing Equipment/Fixtures	10	09-Sep-14	22-Sep-14
A2830	Install GRD's	5	20-Jun-14	26-Jun-14
Electrical Trade		182	17-Dec-13	28-Aug-14
A2840	Layout & Top Track	3	17-Dec-13	19-Dec-13
A2850	R-I Distribution, Power, Systems	25	13-Feb-14	19-Mar-14
A2860	Electric Room R-I	10	28-Feb-14	13-Mar-14
A2870	Lighting & All Trim-Out	52	18-Jun-14	28-Aug-14
Fire Suppression Trade		138	10-Dec-13	20-Jun-14
A2880	Spray Fireproofing	5	10-Dec-13	16-Dec-13
A2890	O/H Sprinkler R-I	10	06-Mar-14	19-Mar-14
A2900	Sprinkler Trim	3	18-Jun-14	20-Jun-14
Finishes Trade		127	04-Apr-14	29-Sep-14
A2910	Wall Finishes	30	04-Apr-14	15-May-14
A2920	Ceiling Finishes	39	22-Apr-14	13-Jun-14
A2930	Install Material & Hardware/Final Clean	51	21-Jul-14	29-Sep-14
Office		259	04-Dec-13	02-Dec-14
Mechanical & Plumbing Trade		207	11-Dec-13	26-Sep-14
A2940	Install Duct (Risers, Main, Branches)	46	11-Dec-13	13-Feb-14
A2950	Install All Piping	16	27-Jan-14	17-Feb-14
A2960	Install HVAC Equipment	2	30-Jan-14	31-Jan-14
A2970	Install Plumbing Equipment/Fixtures	5	22-Sep-14	26-Sep-14
A2980	Install GRD's	5	15-Aug-14	21-Aug-14
Electrical Trade		240	11-Dec-13	12-Nov-14
A2990	Layout & Top Track	5	11-Dec-13	17-Dec-13
A3000	R-I Distribution, Power & Systems	40	03-Feb-14	28-Mar-14
A3010	Electric Room R-I	10	18-Feb-14	03-Mar-14
A3020	Lighting & All Trim-Out	75	31-Jul-14	12-Nov-14
Fire Suppression Trade		186	04-Dec-13	21-Aug-14
A3030	Spray Fireproofing	5	04-Dec-13	10-Dec-13
A3040	O/H Sprinkler R-I	15	17-Feb-14	07-Mar-14
A3050	Sprinkler Trim	12	06-Aug-14	21-Aug-14
Finishes Trade		166	15-Apr-14	02-Dec-14
A3060	Wall Finishes	68	15-Apr-14	17-Jul-14
A3070	Ceiling Finishes	48	13-May-14	17-Jul-14
A3080	Install Material & Hardware/Final Clean	99	17-Jul-14	02-Dec-14
Penthouse		214	17-Dec-13	13-Oct-14
A3090	Mechanical Trade	201	30-Dec-13	06-Oct-14
A3100	Electrical Trade	201	30-Dec-13	06-Oct-14
A3110	Fire Suppression Trade	81	17-Dec-13	09-Apr-14
A3120	Finishes Trade	118	01-May-14	13-Oct-14
Building Systems Start-Up Testing & Com		100	27-Aug-14	13-Jan-15



Actual Level of Effort | Remaining Work | ◆ Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

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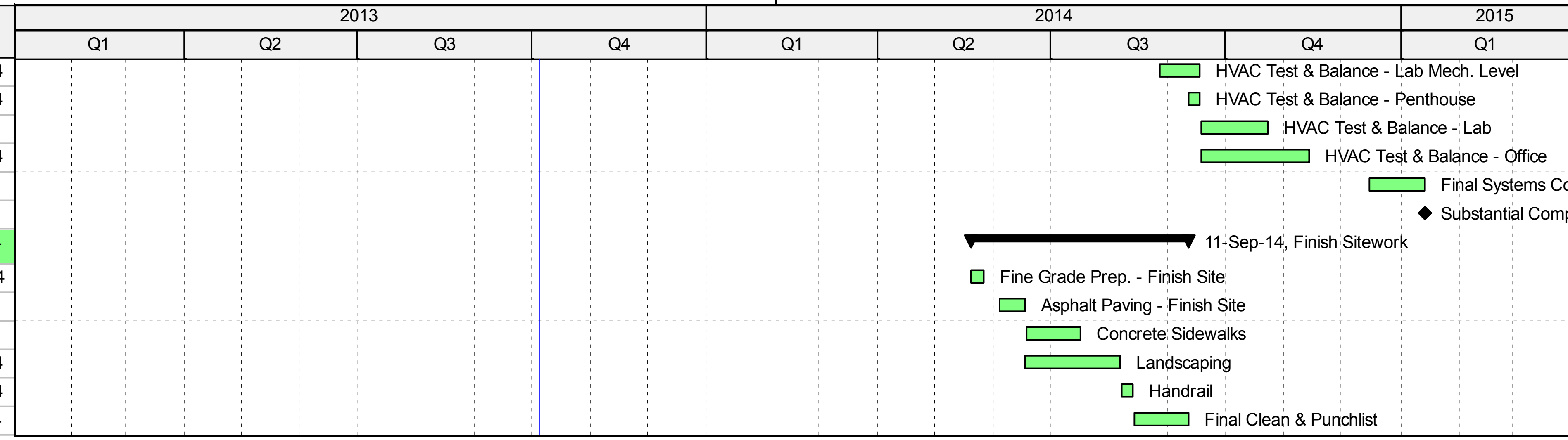
Activity ID	Activity Name	Original Duration	Start	Finish
A3130	HVAC Test & Balance - Lab Mech. Level	16	27-Aug-14	17-Sep-14
A3140	HVAC Test & Balance - Penthouse	5	11-Sep-14	17-Sep-14
A3150	HVAC Test & Balance - Lab	26	18-Sep-14	23-Oct-14
A3160	HVAC Test & Balance - Office	41	18-Sep-14	13-Nov-14
A3170	Final Systems Commissioning	22	15-Dec-14	13-Jan-15
A3240	Substantial Completion	0		13-Jan-15
Finish Sitework		83	20-May-14	11-Sep-14
A3180	Fine Grade Prep. - Finish Site	5	20-May-14	26-May-14
A3190	Asphalt Paving - Finish Site	10	04-Jun-14	17-Jun-14
A3200	Concrete Sidewalks	21	18-Jun-14	16-Jul-14
A3210	Landscaping	37	17-Jun-14	06-Aug-14
A3220	Handrail	5	07-Aug-14	13-Aug-14
A3230	Final Clean & Punchlist	21	14-Aug-14	11-Sep-14



Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

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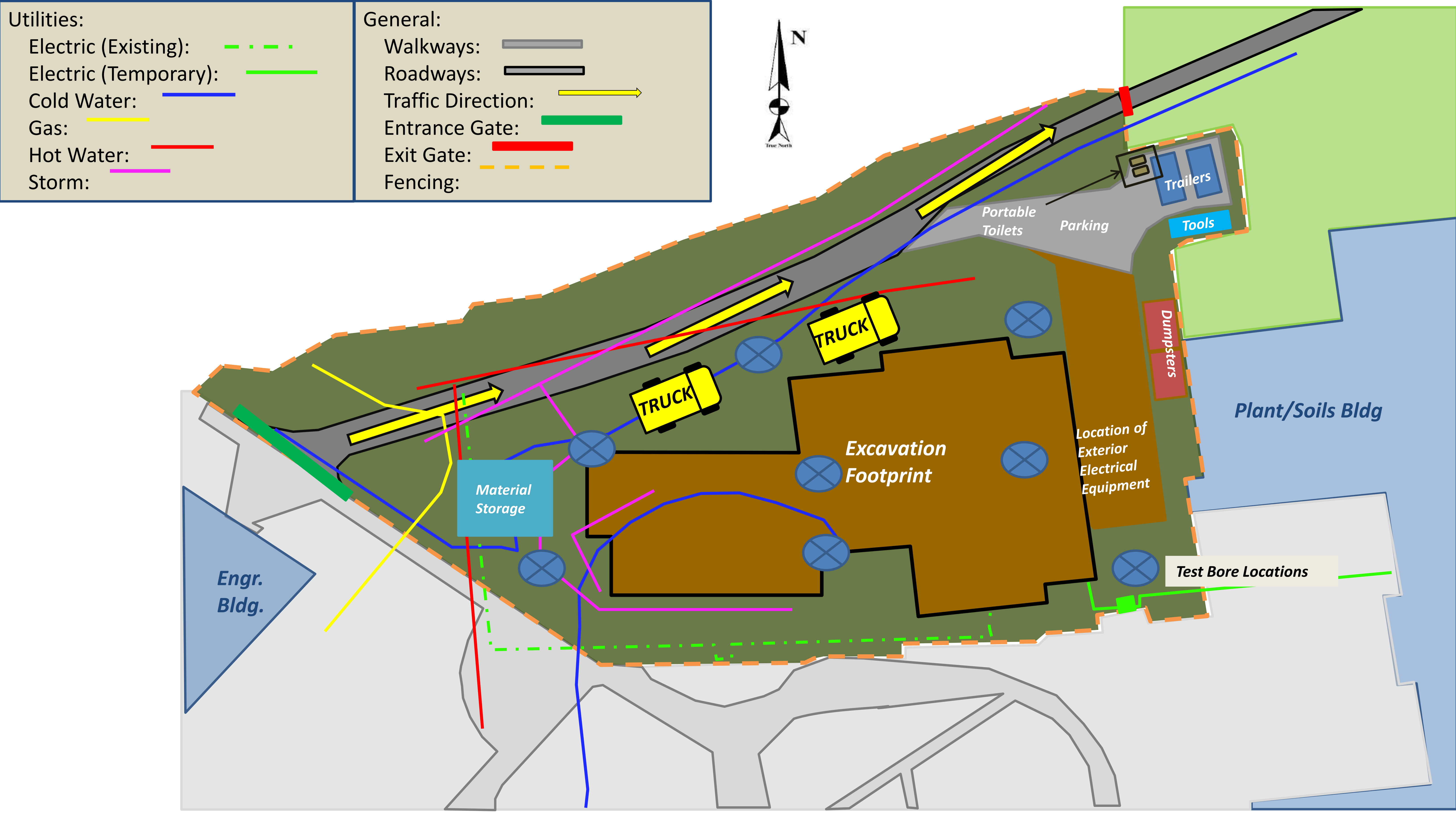
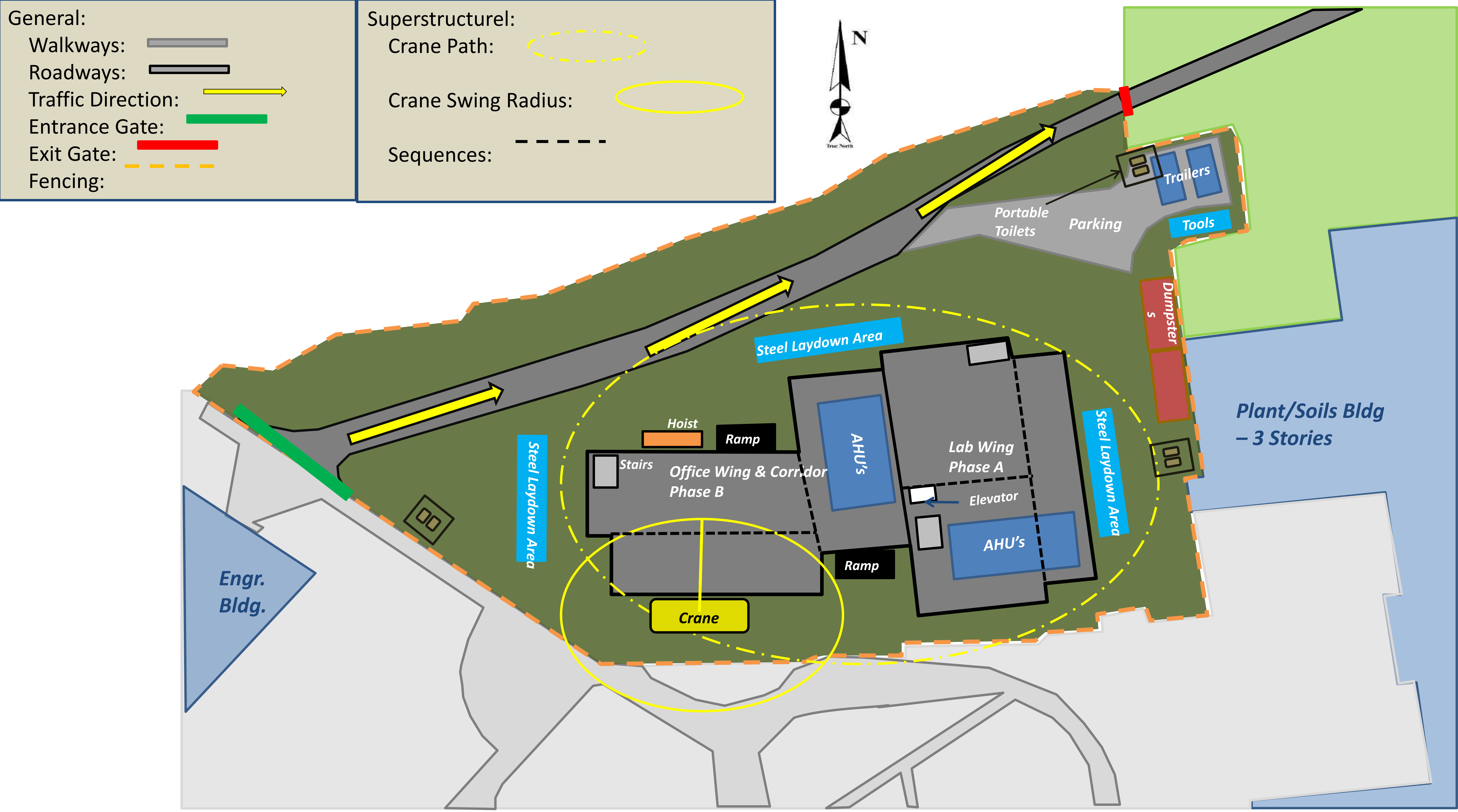
Appendix B – Site Layout Plans

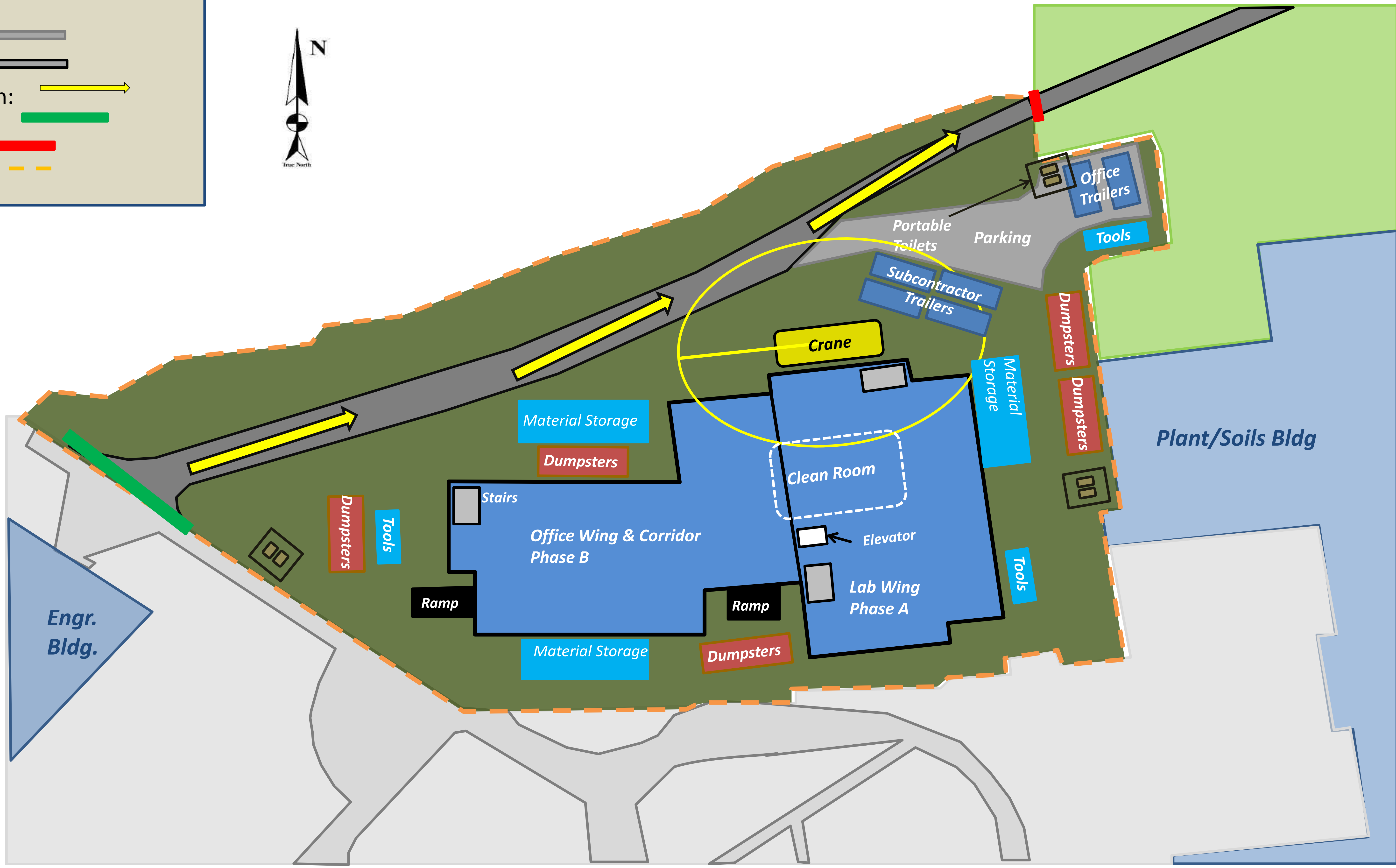


Excavation Plan	***University Engineering Building***	***Jeremy Feath***
Technical Report 2	***Mid-Atlantic University*** ***Mid-Atlantic Region, United States***	***Construction Option*** ***Dr. Dubler***

