



# **THE PENNSYLVANIA STATE UNIVERSITY: INTRAMURAL BUILDING PHASE III**

## **TECHNICAL REPORT NUMBER 2**

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## EXECUTIVE SUMMARY

The purpose of this report is to present a technical evaluation of the Penn State Intramural Building renovation and addition. This report will be the first of three reports, and will provide research and information regarding the project. This part of the project will be the third of its kind. All information included in this report may change, as the construction continues on the project.

Penn State is not only known as an academic university, but also is home to many successful athletic teams. In recent years, Penn State has been named one of the most active campuses in the country. To continue to provide for the ever more active student body, Penn State has set out to create the most up to date and state of the art facilities for their students. Currently on the University Park campus, there are three major buildings to house student activities. These facilities provide space and equipment to students ranging from occasional gym goers to division one athletes. Penn State recently has invested significant funds into one of these three buildings. That building is the Intramural Building, located at the corner of University Drive and Curtain Road. The IM building is the closet recreational facility to the Bryce Jordan Center, Beaver Stadium, and the Pegula Ice Arena, making it a key symbol of the University.

The project seeks to renovate the existing basement and add a new section of the building. The new construction will see a two story addition that will house a rock climbing wall, an indoor turf field, and various lounges and examination rooms. The addition will also contain a mezzanine that will connect to the existing one. The addition will add just under 62,000 square feet to the building. The project is currently ongoing and the end of the project will make the facility accessible to the student body for the entire fall 2017 semester. The building will be up to date and provide the students with one of the best facilities in the country.

Technical report two seeks to analyze one of the building systems of the project. This report seeks to focus on the means and methods associated with the structural steel system. All components of the steel system were analyzed including the steel itself, as well as concrete footings and foundation walls.

How the steel was erected is the first section of the report. The use of a crane, man lifts, and forklifts contribute to the overall construction of the steel. Excavation takes places, followed by the forming and pouring on concrete footings and piers. Once the concrete is cured steel begins to be erected, first installing the columns, then the beams, and then all other components. Estimates were then found for the system based on detailed takeoffs and compared to values from the general contractor and from a square foot estimate. The new estimate, found using estimating software, was just over \$1.5 million. This value was higher than the square foot estimate, and was very similar to the actual price of the structure when factoring in possible discrepancies and features not covered by the square foot cost. Next the site logistics were examined. Detailed plans for each phase were developed, outlining the process for concrete footings, and two phases of steel erection. Each plan contains information regarding where laydown areas can be found for each phase, and the project boundaries and any other relevant information. Finally an interview with the supervisor on the project revealed key information about the process and possible means of accelerating the construction of the project. Weather issues, crane malfunctions, and issues with the anchor bolts all plagued the constructability of the system, and required extra hours for the crews.

All information talked about above, as well as detailed drawings and estimates, can be found in the following sections of this report.



## PRODUCTION PLAN

### System Construction Means and Methods

The steel structure is one of the most important parts of any building. Many building utilize a steel structure as it is very efficient and allows for flexibility of facades and interior spaces. The steel structure not only supports the weight of the building and its entirety, but also helps to distribute the weight to the footings, and the site. This steel structure is one of the first systems to be constructed as it serves as the “bones” of the project.

The structure is made up of several parts. The first part is the footings that will distribute the loads down to the site. Footings are made of concrete and utilize rebar in order to satisfy the loads they will need to support. They are completed after excavation has been finished. The footings are first marked on the site according to the construction documents. They then are formed using corms, as well as having the rebar constructed. They are then poured. The piers, which extend up from the footings, are completed in the same way.



Figure 1: Steel Erection

All steel is designed off site and delivered to the site when the desired pieces are ready to be constructed. The columns are connected to this spread footings using anchor bolts that are imbedded into the concrete forms prior to installation. Next the columns are connect using beams. Steel beams come in a variety of shapes and sizes and for this structure they range from hollow square shapes to wide flanges. Finally, all other steel is installed which includes girders, floor joists and steel decking. These remaining pieces are used to support the slabs and roof which will be poured and installed after erection is complete. All members are lifted by the use of a crawler crane and constructed by a finishing and erection crew.

The project team during the steel erection included Mortenson (general contractor), Somerset Steel Erection (erector), and Lincoln Contracting (fabricator).

The steel was erected using a crawler crane, several two man lifts and several industrial forklifts. A tower crane is not feasible for this project and the crawler crane is able to freely move through the site allowing it to be very efficient. Scaffolding was also not used for this project for the structural system. Two man lifts were utilized which allowed workers to move themselves into position and install the members as the crane was ready. Steel erection consisted of a crane operator, a raising gang, finishing gang, and a ground crew. The ground crew monitored the men in the lifts, as well as prepared pieces for the crane to be lifted. The raising gang would “loosely” install the members allowing the finishing gang to come in and permanently fasten each member. The finishing gang follows the raising gang in sequence, and allows for the process to be overlapped, meaning more efficiency for the system, overall.



### Production Schedule

The overall duration for the steel erection is 38 days, while the activities necessary to start steel erection have a much longer duration at just under 150 days. The activities needed for steel erection to be completed include all foundation work, slab on grade pouring and forming, as well as underground work for mechanical and electrical systems. Each major activity is broken down by task and scheduled using Primavera scheduling software. The detailed breakdown of these activities and their durations are found in the appendix section of this report. Please visit appendix B for the production schedule.

All activities included in the production schedule are on the critical path of the project. The deadlines for these activities are very important to the overall success of the project. Excavation and the pouring of slabs and footings are events directly prior to the structural steel. These activities are also on the critical path, meaning any delays must be accounted for. The overall duration for the system is 130 days. This is the time of footings starting for area E to the finish of steel in area F.

The manpower on the site reaches a maximum around the end of October. This is the time when steel is finishing up and the other trades begin to pick up to enclose the building. Using the estimating software, Primavera, each day will require 300 man hours at the peak of the labor curve. Mostly iron workers will be on the site during the system's construction. Several other parties will be involved at certain times including field engineers, machine operations, and concrete subcontractors.

### Detailed Cost

A detailed cost estimate was developed using the Timberline software. This software utilizes quantity takeoffs of the system. To accurately estimate the cost of this system, items that were taken off include the concrete footings, slab on grade and foundation walls, rebar used in the foundation walls and footings, all steel members including beams, girder, joists and columns, micro piles, steel decking and several other minor constructability quantities. The estimate also includes labor rates that are up to date and coincide with the labor rates of steel union workers in Centre County. The wages reflect a value slightly higher than the mean hourly wage set by the Bureau of Labor Statistics. This takes into account added expenses a general contractor may be responsible for, or employee expenses a subcontractor may be responsible for. The overall price for the structure of the addition comes to \$1,537,495. This price is slightly higher than the steel structure price provided by Mortenson, and located in the Technical Report 1. The value for structural steel alone was estimated to be \$894,563. The price found through a square foot estimate for the structure was found to be \$1,068,499.

There are several reasons for the differences in these prices. The first is that the actual cost of the project, \$894,563 does not include any concrete. Concrete is grouped with several other trades, and some of this cost should be added to the overall structural cost, which would increase the cost. This means that the Timberline estimate, which includes several concrete line items, is



the more accurate of the two estimates. While Timberline is the more accurate estimate, it still has flaws. The program did not contain pricing for Hollow Structural Sections (HSS). Timberline also did not correctly estimate wages for steel workers. To adjust for these changes, as well as others, values were manually adjusted in the program. Some changes that were implemented include: the HSS shapes were estimated for their weight, wages were changed to accurate levels, prices for each anchor bolt were adjusted, a lump sum for cranes, lifts, and forklifts were added, allowances for miscellaneous steel pieces were added, as well as others. The full detailed estimate that includes all these changes, and all quantity information are located in appendix A.

