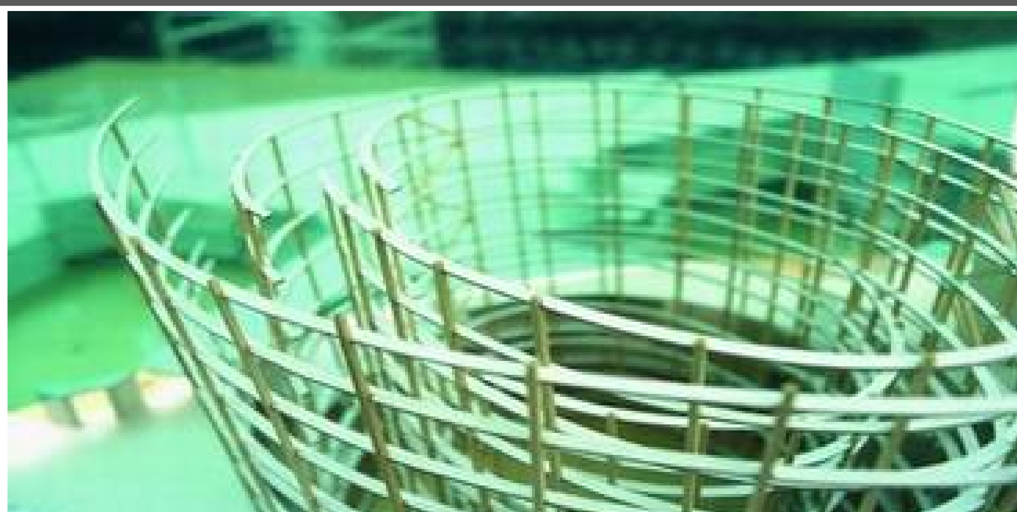
Technical Assignment 2

[Arena Stage]

Washington, DC



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Construction Management
Dr. John I. Messner
Friday, October 24, 2008

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Executive Summary

This Technical Assignment examines several different components of the construction process as they are applicable to the renovation and expansion of Arena Stage in Washington, D.C. Within this report are an in depth project schedule, site layout plans for multiple phases of the project, a detailed estimate of the curtain wall system, and a comprehensive estimate for the project's general conditions. At the end of this document is also an overview of the 2008 PACE Roundtable which took place on Wednesday, October 16th at the Penn Stater Conference Center Hotel.

The project schedule performed for this assignment is very detailed and focuses on major construction activities including mobilization/demolition and excavation, concrete structure, structural steel, the building envelope, and interiors. Also, the sequencing of the project is accurately depicted by breaking the building into identifiable zones and elevations. With 14 milestones and 233 activities, the schedule provides an accurate representation of the progression of the project from its start on January 8, 2008 to its completion in June 2010.

Arena Stage is nestled in a small, triangular-shaped block of downtown Washington, D.C. located directly south of the National Mall. Its awkward shape and the occupancy of the two exiting theatres make site logistics very important for the successful completion and safe management of the project. Different site layout designs were prepared for three critical phases of the project: demolition/excavation, superstructure, and finishing. Pictures from the Clark Construction WebCam accompany the first two site plans to represent the actual flow of work around the site during construction.

A curtain wall estimate was performed in order to determine the square foot costs of the custom system. With the help of two subcontractors working on the design of the Arena Stage curtain wall, a ballpark estimate was achieved for both the glazing and the wooden structural system. With a total cost of $3,924,264 and $143.15 per square foot of glazing, the curtain wall accounts for a little over 3% of the total project cost.

Through the use of a standard list of Clark general conditions line items and R.S. Means Building Construction Cost Data 2008, a GC estimate of $9,987,652 was determined. This value is approximately 8% of the total contract value which is reasonable considering the nature of the project.

In the last section of this assignment there is a summary of the 2008 PACE Roundtable and a discussion of what I learned during the different event sessions. Specifically, the prospect of an Architectural Engineering mentorship program, the Energy and Economy break-out session, new professional contacts, and the benefits of PACE are all addressed.

A. Detailed Project Schedule

In order to create a schedule for Arena Stage, it was necessary to first designate the major activities of the project. These activities included Mobilization/Demolition/Excavation, Concrete Structure, Structural Steel, Building Envelope, and Interiors. The next challenge was to properly depict the "zones" of the building. This was done by indicating one of the 3 theatres or the Back of House area where the parking garage, administrative offices, shop rooms, and public amenity rooms are located. Lastly, the zones were broken out into their respective elevations. Elevations were used since each of the theatres is a different shape and structure, and therefore cannot be defined by "floors."

The Detailed Project Schedule for Arena Stage, which can be found on pages 5 through 11 of this technical report, is 313 line items. Since 66 of these line items are headings that indicate the zone and/or elevation of the building, the schedule only actually consists of 247 activities.

Table 1: Arena Stage Project Schedule Summary

Project Schedule Summary		
ACTIVITY	START	FINISH
Notice to Proceed	01/08/2008	01/08/2008
Mobilization/Demolition/Excavation	01/08/2008	05/20/2008
Concrete Structure	03/24/2008	03/11/2009
Structural Steel	09/26/2008	07/17/2009
Building Envelope	10/13/2008	11/09/2009
Interiors	05/09/2008	06/17/2010
Substantial Completion	06/21/2010	06/21/2010

Table 1 is a summary of the project schedule showing each of the major activities mentioned above. Starting with the Notice to Proceed on January 8, 2008, the schedule begins with the Mobilization/Demolition/Excavation phase. This portion of the project consisted of underpinning, sheeting and shoring, asbestos abatement, major and selective demolition, and site excavation. Although the site excavation ends on April 17, 2008, the selective demolition of the Fichandler and the Kreeger continues on through May 20, 2008.

Next, the activities turn to the Concrete Structure phase. The 2 tower cranes are erect on March 24, 2008 and concrete operations begin on the same day at the Back of House (BOH) parking deck. It then moves clockwise around the site going from the Cradle to the Fichandler to the Kreeger. With the Cradle being the most extensive portion of the concrete work, its completion on March 11, 2009 denotes the end of the concrete operations.

On September 26, 2008, six months after the start of the concrete work, the structural steel makes its way into the schedule. This phase of the work is broken into two categories: Framing Members/Overhang/Decking and High Roof. The first phase contains the structural steel and metal deck of the Fichandler mechanical mezzanine, Kreeger roof, BOH low roof, and the Cradle roof. After the completion of the first phase on March 18, 2009, it is important to note that the tower cranes are removed. From this point on in the schedule, a mobile crane will be used to perform steel work and other heavy lifts. The High Roof phase consists mostly of the trusses for the cantilever and the PSL timber columns that support the curtain wall. This portion of the work is not complete until July 17, 2009.

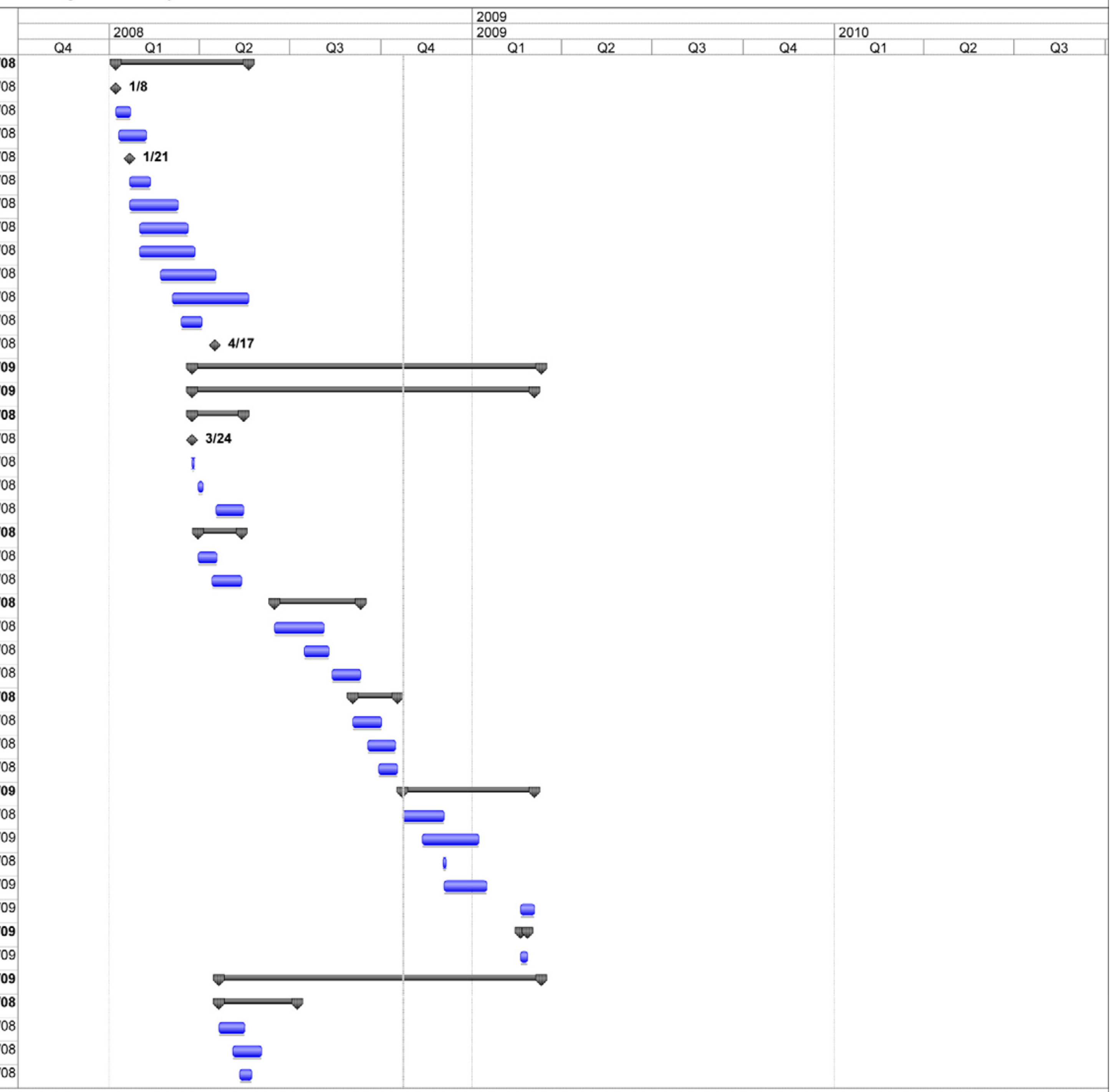
Once the PSL timber columns are in place, Arena Stage is ready for the installation of the Building Envelope. While the BOH is a stucco finish, the glass façade is the more notable portion of this installation. Starting on May 19, 2009, 19 sequences of the support and framing are put into place, which are quickly followed by the 19 respective glazing sequences. Finishing with the theatre entrance and the exterior doors, the building achieves watertight status on November 3, 2009.

The Interiors phase began on May 9, 2008 which is uncharacteristically early seeing as it is prior to the building being watertight. This is due to the fact that the existing Fichandler and Kreeger theatres have the opportunity to undergo some interior work during the erection of the steel and building envelope. However, interior finishes are not scheduled to being until *after* Arena Stage is watertight. During this phase, all interior operations occur from the MEP rough-in and wiring to the dry wall installation and final finishes. Lasting 549 days, this is the longest portion of the schedule.

Occurring simultaneously with the interiors are the site work and the final testing, inspections, and commissioning. The interior of the building is scheduled to finish on June 17, 2010 and Arena Stage is expected to reach substantial completion on June 21, 2010.