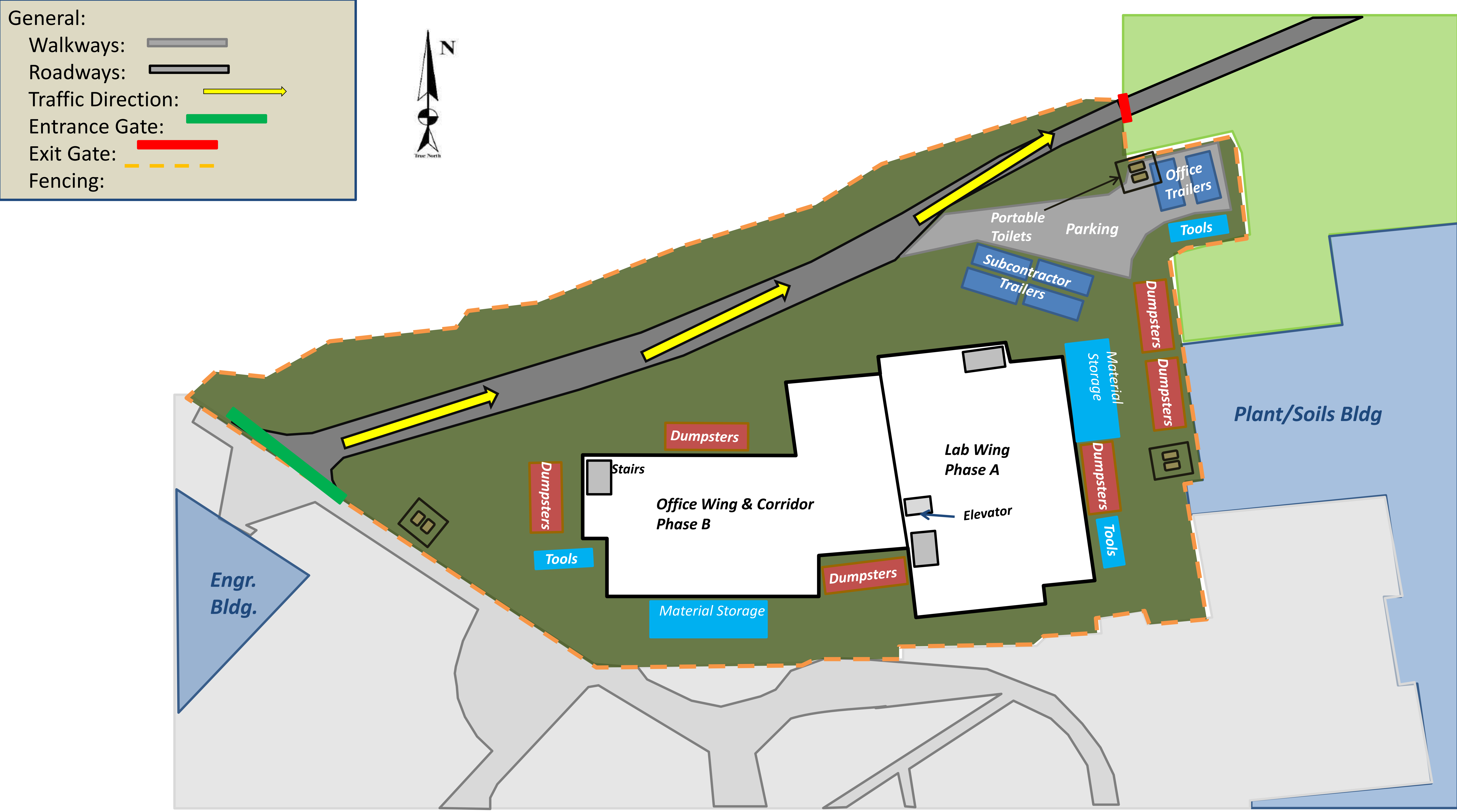


Superstructure Plan Technical Report 2	University Engineering Building Mid-Atlantic University Mid-Atlantic Region, United States	Jeremy Feath Construction Option Dr. Dubler

General:
- Walkways:
- Roadways:
- Traffic Direction:
- Entrance Gate:
- Exit Gate:
- Fencing:



MEP Rough-In Plan ***Technical Report 2***	***University Engineering Building*** ***Mid-Atlantic University*** ***Mid-Atlantic Region, United States***	***Jeremy Feath*** ***Construction Option*** ***Dr. Dubler***



Finishes Plan Technical Report 2	University Engineering Building Mid-Atlantic University Mid-Atlantic Region, United States	Jeremy Feath Construction Option Dr. Dubler

Appendix C – General Conditions Estimate

GENERAL CONDITIONS ESTIMATE			
Item	Unit	Cost/Unit	Total Cost
01-101 Superintendent (month)	24	$9,200.00	$220,800.00
01-103 Field Engineer (month)	24	$6,000.00	$144,000.00
01-105 Foreman (month)	24	$6,000.00	$144,000.00
01-106 Project Manager (month)	24	$9,900.00	$237,600.00
01-107 Material Handling (month)	24	$1,000.00	$24,000.00
01-109 Project Engineer (month)	24	$6,200.00	$148,800.00
01-117 Field - Training (month)	24	$120.00	$2,880.00
01-151 Superintendent Per Diem (month)	24	$1,000.00	$24,000.00
01-154 Vehicle Reimbursements (month)	24	$1,000.00	$24,000.00
01-202 Bonds	LS	0.5%*TC	$215,000.00
01-203 B & O Tax	LS	0.018%*TC	$77,400.00
01-204 Builders Risk Insurance	LS	0.24%*TC	$103,200.00
01-210 Blueprinting	24	0.05%*TC	$21,500.00
01-211 CPM Schedule	LS	0.05%*TC	$21,500.00
01-212 Office Supplies (month)	24	$125.00	$3,000.00
01-213 Postage (month)	24	$125.00	$3,000.00
01-214 Office Trailer (month)	24	$430.00	$10,320.00
01-215 Drinking Water (month)	24	$75.00	$1,800.00
01-218 Project Signs	LS	$2,500.00	$2,500.00
01-221 Safety	LS	$2,000.00	$2,000.00
01-223 Clean Up	LS	$15,000.00	$15,000.00
01-224 Temporary Partitions (ea.)	7	$175.00	$1,225.00
01-226 Final Clean (month)	1	$1,000.00	$1,000.00
01-229 Project Photos (month)	24	$1,575.00	$37,800.00
01-231 Architects Office (month)	24	$250.00	$6,000.00
01-232 Snow Removal/Street Sweeping (month)	24	$400.00	$9,600.00

Item	Unit	Cost/Unit	Total Cost
01-234 Street Repair (month)	24	$300.00	$7,200.00
01-303 Dumpsters (5) (month)	24	$175.00	$4,200.00
01-304 Hoist (month)	12	$2,000.00	$24,000.00
01-306 Small Tools	LS	$1,000.00	$1,000.00
01-404 Special Testing	LS	$5,000.00	$5,000.00
01-406 Other Testing	LS	$5,000.00	$5,000.00
01-501 Temporary Electric (month)	24	$150.00	$3,600.00
01-502 Temporary Phone (month)	24	$85.00	$2,040.00
01-504 Temporary Water (month)	24	$70.00	$1,680.00
01-505 Temporary Toilet Facilities (month)	24	$55.00	$1,320.00
01-506 Temporary Heat (month)	10	$230.00	$2,300.00
01-507 Temp. Weather Protection (month)	24	$150.00	$3,600.00
01-509 Barricades (ea.)	10	$390.00	$3,900.00
01-511 Temporary Stairs/Ramps (ea.)	12	$100.00	$1,200.00
01-512 Temporary Fencing (LF)	1504	$25.00	$37,600.00
01-515 Internet Service (month)	24	$100.00	$2,400.00
01-519 Rodent & Pest Control (month)	24	$120.00	$2,880.00
TOTAL			$1,610,845.00
TOTAL CONSTRUCTION COSTS * 6%			$1,962,000.00
COST DIFFERENCE			$351,155.00
% DIFFERENCE			17.90

Appendix D – Structural Systems Estimate

Structural Steel Estimate									
Type	Quantity	Unit	Material $/Unit	Labor $/Unit	Equip. $/Unit	Total Material	Total Labor	Total Equip.	Total Cost
CONCRETE									
Caisson Concrete									
4000 psi	14286	CF	$4.24	$2.10	$1.31	$60,572.64	$30,000.60	$18,714.66	$109,287.90
Retaining Wall Concrete									
5000 psi	30118	CF	$4.76	$2.10	$1.31	$143,361.68	$63,247.80	$39,454.58	$246,064.06
Grade Beam Concrete									
4000 psi	4014	CF	$4.24	$2.10	$1.31	$17,019.36	$8,429.40	$5,258.34	$30,707.10
Slab on Grade Concrete									
4000 psi	9125	CF	$4.24	$2.10	$1.31	$38,690.00	$19,162.50	$11,953.75	$69,806.25
Slab on Deck Concrete									
4000 psi	22410	CF	$4.24	$2.10	$1.31	$95,018.40	$47,061.00	$29,357.10	$171,436.50
Reinforced Curb Concrete									
4000 psi	582	CF	$4.24	$2.10	$1.31	$2,467.68	$1,222.20	$762.42	$4,452.30
CONCRETE SUBTOTAL									$631,754.11
REINFORCEMENT									
Caisson Rebar									
#3	0.56	tons	$1,000.00			$560.00			$560.00
#4	1.3	tons	$1,000.00			$1,300.00			$1,300.00
#7	2.38	tons	$1,000.00			$2,380.00			$2,380.00
#8	8.22	tons	$1,000.00			$8,220.00			$8,220.00
#9	0.6	tons	$1,000.00			$600.00			$600.00
#10	4.93	tons	$1,000.00			$4,930.00			$4,930.00
#11	1.8	tons	$1,000.00			$1,800.00			$1,800.00
Retaining Wall Rebar									
#5	13.58	tons	$1,000.00			$13,580.00			$13,580.00
#7	17.59	tons	$1,000.00			$17,590.00			$17,590.00
#8	0.64	tons	$1,000.00			$640.00			$640.00
Grade Beam Rebar									
#4 Stirrup	2.97	tons	$1,000.00			$2,970.00			$2,970.00
#7	8.48	tons	$1,000.00			$8,480.00			$8,480.00
#8	0.62	tons	$1,000.00			$620.00			$620.00
#9	2.21	tons	$1,000.00			$2,210.00			$2,210.00
Slab on Grade Rebar									
6x6 W2.9xW2.9 WWR	150	CSF	$22.50	$27.50		$3,375.00	$4,125.00		$7,500.00
Slab on Deck Rebar									
6x6 W2.9xW2.9 WWR	531.15	CSF	$22.50	$27.50		$11,950.88	$14,606.63		$26,557.50
6x6 W4.0xW4.0 WWR	174.75	CSF	$32.00	$29.50		$5,592.00	$5,155.13		$10,747.13
Reinforced Curb Rebar									
#5	0.863	tons	$38.00			$32.79			$32.79
REINFORCEMENT SUBTOTAL									$110,717.42