### Site Plan and Logistics

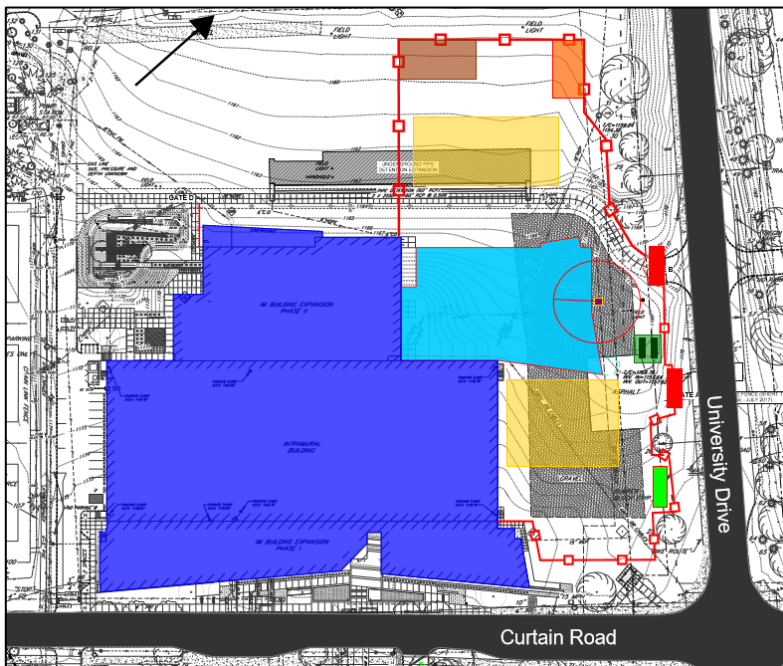


Figure 2: Area E Steel Erection

Overall, three separate site plans were developed to highlight the key differences in the structural process. The three plans include the initial concrete setup for footings and foundations walls, than the site transitions to the two separate phases during steel erection. The details, including key changes in each plan are located in Appendix C. Figure 2 shows the initial steel structure site plan.

The sequencing of the steel began on the interior of the northwest building. The steel was first completed in area E of the addition. The work flow moved in a clockwise rotation. For a better understanding of this work flow, a detailed diagram is located in appendix D.

The concrete Site plan emphasizes the use of temporary roads from University Drive. The layout of the site allowed for concrete trucks to deliver the concrete right to where it needed to be through temporary roads. The site also allowed a lot of space for laydown areas for formwork and reinforcement.

The first phase of steel erection showcases how the temporary roads were removed to allow the crawler crane to move through the site. The plan also highlights which part of the building is being erected and locations of storage and laydown for the steel members.

Finally the last phase of steel erection highlights the change in laydown areas from Area E to Area F. Much of the site plan remains the same to area E, although the laydown areas must be changed to allow the crane to maneuver to the south side of the building.



## PRODUCTION ANALYSIS

### Production

Overall the production for the steel erection process was average in terms of efficiency. The crews on the site were efficient, but faced delays due to unforeseen circumstances. The use of building information modeling, and the requirements set up by Mortenson allowed the steel process to move quickly, when the crews were able to work. Detailed design guides for each part of the steel process were included, and each phase was mapped out before construction allowing for the crews to know what was going on before the day started. Pick guides and integrated work plans were completed by the steel subcontractor.

The number of men on the site were at a minimum during steel erection, as no trades are able to work under the steel placements. During the excavation and foundation construction, more crews and subcontractors were present on the site. Where the productivity was at a minimum was during steel erection, due to several challenges. First rain delayed the crews by several days, and overall decreased the productivity of the crew. Other delays included problems with anchor bolts, inefficient delivery of materials and crane malfunctions. The steel process was on the critical path of the project, and thus these drops in productivity had to be made up by working overtime and extra days. More manpower would not affect the productivity, as the crane is the driver for the productivity.

### Cost Analysis

The estimate that was developed using Timberline was almost half a million dollars more than the square foot estimate developed in Tech 1. The estimate using Timberline was far more precise, and allowed for detailed

takeoffs to be used. Real quantities for materials could be found and utilized in the Timberline estimate. Also included in the timberline estimate are materials and details that the square foot price might not account for. The addition to the Intramural Building is very precise and features unique characteristics that RS Means would not be able to estimate. Square foot estimates are usually very vague. If the error in the estimate was applied to the square foot cost, the square foot price would be closer to the Timberline estimate.

Description	Amount	Cuts/Add	Net Amount	Totals
Labor	501,638		501,638	
Material	972,399		972,399	
Subcontract	50,878		50,878	
Equipment	10,580		10,580	
Other	2,000		2,000	
	<b>1,537,495</b>			<b>1,537,495</b>
<b>Total</b>				<b>1,537,495</b>

Figure 3: Final Cost (Timberline)

To gauge the accuracy of the estimates, the actual prices for the system were compared. The price of structural steel for the project was \$894,563. This price is much lower than the Timberline price. The way the pricing was broken down for the project concrete was included in a grouping of several other activities. Because some of the concrete is needed for the structural system, and other quantities were found through the Timberline Estimate, the actual price of the system would be fairly close to the pricing found by Timberline. For more information regarding pricing the breakdown of the changes in prices please visit the detailed cost section of this report, and also visit appendix A for a full estimate.



### Logistical Analysis

Building on any college campus is a challenge. The addition to the Intramural Building faces these challenges as it is located in a busy part of campus, both in terms of traffic and of pedestrian traffic. To ensure the safety of pedestrians a very sturdy site fence was implemented all around the site only leaving the sidewalk open. The fencing also utilizes special covers that make climbing over the fences difficult allowing for maximum protection. Where the site benefits the project, is that to the north of the building there is a lot of open fields. This serves as the primary soil stockpile for the site, and could also be utilized for storage on the site. Space is limited on the University Drive side, therefore the space to the north is crucial.

Deliveries to the site are also very important, as they will be delivering materials using University Drive. The site utilized two entrances on the University Drive side allowing the delivery trucks to come onto the site right from the road without affecting the moderately heavy traffic on University Drive. To reduce issues deliveries are made early in the day allowing the drivers to beat traffic once they have delivered the materials.

The means and methods for the steel erection process were efficient and the space was used well. Careful planning went into the site logistics by Mortenson, and the use of temporary facilities in the existing building allowed for the site to be utilized to the max for space. The interior facilities also allow for less clutter and less logistical issues that would be caused by the size of the site. Material was only moved when it needed to be moved. The movement of work through the site also was efficient. As one area was completed other work could begin in this area due the structure being stable and covered. Some possible improvements could be utilized for the project. Only one laydown area throughout the process would benefit the site logistics, but issues could arise in terms of transporting the material. A gate could also be located on the west side of the site, and although this could affect the newly landscaped part of the site, it could greatly benefit deliveries. Drivers could come into the site and leave the site on one path. No turning around or navigation around the site would be necessary, and the temporary road would only damage a small part of the land.

