National Museum of the Marine Corps

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Construction Management

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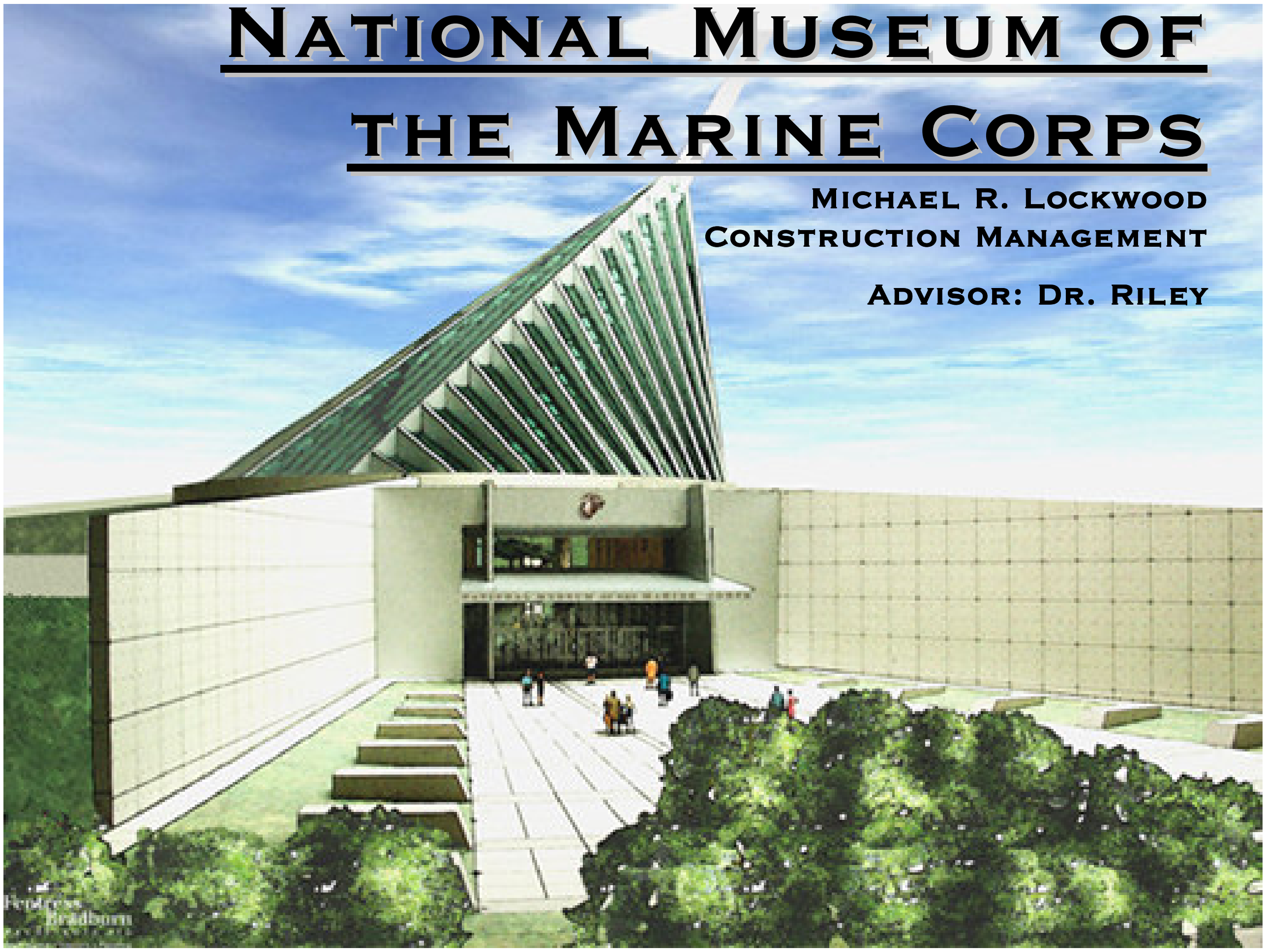

Technical Assignment III – Alternate systems and methods analysis

http://www.arche.psu.edu/thesis/2005/mrl185

Executive Summary

Technical Assignment #3 was an investigation into alternate systems and methods for analysis. The following are a list of topics addressed within this document: Site Layout Planning, Temporary Utilities, Detailed Structural System Estimate, General Conditions Estimate, and Research and Analysis Methods.

The site layout planning consists of three distinct site plans for three phases of construction for the National Museum of the Marine Corps project: excavation phase, steel erection phase, and finishes phase. The site layout of a construction project is very dynamic and adapts to different stages of a project. The site plans included in this document along with narratives illustrate the dynamic nature of a construction site plan.