STRUCTURAL STEEL									
Steel Beams									
W8x10	122	LF	$14.30	$4.58	$2.54	$1,744.60	$558.76	$309.88	$2,613.24
W8x24	55	LF	$34.50	$4.99	$2.77	$1,897.50	$274.45	$152.35	$2,324.30
W10x12	212	LF	$17.15	$4.58	$2.54	$3,635.80	$970.96	$538.48	$5,145.24
W10x22	49	LF	$31.50	$4.58	$2.54	$1,543.50	$224.42	$124.46	$1,892.38
W12x14	1522	LF	$23.00	$3.12	$1.73	$35,006.00	$4,748.64	$2,633.06	$42,387.70
W12x16	1360	LF	$23.00	$3.12	$1.73	$31,280.00	$4,243.20	$2,352.80	$37,876.00
W14x22	277.327	LF	$37.00	$2.77	$1.54	$10,261.10	$768.20	$427.08	$11,456.38
W14x26	230	LF	$37.00	$2.77	$1.54	$8,510.00	$637.10	$354.20	$9,501.30
W14x30	14	LF	$43.00	$3.05	$1.69	$602.00	$42.70	$23.66	$668.36
W16x26	908	LF	$37.00	$2.75	$1.52	$33,596.00	$2,497.00	$1,380.16	$37,473.16
W16x31	271	LF	$44.50	$3.05	$1.69	$12,059.50	$826.55	$457.99	$13,344.04
W1636	24	LF	$57.00	$3.43	$1.91	$1,368.00	$82.32	$45.84	$1,496.16
W16x77	23	LF	$108.00	$3.68	$2.01	$2,484.00	$84.64	$46.23	$2,614.87
W18x35	146	LF	$50.00	$4.13	$1.74	$7,300.00	$602.98	$254.04	$8,157.02
W18x40	246	LF	$57.00	$4.13	$1.74	$14,022.00	$1,015.98	$428.04	$15,466.02
W18x143	28	LF	$175.00	$4.40	$1.85	$4,900.00	$123.20	$51.80	$5,075.00
W21x44	1019	LF	$63.00	$3.73	$1.57	$64,197.00	$3,800.87	$1,599.83	$69,597.70
W21x50	48	LF	$71.50	$3.70	$1.57	$3,432.00	$177.60	$75.36	$3,684.96
W24x55	121	LF	$78.50	$3.57	$1.50	$9,498.50	$431.97	$181.50	$10,111.97
W24x68	1280	LF	$97.00	$3.57	$1.50	$124,160.00	$4,569.60	$1,920.00	$130,649.60
W24x76	33	LF	$109.00	$3.57	$1.50	$3,597.00	$117.81	$49.50	$3,764.31
W27x84	248	LF	$120.00	$3.33	$1.40	$29,760.00	$825.84	$347.20	$30,933.04
W27x94	33	LF	$134.00	$3.30	$1.40	$4,422.00	$108.90	$46.20	$4,577.10
W36x150	33	LF	$215.00	$3.78	$1.59	$7,095.00	$124.74	$52.47	$7,272.21
C12x20.7	16	LF	$12.65	$34.00	$4.00	$202.40	$544.00	$64.00	$810.40
HSS 8x3x3/8	4	LF	$34.50	$4.99	$2.77	$138.00	$19.96	$11.08	$169.04
HSS 16x8x3/8	83	LF	$57.00	$4.13	$1.74	$4,731.00	$342.79	$144.42	$5,218.21
L4x4x3/8	66	LF	$14.30	$4.58	$2.54	$943.80	$302.28	$167.64	$1,413.72
L6x4x3/8	20	LF	$14.30	$4.58	$2.54	$286.00	$91.60	$50.80	$428.40
MC 6x12	48	LF	$21.50	$4.58	$2.54	$1,032.00	$219.84	$121.92	$1,373.76

Steel Columns									
W10x33	254.741	LF	$64.50	$2.66	$1.48	$16,430.79	$677.61	$377.02	$17,485.42
W10x39	31.462	LF	$64.50	$2.66	$1.48	$2,029.30	$83.69	$46.56	$2,159.55
W10x45	190.311	LF	$64.50	$2.66	$1.48	$12,275.06	$506.23	$281.66	$13,062.95
W10x49	60.188	LF	$64.50	$2.66	$1.48	$3,882.13	$160.10	$89.08	$4,131.30
W10x54	67.536	LF	$97.00	$2.79	$1.55	$6,550.99	$188.43	$104.68	$6,844.10
W10x60	66.989	LF	$97.00	$2.79	$1.55	$6,497.93	$186.90	$103.83	$6,788.67
W14x53	381.141	LF	$106.00	$2.79	$1.55	$40,400.95	$1,063.38	$590.77	$42,055.10
W14x61	133.858	LF	$106.00	$2.79	$1.55	$14,188.95	$373.46	$207.48	$14,769.89
W14x74	926.571	LF	$106.00	$2.79	$1.55	$98,216.53	$2,585.13	$1,436.19	$102,237.84
W14x90	722.363	LF	$139.00	$2.83	$1.57	$100,408.46	$2,044.29	$1,134.11	$103,586.85
W14x109	380.93	LF	$172.00	$2.86	$1.59	$65,519.96	$1,089.46	$605.68	$67,215.10
W14x120	711.502	LF	$172.00	$2.86	$1.59	$122,378.34	$2,034.90	$1,131.29	$125,544.53
HSS 10x10x1/4	39.053	LF	$64.50	$2.66	$1.48	$2,518.92	$103.88	$57.80	$2,680.60
HSS 10x10x3/8	254.165	LF	$64.50	$2.66	$1.48	$16,393.64	$676.08	$376.16	$17,445.89
STEEL SUBTOTAL									$993,503.38
FORMWORK									
Foundation Formwork	39434	SFCA	$1.12	$6.05		$44,166.08	$238,575.70		$282,741.78
Slab Formwork	2576.75	SFCA	$1.12	$6.05		$2,885.96	$15,589.34		$18,475.30
FORMWORK SUBTOTAL									$301,217.08
METAL DECKING									
2", 20 Gage, Galvanized	27418	SF	$2.01	$0.45	$0.04	$55,110.18	$12,338.10	$1,096.72	$68,545.00
2.5", 20 Gage, Galvanized	370	SF	$2.11	$0.50	$0.05	$780.70	$185.00	$18.50	$984.20
3", 20 Gage, Galvanized	24588	SF	$2.21	$0.54	$0.05	$54,339.48	$13,277.52	$1,229.40	$68,846.40
METAL DECKING SUBTOTAL									$138,375.60
SUBTOTAL									$2,175,567.58
MISC. STEEL (8%)									$174,045.41
TAX (8%)									$174,045.41
GRAND TOTAL									$2,523,658.39
TOTAL (INCLUDING LOCATION - 0.95)									$2,397,475.47
ACTUAL COST									$2,300,000.00

