Mueller Laboratory Renovation

Technical Report #2
By
Mark Jackson
Construction Management Option
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Executive Summary

The Mueller Building project, being a renovation, is of particular interest and difficulty to analyze. Tightly packed in between a host of other buildings on the Penn State University Park campus, demolishing and rebuilding the laboratory building would have been excessively disruptive. However, choosing to renovate the building introduced many added cost factors and difficulties to the goal of creating modern lab space. Not only are contractors be forced to work within the confines of a 50 year old building, but they have to preserve many of its essential systems to keep it operable for the building's occupants.

Take the HVAC system, for example. In new construction it is difficult enough to pack ductwork and piping into a ceiling plenum. But in a renovation it is many times harder. The old ductwork and piping must be removed, but not haphazardly. HVAC, electrical, and plumbing service to the occupied floors cannot be disturbed. Furthermore, some of the building's flooring is known to contain asbestos, and so contractors have to work with more care than usual. Running four columns of large ductwork on the building's exterior corners the avoided the need to snake supply and exhaust air through the core of the building. But it introduced added cost of steel structure necessary to support the ductwork, and brick veneer to insulate and protect the ducts from the elements.

Though actual construction during the renovation is difficult, estimating the cost of construction is even harder. For new construction estimating is as simple as performing take-offs, counting individual items of known cost, and totaling them up. But for this renovation, the source of costs is often difficult to determine. Penn State quotes the project cost as being around 18 million dollars. But the breakdown of that cost into the respective trades is complicated. Again, examine the HVAC system. Ceilings tiles and wall gypsum have to come down for the renovation: but where should that cost be charged to? Removing the old ductwork will often require working around plumbing and electrical components, some that will stay and some that will be replaced. How long will the coordination of this demolition take? What manpower is needed to do it properly? Are there good records of the building's MEP systems, or will demolition be forced to proceed a few square feet at a time, taking care to disturb only what is needed? The unknowns are countless. And errors are costly, and not only in added work. If the wrong ductwork, piping, or wiring is cut, the building's occupants

could be without heat, water, electricity, or data connections. So even though demolition can theoretically occur at some rate, perhaps extra care and double checking plans is both warranted and wise.

All this to reiterate that performing an estimate for this building is not straightforward. Just down the hill from the Mueller renovation is the Steidle renovation. Those working at the Steidle project have the luxury of being able to use excavators and heavy machinery to do their demolition. Estimates can be done purely by the square foot. But at Mueller, estimating costs is a painstaking process.

Project Schedule

Task	Start date	End date
PROJECT STARTUP		
order electrical switchgear temporary offices utilities survey temporary sidewalk installation site fencing landscape removal site grading temporary access temporary power crane foundation	5/15/2014	
EXISTING CONDITIONS COMPLETED		5/30/2014
ground floor electrical demo ground floor mechanical demo ground floor plumbing demo install switchgear ground floor electrical distribution ground floor emergency power ground floor lighting ground floor receptacles ground floor tele data ground floor fire alarm install ground floor mechanical install ground floor plumbing		
GROUND FLOOR COMPLETE		7/15/2014
first floor duct enclosure structure second floor duct enclosure structure third floor duct enclosure structure fourth floor duct enclosure structure fifth floor duct enclosure structure sixth floor duct enclosure structure roof duct enclosure structure first floor external ducts second floor external ducts third floor external ducts fourth floor external ducts fifth floor external ducts sixth floor external ducts roof external ducts	7/16/2014	
EXTERNAL DUCTS COMPLETE		8/15/2014

