Lehigh Valley Hospital - Cedar Crest Campus

Allentown, PA

2006-2007 Senior Thesis – Final Report

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WHITING-TURNER

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Construction Management

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Background

The client is Lehigh Valley Hospital – Cedar Crest Campus, located in Allentown, PA. They are a not-for-profit hospital who opened their doors in 1899 as the Allentown Hospital and has grown to three campuses, two in Allentown and one in Bethlehem, PA. They are a major clinical campus for The Pennsylvania State University's College of Medicine at the Milton S. Hershey Medical Center. Home to advanced acute care hospital with more than 800 patient beds in operation on three sites. They also were Pennsylvania's first Level I Trauma Center and remains the only Level I trauma center in the Lehigh Valley region with additional qualifications in pediatric trauma.

The reasons that LVH is expanding its facilities is that the emergency room as well as the patient rooms are insufficient in the current facility and they currently end up waiting at times for patient beds to be available. Included in the scope of the work to be done on the entire project are but not included entirely in this report:

- A new seven story patient care building
    - With 330 all private patient rooms
    - Two parking decks for patients and visitors
        - East parking deck in front of the hospital (480 spaces)
        - West parking deck in front of the hospital (544 spaces)
    - A new medical office building - The Center for Advanced Health Care
        - with its own parking deck
    - Increased size of the Emergency Department
    - Expanding X-ray and CT scan testing areas
    - Adding operating rooms
    - More classrooms and education space
    - A bigger cafeteria and expand parking for employees
- An 890 car parking deck on the east side of the campus

Executive Summary

The Lehigh Valley Hospital is expanding its facilities to a new 310,000 square foot addition. I chose this project because I wanted a LEED rated building. My goal was to take the existing plans for the building and expand on some new alternatives. I looked at the building structure and using an alternative pre-cast hollow core plank system versus the original steel deck and elevated slab. I looked at increasing the LEED credit goal. I developed an ICRA plan. I also looked closer at a rainwater harvesting system to be included as a Mechanical Breadth as well as a way to gain an additional LEED credit. The final part of this report outlines a survey completed to help understand how we can bridge the gap between the generations of construction workers in the industry. Below is a summary of my findings.

Construction Management Analysis 1: Gaining a Higher LEED Rating

- Increased the LEED credit to 41 points to achieve Gold certification

Construction Management Analysis 2: **I**nfection **C**ontrol **R**isk **A**ssessement Plan

- Successfully produced an ICRA plan for this project

Mechanical Analysis – Breadth 1: Rainwater Harvesting System

- Can harvest almost 4,000 gallons of rainwater per day
- Successfully eliminated 100% demand for grey water applications
- Designed a retention and distribution system for the harvested water

Structural Analysis – Breadth 2: Precast Hollow-core Plank System

- Schedule reduction of 18 days
- Increase in structural estimate of approximately $400,000
- Precast Hollow core Planks cost: $1.6 million
- Metal Deck and Elevated Slab $601,010

Research Topic: Closing the Gap in Sustainable Design

- Completed survey to help eliminate the generation gap in sustainable design practices

Building System Summary

The expansion project that is included in this report is that of Phase A, B and C located in the site plan Appendix A. The project is a 310,000 square foot addition to the east wing of the Lehigh Valley Hospital. The project is to take place from June of 2005 and to be completed in December of 2008. The total cost of the project as was mentioned on the LVH website is $181.5 million.

The primary project teams are listed below:

- Owner: Lehigh Valley Hospital
- Construction Manager: Whiting-Turner
- Executive Architects: Freeman-White, Inc.
- Design Architects: Venturi, Scott, Brown & Associates
- Structural Engineers: O'Donnel & Naccarato
- Civil Engineers: The Pidcock Company
- LEED/MEP Contractors: TLC Engineering
- Interiors: Freeman-White, Inc.

Structural:

Cast-in-place concrete is used in the entire foundation of the building which consists of 13'x13'x30" and 16'x16'x36" typical spread footings with a 12" cast-in-place concrete basement wall in Phases A and B and a combination of a 12" and 16" cast-in-place concrete basement wall in Phase C. There is also 4" concrete slab on grade with 6x6 W1.4xW1.4 WWF over 4" crushed stone in Phases A and B with some areas of Phase B and all of Phase C requiring the use of 5" concrete slab on grade with 6x6 W2.0xW2.0 WWF over 4" crushed stone. There is 3-1/4" lightweight concrete on top of 3" 20 gauge galvanized LOK-FLOOR decking with 6x6 W2.0xW2.0 WWF designed for the floor system.

The structural steel frame consists of joists ranging from W16x26 to W21x57 typical, girders ranging from W24x76 to W24x103 typical and columns ranging from W8x30 to W14x109 typical. On the roof there is 1-1/2" 22 gauge wide rib type 'B' galvanized deck.

Mechanical System:

The mechanical system is quite elaborate consisting of 14 Air Handling Units ranging from 8,000 CFM to 47,000 CFM, 3 natural gas/fuel oil boilers capable of 27,600 lbs/hr flow, along with 42 480V variable speed fans and 3 9,000 CFM supply fans to heat and cool the building. There are also six 5,000 CFM fan coil units located in Phase C. The mechanical system is housed within a mechanical room in Phase C of the basement as well as in the Penthouse on the roof.

Electrical System:

The electrical system is provided by the existing part of the hospital. There are both 120V and 480V systems that will be used throughout the expansion. The main electrical room is housed in the west corner of Phase A. There are a total of 196 electrical panels throughout the expansion project.

Façade:

The façade consists of a curtain wall system with a series of pre-cast concrete panels along with two types of metal panels to surround the windows.

Project Information

- Actual Building Construction Costs
    - Could not attain because of confidentiality
- Total Project Cost
    - $181,500,000
    - At 310,000 SF - $585.48/SF
- Major Building Systems Cost
    - Mechanical: Could not attain because of confidentiality
    - Electrical: Could not attain because of confidentiality
    - Structural: Could not attain because of confidentiality
    - Site work: Could not attain because of confidentiality

- Square Foot Estimate using Cost Works 2005
    - Used the parameters of:
        - Institutional
        - Hospital
        - 4-8 Stories
    - Modified Location: Allentown, PA
    - Total Estimate Cost Including
        - Basement
        - General Conditions (25%)
        - Architectural Fees (9%)
        - $58,749,075, $189.51/SF

Construction Management Analysis 1: Gaining a Higher LEED Rating

Proposal / Goals:

I chose this building because it was already trying to become a LEED rated building. I wanted to showcase that sustainable building design is necessary for the future of the construction management sector and I believed that this would be a good starting point for me to work and show that there are possibilities to expand a project to a higher LEED rating given the cooperation of the building owner and the coordination of the architects and engineers to make it happen. The building is currently trying to attain a Silver LEED certification, but I would like to push that envelope a little higher and see what would be required in order to attain a Gold rating. As it stands now, the Lehigh Valley Hospital is currently at 33 points for the total amount of credits to be obtained for their LEED certification which is the lowest possible total in order to receive credit for Silver certification. In my analysis I would like to add suggestions to push that total up to 39 which would achieve Gold LEED status.