Temporary utilities are essential aspects of all construction projects. Temporary utilities consist of a wide-range of items. Included in this document are the temporary utilities as required by the contract specifications along with the temporary utilities required for the structural erection phase of the project.

A detailed structural system estimate was done to provide a breakdown of the costs associated with the structural system of the building. The museum consists of two main structural components: steel and concrete. Excluded in the detailed structural estimate are foundations and the entire skylight system (including steel framing).

A general conditions estimate was developed in order to track the costs associated with managing the project and all the necessary temporary utilities and facilities required for the duration of the project. All of the costs associated with both the general conditions estimate and the structural system estimate came from the R.S. Means Costworks 2004 software.

Finally, a description of the research that will be conducted throughout the upcoming semester has been included. The main research will be on the role of the construction manager in the design process. The other two areas of research will be on a structural redesign of the inner ring wall / earth retainage methods and an in depth look into the steel erection sequencing and the implementation of 3D/4D technology to improve upon this process.

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Site Layout Planning

Excavation Phase

The site plan for the excavation phase of the project mainly consists of backfill and soil stockpiles. During the excavation phase, one main access road was built up to the building footprint. The future access road will be built and added to the site in later phases once the large excavation equipment has been removed from site. Also during excavation, the subcontractor trailers arrive on-site. There is a considerable amount of staging, storage and parking because the concrete subcontractor is beginning foundation work and delivering rebar and formwork.

Superstructure Phase

The site plan for the superstructure phase is far more complex than the excavation phase. The complete access road will be completed during this phase. The roads provide access to steel staging areas near the cranes on the site. There are two cranes required for the erection of the skylight structural steel. The crane located on the West side of the building will be used to erect the skylight mast while the other crane will be there to erect the necessary ridge and rib beams until the mast is supported adequately. The two cranes will then finish erecting the skylight steel. Once the skylight is erected, the large crane on the West side of the building will be removed from site. The remaining crane will erect the rest of the steel in the outer ring of the building from the location shown on the site plan. While the structure of the building is being erected, site work will begin on the North parking lot area, therefore, the subcontractor trailers will be required to move to the other side of the access road during this time. Due to the utilities on site, the trailers could not be located in this position originally, and will be required to move again. The location of the owner and general contractor's trailers will not be required to move throughout the duration of the project.

Finishes Phase

During the finishes phase of construction, the two cranes are no longer on site. There is building access via the main entrance and the loading dock as shown. Once again, the subcontractor trailers will be relocated back to the finished parking lot area with a reduced number of trailers since a few of the large subcontractors are no longer on site. While finishes are going on inside the building, the South side parking area will be completed. The backfill stockpile has also been removed as it was used during the backfill following the superstructure phase. The only stockpile remaining is the topsoil which will be used during the exterior landscaping towards to the end of the project.

Analysis of Contractor's Plans

The project is currently in the beginning of the structural phase (concrete only); therefore, a comparison to the superstructure and finishes site plans can not be conducted as the information has not become available. The excavation phase plan (as in place) is similar with the location of stockpiles and the access road. The main difference is the location of the subcontractor's trailers. The general contractor located the subcontractor trailers away from the access road and on top of the future utilities along the north fence. In the revised version of the site plan, I have located the subcontractor trailers along the access road and not interfering with the future utility lines through the area. Another difference is the location and orientation of the owner and general contractor's trailers. The general contractor chose to orient the trailers side by side near the main entrance with the parking adjacent to the access road and general contractor's trailer. In the revised plan, I chose to re-orient the trailers in an L-shape in order to provide the general contractors trailer with a better view of both the site, and the main entrance gate to monitor the traffic flow in and out of the site. This could not be done effectively based on the original orientation of the trailers.

