Architectural Engineering 2012 Senior Thesis

Technical Assignment 1

Reston Station Phase 1 Garage | Reston, VA

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Executive Summary

Reston Station Phase 1 Garage is the first of many new building projects in Reston to usher in the arrival of the Metro Rail Silver Line Expansion in early 2014. The Wiehle Avenue stop on the new route running from downtown Washington D.C to Dulles International Airport lies adjacent to the new Reston Station project being built by Comstock Partners Limited and Fairfax County Virginia (a public-private partnership). The project consists of a 7 level, 1.3 million square foot underground garage that will one day be the foundation for 3 office buildings, a 700 unit apartment building, and a 20 story hotel.

Technical Assignment One investigates an array of project details regarding the in-progress construction of the Garage. This report contains a summary of the project schedule, systems, cost, and delivery method. The project began construction on April 4th, 2011 and its substantial completion date is scheduled for July 17th, 2013. Challenges to the schedule were evaluated including design delays that could put the July date in jeopardy. The building systems of the garage were also evaluated and insights were made regarding their impact on the construction efforts.

The cost data of the project was examined as well as new rough estimates were determined using software and historical reference data. Reston Station is an interesting site in terms of layout and construction methods and these are also analyzed in this report. Even outside of the construction fence, Northern Virginia has a lot environmental influences on the site and these are also considered here within.

Comstock Partners is a commercial developer that has big hopes for the Reston Station property and Fairfax County is an organization serving it's community by providing access to public transit. The background and relationships between these two owners is considered in the latter portions of this report. At its finale, however, the project delivery method and construction management team are investigated

In subsequent reports, the details of the project cost and schedule will be more thoroughly investigated and opportunities for overall better project delivery may be revealed.

Figure 1: Image Courtesy of penguinef (flickr)

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Project Schedule Summary

The Dulles Corridor Metrorail Project, otherwise known as the Metro Silver Line Expansion, is the overarching public transit project dictating the schedule for the Reston Station Garage. With plans for phase 1 of the new rail line to be operational at the beginning of 2014, Fairfax County must ensure that adequate parking is available for commuters that will be using the rail system daily. Fairfax County and Comstock Partner (a public-private partnership) chose to negotiate a Construction Manager at-risk contract with DAVIS Construction at an early stage in design of the garage project, which created unique situations and challenges in the schedule for construction. A summary schedule of the project, including phases of pre-construction, procurement, construction trades, and inspections/occupancy can be found in appendix A of this report.

Comstock Partners, the private entity of the owner team, requested DAVIS to assist with pre-construction in early 2010. At that point in time only schematic drawings were available for the purpose of coordinating construction efforts. Design Development drawings were completed in August of 2010 and a permit set of drawings were submitted on January 21st 2011. The formal notice to proceed for the project was issued for April 4th, 2011. The construction of the project was begun with an in-progress design that was planned to be completed in June of 2011.

The biggest schedule risk to the Reston Station Phase 1 Garage Project was design delays due to the attempt at a fast track project delivery (construction beginning without 100% design). This issue slowed on-site production considerably due to challenges in concrete shop drawing production and trade coordination. As of this date, complete construction drawings are planned to be complete in October of 2012, 16 months late. One major component causing the delay of design is the ongoing design of the buildings planned to go on top of the garage structure. This issue will be discussed in further detail in subsequent technical assignments.

The entire project was phased using an octant system to designate zones. Generally, all trades were to begin work in octant A in the North West corner of the building site and progress in sequence through the remaining octants B through H. A visual of this system in plan view can be seen in Figure 2. This system works well as several octants could be grouped together depending on the particular flow of work for any given trade. The construction sequences of the foundation, structural system, and finishes are available below.

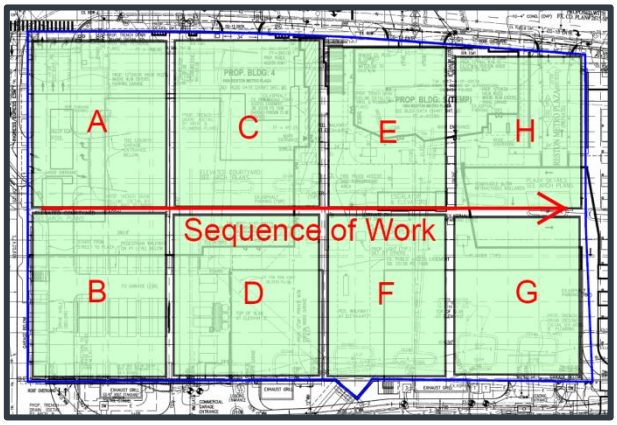


Figure 2: Octant Phasing Layout

Foundation

After almost 4 months of excavation to a depth of approximately 70 feet below original grade foundation activities were able to begin in octants A and B. Footings for columns, walls, and tower cranes were to be poured first. Following this a 5 inch slab on grade garage floor was poured into place. Formwork assembly for the footings began in octants A and B more than a full month before the excavation was complete in neighboring octants C and D.

The events that had the biggest impact on foundation construction were two natural disasters that occurred in August of 2011. The 2011 Virginia Earthquake occurred in the afternoon of August 23rd and 4 days later, on the 27th, Hurricane Irene caused 5 feet of water to accumulate in the excavation. These events and their effect on the schedule of the project will be discussed further in future technical assignments.

Structural

The structural sequencing of the project is driven by the concrete trade. The Western progress of the building consistently stayed 2 levels ahead of the Eastern half due to the phasing of trades. The building separation joint that runs north to south along column line 11 serves as dividing line between these progressions. Drawings, submittals, and work for the concrete trade are all organized in terms of octants. Within each of the eight octants there are approximately 6 separate slab pours. Typically, one slab pour occurs every work day.

Finishes

The rough-in and finishes sequences are broken into West and East halves of the building as opposed to sequencing each octant. MEP system installation, paint, and traffic coatings are to proceed after shoring is removed at each level. The construction of the project concludes after final finishes are put in place on the plaza level. Figure 2 below shows a simplified timeline of the major milestones and activities of the project.

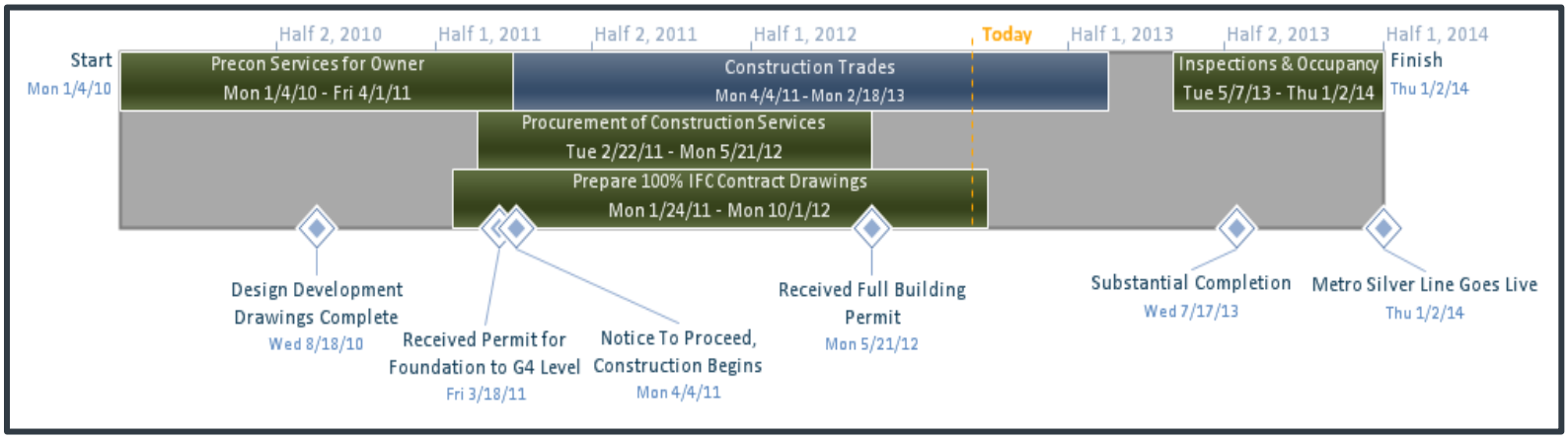


Figure 3: Summary Timeline of Project

Building Systems

Building Systems Checklist		
YES	NO	Building System
X		Demolition
X		Structural Steel
X		Cast in Place Concrete
	X	Precast Concrete
X		Mechanical System
X		Electrical System
X		Masonry
X		Curtain Wall
X		Support of Excavation

Demolition

The demolition at the Reston Station site consisted of the removal of an existing parking lot that was at existing grade level. There were also several utility lines that required relocation or removal. The parking lot was an approximate area of 170,000 square feet and was predominately asphalt with concrete 8" curbs. The demolition of the lot was performed with excavators, front end loaders, and other typical excavation equipment. Figure 3 to the right shows active demolition of the asphalt lot.