Procedure:

The first thing that I did in my analysis was look at the existing credits that were already being applied to this project. I will highlight some of the main credits that the project team at Whiting-Turner is going for. They are using a Construction Waste Management plan in order to recycle waste content on the project, Regional Materials within a 500 mile radius, Certified Wood, Recycled building materials such as roofing, drywall, steel and concrete, and lastly Low Emitting Material which produce Volatile Organic Compounds (VOCs)

Using the LEED – NC handbook for new construction I was able to narrow the credits that I would be able to achieve for this analysis and they are as follows:

Sustainable Sites (1 Credit Each)
SS Credit 6.1: Storm water Design - Quantity Control
SS Credit 6.2: Storm water Design - Quality Control
Water Efficiency (1 Credit Each)

WE Credit 2: Innovative Wastewater Technologies

WE Credit 3.1: Water Use Reduction - 20% Reduction

WE Credit 3.2: Water Use Reduction - 30% Reduction

Energy & Atmosphere (1 Credit Each)

EA Credit 2: On Site Renewable Energy

2.5% =	1 point
7.5% =	2 points
12.5% =	3 points

EA Credit 6: Green Power

Materials & Resources (1 Credit Each)

MR Credit 6: Rapidly Renewable Materials

This new total is 8 points, which when added to the current total of 33 gives me 41 possible points. This new total would put the project into the Gold LEED rating range of 39-51 points.

One idea that I was really eager to look into was a Rainwater Harvesting System which will be looked at in more detail in the Mechanical Breadth.

The first 5 points of the LEED credits I believe can be accomplished with this one system. The sustainable sites requirements are limiting disruption and pollution of natural water flows by managing storm water run off. By using the rainwater harvesting system we can successfully accomplish these credits.

The next credit I would propose the use of a solar panel array incorporated into a covered parking lot. Adjacent to the East of the construction site is a parking lot that I would like to develop a solar panel array which would be housed on top of an angled canopy to shade and cover the cars during the day. This would reduce the heat island effect that is created by the blacktop as well as provide sustainable energy to the building. The second credit which is green power, I am suggesting that LVH contract with a local wind generation plant in order to successfully reduce the buildings load demand by 35%.

The last credit that I would like to incorporate into this project is rapidly renewable resources. Vinyl composite tile is used in most of the rooms as a flooring material and I would like to suggest the use of bamboo as an alternative. Bamboo, I believe, has the same if not longer longevity as vinyl tile and produces less VOCs after installation. The incredible 28,000 psi tensile strength and quick 3-5 year growth pattern allows this product to be used more often. Also since all of the patient rooms are private, using bamboo in the rooms would also create a more inviting atmosphere while they are staying there

Conclusions / Recommendations:

After completing this portion of my analysis, I believe there is a strong hope to be able to successfully incorporate these ideas into this project. Granted there are costs that are involved with each one of them but I hope that there is enough evidence in order to offset the initial costs with the benefits of using these alternative ideas. I was thoroughly pleased with the results from the rainwater harvesting system and I believe that system alone would impact this project immensely. By reducing the amount of water used by the toilets only increases the applications that the harvested water can be used for.

Construction Management Analysis 2: ICRA Plan

Proposal / Goals:

This analysis was designed to look into making sure that the patients and workers of the hospital were not affected by the pollutants and debris from the ongoing construction. I wanted to examine how an ICRA plan can be used in order to protect the Indoor Air Quality (IAQ) of the hospital and how doing this would affect how the phasing of the project would need to take place to maximize the potential for successfully incorporating an ICRA plan.

Procedure:

The first thing that was needed was to gain enough knowledge about ICRA as I could. I have never been involved with this procedure so it was quite a challenge to try and understand what was required. Next, I used an ICRA matrix of precautions for Construction and Renovation in order to complete the initial ICRA plan.

Based on the matrix, the project is a Type D (Major demolition and construction projects) with a Highest Risk patient group (this covers all the basis of operations inside the hospital). This information is then used to identify the class of precautions located in the chart below.

Construction Project Type

Patient Risk Group	**TYPE A**	**TYPE B**	**TYPE C**	**TYPE D**
LOW Risk Group	**I**	**II**	**II**	**III/IV**
MEDIUM Risk Group	**I**	**II**	**III**	**IV**
HIGH Risk Group	**I**	**II**	**III/IV**	**IV**
HIGHEST Risk Group	**II**	**III/IV**	**III/IV**	**IV**

This project requires a class IV because of the Type D project type and Highest Risk Group. Outlined by the class descriptions you will find a list of the requirements of this classification.

During Construction:

1. Isolate HVAC system in area where work is being done to prevent contamination of duct system.

2. Complete all critical barriers i.e. sheetrock, plywood, plastic, to seal area from non work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins.
3. Maintain negative air pressure within work site utilizing HEPA equipped air filtration units.
4. Seal holes, pipes, conduits, and punctures appropriately.
5. Construct anteroom and require all personnel to pass through this room so they can be vacuumed using a HEPA vacuum cleaner before leaving work site or they can wear cloth or paper coveralls that are removed each time they leave the work site.
6. All personnel entering work site are required to wear shoe covers. Shoe covers must be changed each time the worker exits the work area.
7. Do not remove barriers from work area until completed project is inspected by the owner's Safety Department and Infection Control Department and thoroughly cleaned by the owner's Environmental Services Department.