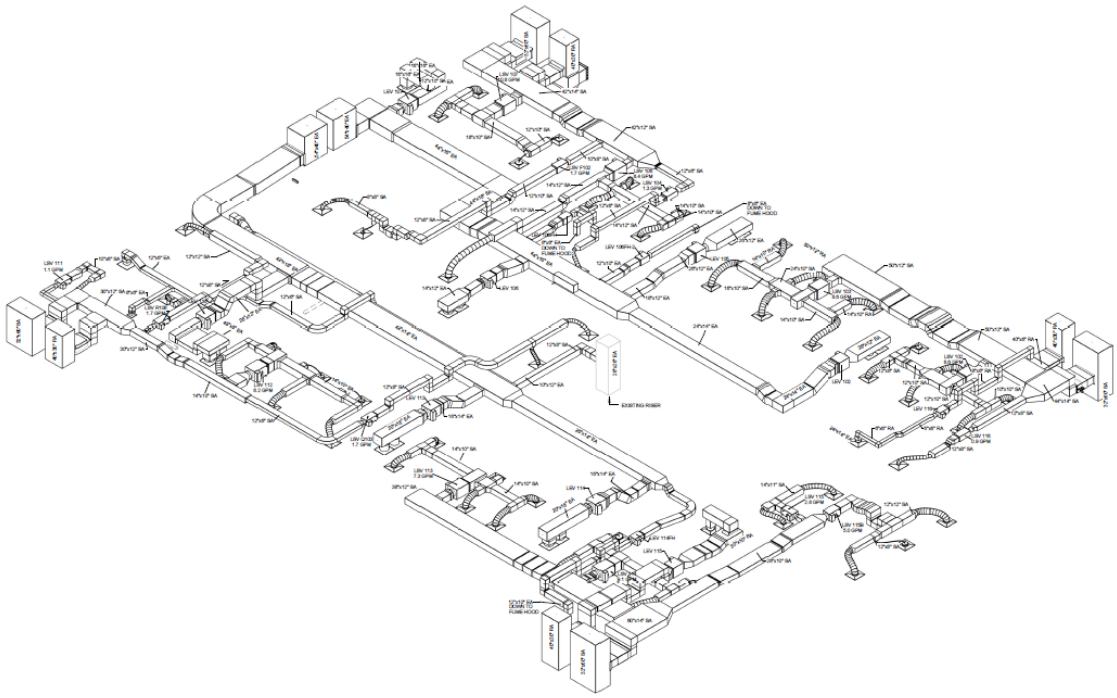
roof demo	8/16/2014	
roof install		
roof mechanical		
roof air handlers		
roof plumbing		
roof electrical		
sixth floor emergency power		
roof tele data		
ROOF COMPLETE		9/15/2014
first floor demo	9/16/2014	
asbestos removal		
first floor mechanical		
first floor plumbing		
first floor bathroom fixtures		
first floor electrical distribution		
first floor emergency power		
first floor lighting		
first floor receptacles		
first floor tele data		
first floor fire alarm		
drywall install		
first floor ceilings		
first floor finishes		
fixtures install		
FIRST FLOOR COMPLETE		11/15/2014
second floor demo	11/16/2014	
second floor mechanical		
second floor plumbing		
second floor electrical distribution		
second floor emergency power		
SECOND FLOOR COMPLETE		12/1/2014
third floor mechanical	12/2/2014	
third floor plumbing		
third floor electrical distribution		
third floor emergency power		
THIRD FLOOR COMPLETE		1/1/2015
fourth floor demo	1/2/2015	
asbestos removal		
fourth floor mechanical		
fourth floor plumbing		
fourth floor electrical distribution		
fourth floor emergency power		
fourth floor lighting		
fourth floor receptacles		

fourth floor tele data		
fourth floor fire alarm		
drywall install		
fourth floor ceilings		
fourth floor finishes		
fixtures install		
FOURTH FLOOR COMPLETE		3/1/2015
fifth floor demo	3/2/2015	
asbestos removal		
fifth floor mechanical		
fifth floor plumbing		
fifth floor electrical distribution		
fifth floor emergency power		
fifth floor lighting		
fifth floor receptacles		
fifth floor tele data		
fifth floor fire alarm		
drywall install		
fifth floor ceilings		
fifth floor finishes		
fixtures install		
FIFTH FLOOR COMPLETE		5/1/2015
sixth floor demo	5/2/2015	
asbestos removal		
sixth floor mechanical		
sixth floor plumbing		
sixth floor bathroom fixtures		
sixth floor electrical distribution		
sixth floor emergency power		
sixth floor lighting		
sixth floor receptacles		
sixth floor tele data		
sixth floor fire alarm		
drywall install		
sixth floor ceilings		
sixth floor finishes		
fixtures install		
SIXTH FLOOR COMPLETE		7/15/2015
brick façade on external ducts	7/16/2015	
repointing of select existing brick		
outdoor accessibility		
landscape installation		
PROJECT COMPLETION		8/20/2015

Detailed Estimate

Since the only structure being erected during the Mueller Building renovation is a small cage to contain and support the ductwork, and estimate of the structural system will give very little idea of what is occurring in the overall project. However, the HVAC system, and especially the ductwork, is the very nature of the renovation, and investigating it tells us much about the scope of the work being done.