Figure 4: Demolition of Parking Lot

There are several considerations for existing utilities that must be removed or relocated in the excavation process as well. An underground electrical and cable television line running up the east side of the site must be safely relocated. In addition, an abandon water line to the southeast of the site needs to be removed.

Structural Steel

Figure 5: Composite Photo of Elephant Stand

Although the parking structure is a concrete two way slab system, there are unique instances in the structure where structural steel is utilized. In particular, a design feature known as the "elephant stand" is a network of transfer girders on the G1 level used to span a 60' by 60' area at the main vehicle entrance to the garage. The typical column spacing in the garage is 30' on center but at the elephant stand, two concentric squares made of W36x650 steel members are incased in 48"x48" concrete beams to span 60'. The steel members assembled in place prior to concrete encasement can be seen in Figure 4 to the left. The opening allows for easier car

accessibility and allows for an extra lane to ease traffic build up in and out of the structure. The columns return to 30' on center continuing up from the elephant stand and transfer their building loads to the inner nodes of the steel frame. There are also two steel trusses at the P1 and P2 levels to support a vehicle ramp through the p2 level directly above the elephant stand steel.

Cast in Place Concrete

The cast in place concrete at Reston Station is the largest system on site in terms of both cost and schedule. The structural system is a 2-way, flat slab with banded beams system with several moment frames throughout the building. Slabs are typically 8 inches thick with drop panels of 10 inches thick. The slabs have a 1.5% to 3% slope to accommodate draining of water into floor drains. North-South oriented column lines are spaced 30' on center while East-West oriented column lines are 15' on center. The rebar used in the concrete slabs is epoxy coated to protect against corrosion from road salt brought into the garage via vehicle tires. The design of upper levels of the garage have been changed to include a large number of post tensioned beams to accommodate construction loads of the above ground buildings without closing operations of the below ground garage.

A building separation joint runs along the North-South 11 line of the building. This joint helps protect the structure against transferring loads and displacements from one portion of the garage to the entire structure. The exterior walls of the garage are 16 inches thick at the G7 (deepest) level and decrease in thickness as each higher level resists a decreasing load due to soil pressures. The minimum thickness at the G2 level is 12 inches. Figure 5 shows active construction of a concrete slabs at the eastern perimeter of the building.

Figure 6: Concrete Slab Construction

Mechanical System

Mechanically, the garage has a fairly simple system but carries heavy loads due to the large volume and floor area of the underground space. There are 4 exhaust shafts at the southern perimeter of the building and 16 exhaust fans per floor. The fans are each 1.5hp and can exhaust a combined, 1.4 million cubic feet of air per minute from the garage. Two air intake shafts at the northern perimeter of the building deliver air to each floor using 8 supply fans on each of the 5 lower levels. In terms of controlling air temperature, heating is provided in limited areas by electric terminal heaters. There are a total of 19 CRAC (computer room air-conditioning) units on floors G7 to G2 to deliver cooling to computer spaces. In addition, DX split-system units are utilized in ticket kiosks and other personnel locations on the upper levels. Plumbing systems within the project are devoted to properly draining rain water from the upper levels to surface water management vaults where they can be pumped back to storm water utilities. There are a few potable water supply and sanitary sewer systems to provide proper plumbing to bathrooms.

Electrical System

The electrical utility provider to the project is Dominion Power. A transformer is located on the G3 level of the garage and feeds approximately 1500KVA to the main electrical switch board. Card readers, CRAC units, and common power receptacles are fed by 208/120V panels, while lighting fixtures, dewatering pumps, supply fans, and exhaust fans are fed by 480/288V. All garage drive aisles and parking areas are illuminated by LED surface mounted fixtures as a result of energy saving initiatives. Some fluorescent lighting is used in wall sconces and stairwell light fixtures.

Masonry

The masonry walls in the garage are not load bearing and are used only for fire rating and veneer anchoring purposes. Stairwells, elevator shafts, and walls dividing two or more areas of different intended uses are required to have a 2 hour fire rating. Masonry walls are to be reinforced at 16" on center and each reinforced cell is to be filled with grout. In some situations decorative CMU is required because there are some situations in which the finish material is exposed CMU. In these cases, pigmented mortar is required and certain non-standard textured units must be used. Although LEED certification is not being sought for this project, there is still a requirement in the project specification that CMUs be manufactured within 500 miles of the project site.

Curtain Wall

The curtain walls on site are above grade and used to create an appealing architectural finish with an aluminum framed glazing system. Several storefronts will also be installed on the plaza level for several retail locations. Curtain walls are mostly found on the north elevation of the building but the elevator lobby and escalator landings are also encased in a curtain wall structure.

Support of Excavation

The 70 foot deep excavation for the garage left behind nearly 120,000 square feet of vertical soil surface area that had to be safely secured to allow for work to proceed in the site. The system used to support the excavation walls was soldier piles and lagging. Over 300 steel H shape soldier piles of 50' in length were placed into the ground surrounding the excavation limits. As excavation progressed, a total of 120,000 square feet of lagging was installed between the piles and over 1000 tiebacks were installed. Tiebacks, also known as steel anchors, were secured into the site soil through the lagging using drilling operations and grout.

Figure 7: Soldier Piles and Lagging

Project Cost

The information provided in this portion of the report was provided by DAVIS Construction and some information has been altered to protect project financial data.

Project Financial Data			
Construction Cost	$79,000,000	Total Cost	$91,500,000
Construction Cost/Sq Ft	$ 60.77	Total Cost/Sq Ft	$ 70.38
Construction Cost/Parking Space	$ 25,599.48	Total Cost/Parking Space	$ 29,650.03

Table 1: Project Financial Data

Square Foot Cost Estimate

The R.S. Means square foot estimate for this structure can be found in APPENDIX C-1 of this report. This estimate was produced by the Means Cost Works software and it totaled a construction cost of $50,151,000. This estimate is almost $30 million dollars less in value than the real project cost. The reason for the large difference is most likely the assumptions that the software makes about the structure. The suggested maximum depth from the square foot estimating tool is 2 stories but Reston Station extends 7 stories underground. The software also doesn't account for the immense excavation demands as it underestimates "Basement Excavation" by $6 million. The system that was approximated the closest was concrete and even then, Means was shy by $5million. Actual data regarding the top 6 trades on site can be seen in table 2.

Major Trade Contracts		
Trade	Value	Value/SF
Concrete	$35,000,000	$26.92
Earthwork	$7,500,000	$5.77
Electrical	$7,000,000	$5.38
Sheeting & Shoring	$5,000,000	$3.85
Mechanical & Plumbing	$4,500,000	$3.46
Waterproofing	$3,000,000	$2.31

Table 2: Major Trade Contracts

System Assembly Estimate

The untraditional nature of a 7 story underground parking garage causes some difficulties in achieving an accurate assembly's estimate using a service like R.S. Means. The most challenging by far was the mechanical system assembly. In the garage, small unitary ductless systems condition the air in certain bathrooms and working areas but there is no central system for the garage. The largest mechanical equipment items are fans that ventilate air at a very high rate, performing a unit cost estimate of these and similar items would likely create a much more accurate estimate. The assembly estimates for several MEP systems can be found in APPENDIX C-2.

Site Plan

Existing Conditions

The Reston Station project site sat directly on top of the parking lot for the previous Metro Bus stop at Wiehle Ave. After closure of this lot, Metro Bus operations were moved one block to the north where street side stops currently occur alongside an annex parking lot. Site logistics on a project the size of Reston Station are incredibly important to the flow of work and efficiency of the project. An existing site layout plan in available in APPENDIX B-1 of this report. The site's closest neighbors are in the Sunset Hills Professional Center, a group of 3, two story office buildings that are also owned by Comstock Partners. While the properties are owned by the same owner, tenant considerations prohibit construction activities to leave the boundaries of construction at Reston Station.

The site is bordered to the East by Wiehle Avenue. This asphalt road is 4 lanes at the entrance to the site with a traffic light and turning lanes accommodating traffic into and out of the site. Once construction vehicles are in the site during preliminary phases it is possible for equipment to proceed to its intended location with little consideration for limitations within the site.

A small adjacent lot at the North East corner of the site provides ample space for construction trailers, waste dumpsters, material laydown area, and equipment storage containers. At the height of construction this space was able to accommodate 8 to 10 trailers plus over 60 personal vehicles.

Existing utility line locations are a vital aspect of the initial stages of construction due to the depth and size of the excavation required. There is a buried electrical line that used to power parking lot street lights running along the south perimeter of the future garage's footprint. Also, an abandoned storm sewer line cuts across the entire building footprint between 4 and 5 feet below grade.