Arena Stage - Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
1	**Mobilization / Demolition / Excavation**	**96 days?**	**Tue 1/8/08**	**Tue 5/20/08**
2	Notice to Proceed	0 days	Tue 1/8/08	Tue 1/8/08
3	Mobilize Site	11 days?	Tue 1/8/08	Tue 1/22/08
4	Asbestos Abatement - Razed Area	20 days?	Fri 1/11/08	Thu 2/7/08
5	Cut and Abandon Permanent Power	0 days	Mon 1/21/08	Mon 1/21/08
6	Detach Theatres / Fichandler Demo	15 days?	Tue 1/22/08	Mon 2/11/08
7	Underpinning Pits	35 days?	Tue 1/22/08	Mon 3/10/08
8	Kreeger Demo	35 days?	Fri 2/1/08	Thu 3/20/08
9	Sheeting and Shoring	40 days?	Fri 2/1/08	Thu 3/27/08
10	Excavation	40 days?	Fri 2/22/08	Thu 4/17/08
11	Fichandler Selective Demo	55 days?	Wed 3/5/08	Tue 5/20/08
12	Bearing Piles	15 days?	Fri 3/14/08	Thu 4/3/08
13	Excavation Complete	0 days	Thu 4/17/08	Thu 4/17/08
14	**Concrete Structure**	**252 days?**	**Mon 3/24/08**	**Wed 3/11/09**
15	**Back of House**	**247 days?**	**Mon 3/24/08**	**Wed 3/4/09**
16	**Level B - Low Basement**	**38 days?**	**Mon 3/24/08**	**Thu 5/15/08**
17	Erect Tower Cranes	0 days	Mon 3/24/08	Mon 3/24/08
18	Install Sump Pit	2 days?	Tue 3/25/08	Wed 3/26/08
19	Footings / Columns	5 days?	Mon 3/31/08	Fri 4/4/08
20	MEP Underground / Walls / SOG	20 days?	Fri 4/18/08	Thu 5/15/08
21	**Level 1 - Basement**	**32 days?**	**Mon 3/31/08**	**Tue 5/13/08**
22	Footings / Columns	15 days?	Mon 3/31/08	Fri 4/18/08
23	MEP Underground / Walls / SOG	22 days?	Mon 4/14/08	Tue 5/13/08
24	**Level 2 - Elevation 19.00**	**63 days?**	**Mon 6/16/08**	**Wed 9/10/08**
25	Form / Pour / Cure Concrete Deck	36 days?	Mon 6/16/08	Mon 8/4/08
26	Strip / Reshore Deck	18 days?	Wed 7/16/08	Sat 8/9/08
27	Walls / Columns	21 days?	Wed 8/13/08	Wed 9/10/08
28	**Level 3 - Elevation 27.50**	**33 days?**	**Wed 9/3/08**	**Fri 10/17/08**
29	Form / Pour / Cure Concrete Deck	21 days?	Wed 9/3/08	Wed 10/1/08
30	Walls / Columns	20 days?	Thu 9/18/08	Wed 10/15/08
31	Strip / Reshore Deck	15 days?	Mon 9/29/08	Fri 10/17/08
32	**Level 4 - Elevation 37.50 / 43.00**	**95 days?**	**Thu 10/23/08**	**Wed 3/4/09**
33	Form / Pour / Cure / Strip / Reshore Concrete Deck	30 days?	Thu 10/23/08	Wed 12/3/08
34	Great Wall / Elevator Shaft Walls	41 days?	Wed 11/12/08	Wed 1/7/09
35	Form / Pour Mechanical Room Deck	3 days?	Wed 12/3/08	Fri 12/5/08
36	Remove Reshores	31 days?	Thu 12/4/08	Thu 1/15/09
37	Rehearsal Hall Isolation Floor	10 days?	Thu 2/19/09	Wed 3/4/09
38	**Elevation 59.00**	**5 days?**	**Thu 2/19/09**	**Wed 2/25/09**
39	Form / Pour Metal Roof Deck	5 days?	Thu 2/19/09	Wed 2/25/09
40	**Cradle Stage**	**233 days?**	**Mon 4/21/08**	**Wed 3/11/09**
41	**Level 1 - Basement**	**57 days?**	**Mon 4/21/08**	**Tue 7/8/08**
42	Footings / Pile Caps / Columns	20 days?	Mon 4/21/08	Fri 5/16/08
43	MEP Underground	21 days?	Mon 5/5/08	Mon 6/2/08
44	Low Walls to 6.50	10 days?	Mon 5/12/08	Fri 5/23/08



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Task		Progress		Summary		External Tasks		Deadline
Split		Milestone	◆	Project Summary		External Milestone	◆	

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Arena Stage - Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
45	SOG / Inner Walls to 19.00	31 days?	Tue 5/27/08	Tue 7/8/08
46	**Level 2 - Elevation 19.00**	**116 days?**	**Tue 7/1/08**	**Tue 12/9/08**
47	Inner Walls to 29.00	67 days?	Tue 7/1/08	Wed 10/1/08
48	Form / Pour Cure Trap Deck	7 days?	Wed 7/16/08	Thu 7/24/08
49	Form / Pour / Cure / Strip / Reshore Inner Slab	46 days?	Wed 8/20/08	Wed 10/22/08
50	Form / Pour / Cure / Strip / Reshore North Slab	19 days?	Wed 8/27/08	Mon 9/22/08
51	Form / Pour / Cure / Strip / Reshore South Slab	19 days?	Wed 9/3/08	Mon 9/29/08
52	Tail Walls to 28.00	10 days?	Thu 9/18/08	Wed 10/1/08
53	Remove Reshores	4 days?	Thu 12/4/08	Tue 12/9/08
54	**Level 3 - Elevation 27.50**	**96 days?**	**Wed 7/30/08**	**Wed 12/10/08**
55	Inner Walls to 39.00	15 days?	Wed 7/30/08	Tue 8/19/08
56	Form / Pour / Cure / Strip / Reshore Concrete Deck	25 days?	Thu 9/18/08	Wed 10/22/08
57	Form / Pour / Cure / Strip / Reshore Outer Slab	26 days?	Thu 10/2/08	Thu 11/6/08
58	Tail Walls to 38.00	10 days?	Thu 10/9/08	Wed 10/22/08
59	Remove Reshores	1 day?	Wed 12/10/08	Wed 12/10/08
60	**Level 4 - Elevation 37.50 / 43.00**	**78 days?**	**Wed 8/20/08**	**Fri 12/5/08**
61	Inner Walls to 49.00	16 days?	Wed 8/20/08	Wed 9/10/08
62	Elevated Ramp and Landing / Tail Walls to 48.00	32 days?	Thu 10/23/08	Fri 12/5/08
63	**Elevation 59.00**	**72 days?**	**Thu 9/11/08**	**Fri 12/19/08**
64	Inner Walls to 59.00	15 days?	Thu 9/11/08	Wed 10/1/08
65	Tail Walls to 58.00	10 days?	Mon 12/8/08	Fri 12/19/08
66	**Elevation 69.00**	**115 days?**	**Thu 10/2/08**	**Wed 3/11/09**
67	Inner Walls to 69.00	20 days?	Thu 10/2/08	Wed 10/29/08
68	Tail Walls to 68.00	13 days?	Mon 12/22/08	Wed 1/7/09
69	Pour Metal Deck - Interstitial Level	5 days?	Thu 3/5/09	Wed 3/11/09
70	**Elevation 79.00**	**75 days?**	**Thu 10/23/08**	**Wed 2/4/09**
71	Inner Walls to 79.00	15 days?	Thu 10/23/08	Wed 11/12/08
72	Tail walls to 78.00	10 days?	Thu 1/8/09	Wed 1/21/09
73	Demobilize Concrete Operations	10 days?	Thu 1/22/09	Wed 2/4/09
74	**Fichandler Stage**	**181 days?**	**Mon 5/19/08**	**Mon 1/26/09**
75	**Level 1 - Basement**	**67 days?**	**Mon 5/19/08**	**Tue 8/19/08**
76	Footings / Columns	16 days?	Mon 5/19/08	Mon 6/9/08
77	MEP Underground	15 days?	Tue 6/3/08	Mon 6/23/08
78	SOG / Walls	46 days?	Tue 6/17/08	Tue 8/19/08
79	**Level 2 - Elevation 19.00**	**109 days?**	**Wed 8/27/08**	**Mon 1/26/09**
80	Form / Pour / Cure / Strip / Reshore Concrete Deck	17 days?	Wed 8/27/08	Thu 9/18/08
81	Walls / Columns	10 days?	Thu 9/11/08	Wed 9/24/08
82	Remove Reshores	3 days?	Thu 1/22/09	Mon 1/26/09
83	**Kreeger Stage**	**149 days?**	**Tue 6/10/08**	**Sun 1/4/09**
84	**Level 1 - Basement**	**46 days?**	**Tue 6/10/08**	**Tue 8/12/08**
85	Footings / Pile Caps / Columns	15 days?	Tue 6/10/08	Mon 6/30/08
86	MEP Underground	11 days?	Tue 6/24/08	Tue 7/8/08
87	Walls / SOG	20 days?	Wed 7/16/08	Tue 8/12/08
88	**Level 2 - Elevation 19.00**	**94 days?**	**Wed 8/13/08**	**Mon 12/22/08**

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Task | Progress | Summary | External Tasks | Deadline
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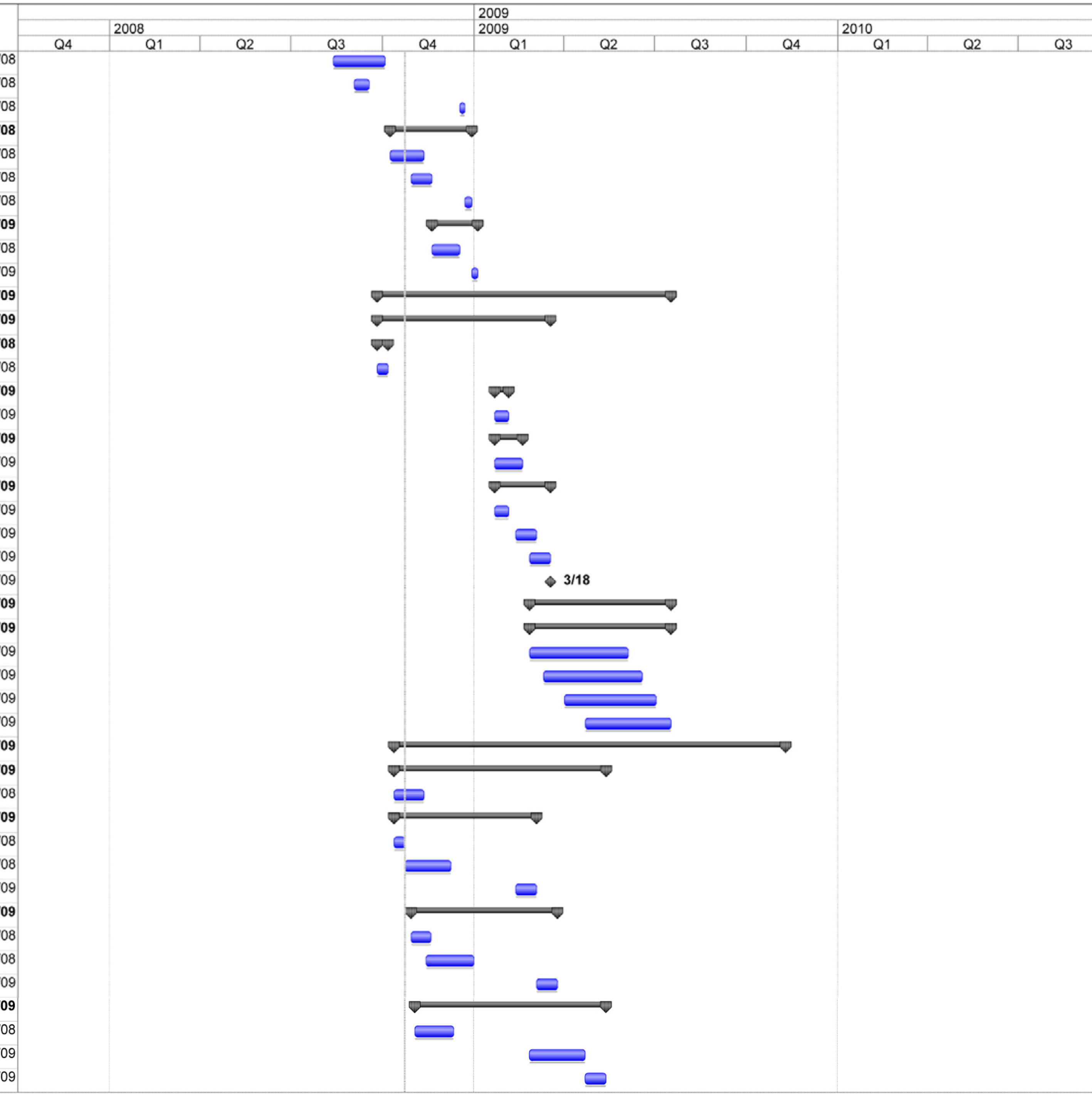
Arena Stage - Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
89	Form / Pour / Cure / Strip / Reshore Concrete Deck	38 days?	Wed 8/13/08	Fri 10/3/08
90	Walls / Columns	11 days?	Wed 9/3/08	Wed 9/17/08
91	Remove Reshores	3 days?	Thu 12/18/08	Mon 12/22/08
92	**Level 3 - Elevation 27.50**	**58 days?**	**Thu 10/9/08**	**Mon 12/29/08**
93	Form / Pour / Cure / Strip / Reshore Concrete Deck	24 days?	Thu 10/9/08	Tue 11/11/08
94	Walls / Columns	15 days?	Thu 10/30/08	Wed 11/19/08
95	Remove Reshores	5 days?	Tue 12/23/08	Mon 12/29/08
96	**Level 4 - Elevation 37.50 / 43.00**	**32 days?**	**Thu 11/20/08**	**Sun 1/4/09**
97	Form / Pour / Cure / Strip / Reshore Concrete Deck	20 days?	Thu 11/20/08	Wed 12/17/08
98	Remove Reshores	4 days?	Tue 12/30/08	Sun 1/4/09
99	**Structural Steel**	**211 days?**	**Fri 9/26/08**	**Fri 7/17/09**
100	**Framing Members / Overhang / Decking**	**124 days?**	**Fri 9/26/08**	**Wed 3/18/09**
101	**Fichandler Mechanical Mezzanine**	**7 days?**	**Fri 9/26/08**	**Mon 10/6/08**
102	Structural Steel / Metal Deck	7 days?	Fri 9/26/08	Mon 10/6/08
103	**Kreeger Roof**	**10 days?**	**Thu 1/22/09**	**Wed 2/4/09**
104	Isolated Beams / Metal Deck	10 days?	Thu 1/22/09	Wed 2/4/09
105	**Back of House - Low Roof**	**20 days?**	**Thu 1/22/09**	**Wed 2/18/09**
106	Strucutural Steel / Metal Deck	20 days?	Thu 1/22/09	Wed 2/18/09
107	**Cradle**	**40 days?**	**Thu 1/22/09**	**Wed 3/18/09**
108	Isolation Brackets	10 days?	Thu 1/22/09	Wed 2/4/09
109	Interstitial Trusses / Joists / Decking	15 days?	Thu 2/12/09	Wed 3/4/09
110	Roof Trusses / Joists / Decking	15 days?	Thu 2/26/09	Wed 3/18/09
111	Remove Tower Cranes	0 days	Wed 3/18/09	Wed 3/18/09
112	**High Roof**	**102 days?**	**Thu 2/26/09**	**Fri 7/17/09**
113	**Sequences 1 - 5**	**102 days?**	**Thu 2/26/09**	**Fri 7/17/09**
114	Timber Columns / Bracing	71 days?	Thu 2/26/09	Thu 6/4/09
115	Trusses and Infill	71 days?	Thu 3/12/09	Thu 6/18/09
116	Final Alignment / Connections / Decking / Specialties	66 days?	Thu 4/2/09	Thu 7/2/09
117	Overhang Decking / Specialties	62 days?	Thu 4/23/09	Fri 7/17/09
118	**Building Envelope**	**281 days?**	**Mon 10/13/08**	**Mon 11/9/09**
119	**Back of House**	**153 days?**	**Mon 10/13/08**	**Wed 5/13/09**
120	Aluminum Windows and Closures	22 days?	Mon 10/13/08	Tue 11/11/08
121	**Level 2 - Elevation 19.00**	**103 days?**	**Mon 10/13/08**	**Wed 3/4/09**
122	Loading Bearing CMU Walls	9 days?	Mon 10/13/08	Thu 10/23/08
123	Ext. CMU Stud Backup / Lintels / Air Barrier	32 days?	Fri 10/24/08	Mon 12/8/08
124	Ext. CMU Façade	15 days?	Thu 2/12/09	Wed 3/4/09
125	**Level 3 - Elevation 27.50**	**105 days?**	**Thu 10/30/08**	**Wed 3/25/09**
126	Loading Bearing CMU Walls	14 days?	Thu 10/30/08	Tue 11/18/08
127	Ext. CMU Stud Backup / Shelf Angles / Air Barrier	34 days?	Fri 11/14/08	Wed 12/31/08
128	Ext. CMU Façade	15 days?	Thu 3/5/09	Wed 3/25/09
129	**Level 4 - Elevation 37.50 / 43.00**	**138 days?**	**Mon 11/3/08**	**Wed 5/13/09**
130	Load Bearing CMU Walls	29 days?	Mon 11/3/08	Thu 12/11/08
131	Ext. CMU Stud Backup / Shelf Angles / Air Barrier	40 days?	Thu 2/26/09	Wed 4/22/09
132	Ext. CMU Façade	15 days?	Thu 4/23/09	Wed 5/13/09