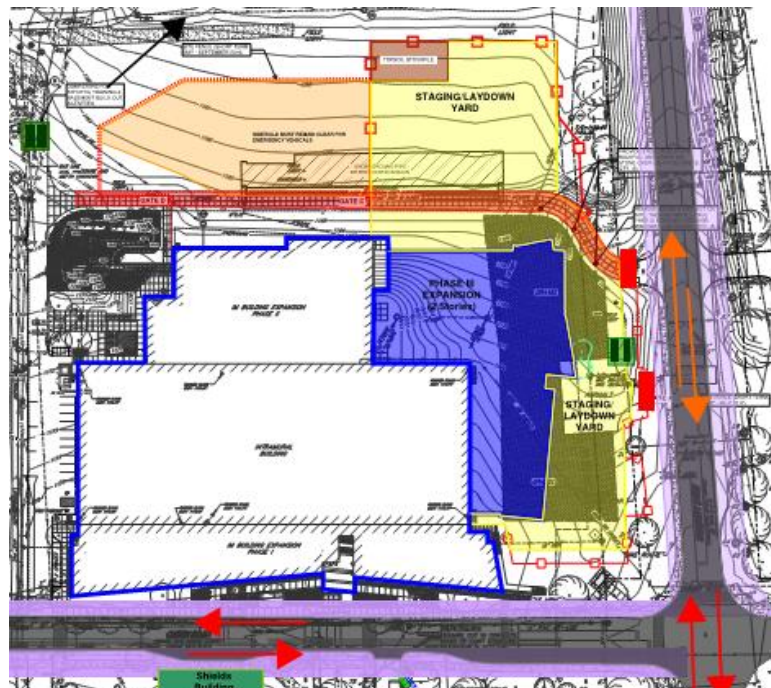


Figure 4: Overall Site Logistics Plan



## ACCELERATION SCENARIOS

The structure of Phase III is part of the critical path. If the steel were to be delayed, the building enclosure would not be able to begin on time, pushing back the entire timeline. One of the biggest challenges with steel erection comes from the weather. When it is very windy, or very rainy, erection cannot happen. There are too many risks for the crane, the safety of the workers, welding and the overall process is not able to continue. Weather is not something that is controllable and the steel was delayed a few days due to the extensive rain State College faces.

After talking with the project manager on the project, to make up for these lost days the workers had to work overtime and on the weekends. Manpower would not have increased the productivity of the erection, due to the need for a crane. The only way to make the process more efficient would be to include a second crane. The benefit of the crane would be great, and allow for the process to cut the work time in half, although the costs associated with another crane would discourage this method. The exponential cost of a second crane outweighs the schedule benefits for a job of this size.

## CONSTRUCTABILITY AND LOGISTICAL CHALLENGES



Figure 4: Early Site Work

One major issue that occurred during the construction of the structural phase of the building, was that submittals for the anchor bolts were not completed promptly. Several issues arose with the anchor bolts on the project. Surveys regarding information on the anchor bolts were distributed to the parties involved. The surveys were not completed by these parties. Due to the surveys not being completed issues arose with the anchor bolts during the erection of the steel. These issues caused down time on the site and delaying the overall process.

Another issues that arose came from the delivery of the steel. The steel was not delivered in sequence. This means that the subcontractor had to effectively handle the steel twice. This also had effects on the project, and contributed to down time in sorting the steel, as the steel was phased on the project.

A final issues that plagued the crews were the weather. Due to the large amount of rain, several rain days were experienced by the erectors. During heavy rains safety is a major concern for the workers, and the crane's stability. Weather is often a common issues for construction projects, and although some consideration is taken for it in the schedule, losses must be made up.



## APPENDIX A: DETAILED COST ESTIMATE





Project name	Phase 3 IM building
Labor rate table	Standard Labor
Equipment rate table	Standard Equipment
Report format	Sorted by 'Group phase/Phase' 'Detail' summary





Item	Description	Takeoff Qty	Labor		Material		Equipment		Total	
			Unit Cost		Unit Cost		Unit Cost		Unit Cost	Amount
<b>2000.000</b>	<b>SITEWORK</b>									
<b>2240.010</b>	<b>Dewater: General</b>									
10	Dewatering All Types	1.00 ea	350.00 /ea		-		120.00 /ea		470.00 /ea	470
20	Temporary Drains	1.00 lf	732.06 /lf		501.97 /lf		-		1,234.03 /lf	1,234
	<b>Dewater: General</b>									<b>1,704</b>
	30.92 Labor hours									
	3.333 Equipment hours									
<b>2315.021</b>	<b>Earthwk: Excav Foot/Misc</b>									
20	Excavate Footing By Machine	1,500.00 cy	7.00 /cy		-		1.44 /cy		8.44 /cy	12,660
	<b>Earthwk: Excav Foot/Misc</b>									<b>12,660</b>
	300.00 Labor hours									
	60.00 Equipment hours									
<b>2455.000</b>	<b>Driven Piles</b>									
10	Micro Piles	22.00 ea	-		-		-		2,213.00 /ea	48,686
	<b>Driven Piles</b>									<b>48,686</b>
<b>2620.080</b>	<b>Drainage: Drainage @ Slab</b>									
60	Gravel At Slab #6	1,500.00 cy	17.50 /cy		14.46 /cy		4.20 /cy		36.16 /cy	54,238
	<b>Drainage: Drainage @ Slab</b>									<b>54,238</b>
	750.00 Labor hours									
	<b>SITEWORK</b>									<b>117,288</b>
	1,080.92 Labor hours									
	63.333 Equipment hours									
<b>3000.000</b>	<b>CONCRETE</b>									
<b>3110.050</b>	<b>Forms: Pile Caps</b>									
20	Pile Cap Forms - 1/2" Plywood	51.00 sf	2.63 /sf		0.25 /sf		-		2.872 /sf	146
	<b>Forms: Pile Caps</b>									<b>146</b>
	3.83 Labor hours									
<b>3110.100</b>	<b>Forms: Footings</b>									
10	Footing Forms	15,460.00 sf	0.60 /sf		0.803 /sf		-		1.403 /sf	21,697
	<b>Forms: Footings</b>									<b>21,697</b>
	463.800 Labor hours									
<b>3110.250</b>	<b>Forms: Piers</b>									
20	Pier Forms - Plywood	10,421.00 sf	4.00 /sf		0.803 /sf		-		4.803 /sf	50,056
	<b>Forms: Piers</b>									<b>50,056</b>
	2,084.20 Labor hours									
<b>3210.150</b>	<b>Rebar: Footings</b>									
46	Footing Rebar #4	1,110.00 lf	0.30 /lf		0.214 /lf		-		0.512 /lf	568
56	Footing Rebar #5	171.00 lf	0.46 /lf		0.33 /lf		-		0.783 /lf	134
66	Footing Rebar #6	15,150.00 lf	0.66 /lf		0.473 /lf		-		1.131 /lf	17,131
76	Footing Rebar #7	434.00 lf	0.892 /lf		0.643 /lf		-		1.54 /lf	666