Construction Site Plan

Excavation Phase

A diagram of the site layout for the excavation phase of construction can be found in APPENDIX B-2 of this report. The key feature of this plan is the ramp access to the excavation. Most importantly about this ramp is that it must both maintain a safe slope for vehicles and it must be in a location that is most advantageous for work flow. Possibly the largest limitation for the site is their inability to use a one-way traffic flow. This limitation is due to the inability for the

Figure 8: Excavation Ramp

site to have 2 ramps as well as the work being done directly to the east of the site on Office Building 1 (OB1). The best solution to this problem is to allow two-way traffic on site except while driving on the ramp.

Another consideration for the layout of the site is that piles must be driven before excavation begins in any given area because of lagging and excavation support concerns. Excavating at one end and slowly moving the ramp and excavation back towards the opposite wall makes clear sense. Considering the duration of excavation lasted 10 months, every gain in productivity can make a difference of days or weeks.

Concrete Structure Phase

The site layout for the structural phase of construction has both incredible assets as well as flaws. The most beneficial aspect of the process of pouring concrete at Reston Station is having two concrete batch plants on site. These plants cut down traffic in and out of the site immensely and the concrete mix contents can be monitored in real time.

Figure 9: Concrete Batch Plant

Even though the batch plants decrease the volume of traffic, the congestion of delivery and trade vehicles is still the biggest flaw in the site logistics. During the structural phase of construction the batch plants narrow the access the road to only 1 lane and there is only one gate for both entry and exit. This means trucks must pull in and back out while other trucks must wait for the delivery in front of them to be completed. This issue can lead to delivery backups at the entrance and in extreme cases trucks must occupy turning lanes outside of the gates until the area is clear for their delivery. Vehicles cannot exit the site at the south east due to the excavation of Office Building 1 (OB-1).

Finishes Phase

The finishes consist largely of painting, curtain walls, and veneers on CMU backing. The most notable consideration in the layout for these trades is the inclusion of scaffolding. The site layout in APPENDIX B-4 shows both a suggested location and progression of these units. At this stage in the project certain demobilization occurs including the tower cranes and some construction trailers.

In this phase of construction most portions of the garage will be open to vehicles. This is useful for the movement of materials and general area accessibility but it also carries certain risks. The floors will at some point be receiving traffic coating as a finish material and after it is applied it becomes the final product. Special care must be taken in this situation to assure that tires do not leave marks on the coating or it will need to be reapplied.

Local Conditions

There are several unique challenges and opportunities that are a result of the project's location in Reston, Virginia. Reston is a planned community of approximately 80,000 residents in northern Fairfax County. The zoning guidelines and enforcement in the area is controlled by the Fairfax County Planning Office. The property was originally zoned for industrial use so rezoning had to be achieved for mixed use office, retail, and residential. A local organization known as the Reston Association has their own planning and zoning committee but does not have statutory authority and only acts as an advisory board to other government authorities.

Soils and water conditions at the Reston Station project are incredibly important given the depth and volume of excavation needed for the construction of the garage. Data from a total of 33 test bores was taken into account when determining building foundations and considerations for the water level in excavation. Test results concluded that the design water table elevation was to begin at 370 feet above sea level (plaza level is at 410'). The lowest footings go down to a depth 37' beneath the designed water level in the soil. This requires water management with pumps and dewatering wells to lower the water table level.

Although a large area is available for construction trailers and vehicles on site, there is not nearly enough room to provide all 400 workers on site with their own space. It was explicit in the DAVIS subcontracts that parking was not the responsibility of the general contractor and two different solutions to this issue have been utilized by subcontractors. Miller & Long, the concrete subcontractor, made arrangements with the neighboring property to rent a portion of their lot for concrete work crews. Another method was used by the electrical subcontractor, J.E. Richards. They chose to use a company bussing system from a remote parking lot at their local office to get

work crews to the site. Both of these solutions saves the site from a lot of car traffic and allows the gates to be more available for daily material deliveries.

Since LEED certification was not sought after for the construction of this project recycling was limited. The only recycling effort that was well documented and carried out was the recycling of all extra steel. This was most evident in the recycling of rebar following concrete forming and placement. There was not any additional tipping fees charge by the local government beyond the charge of the service to remove the waste from the site.

Permits were an interesting challenge in the construction of the garage because of the fast-track method of construction. Since complete drawings were not available when construction was due to begin a building permit was approved up to the G4 level only. Later on, a full building permit was approved midway through construction.

In addition to the considerations listed above there are some trends in the local market and construction methods that impacted the project. For instance, due to the District of Columbia's building height restriction, many buildings are built from concrete to achieve small story heights. This benefits the Reston Station project because the D.C. metro area has an abundance of well qualified concrete sub-contractors. Miller & Long was ultimately awarded the $30 million contract for the cast-in-place concrete and they were able to utilize their own equipment, an experienced work force, and a large enough history of projects to utilize a high level of financial security.

Client Information

The primary incentive and driving motivation for the construction of the Reston Station civic complex is the arrival of the new Metrorail Silver Line. The Wiehle Avenue Station will be located in between the east and west bound lanes of the Dulles Toll Road (Rte. 267) just a few hundred feet to the west from the Wiehle Avenue. Fairfax County has taken this opportunity to expand the limited current parking to the north of the toll road into a mega public parking garage. Realizing the opportunity for a commercial, residential, and retail development, Comstock Partners Ltd. agreed to the terms of a 99 year lease on the private development of the above ground space of the garage. It is worth noting that traditionally, 99 year leases are assumed to be permanent and the 99 year term is considered a formality. Comstock has been in design development of 3 office buildings, a hotel, and an apartment building to be built up from the plaza of the garage.

Figure 10: Seal of the County of Fairfax

The owner team of the Reston Station project is unique due to the public-private partnership structure between Comstock Partners and Fairfax County, Virginia. The agreement between Comstock and Fairfax County divides the cost of construction according to the number of public versus private parking spaces available in the garage. There are a total of 3,058 parking spaces being constructed in the current phase of construction. Out of those spots, 2,318 (roughly 75%) are available to the public for commuting on both metro rail and metro bus services. As a result, the approximate $92 million dollar cost of construction was divided into two portions of roughly $70 million and $22 million to be paid by Fairfax County and Comstock respectfully. In addition to the split cost of construction, Comstock is to pay a monthly rent on the property for the entire duration of the lease.

The split ownership has also caused interesting issues in the phasing of the development and construction of the garage. Fairfax County is not concerned with the building of surface structures and requires that the garage be undisturbed throughout any future construction. This is a challenge to Comstock's future development of the site because traditionally shoring would have to be placed in the garage levels to help support the construction loads of the high rise construction above. This applies to the current garage design because a late structural change switched numerous cast-in-place concrete beams on the P1 level into post tensioned beams. This was a change that Comstock will be fully responsible for financially.

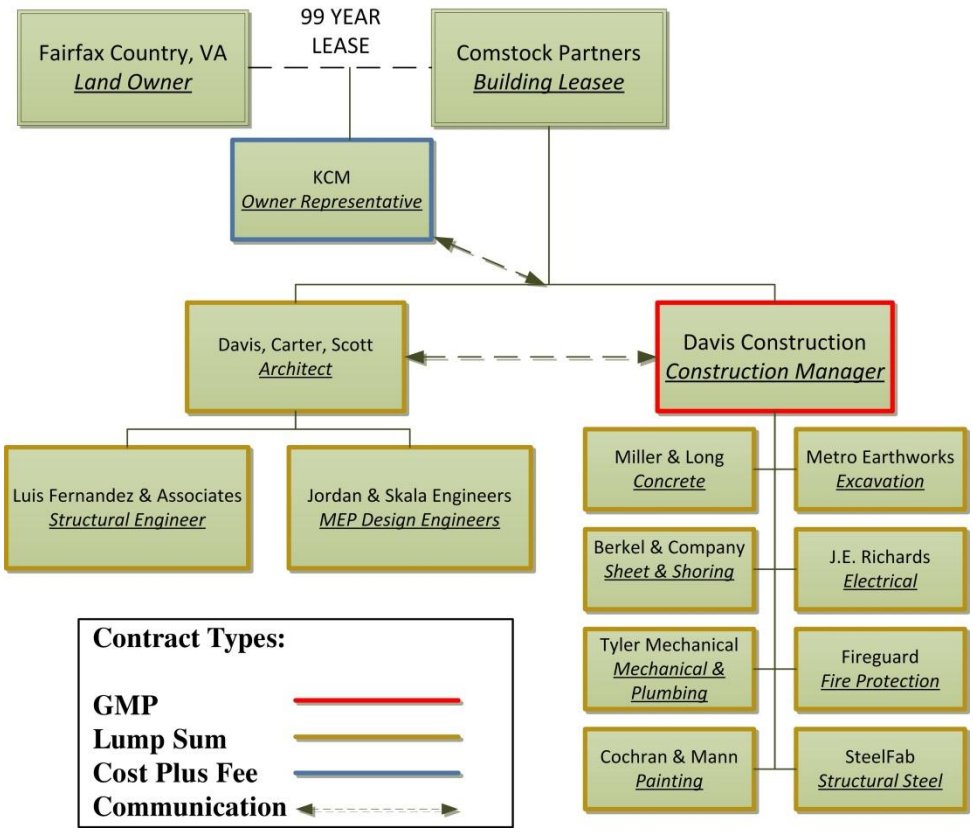
COMSTOCK PARTNERS™

Figure 11: Logo of Comstock Partners Ltd.