Upon Completion of the Project:

1. Remove barrier material carefully to minimize spreading of dirt and debris associated with construction.
2. Contain construction waste before transport in tightly covered containers.
3. Cover transport receptacles or carts. Tape covering unless solid lid
4. Vacuum work area with HEPA filtered vacuums.
5. Wet mop area with disinfectant.
6. Upon completion restore HVAC system where work was performed

Following the recommendations of the ICRA matrix, I believe that it be best that a solid barrier wall with a negative space HEPA filter sealed room be used between the construction site and the three entrances left for tying into the existing building. Contained within the sealed room would be a HEPA vacuum cleaner to get any particles off people before entering the existing hospital. There would also be sticky mats both inside the sealed room as well as on the construction site to prevent as little amount of material to be transferred into the hospital. Once the new construction is completely sealed the use of shoe covers must be worn and changed whenever a worker leaves the building to go outside. Sticky mats would also be used at all entrances to the new construction once the building has been completely sealed. During demolition as well as throughout the construction process, HEPA filter boxes will be built around the existing HVAC systems to prevent as little contaminants from entering the existing building. All HEPA filters will be required to be changed every week or sooner as necessary.

In order to minimize the potential for contaminants entering the existing building during construction, I propose that the phasing of work be from the East side of Phase A in towards the existing building finishing with Phase C before tying into the existing structure. This I believe will allow for Phase A to become sealed off and have a greater control of the cleanliness of the space before the final section of completion in Phase C.

Conclusions / Recommendations:

This was all new to me so it was a challenging experience. I believe that ICRA is a vital process in order to maintain a clean working environment, especially around such a critical area as a hospital. Although it may require a lot more planning and coordination between the construction management team and the contractors and the higher costs for the increased protection, ICRA is well worth protecting the health of the people who are trying to get better and work in the hospital.

Mechanical Analysis – Breadth 1: Rainwater Harvesting System

Proposal / Goals:

I wanted to look at a way to not only get more LEED credits but also to take advantage of something that occurs naturally. I wanted to showcase that with a little ingenuity that there are great benefits of nature. The goal of this analysis is to provide concrete evidence that will make the decision for implementing this system into the Lehigh Valley Hospital expansion project and maybe eventually phasing a similar system into the existing structure.

Procedure:

Pennsylvania receives a moderately good amount of rainfall on average so this system would be very appealing to try and apply to this project. The average annual rainfall for Allentown, PA is 43.71 inches. Coupling this with the very large footprint, approximately 41,701.4 square feet, of just the expansion of the Lehigh Valley Hospital allows great potential. This rainwater would then be used as a grey water application in order to reduce the buildings demand load on the cities water supply. This also would satisfy all three water efficiency credits that are outlined in the LEED-NC handbook.

Rainwater Harvesting System

Roof Area (SF)				
Phase A	Phase B	Phase C	Total	
20,158.50	5,499.12	16,043.80	41,701.40	
Rainfall Total				
Roof Area (SF)	Annual Rainfall (in/12)	Volume (cu ft/yr)	Volume (gal/yr)	Volume (gal/day)
41,701.40	43.71	151,897.35	1,128,597.31	3,092.05

Toilets	Urinals			
206	6			
Quantity	Rate (GPF)	Total Demand	6 Flushes per day (gal)	8 Flushes per day (gal)
206.00	1.60	329.60	1,977.60	2,636.80

Figure 1.1

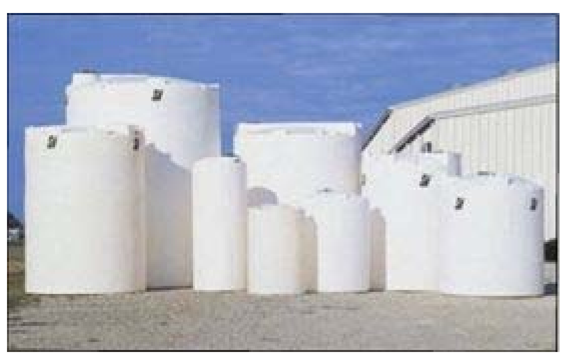
As you can see in Figure 1.1 above, that given the amount of annual rainfall for Allentown, PA there is a potential of 3,092 gallons of rainwater to be harvested each day. Given the total of 206 toilets throughout the expansion you can see also in Figure 1.1 that on a demand of 6 flushes per day there requires 1,977.6 gallons and on a demand of 8 flushes there requires 2,636.8 gallons both of which are less than what can be harvested per day. Using this system will reduce the amount of water needed for grey water applications by 100% satisfying the LEED requirements of 20% and 30% for WE 3.1 and 3.2. This can also be intensified by using an even more efficient toilet. The toilets that are specified are low flush 1.6 gallons per flush fixtures. I would like to suggest the use of Microphor's LF-219 ultra low flush toilet which uses only 0.5 gallons per flush with the assistance of pneumatics. By eliminating even more demand for the collected water there can be other alternatives that the water can be used for in the future. I also would like to use waterless urinals to totally eliminate the need for supplying these fixtures.

The next step that I did was calculated the amount of holding tanks that would be required in order to successfully contain all of this rainwater. According to www.rainfilters.com, they suggest a holding tank capacity of 265 gallons per 151 square feet of roof area.

41,701.4 SF/151 SF = 276.17 SF

276.17 SF (265 gal) = **73,185 gallons**

As you can see in the above calculation, there need to have enough holding tank capacity to contain 73,185 gallons. Researching plastic industrial holding tanks I was able to find a company that would supply a 4,500 gallon tank which had a 142" diameter and 91" height. They had tanks that would hold up to 16,000 gallons, but they would not be able to



be stored inside the building because they were too tall. Using these figures I was then able to calculate that I would need 16 - 4,500 gallon tanks. This is a lot to fit inside of the basement of the building and would require a lot of planning and coordination.

I then created a plan for the layout of the holding tanks in the storage space in Phase A which can be found at the end of the report in Appendix B. The 16 holding tanks would each be fitted with electronically controlled shut off valves which would be tied into level sensors inside the tank. After each tank gets full the valve will shut off on the top of the tanks and the water will be diverted to the next available container. The level sensors will also be used in order to tell the command center which tanks can be used to supply the needed water to the toilets. On the bottom of the tanks there will also be electronically controlled valves that will open so that an external pump located on the back of the command center will be able to supply the water to the toilets throughout the building.

Conclusions / Recommendations:

After completing this analysis I was very pleased with how well I believe this system could work. It will require a lot of planning in order to complete but the benefits of eliminating 100% of the expansions grey water needs and if lower water use toilets and waterless urinals are used then the potential for the harvested rain water is increased even more. One of the possibilities that the grey water can be used for is for irrigation of the landscape.