Item	Description	Takeoff Qty	Labor		Material		Equipment		Total	
			Unit Cost		Unit Cost		Unit Cost		Unit Cost	Amount
	<b>Rebar: Footings</b>									<b>18,500</b>
	307.545 Labor hours									
<b>3310.140</b>	<b>Conc: Footings</b>									
c 30	Footings Conc 3000 psi	870.00 cy	17.50 /cy		61.182 /cy		-		78.682 /cy	68,453
	<b>Conc: Footings</b>									<b>68,453</b>
	435.00 Labor hours									
<b>3310.900</b>	<b>Conc: All Types Generic</b>									
30	Concrete Slab On Grade	4,892.00 cy	31.50 /cy		58.092 /cy		-		89.592 /cy	438,284
	<b>Conc: All Types Generic</b>									<b>438,284</b>
	4,402.804 Labor hours									
<b>3600.100</b>	<b>Grout</b>									
40	Grout Base Pl Metallic 2" (sf)	500.00 sf	7.00 /sf		6.66 /sf		-		13.66 /sf	6,830
	<b>Grout</b>									<b>6,830</b>
	100.00 Labor hours									
	<b>CONCRETE</b>									<b>603,966</b>
	7,797.174 Labor hours									
<b>5000.000</b>	<b>METALS</b>									
<b>5090.010</b>	<b>Fastener: Col Anchor Bolt</b>									
5	Anchor Bolts (All Sizes)	276.00 ea	12.90 /ea		16.00 /ea		-		28.90 /ea	7,976
	<b>Fastener: Col Anchor Bolt</b>									<b>7,976</b>
	101.71 Labor hours									
<b>5090.030</b>	<b>Fastener: Metal Welds</b>									
10	Shear Studs At Beams	360.00 ea	3.50 /ea		7.20 /ea		-		10.70 /ea	3,852
20	Steel to Steel Welds All Sizes	138.00 lf	17.50 /lf		2.58 /lf		-		20.08 /lf	2,771
	<b>Fastener: Metal Welds</b>									<b>6,623</b>
	105.00 Labor hours									
<b>5120.010</b>	<b>Structural: Framing</b>									
25	Studs for Exterior Claddings	3,645.00 lf	5.833 /lf		16.00 /lf		-		21.833 /lf	79,583
40	Structural Framing (ton)	60.00 ton	1,754.39 /ton		1,325.00 /ton		-		3,079.39 /ton	184,763
90	Misc Plates and Steel Pieces Allowance	10.00 ton	250.00 /ton		1,500.00 /ton		-		1,750.00 /ton	17,500
120	Misc Structural Item Allowance	1.00 ea	224.00 /ea		7,680.00 /ea		-		8,096.00 /ea	8,096
	<b>Structural: Framing</b>									<b>289,942</b>
	3,692.85 Labor hours									
<b>5121.010</b>	<b>Structural: W Shapes</b>									
w08a	W Shape W 8x10	72.00 lf	4.15 /lf		6.25 /lf		-		10.40 /lf	749
w10a	W Shape W 10x12	42.00 lf	4.15 /lf		7.50 /lf		-		11.65 /lf	489
w10a	W Shape W 10x12	92.00 lf	4.15 /lf		7.50 /lf		-		11.65 /lf	1,072
w10h	W Shape W 10x33	273.00 lf	8.662 /lf		20.63 /lf		-		29.29 /lf	7,995
w10j	W Shape W 10x45	110.00 lf	11.813 /lf		28.13 /lf		-		39.94 /lf	4,393
w12A	W Shape W 12x14	146.00 lf	3.92 /lf		8.75 /lf		-		12.67 /lf	1,850
w12A	W Shape W 12x14	225.00 lf	3.92 /lf		8.75 /lf		-		12.67 /lf	2,851
w12A	W Shape W 12x14	326.00 lf	3.92 /lf		8.75 /lf		-		12.67 /lf	4,130
w12A	W Shape W 12x14	74.00 lf	3.68 /lf		8.75 /lf		-		12.43 /lf	919
w12B	W Shape W 12x16	26.00 lf	4.20 /lf		10.00 /lf		-		14.20 /lf	369
w14K	W Shape W 16x26	286.00 lf	6.83 /lf		16.25 /lf		-		23.08 /lf	6,599
w14K	W Shape W 16x26	259.00 lf	6.83 /lf		16.25 /lf		-		23.08 /lf	5,976



Item	Description	Takeoff Qty		Labor	Material	Equipment	Total	
				Unit Cost	Unit Cost	Unit Cost	Unit Cost	Amount
<b>5121.010</b>	<b>Structural: W Shapes</b>							
w161	W Shape W 16x26	879.00	lf	8.14 /lf	16.25 /lf	-	24.39 /lf	21,437
w16b	W Shape W 16x36	302.00	lf	9.45 /lf	22.50 /lf	-	31.95 /lf	9,649
w16c	W Shape W 16x40	32.00	lf	11.12 /lf	25.00 /lf	-	36.12 /lf	1,156
w18a	W Shape W 18x35	416.00	lf	9.19 /lf	21.88 /lf	-	31.063 /lf	12,922
w18b	W Shape W 18x40	32.00	lf	11.12 /lf	25.00 /lf	-	36.12 /lf	1,156
w18b	W Shape W 18x40	182.00	lf	11.12 /lf	25.00 /lf	-	36.12 /lf	6,574
w21b	W Shape W 21x50	32.00	lf	14.20 /lf	31.25 /lf	-	45.45 /lf	1,454
w21b	W Shape W 21x50	56.00	lf	14.20 /lf	31.25 /lf	-	45.45 /lf	2,545
w24a	W Shape W 24x55	96.00	lf	14.64 /lf	34.38 /lf	-	49.02 /lf	4,705
w24c	W Shape W 24x68	36.00	lf	18.121 /lf	42.50 /lf	-	60.621 /lf	2,182
	<b>Structural: W Shapes</b>							<b>101,174</b>
	892.11 Labor hours							
<b>5210.010</b>	<b>Structural: Joist K</b>							
1001	K-Series 10 K 1 Joist	407.00	lf	2.60 /lf	2.70 /lf	-	5.30 /lf	2,157
1805	K-Series 18 K 5 Joist	352.00	lf	2.60 /lf	4.16 /lf	-	6.76 /lf	2,379
2003	K-Series 20 K 3 Joist	219.00	lf	2.60 /lf	3.62 /lf	-	6.22 /lf	1,362
2406	K-Series 24 K 6 Joist	652.00	lf	2.92 /lf	5.24 /lf	-	8.16 /lf	5,317
2406	K-Series 24 K 6 Joist	125.00	lf	2.92 /lf	5.24 /lf	-	8.16 /lf	1,019
	<b>Structural: Joist K</b>							<b>12,234</b>
	137.402 Labor hours							
<b>5212.010</b>	<b>Structural: Joist LH/DLH</b>							
5210	DLH-Series 52 DLH10 Joist	145.00	lf	4.12 /lf	13.50 /lf	-	17.62 /lf	2,555
5615	DLH-Series 56 DLH15 Joist	145.00	lf	4.12 /lf	22.68 /lf	-	26.80 /lf	3,886
	<b>Structural: Joist LH/DLH</b>							<b>6,441</b>
	34.14 Labor hours							
<b>5330.010</b>	<b>Structural: Alum. Deck</b>							
20	05 31 00 Steel Roof Decking	14,677.00	sf	3.25 /sf	5.05 /sf	-	8.30 /sf	121,819
	<b>Structural: Alum. Deck</b>							<b>121,819</b>
	1,362.864 Labor hours							
	<b>METALS</b>							<b>546,209</b>
	6,326.07 Labor hours							
<b>14000.000</b>	<b>CONVEYING SYSTEMS</b>							
<b>14400.010</b>	<b>Lifts</b>							
20	Platform Lift	4.00	ea	1,523.063 /ea	1,080.00 /ea	-	2,603.063 /ea	10,412
40	ForkLift	2.00	ea	45.00 /ea	1,000.00 /ea	1,000.00 /ea	4,045.00 /ea	8,090
	<b>Lifts</b>							<b>18,502</b>
	174.064 Labor hours							
<b>14600.010</b>	<b>Hoists &amp; Cranes</b>							
30	Crawler Crane	1.00	ea	1,530.09 /ea	250,000.00 /ea	-	251,530.09 /ea	251,530
	<b>Hoists &amp; Cranes</b>							<b>251,530</b>
	34.002 Labor hours							
	<b>CONVEYING SYSTEMS</b>							<b>270,032</b>
	208.07 Labor hours							

