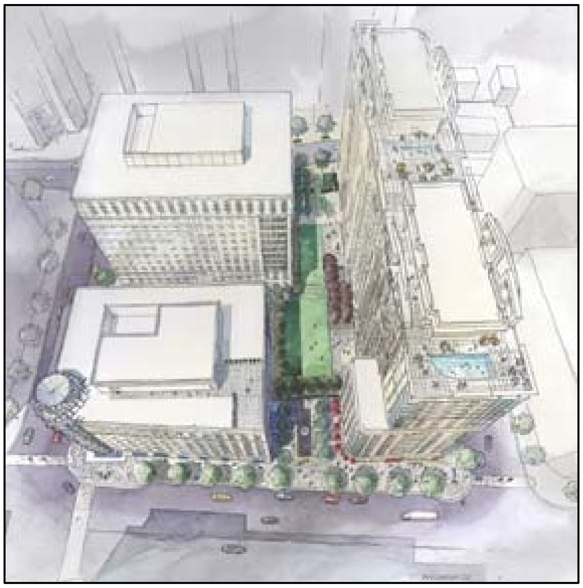
THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF ARCHITECTURAL ENGINEERING
CONSTRUCTION MANAGEMENT

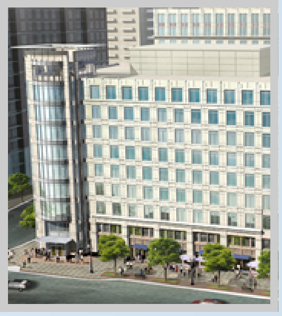
TWO LIBERTY CENTER



NATHANAEL J. PAIST
SENIOR THESIS FINAL REPORT
APRIL 12, 2007

Two Liberty Center

Arlington, VA



Project Overview:

- 34 Million Dollars
- 180,000 SF Class-A office space
- 130,000 SF underground parking
- Ground Floor Retail Spaces
- August 2007 completion
- Phased occupancy by floor
- Part of mixed-use site expansion

Architectural Features:

- Featured Glass Tower
- Pre-Cast concrete façade with textured rock-face detail
- Glass curtain wall sections at ground level
- Natural stone and terrazzo-floored lobby

Structural System:

- Cast-in-Place Concrete
- Concrete Slabs and Frame
- 4 Concrete shear walls at core
- Post-tensioned slabs above ground floor
- Cast-in-Place Concrete Spread Footings

Mechanical Systems:

- 12 Factory Built Air Handling Units
- Electric heating coils
- Chilled water cooling coils fed by central plant
- Digitally controlled multiple zones with VAV boxes

Electrical System:

- 277/480V, 3-phase, 4-wire, 8000A utility service Junction Box
- Two 3000A Main Switchboards
- 1200A bus gutter for retail
- 5,840 kVA total connected load
- Diesel engine emergency generator for minimum 687.5 kVA load

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Executive Summary

This following senior thesis report is a detailed analysis of the design and construction of Two Liberty Center as well as an investigation of current issues facing the construction industry. The body of the report is divided into six major sections.

The first two sections of the report provide information important to gain an understanding of the construction planning and processes as well as basic design elements of the building. Understanding of the content of these first sections is critical to fully grasp the content of the later sections of the report.

Section three of the report is based on research completed based on the effect that the cost of energy is having on the way new construction projects are being developed. This research based analysis considers the role that developers have in initiating construction projects and how there role is moving towards one with greater concern for building efficiency and sustainability.

The fourth section is a construction based analysis that looks to provide an opportunity for substantial schedule savings on Two Liberty Center project. These schedule savings are achieved through an analysis and re-sequencing of the façade construction process.

The final two sections of this report are intended to demonstrate some of the alternative practices identified in the research analysis from section three. Section five is a mechanical based analysis centralizing the mechanical system of Two Liberty Center to provide the building owner with the opportunity for savings on utility costs. The sixth and final analysis is architectural based and focuses on the implementation of green roofs as a sustainable practice and aesthetic marketing tool with functional benefits.

Introduction

Building Introduction

Two Liberty Center is a Class-A office building being built in a rapidly developing section of Arlington County in Virginia. The 180,000 SF of rentable office space will be housed in the second through ninth floors of the nine story building and leased per floor. Ground level space will serve as support space for office building operations, with perimeter spaces leased as high-end retail. Parking for the site will be accomplished though three and a half below grade garage levels. The architectural design for this building was modeled after the neighboring and existing Liberty Center building, with a distinguishing architectural glass tower featured at southwest corner of the building.

Client Introduction

The owner of Two Liberty Center is an investor group led by The Shooshan Company, a full service real estate developing firm from the area. This building is being kept by the owner and will be leased to multiple tenants, so the owner is more involved and has a higher focus on quality than many other developers that focus on upfront savings. These expectations by the owner are exemplified in the high level of material quality being used in construction, including an efficient but slightly more expensive mechanical system as well as the high-end finishes for the lobby and entry areas.

There are already several floors of the building under lease upon completion so there is an aggressive move-in schedule being enforced by the owner. Tenant fit-out will occur in phases by floor and will overlap with construction activities on floors above the completed floors. The potential damages that the owner would incur should the occupancy schedule be delayed are included in the contract between the owner and the contractor as liquidated damages.

1. Project Information

Project Schedule

(See Appendix 1.1 for Detailed Project Schedule)

Key Project Dates

Schematic Design Begins……………………...	14 April 2004
Design Issued for Bid…………………….........	21 March 2005
Begin Foundations and Excavation……………	26 December 2005
Start Above Grade Structure…………………..	15 August 2006
Design Complete………………………………	17 April 2007
Start Hanging Drywall……………...................	18 April 2007
Substantial Completion………………………..	8 September 2007

Key Sequencing Aspects

Foundation footings and slab on grade are to be completed before the start of the concrete frame structure. The structural frame is erected in sequence starting with the columns at the slab on grade, followed by the first elevated slab, then repeating that sequence placing entire levels of columns followed by the full slabs above them. Once the concrete structure is completed to the roof-level slab, the erection of the pre-cast concrete panel façade begins. The exterior walls are erected from the ground to roof at each face before moving the crane and beginning the next face. Following the completion of the final face of exterior wall, the windows and glass are installed per floor, beginning at the ground level and working up to the ninth level. Interior finishes begin prior to each floor's windows and glass being installed. Turn over to the owner is performed per floor as that floor is completed.

Project Cost

Actual Building Costs

Total Construction Costs:

- $34,000,000.00
- $109.00 $/SF

Parametric Estimate

Expected costs for Two Liberty Center have been estimated based on data from similar buildings using the *D4 Cost 2002* estimating software. Buildings from the database were selected for comparison based on building type, building size, location and basic design features. Three buildings were selected and then averaged using the Smart Averaging feature. All three buildings were new construction office buildings with concrete foundations and concrete floors. Two of the three buildings were constructed in the same general region as Two Liberty Center, with of those two also being a second building of a complex built to complement the first, and the other of the two having an attached parking facility similar to Two Liberty Center. The following chart outlines the source data and reports the final data for Two Liberty Center, including the adjustment for location and total square footage:

Summary Chart for Parametric Estimate

(Reports from D4 Cost 2002 can be found in Appendix 1.2)

Parametric Estimate for Two Liberty Center

building	location	year built	size (SF)	Cost/SF	Cost
Woodlands Two	MD	1998	120,000	$41.76	$5,623,260.00
Netplex Plaza	VA	1999	171,800	$47.84	$8,153,214.00
Ha-Lo Headquarters	IL	1998	267,300	$151.21	$40,134,138.00
Two Liberty Center	**VA**	**2005**	**180,000**	**$186.98**	**$33,656,395.00**

Square Foot Estimate

This estimate was performed using the square foot modeling feature of *R.S. Means – Cost Works 2005* software. Since Two Liberty Center has two major components, the below grade parking structure and the above grade office building, two estimates were performed and the addition of the two is meant to produce a single cost estimate for Two Liberty Center. Values were modified by a 15% factor to account for the additional money invested by the owner to produce a high-end and efficient building. The following chart summarizes the square footage estimate produced:

Summary Chart for Square Foot Estimate

(Detailed reports from Cost Works 2005 can be found in Appendix 1.3)

Garage Estimate			
Model Type: Garage, Underground Parking, Reinforced Concrete / R/Conc. Frame			
Stories (Ea.): 4		**Location:**	Arlington, VA
Story Height (L.F.): 10		**Data Release:**	2005
Floor Area (S.F.): 130000		**Wage Rate:**	Union
Basement: Not Applicable			
		Cost/SF	Cost
	Sub-Total	$37.84	$4,919,325.00
GENERAL CONDITIONS (Overhead & Profit)	25%	$9.46	$1,230,000.00
ARCHITECTURAL FEES	8%	$3.78	$492,000.00
CLASS A MODIFIER	15%	$7.66	$996,198.75
TOTAL GARAGE COST		**$58.75**	**$7,637,523.75**
Office Building Estimate			
Model Type: Office, 5-10 Story, Precast Concrete Panel / R/Conc. Frame			
Stories (Ea.): 9		**Location:**	Arlington, VA
Story Height (L.F.): 12		**Data Release:**	2005
Floor Area (S.F.): 180000		**Wage Rate:**	Union
Basement: Not Included			
		Cost/SF	Cost
	Sub-Total	$75.39	$13,570,875.00
GENERAL CONDITIONS (Overhead & Profit)	25%	$18.85	$3,392,500.00
ARCHITECTURAL FEES	6%	$5.66	$1,018,000.00
CLASS A MODIFIER	15%	$14.99	$2,697,206.25
TOTAL OFFICE BUILDING COST		**$114.89**	**$20,678,581.25**
Total Building Cost			
Model Type: Office with Subgrade Garage, 9 Story Office with 4 Story Garage			
Stories (Ea.): 13		**Location:**	Arlington, VA
Story Height (L.F.): 12		**Data Release:**	2005
Floor Area (S.F.): 310,000		**Wage Rate:**	Union
		Cost/SF	Cost
GARAGE COST		$58.75	$7,637,523.75
OFFICE BUILDING COST		$114.89	$20,678,581.25
TOTAL COSTS		**$91.34**	**$28,316,105.00**

Site Conditions

(See Appendix 1.4 for Site Utilization Plan)

Two Liberty Center is being constructed in downtown Ballston, a very rapidly developing and active section of Arlington County. The local conditions leave very little space for site activity and create potential complications with vehicular and pedestrian traffic. Vehicular traffic is most critical on the south side of the site, where the busiest adjacent street is, so the majority of site activity will need to take place on the east and west sides of the site or during the off-peak hours on the south side. Pedestrians are redirected to avoid the east and west sides of the site and provided with a covered walkway along the south side. Concrete jersey barriers line all sides of the site to protect the site and the pedestrians along the south side from vehicular accidents. There is no room for on-site parking, so contractors and site visitors need to make use of existing parking facilities in the area or take advantage of the close proximity to public transportation access.

Local Conditions

Regional Construction

The Arlington area falls into the trends of the Washington DC market because of the close proximity and shared contractors. These contractors typically build structures with steel reinforced cast-in-place concrete, and have recently seen a trend with pre-cast concrete panel exterior wall construction.

Excavation

This site was excavated as part of a larger excavation for all three of the buildings being built on the same complex. There was very little ground-water encountered during the excavation, but some water was removed from the site using standalone pumps. The soils being excavated contained some areas of rock that created the potential for some

concealed conditions costs, but this rock was found to be soft enough for standard excavation methods. There were also contaminated samples of soil discovered during the excavation. These contaminated sections of soil were removed from the site with minimal additional costs. Soil removal was a large portion of the estimated cost of excavation since there was not room on site or nearby for a stock pile. Soils to be reused were shipped to a remote location and stored until backfilling was ready to take place.

Local Constraints

The governing local authorities added additional complications to the planning of this project. Permit review by the local county has an abnormally long lead time. This extended duration places emphasis on early completion of design to ensure construction will not be delayed by permitting. The local authority also places restrictions on the "noisy" working hours since this site is zoned for apartments as well as commercial and office. Noisy work can't begin on site until after 7am on the weekdays and 10am on the weekends. These restrictions limit the types of activities that can occur on the site prior to those times.

Project Delivery

This project is being delivered under a modification of the traditional design-bid-build method. The contractor for this building was selected without bid by the owner and negotiated during the design phase. Negotiations included budgeting at several phases of design to assist the owner in making critical design criteria decisions. The contractor is being held under a cost-plus-fee contract with a guaranteed maximum price. After design was completed, the sub-contracts were released for a competitive bid and awarded based on lowest cost with most reliable scope.

2. Design Information

Construction Details

Two Liberty Center is a shell and core office building being constructed as part of a three building expansion of the Liberty Center complex. The project is being delivered under a modified design-bid-build method. Modification to the traditional method includes the involvement of the general contractor as a negotiator during the design phase. For their services on the project, the general contractor is held under a cost plus fee contract with a guaranteed maximum price. Trade contracts were awarded after a competitive bid, and were selected on the basis of lowest cost with the most reliable scope of work.

Structural System

The super-structure of the building is composed of reinforced cast-in-place concrete slabs and frame. All elevated slabs are 8” thick and slabs for floors 2 through 9 are post-tensioned to accommodate a typical bay size of 20’x 40’. The foundation consists of cast-in-place concrete spread footings with a 5” thick cast-in-place slab on grade.

Curtain Wall

The building enclosure is a combination of pre-cast concrete panels with some areas of glass curtain wall systems. Glass curtain walls are located in two major areas: around the ground floor of the building, and up the architectural glass tower above the main entrance to the building. Pre-cast concrete panels make up the rest of the façade and are finished with traditional punch windows.

Mechanical System

Conditioned air for Two Liberty Center is supplied by 12 Factory-Built Air Handling Units with chilled water cooling coils and electric heating coils. Cooling capacity is provided through a central chilled water plant consisting of 2 centrifugal water chilling units and 2 roof-top cooling towers. Air volume is digitally controlled for multiple zones provided by Variable-Air-Volume boxes.

Electrical System

Service for the building is provided through a 277/480V, 3-phase, 4-wire, 8000A Utility Service Junction Box. Distribution through the building is handled by two 277/480V, 3-phase, 4-wire, 3000A switchboards, with an additional 277/480V, 3-phase, 4-wire, wye-connected, 1200A Bus Gutter for Retail service connection. Total connected loads for the two switchboards, MS1 and MS2, are 1852kVA and 2784kVA respectively, in addition to a total connected load for the retail bus gutter of 1203kVA. Emergency power will be provided through a diesel engine driven electric generator set rated for 277/480V, 3-phase, 4-wire, for a minimum 550kW/687.5kVA load.

3. Research Topic – Building Efficiency for Developers

Problem Statement

During the PACE Roundtable conference of the fall 2006, the recent trends in energy costs were identified and discussed as a critical issue facing the current construction industry. Increases over the past several years have added additional weight to many of the pre-construction decisions made about a building, especially those that directly affect the efficiency of the produced building. Since profit is their primary concern during a construction project, developers are particularly affected by these unpredictable and significant changes in the future operation costs of a new building.

Research Goal

The goal of this research analysis will be to identify the relationships between the leasing models used by a developer and the decisions that they make regarding building efficiency and sustainability. Construction projects for developers are driven by business models and the optimization of profit. The decisions that are made for a building being built for a developer rely heavily on the intended use for that facility and the types of leasing agreements to be used for the tenants of that building. This analysis will provide insight into the effects that energy costs are having on the decisions that developers are making about their building systems.

Research Method

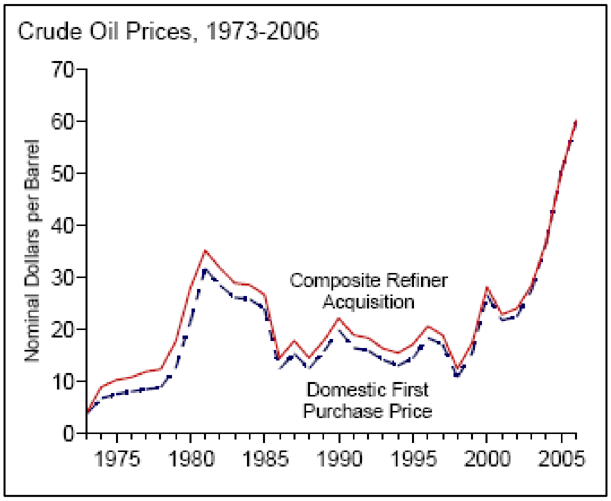
The following steps have been taken to achieve the research goals set forth above. For the purpose of consistency, location dependent information has been focused on Washington, DC and its surrounding areas.

1. Collect information on energy costs and trends to gain perspective on the influence of these figures

2. Collect existing professional articles and documents relative to this research.
3. Develop and conduct interviews with developers and construction professionals to gain insight to current experiences related to the research topic.
4. Document interview responses for future reference.
5. Analyze collected data to find trends within the relationship between building efficiency/sustainability and development options.
6. Make recommendations for developers facing pre-construction decisions relating to the efficiency and sustainability of a building.
7. Draw conclusions and make predictions for the future of this issue in the construction industry.

Recent Trends in Energy Costs

Costs to occupy any space whether it’s an apartment, house, office, or a campus, have increased dramatically and fairly consistently over the past decade due to substantial escalation of the cost of different energy sources. Some of the most dramatic escalation is seen in the crude oil prices as seen in the chart on the right. The reasons for these increases range from political issues to simple supply and demand fluctuations. These cost increases are having direct impacts on every utility cost associated with the basic necessities of occupying homes and offices, with particular impact on the businesses that have little flexibility on their energy consumption habits to maintain business operation.



Crude oil prices are an indirect source of the increases in utility costs. Building systems are powered mostly by electricity and natural gas, but these costs rely heavily on the cost of crude oil so escalation trends are pretty consistent between the different fuels. Building owners are left with no options other than to take any measure available to reduce their consumption of energy.

The Business of Building Efficiently

This section of the analysis is focused on developers building long-term investment properties, and is not meant for developers that build and sell.

Introduction

Developers build buildings with the intention of serving the occupancy needs of specific demographics of potential tenants. These potential tenants range from families looking for houses or apartments to corporations looking for additional office space. The objective of the developer on a construction project is consistent across the board, to produce a building that will fill a void in the market and achieve a fully occupied and profitable building. While the market for rentable space may fluctuate, there are ways to create spaces that will always be in demand.

Marketing Efficient Buildings

The rental market in the past few years has experienced some changing trends for marketable traits of spaces. Utility billing and costs have become two of the top criteria for selection of a space by potential tenants, and the older buildings with less efficient systems are being forced to reduce their rental fees to compensate for high utility costs and prevent increases in vacancy rates. Whether the owner is paying the utility costs, or the tenant is paying them, the buildings with higher operating costs are not returning the same profits to the owner as more efficient buildings are.

Technology and innovation in design for recent new construction projects have added many options to the ways in which building are designed and built. Many of these

innovations are focused on reducing the energy consumed by buildings while maintaining the comfort and aesthetics of a modern building. Developers in particular should take advantage of these efficient design techniques. With proper planning of leasing structures and utility billing for a building, a developer can increase their yearly net earnings from a property through savings in energy costs alone. Efficient buildings can also help attract tenants and keep vacancy low. If the tenant will be responsible for paying the utilities for their rented space, then efficient building systems can be used as a selling point, and rental fees can fall above the averages since energy cost will be low. If the owner is taking the responsibility for the utilities, then the cost to rent can fall slightly below the averages to keep occupancy but high enough that the owner is profiting from the savings in utility cost. Any way that the operation costs for a building are distributed, the owner and the tenant both stand to gain from the use of efficient building systems and materials.

Marketing Sustainable Buildings

There has been much research done about the benefits to the occupants of sustainable buildings. Aspects like day-lighting, improved indoor air quality and increased use of vegetation all add a distinct appeal to any space. Consistent across all research is the fact that sustainable buildings are more desirable to all types of tenants.

Research specific to office spaces has further outlined the benefits of sustainability for occupants. Statistics about employee productivity have been collected for typical office space and for office spaces with designed improvements in indoor air quality and energy efficiency. The workers in the sustainable spaces showed significant improvements in productivity, translating into substantial savings for the corporation paying those employees. Other research and observations have shown reduced sick days for employees working in the sustainable designed buildings, which also translates into substantial savings for the companies.

With just the above statistics alone, which are only partial reports of all of the research done, a company looking to rent a new space would be attracted to a building that utilizes sustainable design practices. Not only can the tenant save money from the added energy efficiency of sustainable spaces, but they can also have more productive employees and less absenteeism.

Sustainable designs have also become a desired status symbol for many higher end clients. With the increasing prevalence of environmental issues in politics and media, many companies are willing to spend money simply to obtain the status and popular appeal of a sustainable building.

Conclusions

There are many arguments for building a more efficient building when you are the owner and tenant of the building, like a single-family home, but traditionally developers are thought to cut first costs at any expense to the building performance and then let the tenant suffer the consequences. With the constantly increasing energy costs in this country, developers building inefficient buildings are going to have an increasingly hard time occupying those buildings. The old methods of cutting upfront costs to make more money are no longer the only options for increasing earnings from an investment. These methods of marketing efficiency and managing utility costs offer developers a chance to increase the bottom line on any new building.