Structural Analysis – Breadth 2: Precast Hollow-core Plank System

Proposal / Goals:

When I first looked at what I could do for a structural analysis the first thing that I thought about, being a construction management option, was how long doing slab on metal deck takes and tried to figure out an alternative solution that would be quicker. So for the structural analysis I wanted to examine the benefits of using a precast hollow core plank system versus the slab on metal deck being used in the current design. I am hoping that by using this proposed system that I will be able to see a reduction in the schedule and lower labor costs. Using this system will also help eliminate some of the interior structural steel members in the original design.

Procedure:

After doing some research I was able to contact Jim Clapper from Spancrete who helped me in deciding that a 10" thick hollow core plank would be able to successfully span the desired 33' which is what I ended up with by dividing the wings of Phase A and Phase C in half and increasing the size of the beam running down the center of the building. I increased the center beam from the original W16x26 to the typical beam being used for the outside members which was a W21x57 to be able to carry the added weight of spanning the extra distance. Examining the current layout I was able to eliminate two of the existing beams that fell in between the outside beams and the interior center beam. I only concentrated my efforts on Phases A and Phase C because I felt that Phase B, the "knuckle" had too many angles to be worth redesigning the system to accommodate the hollow core planks.

Using RS Means 2007 costs data I then did complete structural systems costs comparison between the existing system and the proposed system. I found that I was able to achieve the schedule reduction that I was after, 51 days with the hollow core plank system compared to 69 days with the slab on metal deck system. This inadvertently was not able to be accomplished without a substantial increase in total costs. After comparing the rest of the systems I came to a total of $2.6 million for the structural steel and hollow core plank system whereas the structural steel and slab on metal deck came to a total of $2.2 million.

Because the hollow core plank system has a $7.95 per linear foot of material I ended up with a cost of this system to be $1.6 million and the costs of the decking material and elevated concrete slab only came to a total of $601,010. I was able to make a lot of this difference up with the amount of structural steel members I was able to eliminate, but it was not enough to offset the costs of the hollow core planks.

Below you will find the charts with the breakdown of my work.

Hollow-core Plank System

10" Thick 33' Long Hollow-core plank

Schedule	Area (SF)	Floors	Total (SF)	Daily Output	Total (Days)	Grand Total (Days)	
Phase A	20158.5	7	141109.5	4000	35.28	51	
Phase C	16043.8	4	64175.2	4000	16.04		
Labor	**Area (SF)**	**Floors**	**Total (SF)**	**Labor Hours**	**Labor Cost**	**Total**	**Grand Total**
Phase A	20158.5	7	141109.5	0.018	0.73	$1,854.18	$2,697.44
Phase C	16043.8	4	64175.2	0.018	0.73	$843.26	
Material	**Area (SF)**	**Floors**	**Total (SF)**	**Material Cost**	**Total**	**Grand Total**	
Phase A	20158.5	7	141109.5	$7.95	$1,121,820.53	$1,632,013.37	
Phase C	16043.8	4	64175.2	$7.95	$510,192.84		
Cost						Total	**$1,634,710.81**

Floor 1-A

Beams	Length	Quantity	Total (LF)	Material Cost	Total Material Cost	Labor Cost	Total Labor Cost
W21x57	37.8	9.0	339.8	$56.50	$19,195.88	$3.07	$1,043.03
Girders							
W18x40	19.5	8.0	156.0	$45.00	$7,020.00	$3.40	$530.40
W24x55	28.0	2.0	56.0	$62.00	$3,472.00	$2.94	$164.64
W24x62	28.0	7.0	196.0	$70.00	$13,720.00	$2.94	$576.24
W24x84	28.0	5.0	140.0	$94.50	$13,230.00	$3.03	$424.20
W24x103	47.5	2.0	95.0	$117.00	$11,115.00	$3.11	$295.45
Totals	188.8	33.0	982.8	$445.00	$67,752.88	$18.49	$3,033.96

Floor 2-7-A

Beams	Length	Quantity	Total (LF)	Material Cost	Total Material Cost	Labor Cost	Total Labor Cost
W21x57	36.0	18.0	648.0	$56.50	$36,612.00	$3.07	$1,989.36
W21x57	33.0	126.0	4158.0	$56.50	$234,927.00	$3.07	$12,765.06
W21x57	18.9	6.0	113.5	$56.50	$6,413.88	$3.07	$348.51
Girders							
W18x40	19.5	66.0	1287.0	$45.00	$57,915.00	$3.40	$4,375.80
W24x55	28.0	12.0	336.0	$62.00	$20,832.00	$2.94	$987.84
W24x62	28.0	48.0	1344.0	$70.00	$94,080.00	$2.94	$3,951.36
W24x76	28.0	36.0	1008.0	$94.50	$95,256.00	$3.03	$3,054.24
W24x103	47.5	12.0	570.0	$117.00	$66,690.00	$3.11	$1,772.70
Totals	238.9	324.0	9464.5	$558.00	$612,725.88	$24.63	$29,244.87

Floor 1-C

Beams	Length	Quantity	Total (LF)	Material Cost	Total Material Cost	Labor Cost	Total Labor Cost
W21x57	33.0	6.0	198.0	$56.50	$11,187.00	$3.07	$607.86
W21x57	36.0	1.0	36.0	$56.50	$2,034.00	$3.07	$110.52
Girders							
W18x40	19.5	8.0	156.0	$45.00	$7,020.00	$3.40	$530.40
W24x62	28.0	7.0	196.0	$70.00	$13,720.00	$2.94	$576.24
Totals	116.5	22.0	586.0	$228.00	$33,961.00	$12.48	$1,825.02

Floor 2-4-C

Beams	Length	Quantity	Total (LF)	Material Cost	Total Material Cost	Labor Cost	Total Labor Cost
W21x57	33.0	45.0	1485.0	$56.50	$83,902.50	$3.07	$4,558.95
W21x57	36.0	9.0	324.0	$56.50	$18,306.00	$3.07	$994.68

Girders							
W18x40	19.5	24.0	468.0	$45.00	$21,060.00	$3.40	$1,591.20
W24x62	28.0	45.0	1260.0	$70.00	$88,200.00	$2.94	$3,704.40
Totals	116.5	123.0	3537.0	$228.00	$211,468.50	$12.48	$10,849.23
Grand Totals	544.2	480.0	13984.3	$1,459.00	$925,908.26	$68.08	$44,953.08

Total System Costs	Hollow core Plank	Structural Steel	Grand Total System Costs
	$1,634,710.81	$970,861.33	$2,605,572.14