Estimate Totals



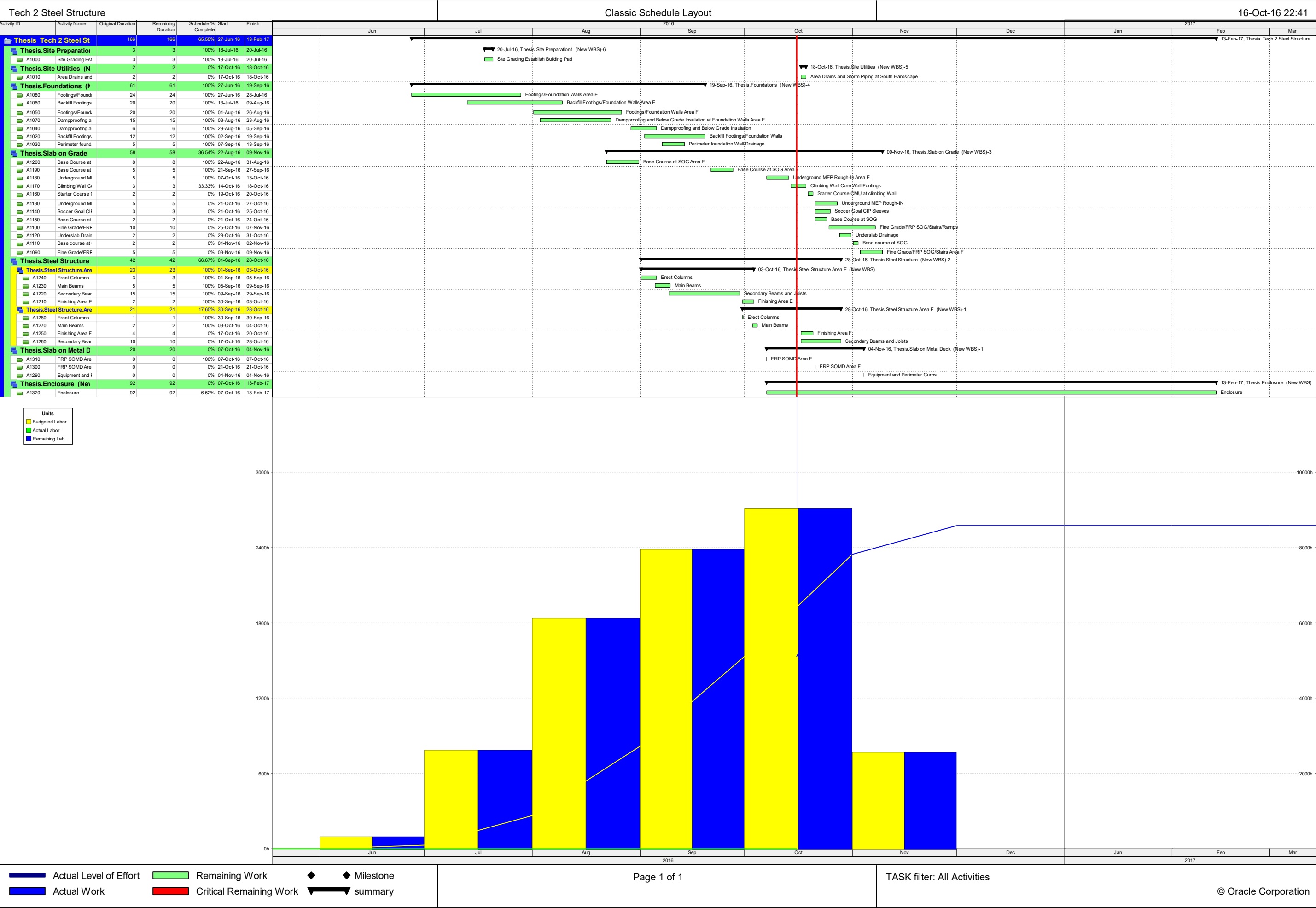
## Estimate Totals

Description	Amount	Cuts/Adds	Net Amount	Totals	Hours	Rate	Cost Basis	Cost per Unit	Percent of Total
Labor	501,638		501,638		15,412.223	hrs			32.63%
Material	972,399		972,399						63.25%
Subcontract	50,878		50,878						3.31%
Equipment	10,580		10,580		63.333	hrs			0.69%
Other	2,000		2,000						0.13%
	<b>1,537,495</b>			<b>1,537,495</b>					<b>100.00 ####</b>
<b>Total</b>				<b>1,537,495</b>					