Summary and Interpretation of Interview Results

(See Appendix 2.1-2.2 for full Interview Responses)

Intent of Interview Process

To gain a perspective of the ways that current developers deal with building efficiency and sustainability decisions, several professionals currently active in development in the Washington, DC area were interviewed. Their experience offers the

best insight into the way in which this energy issue is affecting the business end of the construction market.

Interview Results

Developers building in the DC market are placing more and more emphasis on the efficiency of the building they are constructing. This emphasis is coming from the growing demand of all types of renters in this area to gain savings through efficient building systems and materials. Inefficient buildings have even been known to lead to law suits and disputes between tenants and building owners. Other demands for building efficiency are coming from the owner’s desire to maximize resale value of their building, and outdated or inefficient building systems drastically reduce the value of any property.

Sustainable design is also gaining significant momentum in the DC developer market. These developers are almost always open to sustainable ideas as it can be used a marketing tool for their property. Sustainable practices are also moving towards becoming a requirement for new construction projects in the DC area. However, government agencies are a little slower to embrace sustainable concepts since they do not have opportunity to use it for marketing, but building efficiency does remain a main concern for government work.

The recent changes in energy costs have not necessarily had an impact on the way in which developers make decisions about building efficiency, but have definitely had an impact on the decisions that are being reached. Developers continue to make decisions based on optimized first cost versus life-cycle costs, but these methods may start to change with the increased popularity of sustainable buildings and the marketability of those features.

As sustainable and efficient designs progress and aspects from these designs become more popular and affordable, the buildings that are being built will follow with increased popularity of efficient systems and sustainable elements. Prevailing focus for

developers will remain with the same business models that optimize first cost and operation costs.

Conclusions

Through both research of current studies and the interviewing of professionals involved in development, the same conclusions can be drawn about the current and future trends in building efficiency and business models. Energy costs are contributing to a gradual change in the way developers are building, but in combination with sustainable trends these design practices are having a major impact on the way that developers are marketing what they build. Building efficiency and sustainability are very appealing to any customer looking for a rental property. The direct savings on utilities, indirect savings on improved quality of spaces, and the status from having the most recent trend in building construction all appeal to a wide and all inclusive variety of tenants. As design processes continue to evolve and environmental concerns continue to grow, this movement towards a more efficient development market will continue. Developers can now and will continue to be able to build more efficient and more responsible buildings without sacrificing earnings from their investments.

4. Construction Analysis – Façade Sequencing

Problem Statement

As a developer catering to Class-A tenants, the owners of Two Liberty Center are placing a strong emphasis on the occupancy schedule for the office spaces. The interior work that must be completed prior to the turnover of each office floor is an immediate predecessor of the building enclosure. Therefore, the building enclosure section of the construction schedule has the most potential to benefit the occupancy schedule. The variety of alternative sequences available for façade construction also amplifies the potential impact of these activities on occupancy scheduling. This opportunity was identified through inspection of the project schedule, analysis of the needs of the owner, and conversations with management from the Two Liberty Center contractor.

Analysis Goal

This analysis will develop and compare multiple alternatives for the construction processes and sequences for the building façade of Two Liberty Center. The proposed methods and sequences should provide opportunities for schedule and cost savings on this project, with an emphasis placed on acceleration of the building occupancy schedule.

Building Façade System

Two Liberty Center is enclosed using an architectural pre-cast concrete panel system with a storefront window system at ground level and punch windows on each level above. The southwest corner of the building features an architectural glass tower extending from ground level to above the roof level and is clad with a glass curtain-wall system similar to the system used around the ground level of the building.

Existing Method and Sequencing

Sequencing Description

(See Appendix 3.1 for Existing Detailed Façade Schedule)

The existing construction schedule for Two Liberty Center utilizes a face-by-face façade construction sequence. Staring with the South face of the building, the concrete panels are erected from ground to roof using a mobile crane. Upon completion of each entire face of the building, the crane mobilizes clockwise to the next face and begins erection in the same ground to roof sequence. Window installation begins towards the end of erection of the final face of pre-panels. Windows are installed by floor, beginning at the ground level and continuing upwards as each floor is completed. With moisture as a constant concern on construction projects, interior finish work is not started until the exterior of the building is enclosed. As a tenant fit-out project, interior finish work is concentrated in the core of the building. With the limited interior finishes for this building, and the emphasis placed on occupancy, finish work begins as each floor is enclosed instead of waiting for total building enclosure.

Turnover to Owner

The owner of Two Liberty Center is accepting turnover of the building on a per floor basis. Punchlist and cleaning activities are performed on each floor as the finish work for that floor is completed. This type of building turnover allows the tenants for each floor to begin fit-out work sooner and the owner to arrange earlier starts for their leases. When building for a developer, the earlier that leasing can begin for a building, the earlier that the developer can begin payback on their investment. With priority placed on the building owner and their needs, the Two Liberty Center project demonstrates a very effective method of optimizing an occupancy schedule for a developer.

Turnover Schedule

(See Appendix 3.1 for Existing Detailed Façade Schedule)

The following chart outlines dates for turnover of each floor as indicated by the original construction schedule for Two Liberty Center:

Floor	Activity	Date
1st	Owner Acceptance	9 August 2007
2nd	Owner Acceptance	24 July 2007
3rd	Owner Acceptance	27 July 2007
4th	Owner Acceptance	1 August 2007
5th	Owner Acceptance	14 August 2007
6th	Owner Acceptance	17 August 2007
7th	Owner Acceptance	15 August 2007
8th	Owner Acceptance	30 August 2007
9th	Owner Acceptance	8 September 2007

Alternative 1 – Method and Sequencing

Sequencing Description

(See Appendix 3.2 for Alternative 1 – Detailed Façade Schedule)

For this first alternative façade construction sequence, the existing equipment and methods of construction are being utilized with changes made to the order in which pre-cast concrete panels are erected. Making use of the same mobile crane, pre-cast concrete panels will be erected starting at the south face at ground level and erecting up to and including the fifth floor of panels. After the fifth floor of each face is erected, the crane will mobilize clockwise and repeat that process on the next face of the building. Upon

completion of the first 5 floors of pre-cast panels, the crane will continue around the building erecting the sixth floor and above on each face.

Window installation for this sequencing plan can begin during the erection of the lower level panels on the east face of the building. Starting at the ground floor and working upwards per floor, windows can be installed continuously with the upper levels of pre-cast panels reaching completion before the beginning of window installation on the sixth floor.

This method of sequencing the façade construction of Two Liberty Center allows for an acceleration of the turnover schedule by an average of 40 working days. Schedule savings of this magnitude could translate into an additional month of rent collected by the owner.

Turnover Schedule

(See Appendix 3.2 for Alternative 1 – Detailed Façade Schedule)

The following chart outlines dates for turnover of each floor as indicated by the proposed schedule for Alternative 1:

Floor	Activity	Date
1st	Owner Acceptance	13 June 2007
2nd	Owner Acceptance	28 May 2007
3rd	Owner Acceptance	4 June 2007
4th	Owner Acceptance	11 June 2007
5th	Owner Acceptance	18 June 2007
6th	Owner Acceptance	25 June 2007
7th	Owner Acceptance	2 July 2007
8th	Owner Acceptance	9 July 2007
9th	Owner Acceptance	16 July 2007

Alternative 2 – Method and Sequencing

Sequencing Description

(See Appendix 3.3 for Alternative 2 – Detailed Façade Schedule)

This proposed alternative for the façade construction of Two Liberty Center explores the utilization of the tower crane already on-site that would otherwise not be used for the erection of the building façade. Use of a tower crane for façade panel erection allows a much more flexible sequencing of the process due to the full rotational range of a tower crane compared to the limited range of a mobile crane. Although mobile cranes do have the ability to relocate to different points around a building, it is inefficient to relocate a mobile crane multiple times due to the time needed to break down, mobilize, and re-set the crane in the new location.

With the full use of the on-site tower crane, the pre-cast concrete façade panels will be erected in the same per-floor sequence as the window installation. Panels will be placed starting with the ground level at the south face of the building and erecting each panel of a floor in succession before continuing upward to the next level. Each floor of façade panels can begin after the completion of the concrete work on the floor above, but to keep a continuous work flow for the façade construction the ground level should begin during the 6th floor concrete work. Window installation can start for each floor following the completion of the panel erection for that floor and continue upwards with the flow of the panel placement.

To successfully implement this proposed sequencing of the façade construction for Two Liberty Center, the tower crane would need to be fully utilized for a full shift on every working day. This full utilization of the tower crane would require the use of a second shift operation for façade construction. This second shift could provide an opportunity for significant acceleration to the schedule, either to expedite the completion of the building or to make up for time lost to possible delays. Second shift work would

add some additional cost to the project, but these costs could be countered by the potential early occupancy by the tenants.

This proposed alternative for the sequencing of the façade construction for Two Liberty Center would allow for an average schedule savings of 72 working days from the original construction schedule. Schedule reductions of this magnitude could translate into two additional months of collected rent for the owner of Two Liberty Center.

Turnover Schedule

(See Appendix 3.3 for Alternative 2 – Detailed Façade Schedule)

The following chart outlines dates for turnover of each floor as indicated by the proposed schedule for Alternative 2:

Floor	Activity	Date
1st	Owner Acceptance	30 April 2007
2nd	Owner Acceptance	11 April 2007
3rd	Owner Acceptance	18 April 2007
4th	Owner Acceptance	25 April 2007
5th	Owner Acceptance	2 May 2007
6th	Owner Acceptance	9 May 2007
7th	Owner Acceptance	16 May 2007
8th	Owner Acceptance	23 May 2007
9th	Owner Acceptance	30 May 2007

Conclusions

With some additional planning, there is some potential within the existing schedule for an acceleration of the occupancy of the building. Alternative 2, while it may provide 72 day acceleration of the occupancy schedule, would require significant changes to the construction planning to allow for the full use of the tower crane for the façade panel placement. Adjustments made to accommodate Alternative 2 could also carry

additional costs and resources. The most realistic option for acceleration of the occupancy of Two Liberty Center would be the implementation of the proposed Alternative 1. This alternative schedule offers substantial time savings while maintaining the same required resources and costs as the existing sequencing plan for façade construction. The sequencing proposed in Alternative 1 should be considered as a means to either catch up from a schedule deficit or to achieve an early completion and occupancy.

5. Breadth Analysis 1 – Centralized HVAC for Office Spaces

Problem Statement

The current mechanical system for Two Liberty Center has an individual air handling unit for each office floor, as well as several units to serve retail spaces and common areas. Multiple air handling units adds significant complication to the construction process compared to larger centralized units, with added submittals, purchasing and scheduling for each individual piece of equipment. Units contained in the core of the building also require the planning of the installation around the enclosure process to ensure that units are in place while there is still adequate access. Reducing the number of air handlers for Two Liberty Center could have potential benefits for reduced cost, simplified construction, and schedule reductions.

Analysis Goal

The goal of this analysis is to centralize the HVAC system of Two Liberty Center by placing one or two larger units on the roof. The new unit or units for the HVAC system will be used to serve the office spaces on the 2nd through 9th floors, since design conditions for those floors are consistent. These changes will facilitate a reduction in the construction costs, a simplification of the construction process, and potential reductions to the construction schedule. The changes to the loading on the roof of Two Liberty Center due to the large equipment needed will require some redesign of the current structural system. This type of change to the mechanical system may also require changes to the leasing agreements for the future tenants to manage the utility costs for the building.

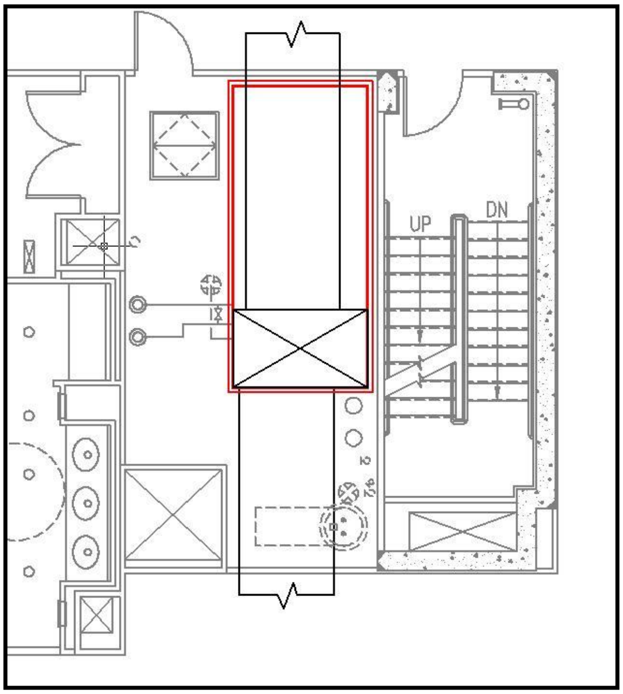
Analysis Method

The following steps have been taken to design and analyze the proposed centralized HVAC system:

1. Collect data on existing equipment for the office spaces
2. Determine existing design conditions
3. Size and locate the distribution ducts for new equipment
4. Determine size and capacities for replacement units
5. Compare and contrast the new system to the existing

Existing System Details

This analysis will focus on the 8 Factory-Built Chilled Water Air Handling Units which serve each of the 8 office floors for Two Liberty Center. These units are located in the core service spaces of the office floors with a large duct split from each unit to distribute air in a loop around the usable office space. Cooling capacity of the existing air handlers is designed for a 73° dry-bulb temperature. Air volume for the 2^{nd} floor is set at 14,500 CFM, for the 3^{rd} – 8^{th} floors at 15,000 CFM, and for the 9^{th} floor at 16,000 CFM: with all 8 air supply fans controlled by a Variable Frequency Drive. The drawing to the right illustrates the placement of the air handlers in the core of each floor, with the red indicating the unit itself.



AHU location in office core

Description of Replacement System

System Layout

The existing 8 units will be replaced by 2 larger identical units located on the roof of Two Liberty Center. Distribution from these units will be achieved through two main duct trunks penetrating down through the core of the building. The chase for these ducts will be located in the mechanical rooms on each floor, replacing the space previously occupied by the air handlers. Air distribution will be divided as the 2nd – 5th floors by one duct riser and the 6th – 9th floors by the other duct riser. Distribution through conditioned spaces will be achieved through the same duct system utilized by the existing mechanical system. This proposed revision to the mechanical system will provide performance equal to that of the existing system.

Air Distribution

The following charts outline the air distribution design for this proposed revision to the mechanical system of Two Liberty Center:

Supply Trunk 1: 2nd – 5th Floors

Section	Duct Size (IN.)	Length (FT.)	Air Volume (CFM)	Static Pressure (IN./100')	External Static Pressure (IN. W.G.)
2-3	**32 x 30**	10.50	12100	0.15	0.016
trans	--	--	12100	--	0.100
3-4	**46 x 42**	10.50	24900	0.10	0.011
trans	--	--	24900	--	0.125
4-5	**56 x 50**	10.50	37700	0.08	0.008
trans	--	--	37700	--	0.150
5-PH	**68 x 60**	52.50	50500	0.06	0.032
Existing AHU	--	--	--	--	1.500
				Total Pressure:	**1.941**

Supply Trunk 2: 6th – 9th Floors

Section	Duct Size (IN.)	Length (FT.)	Air Volume (CFM)	Static Pressure (IN./100')	External Static Pressure (IN. W.G.)
6-7	**32 x 30**	10.50	12800	0.14	0.015
trans	--	--	12800	--	0.100
7-8	**46 x 42**	10.50	25600	0.10	0.011
trans	--	--	25600	--	0.125
8-9	**56 x 50**	10.50	38400	0.08	0.008
trans	--	--	38400	--	0.150
9-PH	**68 x 60**	10.50	52100	0.06	0.006
Existing AHU	--	--	--	--	1.500
				Total:	**1.914**

Air Handling Units

(See Appendix 4.1 for Detailed Equipment Specs)

Each of the proposed new air handling units are factory-built chilled water air handling units, with variable air volume supply from a forward-curved fan controlled by a variable frequency drive. Supply air volume is set at 51,500 CFM maximum air supply with a maximum external static pressure of 2.2 in. Since these new units are to be placed outdoors on the roof, the enclosure is designed with double-wall galvanized steel coated with a water-based polyurethane paint for weather-proofing. Units are to be installed on a factory-supplied 14" high roof curb fastened to the structure of the roof.

Cost and Scheduling Analysis

The following chart outlines potential cost savings for the proposed mechanical redesign:

Costs for Air Handling Units

		Bare Costs		Total Costs	
Qty.	Size (CFM)	Material	Labor	Base	Including O&P
8	15000	$88,800.00	$20,200.00	$109,000.00	$128,000.00
2	51500	$74,800.00	$16,350.00	$91,150.00	$107,000.00
	Savings:	$14,000.00	$3,850.00	$17,850.00	**$21,000.00**

Above figures are based on data from *RS Means Building Construction Cost Data* and are an accurate reflection of the costs involved in the purchasing and installation of air handling units for Two Liberty Center. The data displayed in red text indicates the costs of the proposed alternative mechanical system. Savings in the labor field are representative of the simplification of the construction process when installing air handlers on the roof instead of in the core of the building on each floor. These labor savings are mostly due to a reduction of labor hours from 620 for the 8 small units to only 492 labor hours for the 2 larger units. This magnitude of labor hour savings could translate into as many as 16 days of construction schedule reduction as outlined in the chart shown below:

Labor for Air Handling Units

Qty.	Size (CFM)	Labor Hours	Total	Scheduling Days
8	15000	78	620	78
2	51500	246	492	62
		Savings:	**128**	**16**

Conclusions

This analysis of the existing system and proposed alternative system for the HVAC equipment for the office spaces of Two Liberty Center has presented an opportunity for schedule savings, cost savings, and overall simplification of the mechanical construction process. These benefits are easily achieved through this simple reconfiguration of mechanical equipment and their distribution systems.

The new configuration of the HVAC system for the office spaces would however require adjustments to be made to the lease agreements for the future tenants of Two Liberty Center. Instead of each tenant being responsible for individual utility bills for heating and cooling, the owner of the building would have to pay the utility bill for the entire building and build the costs into the monthly rent of the tenants. While this may not appeal to some owners, this style of lease agreement can create an opportunity for a building owner to reap the benefits of savings from more efficient building systems. Small upfront cost additions for increased efficiency in certain building systems can turn into significant long-term savings for the owner.

Implementing the proposed alternative to the mechanical system of Two Liberty Center would provide an opportunity for savings in cost and schedule while maintaining desired design conditions. The potential complications in leasing structures could outweigh the benefits, but that decision is one of preference by the owner of the building. Either way, this analysis has offered another opportunity for cost and schedule savings that could prove useful for many construction projects.

6. Breadth Analysis 2 – Green Roofs and Sustainable Concepts

Analysis Introduction

The economic benefits of rapid and dense commercial development, similar to the Liberty Center project, often come at a high cost to the environment. Buildings in the United States account for approximately one-third of all water, energy, and materials consumption, as well as similar proportions of contribution to air pollution. Concepts from early 20th century architecture, with slight modernizations, offer an excellent opportunity to reduce these environmental impacts while increasing the aesthetic appeal any building. Two Liberty Center, and the accompanying projects, are ideal candidates for the addition of green roofs and roof gardens on the large flat spans of concrete roof slab.

Green Roofs

Le Corbusier and Roof Gardens

As part of his declaration: *Five Points Towards a New Architecture*, the famous 20th century architect Le Corbusier describes the aesthetic and functional reasoning for including roof gardens in the design of every building. The beginning of the argument for roof gardens declares that flat roof surfaces demand to be utilized for domestic purposes. Typically flat roofs serve only as a protective outer shell, but these areas can easily be converted to functional spaces that maintain the same protection for interior space below. Le Corbusier goes on to describe the demands of a reinforced concrete roof surface to be protected and the capability of the roof garden to maintain ideal conditions at the surface of the slab. The final and most significant argument for roof gardens on every building is one of a more ecological impact. Corbusier declares that a garden on every roof is a way for a city to recover space lost to buildings, and restore some balance to the eco-system of that city.

Modern Green Roofs

Trends towards more sustainable building designs have led to the evolution of the old roof garden concept into a more advanced system referred to as a green roof. These landscaped roofs have been implemented in a wide variety of situations and configurations, from office buildings to homes and from trees to grass. The picture to the right shows the innovation in these systems, with the roof being converted to a small golf course for a corporate office building, where employees can escape their offices for a quick hole of golf or some putting practice.

Modern green roofs have come a long way from the roof gardens of Le Corbusier. Vegetation is planted in a top layer of soil, but below that layer lays the filtering layers, drainage layers, and waterproofing layers that turn an architectural garden into a functional system for stormwater management and building insulation. Vegetation for these green roofs is carefully selected and grown to match the climate conditions of the target building as well as the aesthetic desires of the owner.