Steel Structural System

Slab on Metal Deck

Amount	Area (SF)	Floors	Depth	Total (cu. ft)	Total (CY)	Grand Total (CY)
Phase A	20158.5	7	0.27	38099.57	1411.10	2,052.85
Phase C	16043.8	4	0.27	17327.30	641.75	
Schedule	**Quantity (CY)**	**Daily Output**	**Total (Days)**		**Grand Total (Days)**	
Phase A	1411.10	140	10.08		15	
Phase C	641.75	140	4.58			
Labor	**Quantity (CY)**	**Labor Hours**	**Labor Cost**	**Total**	**Grand Total**	
Phase A	1411.10	0.457	14.20	$9,157.16	$13,321.75	
Phase C	641.75	0.457	14.20	$4,164.59		
Material	**Quantity (CY)**	**Material Cost**	**Total**		**Grand Total**	
Phase A	1411.10	108	$152,398.26		$221,707.48	
Phase C	641.75	108	$69,309.22			
Total Cost					**$235,029.22**	

3" 20 Gauge Galvanized Steel Deck

Schedule	Area (SF)	Floors	Daily Output	Total (Days)	Grand Total (Days)	Total Days SOMD & Deck
Phase A	20158.50	7	3800	37.13	54	69
Phase C	16043.80	4	3800	16.89		
Labor	**Area (SF)**	**Labor Hours**	**Labor Cost**	**Total**	**Grand Total**	
Phase A	141109.50	0.008	0.35	$395.11	$574.80	
Phase C	64175.20	0.008	0.35	$179.69		

Material	Area (SF)	Material Cost	Total		Grand Total	Cost of SOMD & Deck
Phase A	141109.50	1.78	$251,174.91		$365,406.77	
Phase C	64175.20	1.78	$114,231.86			
Total Cost					**$365,981.56**	$601,010.78

Structural Steel
Floor 1-A

Beams	Length	Quantity	Total (LF)	Material Cost	Total Material Cost	Labor Cost	Total Labor Cost
W16x26	33.0	39.0	1287.0	$29.50	$37,966.50	$2.26	$2,908.62
W18x35	36.0	4.0	144.0	$39.50	$5,688.00	$3.40	$489.60
W21x57	36.0	2.0	72.0	$56.50	$4,068.00	$3.07	$221.04
W21x57	33.0	10.0	330.0	$56.50	$18,645.00	$3.07	$1,013.10
Girders							
W18x40	19.5	8.0	156.0	$45.00	$7,020.00	$3.40	$530.40
W24x55	28.0	2.0	56.0	$62.00	$3,472.00	$2.94	$164.64
W24x62	28.0	7.0	196.0	$70.00	$13,720.00	$2.94	$576.24
W24x84	28.0	5.0	140.0	$94.50	$13,230.00	$3.03	$424.20
W24x103	47.5	2.0	95.0	$117.00	$11,115.00	$3.11	$295.45
Totals	289.0	79.0	2476.0	$570.50	$114,924.50	$27.22	$6,623.29

Floor 2-7-A

Beams	Length	Quantity	Total (LF)	Material Cost	Total Material Cost	Labor Cost	Total Labor Cost
W16x26	33.0	234.0	7722.0	$29.50	$227,799.00	$2.26	$17,451.72
W18x35	36.0	30.0	1080.0	$39.50	$42,660.00	$3.40	$3,672.00
W21x57	33.0	144.0	4752.0	$56.50	$268,488.00	$3.07	$14,588.64
W21x57	36.0	24.0	864.0	$56.50	$48,816.00	$3.07	$2,652.48
Girders							
W18x40	19.5	66.0	1287.0	$45.00	$57,915.00	$3.40	$4,375.80
W24x55	28.0	12.0	336.0	$62.00	$20,832.00	$2.94	$987.84
W24x62	28.0	48.0	1344.0	$70.00	$94,080.00	$2.94	$3,951.36
W24x76	28.0	36.0	1008.0	$94.50	$95,256.00	$3.03	$3,054.24
W24x103	47.5	12.0	570.0	$117.00	$66,690.00	$3.11	$1,772.70
Totals	289.0	606.0	18963.0	$570.50	$922,536.00	$27.22	$52,506.78

Floor 1-C

Beams	Length	Quantity	Total (LF)	Material Cost	Total Material Cost	Labor Cost	Total Labor Cost
W16x26	33.0	27.0	891.0	$29.50	$26,284.50	$2.26	$2,013.66
W18x35	36.0	4.0	144.0	$39.50	$5,688.00	$3.40	$489.60
W21x57	33.0	15.0	495.0	$56.50	$27,967.50	$3.07	$1,519.65
W21x57	36.0	3.0	108.0	$56.50	$6,102.00	$3.07	$331.56
Girders							
W18x40	19.5	9.0	175.5	$45.00	$7,897.50	$3.40	$596.70
W24x62	28.0	14.0	392.0	$70.00	$27,440.00	$2.94	$1,152.48
Totals	185.5	72.0	2205.5	$297.00	$101,379.50	$18.14	$6,103.65
Floor 2-4-C							
Beams	Length	Quantity	Total (LF)	Material Cost	Total Material Cost	Labor Cost	Total Labor Cost
W16x26	33.0	81.0	2673.0	$29.50	$78,853.50	$3.07	$8,206.11
W18x35	33.0	3.0	99.0	$39.50	$3,910.50	$3.40	$336.60
W18x35	36.0	15.0	540.0	$39.50	$21,330.00	$3.40	$1,836.00
W21x57	33.0	60.0	1980.0	$56.50	$111,870.00	$3.07	$6,078.60
W21x57	36.0	9.0	324.0	$56.50	$18,306.00	$3.07	$994.68
Girders							
W18x40	19.5	24.0	468.0	$45.00	$21,060.00	$3.40	$1,591.20
W24x62	28.0	45.0	1260.0	$70.00	$88,200.00	$2.94	$3,704.40
Totals	218.5	237.0	7344.0	$336.50	$343,530.00	$22.35	$22,747.59
Grand Totals	982.0	994.0	30988.5	$1774.50	$1,482,370.00	$94.93	$87981.31

Total System Costs	SOMD & Deck	Structural Steel	Grand Total System Costs
	$601,010.78	$1,570,351.31	$2,171,362.09

Conclusions / Recommendations:

I was happy to be able to get the expected schedule reduction, but I was not pleased to see at what expense this would come at. Even though the costs are increased slightly with the precast hollow core planks from what it is for the elevated slab on metal deck, I would still recommend using the precast hollow core planks because this is saving critical time that the hospital can be turned over to the owner. Since the project is already 32 months in length any schedule reduction would be a good plan.