## APPENDIX B: SYSTEM SUMMARY SCHEDULE







## APPENDIX C: SITE LOGISTICS PLANS

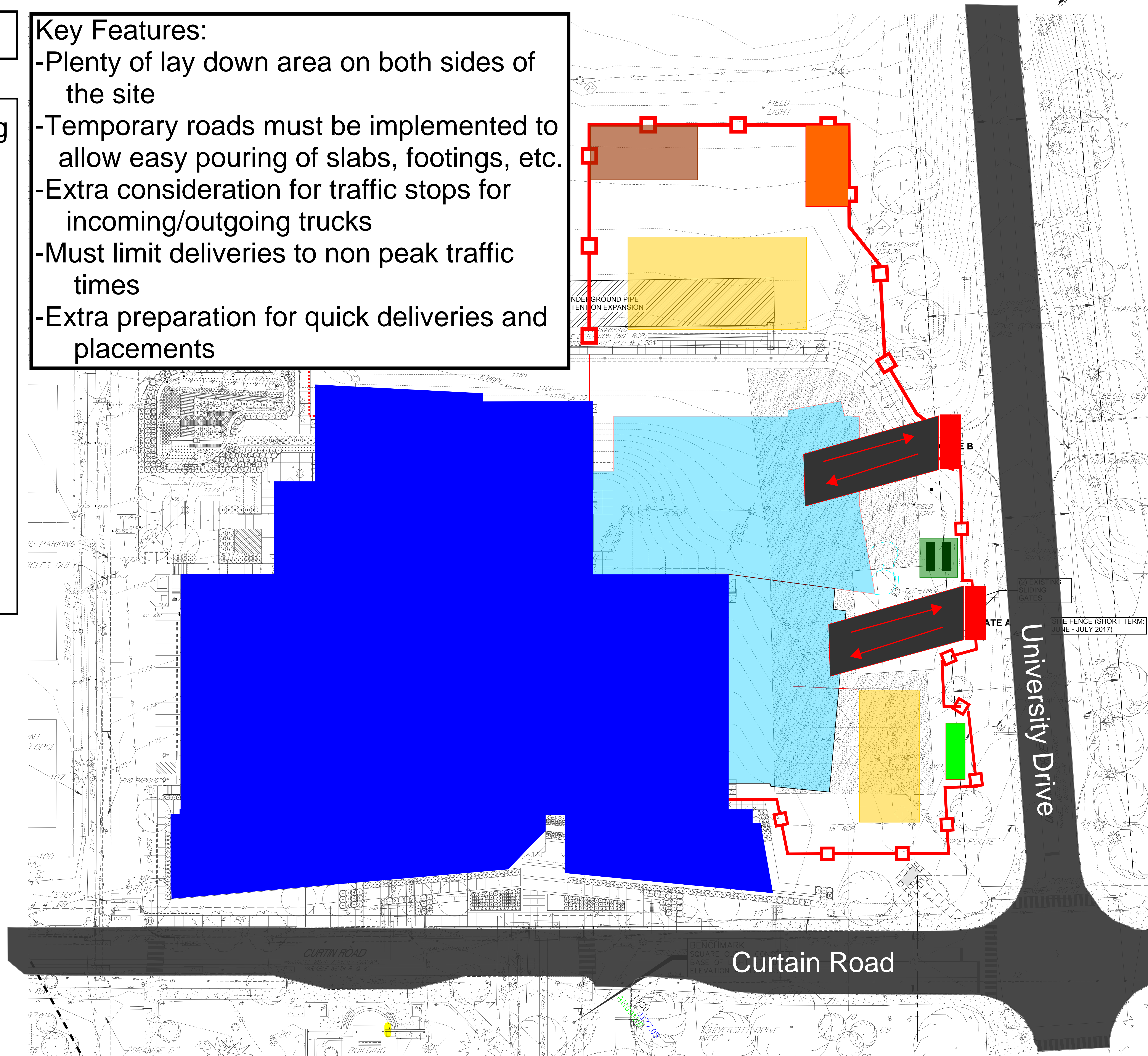


## Key

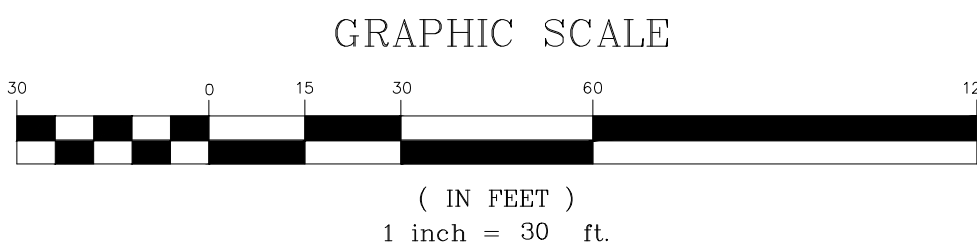
-  Existing Building
-  Phase III
-  Laydown
-  Site Storage
-  Bathrooms
-  Waste Removal
-  Site Fence
-  Gate / Entrance
-  Temp. Roads

### Key Features:

- Plenty of lay down area on both sides of the site
- Temporary roads must be implemented to allow easy pouring of slabs, footings, etc.
- Extra consideration for traffic stops for incoming/outgoing trucks
- Must limit deliveries to non peak traffic times
- Extra preparation for quick deliveries and placements



# The Pennsylvania State: Intramural Addition Phase III



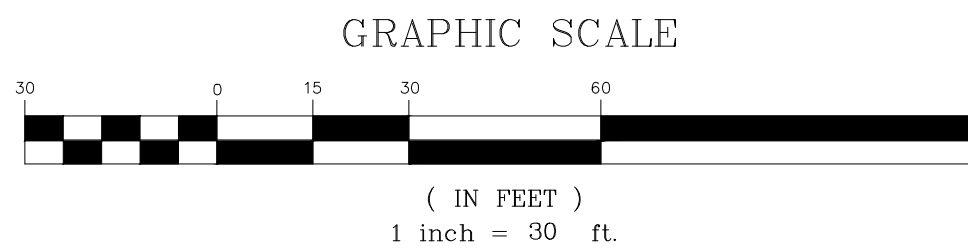
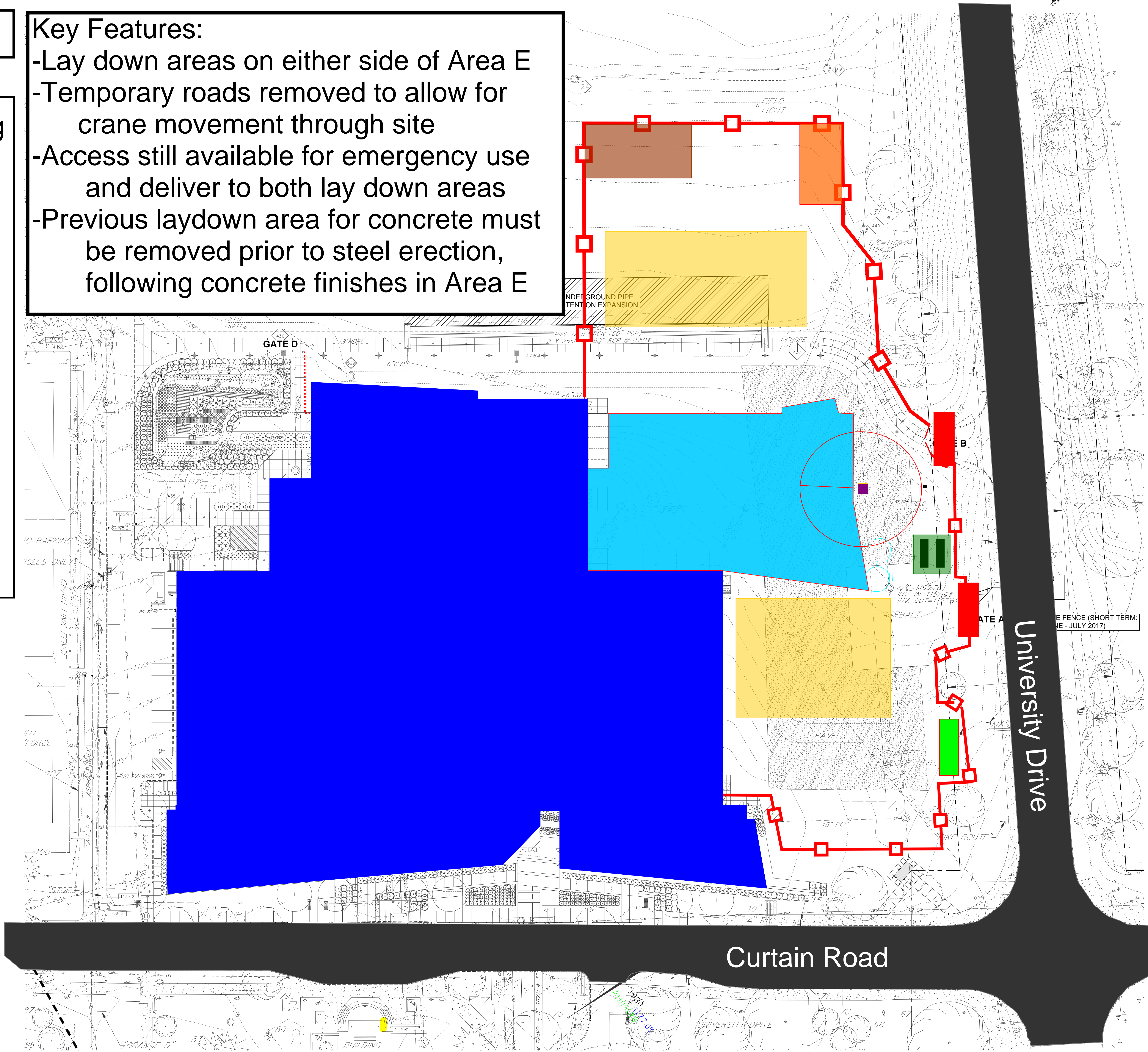


## Key

- Existing Building
- Area E
- Steel Lay down
- Site Storage
- Bathrooms
- Waste Removal
- Site Fence
- Gate / Entrance
- Crane

### Key Features:

- Lay down areas on either side of Area E
- Temporary roads removed to allow for crane movement through site
- Access still available for emergency use and deliver to both lay down areas
- Previous laydown area for concrete must be removed prior to steel erection, following concrete finishes in Area E