Building Benefits of Green Roofs

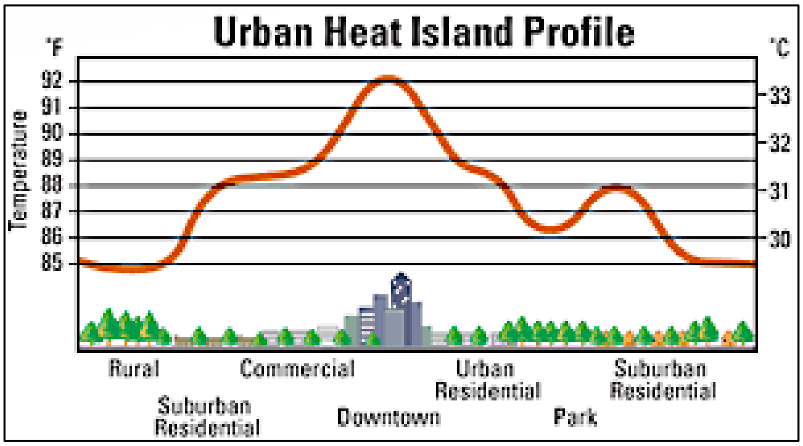
Other than the luxurious appeal of the garden-like roof environment, the modern green roof offers a variety of performance benefits for the buildings they serve. Considering first the direct performance of a green roof as a roofing membrane, it is estimated that a green roof will last nearly twice as long as most conventional roofing membrane systems. Green systems also perform exceptionally as roof insulation and natural cooling sources, with great potential for savings in both cooling loads and heating

loads. Certain applications have even provided substantial enough heat gain reductions to allow for downsizing of mechanical equipment. Additional design savings from green roof benefits often include a reduction of roof drainage due to the absorption and evaporation of rainwater and depending on the location there may also be continued savings in stormwater/wastewater utility charges. Other potential benefits exist and have been demonstrated in existing green roof applications, and with research innovations in design there may be even more benefits to be found.

Environmental Benefits of Green Roofs

Aside from the advantages for the building performance, green roofs can change the way that a building impacts the environment. Urban development not only adds to the consumption of resources and production of pollution, but there is also a displacement of natural habitats. Green roofs can replace, nearly in entirety, the amount of habitat space that is displaced by the building footprint, and the roof itself can even be designed to mimic the affected habitats. Green replacement can furthermore counter the addition of carbon dioxide emissions from the new building construction.

Another major effect of dense urban development is commonly referred to as the heat island effect. This term refers to the increase in mean temperature of heavily developed areas as illustrated in the image below. Increased temperatures can be attributed a combination of the high thermal masses of the buildings, reduced air flow from narrow streets and tall buildings, and the excessive waste heat from the concentration of cars and building



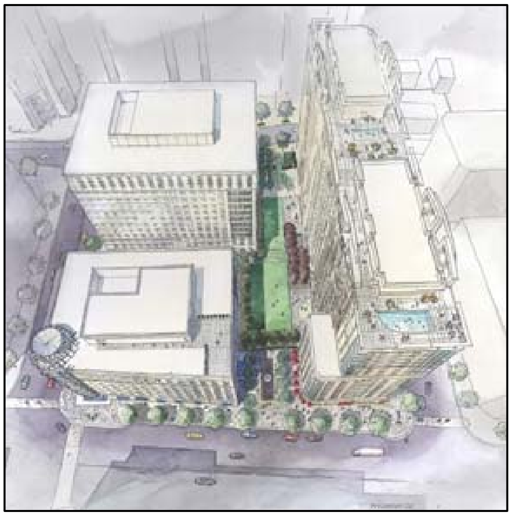
mechanical equipment. Green roofs are very effective at reducing the heat island effect in any developed area. This roofing method mitigates the heat island through two methods. The vegetation on the reduced the heat absorbed by the building as well as providing a natural cooling effect through evaporation of moisture.

Green Roof for Two Liberty Center

Green Roof as an Architectural Feature

Two Liberty Center is intended to serve high-end tenants with expensive taste in interior finishes and quality of spaces. Lobby spaces for the office tenants are finished with terrazzo floors with natural stone details, exterior finishes also boast natural stone accents, and courtyard spaces between the buildings feature trees, flowers, fountains and again natural stone accents. The featured glass tower and large windows provide interior office spaces with plenty of sunlight and further adds to the luxurious feel of the building. The architectural language of this building and others in the complex speaks to a tenant with a taste for high-end natural materials and well landscaped spaces.

The addition of a well landscaped green roof to Two Liberty Center would continue the architectural styling of the interior and existing exterior spaces of the building onto the roof and help integrate the building with the environment. The picture to the right illustrates the Liberty Center site, with Two Liberty Center in the bottom left corner. With trees lining the streets, heavy vegetation in the courtyards, and planters and swimming pools on the neighboring roof, a green roof on Two Liberty Center would tie together the site and communicate more of a community feel for this mixed-use complex.



Green Roof as a Benefit to the Owner

Since a green roof would fit so well with the architectural language of the Liberty Center complex, the owner should work with the architect to incorporate one into the design and reap the benefits of the modern green roof system. While energy savings for the building would prove beneficial to the tenants paying the utilities, most owners would not be inclined to pay for a green roof that does not benefit their own interests. However, there are some benefits of a green roof that would advantage the owner of Two Liberty Center.

The most direct benefit of the green roof to the owner is the reduction of future costs for roof repair and replacement. As mentioned earlier in this analysis, life spans of green roofs have been proven to nearly double those of more conventional materials and methods. Added durability of that magnitude would cut roof maintenance costs, which are the responsibility of the building owner, in half.

A less quantifiable, but equally valuable benefit to green roof addition for Two Liberty Center is the marketability of a rooftop garden environment. Distinct spaces, like the proposed green roof on Two Liberty Center have a marketability factor, especially when dealing with high class corporate tenants. Employee satisfaction with their working environment has shown to significantly increase productivity and job satisfaction. This marketability factor would allow the owners of Two Liberty Center to not only reduce their vacancy rates, but they could also increase the rent per square foot of office space without loosing tenant interest.

Conclusions

As an added architectural feature, a courtyard style green roof for Two Liberty Center would round off the architectural concept of the building and integrate it with the surrounding courtyards and neighboring buildings to complete the community of the mixed-use complex. Additional costs for this feature would be more than compensated for through maintenance savings and marketability to potential tenants.

Conclusions

Recent trends in energy costs and environmental concern are forcing the construction industry to amend the design and construction processes to account for the impacts they have on a buildings interaction with the environment. Whether through efficiency methods or sustainability practices, every aspect of construction will eventually adapt to the trends.

The first analysis of this report, through research has identified the ways in which development practices have already adapted to environmental trends and how they may continue to adapt over the years. Development is driven by business models and bottom lines, but these figures are beginning to be countered by an emergence of new marketing tools that focus on the sustainable features of a building and the appeal of those features to potential tenants.

The second analysis, while not directly focused on the environmental topics, has provided an insight into an opportunity for schedule and potential cost savings for Two Liberty Center. The savings achieved through planning of an alternate façade construction sequence could be applied to nearly any building with a similar façade system. These schedule savings, if translated into cost savings could provide an owner with more opportunity to invest in the efficiency and sustainability of their building.

A centralized mechanical system designed through the third analysis, offers savings in both time and money from the original system, but additionally creates the opportunity for the building owner to simplify utility billing and take on any savings from building efficiency improvements.

The fourth and final analysis uses a modernized version of the old architectural concept of the roof garden. These rooftop paradises are unique and highly marketable spaces with modern design elements that add performance to the building and minimize the impact that a building has on the environment. Green roofs are a great example of the appeal of sustainable concepts to building owners and tenants.

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"Energy Information Administration/Monthly Energy Review March 2007." 11 APR 2007 <http://www.eia.doe.gov/emeu/mer/pdf/pages/sec9.pdf>.

Appendix 1

This appendix contains the following referenced documents:

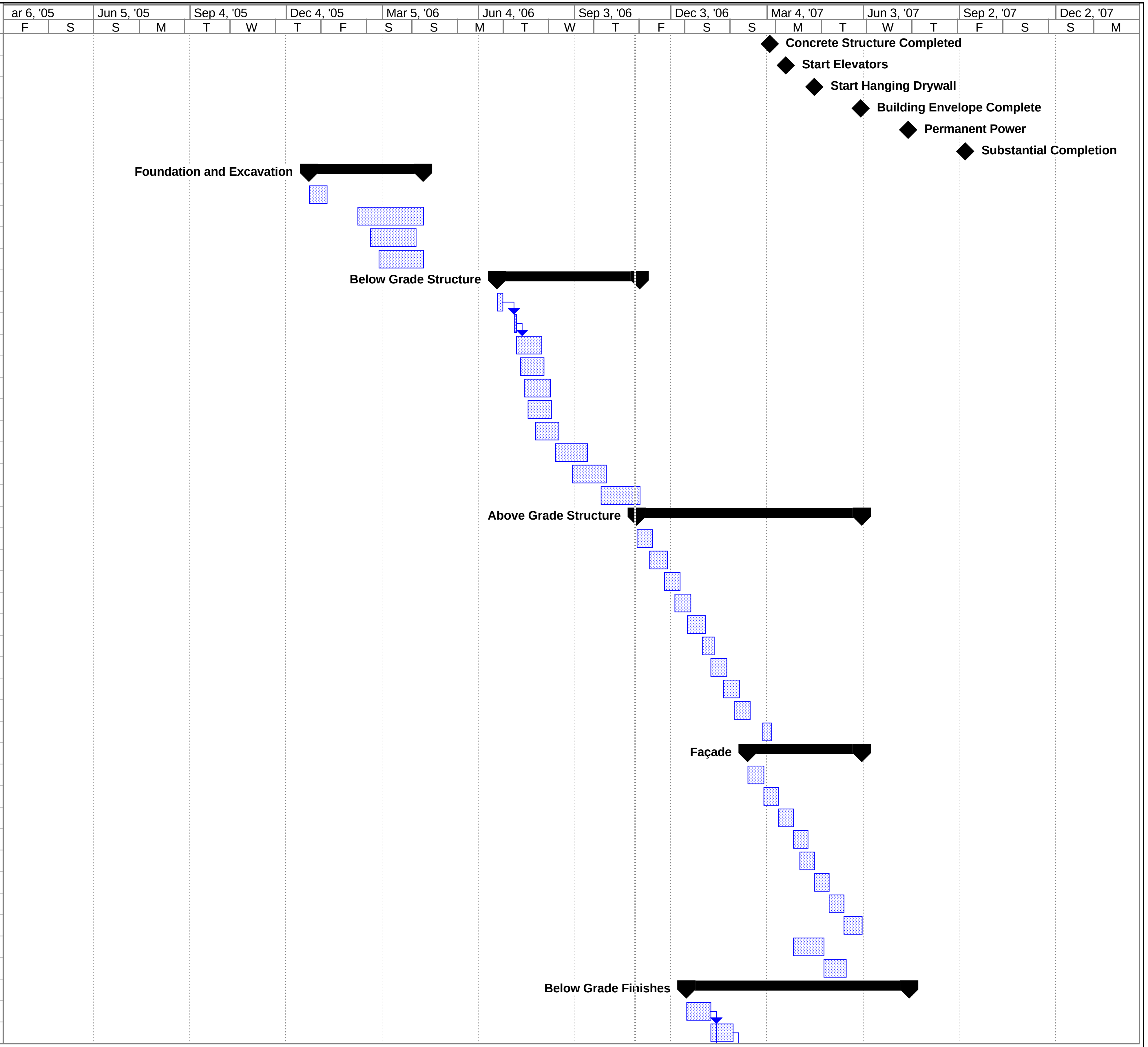
1. **Detailed Project Schedule**

2. **Detailed Parametric Estimate Reports from *D4 Cost***

3. **Detailed Square Foot Estimate Reports from *CostWorks 2005***

4. **Site Utilization Plan**

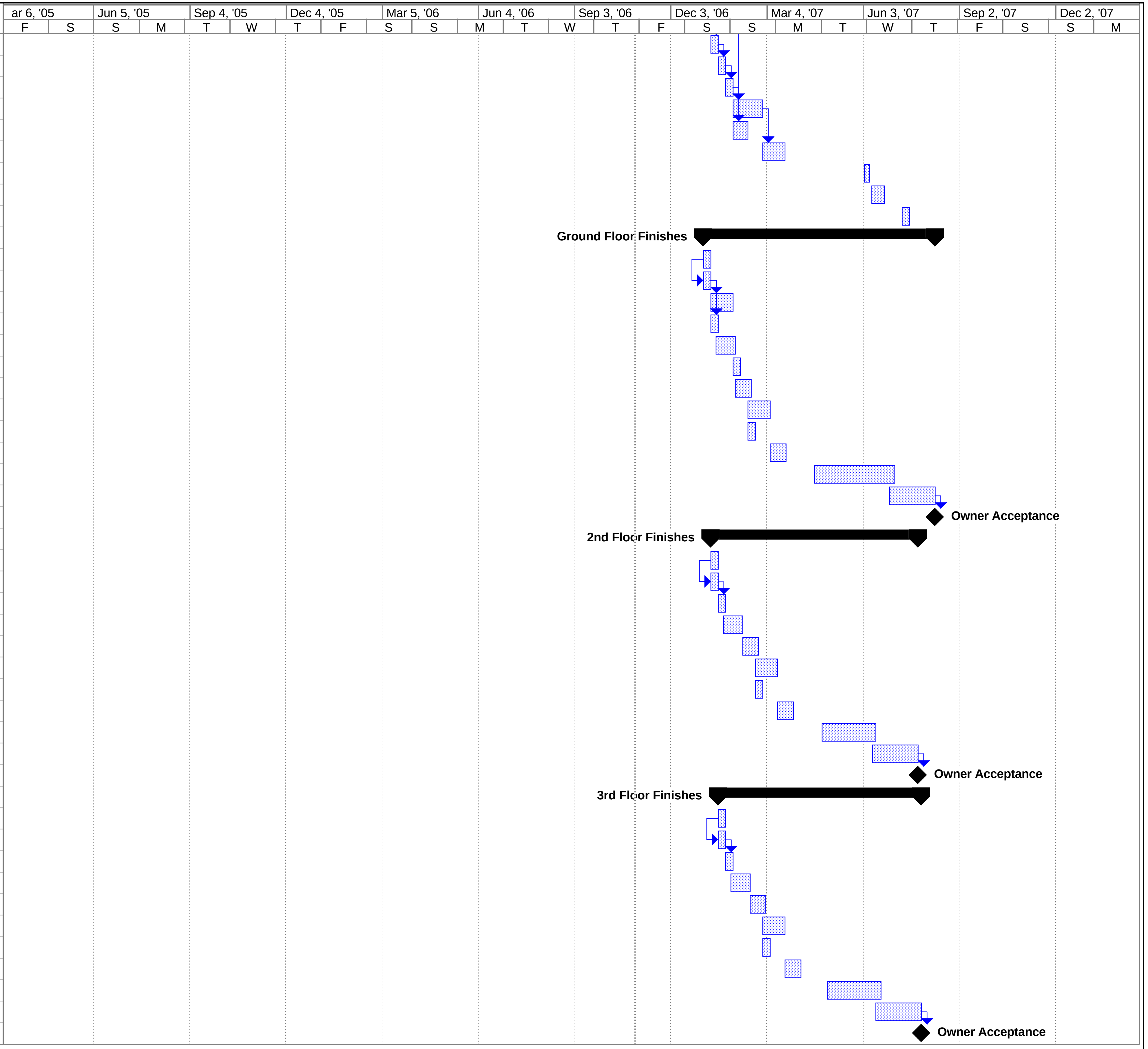
ID	ℹ	Task Name	Duration	Start	Finish
1	▦	Concrete Structure Completed	0 days	Wed 3/7/07	Wed 3/7/07
2	▦	Start Elevators	0 days	Thu 3/22/07	Thu 3/22/07
3	▦	Start Hanging Drywall	0 days	Wed 4/18/07	Wed 4/18/07
4	▦	Building Envelope Complete	0 days	Fri 6/1/07	Fri 6/1/07
5	▦	Permanent Power	0 days	Mon 7/16/07	Mon 7/16/07
6	▦	Substantial Completion	0 days	Sat 9/8/07	Sat 9/8/07
7		**Foundation and Excavation**	**78 days**	**Mon 12/26/05**	**Wed 4/12/06**
8	▦	Drill Piles	13 days	Mon 12/26/05	Wed 1/11/06
9	▦	Excavate and Lag	44 days	Fri 2/10/06	Wed 4/12/06
10	▦	Drill Tiebacks	31 days	Wed 2/22/06	Wed 4/5/06
11	▦	Stress Tiebacks	30 days	Thu 3/2/06	Wed 4/12/06
12		**Below Grade Structure**	**98 days?**	**Thu 6/22/06**	**Fri 11/3/06**
13	▦	Excavate and Place Tower Crane Footing	3 days?	Thu 6/22/06	Mon 6/26/06
14	▦	Set Tower Crane	1 day?	Sat 7/8/06	Sun 7/9/06
15	▦	B4 - Excavate and Place Footings - Pours 1-	18 days?	Mon 7/10/06	Wed 8/2/06
16	▦	B4 - MEP Underslab Rough-in - Pours 1-5	16 days?	Fri 7/14/06	Fri 8/4/06
17	▦	B4 - Prep subgrade - Pours 1-5	18 days?	Tue 7/18/06	Thu 8/10/06
18	▦	B4 - Place Slab - Pours 1-5	16 days?	Fri 7/21/06	Fri 8/11/06
19	▦	B3 - Frame and Place Slab - Pours 1-4	16 days?	Fri 7/28/06	Fri 8/18/06
20	▦	B2 - Frame and Place Slab - Pours 1-6	22 days?	Wed 8/16/06	Thu 9/14/06
21	▦	B1 - Frame and Place Slab - Pours 1-6	22 days?	Fri 9/1/06	Mon 10/2/06
22	▦	Ground Floor - Frame and Place Slab - Pour	27 days?	Thu 9/28/06	Fri 11/3/06
23		**Above Grade Structure**	**153 days?**	**Wed 11/1/06**	**Fri 6/1/07**
24	▦	2nd Floor - Frame and Place Slab - Pours 1-	11 days?	Wed 11/1/06	Wed 11/15/06
25	▦	3rd Floor - Frame and Place Slab - Pours 1-	13 days?	Mon 11/13/06	Wed 11/29/06
26	▦	4th Floor - Frame and Place Slab - Pours 1-	11 days?	Mon 11/27/06	Mon 12/11/06
27	▦	5th Floor - Frame and Place Slab - Pours 1-	11 days?	Thu 12/7/06	Thu 12/21/06
28	▦	6th Floor - Frame and Place Slab - Pours 1-	13 days?	Tue 12/19/06	Thu 1/4/07
29	▦	7th Floor - Frame and Place Slab - Pours 1-	9 days?	Tue 1/2/07	Fri 1/12/07
30	▦	8th Floor - Frame and Place Slab - Pours 1-	11 days?	Wed 1/10/07	Wed 1/24/07
31	▦	9th Floor - Frame and Place Slab - Pours 1-	11 days?	Mon 1/22/07	Mon 2/5/07
32	▦	Roof Level - Frame and Place Slab - Pours 1	11 days?	Thu 2/1/07	Thu 2/15/07
33	▦	Elevator Roof - Frame and Place Slab	6 days?	Wed 2/28/07	Wed 3/7/07
34		**Façade**	**78 days?**	**Wed 2/14/07**	**Fri 6/1/07**
35	▦	Precast South Side	11 days?	Wed 2/14/07	Wed 2/28/07
36	▦	Precast West Side	10 days?	Thu 3/1/07	Wed 3/14/07
37	▦	Precast North Side	10 days?	Thu 3/15/07	Wed 3/28/07
38	▦	Precast East Side	10 days?	Thu 3/29/07	Wed 4/11/07
39	▦	Windows Floors 1-3	10 days?	Wed 4/4/07	Tue 4/17/07
40	▦	Windows Floors 4-5	10 days?	Wed 4/18/07	Tue 5/1/07
41	▦	Windows Floors 6-7	10 days?	Wed 5/2/07	Tue 5/15/07
42	▦	Windows Floors 8-9	13 days?	Wed 5/16/07	Fri 6/1/07
43	▦	Roof Field	21 days?	Thu 3/29/07	Thu 4/26/07
44	▦	Roof edge and details	15 days?	Fri 4/27/07	Thu 5/17/07
45		**Below Grade Finishes**	**151 days?**	**Mon 12/18/06**	**Mon 7/16/07**
46	▦	CMU Block	17 days?	Mon 12/18/06	Tue 1/9/07
47	▦	Set Mechanical Equipment	15 days?	Wed 1/10/07	Tue 1/30/07



Project: Detailed Schedule
Date: Mon 10/30/06

Task	▨	Milestone	◆	Rolled Up Task	▨	Rolled Up Progress	▬	External Tasks	▭	Group By Summary	▬
Progress	▬	Summary	▬	Rolled Up Milestone	◇	Split	⋯	Project Summary	▬	Deadline	⇩