In order to secure the negotiated contract, DAVIS Construction, the construction management firm, agreed to a $5 million fee holiday. This means that for the first $5 million of change orders, there was to be no CM fee attached to the cost, the owner would simply pay the sub-contractor's time and material costs. With ongoing design changes at the upper levels due to the development of above ground buildings, the cost of changes is quickly approaching the holiday limit. Ownership is deeply concerned about these rising costs and is actively seeking solutions through design and construction integration.

Time is of the essence for the ownership of the project. Even though the substantial completion date and the planned arrival of the silver line are 6 months apart, gains can be made from the Metro bus terminal in the garage immediately after the garage is opened. The schedule has been critically delayed due to design delays. As construction catches up with current design progress, concrete crews have been decreased in man power and coordination with MEP trades has come to a standstill. This is of great concern to the CM because if the date of substantial completion is missed, the owner will surly seek after liquidated damages resulting from lost parking fees and bus ticket sales. Delivery of a finished product within the budgeted amount of time and without going egregiously over budget will be the key to pleasing the owner

Project Delivery



The project delivery method for the construction of the Reston Station Phase 1 Garage project was a negotiated GMP with DAVIS Construction as CM at-risk. DAVIS was chosen by Comstock in a large part due to their experience with DAVIS on another similar project at Louden Station in Louden County, VA. This project consisted of 3 large condominium facilities and the long term plans for the deployment of the property are very similar to the current plans for the Reston Station property. To assist with project team cohesion and general oversight, KCM was brought on by Fairfax County to act as an owner representative.

The delivery system for the project was unique and not typical of public owned projects. The 99 year lease that was mentioned previously allowed Comstock to negotiate a GMP with a CM at-risk for the construction of the garage. This was beneficial to Fairfax County because public entities are usually bound to taking the lowest bidder in an open bid, lump sum format. The county and Comstock Partners now has the benefit of preconstruction services and the luxury of a best value builder selection as opposed to being forced to take a risk on a low bidder.

The Davis GMP included a $5million fee holiday meaning that the first $5million of change orders would not include a GC fee, this effectively the contingency. The base contract included a GC fee of 3%. The preconstruction services up to the start of construction totaled approximately $200,000. Insurance on the project consists of commercial general liability insurance, a builder's risk insurance, and a payment & performance bond. The total cost of bonds and insurance amounts to 1.4% of the project value. Each subcontractor to DAVIS also had their own payment & performance bonds for their respected trades. These subcontracts are all lump-sum in nature.

The biggest challenge of the delivery method has arisen in the design. Due to the fast tracking of construction and continuously changing designs of above buildings, design firms are running out of money in their contracts to continue proper design delivery. The issues resulting from the delays has quickly compounded into higher prices than were originally projected in every aspect of the project.

Staffing Plan

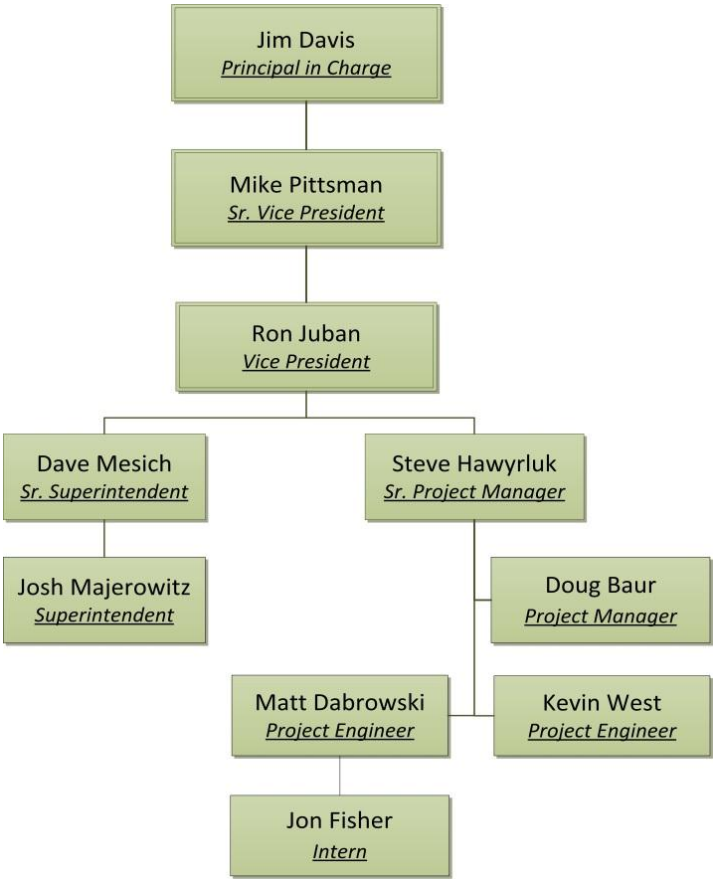


Figure 13: Project Staffing Diagram

The project team at Reston Station is typical of other projects led by DAVIS Construction. A Vice President (Ron Juban) is the project executive and oversees the operations of the project as well as several other large northern Virginia projects. The Sr. Vice President (Mike Pittsman) and company President (Jim Davis) are involved in leadership meetings on a bi-weekly basis but are not involved day to day.

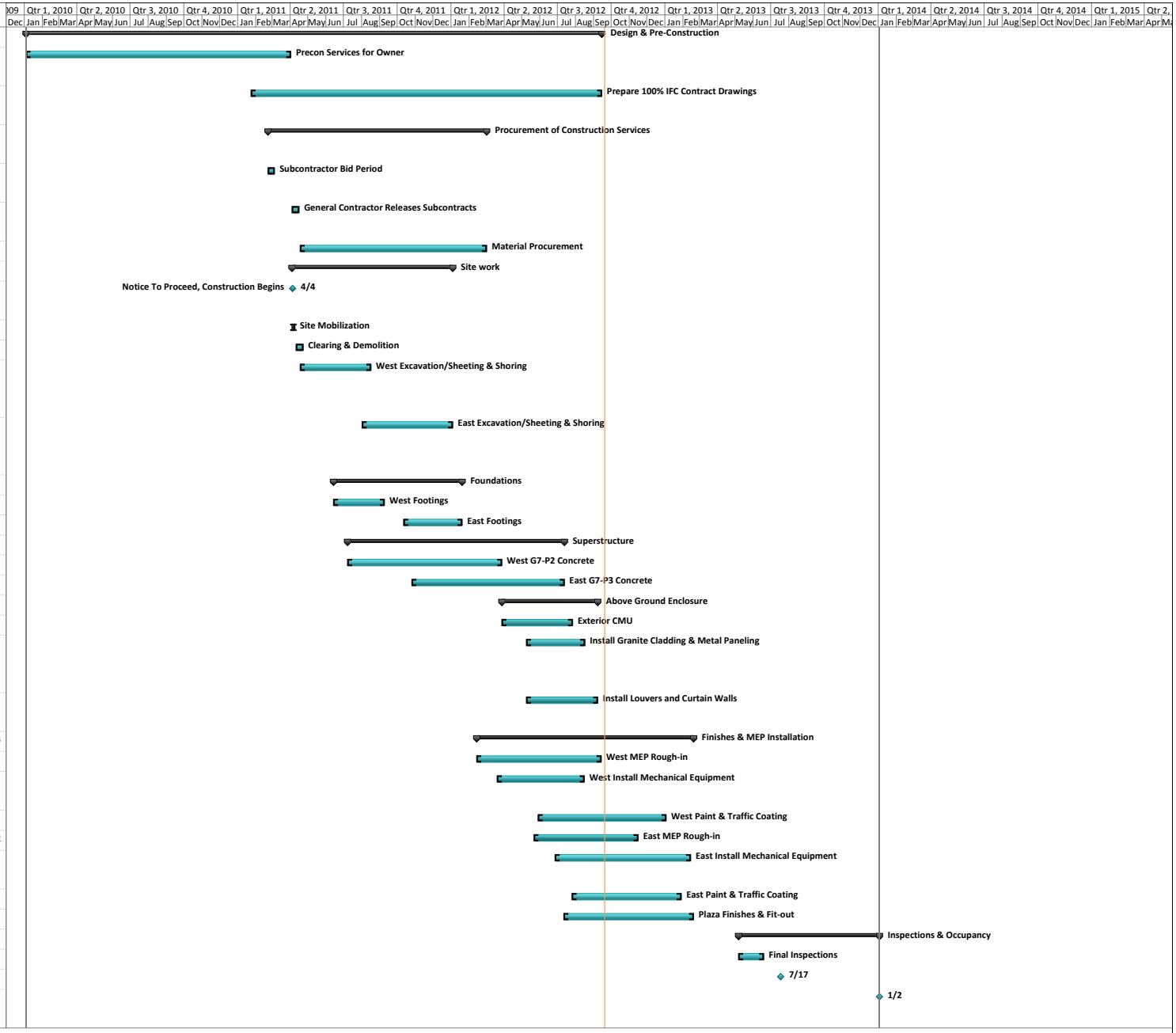
The full time personnel on site are divided into a field and a project management staff. A senior project manager is ultimately responsible for the project success and leads the project trailer. The project manager deals with day-to-day communications with the owner and project cost and schedule controls. Two project engineers split the management of trade work and the processing of submittals, RFI's, pay applications, and BIM integration. An additional project manager (Doug Baur) was brought onto the team when the degree of design changes and updates were realized. Given his wealth of experience in construction he was responsible for primary drawing review and preliminary trade coordination. An intern assists the project team in the summer months.