Caisson Lengths				*Caisson Rebar Length*						*Caisson Rebar Weight*				*Caisson Concrete*		
				Rebar Diameter		# of Bars		Total Rebar Length (LF)		lb/LF		Total (tons)				
Caisson Diameter (ft)	**Top (LF)**	**Base (LF)**	**Length (LF)**	**Vertical (in.)**	**Ties (in.)**	**Vertical**	**Ties**	**Vertical**	**Ties**	**Vertical**	**Ties**	**Vertical**	**Ties**	**Area**	**Cub. Ft.**	**Cub. Yd.**
Line Marker 2.8																
2.5	1129.67	1096	33.67	0.875	0.375	6	29	202.02	47.10	2.044	0.376	0.21	0.009	4.91	165.19	6.12
2.5	1129.67	1095.08	34.59	0.875	0.375	6	30	207.54	47.10	2.044	0.376	0.21	0.009	4.91	169.71	6.29
3	1129.67	1093.67	36	1	0.375	7	27	252	65.94	2.670	0.376	0.34	0.012	7.07	254.34	9.42
3	1129.67	1091.5	38.17	1	0.375	7	29	267.19	65.94	2.670	0.376	0.36	0.012	7.07	269.67	9.99
3	1129.67	1089.83	39.84	1	0.375	7	30	278.88	65.94	2.670	0.376	0.37	0.012	7.07	281.47	10.42
3	1129.67	1088	41.67	1	0.375	7	31	291.69	65.94	2.670	0.376	0.39	0.012	7.07	294.40	10.90
Line Marker 4.5																
2.5	1129.67	1099.08	30.59	0.875	0.375	6	26	183.54	47.10	2.044	0.376	0.19	0.009	4.91	150.08	5.56
2.5	1129.67	1098	31.67	0.875	0.375	6	27	190.02	47.10	2.044	0.376	0.19	0.009	4.91	155.38	5.75
Line Marker 4.8																
2.5	1129.67	1097.83	31.84	0.875	0.375	6	27	191.04	47.10	2.044	0.376	0.20	0.009	4.91	156.22	5.79
3	1129.67	1096.58	33.09	1	0.375	7	25	231.63	65.94	2.670	0.376	0.31	0.012	7.07	233.78	8.66
3	1129.67	1096.33	33.34	1	0.375	7	25	233.38	65.94	2.670	0.376	0.31	0.012	7.07	235.55	8.72
3	1129.67	1094.25	35.42	1	0.375	7	27	247.94	65.94	2.670	0.376	0.33	0.012	7.07	250.24	9.27
3	1129.67	1093	36.67	1	0.375	7	28	256.69	65.94	2.670	0.376	0.34	0.012	7.07	259.07	9.60
Line Marker 5.2																
2.5	1129.67	1100	29.67	0.875	0.375	6	25	178.02	47.10	2.044	0.376	0.18	0.009	4.91	145.57	5.39
2.5	1129.67	1099.42	30.25	0.875	0.375	6	26	181.5	47.10	2.044	0.376	0.19	0.009	4.91	148.41	5.50
3	1129.67	1098.83	30.84	1	0.375	7	23	215.88	65.94	2.670	0.376	0.29	0.012	7.07	217.88	8.07
3	1129.67	1097.83	31.84	1	0.375	7	24	222.88	65.94	2.670	0.376	0.30	0.012	7.07	224.95	8.33
3	1129.67	1096.83	32.84	1	0.375	7	25	229.88	65.94	2.670	0.376	0.31	0.012	7.07	232.01	8.59
3	1129.67	1095.83	33.84	1	0.375	7	25	236.88	65.94	2.670	0.376	0.32	0.012	7.07	239.08	8.85
3	1129.67	1094.83	34.84	1	0.375	7	26	243.88	65.94	2.670	0.376	0.33	0.012	7.07	246.14	9.12
Line Marker 6.8																
3	1129.67	1101.67	28	1	0.375	7	21	196	65.94	2.670	0.376	0.26	0.012	7.07	197.82	7.33
3	1129.67	1101.17	28.5	1	0.375	7	21	199.5	65.94	2.670	0.376	0.27	0.012	7.07	201.35	7.46
3	1129.67	1100.67	29	1	0.375	7	22	203	65.94	2.670	0.376	0.27	0.012	7.07	204.89	7.59
3	1129.67	1100.17	29.5	1	0.375	7	22	206.5	65.94	2.670	0.376	0.28	0.012	7.07	208.42	7.72
3.5	1129.67	1099.67	30	1.128	0.5	7	20	210	76.93	3.400	0.668	0.36	0.026	9.62	288.49	10.68
2.5	1129.67	1099.5	30.17	0.875	0.375	6	26	181.02	47.10	2.044	0.376	0.19	0.009	4.91	148.02	5.48
3	1129.67	1099.17	30.5	1	0.375	7	23	213.5	65.94	2.670	0.376	0.29	0.012	7.07	215.48	7.98

Line Marker 1.0																
3	1110	1090.75	19.25	1	0.375	7	14	134.75	65.94	2.670	0.376	0.18	0.012	7.07	136.00	5.04
3	1110	1090.08	19.92	1	0.375	7	15	139.44	65.94	2.670	0.376	0.19	0.012	7.07	140.73	5.21
4	1110	1089.17	20.83	1.27	0.5	7	14	145.81	87.92	4.303	0.668	0.31	0.029	12.56	261.62	9.69
4	1110	1087.67	22.33	1.27	0.5	7	15	156.31	87.92	4.303	0.668	0.34	0.029	12.56	280.46	10.39
4.5	1110	1085.75	24.25	1.27	0.5	9	16	218.25	127.17	4.303	0.668	0.47	0.042	15.90	385.48	14.28
3	1110	1084	26	1	0.375	7	20	182	65.94	2.670	0.376	0.24	0.012	7.07	183.69	6.80
3	1110	1081.17	28.83	1	0.375	7	22	201.81	65.94	2.670	0.376	0.27	0.012	7.07	203.68	7.54
Line Marker 2.0																
4	1110	1096.58	13.42	1.27	0.5	7	9	93.94	87.92	4.303	0.668	0.20	0.029	12.56	168.56	6.24
4.5	1110	1095.33	14.67	1.27	0.5	9	10	132.03	127.17	4.303	0.668	0.28	0.042	15.90	233.20	8.64
4.5	1110	1094.17	15.83	1.27	0.5	9	11	142.47	127.17	4.303	0.668	0.31	0.042	15.90	251.64	9.32
4	1110	1092.08	17.92	1.27	0.5	7	12	125.44	87.92	4.303	0.668	0.27	0.029	12.56	225.08	8.34
3	1110	1084.5	25.5	1	0.375	7	19	178.5	65.94	2.670	0.376	0.24	0.012	7.07	180.16	6.67
Line Marker 3.0																
4	1110	1102.33	7.67	1.27	0.5	7	5	53.69	87.92	4.303	0.668	0.12	0.029	12.56	96.34	3.57
4.5	1110	1101.08	8.92	1.27	0.5	9	6	80.28	127.17	4.303	0.668	0.17	0.042	15.90	141.79	5.25
4.5	1110	1100.25	9.75	1.27	0.5	9	7	87.75	127.17	4.303	0.668	0.19	0.042	15.90	154.99	5.74
5	1110	1098.5	11.5	1.41	0.5	9	8	103.5	141.30	5.313	0.668	0.27	0.047	19.63	225.69	8.36
2.5	1110	1094	16	0.875	0.375	6	14	96	47.10	2.044	0.376	0.10	0.009	4.91	78.50	2.91
4.5	1110	1088.17	21.83	1.27	0.5	9	15	196.47	127.17	4.303	0.668	0.42	0.042	15.90	347.02	12.85
Line Marker 4.0																
4	1110	1103	7	1.27	0.5	7	5	49	87.92	4.303	0.668	0.11	0.029	12.56	87.92	3.26
4.5	1110	1103	7	1.27	0.5	9	5	63	127.17	4.303	0.668	0.14	0.042	15.90	111.27	4.12
4.5	1110	1103	7	1.27	0.5	9	5	63	127.17	4.303	0.668	0.14	0.042	15.90	111.27	4.12
3	1108	1101	7	1	0.375	7	5	49	65.94	2.670	0.376	0.07	0.012	7.07	49.46	1.83
5	1108	1101	7	1.41	0.5	9	5	63	141.30	5.313	0.668	0.17	0.047	19.63	137.38	5.09
2.5	1110	1097.33	12.67	0.875	0.375	6	11	76.02	47.10	2.044	0.376	0.08	0.009	4.91	62.16	2.30
3	1108	1101	7	1	0.375	7	5	49	65.94	2.670	0.376	0.07	0.012	7.07	49.46	1.83
5	1108	1101	7	1.41	0.5	9	5	63	141.30	5.313	0.668	0.17	0.047	19.63	137.38	5.09
2.5	1110	1099.08	10.92	0.875	0.375	6	9	65.52	47.10	2.044	0.376	0.07	0.009	4.91	53.58	1.98
4.5	1110	1095.25	14.75	1.27	0.5	9	10	132.75	127.17	4.303	0.668	0.29	0.042	15.90	234.47	8.68
Line Marker 5.0																
2.5	1110	1103	7	0.875	0.375	6	6	42	47.10	2.044	0.376	0.04	0.009	4.91	34.34	1.27
4	1110	1103	7	1.27	0.5	7	5	49	87.92	4.303	0.668	0.11	0.029	12.56	87.92	3.26
5	1110	1103	7	1.41	0.5	9	5	63	141.30	5.313	0.668	0.17	0.047	19.63	137.38	5.09
5	1110	1103	7	1.41	0.5	9	5	63	141.30	5.313	0.668	0.17	0.047	19.63	137.38	5.09
2.5	1110	1103	7	0.875	0.375	6	6	42	47.10	2.044	0.376	0.04	0.009	4.91	34.34	1.27
5	1110	1103	7	1.41	0.5	9	5	63	141.30	5.313	0.668	0.17	0.047	19.63	137.38	5.09
4.5	1110	1095.25	14.75	1.27	0.5	9	10	132.75	127.17	4.303	0.668	0.29	0.042	15.90	234.47	8.68

Line Marker 5.5																
3	1110	1103	7	1	0.375	7	5	49	65.94	2.670	0.376	0.07	0.012	7.07	49.46	1.83
5	1110	1103	7	1.41	0.5	9	5	63	141.30	5.313	0.668	0.17	0.047	19.63	137.38	5.09
4	1110	1102	8	1.27	0.5	7	5	56	87.92	4.303	0.668	0.12	0.029	12.56	100.48	3.72
4	1110	1101	9	1.27	0.5	7	6	63	87.92	4.303	0.668	0.14	0.029	12.56	113.04	4.19
2.5	1110	1096.33	13.67	0.875	0.375	6	12	82.02	47.10	2.044	0.376	0.08	0.009	4.91	67.07	2.48
Line Marker 6.0																
4	1110	1103	7	1.27	0.5	7	5	49	87.92	4.303	0.668	0.11	0.029	12.56	87.92	3.26
5	1110	1103	7	1.41	0.5	9	5	63	141.30	5.313	0.668	0.17	0.047	19.63	137.38	5.09
5	1110	1103	7	1.41	0.5	9	5	63	141.30	5.313	0.668	0.17	0.047	19.63	137.38	5.09
Line Marker 6.5																
2.5	1125	1105	20	0.875	0.375	6	17	120	47.10	2.044	0.376	0.12	0.009	4.91	98.13	3.63
4	1110	1102.83	7.17	1.27	0.5	7	5	50.19	87.92	4.303	0.668	0.11	0.029	12.56	90.06	3.34
5	1110	1102.25	7.75	1.41	0.5	9	5	69.75	141.30	5.313	0.668	0.19	0.047	19.63	152.09	5.63
Line Marker 7.0																
3	1125	1105	20	1	0.375	7	15	140	65.94	2.670	0.376	0.19	0.012	7.07	141.30	5.23
3.5	1125	1105	20	1.125	0.5	7	13	140	76.93	3.400	0.668	0.24	0.026	9.62	192.33	7.12
4	1125	1103.67	21.33	1.27	0.5	7	14	149.31	87.92	4.303	0.668	0.32	0.029	12.56	267.90	9.92
Line Marker 7.5																
2.5	1125	1105	20	0.875	0.375	6	17	120	47.10	2.044	0.376	0.12	0.009	4.91	98.13	3.63
3	1125	1104.5	20.5	1	0.375	7	15	143.5	65.94	2.670	0.376	0.19	0.012	7.07	144.83	5.36
3	1125	1104	21	1	0.375	7	16	147	65.94	2.670	0.376	0.20	0.012	7.07	148.37	5.50
3	1125	1103.42	21.58	1	0.375	7	16	151.06	65.94	2.670	0.376	0.20	0.012	7.07	152.46	5.65