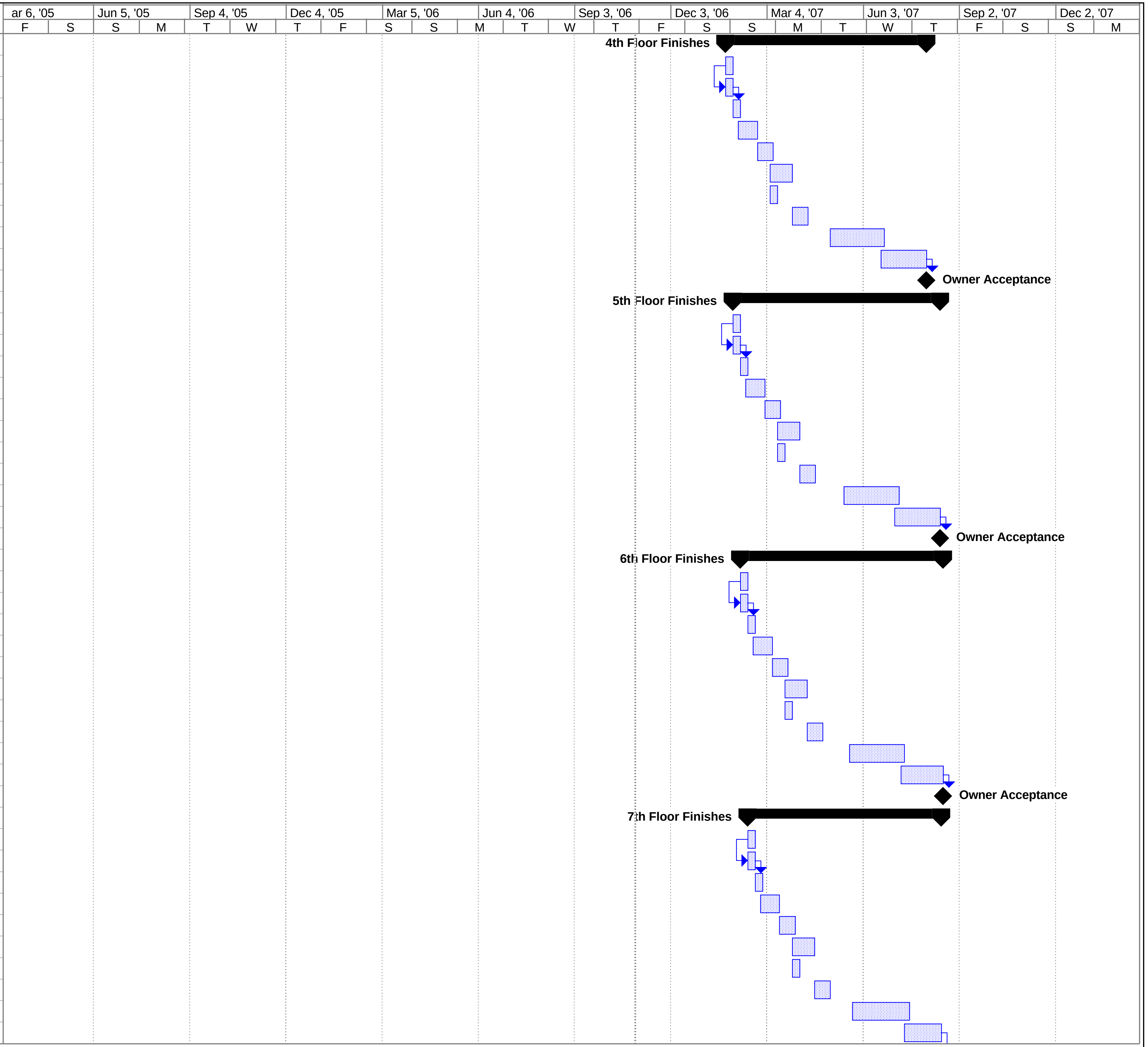
ID	ℹ	Task Name	Duration	Start	Finish
50	▦	Set Switchgear	5 days?	Wed 1/10/07	Tue 1/16/07
51	▦	Set CT Cabinets	5 days?	Wed 1/17/07	Tue 1/23/07
52	▦	Set Electrical Room Panels	5 days?	Wed 1/24/07	Tue 1/30/07
48	▦	Rough In Mechanical Equipment Pipe	20 days?	Wed 1/31/07	Tue 2/27/07
53	▦	Wire and Connect Equipment	10 days?	Wed 1/31/07	Tue 2/13/07
49	▦	Connect Mechanical Equipment	15 days?	Wed 2/28/07	Tue 3/20/07
54	▦	Set Transformers	5 days?	Mon 6/4/07	Fri 6/8/07
55	▦	Pull Wire to Transformers	10 days?	Mon 6/11/07	Fri 6/22/07
56	▦	Energize Electrical Room	5 days?	Tue 7/10/07	Mon 7/16/07
57		**Ground Floor Finishes**	**157 days?**	**Wed 1/3/07**	**Thu 8/9/07**
58	▦	Layout	5 days?	Wed 1/3/07	Tue 1/9/07
59	▦	MEP Risers	5 days?	Wed 1/3/07	Tue 1/9/07
60	▦	CMU Block	15 days?	Wed 1/10/07	Tue 1/30/07
64	▦	Install Duct	5 days?	Wed 1/10/07	Tue 1/16/07
65	▦	Overhead MEP Rough-In	14 days?	Mon 1/15/07	Thu 2/1/07
61	▦	Set Emergency Generator	5 days?	Wed 1/31/07	Tue 2/6/07
62	▦	Frame Out Interior Walls	11 days?	Fri 2/2/07	Fri 2/16/07
63	▦	MEP Wall Rough-In	15 days?	Wed 2/14/07	Tue 3/6/07
66	▦	Install Fire-Stop	5 days?	Wed 2/14/07	Tue 2/20/07
67	▦	MEP Close-In Inspections	11 days?	Wed 3/7/07	Wed 3/21/07
68	▦	Finishes and Fixtures	54 days?	Wed 4/18/07	Mon 7/2/07
69	▦	Punchlists and Cleaning	31 days?	Thu 6/28/07	Thu 8/9/07
70	▦	Owner Acceptance	0 days	Thu 8/9/07	Thu 8/9/07
71		**2nd Floor Finishes**	**140 days?**	**Wed 1/10/07**	**Tue 7/24/07**
72	▦	Layout	5 days?	Wed 1/10/07	Tue 1/16/07
73	▦	MEP Risers	5 days?	Wed 1/10/07	Tue 1/16/07
76	▦	Install Duct	5 days?	Wed 1/17/07	Tue 1/23/07
77	▦	Overhead MEP Rough-In	14 days?	Mon 1/22/07	Thu 2/8/07
74	▦	Frame Out Interior Walls	11 days?	Fri 2/9/07	Fri 2/23/07
75	▦	MEP Wall Rough-In	15 days?	Wed 2/21/07	Tue 3/13/07
78	▦	Install Fire-Stop	5 days?	Wed 2/21/07	Tue 2/27/07
79	▦	MEP Close-In Inspections	11 days?	Wed 3/14/07	Wed 3/28/07
80	▦	Finishes and Fixtures	37 days?	Wed 4/25/07	Thu 6/14/07
81	▦	Punchlists and Cleaning	31 days?	Tue 6/12/07	Tue 7/24/07
82	▦	Owner Acceptance	0 days	Tue 7/24/07	Tue 7/24/07
83		**3rd Floor Finishes**	**138 days?**	**Wed 1/17/07**	**Fri 7/27/07**
84	▦	Layout	5 days?	Wed 1/17/07	Tue 1/23/07
85	▦	MEP Risers	5 days?	Wed 1/17/07	Tue 1/23/07
88	▦	Install Duct	5 days?	Wed 1/24/07	Tue 1/30/07
89	▦	Overhead MEP Rough-In	14 days?	Mon 1/29/07	Thu 2/15/07
86	▦	Frame Out Interior Walls	11 days?	Fri 2/16/07	Fri 3/2/07
87	▦	MEP Wall Rough-In	15 days?	Wed 2/28/07	Tue 3/20/07
90	▦	Install Fire-Stop	5 days?	Wed 2/28/07	Tue 3/6/07
91	▦	MEP Close-In Inspections	11 days?	Wed 3/21/07	Wed 4/4/07
92	▦	Finishes and Fixtures	37 days?	Mon 4/30/07	Tue 6/19/07
93	▦	Punchlists and Cleaning	31 days?	Fri 6/15/07	Fri 7/27/07
94	▦	Owner Acceptance	0 days	Fri 7/27/07	Fri 7/27/07



Project: Detailed Schedule.mpp
Date: Mon 10/30/06

Task	▨	Milestone	◆	Rolled Up Task	▨	Rolled Up Progress	▬	External Tasks	▭	Group By Summary	▬
Progress	▬	Summary	▬	Rolled Up Milestone	◇	Split	⋯	Project Summary	▬	Deadline	⇩

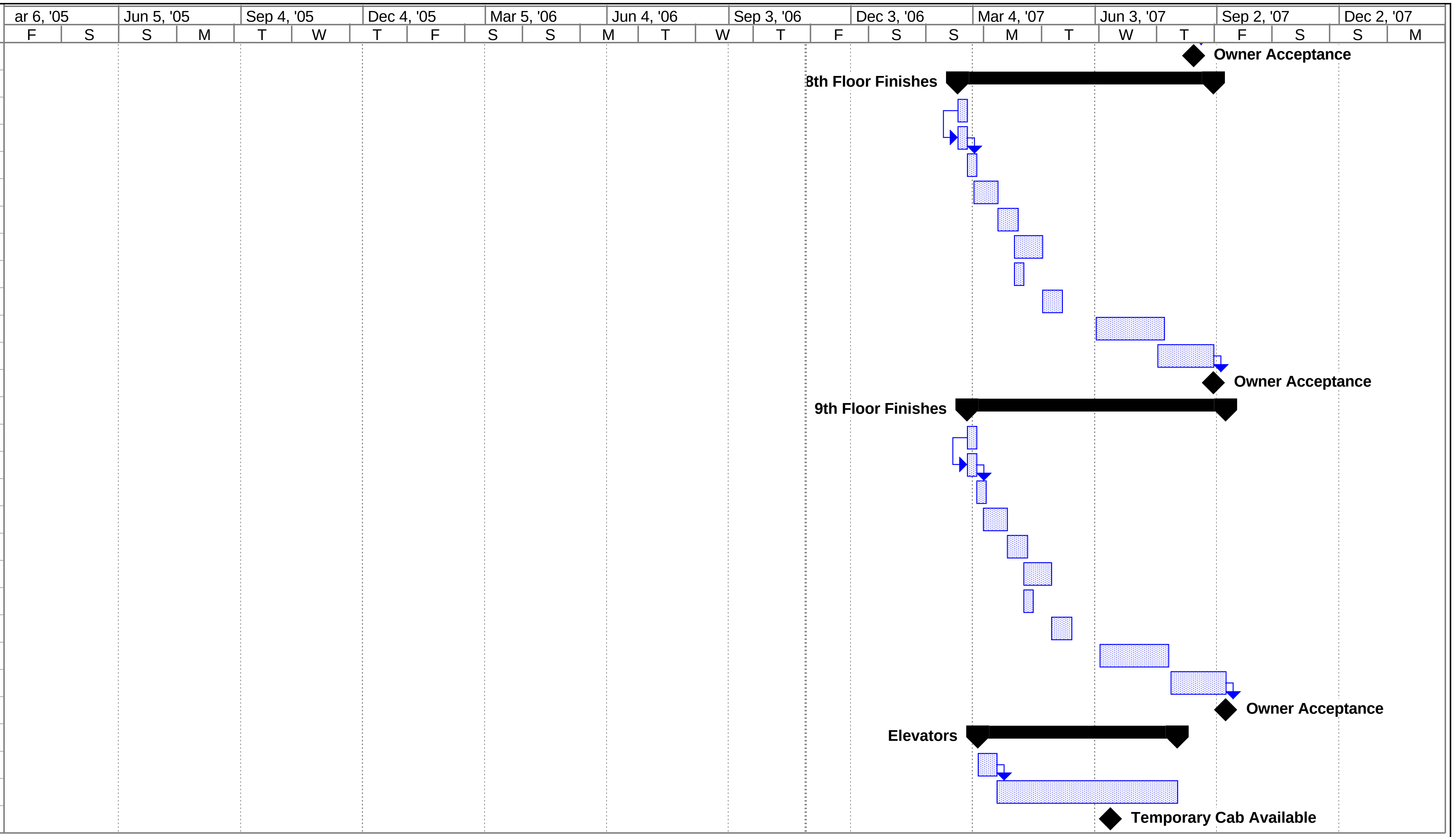
ID	ℹ	Task Name	Duration	Start	Finish
95		**4th Floor Finishes**	**136 days?**	**Wed 1/24/07**	**Wed 8/1/07**
96	▦	Layout	5 days?	Wed 1/24/07	Tue 1/30/07
97	▦	MEP Risers	5 days?	Wed 1/24/07	Tue 1/30/07
100	▦	Install Duct	5 days?	Wed 1/31/07	Tue 2/6/07
101	▦	Overhead MEP Rough-In	14 days?	Mon 2/5/07	Thu 2/22/07
98	▦	Frame Out Interior Walls	11 days?	Fri 2/23/07	Fri 3/9/07
99	▦	MEP Wall Rough-In	15 days?	Wed 3/7/07	Tue 3/27/07
102	▦	Install Fire-Stop	5 days?	Wed 3/7/07	Tue 3/13/07
103	▦	MEP Close-In Inspections	11 days?	Wed 3/28/07	Wed 4/11/07
104	▦	Finishes and Fixtures	37 days?	Thu 5/3/07	Fri 6/22/07
105	▦	Punchlists and Cleaning	31 days?	Wed 6/20/07	Wed 8/1/07
106	▦	Owner Acceptance	0 days	Wed 8/1/07	Wed 8/1/07
107		**5th Floor Finishes**	**140 days?**	**Wed 1/31/07**	**Tue 8/14/07**
108	▦	Layout	5 days?	Wed 1/31/07	Tue 2/6/07
109	▦	MEP Risers	5 days?	Wed 1/31/07	Tue 2/6/07
112	▦	Install Duct	5 days?	Wed 2/7/07	Tue 2/13/07
113	▦	Overhead MEP Rough-In	14 days?	Mon 2/12/07	Thu 3/1/07
110	▦	Frame Out Interior Walls	11 days?	Fri 3/2/07	Fri 3/16/07
111	▦	MEP Wall Rough-In	15 days?	Wed 3/14/07	Tue 4/3/07
114	▦	Install Fire-Stop	5 days?	Wed 3/14/07	Tue 3/20/07
115	▦	MEP Close-In Inspections	11 days?	Wed 4/4/07	Wed 4/18/07
116	▦	Finishes and Fixtures	38 days?	Wed 5/16/07	Fri 7/6/07
117	▦	Punchlists and Cleaning	31 days?	Tue 7/3/07	Tue 8/14/07
118	▦	Owner Acceptance	0 days	Tue 8/14/07	Tue 8/14/07
119		**6th Floor Finishes**	**138 days?**	**Wed 2/7/07**	**Fri 8/17/07**
120	▦	Layout	5 days?	Wed 2/7/07	Tue 2/13/07
121	▦	MEP Risers	5 days?	Wed 2/7/07	Tue 2/13/07
124	▦	Install Duct	5 days?	Wed 2/14/07	Tue 2/20/07
125	▦	Overhead MEP Rough-In	14 days?	Mon 2/19/07	Thu 3/8/07
122	▦	Frame Out Interior Walls	11 days?	Fri 3/9/07	Fri 3/23/07
123	▦	MEP Wall Rough-In	15 days?	Wed 3/21/07	Tue 4/10/07
126	▦	Install Fire-Stop	5 days?	Wed 3/21/07	Tue 3/27/07
127	▦	MEP Close-In Inspections	11 days?	Wed 4/11/07	Wed 4/25/07
128	▦	Finishes and Fixtures	38 days?	Mon 5/21/07	Wed 7/11/07
129	▦	Punchlists and Cleaning	30 days?	Mon 7/9/07	Fri 8/17/07
130	▦	Owner Acceptance	0 days	Fri 8/17/07	Fri 8/17/07
131		**7th Floor Finishes**	**131 days?**	**Wed 2/14/07**	**Wed 8/15/07**
132	▦	Layout	5 days?	Wed 2/14/07	Tue 2/20/07
133	▦	MEP Risers	5 days?	Wed 2/14/07	Tue 2/20/07
136	▦	Install Duct	5 days?	Wed 2/21/07	Tue 2/27/07
137	▦	Overhead MEP Rough-In	14 days?	Mon 2/26/07	Thu 3/15/07
134	▦	Frame Out Interior Walls	11 days?	Fri 3/16/07	Fri 3/30/07
135	▦	MEP Wall Rough-In	15 days?	Wed 3/28/07	Tue 4/17/07
138	▦	Install Fire-Stop	5 days?	Wed 3/28/07	Tue 4/3/07
139	▦	MEP Close-In Inspections	11 days?	Wed 4/18/07	Wed 5/2/07
140	▦	Finishes and Fixtures	38 days?	Thu 5/24/07	Mon 7/16/07
141	▦	Punchlists and Cleaning	25 days?	Thu 7/12/07	Wed 8/15/07



Project: Detailed Schedule.mpp
Date: Mon 10/30/06

Task	▨	Milestone	◆	Rolled Up Task	▨	Rolled Up Progress	▬	External Tasks	▬	Group By Summary	▬
Progress	▬	Summary	▬	Rolled Up Milestone	◇	Split	⋯	Project Summary	▬	Deadline	⇩

ID	ℹ	Task Name	Duration	Start	Finish
142	▦	Owner Acceptance	0 days	Wed 8/15/07	Wed 8/15/07
143		**8th Floor Finishes**	**137 days?**	**Wed 2/21/07**	**Thu 8/30/07**
144	▦	Layout	5 days?	Wed 2/21/07	Tue 2/27/07
145	▦	MEP Risers	5 days?	Wed 2/21/07	Tue 2/27/07
148	▦	Install Duct	5 days?	Wed 2/28/07	Tue 3/6/07
149	▦	Overhead MEP Rough-In	14 days?	Mon 3/5/07	Thu 3/22/07
146	▦	Frame Out Interior Walls	11 days?	Fri 3/23/07	Fri 4/6/07
147	▦	MEP Wall Rough-In	15 days?	Wed 4/4/07	Tue 4/24/07
150	▦	Install Fire-Stop	5 days?	Wed 4/4/07	Tue 4/10/07
151	▦	MEP Close-In Inspections	11 days?	Wed 4/25/07	Wed 5/9/07
152	▦	Finishes and Fixtures	37 days?	Mon 6/4/07	Tue 7/24/07
153	▦	Punchlists and Cleaning	30 days?	Fri 7/20/07	Thu 8/30/07
154	▦	Owner Acceptance	0 days	Thu 8/30/07	Thu 8/30/07
155		**9th Floor Finishes**	**139 days?**	**Wed 2/28/07**	**Sat 9/8/07**
156	▦	Layout	5 days?	Wed 2/28/07	Tue 3/6/07
157	▦	MEP Risers	5 days?	Wed 2/28/07	Tue 3/6/07
160	▦	Install Duct	5 days?	Wed 3/7/07	Tue 3/13/07
161	▦	Overhead MEP Rough-In	14 days?	Mon 3/12/07	Thu 3/29/07
158	▦	Frame Out Interior Walls	11 days?	Fri 3/30/07	Fri 4/13/07
159	▦	MEP Wall Rough-In	15 days?	Wed 4/11/07	Tue 5/1/07
162	▦	Install Fire-Stop	5 days?	Wed 4/11/07	Tue 4/17/07
163	▦	MEP Close-In Inspections	11 days?	Wed 5/2/07	Wed 5/16/07
164	▦	Finishes and Fixtures	37 days?	Thu 6/7/07	Fri 7/27/07
165	▦	Punchlists and Cleaning	31 days?	Mon 7/30/07	Sat 9/8/07
166	▦	Owner Acceptance	0 days	Sat 9/8/07	Sat 9/8/07
167		**Elevators**	**107 days?**	**Thu 3/8/07**	**Fri 8/3/07**
168	▦	Temporary Watertight	10 days?	Thu 3/8/07	Wed 3/21/07
169	▦	Install Elevators	97 days?	Thu 3/22/07	Fri 8/3/07
170	▦	Temporary Cab Available	0 days	Fri 6/15/07	Fri 6/15/07



Task	▨	Milestone	◆	Rolled Up Task	▨	Rolled Up Progress	▬	External Tasks	▨	Group By Summary	▬
Progress	▬	Summary	▬	Rolled Up Milestone	◇	Split	⋯	Project Summary	▬	Deadline	⇩