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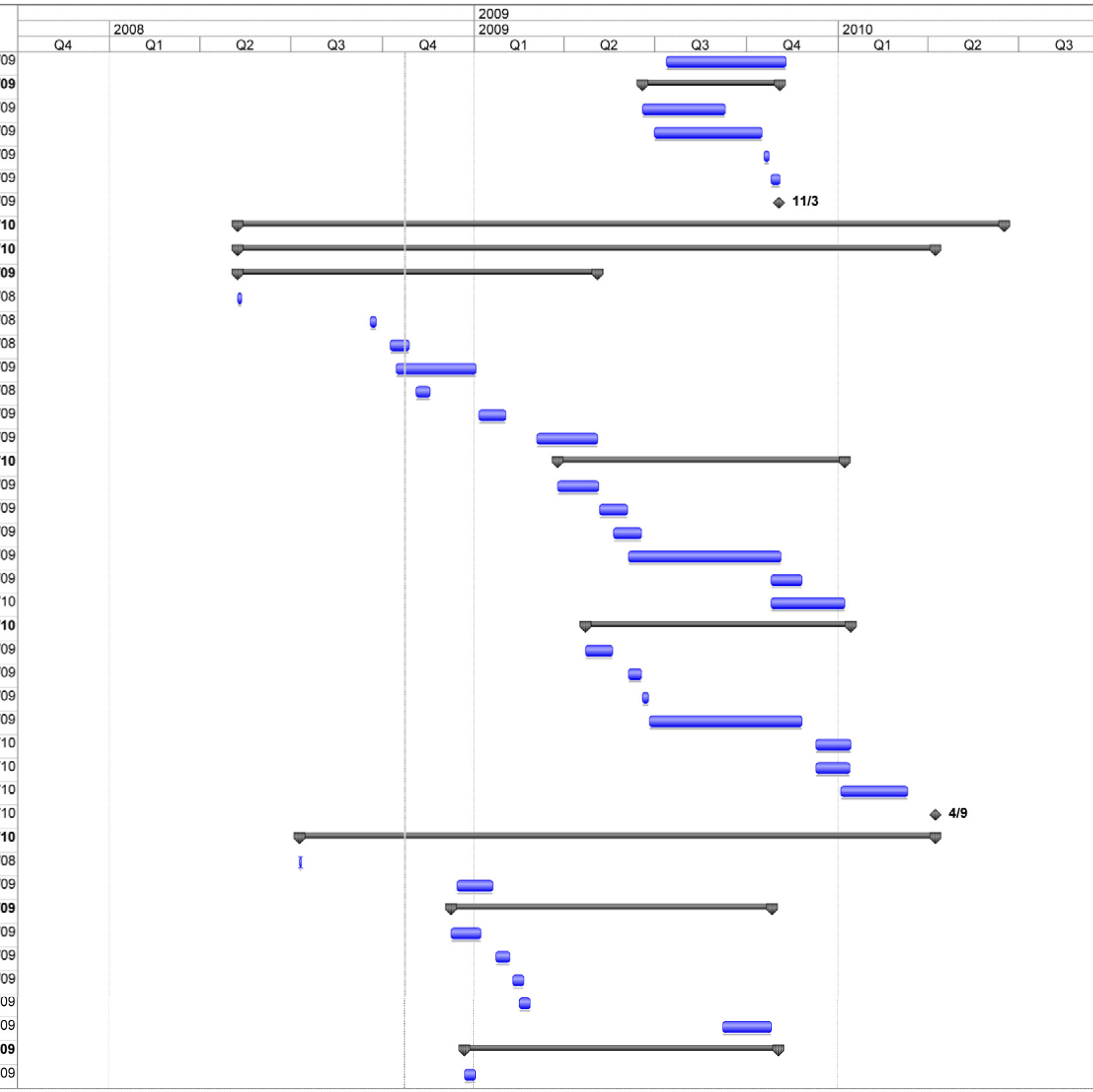
Arena Stage - Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
133	Soffit Framing and Stucco	86 days?	Mon 7/13/09	Mon 11/9/09
134	**Glass Façade**	**98 days?**	**Fri 6/19/09**	**Tue 11/3/09**
135	Support / Framing - Sequences 1 - 19	59 days?	Fri 6/19/09	Wed 9/9/09
136	Inclined Wall Glazing - Sequences 1 - 19	78 days?	Wed 7/1/09	Fri 10/16/09
137	Frame Theatre Entrance	5 days?	Mon 10/19/09	Fri 10/23/09
138	Exterior Doors and Hardware	7 days?	Mon 10/26/09	Tue 11/3/09
139	Building Watertight	0 days	Tue 11/3/09	Tue 11/3/09
140	**Interiors**	**549 days?**	**Fri 5/9/08**	**Thu 6/17/10**
141	**Fichandler Back of House / Administration**	**500 days?**	**Fri 5/9/08**	**Fri 4/9/10**
142	**Level B - Low Basement (Mechanical Room)**	**257 days?**	**Fri 5/9/08**	**Mon 5/4/09**
143	Set Chillers No. 1 & 2	2 days?	Fri 5/9/08	Tue 5/13/08
144	CMU Partitions	4 days?	Fri 9/19/08	Thu 9/25/08
145	Set AHUs No. 1, 2, 7, 8 / Water Pumps	13 days?	Thu 10/9/08	Mon 10/27/08
146	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	58 days?	Wed 10/15/08	Fri 1/2/09
147	MEP Rough-in	10 days?	Tue 11/4/08	Mon 11/17/08
148	Equipment Hook-up / Set Fire Pump and Jockey Pump	19 days?	Tue 1/6/09	Mon 2/2/09
149	Wiring / Light Fixtures / HM Doors and Hardware / Final Paint	43 days?	Thu 3/5/09	Mon 5/4/09
150	**Level 1 - Basement (w/ Administration)**	**206 days?**	**Thu 3/26/09**	**Thu 1/7/10**
151	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	29 days?	Thu 3/26/09	Tue 5/5/09
152	Sprinklers	20 days?	Thu 5/7/09	Thu 6/4/09
153	CMU Walls	20 days?	Thu 5/21/09	Thu 6/18/09
154	Frame / Rough-in / Hang Drywall and Ceiling	109 days?	Fri 6/5/09	Wed 11/4/09
155	Rest Rooms	23 days?	Mon 10/26/09	Wed 11/25/09
156	Wiring / Light Fixtures / Doors and Hardware / Final Paint	54 days?	Mon 10/26/09	Thu 1/7/10
157	**Level 2 - Elevation 19.00**	**190 days?**	**Thu 4/23/09**	**Wed 1/13/10**
158	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	19 days?	Thu 4/23/09	Tue 5/19/09
159	Sprinklers	9 days?	Fri 6/5/09	Thu 6/18/09
160	CMU Walls	4 days?	Fri 6/19/09	Thu 6/25/09
161	Frame / Rough-in / Hang Drywall and Ceiling	109 days?	Fri 6/26/09	Wed 11/25/09
162	Wiring / Light Fixtures / Doors and Hardware / Final Paint	25 days?	Thu 12/10/09	Wed 1/13/10
163	Rest Rooms	24 days?	Thu 12/10/09	Wed 1/13/10
164	Systems and Commissioning	49 days?	Mon 1/4/10	Fri 3/12/10
165	Fichandler BOH - Performance Ready	0 days	Fri 4/9/10	Fri 4/9/10
166	**Back of House**	**456 days?**	**Thu 7/10/08**	**Fri 4/9/10**
167	Set AHUs No. 12, 18, 19, 20	2 days?	Thu 7/10/08	Fri 7/11/08
168	Set Cooling Towers	26 days?	Mon 12/15/08	Mon 1/19/09
169	**Level 1 - Basement**	**230 days?**	**Tue 12/9/08**	**Mon 10/26/09**
170	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	22 days?	Tue 12/9/08	Wed 1/7/09
171	Sprinklers	10 days?	Fri 1/23/09	Fri 2/6/09
172	CMU Block Walls	9 days?	Mon 2/9/09	Fri 2/20/09
173	Electrical Rough-in	9 days?	Mon 2/16/09	Fri 2/27/09
174	Wiring / Light Fixtures / HM Doors and Hardware / Final Paint	35 days?	Tue 9/8/09	Mon 10/26/09
175	**Level 2 - Elevation 19.00**	**225 days?**	**Tue 12/23/08**	**Mon 11/2/09**
176	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	9 days?	Tue 12/23/08	Fri 1/2/09



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Task	Progress	Summary	External Tasks	Deadline
Split	Milestone	Project Summary	External Milestone	