Research Topic: Closing the Gap in Sustainable Design

Proposal / Goals:

Although I have been taught with the ideas of sustainable design throughout my experience here at Penn State, I don't believe that there has been that much of an acceptance in the construction industry for sustainable design to have an impact. I wanted to look at what are the reasons for the slow acceptance of sustainable design and suggest ways in order to reduce and hopefully eliminate the generation gap that plagues our industry.

Procedure:

The procedure that occurred for this part of my thesis was that I sent out a 10 question survey to various individuals around the country and tried to get feedback on their past experiences and see how they would like to see changes. I focused on all construction management firms that I found as the top 50 according ENR magazine. I contacted about 22 companies but I only received back about 8 replies and of the 8 half of them were to notify me that the company had not been involved with a sustainable design project and could not successfully answer my survey.

Although I was upset that not more companies were able to reply and the ones that I did I had originally thought I couldn't use, but I am now realizing that the ones who could not participate in the survey further goes to demonstrate the need for more education on building with sustainability in mind.

The ones that did reply with answers for me were very helpful. Some suggested having classes that would help teach the people who are unfamiliar with the LEED certification process or sustainable design in general so that they would be more comfortable in the future. One person did not think there was a "generation gap" per say and even went on to explain that if there was any sort of gap it would be that of the older generation having more knowledge because of the energy crisis of the 1970s. Maybe sustainable design is only becoming a larger part of this industry because of the media attention to "global warming", but as every one that replied agrees it is something that all ethical engineers need to strive for. Making good decisions when it comes to designing a building needs to take upmost care in how we impact our surroundings, LEED is just a set of guidelines to help us get there successfully.

Conclusions / Recommendations:

I will conclude by saying that I like the way things are going with our industry. I just would like more people to know about the benefits of green building design. I would like it to be easier for individuals to understand the risks involved and be able to accept the risks fully knowing that in the lifespan of their building they will see inevitable returns for the decisions they made during the construction process.

Final Thoughts

I would like to sum up this report by saying that I enjoyed the experience. However stressful this project has been, I think the advantages won't really sink in until a few days, months maybe years from now, but I am glad that I had the opportunity to complete such a daunting task for this type of experience only molds an individual into a better professional.

That being said I believe that with all of the results outlined within my thesis that I was able to accomplish what I set out trying to achieve. I like thinking outside of the box and being able to prove or at least illustrate how alternatives can be employed on a project to make it better is the best type of reward.

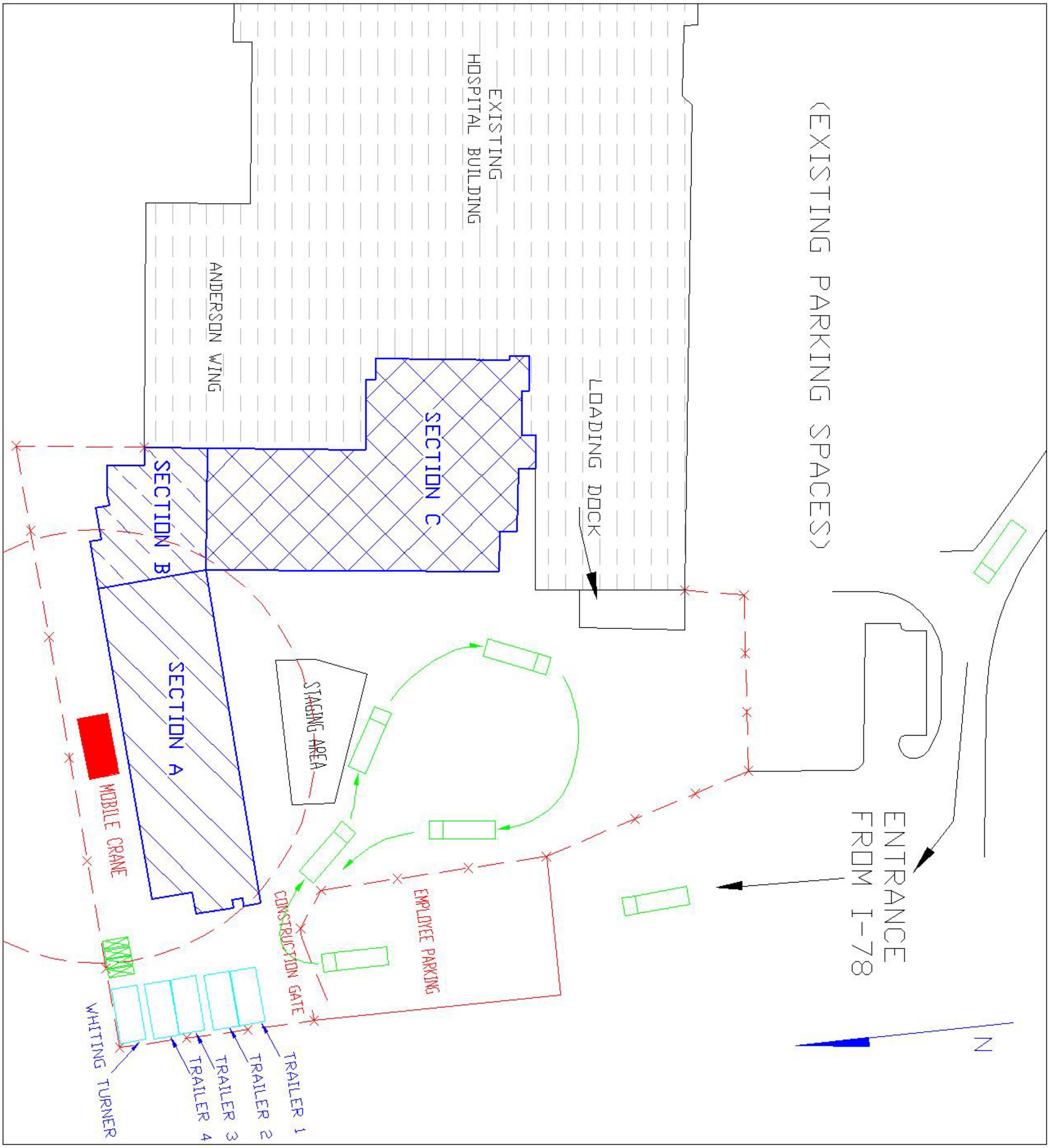
My favorite detail of this entire project was the rainwater harvesting system. Even though I know that the cost of adding such an intricate project to this already monstrous project will allow the hospital to have a even greater impact of giving back to the community, by leaving less of an impact on its environment.