For this estimate the first floor of Mueller was used as the standard pattern. The first, fifth, and sixth floors all share very similar and extensive ductwork renovation plans. An isometric view of the first floor sheet metal is shown below.



The required ductwork layout is complex. Both supply, return, and laboratory exhaust ducts snake throughout the ceiling, running to ducts on the perimeter of the building and one in the core. The estimated cost is as follows:

Duct size	length, ft	unit SA in^2	unit SA ft^2	total ft^2
6x6	16	36	0.25	4.00
8x6	8	48	0.33	2.67
8x8	44	64	0.44	19.56
10x6	8	60	0.42	3.33
10x8	24	80	0.56	13.33
10x10	16	100	0.69	11.11
12x6	128	72	0.50	64.00
12x8	124	96	0.67	82.67
12x10	148	120	0.83	123.33

12x12	12	144	1.00	12.00
14x10	36	140	0.97	35.00
14x11	8	154	1.07	8.56
14x12	44	168	1.17	51.33
16x10	8	160	1.11	8.89
16x12	16	192	1.33	21.33
16x14	16	224	1.56	24.89
16x16	8	256	1.78	14.22
18x10	16	180	1.25	20.00
18x12	16	216	1.50	24.00
20x12	8	240	1.67	13.33
20x18	16	360	2.50	40.00
24x10	12	240	1.67	20.00
24x14	44	336	2.33	102.67
26x12	16	312	2.17	34.67
26x14	28	364	2.53	70.78
28x8	16	224	1.56	24.89
28x10	12	280	1.94	23.33
30x10	32	300	2.08	66.67
30x12	28	360	2.50	70.00
38x12	28	456	3.17	88.67
40x30	288	1200	8.33	2400.00
42x14	128	588	4.08	522.67
44x14	4	616	4.28	17.11
44x16	36	704	4.89	176.00
44x20	36	880	6.11	220.00
48x8	4	384	2.67	10.67
50x12	40	600	4.17	166.67
54x40	384	2160	15.00	5760.00
60x14	12	840	5.83	70.00
60x32	192	1920	13.33	2560.00
		Total duct surface area:		13002.33
			weight/ft^2:	0.75lb
		Total weight, lbs:		9751.75
		Cost/lb installed:		$ 7.45
		Total sheet metal cost:		$ 72,650.54
26	duct terminals		$785.50 per unit	$20,423.00
42	diffusers		$30.55 per unit	$1,283.10
	Total cost for 1st floor ductwork:			**$ 94,356.64**

Thus, the sheet metal ductwork for the first floor will cost just under $100,000. This cost can be extrapolated to the rest of the building. In addition to the ductwork, the HVAC system includes the air handler equipment and pumps, and air handler piping. Details of these estimates are shown below.

Air handler equipment estimate			
2	shell/tube heat exchangers	$ 120,300.00	$ 240,600.00
1	plate heat exchanger	$ 162,100.00	$ 162,100.00
3	cabinet unit heaters	$ 5,175.00	$ 15,525.00
1	AC for computer room	$ 2,815.00	$ 2,815.00
1	reheat coil	$ 23,175.00	$ 23,175.00
8	pumps	$ 3,844.27	$ 30,754.16
3	expansion tanks	$ 1,275.00	$ 3,825.00
		Total AHU cost:	**$ 478,794.16**
Total ductwork estimate			
	ground floor ductwork		$ 94,356.64
	1st floor ductwork		$ 94,356.64
	4th floor ductwork		$ 47,178.32
	5th floor ductwork		$ 94,356.64
	6th floor ductwork		$ 94,356.64
	roof ductwork		$ 94,356.64
	Total ductwork cost:		**$ 518,961.52**
First floor air handler piping estimate			
	106 feet	$16.10/ft	**$ 1,706.60**
Total air handler piping estimate			
1	ground floor piping		$ 1,706.60
1	1st floor piping		$ 1,706.60
0.5	4th floor piping		$ 853.30

1	5th floor piping		$ 1,706.60
1	6th floor piping		$ 1,706.60
1	roof piping		$ 1,706.60
	Total piping cost		**$ 9,386.30**

These individual costs can be summed together.