Retaining Wall Concrete					
Location	Length (LF)	Thickness (LF)	Height (LF)	Cu. Ft.	Cu. Yd.
Office	425	1.75	10	7437.50	275.46
Lab	540	1.75	24	22680.00	840.00
Total	965.00			30118.00	1116.00

Slab on Deck Concrete (Level 1)				
Type	Area (SF)	Conc. Thickness (in.)	Cu. Ft.	Cu. Yd.
S-5.5	8929.48	3.5	2604.432	96.460
S-5.5A	209.818	3.5	61.197	2.267
S-6.5 (PH)	369.42	4	123.140	4.561
S-8	8196.25	5	3415.104	126.485
6" Conc. Slab (PH)	356.23	6	178.115	6.597
Total (1 Level)			6382.000	237.000
Total (3 Levels)			18543.453	711.000

Slab on Grade Concrete				
Type	Area (SF)	Conc. Thickness (in.)	Cu. Ft.	Cu. Yd.
4" Slab	554	4	184.67	6.84
6" Slab	6543.19	6	3271.60	121.17
8" Slab	6422.42	8	4281.61	158.58
12" Slab	1386.41	12	1386.41	51.35
Total			9125.00	338.00

Reinforced Concrete Curb					
Type	Width (in.)	Height (in.)	Length (LF)	Cu. Ft.	Cu. Yd.
12" w x 10" h	12	10	397.15	330.96	12.26
7" w x 12" h	7	12	430.24	250.97	9.30
Total				582.00	22.00

Slab on Deck Concrete (Penthouse)				
Type	Area (SF)	Conc. Thickness (in.)	Cu. Ft.	Cu. Yd.
S-8	9278.57	5	3866.0708	144

Grade Beams					
Type	Width (ft.)	Depth (ft.)	Length (LF)	Cu. Ft.	Cu. Yd.
GB2424	2	2	6	24.00	0.89
GB3024	2.5	2	830	4150.00	153.70
GB3624	3	2	100	600.00	22.22
GB4824	4	2	30	240.00	8.89
Total				5014.00	185.70

Retaining Wall Reinforcement									
Rebar Desc.	Rebar Diameter	# of Rebar per Dimension	Retaining Wall Dimension	Total # of Rebar	Rebar Length (per bar)	Total Rebar Length	Rod Weight (lb) per LF	Total Weight (lb)	Total Weight (Tons)
Lab Space									
#7 @ 12" Vert. Inside Face	0.875	1	540	540.00	24	12960	2.044	26490.24	13.25
#5 @ 12" Vert. Soil Face	0.625	1	540	540.00	24	12960	1.043	13517.28	6.76
#5 @ 12" Horiz. Each Face	0.625	2	24	48.00	144.795	6950.16	1.043	7249.02	3.62
(2) #8 Cont. Length	1	2	540	2	144.795	289.59	2.67	773.21	0.39
Office Space									
#7 @ 12" Vert. Inside Face	0.875	1	425	425	10	4250	2.044	8687.00	4.34
#5 @ 12" Vert. Soil Face	0.625	1	425	425	10	4250	1.043	4432.75	2.22
#5 @ 12" Horiz. Each Face	0.625	2	10	20	93.801	1876.02	1.043	1956.69	0.98
(2) #8 Cont. Length	1	2	425	2	93.801	187.602	2.67	500.90	0.25
Total									
#7 @ 12" Vert. Inside Face								35177.24	17.59
#5 @ 12" Vert. Soil Face								17950.03	8.98
#5 @ 12" Horiz. Each Face								9205.71	4.60
(2) #8 Cont. Length								1274.10	0.64

Reinforced Concrete Curb							
Type	Rebar Size	# of Rebar per Length	Length (LF)	Total LF	lb/LF	Total Weight (lb)	Total Weight (tons)
12" w x 10" h	#5	2	397.15	794.3	1.043	828.45	0.414
7" w x 12" h	#5	2	430.24	860.48	1.043	897.48	0.449
Total						1725.94	0.863

Slab on Deck Reinforcement (Level 1)		
Slab & Reinforcement Type	Area (SF)	# of Squares
S-5.5, 6x6 W2.9xW2.9 WWR	8929.48	90.00
S-5.5A, 6x6 W2.9xW2.9 WWR	209.818	3.00
S-6.5, 6x6 W2.9xW2.9 WWR	369.42	4.00
S-8, 6x6 W4.0xW4.0 WWR	8196.25	82.00
Total (1 Level)	17704.968	179
Total (3 Levels)	53114.904	537
Total (3 Levels+Penthouse)	62393.474	623.93474

Slab on Grade Reinforcement		
Slab & Reinforcement Type	Area (SF)	# of Squares
4", 6x6 W2.9xW2.9 WWR	554	6.00
6", 6x6 W2.9xW2.9 WWR	6543.19	66.00
8", 6x6 W2.9xW2.9 WWR	6422.42	65.00
12", 6x6 W2.9xW2.9 WWR	1386.41	14.00
Total	14906.02	151.00

Metal Decking (Level 1)	
Type	Area (SF)
2", 20 Gage, Galvanized	9139.298
2.5", 20 Gage, Galvanized	369.42
3", 20 Gage, Galvanized	8196.25
Total (1 Level)	17335.55
Total (3 Levels)+Penthouse	52376.06

Grade Beams Reinforcement										
Type	Top Bars	Bottom Bars	Side Bars (Each Face)	Grade Beam Length	Total Top Bar Length	Total Bottom Bar Length	Total Side Bar Length	Rebar lb/LF	Total Weight (lb.)	Total Weight (tons)
GB2424	(4) #8	(4) #8		6	24	24		2.67	128.16	0.06
GB3024	(4) #7	(4) #7	(2) #7	830	3320	3320	1660	2.044	16965.20	8.48
GB3624	(5) #9	(5) #9	(3) #9	100	500	500	300	3.4	4420.00	2.21
GB4824	(6) #8	(6) #8	(2) #8	30	180	180	60	2.67	1121.40	0.56

Steel Beam - Lab Space (Level 1)				
Beam Size	Weight (lb./ft.)	Length (LF)	Weight (lb.)	Tons
W8x10	10	11.82	118.20	0.06
W8x24	24	18.179	436.30	0.22
W10x12	12	12.519	150.23	0.08
W10x22	22	15.072	331.58	0.17
W12x14	14	9.667	135.34	0.07
W14x22	22	63.945	1406.79	0.70
W14x30	30	4.824	144.72	0.07
W16x26	26	5.35	139.10	0.07
W16x77	77	5.058	389.47	0.19
W18x40	40	65.994	2639.76	1.32
W21x44	44	199.135	8761.94	4.38
W21x50	50	15.991	799.55	0.40
W24x68	68	83.35	5667.80	2.83
W27x84	84	77.766	6532.34	3.27
C12x20.7	20.7	5.359	110.93	0.06
HSS 8x3x3/8		8.035	0.00	0.00
HSS 16x8x3/8		2.927	0.00	0.00
Total (1 Level)			27764.05	13.88
Total (3 Levels)			83292.14	41.65

Steel Beam - Penthouse Space				
Beam Size	Weight (lb./ft.)	Length (LF)	Weight (lb.)	Tons
W8x10	10	26.119	261.19	0.13
W10x12	12	9.488	113.86	0.06
W12x14	14	24.665	345.31	0.17
W14x22	22	145.13	3192.86	1.60
W14x26	26	76.747	1995.42	1.00
W16x26	26	178.945	4652.57	2.33
W16x31	31	16.018	496.56	0.25
W16x36	36	7.867	283.21	0.14
W18x35	35	29.189	1021.62	0.51
W18x40	40	15.983	639.32	0.32
W21x44	44	57.011	2508.48	1.25
MC 6x12	12	16.089	193.07	0.10
Total			15703.47	7.85

Steel Beam - Office Space (Level 1)				
Beam Size	Weight (lb./ft.)	Length (LF)	Weight (lb.)	Tons
W8x10	10	2.883	28.83	0.01
W10x12	12	48.268	579.22	0.29
W10x22	22	1.508	33.18	0.02
W12x14	14	1.927	26.98	0.01
W12x16	16	28.323	453.17	0.23
W14x22	22	68.252	1501.54	0.75
W16x26	26	118.417	3078.84	1.54
W16x31	31	74.412	2306.77	1.15
W16x77	77	2.677	206.13	0.10
W18x35	35	19.405	679.18	0.34
W18x143	143	9.422	1347.35	0.67
W21x44	44	83.656	3680.86	1.84
W24x55	55	40.37	2220.35	1.11
W24x68	68	343.509	23358.61	11.68
W24x76	76	11.011	836.84	0.42
W27x84	84	5.07	425.88	0.21
W27x94	94	11.002	1034.19	0.52
W36x150	150	11.078	1661.70	0.83
L4x4x3/8		2	0.00	0.00
L6x4x3/8		6.65	0.00	0.00
Total (1 Level)			43459.61	21.73
Total (3 Levels)			130378.82	65.19