The field staff is led by a Sr. Superintendent (Dave Mesich) who is responsible for the safe and accurate construction of the garage. An additional superintendent and two layout engineers assist with the construction coordination of the garage. There are two additional contracts on the same site at the Phase 1 Garage, one is for the construction of the Office Building 1 garage, adjacent to Phase 1, and the other is for the road construction around the site. An additional project engineer and superintendent are on site full time for the construction of these projects.

APPENDIX A

Project Summary Schedule

ID	Task Name	Duration	Start	Finish
1	**Design & Pre-Construction**	**705 days**	**Mon 1/4/10**	**Fri 9/14/12**
2	Precon Services for Owner	325 days	Mon 1/4/10	Fri 4/1/11
3	Prepare 100% IFC Contract Drawings	430 days	Mon 1/24/11	Fri 9/14/12
4	**Procurement of Construction Services**	**268 days**	**Tue 2/22/11**	**Thu 3/1/12**
5	Subcontractor Bid Period	9 days	Tue 2/22/11	Fri 3/4/11
6	General Contractor Releases Subcontracts	10 days	Mon 4/4/11	Fri 4/15/11
7	Material Procurement	229 days	Mon 4/18/11	Thu 3/1/12
8	**Site work**	**197 days**	**Mon 4/4/11**	**Tue 1/3/12**
9	Notice To Proceed, Construction Begins	1 day	Mon 4/4/11	Mon 4/4/11
10	Site Mobilization	5 days	Mon 4/4/11	Fri 4/8/11
11	Clearing & Demolition	10 days	Mon 4/11/11	Fri 4/22/11
12	West Excavation/Sheeting & Shoring	87 days	Mon 4/18/11	Tue 8/16/11
13	East Excavation/Sheeting & Shoring	111 days	Tue 8/2/11	Tue 1/3/12
14	**Foundations**	**158 days**	**Tue 6/14/11**	**Thu 1/19/12**
15	West Footings	63 days	Tue 6/14/11	Thu 9/8/11
16	East Footings	72 days	Wed 10/12/11	Thu 1/19/12
17	**Superstructure**	**265 days**	**Fri 7/8/11**	**Thu 7/12/12**
18	West G7-P2 Concrete	188 days	Fri 7/8/11	Tue 3/27/12
19	East G7-P3 Concrete	187 days	Wed 10/26/11	Thu 7/12/12
20	**Above Ground Enclosure**	**118 days**	**Wed 3/28/12**	**Fri 9/7/12**
21	Exterior CMU	87 days	Wed 3/28/12	Thu 7/26/12
22	Install Granite Cladding & Metal Paneling	72 days	Wed 5/9/12	Thu 8/16/12
23	Install Louvers and Curtain Walls	88 days	Wed 5/9/12	Fri 9/7/12
24	**Finishes & MEP Installation**	**265 days**	**Tue 2/14/12**	**Mon 2/18/13**
25	West MEP Rough-in	153 days	Tue 2/14/12	Thu 9/13/12
26	West Install Mechanical Equipment	107 days	Tue 3/20/12	Wed 8/15/12
27	West Paint & Traffic Coatin	157 days	Tue 5/29/12	Wed 1/2/13
28	East MEP Rough-in	128 days	Tue 5/22/12	Thu 11/15/12
29	East Install Mechanical Equipment	166 days	Wed 6/27/12	Wed 2/13/13
30	East Paint & Traffic Coating	133 days	Thu 7/26/12	Mon 1/28/13
31	Plaza Finishes & Fit-out	158 days	Thu 7/12/12	Mon 2/18/13
32	**Inspections & Occupancy**	**173 days**	**Tue 5/7/13**	**Thu 1/2/14**
33	Final Inspections	31 days	Tue 5/7/13	Tue 6/18/13
34	Substantial Completion	1 day	Wed 7/17/13	Wed 7/17/13
35	Metro Silver Line Goes Live	1 day	Thu 1/2/14	Thu 1/2/14



Project: Summary Schedule
Date: Thu 9/20/12

Task	Summary	External Milestone	Inactive Summary	Manual Summary Rollup	Finish-only		
Split	Project Summary	Inactive Task	Manual Task	Manual Summary	Deadline		
Milestone	External Tasks	Inactive Milestone	Duration-only	Start-only	Progress		

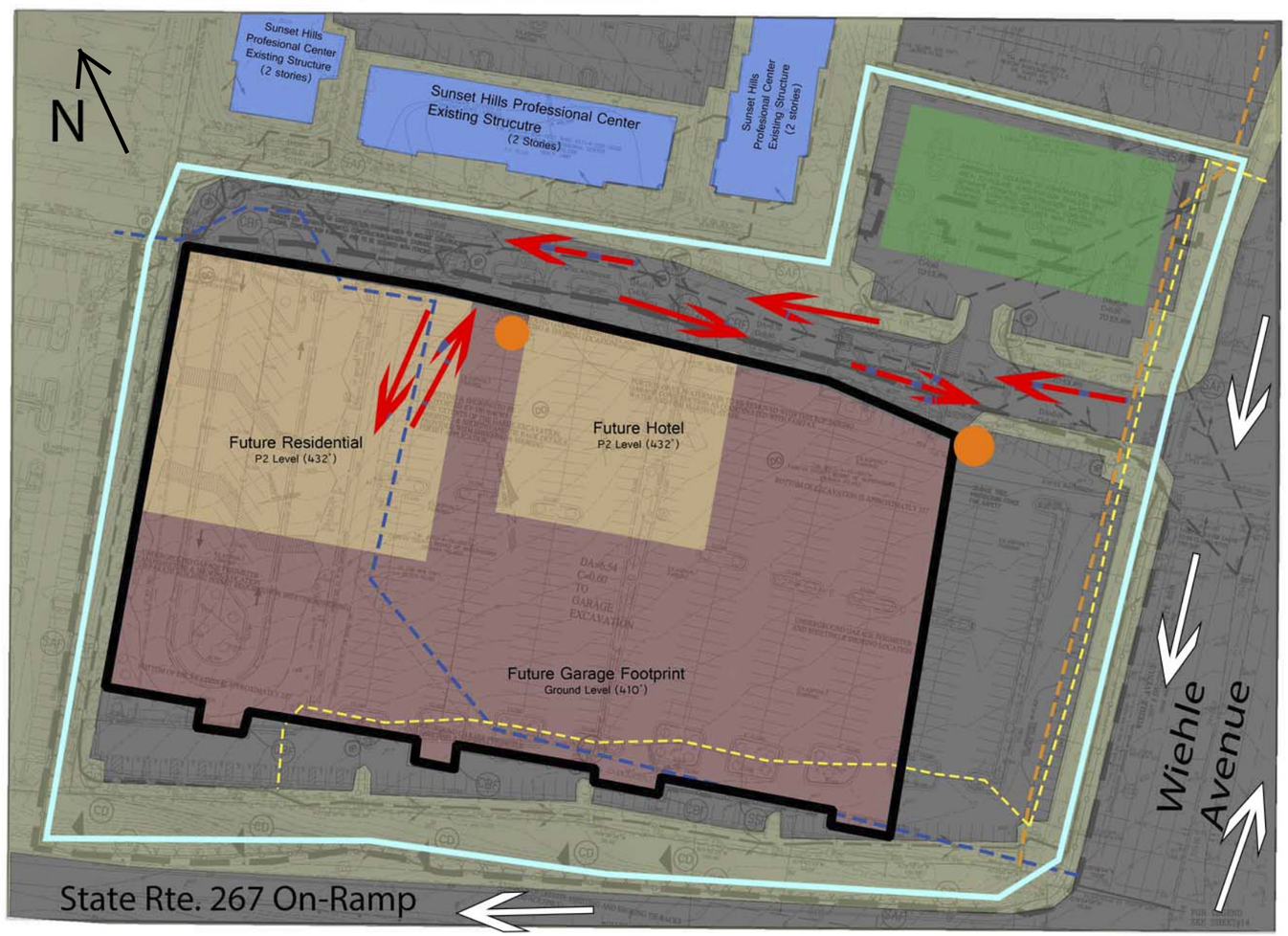
Jon Fisher
Building Summary Schedule
Date: 9/17/2012