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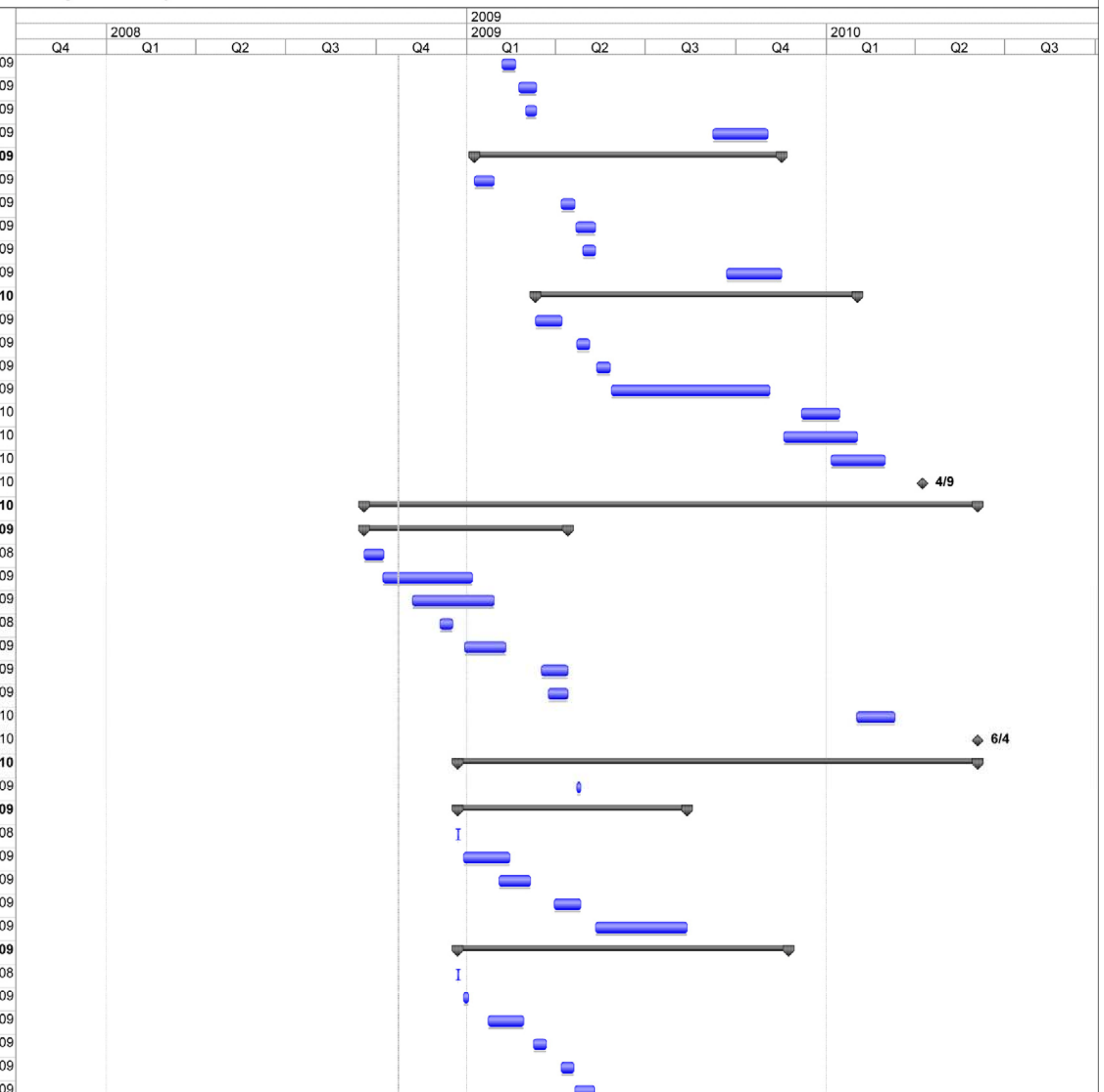
Arena Stage - Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
177	Sprinklers	10 days?	Fri 2/6/09	Fri 2/20/09
178	CMU Block Walls	14 days?	Mon 2/23/09	Fri 3/13/09
179	Electrical Rough-in	9 days?	Mon 3/2/09	Fri 3/13/09
180	Wiring / Light Fixtures / HM Doors and Hardware / Final Paint	40 days?	Tue 9/8/09	Mon 11/2/09
181	**Level 3 - Elevation 27.50**	**222 days?**	**Fri 1/9/09**	**Mon 11/16/09**
182	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	14 days?	Fri 1/9/09	Wed 1/28/09
183	Sprinklers	10 days?	Tue 4/7/09	Tue 4/21/09
184	CMU Block Walls	14 days?	Wed 4/22/09	Tue 5/12/09
185	Electrical Rough-in	9 days?	Wed 4/29/09	Tue 5/12/09
186	Wiring / Light Fixtures / HM Doors and Hardware / Final Paint	40 days?	Tue 9/22/09	Mon 11/16/09
187	**Level 4 - Elevation 37.50 / 43.00**	**233 days?**	**Thu 3/12/09**	**Mon 2/1/10**
188	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	19 days?	Thu 3/12/09	Tue 4/7/09
189	Sprinklers	9 days?	Thu 4/23/09	Wed 5/6/09
190	CMU Walls	10 days?	Wed 5/13/09	Wed 5/27/09
191	Frame / Rough-in / Hang Drywall and Ceiling	115 days?	Thu 5/28/09	Wed 11/4/09
192	Rest Rooms	29 days?	Mon 12/7/09	Fri 1/15/10
193	Wiring / Light Fixtures / Doors and Hardware / Final Paint	53 days?	Thu 11/19/09	Mon 2/1/10
194	Systems and Commissioning	39 days?	Wed 1/6/10	Tue 3/2/10
195	Back of House - Performance Ready	0 days	Fri 4/9/10	Fri 4/9/10
196	**Fichandler Theatre**	**445 days?**	**Fri 9/19/08**	**Fri 6/4/10**
197	**Rough-in**	**147 days?**	**Fri 9/19/08**	**Tue 4/14/09**
198	Catwalk	14 days?	Fri 9/19/08	Thu 10/9/08
199	MEP Rough-in / Conduit and Wiring	65 days?	Wed 10/8/08	Tue 1/6/09
200	Remove Seats and Refurbish	59 days?	Fri 11/7/08	Thu 1/29/09
201	Sprinklers	9 days?	Fri 12/5/08	Thu 12/18/08
202	House & Theatre Lighting Fixtures / Connect	30 days?	Tue 12/30/08	Tue 2/10/09
203	Reinstall Seats	19 days?	Wed 3/18/09	Tue 4/14/09
204	Drywall / Finishes	14 days?	Wed 3/25/09	Tue 4/14/09
205	Systems and Commissioning	29 days?	Mon 2/1/10	Fri 3/12/10
206	Fichandler - Performance Ready	0 days	Fri 6/4/10	Fri 6/4/10
207	**Kreeger Back of House / Administration**	**378 days?**	**Tue 12/23/08**	**Fri 6/4/10**
208	Set AHUs No. 10, 11, 13, 14	2 days?	Thu 4/23/09	Mon 4/27/09
209	**Level B - Low Basement (Mechanical Room)**	**167 days?**	**Tue 12/23/08**	**Wed 8/12/09**
210	Set AHUs	1 day?	Tue 12/23/08	Wed 12/24/08
211	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	35 days?	Mon 12/29/08	Fri 2/13/09
212	MEP Rough-in	24 days?	Tue 2/3/09	Fri 3/6/09
213	Equipment Hook-up	19 days?	Tue 3/31/09	Mon 4/27/09
214	Wiring / Light Fixtures / Doors and Hardware / Final Paint	67 days?	Tue 5/12/09	Wed 8/12/09
215	**Level 1 - Basement**	**240 days?**	**Tue 12/23/08**	**Mon 11/23/09**
216	Set AHUs No. 3 & 4	1 day?	Tue 12/23/08	Wed 12/24/08
217	Set OHU No. 2 / Water Pumps	5 days?	Mon 12/29/08	Fri 1/2/09
218	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	26 days?	Fri 1/23/09	Fri 2/27/09
219	MEP Rough-in	9 days?	Tue 3/10/09	Mon 3/23/09
220	Sprinklers	9 days?	Tue 4/7/09	Mon 4/20/09
221	CMU Walls	14 days?	Tue 4/21/09	Mon 5/11/09



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Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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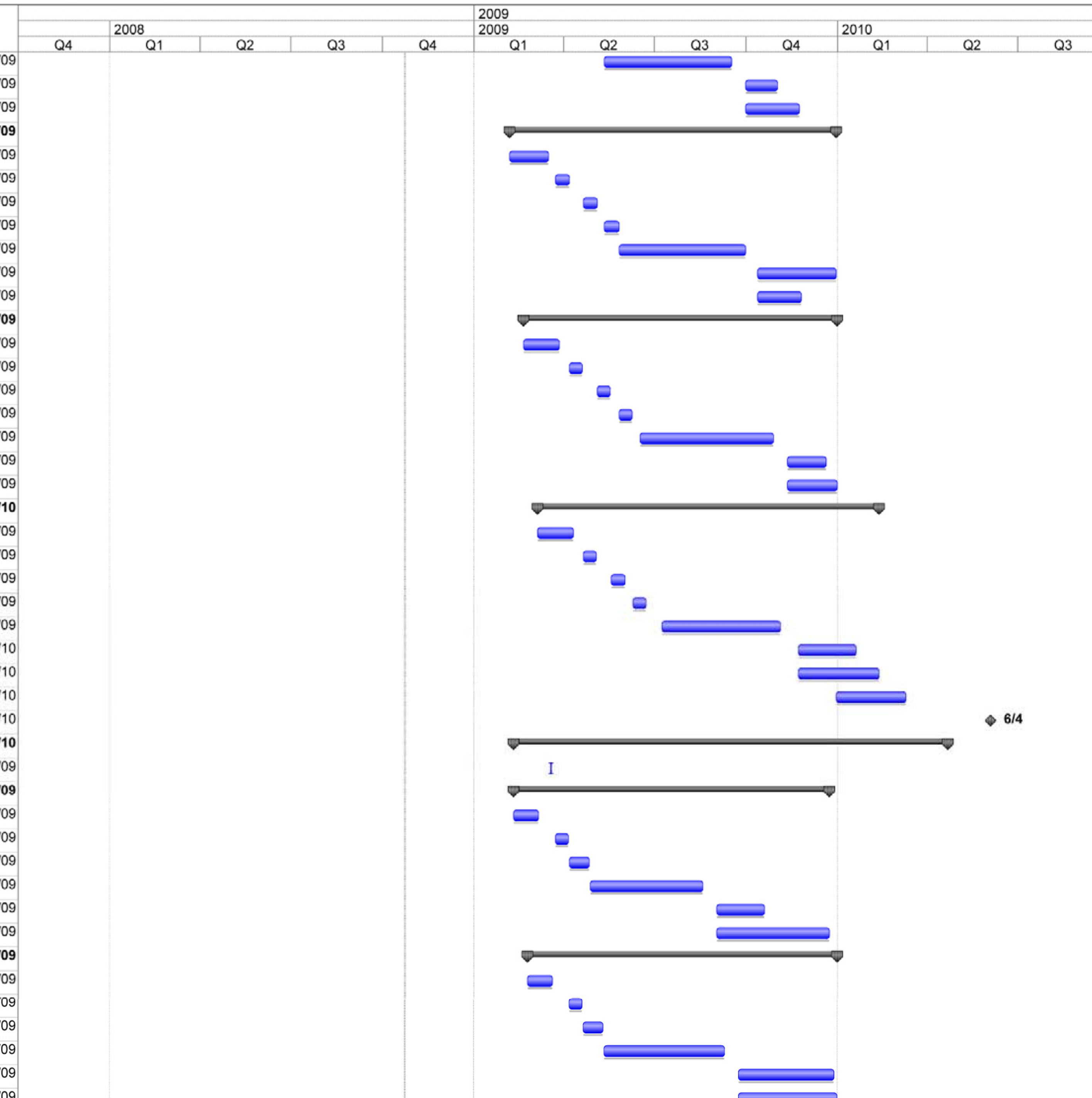
Arena Stage - Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
222	Frame / Rough-in / Hang Drywall and Ceiling	92 days?	Tue 5/12/09	Wed 9/16/09
223	Rest Rooms	22 days?	Thu 10/1/09	Mon 11/2/09
224	Wiring / Light Fixtures / Doors and Hardware / Final Paint	38 days?	Thu 10/1/09	Mon 11/23/09
225	**Level 2 - Elevation 19.00**	**234 days?**	**Fri 2/6/09**	**Wed 12/30/09**
226	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	27 days?	Fri 2/6/09	Mon 3/16/09
227	MEP Rough-in	10 days?	Tue 3/24/09	Mon 4/6/09
228	Sprinklers	10 days?	Tue 4/21/09	Mon 5/4/09
229	CMU Walls	11 days?	Tue 5/12/09	Tue 5/26/09
230	Frame / Rough-in / Hang Drywall and Ceiling	91 days?	Wed 5/27/09	Wed 9/30/09
231	Rest Rooms / Kitchen	57 days?	Tue 10/13/09	Wed 12/30/09
232	Wiring / Light Fixtures / Doors and Hardware / Final Paint	32 days?	Tue 10/13/09	Wed 11/25/09
233	**Level 3 - Elevation 27.50**	**225 days?**	**Fri 2/20/09**	**Thu 12/31/09**
234	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	26 days?	Fri 2/20/09	Fri 3/27/09
235	MEP Rough-in	9 days?	Tue 4/7/09	Mon 4/20/09
236	Sprinklers	9 days?	Tue 5/5/09	Mon 5/18/09
237	CMU Walls	9 days?	Wed 5/27/09	Tue 6/9/09
238	Frame / Rough-in / Hang Drywall and Ceiling	96 days?	Wed 6/17/09	Wed 10/28/09
239	Rest Rooms	27 days?	Thu 11/12/09	Mon 12/21/09
240	Wiring / Light Fixtures / Doors and Hardware / Final Paint	36 days?	Thu 11/12/09	Thu 12/31/09
241	**Level 4 - Elevation 37.50 / 43.00**	**245 days?**	**Fri 3/6/09**	**Thu 2/11/10**
242	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	26 days?	Fri 3/6/09	Fri 4/10/09
243	MEP Rough-in	9 days?	Tue 4/21/09	Mon 5/4/09
244	Sprinklers	10 days?	Tue 5/19/09	Tue 6/2/09
245	CMU Walls	9 days?	Wed 6/10/09	Tue 6/23/09
246	Frame / Rough-in / Hang Drywall and Ceiling	85 days?	Thu 7/9/09	Wed 11/4/09
247	Wiring / Light Fixtures / Doors and Hardware / Final Paint	42 days?	Mon 11/23/09	Tue 1/19/10
248	Rest Rooms / Café	59 days?	Mon 11/23/09	Thu 2/11/10
249	Systems and Commissioning	50 days?	Thu 12/31/09	Thu 3/11/10
250	Kreeger BOH - Performance Ready	0 days	Fri 6/4/10	Fri 6/4/10
251	**Cradle Back of House / Administration**	**312 days?**	**Tue 2/10/09**	**Thu 4/22/10**
252	Set AHU s No. 1 & 5	1 day?	Thu 3/19/09	Thu 3/19/09
253	**Level B - Low Basement**	**227 days?**	**Tue 2/10/09**	**Thu 12/24/09**
254	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	19 days?	Tue 2/10/09	Fri 3/6/09
255	Sprinklers	9 days?	Tue 3/24/09	Mon 4/6/09
256	CMU Walls	14 days?	Tue 4/7/09	Mon 4/27/09
257	Frame / Rough-in / Hang Drywall and Ceiling	81 days?	Tue 4/28/09	Tue 8/18/09
258	Wiring / Light Fixtures / Doors and Hardware / Final Paint	34 days?	Wed 9/2/09	Mon 10/19/09
259	Rest Rooms / Dressing Rooms	81 days?	Wed 9/2/09	Thu 12/24/09
260	**Level 2 - Elevation 19.00**	**223 days?**	**Tue 2/24/09**	**Thu 12/31/09**
261	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	19 days?	Tue 2/24/09	Fri 3/20/09
262	Sprinklers	9 days?	Tue 4/7/09	Mon 4/20/09
263	CMU Walls	14 days?	Tue 4/21/09	Mon 5/11/09
264	Frame / Rough-in / Hang Drywall and Ceiling	87 days?	Tue 5/12/09	Wed 9/9/09
265	Rest Rooms / Box Office / Wood Slat Wall	68 days?	Thu 9/24/09	Tue 12/29/09
266	Wiring / Light Fixtures / Doors and Hardware / Final Paint	71 days?	Thu 9/24/09	Thu 12/31/09