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SITE PLAN: EXCAVATION & SITE PREPARATION PHASE

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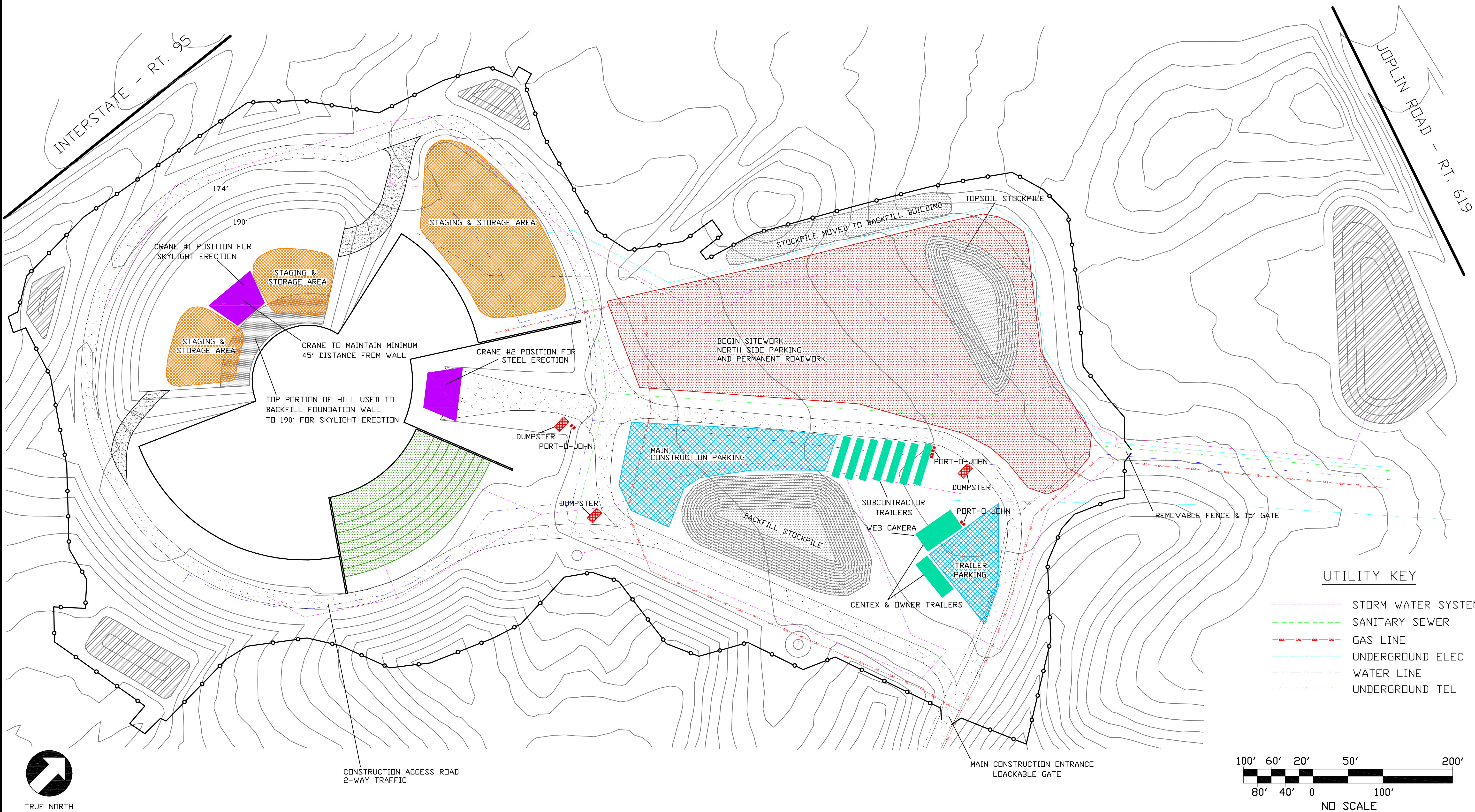