Reston Station Phase 1 Garage
Reston, VA

Advisor: Dr. Leicht

APPENDIX B-1

Existing Site Conditions



1 Site
1" = 100'-0"

Temporary Fire Safety

Planned Garage Perimeter

Fence & Property Line

Construction Traffic

Public Use Traffic

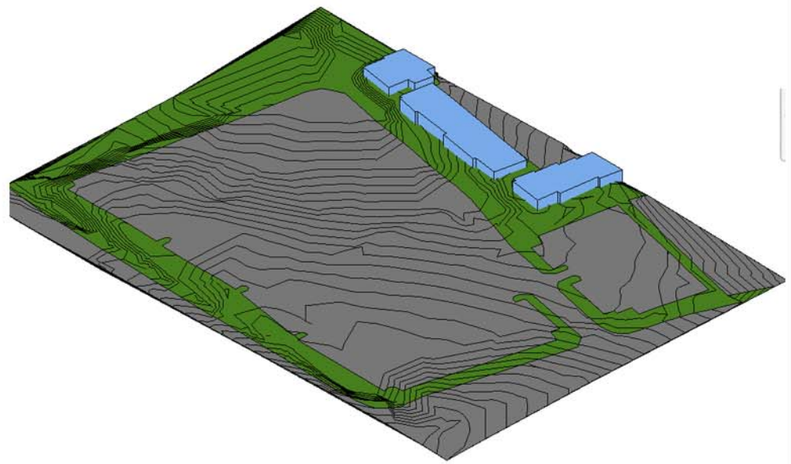
Below Grade Electrical

Below Grade Water & Storm

Below Grade Data

Existing Structures

Future Temporary Facilities



PENNSTATE
Department of
Architectural Engineering

Reston Station Phase 1 Garage

Jon Fisher

No.	Description	Date

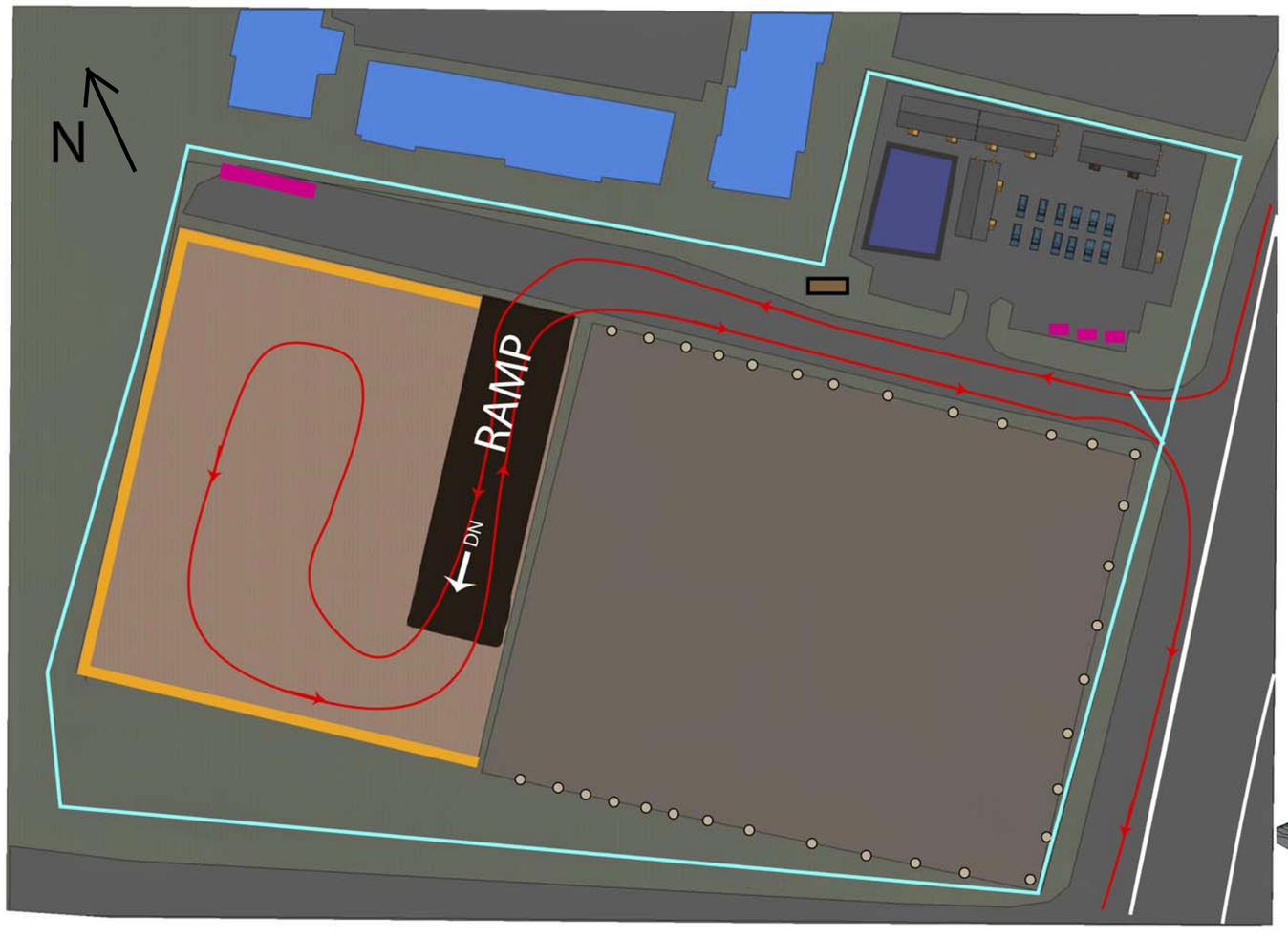
Existing Conditions Plan

Project number	TA1	001
Date	9/21/2012	
Drawn by	Jon Fisher	
Checked by		Scale 1" = 100'-0"

9/16/2012 8:03:11 PM

APPENDIX B-2

Excavation Phase Site Plan



1 Site
1" = 100'-0"

Contruction Trailer

12% Grade Ramp Access

Piles w/ Lagging

Piles (Limits of future excavation)

Soil Haul Traffic Pattern

Public Traffic

Portable Toilets

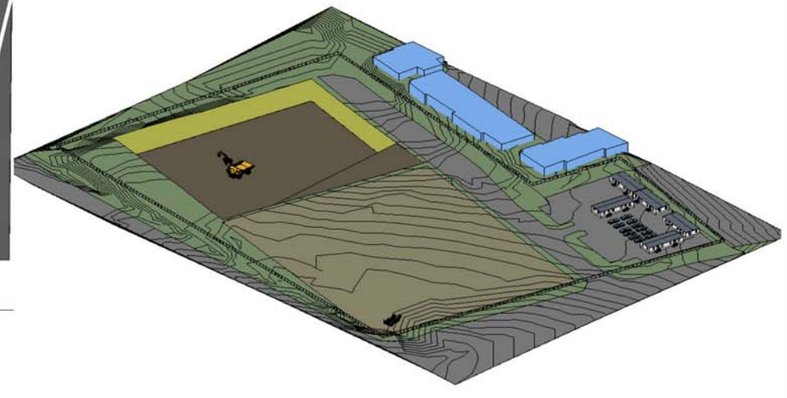
Limited Parking

Temp Power Transformer

Construction Fence and Gate

Laydown Area & Equipment Storage

Existing Structures



PENNSTATE
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Architectural Engineering

Technical Assignment 1

Jon Fisher

No.	Description	Date

Excavation Phase Logistics

Project number	TA1	002
Date	9/21/2012	
Drawn by	Jon Fisher	
Checked by	Checker	Scale 1" = 100'-0"