TOTAL MECHANICAL COSTS

Ductwork estimate	$ 518,961.52
Mechanical piping estimate	$ 9,386.30
Mechanical equip. estimate	$ 478,794.16
Total mechanical cost:	**$ 1,007,141.98**

Thus, the estimate of the cost of the mechanical is just over one million dollars. However, there is a problem. Penn State's quoted estimate of the cost of the mechanical system is $5,977,210. This is nearly six times the cost the author estimated for the system. This discrepancy is huge, and as yet unaccounted for. It is possible that Penn State included demolition of the old HVAC system in their estimate. Or perhaps the installation cost of ductwork is more than the RS means value the author found.

Site Layout Planning (see also attached 11x17 pages)

The Mueller renovation project is located on a tight site. At the north it is bounded by an access road for the library. To the west is the library itself. To the east is North Frear building. And to the south is Whitmore laboratory and a steep grade. Pedestrian walkways crisscross all around Mueller Building. The only place where a crane, material deliveries, and contractor vehicles could fit is in the small green space between Mueller and the library. An added difficulty are the trees in that area that need to be protected; but provided that is done satisfactorily, the space will serve adequately as a job site. Putting a gate along the access road for the library allows for secure access to the jobsite. And rerouting a sidewalk to right next to the library avoids impeding pedestrian traffic. Mueller building is fenced off all around, except for at the south end to allow entrance for the building's occupants. The crane is placed on the west side of the building, taking care to be clear of the protected trees. Inside the fence is enough area for both contractor parking and material staging.

General Conditions Estimate

As previously discussed, the Mueller Building is located on a tight site between several other Penn State buildings. This means several things in terms of general conditions. First, it is imperative to fence off the site to keep pedestrians safe. And second, placement of job site office trailers would be difficult, if not impossible. Locating them next to Mueller would take up too much valuable material staging space. Fortunately, Penn State allowed Barton Malow to set up offices in the basement of the adjacent South Frear building. Doing this saves the cost of trailer delivery, rental, and connection to utilities.

Below are listed the estimated General Conditions Costs.

General Conditions Costs

Staffing	cost/week	week/month	months worked	total cost
Project director	$ 2,300.00	4.35	15	$ 150,075.00
Senior project manager	$ 1,500.00	4.35	15	$ 97,875.00
Safety supervisor	$ 1,325.00	4.35	15	$ 86,456.25
2 Project engineers	$ 2,050.00	4.35	15	$ 133,762.50
Project manager	$ 1,875.00	4.35	15	$ 122,343.75
Superintendent	$ 1,825.00	4.35	15	$ 119,081.25
		Total project staffing cost:		$ 709,593.75
		Staffing cost per month:		$ 47,306.25

Site fencing	1000LF	$5.81/LF	$ 5,810.00
Temporary road/parking	1000yd^2	$12.23/yd^2	$12,230.00
Tree removal	10 trees	$4.15	$41.50

Total General Conditions Cost:	**$ 727,675.25**

This cost of about $727,000 is roughly 4% of the overall project cost, which is close to the industry average.

LEED Evaluation

The Mueller Building, though being updated in many important ways, misses out on many pieces of Penn State's sustainability recommendations. Even before the renovation started Mueller could claim the "Access to Quality Transit" and "Bicycle