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SITE PLAN: STRUCTURAL STEEL ERECTION PHASE

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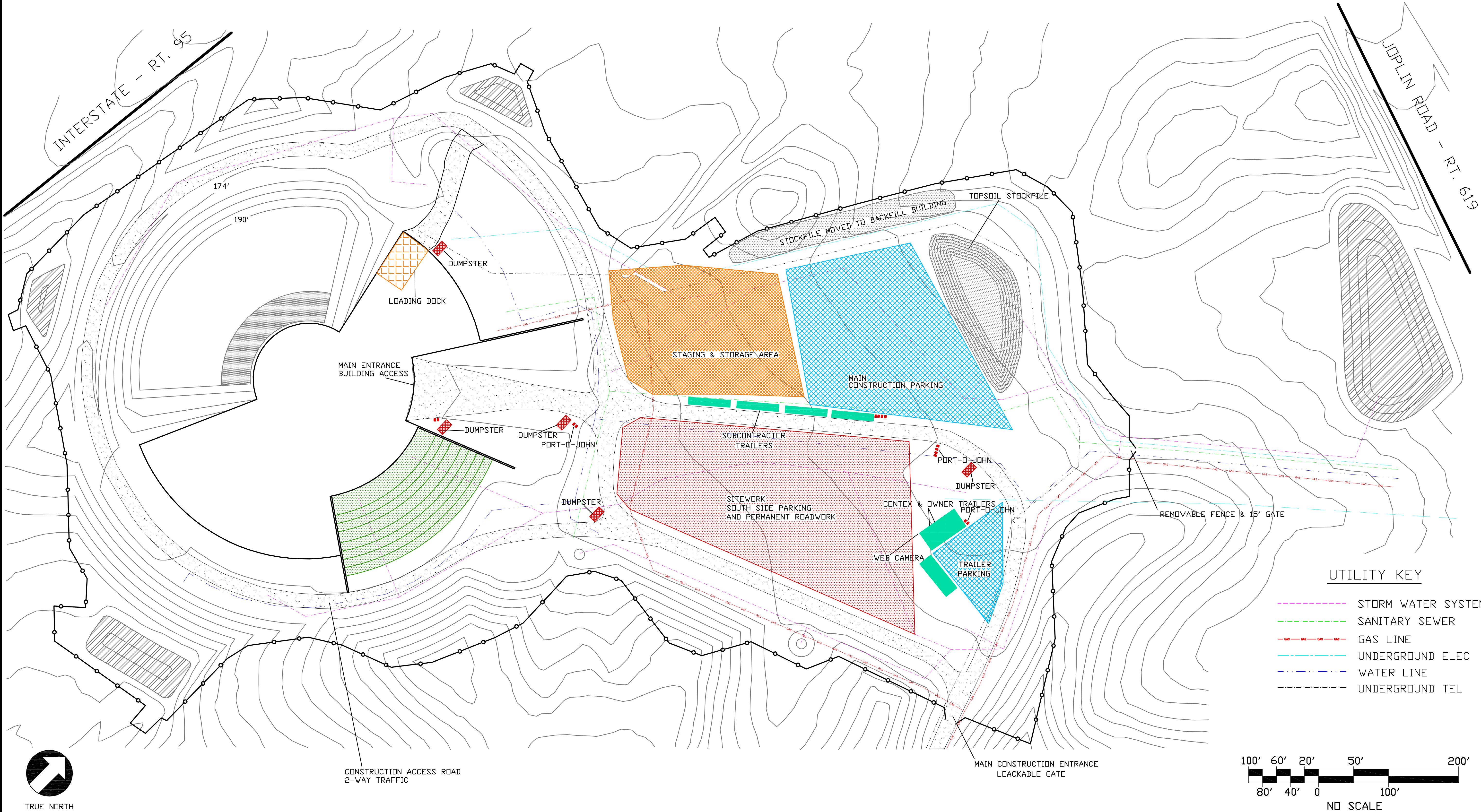

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SITE PLAN: FINISHES PHASE

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Temporary Utilities

Temporary Facilities for Superstructure Erection

Cast-in-Place Concrete

The use of cast-in-place concrete for the structure of a building requires the use of many temporary facilities. The installation of the cast-in-place concrete structural components begins in July 2004 and is complete in March 2005. Therefore, the cast-in-place activities take place during both extremes of the climate for the geographic region.

The list below represents the temporary facilities required for the cast-in-place concrete activities on this project:

- Temporary water supply
- Truck wash-out area
- Temporary electric
- Access road
- Heating (winter months)
- Cooling (summer months)
- Formwork storage area
- Rebar storage area

Concrete specifications require that concrete be allowed to cure within a certain temperature range. During the summer months, concrete contractors must utilize cooling methods to reduce the temperature of the concrete during curing and reduce the moisture loss. In many instances, the use of some form of wrap such as wet burlap will reduce both the temperature of the concrete as it cures and the access moisture loss of the concrete. During the winter months, the concrete contractor will be required to provide heating techniques to maintain the adequate temperature of the curing concrete. In most cases, the use of propane heaters within an enclosed space around the concrete element will accomplish this task.

Structural Steel

During the erection of the structural steel, certain temporary utilities/facilities will be required. The following is a list of the temporary utilities/facilities required:

- Steel staging area
- Crane swing radius
- Adequate soil for crane location

There are not many temporary utilities required for steel erection because the crane is self-sufficient and does not require any power connections.

Specified Temporary Facilities

The contract specifications clearly list a number of temporary facilities required by the general contractor. The following is a detailed list of the temporary facilities required per specifications section 01500.

Temporary Facilities for Owner

- Double Wide Trailer
    - Hot & Cold Water
    - Sewer
    - Electric
    - Phone
    - Internet
- Office Trailer Furniture
- Office Equipment

Temporary Facilities for Contractor

- Triple Wide Trailer
    - Hot & Cold Water
    - Sewer
    - Electric
    - Phone
    - Internet
- Office Trailer Furniture
- Office Equipment

Temporary Utilities

- *Electricity*:

    The owner will provide the installation and connection of the permanent electricity once the site conditions allow for it. Once the permanent power feed has been connected to a point on site, the contractor will be responsible for the electric costs during the construction phase of the project.
- *Potable Water and Sanitary Sewer*:

The owner will prove the potable water and sanitary sewer for the project once the site is prepared to accept these services. At that time the contractor may take use of these services and will bear the costs associated with them throughout the duration of construction.