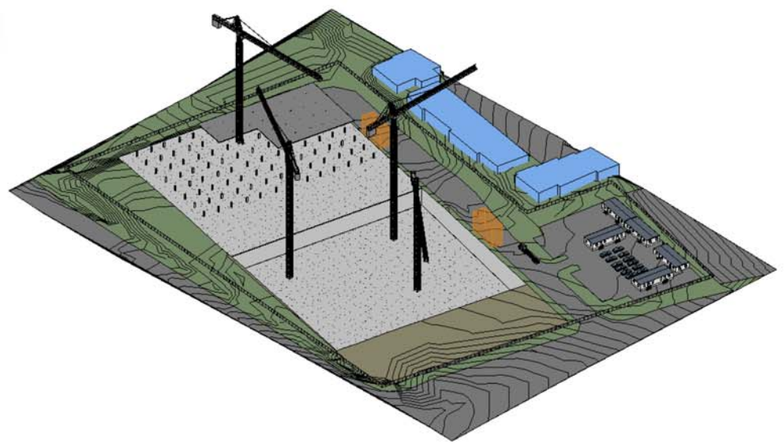
9/19/2012 10:31:28 PM

APPENDIX B-3

Structure Phase Site Plan

1 Site
1" = 100'-0"

Limited Parking
Construction Trailers
Pull-in Back-out Delivery Route
Public Traffic
Portable Toilets
Temp Power Transformer
Construction Fence & Gate
Laydown Area & Equipment Storage
Existing Buildings
Concrete Batch Plants
Site Access Points



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Technical Assignment 1

Jon Fisher

No.	Description	Date

Concrete Erection Phase Logistics

Project number	TA1	003
Date	9/21/2012	
Drawn by	Jon Fisher	
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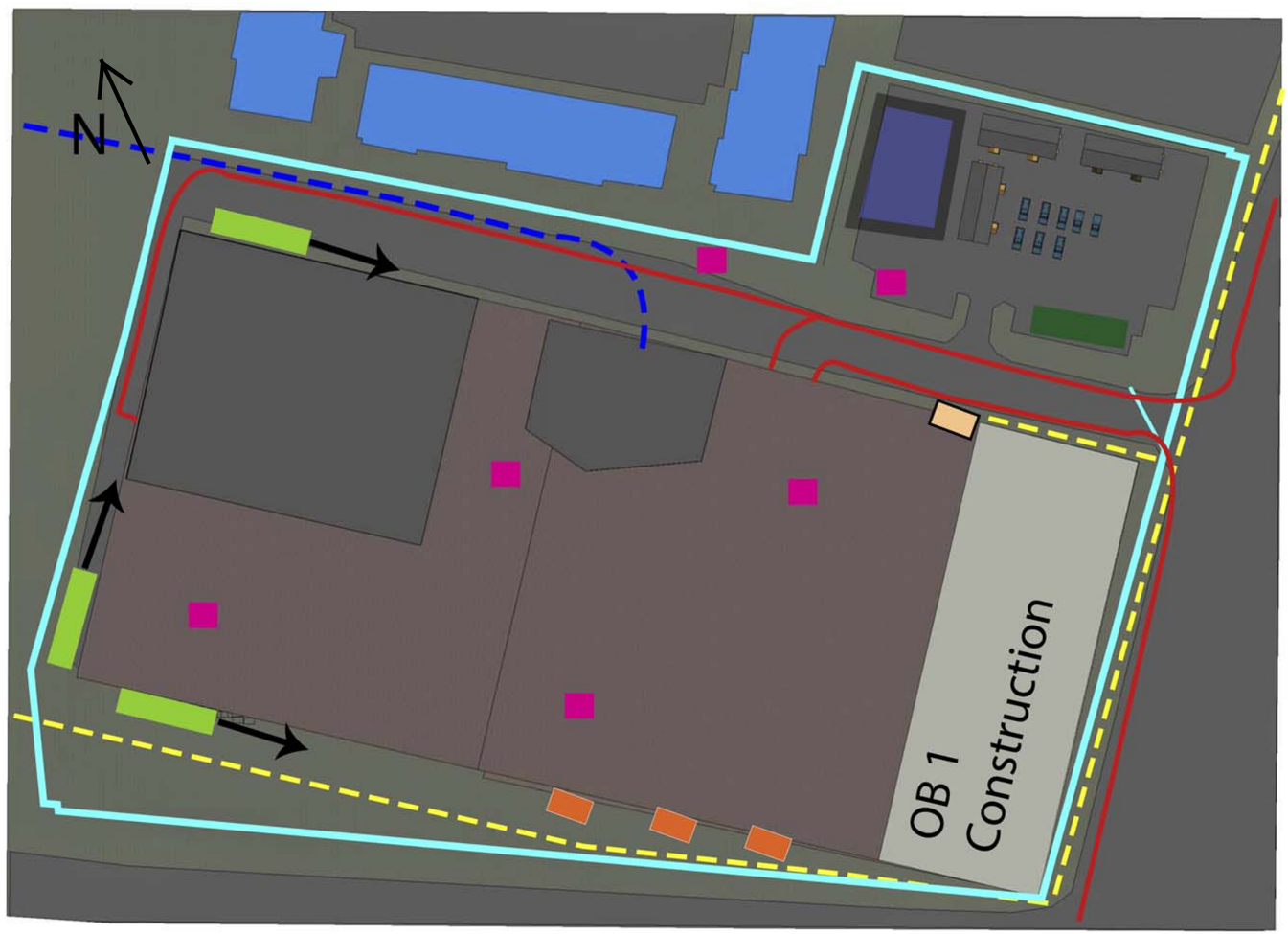
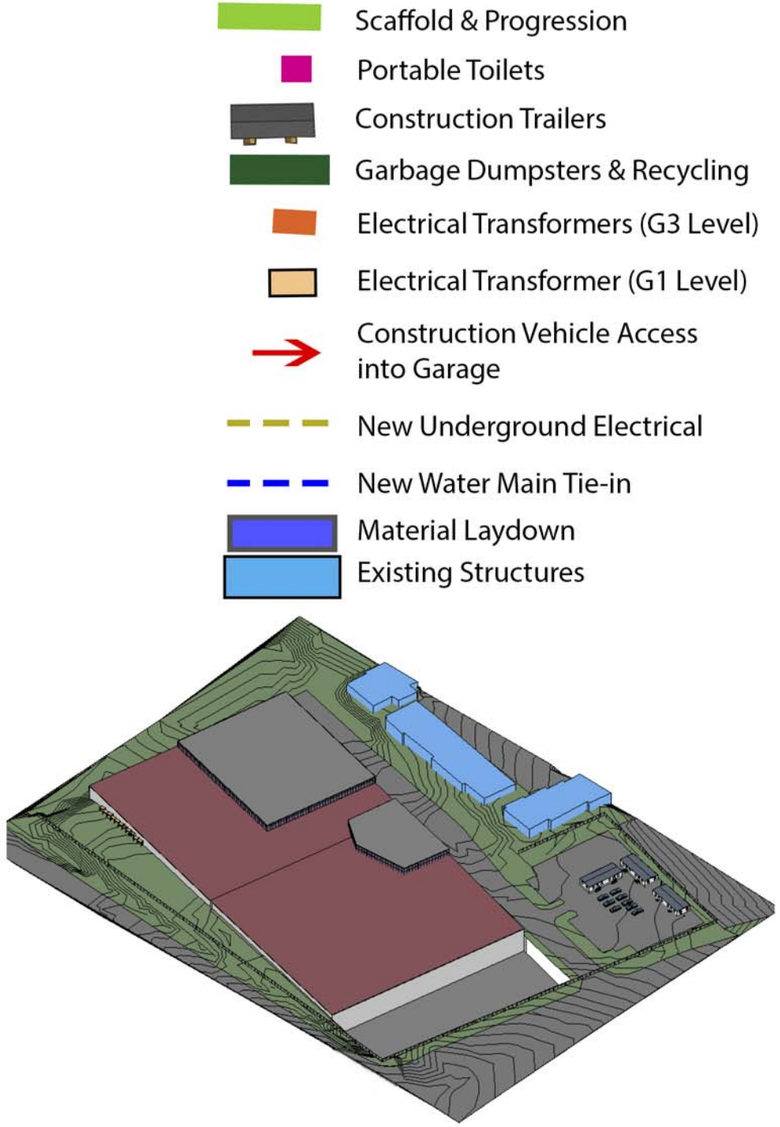
APPENDIX B-4