Even though I was not completely successful in demonstrating the benefits of the precast hollow core planks, I think that I accomplished what I wanted out of it and that was a reduction in the schedule.

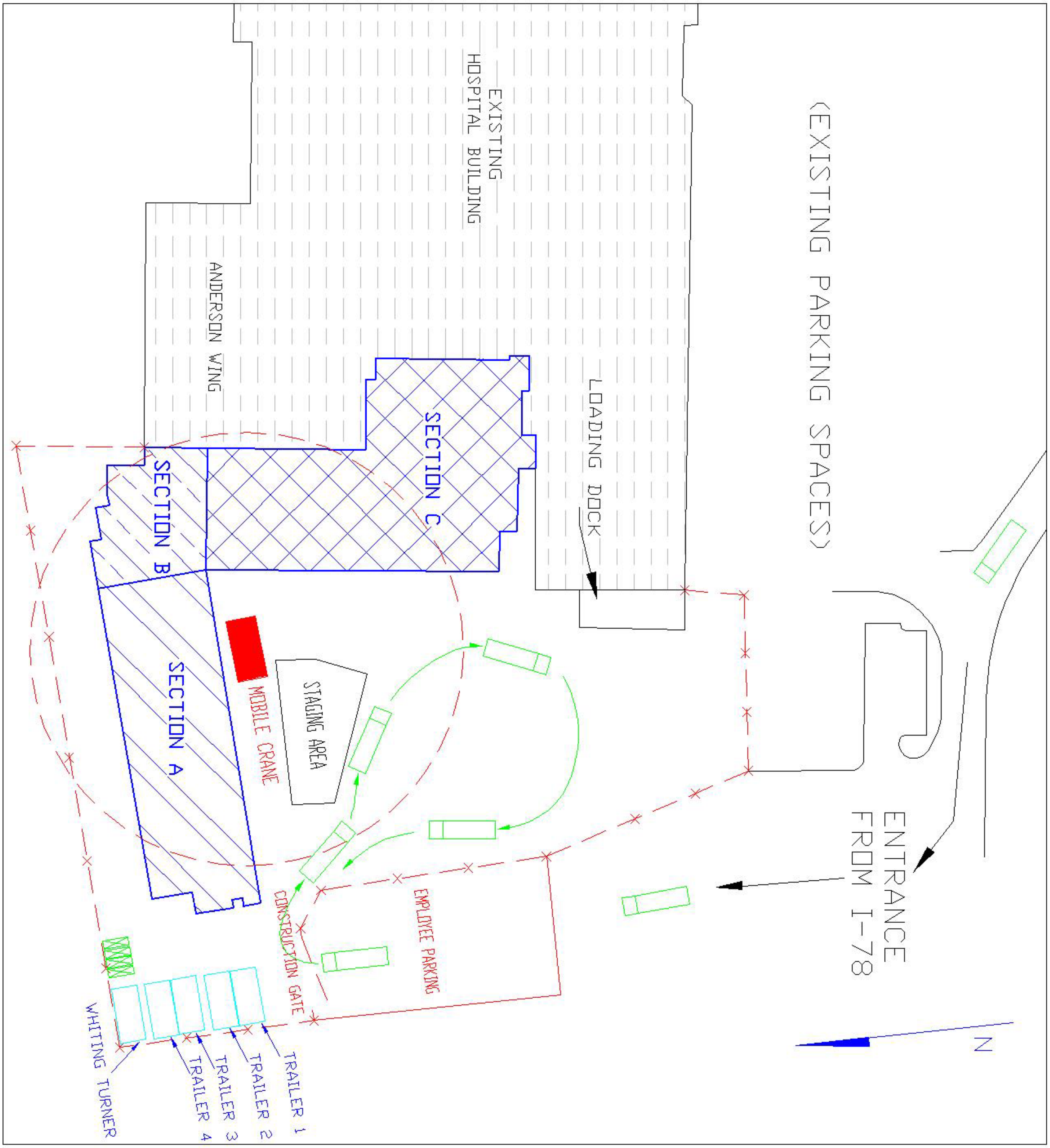
Credits & Acknowledgements

I would like to thank everyone who helped me in this process. I would especially like to thank Eden Evans from Whiting Turner for being my contact and getting all the information that I requested for my thesis. I also would like to thank Gary Smith from PBS&J for his extensive reply to my survey. Thanks also to all the Penn State Faculty for the knowledge that they bestowed upon me in order to get all of this completed.