- *Natural Gas*:

  The owner will provide the installation of the natural gas lines up to 5 feet outside the building perimeter. The contractor will be required to coordinate the installation effort and make the connection to the building.

Weather Protection

- Contractor is required to take necessary precautions to ensure roof openings and other openings are monitored carefully. Preventative action is required to protect building and materials against inclement weather.

Building and Site Storm Protection

- When gale force winds are forecasted, the contractor is required to take necessary precautions to ensure safety of persons and protection of work and nearby Government property. The following are some, but not all, of the precautions:
  - closing openings
  - removing loose materials
  - removing tools and equipment from exposed locations
  - removing or securing temporary work or equipment

Temporary Sanitary Facilities

- The contractor is required to provide adequate temporary sanitary facilities to accommodate all of the workers on the site at all times during construction per code.

Detailed Systems Estimate

The following pages provide a detailed estimate of the structural system for the National Museum of the Marine Corps. A list of assumptions and exclusions is provided to better illustrate the content of the estimate. The concrete estimate includes all cast-in-place walls, slab-on-grade, and slab-on metal deck along with the reinforcing. The steel estimate includes steel beams, columns, and metal decking. The massive skylight system was not included in this structural take-off.

Assumptions

- 5 % waste factor included in concrete take-off
- 10 % included for steel connections

Exclusions

- Steel skylight system
- Foundations
- Overhead and Profit

Detailed Structural Estimate Summary Table

Cost Summary of Structural System Take-Off		
Division		**Total Cost**
1	General Conditions	$0
2	Site Work	$0
3	Concrete	$1,464,973
4	Masonry	$0
5	Metals	$736,478
6	Woods and Plastics	$0
7	Thermal and Moisture Protection	$0
8	Doors and Windows	$0
9	Finishes	$0
10	Specialties	$0
11	Equipment	$0
12	Furnishings	$0
13	Special Construction	$0
14	Conveying Systems	$0
15	Mechanical	$0
16	Electrical	$0
	Total Structural Cost	**$2,201,451**

CostWorks 2004 - National Museum of the Marine Corps **_Structural Concrete Estimate_**

Qty	CSI Number	Description	Unit	Bare Mat.	Bare Labor	Bare Equip.	Total	Total Incl. O&P
3,690.000	03310 220 0300	Structural concrete, ready mix, normal weight, 4000 PSI, includes material only	C.Y.	274,905.00	0.00	0.00	274,905.00	302,580.00
4,547.000	03310 220 0400	Structural concrete, ready mix, normal weight, 5000 psi, includes material only	C.Y.	359,213.00	0.00	0.00	359,213.00	395,589.00
1,642.000	03310 700 4650	Structural concrete, placing, slab on grade, pumped, over 6" thick, excludes material	C.Y.	0.00	12,643.40	6,912.82	19,556.22	27,093.00
4,547.000	03310 700 5350	Structural concrete, placing, walls/columns, pumped, 15" thick, excludes material	C.Y.	0.00	54,109.30	29,555.50	83,664.80	115,948.50
1,480.000	03310 700 1400	Structural concrete, placing, elevated slab, pumped, less than 6" thick, excludes material	C.Y.	0.00	15,022.00	8,214.00	23,236.00	31,820.00
157,230.000	03350 300 0250	Concrete finishing, floors, monolithic, machine trowel finish	S.F.	0.00	58,175.10	0.00	58,175.10	84,904.20
119.000	03210 600 0250	Reinforcing steel, in place, columns, #8 to #18, A615, grade 60	Ton	55,335.00	51,170.00	0.00	106,505.00	145,775.00
134.000	03210 600 0700	Reinforcing steel, in place, walls, #3 to #7, A615, grade 60	Ton	60,970.00	44,220.00	0.00	105,190.00	140,700.00
150.000	03210 600 0750	Reinforcing steel, in place, walls, #8 to #18, A615, grade 60	Ton	68,250.00	37,200.00	0.00	105,450.00	136,500.00
1,246.000	03220 200 0300	Welded wire fabric, sheets, 6 x 6 - W2.9 x W2.9 (6 x 6) 42 lb. per C.S.F., A185	C.S.F.	13,083.00	21,368.90	0.00	34,451.90	49,840.00
44,958.000	03110 455 2850	C.I.P. concrete forms, wall, job built, plywood, exterior, over 16' high, 4 use, includes erecting,	SFCA	25,626.06	156,903.42	0.00	182,529.48	271,995.90
33,600.000	03110 455 3000	C.I.P. concrete forms, wall, job built, plywood, for architectural finish, add, includes erecting,	SFCA	21,168.00	21,168.00	0.00	42,336.00	56,448.00
		Waste Factor (5%)					69,760.63	87,959.68
		Totals		**$878,550.06**	**$471,980.12**	**$44,682.32**	**$1,464,973.13**	**$1,847,153.28**