Finishes & Enclosure Phase
Site Plan



1 Site
1" = 100'-0"



- Limited Parking
- Construction Fence & Gate
- Scaffold & Progression
- Portable Toilets
- Construction Trailers
- Garbage Dumpsters & Recycling
- Electrical Transformers (G3 Level)
- Electrical Transformer (G1 Level)
- Construction Vehicle Access into Garage
- New Underground Electrical
- New Water Main Tie-in
- Material Laydown
- Existing Structures

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Technical Assignment 1

Jon Fisher

No.	Description	Date

Finish Trades Phase

Project number	TA1	004
Date	9/21/2012	
Drawn by	Jon Fisher	
Checked by	Checker	Scale 1" = 100'-0"

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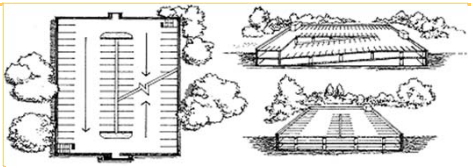
APPENDIX C-1

Square Foot Cost Estimate Data

Square Foot Cost Estimate Report

Estimate Name:	**Reston Station Phase 1 Garage**
Building Type:	**Garage, Underground Parking with Reinforced Concrete / R/Conc. Frame**
Location:	**FAIRFAX, VA**
Story Count:	**7**
Story Height (L.F.):	**10**
Floor Area (S.F.):	**1300000**
Labor Type:	**Union**
Basement Included:	**No**
Data Release:	**Year 2010**
Cost Per Square Foot:	**$38.58**
Building Cost:	**$50,151,000**



Costs are derived from a building model with basic components.

Scope differences and market conditions can cause costs to vary significantly.

		% of Total	Cost Per S.F.	Cost
A Substructure		**10.30%**	**$3.98**	**$5,168,500**
A1010	**Standard Foundations**		**$2.00**	**$2,602,500**
	KSF, 12" deep x 24" wide			
	8' -6" square x 20" deep			
	10' - 6" square x 25" deep			
	Foundation dampproofing, asphalt with fibers, 1/8" thick, 8' high			
A1030	**Slab on Grade**		**$0.83**	**$1,078,500**
	Slab on grade, 5" thick, light industrial, reinforced			
A2010	**Basement Excavation**		**$1.14**	**$1,487,500**
	site storage			
B Shell		**62.90%**	**$24.27**	**$31,551,500**
B1010	**Floor Construction**		**$18.95**	**$24,639,500**
	1000K load, 10'-14' story height, 740 lbs/LF, 4000PSI			
	bay, 200 PSF superimposed load, 355 PSF total load			
	superimposed load, 165 PSF total load			
B1020	**Roof Construction**		**$3.02**	**$3,923,500**
	deep beam, 9" slab, 209 PSF total load			
B2010	**Exterior Walls**		**$1.62**	**$2,102,000**
	Concrete wall, reinforced, 8' high, 8" thick, plain finish, 4000 PSI			
B2030	**Exterior Doors**		**$0.17**	**$217,500**
	6'-0" x 10'-0" opening			
	0" opening			
B3010	**Roof Coverings**		**$0.51**	**$669,000**
	Vinyl and neoprene membrane traffic deck			
C Interiors		**0.80%**	**$0.31**	**$402,000**
C1010	**Partitions**		**$0.05**	**$61,500**
	Concrere block (CMU) partition, light weight, hollow, 8" thick, no finish			
	8" concrete block partition			
C1020	**Interior Doors**		**$0.01**	**$7,500**
	0" x 7'-0" x 1-3/8"			
C2010	**Stair Construction**		**$0.25**	**$326,000**
	Stairs, CIP concrete, w/landing, 16 risers, with nosing			
C3010	**Wall Finishes**		**$0.01**	**$7,000**
	Painting, masonry or concrete, latex, brushwork, primer & 2 coats			

D Services		**24.80%**	**$9.55**	**$12,413,000**
D1010	**Elevators and Lifts**		**$1.58**	**$2,056,500**
	2 - Hydraulic, passenger elevator, 2500 lb, 2 floors, 100 FPM			
	Hydraulic passenger elevator, 2500 lb., 2 floor, 125 FPM			
D2010	**Plumbing Fixtures**		**$0.05**	**$60,500**
	Water closet, vitreous china, bowl only with flush valve, floor mount			
	Lavatory w/trim, wall hung, PE on CI, 19" x 17"			
D2020	**Domestic Water Distribution**		**$0.10**	**$124,000**
	Electric water heater, commercial, 100< F rise, 50 gallon tank, 9 KW 37 GPH			
D2040	**Rain Water Drainage**		**$0.93**	**$1,209,000**
	Roof drain, steel galv sch 40 threaded, 3" diam piping, 10' high			
	foot add			
D3050	**Terminal & Package Units**		**$0.14**	**$186,000**
	16000 CFM, 5 HP vane axial fan			
D4010	**Sprinklers**		**$3.27**	**$4,253,500**
	Dry pipe sprinkler systems, steel, ordinary hazard, 1 floor, 50,000 SF			
	50,000 SF			
D4020	**Standpipes**		**$0.12**	**$158,000**
	Dry standpipe risers, class III, steel, black, sch 40, 4" diam pipe, 1 floor			
	floors			
D5010	**Electrical Service/Distribution**		**$0.12**	**$154,500**
	phase, 4 wire, 120/208 V, 200 A			
	Feeder installation 600 V, including RGS conduit and XHHW wire, 200 A			
	Switchgear installation, incl switchboard, panels & circuit breaker, 400 A			
D5020	**Lighting and Branch Wiring**		**$3.01**	**$3,915,000**
	Receptacles incl plate, box, conduit, wire, 2.5 per 1000 SF, .3 watts per SF			
	Miscellaneous power, to 1 watts			
	fixtures @32 watt per 1000 SF			
D5030	**Communications and Security**		**$0.16**	**$214,500**
	detectors, includes outlets, boxes, conduit and wire			
	conduit			
D5090	**Other Electrical Systems**		**$0.06**	**$81,500**
	gas/gasoline operated, 3 phase, 4 wire, 277/480 V, 11.5 kW			
E Equipment & Furnishings		**1.20%**	**$0.47**	**$616,000**
E1030	**Vehicular Equipment**		**$0.36**	**$463,500**
	way			
	economy			
	computing			
E1090	**Other Equipment**		**$0.12**	**$152,500**
	posts			
	3000 - Pavement markings, parking stall, paint, white, 4" wide			
	1 - Parking control equipment, parking control software, max			
F Special Construction		**0.00%**	**$0.00**	**$0**
G Building Sitework		**0.00%**	**$0.00**	**$0**

SubTotal	**100%**	**$38.58**	**$50,151,000**
Contractor Fees (General Conditions,Overhead,Profit)	**0.00%**	**$0.00**	**$0**
Architectural Fees	**0.00%**	**$0.00**	**$0**
User Fees	**0.00%**	**$0.00**	**$0**
Total Building Cost		**$38.58**	**$50,151,000**

APPENDIX C-2

Assembly Cost Estimate Data

MEP Assemblies Cost Estimate

Assembly Number	Description	Quantity	Unit	Materials	Labor	Total	Total Cost of Assembly
Mechanical Systems							
D3050 185 0580	CRAC, 3TON, Air cooled, Includes Remote Condenser	19	Ea	$19,600.00	$2,425.00	$22,025.00	$418,475.00
Total Mechanical							**$418,475.00**
Electrical Systems							
D5010 240 0400	2000A Switchgear	2	Ea	$ 35,800.00	$ 20,600.00	$ 56,400.00	$ 112,800.00
D5020 218 0400	Flourescent lighting, 1 Watt/SF	1,500,000	SF	$ 1.58	$ 2.06	$ 3.64	$ 5,460,000.00
D5020 135 0440	Misc Power to 2 Watts	1,500,000	SF	$ 0.13	$ 0.40	$ 0.53	$ 795,000.00
Total Electrical							**$ 6,367,800.00**
Fire Protection System							
D4010 310 0640	Dry Pipe Sprinkler System, Light Haz 50,000SF (1st floor)	200,000	SF	$ 1.80	$ 1.72	$ 3.52	$ 704,000.00
D4010 310 0760	Dry Pipe Sprinkler System, Light Haz 50,000SF(additional floors)	1,300,000	SF	$ 1.37	$ 1.53	$ 2.90	$ 3,770,000.00
Total Fire Protection							**$ 4,474,000.00**
Plumbing							
D2010 310 1560	Lavatory w/ trim	3	Ea	$ 800.00	$ 700.00	$ 1,500.00	$ 4,500.00
D2010 110 2080	Wall Hung Water Closet	3	Ea	$ 1,800.00	$ 795.00	$ 2,595.00	$ 7,785.00
D2020 240 2020	Electric Water Heater	2	Ea	$ 29,900.00	$ 1,825.00	$ 31,725.00	$ 63,450.00
Total Plumbing							**$ 75,735.00**