Estimate of Probable Cost

Two Liberty - Jun 2005 - VA - Arlington

Prepared By:	**Nathanael Paist** **Penn State AE - Construction Management**	Prepared For:	**Existing Construction Conditions**
	, **Fax:**		**,** **Fax:**
Building Sq. Size:	**180000**	Site Sq. Size:	**255802**
Bid Date:		Building use:	**Office**
No. of floors:	**9**	Foundation:	**CON**
No. of buildings:	**1**	Exterior Walls:	**CUR**
Project Height:		Interior Walls:	**DRY**
1st Floor Height:	**10**	Roof Type:	**BAL**
1st Floor Size:	**20000**	Floor Type:	**CON**
		Project Type:	**NEW**

Division		Percent	Sq. Cost	Amount
00	**Bidding Requirements**	**2.22**	**4.15**	**746,187**
	Bidding Requirements	2.22	4.15	746,187
01	**General Requirements**	**7.08**	**13.25**	**2,384,488**
	General Requirements	7.08	13.25	2,384,488
02	**Site Work**	**2.01**	**3.76**	**677,686**
	Site Work	2.01	3.76	677,686
03	**Concrete**	**13.86**	**25.91**	**4,663,932**
	Concrete	13.86	25.91	4,663,932
04	**Masonry**	**1.92**	**3.59**	**646,092**
	Masonry	1.92	3.59	646,092
05	**Metals**	**6.18**	**11.56**	**2,080,251**
	Metals	6.18	11.56	2,080,251
06	**Wood & Plastics**	**0.33**	**0.61**	**110,423**
	Wood & Plastics	0.33	0.61	110,423
07	**Thermal & Moisture Protection**	**0.92**	**1.72**	**308,906**
	Thermal & Moisture Protection	0.92	1.72	308,906
08	**Doors & Windows**	**11.47**	**21.45**	**3,861,413**
	Doors & Windows	11.47	21.45	3,861,413
09	**Finishes**	**2.22**	**4.15**	**746,506**
	Finishes	2.22	4.15	746,506
10	**Specialties**	**1.72**	**3.21**	**577,348**
	Specialties	1.72	3.21	577,348
12	**Furnishings**	**0.69**	**1.29**	**232,993**
	Furnishings	0.69	1.29	232,993
13	**Special Construction**	**0.21**	**0.40**	**71,942**
	Special Construction	0.21	0.40	71,942
14	**Conveying Systems**	**2.67**	**5.00**	**900,187**
	Conveying Systems	2.67	5.00	900,187
15	**Mechanical**	**4.71**	**8.80**	**1,584,114**
	Mechanical	4.71	8.80	1,584,114
16	**Electrical**	**1.63**	**3.06**	**550,260**
	Electrical	1.63	3.06	550,260
21	**Fire Suppression**	**2.93**	**5.47**	**985,059**
	Fire Suppression	2.93	5.47	985,059
22	**Plumbing**	**2.11**	**3.95**	**711,466**
	Plumbing	2.11	3.95	711,466

23	**HVAC**	**14.58**	**27.25**	**4,905,676**
	HVAC	14.58	27.25	4,905,676
26	**Electrical**	**11.25**	**21.04**	**3,786,421**
	Electrical	11.25	21.04	3,786,421
31	**Earthwork**	**2.04**	**3.81**	**685,482**
	Earthwork	2.04	3.81	685,482
32	**Exterior Improvements**	**4.93**	**9.23**	**1,660,906**
	Exterior Improvements	4.93	9.23	1,660,906
33	**Utilities**	**2.31**	**4.33**	**778,658**
	Utilities	2.31	4.33	778,658
Total Building Costs		**100.00**	**186.98**	**33,656,395**
Total Site Costs		**100.00**	**0.00**	**0**
Total Project Costs		**--**	**--**	**33,656,395**

Estimate of Probable Cost

Woodlands Two - Aug 1998 - MD - Other

Prepared By:	**DRBrasher, Inc.** **5560 Sterrett Place, #300** **Coumbia, MD 21044** **Fax:**	Prepared For:	**,** **Fax:**
Building Sq. Size:	**120000**	Site Sq. Size:	**376224**
Bid Date:	**8/1/1998**	Building use:	**Office**
No. of floors:	**4**	Foundation:	**CON**
No. of buildings:	**1**	Exterior Walls:	**PRE**
Project Height:	**65.4**	Interior Walls:	**GYP**
1st Floor Height:	**10**	Roof Type:	**EPD**
1st Floor Size:	**30000**	Floor Type:	**CON**
		Project Type:	**NEW**

Division		Percent	Sq. Cost	Amount
00	**Bidding Requirements**	**6.90**	**2.72**	**325,983**
01	**General Requirements**	**1.85**	**0.73**	**87,477**
03	**Concrete**	**14.18**	**5.58**	**670,063**
04	**Masonry**	**2.56**	**1.01**	**121,077**
05	**Metals**	**17.20**	**6.77**	**812,401**
06	**Wood & Plastics**	**1.75**	**0.69**	**82,814**
07	**Thermal & Moisture Protection**	**2.97**	**1.17**	**140,384**
08	**Doors & Windows**	**8.39**	**3.30**	**396,474**
09	**Finishes**	**9.31**	**3.67**	**439,993**
10	**Specialties**	**1.18**	**0.47**	**55,926**
12	**Furnishings**	**0.60**	**0.24**	**28,497**
14	**Conveying Systems**	**3.74**	**1.47**	**176,919**
15	**Mechanical**	**21.70**	**8.54**	**1,025,039**
16	**Electrical**	**7.65**	**3.01**	**361,574**
Total Building Costs		**100.00**	**39.37**	**4,724,621**
02	**Site Work**	**100.00**	**2.39**	**898,639**
Total Site Costs		**100.00**	**2.39**	**898,639**
Total Project Costs		**--**	**--**	**5,623,260**

Estimate of Probable Cost

Project Notes

Woodlands Two - Aug 1998 - MD - Other

*Columbia, Maryland
*Construction Period Oct 98 to Sep 99

Special Project Notes

Located within the Gateway Corporate Park in Columbia, Maryland, Woodlands Two is a 4-story, Class #A# office building. DRBrasher was hired by Corporate Development Services, LLC, a subsidiary of Corporate Office Properties Trust, one of the largest REIT developers in the Maryland area.

The challenge of this project was meeting the client#s request of designing a building that was different, yet complimentary to a previously built office building on the same property.

The site was a heavily wooded area and DRBrasher wanted to preserve as much as possible to capitalize and maximize the views that would be seen from the office windows. The storm water management was already in place between the two buildings. There were environmental wetland areas, which needed to be preserved as well. To take advantage of these areas, a walking path was designed around the natural areas for the tenant#s enjoyment and relaxation and to provide a connection for the two buildings.

Corporate Development Services requested a building designed for not only today#s technology users but for the future as well. The 30,000-square-foot large floor plates were structurally designed for 100 psf live load per floor to accommodate the dense population of office users today. These large floor plates allowed for open space plans, which are a must for many of today#s tenants. Fiber optics were installed in the building and the electrical systems were enhanced. The mechanical system was designed with multiple systems per floor to provide flexibility for tenant users.

Woodlands Two has a unique wing-shaped design, which gives it a monumental presence, emphasizing and projecting the curve of the building and provides for more exterior windows. For the exterior skin of the building, DRBrasher chose the SlenderWall# system manufactured by the Smith-Midland Corporation. The system is an integrated precast-concrete brick finish with precast accent band panels. The curved precast panels set this building apart from other buildings in the corporate park. The architect was able to achieve the desired design of combined masonry and precast in one panel, which saved significant cost over the conventional brick veneer and precast method. This system allowed the building to be constructed with a masonry appearance in the dead of winter without cold weather delays and added costs for winterized construction. The system's erection time also provided cost savings.

To coincide with the building#s exterior, the interior had to be upscale. The interior finishes included granite flooring in the lobby, with custom wood millwork and glass. These finishes continued into the elevators. But one of the most unique features of the interior is an 11-foot 6-inch ceiling height with a back-lit luminous ceiling system, which created the illusion of a skylight and of a much higher ceiling. By using this system to create an atrium effort, the architect was able to maximize the rentable square footage area per floor.

Woodlands Two recently won a NAIOP (National Association of Industrial and Office Properties) Design of Excellence Award 2000 for the office building mid-rise 3-4 floors category.

MANUFACTURERS/SUPPLIERS

DIV 03: Precast Concrete Brick Finish: SlenderWall# by Smith Midland Corporation.
DIV 07: Roof Insulation: Owens Corning; Membrane Roof: Firestone.
DIV 08: Entrances & Storefronts: YKK AP America. Wood & Plastic Doors: Marshfield DoorSystems.
DIV 09: Floor Tile: Dal-Tile; Resilient Flooring: Azrock; Carpet: Monterey Spoolcraft; Gypsum Board: United States Gypsum; Painting: Duron.
DIV 14: Elevators: Otis.

Photo Courtesy of James Parker Photography
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Estimate of Probable Cost

Netplex Plaza - Nov 1999 - VA - Other

Prepared By:	**Davis Carter Scott** **1676 International Drive, #500** **McLean, VA 22102** **Fax:**	Prepared For:	**,** **Fax:**
Building Sq. Size:	**171809**	Site Sq. Size:	**151759**
Bid Date:	**11/1/1999**	Building use:	**Office**
No. of floors:	**4**	Foundation:	**CON**
No. of buildings:	**1**	Exterior Walls:	**MAS**
Project Height:	**66**	Interior Walls:	**GYP**
1st Floor Height:	**14**	Roof Type:	**BUP**
1st Floor Size:	**14629**	Floor Type:	**CON**
		Project Type:	**NEW**

Division		Percent	Sq. Cost	Amount
01	**General Requirements**	**7.58**	**3.37**	**579,730**
03	**Concrete**	**34.13**	**15.19**	**2,610,400**
04	**Masonry**	**8.55**	**3.81**	**653,970**
05	**Metals**	**4.91**	**2.19**	**375,517**
06	**Wood & Plastics**	**1.13**	**0.50**	**86,457**
07	**Thermal & Moisture Protection**	**2.19**	**0.97**	**167,223**
08	**Doors & Windows**	**5.74**	**2.56**	**439,374**
09	**Finishes**	**8.89**	**3.96**	**679,955**
10	**Specialties**	**0.38**	**0.17**	**29,437**
12	**Furnishings**	**0.43**	**0.19**	**32,523**
13	**Special Construction**	**0.68**	**0.30**	**52,000**
14	**Conveying Systems**	**3.14**	**1.40**	**240,316**
15	**Mechanical**	**16.57**	**7.38**	**1,267,098**
16	**Electrical**	**5.68**	**2.53**	**434,636**
Total Building Costs		**100.00**	**44.52**	**7,648,636**
02	**Site Work**	**100.00**	**3.32**	**504,578**
Total Site Costs		**100.00**	**3.32**	**504,578**
Total Project Costs		**--**	**--**	**8,153,214**

Estimate of Probable Cost

Project Notes

Netplex Plaza - Nov 1999 - VA - Other

*Reston, Virginia
*Construction Period May 2000 to Feb 2001

Special Project Notes:

Located along the fast-growing Dulles Airport Corridor, Netplex Plaza is at home in the edge city of Reston, Virginia. The site lies immediately adjacent to Sunset Hills Road which bounds its northern edge. The location assures a strong presence along Sunset Hills Road, not withstanding its visibility from the Dulles Airport access road.

Initiated in early 1999, the masterplan developed for this speculative office development, includes 90,000 square feet of office space and an adjacent 60,000 square feet for parking.

Contextualism plays a large role in designing buildings in the planned community of Reston. Netplex Plaza seeks to coexist with the countless low-rise commercial office buildings nearby, while re-composing the traditional elements of these buildings to create an aesthetic more in tune with this high-tech, fast-moving environment. The choice of masonry construction afforded the opportunity to design a building that has the economical leasing efficiency of a rectangular floorplate, without the visual brutality of a typical rectangular office building. Interior appointments include stone flooring, pendant and wall scone light fixtures, and stainless steel to complete the contemporary look of the building.

A long and narrow site with a strong slope along its shortest length provided the first of many challenges. Because of the slope, Netplex Plaza appears to be six stories as viewed from the west and five stories as viewed from the east. The road leading into the development provides direct access to a pedestrian drop-off at the building#s main entrance, one floor up from the entrance that serves on-grade parking on the other side. The main entrance also serves those coming from the level of structured parking to the south of the building. Fitting adequate landscaping and parking to the site was a challenge due to its narrowness and the proximity of numerous utility lines running through it and along its boundaries.

MANUFACTURERS/SUPPLIERS

DIV 07: Built-Up: Tamko; Metal: Petersen Aluminum.
DIV 08: Entrances & Storefronts, Metal Windows, Curtainwall: YKK AP America, Inc.; Metal Doors & Frames: Curries; Wood & Plastic Doors: Marshfield DoorSystems, Inc.
DIV 09: Resilient Flooring: Armstrong; Acoustical Treatment: Armstrong; Gypsum Board: United States Gypsum.
DIV 14: Elevators: Otis.

Photo Courtesy of Gunnar Westerlind
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Estimate of Probable Cost

Ha-Lo Headquarters - Aug 1998 - IL - Other

Prepared By:	**Harbour Contractors, Inc.** **215 West Main Street** **Plainfield, IL 60544** **Fax:**	Prepared For:	**,** **Fax:**
Building Sq. Size:	**267334**	Site Sq. Size:	**239425**
Bid Date:	**8/1/1998**	Building use:	**Office**
No. of floors:	**7**	Foundation:	**CON**
No. of buildings:	**1**	Exterior Walls:	**CUR**
Project Height:	**93.6**	Interior Walls:	**DRY**
1st Floor Height:	**12**	Roof Type:	**MEM**
1st Floor Size:	**37528**	Floor Type:	**CON**
		Project Type:	**NEW**

Division		Percent	Sq. Cost	Amount
00	**Procurement and Contracting Require**	**2.14**	**3.02**	**806,423**
01	**General Requirements**	**12.81**	**18.03**	**4,820,568**
03	**Concrete**	**19.43**	**27.36**	**7,315,381**
04	**Masonry**	**1.78**	**2.51**	**670,284**
05	**Metals**	**9.45**	**13.31**	**3,558,652**
06	**Wood, Plastics, and Composites**	**0.20**	**0.28**	**75,295**
07	**Thermal and Moisture Protection**	**1.03**	**1.45**	**388,040**
08	**Openings**	**21.43**	**30.18**	**8,068,778**
09	**Finishes**	**1.42**	**2.00**	**534,876**
10	**Specialties**	**3.32**	**4.67**	**1,248,814**
12	**Furnishings**	**1.26**	**1.78**	**475,540**
14	**Conveying Systems**	**4.37**	**6.15**	**1,643,178**
21	**Fire Suppression**	**2.02**	**2.85**	**762,128**
22	**Plumbing**	**1.46**	**2.06**	**550,453**
23	**HVAC**	**10.08**	**14.20**	**3,795,463**
26	**Electrical**	**7.78**	**10.96**	**2,929,509**
Total Building Costs		**100.00**	**140.81**	**37,643,382**
02	**Existing Conditions**	**2.93**	**0.30**	**72,946**
31	**Earthwork**	**21.29**	**2.22**	**530,349**
32	**Exterior Improvements**	**51.59**	**5.37**	**1,285,023**
33	**Utilities**	**24.19**	**2.52**	**602,438**
Total Site Costs		**100.00**	**10.40**	**2,490,756**
Total Project Costs		**--**	**--**	**40,134,138**

*Niles, Illinois
*Construction Period Nov 98 to Oct 00

Special Project Notes

The conceptual ideas about the Ha-Lo Headquarters deal with urban planning, function and technology. The building is arranged like a simple and clear diagram. Its components are placed in a logical, rational and constructed way. Interest is in engineering and performance, rather than design and style. The result is a building of maximum transparency. Transparency deals with light. Traditionally light has been directed at the material fabric of a building, illuminating the solid. At the Ha-Lo Headquarters they are moving into a realm, where light is the essence of the design. The building is luminous, not illuminated. The facade acts as a fabric which moderates the natural and the artificial light, it becomes a screen. The functions are within an adaptable envelope, which responds to the exterior environmental conditions and creates the desired interior environment.

The 7-story building establishes the desired identity at Touhy and Leigh. Projecting loggias from entries at both ends. Building, parking and warehouse are organized through the landscaping like a collage of shifted geometries.

The functions are placed around a 7-story open court. The low floors are loft-type offices. The top 2 floors are showrooms and executive offices around a 2-story skycourt. This clear stacking is readable at the entry facade and contributes to the building's transparency.

Technology is not added, it is an integral part of the design. Technology is not exhibited, but working towards meeting the building's functional, spatial and environmental goals. Technology is advanced, but more in the way that proven and tested materials and components are put together than through invention. Newness is achieved through the elimination of the inessential.

The only way architecture can be new today is through assuming responsibility for more than form and aesthetic. Responsible architecture has to control its environment through design not solely through added technical and mechanical systems. Otherwise technology becomes self-purpose.

Daylight, solar energy and the idea that the skin of a building modulates its own climate have not yet been integrated as essential components in commercial design. The inclusion of these methodologies is a desirable goal. Through this, we can rededicate ourselves towards our natural reflexes and intuitive actions. The result: Buildings with high technology and low energy.

This meets an "eco-tech" approach. A building in harmony between people, technology and nature.

MANUFACTURERS/SUPPLIERS

DIV 07: Skylights: ASI Advanced Structural Systems; Modified Bituminous Membrane: The Garland Company.
DIV 08: Curtainwall: Gardner Metal Products; Insulated Glass Units: Viracon; Structural Glazing: ASI Advanced Structural Systems; Low Iron Glass: Eckelt; Hollow Metal Doors: Curries; Sliding Fire Doors: American Metal Door Co.; Glass Revolving Doors: Boon-Edam; Wood Doors: VT Industries.
DIV 09: Ceramic Tile: Dal-Tile; Drywall, Metal Studs: United States Gypsum.
DIV 10: Access Flooring: Tate Access Floor; Toilet Partitions: Flush Metal Corp.; Toilet & Bath Accessories: American Specialties, Inc.
DIV 14: Elevators: Fujitec Co. Limited; Glass Cabs: Hauenstein & Burmeister Custom Cabs.

Photo Courtesy of Doug Snower

Office Building Cost Report

Project Name: Two Liberty Center

Model Type: Office, 5-10 Story, Precast Concrete Panel / R/Conc. Frame

Stories (Ea.): 9		**Location:**	Arlington, VA
Story Height (L.F.): 12		**Data Release**	2005
Floor Area (S.F.): 180000		**Wage Rate:**	Union
Basement: Not Included			

Costs are derived from a building model with basic components. Scope differences and local market conditions can cause costs to vary.