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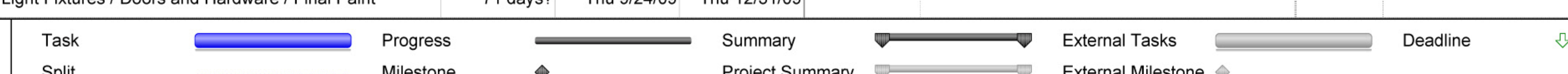

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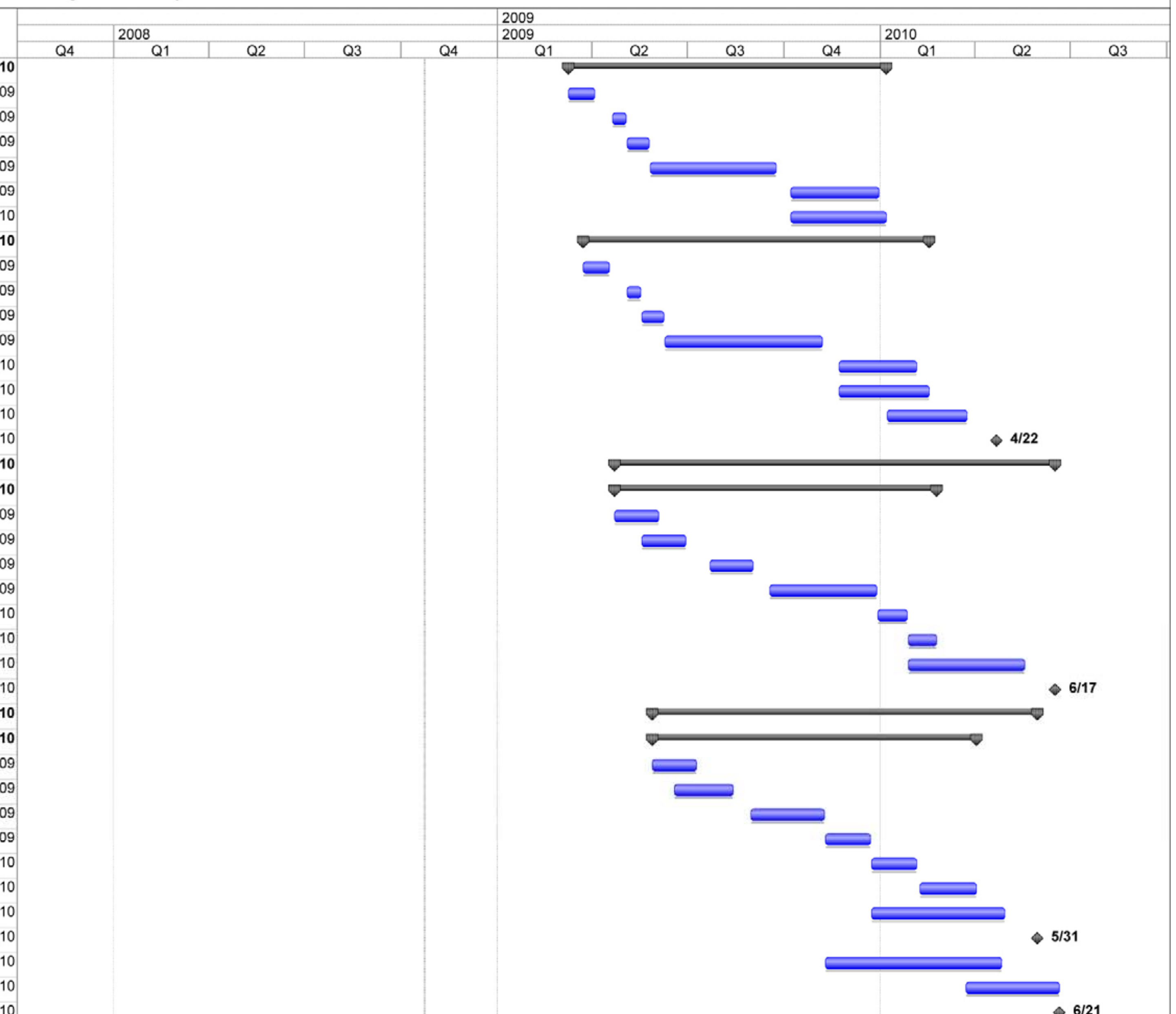
Arena Stage - Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
267	**Level 3 - Elevation 27.50**	**217 days?**	**Tue 3/10/09**	**Wed 1/6/10**
268	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	19 days?	Tue 3/10/09	Fri 4/3/09
269	Sprinklers	9 days?	Tue 4/21/09	Mon 5/4/09
270	CMU Walls	15 days?	Tue 5/5/09	Tue 5/26/09
271	Frame / Rough-in / Hang Drywall and Ceiling	86 days?	Wed 5/27/09	Wed 9/23/09
272	Rest Rooms / Dressing Rooms	60 days?	Thu 10/8/09	Thu 12/31/09
273	Wiring / Light Fixtures / Doors and Hardware / Final Paint	65 days?	Thu 10/8/09	Wed 1/6/10
274	**Level 4 - Elevation 37.50 / 43.00**	**236 days?**	**Tue 3/24/09**	**Tue 2/16/10**
275	Ductwork / HVAC Piping / Plumbing Risers / Drain Lines	19 days?	Tue 3/24/09	Fri 4/17/09
276	Sprinklers	9 days?	Tue 5/5/09	Mon 5/18/09
277	CMU Walls	15 days?	Tue 5/19/09	Tue 6/9/09
278	Frame / Rough-in / Hang Drywall and Ceiling	108 days?	Wed 6/10/09	Fri 11/6/09
279	Rest Rooms / Wood Slat Wall	54 days?	Mon 11/23/09	Thu 2/4/10
280	Wiring / Light Fixtures / Doors and Hardware / Final Paint	62 days?	Mon 11/23/09	Tue 2/16/10
281	Systems and Commissioning	54 days?	Fri 1/8/10	Thu 3/25/10
282	Cradle BOH - Performance Ready	0 days	Thu 4/22/10	Thu 4/22/10
283	**Cradle Theatre**	**300 days?**	**Thu 4/23/09**	**Thu 6/17/10**
284	**Rough-in**	**219 days?**	**Thu 4/23/09**	**Wed 2/24/10**
285	Catwalks / Rigging	30 days?	Thu 4/23/09	Thu 6/4/09
286	MEP Rough-in	30 days?	Tue 5/19/09	Tue 6/30/09
287	Ceiling Finishes / Trim Out	29 days?	Thu 7/23/09	Wed 9/2/09
288	Wall Rough-in / Finishes / Slat Wall	72 days?	Fri 9/18/09	Tue 12/29/09
289	Demountable Platform / Rigging	20 days?	Wed 12/30/09	Wed 1/27/10
290	House & Theatre Lights / Power Devices / Fuses / Disconnects	19 days?	Thu 1/28/10	Wed 2/24/10
291	Systems and Commissioning	79 days?	Thu 1/28/10	Wed 5/19/10
292	Cradle - Performance Ready	0 days	Thu 6/17/10	Thu 6/17/10
293	**Kreeger Theatre**	**261 days?**	**Fri 5/29/09**	**Mon 5/31/10**
294	**Rough-in**	**221 days?**	**Fri 5/29/09**	**Fri 4/2/10**
295	MEP Rough-in	30 days?	Fri 5/29/09	Fri 7/10/09
296	Ceiling Finishes / Trim Out	40 days?	Fri 6/19/09	Fri 8/14/09
297	Wall Rough-in / Finishes	50 days?	Mon 8/31/09	Mon 11/9/09
298	Stage Rigging	31 days?	Tue 11/10/09	Wed 12/23/09
299	Power Devices / Fuses / Disconnects	31 days?	Thu 12/24/09	Fri 2/5/10
300	Flooring / Seating	40 days?	Mon 2/8/10	Fri 4/2/10
301	Systems and Commissioning	91 days?	Thu 12/24/09	Fri 4/30/10
302	Kreeger - Performance Ready	0 days	Mon 5/31/10	Mon 5/31/10
310	Site Work	120 days?	Tue 11/10/09	Mon 4/26/10
312	Final Inspections	63 days?	Wed 3/24/10	Mon 6/21/10
313	Substantial Completion	0 days	Mon 6/21/10	Mon 6/21/10



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Task		Progress		Summary		External Tasks		Deadline
Split		Milestone	◆	Project Summary		External Milestone	◆