CostWorks 2004 - National Museum of the Marine Corps *Structural Steel Estimate*

Qty	CSI Number	Description	Unit	Bare Mat.	Bare Labor	Bare Equip.	Total	Total Incl. O&P
1,347.000	05120 640 1300	Structural steel member, 100-ton project, 1 to 2 story building, W12x16, A36 steel, shop	L.F.	17,847.75	2,976.87	2,195.61	23,020.23	26,940.00
2,456.000	05120 640 4100	Structural steel member, 100-ton project, 1 to 2 story building, W21x44, A36 steel, shop	L.F.	65,084.00	6,508.40	3,462.96	75,055.36	85,960.00
336.000	05120 640 3300	Structural steel member, 100-ton project, 1 to 2 story building, W18x35, A36 steel, shop	L.F.	7,056.00	984.48	527.52	8,568.00	10,080.00
224.000	05120 640 6100	Structural steel member, 100-ton project, 1 to 2 story building, W30x99, A36 steel, shop	L.F.	13,328.00	524.16	280.00	14,132.16	15,904.00
199.000	05120 640 5700	Structural steel member, 100-ton project, 1 to 2 story building, W24x84, A36 steel, shop	L.F.	10,049.50	521.38	276.61	10,847.49	12,238.50
20.000	05120 640 4300	Structural steel member, 100-ton project, 1 to 2 story building, W21x50, A36 steel, shop	L.F.	600.00	53.00	28.20	681.20	780.00
20.000	05120 640 4500	Structural steel member, 100-ton project, 1 to 2 story building, W21x57, A36 steel, shop	L.F.	750.00	54.40	29.00	833.40	950.00
776.000	05120 640 4900	Structural steel member, 100-ton project, 1 to 2 story building, W24x55, A36 steel, shop	L.F.	25,608.00	1,971.04	1,047.60	28,626.64	32,980.00
54.000	05120 640 3500	Structural steel member, 100-ton project, 1 to 2 story building, W18x40, A36 steel, shop	L.F.	1,296.00	158.22	84.78	1,539.00	1,809.00
50.000	05120 640 1900	Structural steel member, 100-ton project, 1 to 2 story building, W14x22, A36 steel, shop	L.F.	782.50	98.00	72.00	952.50	1,100.00
58.000	05120 640 4700	Structural steel member, 100-ton project, 1 to 2 story building, W24x68, A36 steel, shop	L.F.	2,349.00	157.76	84.10	2,590.86	2,987.00
1,212.000	05120 640 5800	Structural steel member, 100-ton project, 1 to 2 story building, W27x84, A36 steel, shop	L.F.	61,206.00	2,872.44	1,527.12	65,605.56	73,932.00
36.000	05120 640 6500	Structural steel member, 100-ton project, 1 to 2 story building, W30x116, A36 steel, shop	L.F.	2,520.00	87.48	46.80	2,654.28	2,952.00
1,032.000	05120 640 6560	Structural steel member, 100-ton project, 1 to 2 story building, W30x173, A36 steel, shop	L.F.	107,328.00	2,600.64	1,382.88	111,311.52	123,840.00
496.000	05120 640 5900	Structural steel member, 100-ton project, 1 to 2 story building, W27x94, A36 steel, shop	L.F.	28,024.00	1,175.52	624.96	29,824.48	33,480.00
132.000	05120 640 5920	Structural steel member, 100-ton project, 1 to 2 story building, W27x114, A36 steel, shop	L.F.	9,042.00	323.40	172.92	9,538.32	10,692.00
72.000	05120 640 5100	Structural steel member, 100-ton project, 1 to 2 story building, W24x62, A36 steel, shop	L.F.	2,700.00	182.88	97.20	2,980.08	3,384.00
64.000	05120 640 5740	Structural steel member, 100-ton project, 1 to 2 story building, W24x104, A36 steel, shop	L.F.	4,000.00	171.52	91.52	4,263.04	4,800.00
1,008.000	05120 640 1700	Structural steel member, 100-ton project, 1 to 2 story building, W12x72, A36 steel, shop	L.F.	43,848.00	3,064.32	2,247.84	49,160.16	55,440.00
120.000	05120 640 1560	Structural steel member, 100-ton project, 1 to 2 story building, W12x50, A36 steel, shop	L.F.	3,600.00	312.00	229.20	4,141.20	4,740.00
36,000.000	05310 300 1000	Metal decking, steel, cellular units, galvanized, over 15 Sq, 4-1/2" D, 20-18 ga	S.F.	181,800.00	38,880.00	2,520.00	223,200.00	271,800.00
		Connections (10%)					66,952.55	77,678.85
		Totals		**$588,818.75**	**$63,677.91**	**$17,028.82**	**$736,478.03**	**$854,467.35**