Steel Columns - All Levels				
Column Size	Weight (lb./ft.)	Length (LF)	Weight (lb.)	Tons
W10x33	33	254.741	8406.45	4.20
W10x39	39	31.462	1227.02	0.61
W10x45	45	190.311	8564.00	4.28
W10x49	49	60.188	2949.21	1.47
W10x54	54	67.536	3646.94	1.82
W10x60	60	66.989	4019.34	2.01
W14x53	53	381.141	20200.47	10.10
W14x61	61	133.858	8165.34	4.08
W14x74	74	926.571	68566.25	34.28
W14x90	90	722.363	65012.67	32.51
W14x109	109	380.93	41521.37	20.76
W14x120	120	711.502	85380.24	42.69
HSS 10x10x1/4		39.053	0.00	0.00
HSS 10x10x3/8		254.165	0.00	0.00
Total			317659.31	158.83

Retaining Wall Formwork			
Location	Length (LF)	Height (LF)	SFCA
Office	425	10	8500
Lab	540	24	25920
Total			34420

Grade Beam Formwork			
Type	Width (ft.)	Length (LF)	SFCA
GB2424	2	6	24
GB3024	2.5	830	4150
GB3624	3	100	600
GB4824	4	30	240
Total			5014

Slab on Grade Formwork			
Type	Length (LF)	Thickness (in.)	SFCA
4" Slab	128.75	4	42.92
6" Slab	590.25	6	295.13
8" Slab	342.2	8	228.13
12" Slab	262.05	12	262.05
Total			828.23

Slab on Deck Formwork			
Type	Length (LF)	Thickness (in.)	SFCA
S-5.5	2026.5	3.5	591.06
S-5.5A	798.39	3.5	232.86
S-6.5 (PH)	135.55	4	45.18
S-8	1939.25	5	808.02
6" Conc. Slab (PH)	142.78	6	71.39
Total			1748.52

Appendix E – MEP Assemblies Estimate

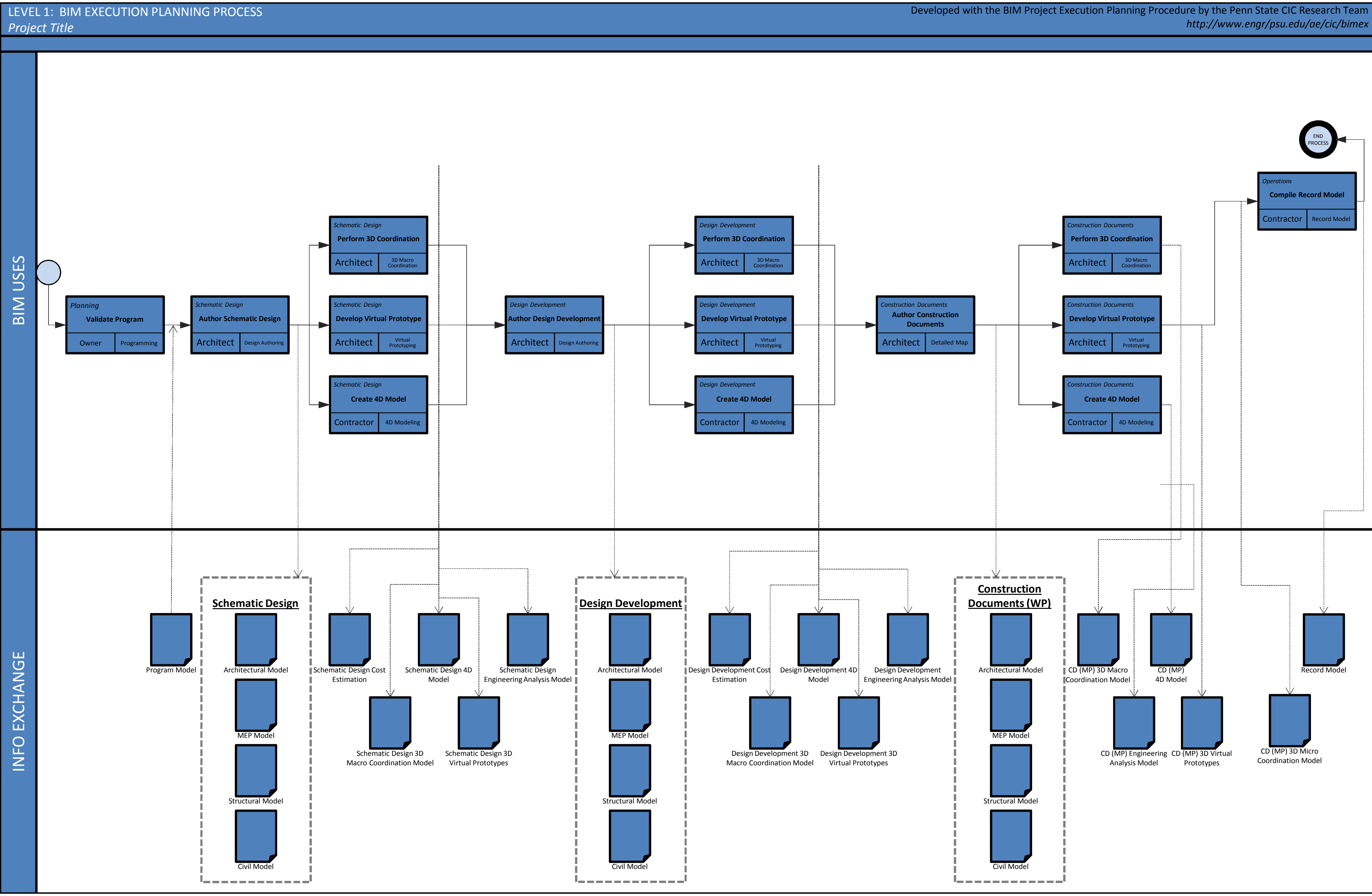
MEP ASSEMBLIES ESTIMATE								
Code No.	Item	Quantity	Unit	Material $/Unit	Installation $/Unit	Material $	Installation $	Total $
260000	***ELECTRICAL***							
262413	*Switchgear*							
	480Y/277V, 800 A	1	Ea.	$18,900.00	$6,275.00	$18,900.00	$6,275.00	$25,175.00
	480Y/277V, 1200 A	1	Ea.	$25,700.00	$7,825.00	$25,700.00	$7,825.00	$33,525.00
	480Y/277V, 4000 A	1	Ea.	$85,000.00	$11,975.00	$85,000.00	$11,975.00	$96,975.00
262416	*Panelboard*							
	100 A	9	Ea.	$2,525.00	$3,025.00	$22,725.00	$27,225.00	$49,950.00
	200 A	41	Ea.	$8,400.00	$5,300.00	$344,400.00	$217,300.00	$561,700.00
	250 A	2	Ea.	$8,400.00	$5,300.00	$16,800.00	$10,600.00	$27,400.00
	800 A	1	Ea.	$22,300.00	$12,500.00	$22,300.00	$12,500.00	$34,800.00
	1000 A	4	Ea.	$22,300.00	$12,500.00	$89,200.00	$50,000.00	$139,200.00
260590	*Receptacle*							
	Office (20/1000 SF)	27420	SF	$0.73	$3.15	$20,016.60	$86,373.00	$106,389.60
	Lab (31/1000 SF)	39495	SF	$1.10	$3.15	$43,444.50	$124,409.25	$167,853.75
	Level 0 (31/1000 SF)	15076	SF	$1.10	$3.15	$16,583.60	$47,489.40	$64,073.00
265113	*Lighting Fixtures*							
	Fluorescent - Office (14/1000 SF)	27420	SF	$2.95	$6.00	$80,889.00	$164,520.00	$245,409.00
	Fluorescent - Lab (18/1000 SF)	39495	SF	$2.95	$6.00	$116,510.25	$236,970.00	$353,480.25
	Fluorescent - Level 0 (18/1000 SF)	15076	SF	$2.95	$6.00	$44,474.20	$90,456.00	$134,930.20

260505	*Generator*							
	300 kW, 480Y/277V	1	Ea.	$208.00	$26.00	$208.00	$26.00	$234.00
262413	*Feeder Installation*							
	100 A (9*3)	1404	LF	$11.75	$15.00	$16,497.00	$21,060.00	$37,557.00
	200 A (41*4)	8528	LF	$28.00	$22.50	$238,784.00	$191,880.00	$430,664.00
	250 A (2*4)	416	LF	$28.00	$22.50	$11,648.00	$9,360.00	$21,008.00
	800 A (1*4)	208	LF	$135.00	$87.50	$28,080.00	$18,200.00	$46,280.00
	1000 A (4*4)	832	LF	$168.00	$115.00	$139,776.00	$95,680.00	$235,456.00
267113	*Motors*							
	0.75 HP	4	Ea.	$730.00	$1,050.00	$2,920.00	$4,200.00	$7,120.00
	1.0 HP	2	Ea.	$730.00	$1,050.00	$1,460.00	$2,100.00	$3,560.00
	1.5 HP	3	Ea.	$730.00	$1,050.00	$2,190.00	$3,150.00	$5,340.00
	2.0 HP	1	Ea.	$730.00	$1,050.00	$730.00	$1,050.00	$1,780.00
	3.0 HP	5	Ea.	$785.00	$1,150.00	$3,925.00	$5,750.00	$9,675.00
	5.0 HP	6	Ea.	$850.00	$1,275.00	$5,100.00	$7,650.00	$12,750.00
	10 HP	4	Ea.	$1,400.00	$1,650.00	$5,600.00	$6,600.00	$12,200.00
	15 HP	3	Ea.	$1,800.00	$1,825.00	$5,400.00	$5,475.00	$10,875.00
	20 HP	6	Ea.	$2,325.00	$2,100.00	$13,950.00	$12,600.00	$26,550.00
	25 HP	4	Ea.	$2,375.00	$2,125.00	$9,500.00	$8,500.00	$18,000.00
	30 HP	3	Ea.	$3,675.00	$2,500.00	$11,025.00	$7,500.00	$18,525.00
	40 HP	4	Ea.	$4,700.00	$2,950.00	$18,800.00	$11,800.00	$30,600.00
	50 HP	6	Ea.	$7,875.00	$3,450.00	$47,250.00	$20,700.00	$67,950.00
	SUBTOTAL							$3,036,984.80
	TAX (8%)							$242,958.78
	TOTAL (INCLUDES LOCATION - 0.95)							$3,128,094.34
	ACTUAL							$3,400,000.00