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B. Site Layout Planning

Excavation/Demolition Phase

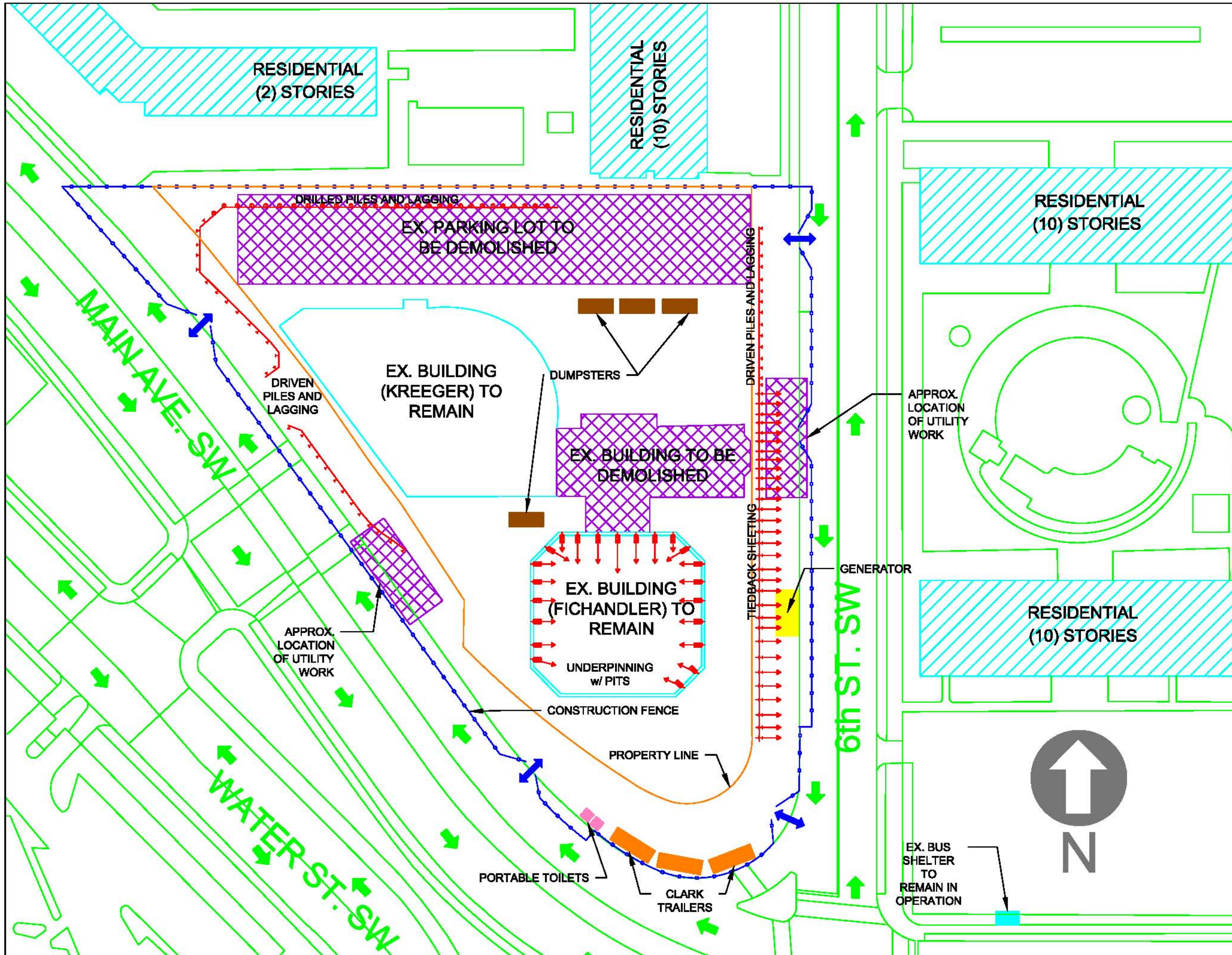
This phase of the project primarily consists of the partial demolition of the existing Arena Stage facility, as well as razing the adjacent parking lots and hardscaping. The site fence, which changes only slightly throughout construction, surrounds the perimeter of the triangle-shaped block and extends out onto both Main Avenue SW and 6th Street SW.

Due to its awkward shape, the south corner of the site was chosen to house the Clark site trailers and the portable toilets. That location allows Clark to monitor the traffic flow of the site and it is an area that is rarely disturbed by construction. Dumpsters are strewn around the site to collect the massive amounts of debris from the building and hardscaping demolition.

During excavation, the surrounding site, utility lines, and the Fichandler theatre had to be supported. Using both temporary and permanent supports, the base of the Fichandler was underpinned and the perimeter of the site contains several runs of driven or drilled soldier piles and lagging. At this point in the construction process, the entire site is free-range for the excavation equipment with the exception of some areas, which begin to take form as lay down spaces for the superstructure material deliveries.

Please find the Excavation/Demolition Site Plan on the following page.

Figure 1: Arena Stage during excavation in March 2008
(Provided by Clark Construction WebCam)



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TECHNICAL REPORT 2

ARENA STAGE

1101 6th ST. SW
WASHINGTON, DC 20024

EXCAVATION / DEMOLITION SITE PLAN

NOT TO SCALE

SHEET 1 OF 1

Superstructure Phase

In order to facilitate the lift requirements of the concrete and steel operations, two tower cranes were erected on site. One is located on the east side of the Fichandler theatre and the other is nestled in between the BOH and a neighboring apartment building. The generator is located on higher ground along 6th Street SW next to the Fichandler. Once work started on the common areas between the theatres, a temporary two-way road was installed to direct traffic around the building footprint. Entry to the site can be made from either Main Avenue SW or 6th Street SW.

Since this phase of construction causes the site to become very congested, everything temporary is pushed out to the open areas around the perimeter of the property. Subcontractors mobilize their trailers along the southwest perimeter fence, additional portable toilets are brought in, and the dumpsters are placed in more strategic locations for ease of haul away. Large staging areas are located on either side of the site to store the extensive Cradle formwork, reinforcing, and structural steel.

Please find the Superstructure Site Plan on the following page.

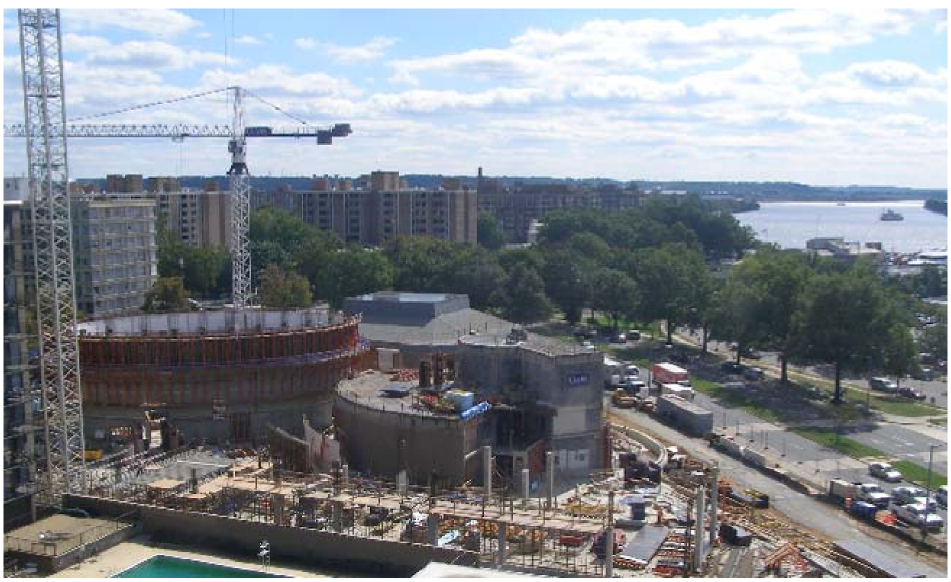
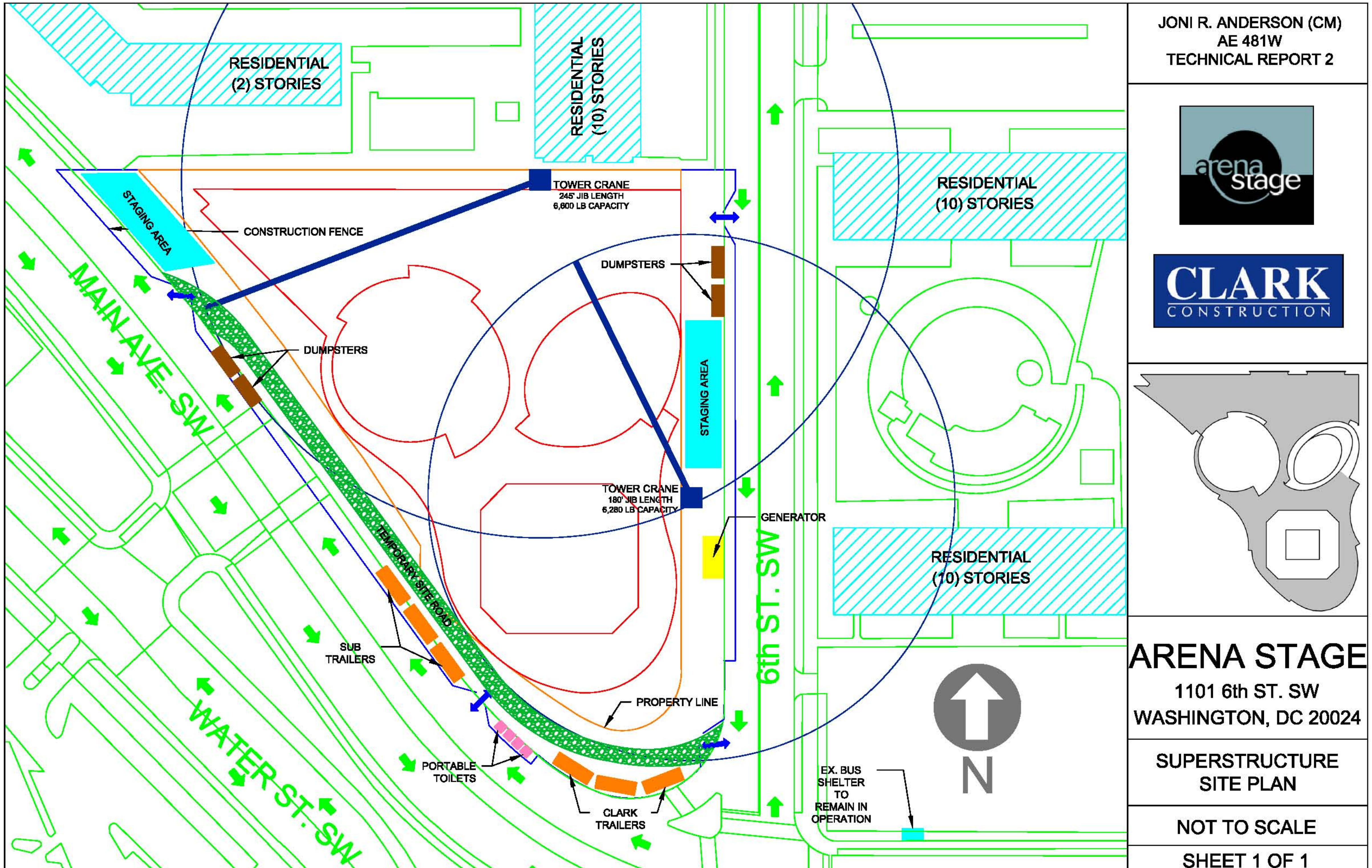


Figure 2: Arena Stage during construction of the superstructure in October 2008
(Provided by Clark Construction WebCam)


RESIDENTIAL
(2) STORIES
RESIDENTIAL
(10) STORIES
RESIDENTIAL
(10) STORIES
RESIDENTIAL
(10) STORIES
TOWER CRANE
245' JIB LENGTH
6,600 LB CAPACITY
STAGING AREA
CONSTRUCTION FENCE
DUMPSTERS
DUMPSTERS
STAGING AREA
MAIN AVE. SW
TOWER CRANE
180' JIB LENGTH
6,280 LB CAPACITY
GENERATOR
6th ST. SW
TEMPORARY SITE ROAD
SUB
TRAILERS
PROPERTY LINE
PORTABLE
TOILETS
CLARK
TRAILERS
WATER ST. SW
EX. BUS
SHELTER
TO
REMAIN IN
OPERATION
N
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ARENA STAGE
1101 6th ST. SW
WASHINGTON, DC 20024
SUPERSTRUCTURE
SITE PLAN
NOT TO SCALE
SHEET 1 OF 1