General Conditions Estimate

The table on the following page is a general conditions estimate for the National Museum of the Marine Corps project. All of the information within the general conditions estimate was developed solely by Michael Lockwood and cost information was obtain from Costworks 2004. The general conditions estimate provides the estimated costs for project staff, temporary utilities, and temporary facilities. The overall general conditions cost estimate was $ 1,059,073.32 without overhead and profit. The cost including the overhead and profit provided by Costworks 2004 was $1,572,423.80.

Note: The cost information provided in the general conditions estimate is solely developed by Michael Lockwood with the use of Costworks 2004 data.

CostWorks 2004 - National Museum of the Marine Corps

Qty	CSI Number	Description	Unit	Bare Mat.	Bare Labor	Bare Equip.	Total	Total Incl. O&P
1,200.00	01510 800 0350	Temporary Power, lighting, incl. service lamps, wiring and outlets, min	CSF Flr	$2,484.00	$9,300.00	$0.00	$11,784.00	$16,680.00
5.00	01520 500 0550	Office Trailer, furnished, rent per month, 50' x 12', excl. hookups	Ea.	$1,405.00	$0.00	$0.00	$1,405.00	$1,550.00
24.00	01520 550 0120	Field Office Expense, office supplies, average	Month	$1,968.00	$0.00	$0.00	$1,968.00	$2,172.00
24.00	01520 550 0140	Field Office Expense, telephone bill; avg. bill/month, incl. long dist.	Month	$4,800.00	$0.00	$0.00	$4,800.00	$5,280.00
24.00	01520 550 0160	Field Office Expense, field office lights & HVAC	Month	$2,220.00	$0.00	$0.00	$2,220.00	$2,424.00
2.00	01540 790 0100	Surveyor Stakes, hardwood, 2" x 2" x 18" long	C	$119.00	$0.00	$0.00	$119.00	$131.00
2,328.00	01550 700 0100	Temporary, roads, gravel fill, 8" gravel depth, excl surfacing	S.Y.	$14,084.40	$4,190.40	$791.52	$19,066.32	$22,930.80
30.00	01590 400 2200	Rent electric generator gas engine 1.5 KW	Day	$0.00	$0.00	$960.00	$960.00	$1,056.00
1,200.00	01740 500 0100	Cleaning Up, cleanup of floor area, final by GC at end of job	M.S.F.	$3,120.00	$40,800.00	$3,216.00	$47,136.00	$70,800.00
1,200.00	01510 800 0600	Temporary Utilities, power for job duration, incl. elevator, etc, min	CSF Flr	$0.00	$0.00	$0.00	$51,600.00	$56,400.00
15,000.00	01540 800 0300	Tarpaulins, reinforced polyethylene, white, clear or black, 4 mils thick	S.F.	$2,100.00	$0.00	$0.00	$2,100.00	$2,250.00
Project Staff								
76.00	01310 700 0120	Field engineer, average	Week	$0.00	$61,180.00	$0.00	$61,180.00	$95,000.00
95.00	01310 700 0121	Office engineer, average	Week	$0.00	$76,475.00	$0.00	$76,475.00	$118,750.00
90.00	01310 700 0160	Field Personnel, general purpose laborer, average	Week	$0.00	$77,400.00	$0.00	$77,400.00	$121,500.00
90.00	01310 700 0160	Field Personnel, safety carpenter, average	Week	$0.00	$77,400.00	$0.00	$77,400.00	$121,500.00
104.00	01310 700 0200	Field Personnel, project manager, average	Week	$0.00	$137,800.00	$0.00	$137,800.00	$213,200.00
104.00	01310 700 0260	Field Personnel, superintendent, average	Week	$0.00	$127,400.00	$0.00	$127,400.00	$197,600.00
76.00	01310 700 0260	Field Personnel, chief field engineer, average	Week	$0.00	$76,380.00	$0.00	$76,380.00	$129,200.00
104.00	01310 700 0200	Field Personnel, qc manager, average	Week	$0.00	$117,000.00	$0.00	$117,000.00	$171,600.00
90.00	01310 700 0200	Field Personnel, assistant qc manager, average	Week	$0.00	$90,000.00	$0.00	$90,000.00	$108,000.00
104.00	01310 700 0290	Field Personnel, office manager, average	Week	$0.00	$74,880.00	$0.00	$74,880.00	$114,400.00
		Totals		**$32,300.40**	**$970,205.40**	**$4,967.52**	**$1,059,073.32**	**$1,572,423.80**

Research and Analysis Methods

Depth Research

In typical project delivery approaches, the contractor is not brought on board until the design is nearly complete. Contractors have been trying to make the design process a more integrated approach and include the contractor in design to address constructability concerns with designs.