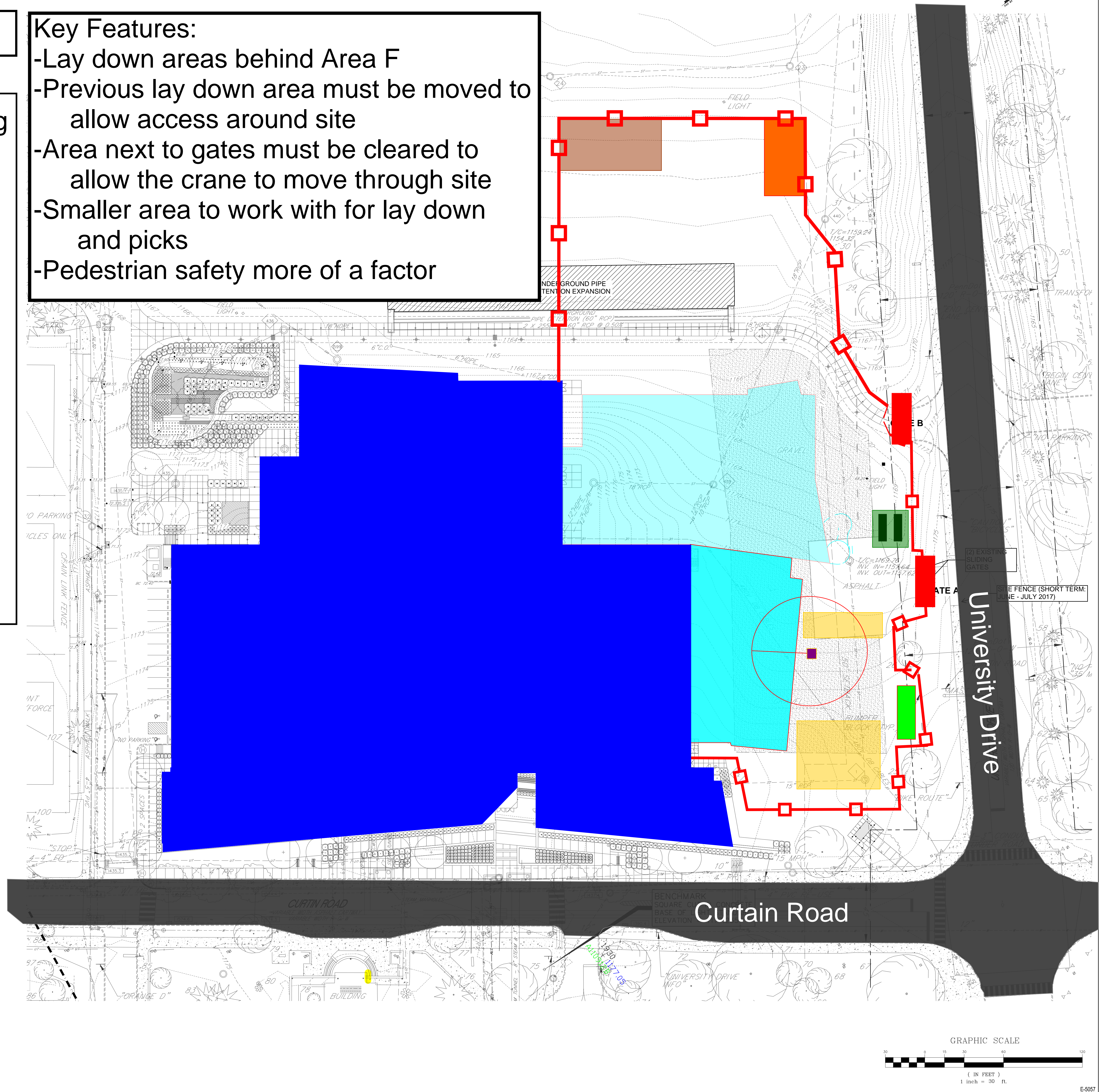


The  
Pennsylvania  
State:  
Intramural  
Addition Phase  
III

Key

- Existing Building
- Area F
- Steel Lay down
- Site Storage
- Bathrooms
- Waste Removal
- Site Fence
- Gate / Entrance
- Crane
- Area E

- Key Features:
- Lay down areas behind Area F
  - Previous lay down area must be moved to allow access around site
  - Area next to gates must be cleared to allow the crane to move through site
  - Smaller area to work with for lay down and picks
  - Pedestrian safety more of a factor





## APPENDIX D: WORKFLOW AND SEQUENCING PLANS



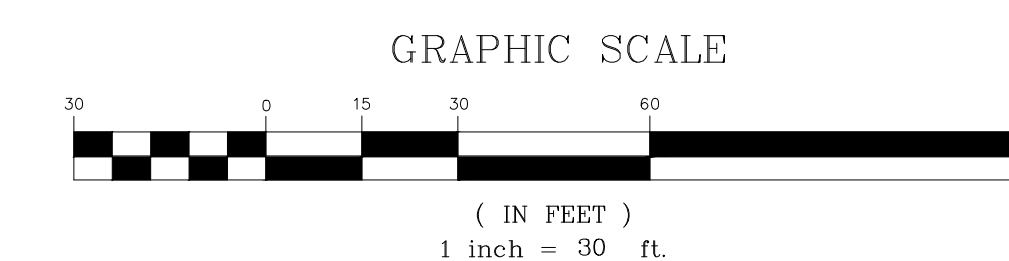
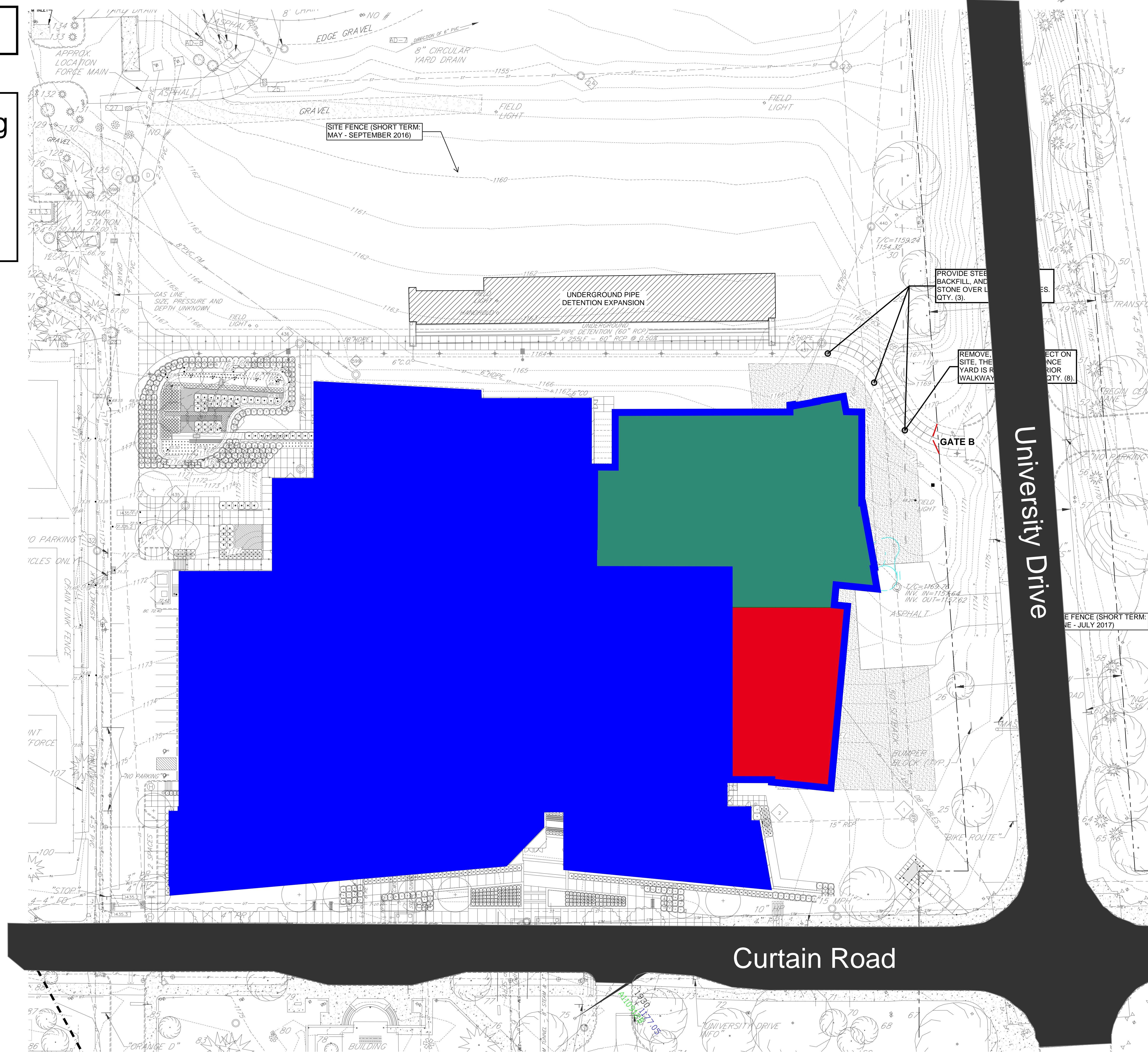
# The Pennsylvania State: Intramural Addition Phase III