Finishing Phase

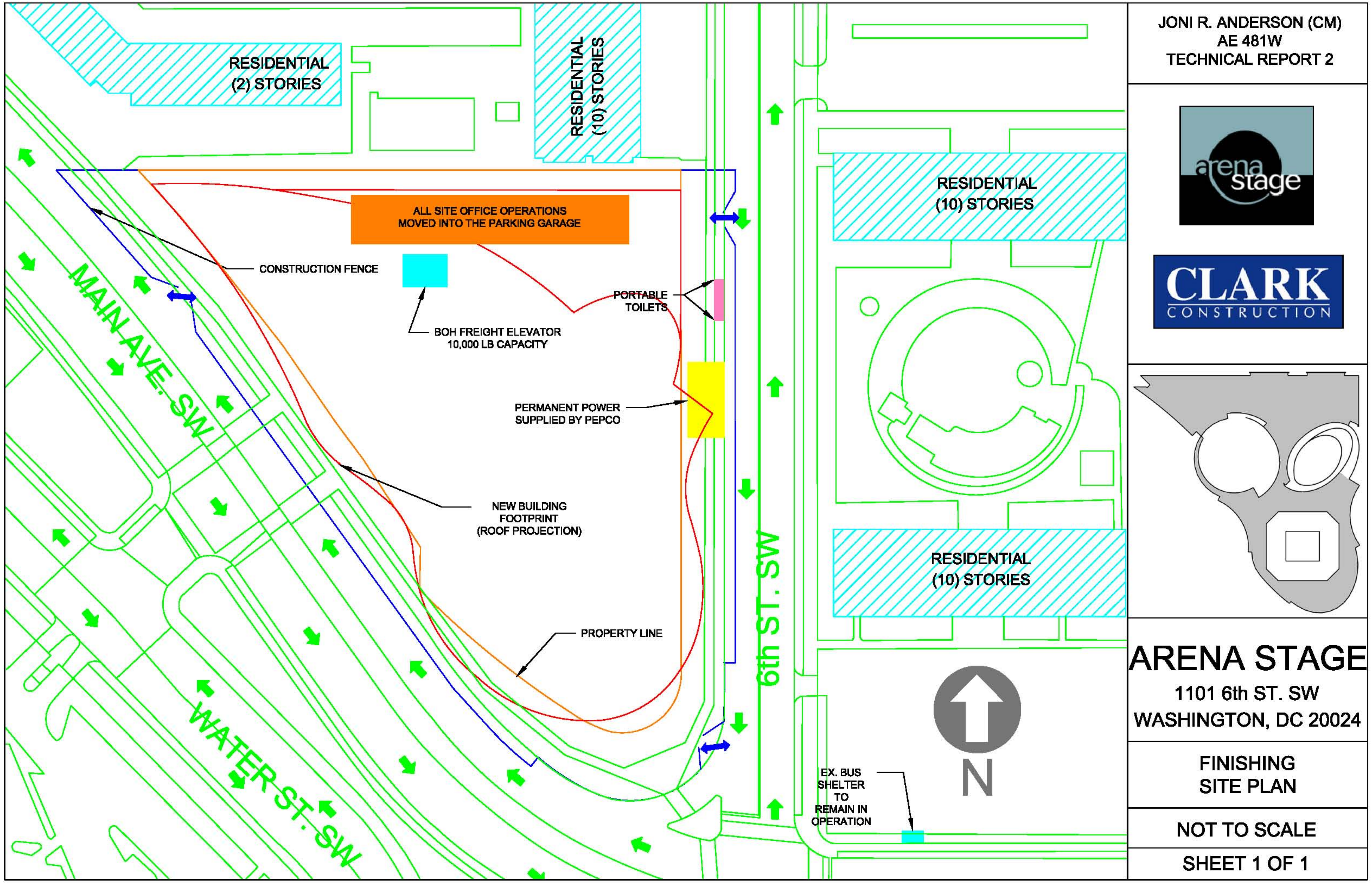
As the heavy construction work at Arena Stage comes to an end, the site begins to clean up and operations move into the new building. All of the jobsite trailers are removed from site and the office personnel are moved into the ground floor of the BOH parking garage. Permanent power is set up by Pepco Supply and material deliveries are brought into to parking garage and distributed throughout the building via the permanent freight elevator in the BOH. It is a conventional holed hydraulic elevator with a 9' cab height and a 10,000 pound lifting capacity.

Final building inspections and commissioning take place inside the building during the execution of the interior finishes. New hardscaping is laid out around the perimeter of the building and tied back into the neighboring sidewalks. The land around Arena Stage is designed to be pedestrian friendly and provide passers-by with an opportunity to marvel at the beauty of the new complex.

Please find the Finishing Site Plan on the following page.

Figure 3: Section of Arena Stage showing the interior of the Fichandler and Kreeger theatres (Provided by Bing Thom Architects)

Since this phase of construction has not yet begun, no photos from the Clark Construction WebCam are available.


RESIDENTIAL
(2) STORIES
RESIDENTIAL
(10) STORIES
RESIDENTIAL
(10) STORIES
RESIDENTIAL
(10) STORIES
ALL SITE OFFICE OPERATIONS
MOVED INTO THE PARKING GARAGE
CONSTRUCTION FENCE
BOH FREIGHT ELEVATOR
10,000 LB CAPACITY
PORTABLE
TOILETS
PERMANENT POWER
SUPPLIED BY PEPCO
NEW BUILDING
FOOTPRINT
(ROOF PROJECTION)
PROPERTY LINE
MAIN AVE. SW
WATER ST. SW
6th ST. SW
EX. BUS
SHELTER
TO
REMAIN IN
OPERATION
N
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TECHNICAL REPORT 2
arena stage
CLARK
CONSTRUCTION
ARENA STAGE
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FINISHING
SITE PLAN
NOT TO SCALE
SHEET 1 OF 1

C. Detailed Curtain Wall System Estimate

The detailed system estimate performed for this technical assignment was the curtain wall system of Arena Stage. Since it is both a structural component and an architectural feature, it presented itself as a potential area of reform in later submissions of this thesis. While the curtain wall does not enclose the entire building, it runs continuously from the Kreeger to the Cradle theatre and is the most prominent exterior enclosure.

Primarily, the curtain wall consists of two components: the glazing and the structural system. The glazing follows a serpentine path along the outside of the three theatres and sits on a 4 degree inclined slope. It is sectioned off into 7/8”-thick insulated glass frames that are custom cut to achieve the architectural curve of the façade. To do this, each face of the façade is 7 frames high and is a combination of rectangular and trapezoidal pieces.

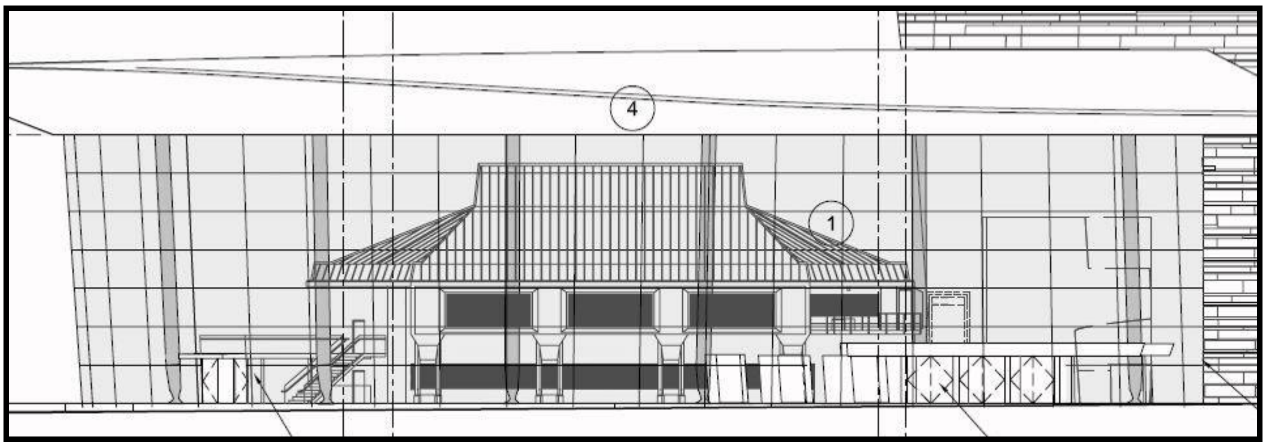

Figure 4: Architectural Elevation showing the faces of the façade with glazing runs at 7 frames high

A general take-off was performed by scaling the 52 faces of the façade off of the architectural plans. Once the widths of the faces were recorded, an average approximate height of the panels was calculated at 6’-4”. This value was applied to all of the frames in lieu of trying to determine the custom heights of each panel. It was determined from mock-up drawings that were provided by Icon Exterior Building Solutions. The square footage of each face was then multiplied by 7 to account for the 7 frames that make up each of the 52 faces. These calculations revealed that approximately 27,411 square feet of glazing make up the façade in the form of 364 custom cut frames.

Pricing for the glazing came from R.S. Means Square Foot Costs 2008 for glazed curtain walls. Using both the minimum and maximum values provided by Means, an extrapolated value of $120/SF of glazing was used. While this square foot cost is considerably high, it was used to account for the custom cuts of the frames, especially for those that are trapezoids. This resulted in a value of $3,289,332 for the glazing alone. Please find these calculations in Table 2 on the next page.

Table 2: Curtain Wall Glazing Take-off and Estimate

Curtain Wall - Glazing Take-off

Face	Approx. Width (ft)	Approx. Height (ft)	Frame Count	SF
1	11.25	6.333	7	498.72
2	11.25	6.333	7	498.72
3	11.25	6.333	7	498.72
4	11.25	6.333	7	498.72
5	11.25	6.333	7	498.72
6	11.25	6.333	7	498.72
7	11.25	6.333	7	498.72
8	11.25	6.333	7	498.72
9	11	6.333	7	487.64
10	11.25	6.333	7	498.72
11	11.25	6.333	7	498.72
12	11.25	6.333	7	498.72
13	11.25	6.333	7	498.72
14	16	6.333	7	709.30
15	18	6.333	7	797.96
16	13	6.333	7	576.30
17	11.25	6.333	7	498.72
18	12.33	6.333	7	546.60
19	12	6.333	7	531.97
20	12	6.333	7	531.97
21	10	6.333	7	443.31
22	14	6.333	7	620.63
23	11	6.333	7	487.64
24	11.25	6.333	7	498.72
25	11.25	6.333	7	498.72
26	12	6.333	7	531.97
27	11.25	6.333	7	498.72
28	11.25	6.333	7	498.72
29	12	6.333	7	531.97
30	11	6.333	7	487.64
31	11.25	6.333	7	498.72
32	11.25	6.333	7	498.72
33	11	6.333	7	487.64
34	11.25	6.333	7	498.72
35	11.25	6.333	7	498.72
36	10.666	6.333	7	472.83
37	11	6.333	7	487.64
38	11.25	6.333	7	498.72
39	11.25	6.333	7	498.72
40	10.666	6.333	7	472.83
41	12	6.333	7	531.97
42	11	6.333	7	487.64
43	11	6.333	7	487.64
44	11.666	6.333	7	517.17
45	12	6.333	7	531.97
46	22	6.333	7	975.28
47	12	6.333	7	531.97
48	12	6.333	7	531.97
49	12	6.333	7	531.97
50	12	6.333	7	531.97
51	12	6.333	7	531.97
52	12.25	6.333	7	543.05
			Total (SF)	**27,411**

Cost per SF of Glazing	$120.00
Total Cost of Glazing	**$3,289,332**

After review by an employee at Icon Exterior Building Solutions, the glazing take-off was determined to be within 400 square feet of the actual size and the cost estimate was only about 5% high.

Parallel strand lumber (PSL) timber columns provide the support for the entire curtain wall system. These solid wood columns, ranging from 48' to 58' tall, are shaped into ellipses on a lathe. To provide enough support for the glazing, 18 columns, sitting 3' off the glass, are placed 36' on center along the perimeter of the building.

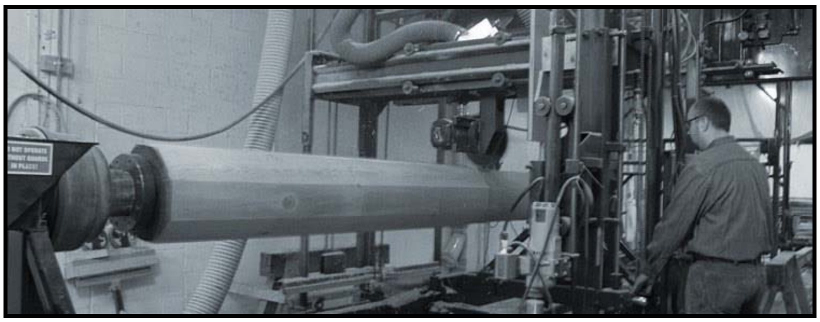

Figure 5: Shaping the PSL timber columns on the lathe
(Provided by StructureCraft Inc.)

The columns support the glazing through a series of structural components. Each column has a cast ductile-iron base and top, 12 wooden support arms, 12 wooden muntins, 12 aluminum plates and 2 stainless steel cables ranging in length. After discussion with a representative from StructureCraft Inc., a rough unit cost was determined for each of these components.