	MECHANICAL & PLUMBING							
224113	*Water Closets*							
	Bowl Only w/ Flush Valve, Wall Hung	30	Ea.	$1,900.00	$810.00	$57,000.00	$24,300.00	$81,300.00
224113	*Urinal Systems*							
	Wall Hung	8	Ea.	$625.00	$800.00	$5,000.00	$6,400.00	$11,400.00
224116	*Lavatory Systems*							
	Wall Hung 20"x18"	16	Ea.	$830.00	$790.00	$13,280.00	$12,640.00	$25,920.00
224116	*Vanity Top*							
	18" Round	18	Ea.	$705.00	$715.00	$12,690.00	$12,870.00	$25,560.00
224716	*Water Cooler System*							
	Electric, Wall Hung	2	Ea.	$1,175.00	$610.00	$2,350.00	$1,220.00	$3,570.00
221426	*Roof Drain Systems*							
	6" Diameter	6	Ea.	$1,350.00	$1,125.00	$8,100.00	$6,750.00	$14,850.00
223313	*Water Heaters*							
	200 gal, 120 kW 490 GPH	2	Ea.	$28,750.00	$1,850.00	$57,500.00	$3,700.00	$61,200.00
226219	*Lab Vacuum Pump System*							
	Triplex, 180 SCFM	1	Ea.	$53,121.60	$1,312.25	$53,121.60	$1,312.25	$54,433.85
221123	*Elevator Sump Pump*							
	150 HP, to 4000 GPM	1	Ea.	$39,888.00	$6,310.00	$39,888.00	$6,310.00	$46,198.00
221123	*Domestic Water Booster Pump*							
	100 HP, to 3000 GPM	1	Ea.	$28,254.00	$5,842.00	$28,254.00	$5,842.00	$34,096.00
221123	*Hot Water Recirculating Pump*							
	75 HP, 2500 GPM	3	Ea.	$22,270.80	$5,418.90	$66,812.40	$16,256.70	$83,069.10
237313	*Air-Handling Units*							
	AHU-01	1	Ea.	$144,250.00	$100,000.00	$144,250.00	$100,000.00	$244,250.00
	AHU-02	1	Ea.	$144,250.00	$100,000.00	$144,250.00	$100,000.00	$244,250.00
	AHU-03	1	Ea.	$80,000.00	$34,000.00	$80,000.00	$34,000.00	$114,000.00
	AHU-05	1	Ea.	$24,500.00	$7,825.00	$24,500.00	$7,825.00	$32,325.00
	AHU-06	1	Ea.	$46,000.00	$9,800.00	$46,000.00	$9,800.00	$55,800.00
	AHU-07	1	Ea.	$68,000.00	$10,550.00	$68,000.00	$10,550.00	$78,550.00
	AHU-08	1	Ea.	$58,500.00	$11,250.00	$58,500.00	$11,250.00	$69,750.00
	AHU-10	1	Ea.	$69,500.00	$12,780.00	$69,500.00	$12,780.00	$82,280.00
	AHU-11	1	Ea.	$85,000.00	$30,000.00	$85,000.00	$30,000.00	$115,000.00
	AHU-12	1	Ea.	$77,500.00	$15,875.00	$77,500.00	$15,875.00	$93,375.00
	AHU-13	1	Ea.	$96,500.00	$32,450.00	$96,500.00	$32,450.00	$128,950.00
	AHU-14	1	Ea.	$31,000.00	$9,450.00	$31,000.00	$9,450.00	$40,450.00

235413	*Terminal Heating Units*							
	Unit Heater	18	Ea.	$17,661.40	$13,467.25	$317,905.20	$242,410.50	$560,315.70
	Cabinet Unit Heater	6	Ea.	$17,661.40	$13,467.25	$105,968.40	$80,803.50	$186,771.90
233433	*Air Curtain*							
	72" Wide	2	Ea.	$873.41	$325.97	$1,746.82	$651.94	$2,398.76
	144" Wide	1	Ea.	$1,752.05	$374.43	$1,752.05	$374.43	$2,126.48
235716	*Shell and Tube Heat Exchanger*							
	240 GPM	2	Ea.	$23,157.00	$1,406.48	$46,314.00	$2,812.96	$49,126.96
235716	*Plate and Frame Heat Exchanger*							
	64 GPM	1	Ea.	$6,882.00	$366.13	$6,882.00	$366.13	$7,248.13
233416	*Exhaust Fan*							
	21670 CFM	4	Ea.	$2,039.70	$330.38	$8,158.80	$1,321.52	$9,480.32
	1750 CFM	2	Ea.	$381.79	$123.34	$763.58	$246.68	$1,010.26
	675 CFM	1	Ea.	$182.00	$85.90	$182.00	$85.90	$267.90
	10000 CFM	4	Ea.	$1,307.50	$191.18	$5,230.00	$764.72	$5,994.72
	300 CFM	1	Ea.	$182.00	$85.90	$182.00	$85.90	$267.90
	4500 CFM	2	Ea.	$1,098.30	$171.80	$2,196.60	$343.60	$2,540.20
	165 CFM	1	Ea.	$182.00	$85.90	$182.00	$85.90	$267.90
	1700 CFM	1	Ea.	$381.79	$123.34	$381.79	$123.34	$505.13
	1250 CFM	1	Ea.	$303.34	$107.48	$303.34	$107.48	$410.82
	1600 CFM	1	Ea.	$381.79	$123.34	$381.79	$123.34	$505.13
233416	*Supply Fan*							
	3000 CFM	1	Ea.	$5,125.40	$252.85	$5,125.40	$252.85	$5,378.25
	4800 CFM	2	Ea.	$5,726.85	$308.35	$11,453.70	$616.70	$12,070.40
	1700 CFM	1	Ea.	$726.97	$286.33	$726.97	$286.33	$1,013.30
	100 CFM	2	Ea.	$185.16	$98.44	$370.32	$196.88	$567.20
236400	*Water Chiller*							
	90 ton	3	Ea.	$62,760.00	$5,990.80	$188,280.00	$17,972.40	$206,252.40
233113	*Duct Work*	1	LS	$4,000,000.00		$4,000,000.00		$4,000,000.00
	Lab Equipment	1	LS	$3,000,000.00		$3,000,000.00		$3,000,000.00
	TOTAL							$9,713,796.71
	TAX (8%)							$777,103.74
	TOTAL (INCLUDES LOCATION - 0.95)							$10,005,210.61
	ACTUAL							$11,000,000.00

Appendix F – BIM Plan


LEVEL 1: BIM EXECUTION PLANNING PROCESS
Project Title
Developed with the BIM Project Execution Planning Procedure by the Penn State CIC Research Team
http://www.engr/psu.edu/ae/cic/bimex
BIM USES
INFO EXCHANGE
Planning
Validate Program
Owner
Programming
Schematic Design
Author Schematic Design
Architect
Design Authoring
Schematic Design
Perform 3D Coordination
Architect
3D Macro Coordination
Schematic Design
Develop Virtual Prototype
Architect
Virtual Prototyping
Schematic Design
Create 4D Model
Contractor
4D Modeling
Design Development
Author Design Development
Architect
Design Authoring
Design Development
Perform 3D Coordination
Architect
3D Macro Coordination
Design Development
Develop Virtual Prototype
Architect
Virtual Prototyping
Design Development
Create 4D Model
Contractor
4D Modeling
Construction Documents
Author Construction Documents
Architect
Detailed Map
Construction Documents
Perform 3D Coordination
Architect
3D Macro Coordination
Construction Documents
Develop Virtual Prototype
Architect
Virtual Prototyping
Construction Documents
Create 4D Model
Contractor
4D Modeling
Operations
Compile Record Model
Contractor
Record Model
END PROCESS
Program Model
Schematic Design
Architectural Model
MEP Model
Structural Model
Civil Model
Schematic Design Cost Estimation
Schematic Design 4D Model
Schematic Design Engineering Analysis Model
Schematic Design 3D Macro Coordination Model
Schematic Design 3D Virtual Prototypes
Design Development
Architectural Model
MEP Model
Structural Model
Civil Model
Design Development Cost Estimation
Design Development 4D Model
Design Development Engineering Analysis Model
Design Development 3D Macro Coordination Model
Design Development 3D Virtual Prototypes
Construction Documents (WP)
Architectural Model
MEP Model
Structural Model
Civil Model
CD (MP) 3D Macro Coordination Model
CD (MP) 4D Model
CD (MP) Engineering Analysis Model
CD (MP) 3D Virtual Prototypes
CD (MP) 3D Micro Coordination Model
Record Model