Problem:

- Contractors do not know how to portray that they provide value to the owner with early involvement in design and therefore, have difficulty converting owners to an integrated design approach.

Goals:

- To determine the value contractors can add to the design process that would be beneficial to the owner
- To develop a way in which contractors and owners can measure the value of a contractor in design

Audience:

- Architects, Contractors, and Owners because results will potentially benefit and/or affect all of them.

Objectives:

1. Determine the positive and negatives of contractor involvement early in the design process based on case study projects.
2. Establish criteria to measure the value added in the design process by a contractor.
3. Develop a set of tools to measure the value added by a contractor during early design involvement.

4. Develop value adding traits of a contractor to the design process.

Research Methods:

1. Interviews / Surveys to architects, owners, and contractors.
2. Compare results from interviews/surveys and conduct a literature review of similar studies about integrated design.
3. Criteria will be based on the results from 1 and 2 above.
4. Based on the results from the other three methods of research.

Outside Information Sources:

- Bob Grottenthaler, Barton Malow
- Others at Barton Malow
- Chris Magent, Graduate Student – Penn State University
- Other to be determined

Building System Analysis #1

The first analysis to be conducted on my building will be looking into an alternate earth retainage system around the C1 Wall area. The current design requires earth to be backfilled approximately 30' up the C1 cast-in-place concrete wall. The horizontal loads associated with this amount of backfill requires the concrete wall to be 2' thick with #11 reinforcement bars vertically at 6" on center and #5 reinforcement bars running horizontally. Also located in the backfilled area is a run of buried exterior ductwork. This unique element creates a constructability issue of backfilling without damaging the ductwork.

For this analysis, I plan to research alternative methods for retaining the earth around this area while still maintaining the architects design intent. The outcome of this should result in a method that does not require the wall to carry the load of the earth, thus allowing for a smaller wall and decrease footing capacity, which will lead to a potential cost savings.

Building System Analysis #2

At this time, a second area of analysis has not been clearly defined. However, a more in depth investigation in the structural steel skylight system appears to be the likely choice. The unique skylight system features a challenging component to this building. The sequence of erection of all the members associated with the skylight system will be very challenging and the use of 3D/4D modeling could potentially assist in determining the best erection sequence for the steel. Therefore, analysis #2 will look into the steel erection sequence of the skylight and implementation of 3D/4D technologies to improve upon this process.

Draft of Interview Questions

Architect

1. Have you ever been involved in an integrated design project in which a CM was involved early in the design process?
2. What were some of the benefits of having the CM involved during design?
3. What information did the CM bring to design that could be beneficial on other projects?
4. Where were some of the negatives of having a CM on board in design?
5. If any negatives, why do you feel those were negatives to the design process?
6. Would you recommend the early involvement of a CM in design to other owners?
7. Do you feel that the integrated design approach creates a team approach to a construction project?
8. If the opportunity to work on another integrated design project came up, would you chose to do it? If so, why? Why not?

Contractor

1. Have you ever been involved early in the design phases of a project?
2. What were some of the positive things you brought to the table during the design?
3. What were some specific ways in which you may have benefited the owner and the project as a whole during design?
4. What were some of the negatives of being involved early in the project?
5. In comparison to other projects you have completed, how did the integrated design approach affect the overall project (i.e. cost, changes, schedule, quality, etc)?
6. Would you recommend this approach to an owner?
7. What value do you feel you bring to the design process that could benefit the owner and the project as a whole?
8. Do you feel the integrated design approach creates a team-like atmosphere?

Owner

1. Have you used an integrated design approach with early CM involvement for a project?
    a. If so, why did you choose this approach?
        i. And what value and/or benefits did you feel this approach brought to you as an owner?
        ii. Would you recommend this approach to other owners for use on their projects?
        iii. Were there any negatives that the CM brought to the project that may not have existed in the regular design approach?
    b. If not, have you considered involving a CM early in the design process?
        i. If so, why did you elect not to use this approach?
        ii. If not, if shown the benefit of a CM on board during design, would you be convinced to use this approach?
        iii. Do you feel that a CM could provide value to you as an owner? Why or why not?