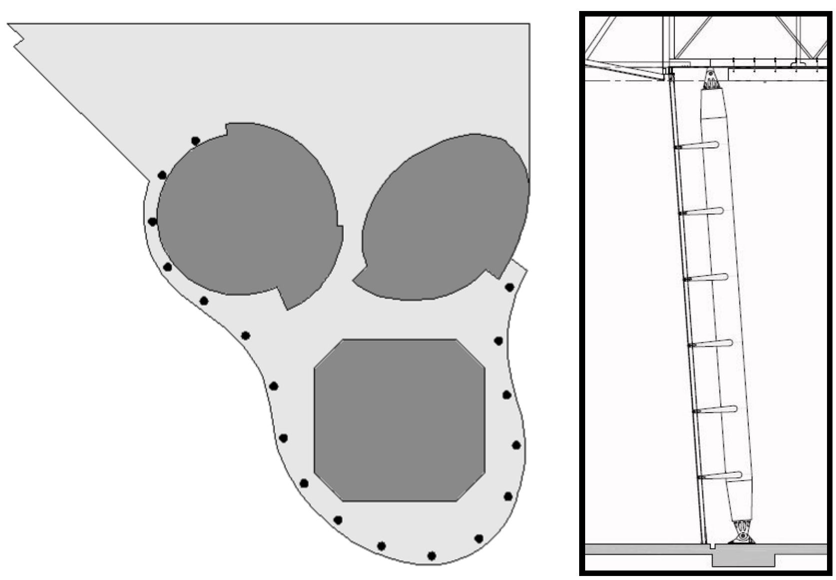

Figure 6: Plan view of the 18 columns (left) & an elevation of a column showing the 6 rows of support arms tying into the glazing (right)

Table 3: Curtain Wall Structural System Take-off and Estimate

Curtain Wall - Structural System Take-off

PSL Columns	Base / Top	Support Arms	Muntins	Aluminum Plates	SS Cables (LF)
1	2	12	12	12	48
2	2	12	12	12	48.6
3	2	12	12	12	49.2
4	2	12	12	12	49.8
5	2	12	12	12	50.4
6	2	12	12	12	51
7	2	12	12	12	51.6
8	2	12	12	12	52.2
9	2	12	12	12	52.8
10	2	12	12	12	53.4
11	2	12	12	12	54
12	2	12	12	12	54.6
13	2	12	12	12	55.2
14	2	12	12	12	55.8
15	2	12	12	12	56.4
16	2	12	12	12	57
17	2	12	12	12	57.6
18	2	12	12	12	58
Total:	36	216	216	216	960

Item	Quantity	Unit Cost	Expanded Cost
Columns	18	$15,890.00	$286,020.00
Base / Top	36	$4,150.00	$149,400.00
Support Arms	216	$250.00	$54,000.00
Muntins	216	$560.00	$120,960.00
Aluminum Plates	216	$47.00	$10,152.00
SS Cables	960	$3.75	$3,600.00
Accessories	18	$600.00	$10,800.00
		Total Cost of Structural System	**$634,932.00**

The take-off and estimate of the curtain wall structural system can be found in Table 3. After applying the discussed unit costs of the materials and those of some extra accessories, the cost of the custom support structure amounted to $634,932.

Next, the two components of the curtain wall system were combined in order to compute the cost of the curtain wall per square foot of the building.

Table 4: Arena Stage Curtain Wall System Estimate Summary

Curtain Wall System Estimate Summary			
DESCRIPTION	COST	COST PER SF CURTAIN WALL	COST PER SF BUILDING
Glazing	$3,289,332	$120	$16.45
Structural Components	$634,932	$23.15	$3.17
Curtain Wall System	**$3,924,264**	**$143.15**	**$19.62**

The total cost of the curtain wall system for Arena Stage is **$3,924,264**, which amounts to $19.62 per square foot of the building. This price is actually relatively high considering the curtain wall only accounts for about half of the façade of the complex. It is approximately **3.15%** of the total building cost. Since the system is 27,411 square feet, an even more practical number to consider is the cost per square foot of the curtain wall: $143.15.

In order to honor the request of Arena Stage and not publicize any hard costs, the actual value of the curtain wall system is unknown and therefore cannot be used as a comparison. Very little reference was made to estimating resources or literature because of the uniqueness of the curved glass and the wood structure. The prices used in the above estimates are ballpark values suggested by the subcontractors to produce a relatively accurate cost of the system.

D. General Conditions Estimate

In order to estimate the General Conditions cost for Arena Stage, a standard Clark GCs items list was used to comprehend what type of items are typically included in this cost. The list was reviewed and modified to include only those line items that are applicable to Arena Stage. R.S. Means Building Construction Cost Data 2008 was then used to determine the unit, duration (if applicable), and unit cost of each line item.

Table 5: Arena Stage General Conditions Estimate Summary

General Conditions Estimate Summary	
DESCRIPTION	COST
Supervision/Project Management	$3,517,265
Administrative Facilities and Supplies	$441,670
Safety	$8,000
Cleanup	$852,930
Jobsite Work Requirements	$5,197,840
Total	$10,017,705
Location Factor (Washington, D.C.)	0.997
Total GCs	**$9,987,652**
Percent of Project Cost	**8.0%**

Table 5 shows the summary of the General Conditions costs for the project in the five main categories that Clark utilizes; Supervision/Project Management, Administrative Facilities and Supplies, Safety, Cleanup, and Jobsite Work Requirements. After computing the initial total, it was adjusted using the R.S. Means location factor for Washington, D.C. The final calculated cost of the GCs was **$9,987,652** which is approximately **8%** of the overall project cost.

Although the actual cost of the GCs on Arena Stage is unknown, this value seems reasonable since Clark's GCs generally fall between 5 and 8% of the cost of the work. However, according to this estimate, the Jobsite Work Requirements account for over 52% of the GCs, which seems inaccurate. This is probably due to the fact that R.S. Means assigns high values to permits and liability insurance which were included in that category. Also, it was originally expected that Supervision/Project Management would have been the highest percentage of the general conditions. This is most likely the case for Clark's actual General Conditions. Since R.S. Means offers conservative values, it does not take into account the experience levels of the project personnel. Therefore, discrepancies between Clark's actual salaries, based on experience and tenure, and the assigned R.S. Means values are probably responsible for the lower than expected Supervision/PM estimate.

Please find the complete General Conditions Estimate in Table 6 on the next page. It reflects the monthly fees and unit costs of each line item as they pertain to the project.

Table 6: Detailed General Conditions Estimate

Arena Stage - General Conditions					
	Qty.	Amount	Units	Unit Price	Total
SUPERVISION/PROJECT MANAGEMENT					
Project Executive	1	127	WK	$2,400.00	$304,800
Construction Executive	1	127	WK	$2,400.00	$304,800
Project Manager	1	127	WK	$2,125.00	$269,875
Superintendent	1	127	WK	$2,350.00	$298,450
Assistant Superintendent	2	127	WK	$1,600.00	$406,400
Safety Manager	1	127	WK	$1,350.00	$171,450
Quality Control	1	127	WK	$1,165.00	$147,955
Project Engineer	1	127	WK	$1,350.00	$171,450
MEP Coordinator	1	127	WK	$1,600.00	$203,200
Office Engineer	4	127	WK	$1,165.00	$591,820
Field Engineer	3	127	WK	$1,165.00	$443,865
Secretarial Support	2	127	WK	$800.00	$203,200
ADMINSTRATIVE FACILITIES AND SUPPLIES					
Trailer Set-Up and Rental	3	30	EA/MO	$375.00	$33,750
Office Equipment Rental	3	30	EA/MO	$155.00	$13,950
Office Supplies	3	30	EA/MO	$85.00	$7,650
Office Telephone / Cell Phones	20	30	EA/MO	$125.00	$75,000
IT Expenses	20	30	EA/MO	$75.00	$45,000
Drawings and Specifications	-	-	LS	$7,000.00	$7,000
Storage Boxes	2	30	EA/MO	$72.00	$4,320
Motor Vehicle Expenses	4	30	EA/MO	$1,000.00	$120,000
Travel/Relocation Expenses	-	30	MO	$4,500.00	$135,000
SAFETY					
Job Safety Materials & PPE	-	-	LS	$8,000.00	$8,000
CLEANUP					
Periodic Cleanup	200	127	MSF/DAY	$27.23	$691,642
Final GC Cleanup	200	-	MSF	$56.44	$11,288
Dumpster Service	2	30	EA/MO	$2,500.00	$150,000
JOBSITE WORK REQUIREMENTS					
Temporary Fencing	1200	2.5	LF/YR	$3.95	$11,850
Signage	-	-	LS	$1,500.00	$1,500
Misc. Tools & Equipment	-	-	LS	$2,500.00	$2,500
Generator (includes fuel)	2	25	EA/MO	$980.00	$49,000
Drinking Water	3	30	EA/MO	$75.00	$6,750
Temporary Lighting	2000	-	CSF	$18.75	$37,500
Temporary Power (Lighting)	2000	25	CSF/MO	$2.85	$142,500
Temporary Heat	2000	24	CSF/WK	$30.27	$1,452,960
Temporary Toilets	6	30	EA/MO	$171.00	$30,780
Licenses & Permits	-	-	% Job	0.75	$937,500
Liability Insurance	-	-	% Job	2.02	$2,525,000
Total					$10,017,705
Location Factor					0.997
Total GCs					**$9,987,652**
Percent of Project Cost					**8.0%**

E. Critical Industry Issues

During the PACE Roundtable Meeting, I learned a lot about the expectations industry members and the current state of the construction market. My favorite part of the PACE Roundtable was the mixer where a potential mentorship program for architectural engineering students was discussed. It initiated a very interesting and compelling conversation between me, my peers, and Mr. Bill Moyer from James G. Davis Construction Corporation. We established several benefits that a mentorship program would provide both AE students and the industry members which are listed in Table 7 below.

Table 7: Benefits of an AE/Industry Mentorship Program

Benefits for Students	Benefits for Industry Members	Benefits for Both
Learning about the industry from those who do	Insight to new generations of students	Creating long-term relationships
Career guidance	Self-satisfaction / Service	Closing the age gap
Developing professional communication skills / Networking	Learning about expectations and desires of students as potential employees	Understanding and respecting each other and the knowledge they have to offer

It was also agreed upon that the mentorship program should not be used as a marketing technique by industry members nor should students consider it a definite employment opportunity. Although that may be the outcome in some cases, the purpose of the mentorship program is to create relationships and to use them as resources throughout your life. This session made me realize what a benefit it would have been to have this sort of opportunity during my undergraduate career, especially as preparation for senior thesis.

The technical training topic that I attended was the “Energy & Economy” session facilitated by Dr. Riley. Industry members generated the majority of the discussion seeing as they are currently experiencing the impacts that the economy is having on the construction industry. The volatility of materials and their dependence on oil was the first topic. With oil prices as high and they are, it is wise to consider using local materials in order to cut down on transportation costs. Also, using alternative materials, which may or may not be known to the market, is a cost-saving measure that is often overlooked due to lack of education. It was suggested to explore both of these possibilities and to observe escalation factors, including buyout tactics and historic trends.

While discussing building systems, the general consensus was the importance of educating the owner and stressing the life-cycle cost of the building. There is a high demand for energy retrofits and clients need to be aware of the long term cost savings despite a high upfront cost. When an early focus is placed on the design of controls and criteria changes, high energy savings can be expected. Many buildings have power inefficiencies and steps need to be taken to avoid them. Understanding the importance of commissioning and making sure that the systems are running properly will prevent certain sources of power inefficiency. Using TP-1 transformers, sizing conductors with more copper, and changing lighting systems from high pressure sodium to high pressure fluorescent were all measures suggested by the industry members.

Regardless of the state of the economy, it was discussed that there are still some construction markets that are prosperous. Federal work has been maintained due to the Base Realignment and Closure (BRAC) Commission and the renovation/restoration of historic buildings. The need for new data centers will continue since they are dependent on ever changing technical innovations. Healthcare facilities will continue to be necessary to accommodate for the growing demographic of older citizens. A large stock of old, inefficient buildings will perpetuate the need for educational facilities as well. Public-private partnership (PPP) projects are also providing work during recession.

Industry members noted a consistent availability for work in renovation and retrofitting, as well as picking up abandoned projects and completing them. Although the latter is often viewed as an undesirable job, some see it as an opportunity. Markets that are expected to slow down include gaming/sports complexes, condos/residential, and speculative office building.

What surprised me most about these sessions were the optimistic views of the industry professionals during this time of economic crisis. For the most part, they tried to stress that although the economy is down, there are still opportunities for work. As imminent graduates, they advised all AE students to learn as much as they could at their new places of employment and when the economy shifts direction our training will have prepared us to take on the inevitable boom of jobs. Also, I was pleasantly surprised to see an extremely positive response to the potential mentorship program. People in the construction industry are very busy individuals and it is inspirational to see that they are still willing to take the time to make a difference in the lives of prospective students.

Although the issues discussed at the Roundtable may not be directly applicable to my thesis project, including BIM and LEED, I met several people that might be able to advise me in my personal areas of interest. The first is Andreas Phelps, an undergraduate student that I sat with at the banquet dinner. He helped me to start exploring ideas for my depth and breadth topics, specifically in a non-technical field. Since the majority of the Arena Stage design team is located in Canada and the construction team is essentially from the Washington, D.C. area, Andreas suggested looking at communication barriers that may exist due to the geographic separation of the project team. Bill Moyer, who I spoke with at the mentoring mixer, would also be a useful contact since Davis is primarily active in the D.C. region. His familiarity with the area could help me with exploring issues that are specifically applicable to Washington, D.C. The last is Jeremy Sibert from Hensel Phelps Construction Company. Although he was not present at the PACE Roundtable, he is a PACE industry member and I know him through my internship experience at Hensel Phelps. Jeremy is a project manager at the Pentagon and he has worked on several other projects. If I choose to examine issues pertaining to the Arena Stage project team, it may be smart to utilize Jeremy's management knowledge and conflict resolution suggestions.

I enjoyed the PACE Roundtable and thought that it provided the faculty, industry members and students with a lot of valuable information. The organization is an excellent way to promote communication and interaction between those who teach, those who do, and those who will "build" the future.