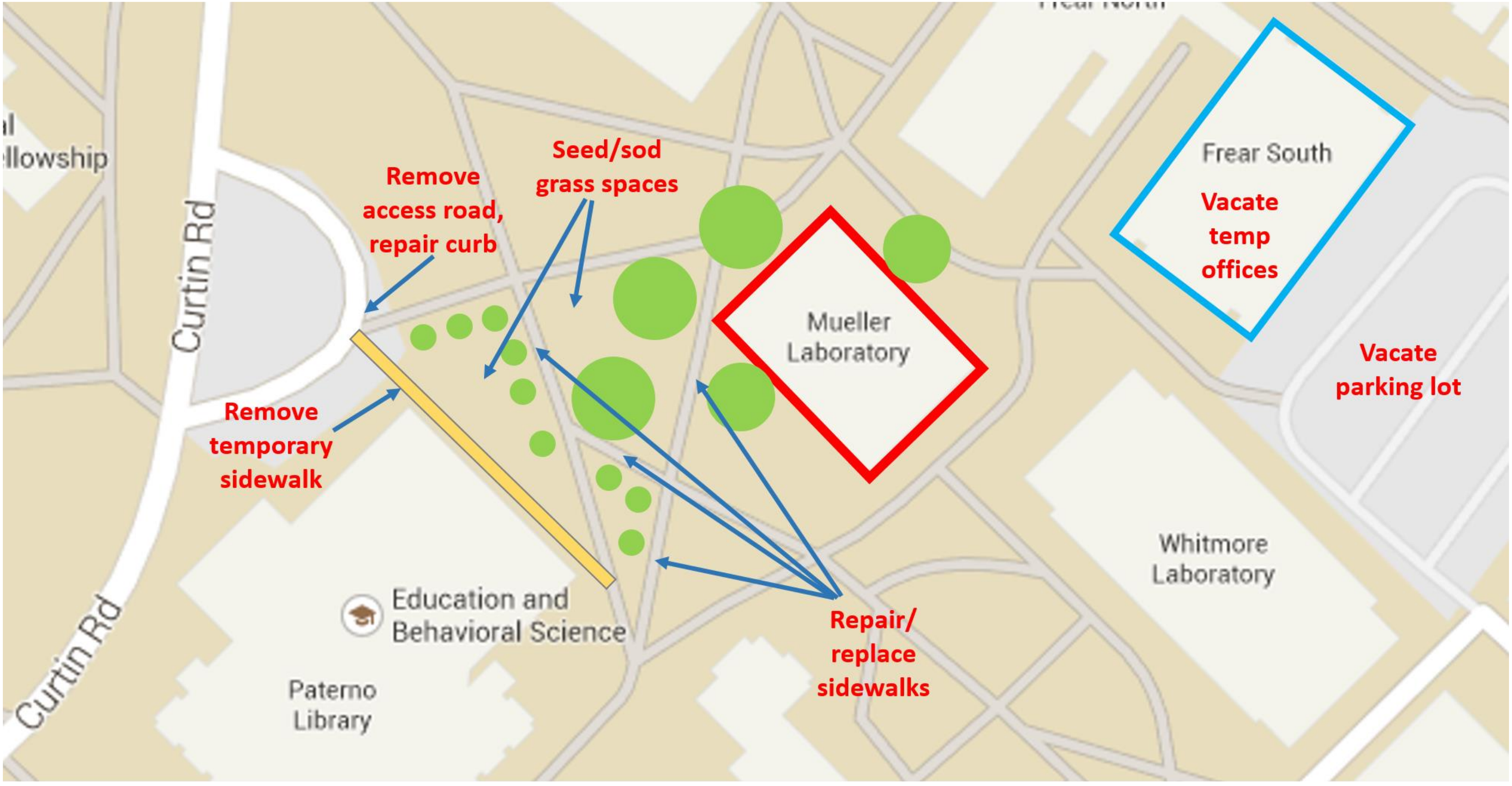
Facilities" credits. It was close to bus stops, it was accessible from many sidewalks and paths, and it had bike racks nearby. The "Reduced Parking Footprint" credit was also a given, since Mueller had no parking lot of its own. Penn State has chosen to put "minimal effort" in to building reuse credits, and so has not aggressively pursued LEED certification for the Mueller renovation.

Yet the Mueller renovation project does have a few sustainability aspects. As with all Penn State construction projects, the renovation jobsite will be set up to control soil erosion and airborne dust, thus claiming the "Construction Activity Pollution Prevention" credit. Also, the "Site Development: Protect or Restore Habitat" credit is gained through the careful preservation of the trees on the job site. Furthermore, the completed building will meet the "Minimum Energy Performance" requirement and thus earn another credit. The "Enhanced Indoor Air Quality Strategies" credit can be claimed, since the building's air handlers are being completely overhauled and modernized. And the installation of efficient LED lighting fixtures meets the criteria of the "Interior Lighting" credit.

So, even though Mueller cannot claim many of the "easy" credits earned by other projects, using good construction practices and installing quality equipment will earn the project a number of LEED credits. Furthermore, Penn State is following the spirit of LEED, if not obtaining the official certificate. Updating the ancient mechanical and electrical systems in Mueller will make the building far more energy efficient, and provide a healthier building environment for its occupants. So while not as flashy as some of Penn State's LEED Gold buildings, Mueller is demonstrating that a goal of sustainability is entirely reachable for any building.

Site Plan: Site Preparation Phase

Site Plan: Renovation Phase



Site Plan: End of construction site work