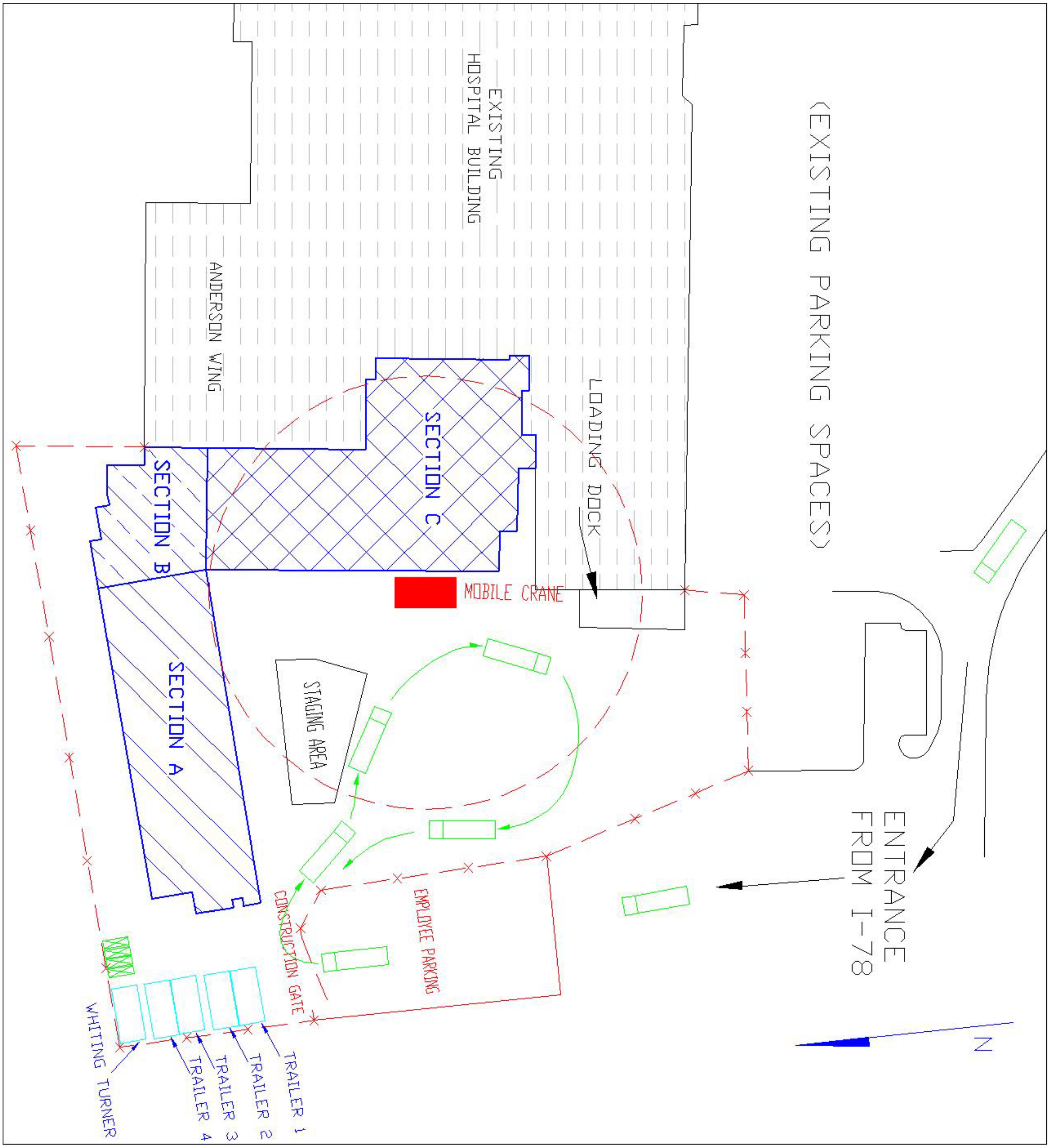
Appendix A



Site Plan with Crane Location – Phase A

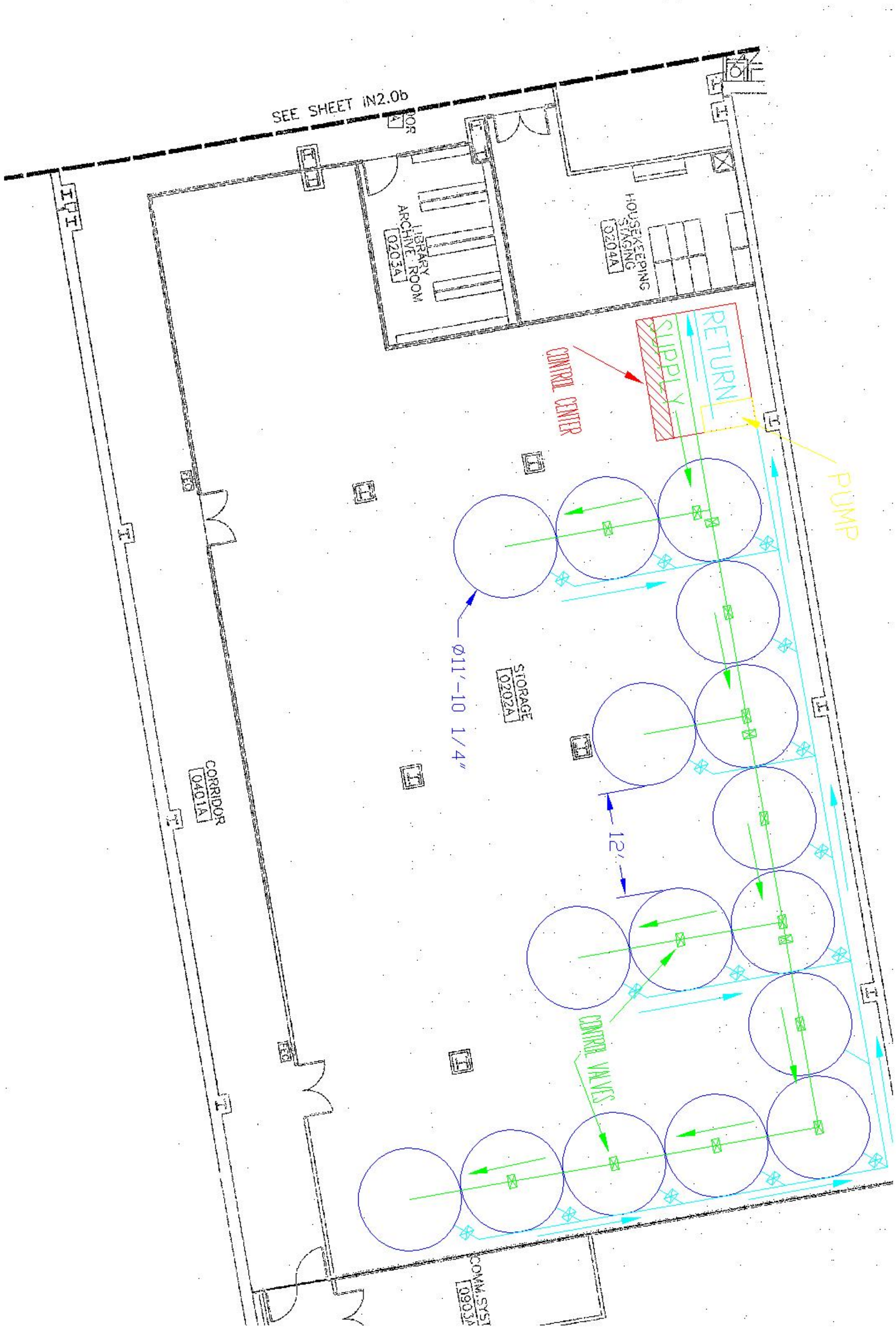


Site Plan with Crane Location – Phase B



Site Plan with Crane Location – Phase C

Appendix B


SEE SHEET IN2.0b
LIBRARY ARCHIVE ROOM 0203A
HOUSEKEEPING STAGING 0204A
RETURN
SUPPLY
CONTROL CENTER
PUMP
STORAGE 0202A
Ø11'-10 1/4"
12'
CORRIDOR 0401A
CONTROL VALVES
COMM.SYST 0903A