## Key

■ Existing Building

■ Area F

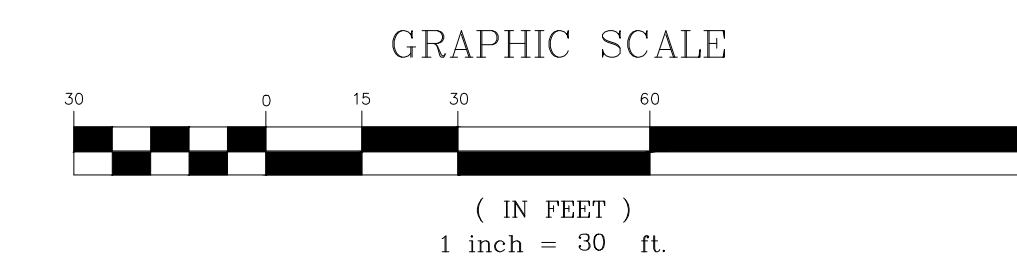
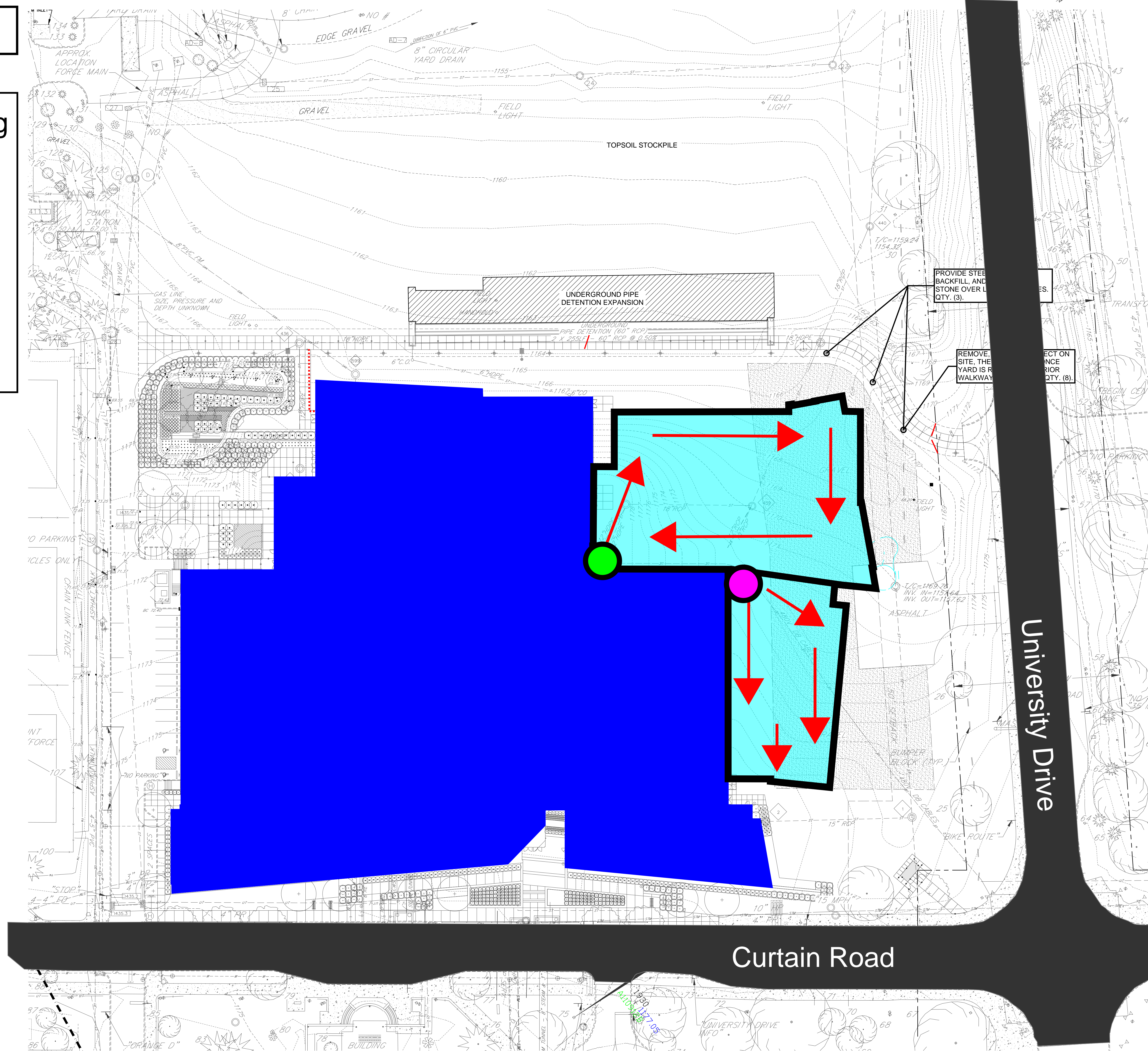
 Area E





# Key

- Existing Building
- Phase III
- Start (E)
- Start (F)
- WorkFlow



## The Pennsylvania State: Intramural Addition Phase III



## APPENDIX E: INTERVIEW QUESTIONS AND SUMMARY



**The interview took place with Richard Chazal, the senior project manager on the site.**

1. Means and methods of the steel erection?

The means and methods were discussed by referring to several erection plans and detailed drawings. The drawings were not included in these questions, but can be provided if necessary.

2. How the site was planned for steel erection and describe the different stages of phasing the steel? Possible diagrams?

This question was also talked about when referring to several drawings, including the ones previously mentioned. Once again, for privacy reasons these drawings were not included in this section, but can be provided.

3. Describe how the steel erection related to the critical path of the project.

Critical path ran through steel erection. Steel in Area E needed to be completed to allow the enclosure to start on time which drives building dry in which ties to finishes.

4. What are some of the biggest risks that could affect the steel erection and the critical path?

Anchor bolt layout was a problem which resulted in remediation. The steel erector had to work overtime to recover the lost days from remediation.

5. What is a possible hypothetical way to accelerate the schedule for steel erection ? (manpower, extra hours, resources, etc.) And what concerns or cost concerns would accompany this change?

Overtime. We only had one crane on site so adding man power does not help the schedule for erection. Having a second crane would help accelerate, however it was prohibitively expensive.

6. Were there any issues on the site while steel erection was taking place? (Problems with other subcontractors, deliveries, site logistics, weather, etc...) If so how were they dealt with by the parties involved?

Steel was not loaded on trucks and delivered in sequence which resulted in double handling of material by the subcontractor.

We had three rain days that were made up over weekends

We had one lost day due to the crane breaking down. We used this time to detail the steel and hang enclosure steel with a fork lift. We made up the lost time by working 10 hour days instead of 8 hour days.

7. If you could change anything about the process (site logistics, cooperation, manpower, methods) what would it be and why?

Steel erector owed us an anchor bolt survey two weeks prior to mobilizing but did not deliver. This resulted in down time due to discovering anchor bolt issues late.

Ensure steel is loaded and delivered in sequence to eliminate double handling of material.