			$Cost/ Per S.F.	$ Total Cost	% Of Sub-Total	
A Substructure					2.7%	
A1010	Standard Foundations		1.36	244,000.00		
A1030	Slab on Grade		0.45	81,000.00		
A2010	Basement Excavation		0.03	4,700.00		
A2020	Basement Walls		0.24	42,600.00		
B Shell					30.4%	
B1010	Floor Construction		13.01	2,341,000.00		
B1020	Roof Construction		1.36	245,000.00		
B2010	Exterior Walls		6.26	1,126,000.00		
B2020	Exterior Windows		1.69	303,500.00		
B2030	Exterior Doors		0.15	27,100.00		
B3010	Roof Coverings		0.44	78,500.00		
C Interiors					19.8%	
C1010	Partitions		1.77	319,500.00		
C1020	Interior Doors		1.38	248,000.00		
C1030	Fittings		0.63	112,500.00		
C2010	Stair Construction		1.24	223,000.00		
C3010	Wall Finishes		0.71	128,500.00		
C3020	Floor Finishes		5.47	985,500.00		
C3030	Ceiling Finishes		3.71	667,500.00		
D Services					45.9%	
D1010	Elevators and Lifts		10.38	1,869,000.00		
D2010	Plumbing Fixtures		1.28	231,000.00		
D2020	Domestic Water Distribution		0.09	16,000.00		
D2040	Rain Water Drainage		0.04	7,975.00		
D3050	Terminal & Package Units		12.79	2,302,000.00		
D4020	Standpipes		0.08	14,500.00		
D5010	Electrical Service/Distribution		0.54	97,000.00		
D5020	Lighting and Branch Wiring		8.46	1,523,000.00		
D5030	Communications and Security		0.51	92,500.00		
D5090	Other Electrical Systems		0.41	73,500.00		
E Equipment & Furnishings					1.2%	
E1090	Other Equipment		0.93	166,500.00		
		Sub-Total	75.39	13,570,875.00	100%	
	GENERAL CONDITIONS (Overhead & Pr	**25%**	18.85	3,392,500.00		
	ARCHITECTURAL FEES	**6%**	5.66	1,018,000.00		
	USER FEES	**0%**	0.00	0.00		
	TOTAL BUILDING COST		**99.90**	**17,981,375.00**		

Garage Cost Report

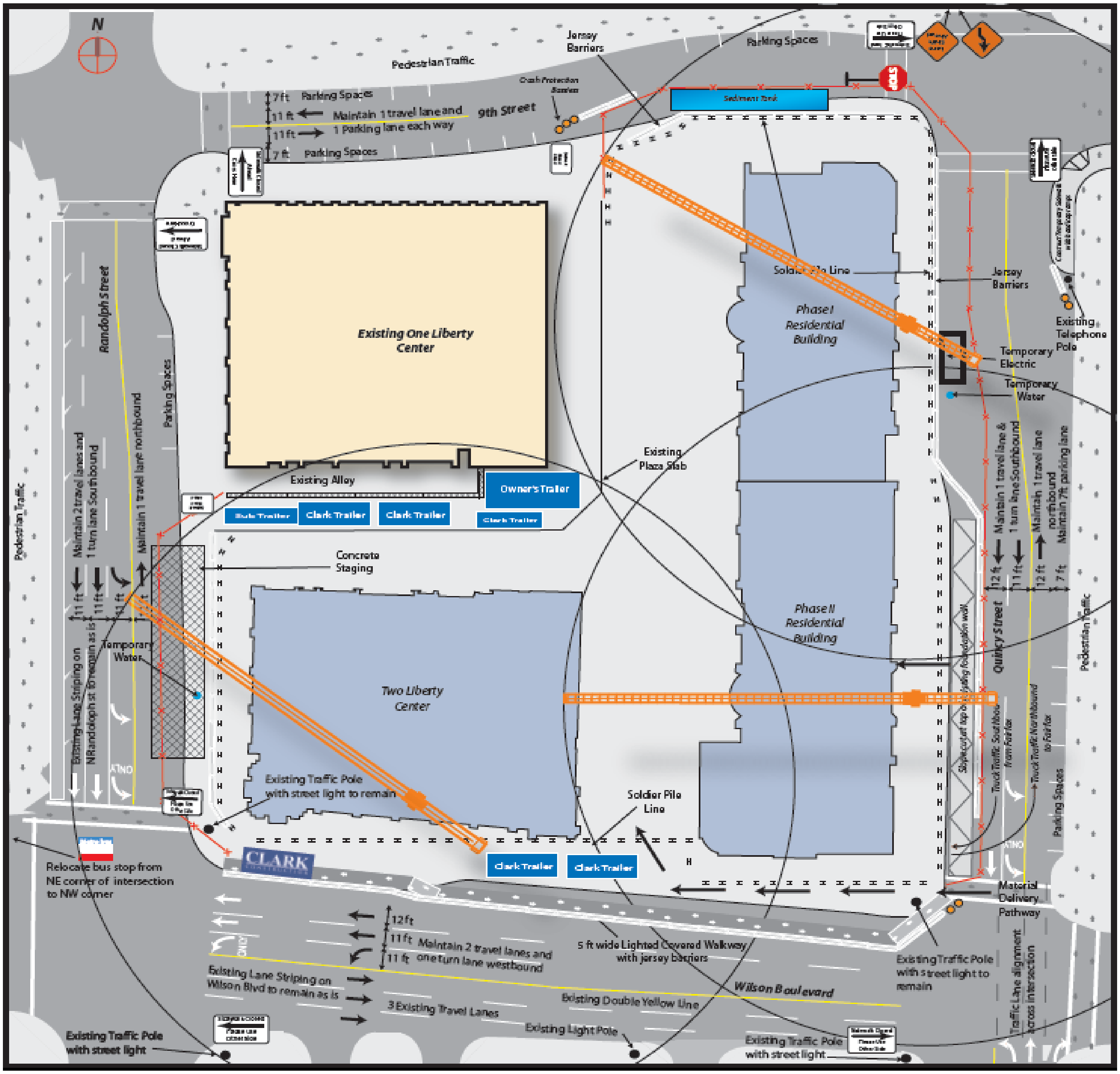
Project Name: Two Liberty Center

Model Type: Garage, Underground Parking, Reinforced Concrete / R/Conc. Frame

Stories (Ea.): 4		**Location:**	Arlington, VA
Story Height (L.F.): 10		**Data Release**	2005
Floor Area (S.F.): 130000		**Wage Rate:**	Union
Basement: Not Applicable			

Costs are derived from a building model with basic components. Scope differences and local market conditions can cause costs to vary.

			$Cost/ Per S.F.	$ Total Cost	% Of Sub-Total	
A Substructure					22.0%	
A1010	Standard Foundations		2.47	321,500.00		
A1030	Slab on Grade		2.33	302,500.00		
A2010	Basement Excavation		3.52	457,000.00		
B Shell					63.1%	
B1010	Floor Construction		10.00	1,300,500.00		
B1020	Roof Construction		9.27	1,205,500.00		
B2010	Exterior Walls		2.90	376,500.00		
B2030	Exterior Doors		0.12	15,600.00		
B3010	Roof Coverings		1.57	203,500.00		
C Interiors					2.0%	
C1010	Partitions		0.41	53,500.00		
C1020	Interior Doors		0.03	4,400.00		
C2010	Stair Construction		0.25	33,000.00		
C3010	Wall Finishes		0.05	6,725.00		
D Services					11.9%	
D1010	Elevators and Lifts		1.07	139,500.00		
D2010	Plumbing Fixtures		0.23	29,800.00		
D2020	Domestic Water Distribution		0.06	7,650.00		
D2040	Rain Water Drainage		0.62	80,500.00		
D3050	Terminal & Package Units		0.09	11,700.00		
D4020	Standpipes		0.07	8,650.00		
D5010	Electrical Service/Distribution		0.09	11,100.00		
D5020	Lighting and Branch Wiring		1.90	247,500.00		
D5030	Communications and Security		0.32	41,700.00		
D5090	Other Electrical Systems		0.04	5,800.00		
E Equipment & Furnishings					1.1%	
E1030	Vehicular Equipment		0.29	37,500.00		
E1090	Other Equipment		0.14	17,700.00		
		Sub-Total	37.84	4,919,325.00	100%	
	GENERAL CONDITIONS (Overhead & Pr	**25%**	9.46	1,230,000.00		
	ARCHITECTURAL FEES	**8%**	3.78	492,000.00		
	USER FEES	**0%**	0.00	0.00		
	TOTAL BUILDING COST		**51.09**	**6,641,325.00**		



N
Pedestrian Traffic
Jersey Barriers
Crash Protection Barriers
Parking Spaces
7 ft
11 ft
11 ft
7 ft
Maintain 1 travel lane and 1 Parking lane each way
9th Street
Sediment Tank
STOP
Randolph Street
Parking Spaces
Maintain 2 travel lanes and 1 turn lane Southbound
Maintain 1 travel lane northbound
Existing One Liberty Center
Existing Alley
Owner's Trailer
Clark Trailer
Clark Trailer
Clark Trailer
Concrete Staging
Existing Plaza Slab
Soldier Pile Line
Phase I Residential Building
Phase II Residential Building
Jersey Barriers
Existing Telephone Pole
Temporary Electric
Temporary Water
Maintain 1 travel lane & 1 turn lane Southbound
Maintain 1 travel lane northbound
Maintain 7ft parking lane
12 ft
11 ft
12 ft
7 ft
Quincy Street
Pedestrian Traffic
Truck Traffic Southbound from Fairfax
Truck Traffic Northbound to Fairfax
Parking Spaces
11 ft
11 ft
11 ft
Temporary Water
Existing Lane Striping on NRandolph st to remain as is
ONLY
Two Liberty Center
Existing Traffic Pole with street light to remain
Relocate bus stop from NE corner of intersection to NW corner
CLARK
Clark Trailer
Clark Trailer
Soldier Pile Line
Material Delivery Pathway
12 ft
11 ft
11 ft
Maintain 2 travel lanes and one turn lane westbound
5 ft wide Lighted Covered Walkway with jersey barriers
Existing Traffic Pole with street light to remain
Existing Lane Striping on Wilson Blvd to remain as is
3 Existing Travel Lanes
Wilson Boulevard
Existing Double Yellow Line
Existing Light Pole
Existing Traffic Pole with street light
Existing Traffic Pole with street light
Traffic Lane alignment across intersection

Appendix 2

This appendix contains the following referenced documents

1. **Interview responses from Person 1**

2. **Interview responses from Person 2**

1. Currently, what are the three most common types of development in the Washington, DC area?
    a. *Commercial Office*
    b. *Multi-Family Residential*
    c. *Federal Government facilities*

2. For each of the three types of development above, describe the most common leasing structures being used for the tenants of these buildings.
    a. *Commercial Office – Leases are generally long term agreements with tenants based on $/SF per month. Leases can be anywhere from 3 to 30 years in length but are generally in the 5-10 years range.*
    b. *Multi-Family Residential – Condominiums are for sale units. Apartment buildings are generally short term lease agreements with monthly lump sum payments. Terms of the lease are usually one year with options to renew.*
    c. *Federal Government Development covers a wide range of facilities with development services directed by many different government organizations such as GSA, USCOE, VA, etc. The lease arrangements are generally internally handled within the agency where the government is the owner of the facility. However, privatized developments are becoming more common where a private developer owns the facility with a guaranteed long term lease agreement with the government. This is currently the case with the privatized military housing where the private developer owns the housing which is used for the military personnel on or off government property with certain lease guarantees provided by the government.*

3. For each of the three types of development above, describe the emphasis placed on the efficiency of the buildings being constructed.

    More and more emphasis is being placed on the efficiency of buildings for several reasons as noted below:

    a. *Commercial Office – Long term tenants who pay to operate the building or at a minimum pay for utilities, want a building that operates efficiently. Some even consider more up front costs for peak shaving systems*
    b. *Residential – Condominiums must be designed and constructed with efficiency in mind as the purchasers will not be happy with excessive utility bills for poorly designed building envelopes. Inefficient condominium buildings lead to law suits and disputes. On rental apartment buildings, inefficient buildings will lead to higher utility usage and maintenance costs which will be borne by the building owner for common space and each renter for his unit. In either case, condominium or rental, the negative impact of owning an inefficient building will result in lower value at resale, whether you are talking about a single unit or an entire apartment building.*
    c. *Government Facilities – The government remains deeply concerned about the efficiency of its facilities. As they are generally the long term operator and owner of the majority of their facilities, they are more focused on the long term operating costs than the initial cost of construction.*

4. For each of the three types of development above, identify the popularity of sustainable, or LEED rated, construction.
    a. *In general, LEED rated construction is gaining momentum. Locally in the Washington area, Arlington County, VA has already adopted its own version of LEED requirements for green construction. The District of Columbia will enact its own requirements in 2008 and Montgomery County, MD is not far behind. Most private developers are also engaged and willing to participate as they see it as a marketing tool now and moving quickly toward a requirement. The federal government has not completely embraced the concepts yet as they are generally not influenced by the positive "marketing" aspects. However, they have and will continue to be focused on energy efficient designs and will likely embrace the sustainable design concepts when it is politically necessary.*

5. In your professional opinion, have the recent changes in the cost of energy had a significant effect on the decisions made about building efficiency and sustainability for developers?
    a. *Most of the drive toward sustainable designs has little to do with the cost of energy but is more the result of the ability to market the fact that they are focused on the environmental issues and can market and sell their buildings as "Green" buildings. Most of the designs are fairly energy efficient designs and the systems are generally designed with economics in mind anyway. Most designs are evaluated with the first cost/operating cost analysis to determine the most cost efficient approach, depending on the type of building, use, and ownership duration (strictly a business/financial decision). In general, I do not believe that the recent rise in energy costs has resulted in significant changes in the efficiency of building designs as they have always been focused on the best financial approach for the Owner.*

6. Are developers becoming more willing to spend more money upfront to produce a building with lower lifecycle costs?
    a. *Again, this depends on what the Owner intends to do with the building. If they intend to hold the property, they are more likely to consider spending upfront in order to lower the operating costs and maintenance costs. If the Owner intends to sell or turn over the project quickly, they lean toward minimizing the upfront costs as they will not be responsible for the lifecycle costs down the road. However, with the rising popularity and emphasis on sustainable and Green buildings, this approach may be changing as it will now affect the salability and price of their buildings.*

7. In your professional opinion, are more efficient and sustainable buildings significantly more attractive to potential tenants? If so, does the marketability of these buildings make up for the additional money invested in the construction?
    a. *I think that the sustainable buildings are more attractive to potential tenants but I don't believe that they are yet willing to pay a large premium for it. I do believe that all other things being equal, a sustainable building will lease up before a building that has no consideration towards sustainability. The tenants who are responsible for operating costs would certainly perform their analysis of operating costs when making a decision about where to sign a lease. Therefore, more efficient buildings with lower operating costs will have an advantage over less efficient buildings.*

8. In your professional opinion, are LEED rated buildings significantly more attractive to potential tenants? If so, does the marketability of these buildings make up for the additional money invested in the construction?
    a. *LEED rated buildings are becoming more popular and the label is being used as a marketing tool. However, I do not believe that most tenants are willing to pay a premium for the label at this time. Again, the focus remains on economics. If the tenant feels that a LEED rated building will provide financial advantages such as lower utility charges, increased productivity of its employees, etc., then they may pay more for it. If the LEED rated building can not be demonstrated to provide such concrete advantages, I believe there are very few tenants who would pay extra just to have the LEED label.*

9. Please provide any further insight into the relationship between building efficiency/sustainability and development options.
    a. *Developments in recent years have and will continue to revolve around economics. Efficient and sustainable design elements will continue to be introduced as technology and processes are refined. These advances will be fueled by the desire to minimize operating costs. Where these elements*

can be feasibly incorporated and will reduce operating costs and energy consumption, they will be used extensively. All such efficiency/sustainable improvements will continue to be evaluated financially and to the extent they make financial sense; they will become mainstream in future developments.

b. The other factor that will affect future development relative to efficiency and sustainability is future jurisdictional regulations. As local jurisdictions begin to implement and enforce sustainable and efficiency requirements in future developments, the developers will be forced to comply, regardless of cost. These costs will eventually be borne by the tenants or end users of the developments.

1. Currently, what are the three most common types of development in the Washington, DC area?
    1. *Multi-family (apartments)*
    2. *office*
    3. *high bay industrial*

2. For each of the three types of development above, describe the most common leasing structures being used for the tenants of these buildings.
    1. *all inclusive except electrical;*
    2. *full-service (all costs included);*
    3. *Triple-net (tenant pays for all costs above the base rent)*

3. For each of the three types of development above, describe the emphasis placed on the efficiency of the buildings being constructed.
    1. *HIGH Emphasis through all three types.*

4. For each of the three types of development above, identify the popularity of sustainable, or LEED rated, construction.
    1. *In a nutshell, all developers today include LEED 'rated' construction techniques, however, a minute few are interested in achieving a fully compliant LEED building – too expensive and time consuming.*

5. In your professional opinion, have the recent changes in the cost of energy had a significant effect on the decisions made about building efficiency and sustainability for developers?
    1. *Without a doubt. Helps attract tenants.*

6. Are developers becoming more willing to spend more money upfront to produce a building with lower lifecycle costs?
    1. *Yes, but only too a certain extent. There is a point of diminishing return for developers in today's market. This 'point' will move to a more LEED*

tolerant position as time goes by. Maybe within 5-10 years we'll vastly increase the efficiency of our buildings in a more holistic manner. Seems that in today's construction we're mainly focusing on reducing electrical usage and in providing cleaner air.

7. In your professional opinion, are more efficient and sustainable buildings significantly more attractive to potential tenants? If so, does the marketability of these buildings make up for the additional money invested in the construction?
    a. *Yes, easier to attract tenants from a marketing point of view. However, I do not believe that additional $'s spent today to create more efficient and sustainable buildings offsets the predominant decision that tenants make re: their space: what's the price? What will this lease cost be in the short and long terms? Price dictates all! [At least most of the time…]*

8. In your professional opinion, are LEED rated buildings significantly more attractive to potential tenants? If so, does the marketability of these buildings make up for the additional money invested in the construction?
    a. *See #7 above.*

9. Please provide any further insight into the relationship between building efficiency/sustainability and development options.
    a. *COST, COST, COST*

Appendix 3

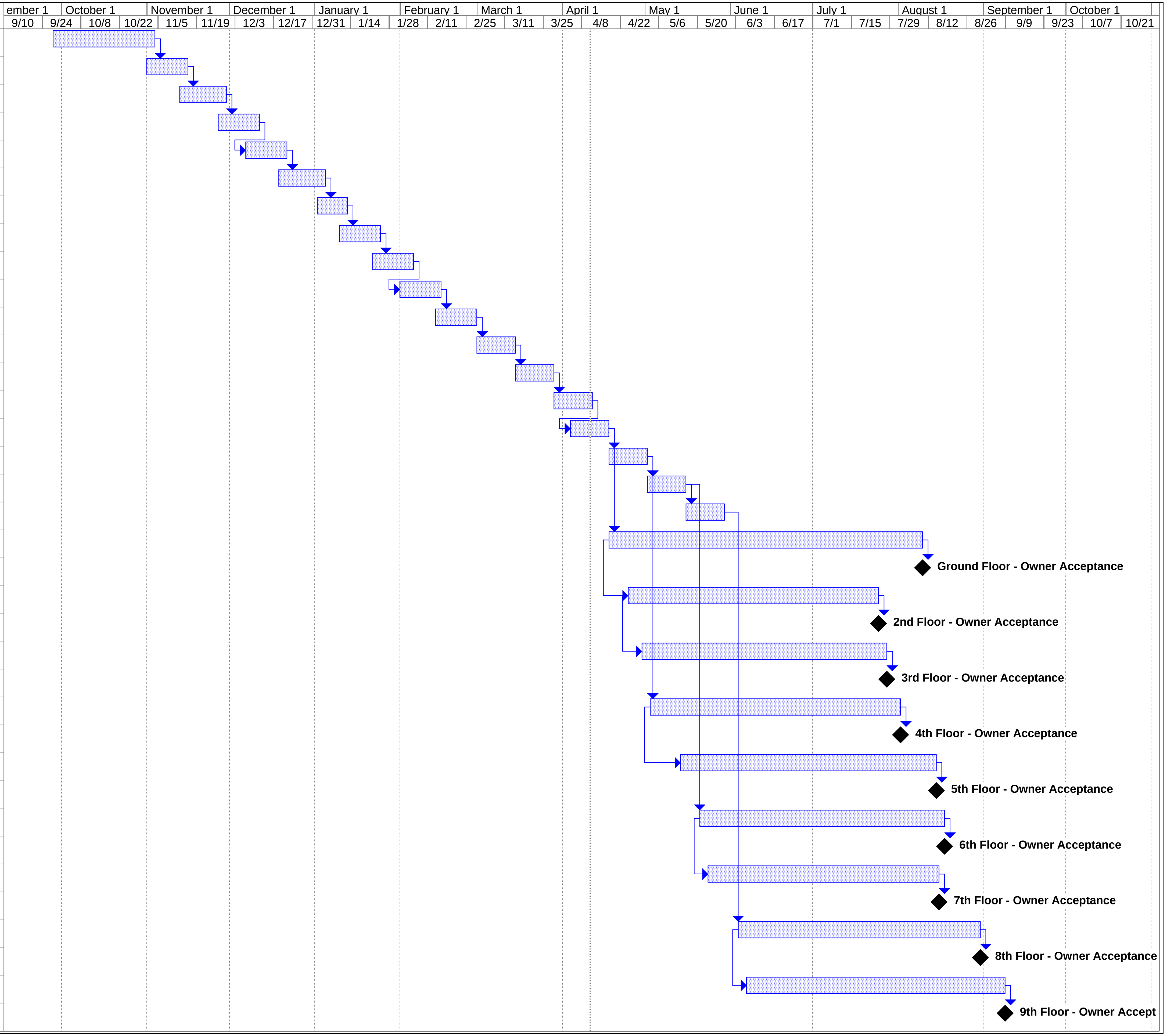
This appendix contains the following referenced documents:

1. **Existing Schedule – Detailed Façade Schedule**

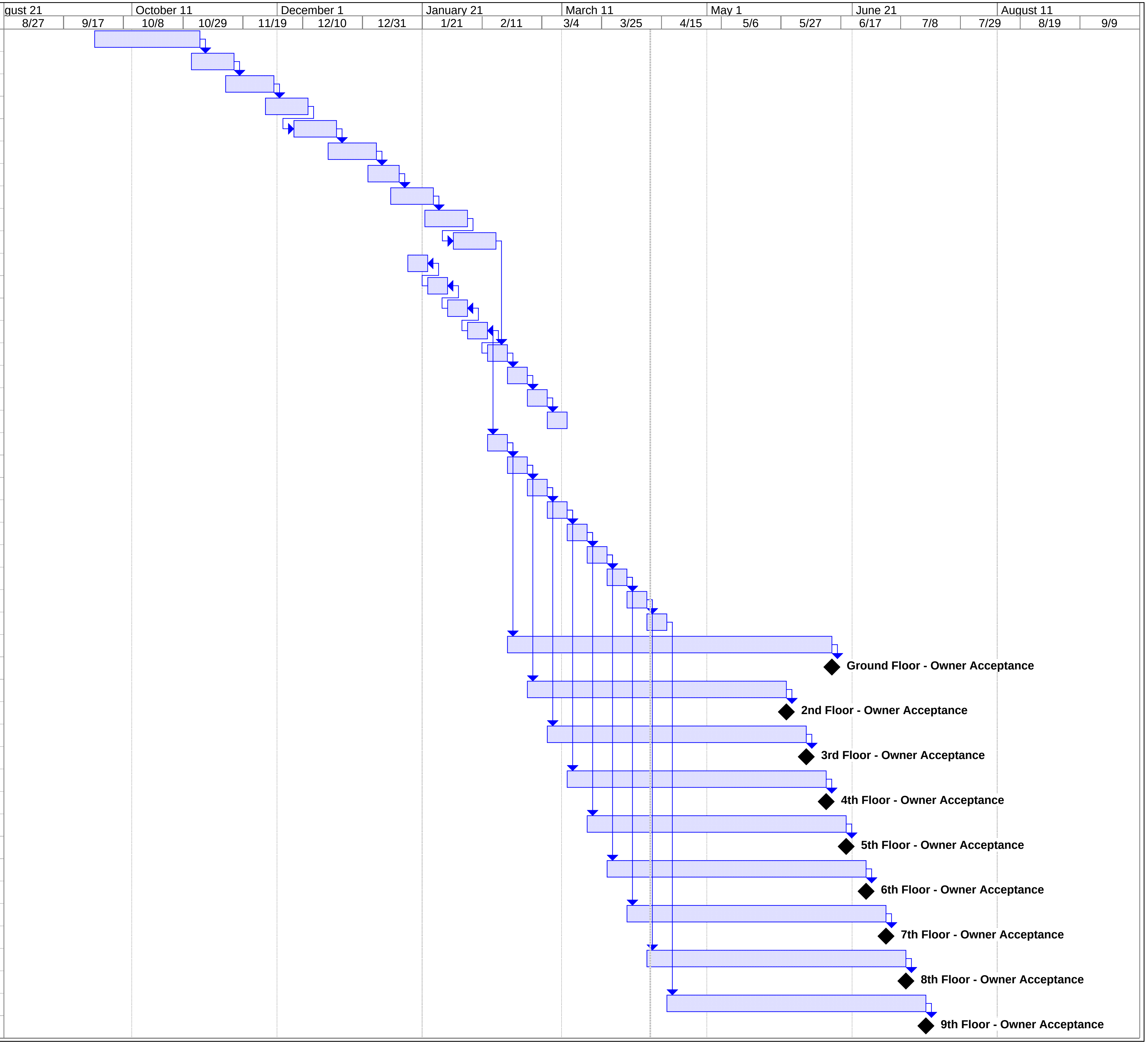
2. **Alternate 1 – Detailed Façade Schedule**

3. **Alternate 2 – Detailed Façade Schedule**

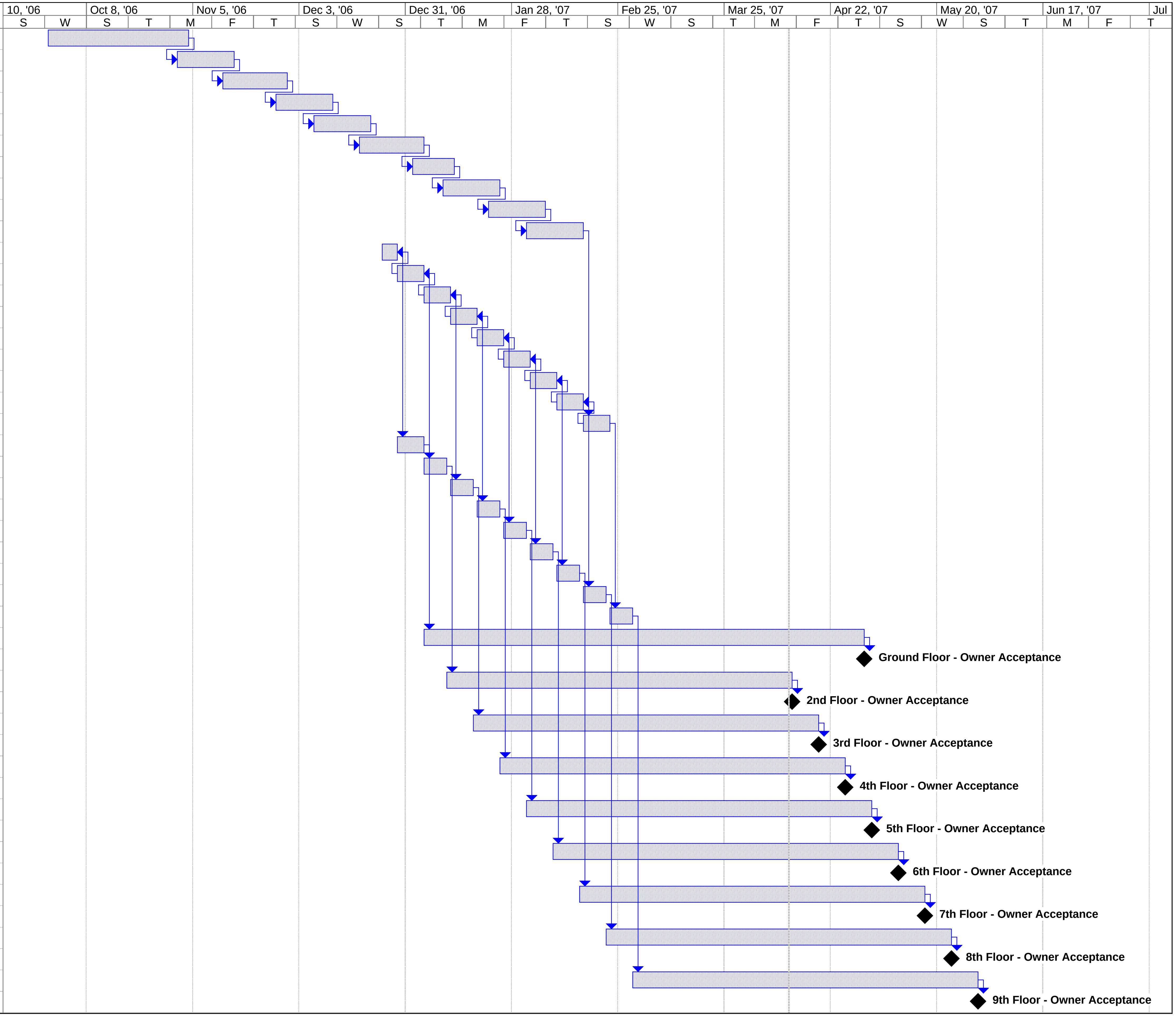
ID	Task Name	Duration	Start	Finish
1	Ground Floor - Frame and Place Slab	27 days	Thu 9/28/06	Fri 11/3/06
2	2nd Floor - Frame and Place Slab - Pc	11 days	Wed 11/1/06	Wed 11/15/06
3	3rd Floor - Frame and Place Slab - Po	13 days	Mon 11/13/06	Wed 11/29/06
4	4th Floor - Frame and Place Slab - Po	11 days	Mon 11/27/06	Mon 12/11/06
5	5th Floor - Frame and Place Slab - Po	11 days	Thu 12/7/06	Thu 12/21/06
6	6th Floor - Frame and Place Slab - Po	13 days	Tue 12/19/06	Thu 1/4/07
7	7th Floor - Frame and Place Slab - Po	9 days	Tue 1/2/07	Fri 1/12/07
8	8th Floor - Frame and Place Slab - Po	11 days	Wed 1/10/07	Wed 1/24/07
9	9th Floor - Frame and Place Slab - Po	11 days	Mon 1/22/07	Mon 2/5/07
10	Roof Level - Frame and Place Slab - F	11 days	Thu 2/1/07	Thu 2/15/07
11	Precast - Office South Side	11 days	Wed 2/14/07	Wed 2/28/07
12	Precast - Office West Side	10 days	Thu 3/1/07	Wed 3/14/07
13	Precast - Office North Side	10 days	Thu 3/15/07	Wed 3/28/07
14	Precast - Office East Side	10 days	Thu 3/29/07	Wed 4/11/07
15	Windows - Office Floors 1-2-3	10 days	Wed 4/4/07	Tue 4/17/07
16	Windows - Office Floors 4-5	10 days	Wed 4/18/07	Tue 5/1/07
17	Windows - Office Floors 6-7	10 days	Wed 5/2/07	Tue 5/15/07
18	Windows Office Floors 8-9	10 days	Wed 5/16/07	Tue 5/29/07
19	Ground Floor - Finishes and Punchlist	82 days	Wed 4/18/07	Thu 8/9/07
20	Ground Floor - Owner Acceptance	0 days	Thu 8/9/07	Thu 8/9/07
21	2nd Floor - Finishes and Punchlists	65 days	Wed 4/25/07	Tue 7/24/07
22	2nd Floor - Owner Acceptance	0 days	Tue 7/24/07	Tue 7/24/07
23	3rd Floor - Finishes and Punchlists	65 days	Mon 4/30/07	Fri 7/27/07
24	3rd Floor - Owner Acceptance	0 days	Fri 7/27/07	Fri 7/27/07
25	4th Floor - Finishes and Punchlists	65 days	Thu 5/3/07	Wed 8/1/07
26	4th Floor - Owner Acceptance	0 days	Wed 8/1/07	Wed 8/1/07
27	5th Floor - Finishes and Puchlists	67 days	Mon 5/14/07	Tue 8/14/07
28	5th Floor - Owner Acceptance	0 days	Tue 8/14/07	Tue 8/14/07
29	6th Floor - Finishes and Punchlists	65 days	Mon 5/21/07	Fri 8/17/07
30	6th Floor - Owner Acceptance	0 days	Fri 8/17/07	Fri 8/17/07
31	7th Floor - Finishes and Punchlists	60 days	Thu 5/24/07	Wed 8/15/07
32	7th Floor - Owner Acceptance	0 days	Wed 8/15/07	Wed 8/15/07
33	8th Floor - Finishes and Punchlists	64 days	Mon 6/4/07	Thu 8/30/07
34	8th Floor - Owner Acceptance	0 days	Thu 8/30/07	Thu 8/30/07
35	9th Floor - Finishes and Punchlists	67 days	Thu 6/7/07	Sat 9/8/07
36	9th Floor - Owner Acceptance	0 days	Sat 9/8/07	Sat 9/8/07



ID	Task Name	Duration	Start	Finish
1	Ground Floor - Frame and Place Slab - Pou	27 days	Thu 9/28/06	Fri 11/3/06
2	2nd Floor - Frame and Place Slab - Pours 1	11 days	Wed 11/1/06	Wed 11/15/06
3	3rd Floor - Frame and Place Slab - Pours 1	13 days	Mon 11/13/06	Wed 11/29/06
4	4th Floor - Frame and Place Slab - Pours 1	11 days	Mon 11/27/06	Mon 12/11/06
5	5th Floor - Frame and Place Slab - Pours 1	11 days	Thu 12/7/06	Thu 12/21/06
6	6th Floor - Frame and Place Slab - Pours 1	13 days	Tue 12/19/06	Thu 1/4/07
7	7th Floor - Frame and Place Slab - Pours 1	9 days	Tue 1/2/07	Fri 1/12/07
8	8th Floor - Frame and Place Slab - Pours 1	11 days	Wed 1/10/07	Wed 1/24/07
9	9th Floor - Frame and Place Slab - Pours 1	11 days	Mon 1/22/07	Mon 2/5/07
10	Roof Level - Frame and Place Slab - Pours	11 days	Thu 2/1/07	Thu 2/15/07
11	Precast - South Office Floors 1-5	5 days	Tue 1/16/07	Tue 1/23/07
12	Precast - West Office Floors 1-5	5 days	Tue 1/23/07	Tue 1/30/07
13	Precast - North Office Floors 1-5	5 days	Tue 1/30/07	Tue 2/6/07
14	Precast - East Office Floors 1-5	5 days	Tue 2/6/07	Tue 2/13/07
15	Precast - South Office Floors 6-9	5 days	Tue 2/13/07	Mon 2/19/07
16	Precast - West Office Floors	5 days	Tue 2/20/07	Mon 2/26/07
17	Precast - North Office Floors 6-9	5 days	Tue 2/27/07	Mon 3/5/07
18	Precast - East Office Floors 6-9	5 days	Tue 3/6/07	Mon 3/12/07
19	Windows - Ground Floor	5 days	Tue 2/13/07	Mon 2/19/07
20	Windows - 2nd Floor	5 days	Tue 2/20/07	Mon 2/26/07
21	Windows - 3rd Floor	5 days	Tue 2/27/07	Mon 3/5/07
22	Windows - 4th Floor	5 days	Tue 3/6/07	Mon 3/12/07
23	Windows - 5th Floor	5 days	Tue 3/13/07	Mon 3/19/07
24	Windows - 6th Floor	5 days	Tue 3/20/07	Mon 3/26/07
25	Windows - 7th Floor	5 days	Tue 3/27/07	Mon 4/2/07
26	Windows - 8th Floor	5 days	Tue 4/3/07	Mon 4/9/07
27	Windows - 9th Floor	5 days	Tue 4/10/07	Mon 4/16/07
28	Ground Floor - Finishes and Punchlists	82 days	Tue 2/20/07	Wed 6/13/07
29	Ground Floor - Owner Acceptance	0 days	Wed 6/13/07	Wed 6/13/07
30	2nd Floor - Finishes and Punchlists	65 days	Tue 2/27/07	Mon 5/28/07
31	2nd Floor - Owner Acceptance	0 days	Mon 5/28/07	Mon 5/28/07
32	3rd Floor - Finishes and Punchlists	65 days	Tue 3/6/07	Mon 6/4/07
33	3rd Floor - Owner Acceptance	0 days	Mon 6/4/07	Mon 6/4/07
34	4th Floor - Finishes and Punchlists	65 days	Tue 3/13/07	Mon 6/11/07
35	4th Floor - Owner Acceptance	0 days	Mon 6/11/07	Mon 6/11/07
36	5th Floor - Finishes and Puchlists	65 days	Tue 3/20/07	Mon 6/18/07
37	5th Floor - Owner Acceptance	0 days	Mon 6/18/07	Mon 6/18/07
38	6th Floor - Finishes and Punchlists	65 days	Tue 3/27/07	Mon 6/25/07
39	6th Floor - Owner Acceptance	0 days	Mon 6/25/07	Mon 6/25/07
40	7th Floor - Finishes and Punchlists	65 days	Tue 4/3/07	Mon 7/2/07
41	7th Floor - Owner Acceptance	0 days	Mon 7/2/07	Mon 7/2/07
42	8th Floor - Finishes and Punchlists	65 days	Tue 4/10/07	Mon 7/9/07
43	8th Floor - Owner Acceptance	0 days	Mon 7/9/07	Mon 7/9/07
44	9th Floor - Finishes and Punchlists	65 days	Tue 4/17/07	Mon 7/16/07
45	9th Floor - Owner Acceptance	0 days	Mon 7/16/07	Mon 7/16/07



ID	Task Name	Duration	Start	Finish
1	Ground Floor - Frame and Plac	27 days	Thu 9/28/06	Fri 11/3/06
2	2nd Floor - Frame and Place Sl	11 days	Wed 11/1/06	Wed 11/15/06
3	3rd Floor - Frame and Place Sla	13 days	Mon 11/13/06	Wed 11/29/06
4	4th Floor - Frame and Place Sla	11 days	Mon 11/27/06	Mon 12/11/06
5	5th Floor - Frame and Place Sla	11 days	Thu 12/7/06	Thu 12/21/06
6	6th Floor - Frame and Place Sla	13 days	Tue 12/19/06	Thu 1/4/07
7	7th Floor - Frame and Place Sla	9 days	Tue 1/2/07	Fri 1/12/07
8	8th Floor - Frame and Place Sla	11 days	Wed 1/10/07	Wed 1/24/07
9	9th Floor - Frame and Place Sla	11 days	Mon 1/22/07	Mon 2/5/07
10	Roof Level - Frame and Place S	11 days	Thu 2/1/07	Thu 2/15/07
11	Precast - Office Floor G	4 days	Mon 12/25/06	Fri 12/29/06
12	Precast - Office Floor 2	5 days	Fri 12/29/06	Fri 1/5/07
13	Precast - Office Floor 3	5 days	Fri 1/5/07	Fri 1/12/07
14	Precast - Office Floor 4	5 days	Fri 1/12/07	Fri 1/19/07
15	Precast - Office Floor 5	5 days	Fri 1/19/07	Fri 1/26/07
16	Precast Office Floor 6	5 days	Fri 1/26/07	Fri 2/2/07
17	Precast - Office Floor 7	5 days	Fri 2/2/07	Fri 2/9/07
18	Precast - Office Floor 8	5 days	Fri 2/9/07	Fri 2/16/07
19	Precast - Office Floor 9	5 days	Fri 2/16/07	Thu 2/22/07
20	Windows - Office Floor G	5 days	Fri 12/29/06	Thu 1/4/07
21	Windows - Office Floor 2	4 days	Fri 1/5/07	Wed 1/10/07
22	Windows - Office Floor 3	4 days	Fri 1/12/07	Wed 1/17/07
23	Windows - Office Floor 4	4 days	Fri 1/19/07	Wed 1/24/07
24	Windows - Office Floor 5	4 days	Fri 1/26/07	Wed 1/31/07
25	Windows - Office Floor 6	4 days	Fri 2/2/07	Wed 2/7/07
26	Windows - Office Floor 7	4 days	Fri 2/9/07	Wed 2/14/07
27	Windows - Office Floor 8	4 days	Fri 2/16/07	Wed 2/21/07
28	Windows - Office Floor 9	4 days	Fri 2/23/07	Wed 2/28/07
29	Ground Floor - Finishes and Pu	82 days	Fri 1/5/07	Mon 4/30/07
30	Ground Floor - Owner Acceptar	0 days	Mon 4/30/07	Mon 4/30/07
31	2nd Floor - Finishes and Punch	65 days	Thu 1/11/07	Wed 4/11/07
32	2nd Floor - Owner Acceptance	0 days	Wed 4/11/07	Wed 4/11/07
33	3rd Floor - Finishes and Punchl	65 days	Thu 1/18/07	Wed 4/18/07
34	3rd Floor - Owner Acceptance	0 days	Wed 4/18/07	Wed 4/18/07
35	4th Floor - Finishes and Punchl	65 days	Thu 1/25/07	Wed 4/25/07
36	4th Floor - Owner Acceptance	0 days	Wed 4/25/07	Wed 4/25/07
37	5th Floor - Finishes and Puchlis	65 days	Thu 2/1/07	Wed 5/2/07
38	5th Floor - Owner Acceptance	0 days	Wed 5/2/07	Wed 5/2/07
39	6th Floor - Finishes and Punchl	65 days	Thu 2/8/07	Wed 5/9/07
40	6th Floor - Owner Acceptance	0 days	Wed 5/9/07	Wed 5/9/07
41	7th Floor - Finishes and Punchl	65 days	Thu 2/15/07	Wed 5/16/07
42	7th Floor - Owner Acceptance	0 days	Wed 5/16/07	Wed 5/16/07
43	8th Floor - Finishes and Punchl	65 days	Thu 2/22/07	Wed 5/23/07
44	8th Floor - Owner Acceptance	0 days	Wed 5/23/07	Wed 5/23/07
45	9th Floor - Finishes and Punchl	65 days	Thu 3/1/07	Wed 5/30/07
46	9th Floor - Owner Acceptance	0 days	Wed 5/30/07	Wed 5/30/07



Appendix 4

This appendix contains the following referenced documents:

1. **Air Handling Units – Mechanical Specifications**

2. **Air Handling Units – Product Report**

3. **Air Handling Units – Dimension Drawing**

GENERAL

The units must be rigged and lifted in strict accordance with the Installation Operation and Maintenance manual (CLCH-IM-16). The units are to be installed in strict accordance with the specifications.

Units may be shipped fully assembled up to nominal 25,000 cfm units or disassembled to the minimum component size according to shipping or jobsite requirements. Units shipped in one piece will have no more than 6 points of lift required. These lift points will be permanently attached to the unit base and be designed to accept standard rigging devices. Units shipped in sections will have no more than 4 points of lift required. Units are UL and CUL listed L1995, CSA C-22.2 as manufactured by the factory. Modifications to the units at the job site or by a third party may void this listing. Refer to the Product Data Sheet for door and drain pan connection locations. This mechanical specification describes options selected from all or just one of the T-Series units on the job.

Since The Trane Company has a policy of continuous product improvement, it reserves the right to change design and specification without notice.

Unit Construction

The unit panels feature galvanized steel double wall construction. The casing is able to withstand up to 6 inches of static pressure with no more than 0.005 inch (0.127mm) deflection per inch (25.4mm) of panel span. The entire length and width under the base is sealed for additional water management protection.

Single Point Power Wiring motor only

For airhandling units requiring both a supply and return/exhaust fan, the unit manufacturer shall supply single point power wiring to both factory installed and tested fan motor starters or variable frequency drives. On units supplied with starters on both fan motors, both motor starters shall be installed in the supply fan high voltage electrical enclosure. If both fans do not have starters, then individual high voltage enclosures will be supplied for both the supply and return/exhaust fans. Single point power wiring shall include a high voltage distribution block and main unit disconnect with lockout/tagout capabilities. Single point power wiring shall not compromise the UL or ETL certification of the unit. Single point power wiring is not available to either (or both) electric heat, or a rotary energy recovery wheel. Separate power supplies for these options must be field supplied.

Motor Wiring Conduit

High voltage wiring from either a wiring raceway/trough or directly from a motor starter or variable frequency drive to the air handling unit motor(s) shall be done through flexible conduit. Wiring through conduit shall not compromise the UL or ETL certification of the unit.

Switch Option

No light switches or 115 volt power receptacle supplied with unit.

Panel Construction

Panels feature solid double wall construction with totally enclosed closed-cell insulation providing a minimum R-value of 12. The insulation conforms to NFPA 90 requirements.

Access Doors

Access doors are fully insulated double-wall construction (with solid galvanized steel interior panels). Automotive style neoprene gasketing around the full perimeter of the access doors minimize air leakage. All access doors have a single door handle system. The first handle movement relives unit pressure.

Galvanized IAQ Drain Pan

Drain pans have two-way sloping galvanized IAQ drain pan to allow for proper condensate removal in sections specified.

Unit Roof

Unit roof is constructed of two pieces. Inner roof is installed in such a manner as to prevent air bypass between internal components. Outer roof is sloped either from one side of unit to other, or from center to sides of the unit. Roof assembly overhangs all walls of units by 2" (50.8mm) minimum.

Unit Paint

External surface of unit casing is coated with water based polyurethane paint. Color to be standard "Slate Gray". Units painted in the factory are able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours.

Factory Supplied Roof Curb
Unit to be mounted to factory supplied 14-inch tall roof curb. Curb will be shipped to jobsite disassembled. Contractor will be responsible for assembly and mounting to roof structure per T-Series Climate Changer Roof Curb IOM (CLCH-IN-18). On units requiring external piping cabinet(s), factory supplied curb to include curb for external pipe cabinet(s) and pipe cabinet curb(s) to main unit curb gutter(s).

MIXING SECTION
A section is provided that supports damper assembly for outside, return, and/or exhaust air.

Dampers
Dampers modulate the volume of outside, return, or exhaust air. Dampers are Ruskin CD-60 with double skin air foil blades, ultra low-leak metal compressible jamb seals, and extruded vinyl blade edge seals. The dampers are rated for a maximum leakage rate of 3 (cfm)/(foot squared) at 1" wg and 8 (cfm)/(foot squared) at 4" wg. Blades rotate on stainless steel sleeve bearings. Dampers are arranged in parallel or opposed blade configuration.

Mixing Box Damper Actuators
Spring return actuators are mounted with the outside air damper linked normally closed and the return air damper linked normally open.

EXHAUST SECTION
This section supports damper assemblies for exhaust air.

ANGLED FILTERS
Filter sections have filter racks, an access door for filter installation & removal, and block-offs as required to prevent air bypass around filters. Units can be supplied with 2-inch (51.8mm) or 4-inch (103.6mm) flat filters.

Pleated Media
Filters are 2-inch or 4-inch thick non-woven fabric, treated with adhesive and continuously laminated to a supported steel wire grid. Filters are capable of operating up to 625 fpm face velocity without loss of filter efficiency and holding capacity. Filters have a rated average dust spot efficiency of not less than 25 to 35 percent when tested in accordance with ASHRAE 52.1 atmospheric dust spot method, and MERV 7 based on ASHRAE Standard 52.2.

Filter Status Switch
A differential pressure switch piped to both sides of the filter will indicate filter status.

COILS
Coils have aluminum plate fins and seamless copper tubes. (Copper fins are available on 5/8 inch (15.9mm) tube coils.) Fin collars are drawn, belled, and firmly bonded to the tubes by mechanical expansion of the tubes. Capacities, pressure drops and selection procedure are certified in accordance with ARI Standard 410.

Coils are installed such that headers and return bends are enclosed by unit casings. Coil casings are a minimum of 16-gauge galvanized steel formed end supports, top, and bottom channels. If two or more coils are stacked in the unit, intermediate drain channels are installed between coils to drain condensate to the main drain pans without flooding the lower coils or passing condensate through the airstream of the lower coil.

Water Coils
Supply and return headers are clearly labeled on the outside of the unit to ensure that direction of coil water flow is counter to direction of unit airflow. Coils are burst tested to 300 psig and proof tested under water to 200 psig. Coil types are UW,UU,W,WD,D,DD,K,P,5A,5W and TT coils.

Tube Material
Tubes are 5/8 inch (15.9mm) OD, 0.020 inch (0.51m) thick copper. (Refer to the Product Data Sheet)

External Pipe Cabinet
Piping cabinet is supplied by the manufacturer factory assembled and constructed the same as the main unit casing. Piping cabinet is mounted external to the unit and shipped separate to be field installed. Piping cabinet has separate access door of the same construction as the unit casing door.

External Pipe Cabinet

Piping cabinet is supplied by the manufacturer factory assembled and constructed the same as the main unit casing. Piping cabinet is mounted external to the unit and shipped separate to be field installed.

Averaging Temperature Sensor

The averaging temperature sensor is a 1000 OHM @ 0 degree Celsius, platinum 385 curve, resistive temperature detector (RTD). Each capillary is serpentined across the coil module frame. Bends of the capillaries are curved and fastened with capillary clips to prevent crimping and minimize wear.

Control Valves

Control valves are shipped separately from the air handling unit. The valves must be field piped by the piping contractor. Please ensure the valves are piped within the 4' reach of the flexible conduit quick connect. Valves, flex conduit, and quick connects are rated for indoor use only. We recommend imstalling them in an oversized pipe cabinet or inside the building.

BLANK / ACCESS / INSPECTION

Additional unit length is provided to allow extra interior space for, access to, or inspection of unit components. This section may also be used for field installed components.

External Pipe Cabinet

A piping cabinet with access door is supplied factory assembled of the same construction as the main unit casing. Piping cabinets are shipped separately for field installion on the side of the unit.

FAN SECTION

Fans are factory balanced. Fan shafts are solid, protectively coated with lubricating oil, and designed so fan will not exceed 75 percent of the first critical speed at any cataloged rpm. Fan wheels are keyed to the shaft to prevent slipping. Access doors are provided on the drive side of the fan section. A separate power source is required for each fan section without single point power. Units with single point power require one power source in the supply fan section.

Forward Curved Fan

The forward curved (FC) fan is a double-width, double-inlet, multiblade type as required for stable operation and optimum energy efficiency. Bearings are self-aligning, antifriction bearings with a L-50 life of 200,000 hours. For any bearing requiring relubrication, the grease line shall be extended to the fan support bracket on the drive side. Refer to Product Data Sheets. Fan performance is certified in accordance with ARI Standard 430-89.

Motor Voltage

460 Volt / 3 Phase / 60 Hz.(Refer to the Product Data Sheet)

Open Drip-Proof Motor

The motor is a T-frame, squirrel cage, open drip-proof with horsepower, type, and electrical characteristics as shown on equipment schedule. Motor is mounted inside the unit casing integral to an isolated fan assembly. A slide base permits adjustment of drive belt tension..(Refer to the Product Data Sheet)

Fixed Pitch Drives

Sheaves are fixed pitch for constant speed at the specified rpm.

Fan Isolation

Two Inch (51.8mm) Spring Isolators - Fan and motor assembly (sizes #10 - #100) is internally isolated from the unit casing with 2 inch (51.8mm) deflection spring isolators. The fan discharge is also isolated from unit casing by a flexible canvas duct. The isolation system is designed to resist loads produced by external forces such as earthquakes and conform to the current requirements for Seismic Zone IV.

Fan Options

Inverter balancing. Fan systems will be checked with a variable frequency drive for resonant frequencies. Fans, shafts, and drives will meet vibrations tolerance specs from 25% to 100% of selected RPM.

Starter / Disconnect Package
Combination starter / disconnect packages are factory mounted inside a weather-tight cabinet and include:
a) Line break switch
b) starter
c) Hand-Off-Auto (HOA) selector switch
d) one N.O. auxiliary contact
e) 120V control transformer
f) power wiring from starter to motor

Starter Options
The starter includes a control transformer to power the factory mounted temperature control system. Power wiring from the starter transformer to the controls, start/stop relay, and start/stop wiring to the HOA switch are wired and tested at the factory.

VFD Options
The VFD includes an oversized control transformer to power the factory mounted control system. Power wiring from the VFD transformer to the controls, start/stop relay, start/stop wiring to the VFD, and analog speed signal are wired and tested at the factory.

Airflow Switch
A differential pressure switch piped to the discharge and suction sides of the fan indicates fan status.

DISCHARGE PLENUM
A discharge plenum is provided to efficiently turn air and/or provide sound attenuation. A protective covering will be provided over bottom openings.

FACTORY MOUNTED DIRECT DIGITAL CONTROL (DDC) SYSTEM
"Turn-key" control systems are engineered, mounted, wired, and tested in the factory to reduce installed costs, save time, and improve reliability. Each control system is fully functional as a standalone unit or can be tied to a Tracer building automation system.

Unit Mounted Controller
The DDC controller is factory mounted in the unit.

Outside Air Sensor
Thermistor type outside air sensor (10,000 ohm @ 77 degrees F) is provided for field mounting and wiring.

Low Limit
Low limits are double pole low limit switches wired to a momentary push button reset circuit. Capillaries are serpentined across the leaving side of the coil. Bends of the capillaries are curved and fastened with capillary clips to prevent crimping and minimize wear. A separate low limit is provided for each coil in a coil stack.

VFD / Disconnect Package

Combination VFD / disconnect packages are factory mounted and wired in a weather-tight cabinet and include:

a) circuit breaker disconnect
b) Pulse Width Modulated (PWM) VFD w/ intelligent power modules
c) LCD display and keypad
d) English language electrical values, parameters, self test, faults, and diagnostics
e) form C fault contacts
f) 0-10 V speed input signal
g) VFD-Hand-Off keypad switch
h) Electronic manual speed control
i) auto restart after momentary power loss
j) critical frequency avoidance
k) power wiring from VFD to motor
l) voltage and FLA are factory-set for the exact motor used in the air handler
m) Factory commissioning

Control Valve

Control valves are provided by the air handling unit manufacturer and field piped by the piping contractor. Power and signal wiring is of a simple quick connect provided by the air handler manufacturer.

Outdoor T-Series Climate Changer air handler

Job Name	Breadth Analysis 1
User Name	
Address	Washington DC

Outdoor T-Series Climate Changer air handler **RTAHU-1**

Quantity 2

Job Comments

Coil performance data is certified in accordance with ARI standard 410. Propylene glycol and calcium chloride, or mixtures thereof, are not covered under the scope of ARI 410.

Air-handling performance data is certified in accordance with ARI standard 430. Air handlers with Q-fans, air handlers with plenum fans, and vertical draw-thru air handlers where the coil is mounted immediately below the fan module are not covered under the scope of ARI 430.

All weights and dimensions are approximate. Certified prints on request.

Outdoor T-Series Climate Changer air handler

Unit level

Module Position: 0

Actual airflow	51500 cfm
Elevation relative to sea level	0.00 ft
Size criteria component	Largest 1/2" coil
Target face velocity	500 ft/min
Run acoustics	Yes
Inlet type (for acoustics)	Ducted
Unit size	100
Unit coil - max face velocity	600 ft/min
Unit coil - min face velocity	250 ft/min
Shipping coil - max face velocity	600 ft/min
Shipping coil - min face velocity	250 ft/min
Face & bypass coil - max face velocity	600 ft/min
Face & bypass coil - min face velocity	250 ft/min
Flat filter - max face velocity	625 ft/min
Flat filter - min face velocity	0 ft/min
Angled filter - max face velocity	625 ft/min
Angled filter - min face velocity	0 ft/min
Bag/cartridge - max face velocity	625 ft/min
Bag/cartridge - min face velocity	0 ft/min
HEPA filter - max face velocity	500 ft/min
HEPA filter - min face velocity	0 ft/min
Unit shipping split type	Maximum Size Splits
Roof curb type	14" tall roof curb
Paint	Factory painted - gray
Light wiring	No light wiring
Power wiring	Single point power (2-fan motors
UL listed unit	Yes
Unit length (less hoods)	494.000 in
Roof curb weight	1061.7 lb
Rigging unit weight	25975.1 lb
Installed unit weight	28115.0 lb
Single or front discharge - 63 Hz	93 dB

Single or front discharge - 125 Hz	93 dB
Single or front discharge - 250 Hz	99 dB
Single or front discharge - 500 Hz	92 dB
Single or front discharge - 1K Hz	88 dB
Single or front discharge - 2K Hz	86 dB
Single or front discharge - 4K Hz	83 dB
Single or front discharge - 8K Hz	77 dB
Side discharge - 63 Hz	0 dB
Side discharge - 125 Hz	0 dB
Side discharge - 250 Hz	0 dB
Side discharge - 500 Hz	0 dB
Side discharge - 1 kHz	0 dB
Side discharge - 2 kHz	0 dB
Side discharge - 4 kHz	0 dB
Side discharge - 8 kHz	0 dB
Ducted inlet - 63 Hz	97 dB
Ducted inlet - 125 Hz	93 dB
Ducted inlet - 250 Hz	97 dB
Ducted inlet - 500 Hz	91 dB
Ducted inlet - 1 kHz	89 dB
Ducted inlet - 2 kHz	86 dB
Ducted inlet - 4 kHz	80 dB
Ducted inlet - 8 kHz	74 dB
Casing - 63 Hz	90 dB
Casing - 125 Hz	92 dB
Casing - 250 Hz	92 dB
Casing - 500 Hz	84 dB
Casing - 1 kHz	78 dB
Casing - 2 kHz	73 dB
Casing - 4 kHz	68 dB
Casing - 8 kHz	64 dB

Controls package

Module Position: 0

Factory controls package	Variable volume
Controls mounting	Unit (drive side #66-100)
Automatic control selection type	Validation only
DDC controller	MP580 controller

LCD screen and keypad	No
AH540 valid unit	Non-valid arrangement
Outside air sensors	Yes

Coil performance data is certified in accordance with ARI standard 410. Propylene glycol and calcium chloride, or mixtures thereof, are not covered under the scope of ARI 410.

Air-handling performance data is certified in accordance with ARI standard 430. Air handlers with Q-fans, air handlers with plenum fans, and vertical draw-thru air handlers where the coil is mounted immediately below the fan module are not covered under the scope of ARI 430.

All weights and dimensions are approximate. Certified prints on request.

Outdoor T-Series Climate Changer air handler

Exhaust dampers **Module Position:** 1

Exhaust module PD	1.32 in H2O	Exhaust damper module airflow	51500 cfm
Module	Exhaust fan damper module	Exhaust module ASP	0.00 in H2O
Insulation	Solid dble wall	Exhaust damper area	24.67 sq ft
Access door	Right	Exhaust damper PD	0.76 in H2O
Exhaust damper hood	Yes	Exhaust hood area	20.06 sq ft
Actuator	Electronic normally closed	Exhaust hood PD	0.55 in H2O

Fan **Module Position:** 2

Fan [2]-1

Fan airflow	41500 cfm	Single or front discharge - 500 Hz	81 dB
Fan size and type	A100 - 40" FC	Single or front discharge - 1K Hz	81 dB
Fan discharge	Back - top	Single or front discharge - 2K Hz	80 dB
Drive location	Right	Single or front discharge - 4K Hz	75 dB
Motor HP	40	Single or front discharge - 8K Hz	67 dB
Motor voltage	460/3	Inlet and casing - 63 Hz	94 dB
ESP	0.75 in H2O	Inlet and casing - 125 Hz	85 dB
Total static pressure	2.23 in H2O	Inlet and casing - 250 Hz	88 dB
BHP	31.644 hp	Inlet and casing - 500 Hz	89 dB
Speed	407 rpm	Inlet and casing - 1 kHz	88 dB
Module	Fan	Inlet and casing - 2 kHz	83 dB
Insulation	Solid dble wall	Inlet and casing - 4 kHz	79 dB
Access door	Right	Inlet and casing - 8 kHz	72 dB
Inlet location	Vertical exhaust fan	Ducted inlet - 63 Hz	96 dB
Fan isolation	Spring	Ducted inlet - 125 Hz	86 dB
Fan wheel balance	Inverter balance	Ducted inlet - 250 Hz	87 dB
Motor class	ODP E+ motor	Ducted inlet - 500 Hz	88 dB
Motor frame type	T-frame	Ducted inlet - 1 kHz	88 dB
Cycle	60 cycle/sec	Ducted inlet - 2 kHz	83 dB
Drive service factor and type	1.5 fixed	Ducted inlet - 4 kHz	78 dB
Starter or VFD mounted and wired	TR1 VFD / disconnect	Ducted inlet - 8 kHz	72 dB
Airflow switch	Yes	Casing - 63 Hz	80 dB
Elevation	0.00 ft	Casing - 125 Hz	69 dB
Min temperature	10.00 F	Casing - 250 Hz	62 dB
Design temperature	70.00 F	Casing - 500 Hz	56 dB
Max BHP	35.687 hp	Casing - 1 kHz	48 dB
Fan module PD	0.91 in H2O	Casing - 2 kHz	43 dB
Unit controller	MP580 Unit Controller	Casing - 4 kHz	35 dB
Unit low limit	Unit Low Limit	Casing - 8 kHz	33 dB
Single or front discharge - 63Hz	90 dB	Design sequence	L
Single or front discharge - 125Hz	83 dB	Fan discharge loss PD	0.16 in H2O
Single or front discharge - 250 Hz	84 dB		

Outdoor T-Series Climate Changer air handler

Mixing

Module Position: 3

Module	Mixing
Mix module type	W/O filter frame
Insulation	Solid dble wall
Door	Right
Back damper	Parallel
Inlet hood back	No
Back inlet type	Unducted
Right side damper	No
Inlet hood right hand	No
Left side damper	Parallel
Inlet hood left hand	Yes
Left inlet type	Unducted
Bottom damper	No
Design sequence	G
Mixing box damper actuator(s)	Electronic
Outside air location	Left side
Back opening airflow	51500 cfm
Right opening airflow	26300 cfm

Left opening airflow	25200 cfm
Bottom opening airflow	0 cfm
Filter condition	Clean
Customer supplied filter PD	0.00 in H2O
Customer supplied filter area	0.00 sq ft
Back opening/damper area	41.76 sq ft
Back opening/damper PD	0.24 in H2O
Left side opening/damper area	24.67 sq ft
Left opening/damper PD	0.18 in H2O
Left inlet hood area	26.57 sq ft
Left hood PD	0.37 in H2O
Total filter PD	0.00 in H2O
Total mixing box PD	0.55 in H2O
Bottom entry PD	0.00 in H2O
Back entry PD	0.24 in H2O
Right side entry PD	0.00 in H2O
Left side entry pressure drop	0.55 in H2O
Greatest entry PD	0.55 in H2O

Flat or angled filters

Module Position: 4

Filter module PD	0.58 in H2O
Filter condition	Mid-Life
Module	Angled or flat filter
Angled or flat filter module	Angled
Insulation	Solid dble wall
Access door	Right
Filter frame	2" (51mm)

Unit filter type	Pleated media - MERV 7
Dirty filter switch	Yes
Filter airflow	51500 cfm
Customer supplied filter PD	0.00 in H2O
Filter area	161.10 sq ft
Filter PD - mid-life	0.58 in H2O
Filter PD	0.58 in H2O

Access

Module Position: 5

Module	Access/blank
Access/blank module size	Medium
Insulation	Solid dble wall

Access inspection door	Right
ASP	0.00 in H2O

Access

Module Position: 6

Module	Access/blank
Access/blank module size	Large
Insulation	Solid dble wall

Access inspection door	Right
ASP	0.20 in H2O

Coil performance data is certified in accordance with ARI standard 410. Propylene glycol and calcium chloride, or mixtures thereof, are not covered under the scope of ARI 410.

Air-handling performance data is certified in accordance with ARI standard 430. Air handlers with Q-fans, air handlers with plenum fans, and vertical draw-thru air handlers where the coil is mounted immediately below the fan module are not covered under the scope of ARI 430.

All weights and dimensions are approximate. Certified prints on request.

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Outdoor T-Series Climate Changer air handler

Access

Module Position: 7

Module	Access/blank	External piping/service module	Std depth
Access/blank module size	Medium	External pipe cabinet door	Yes
Insulation	Solid dble wall	ASP	0.00 in H2O
External piping cabinet location	Right		

Horizontal coil

Module Position: 8

Horizon [8]-1

Horizontal coil module	Medium large	Electronic coil control valve type	3-way valve water
Module	Horizontal coil	Valve normal position	Normally Closed
Insulation	Solid dble wall	Coil height	Unit - Max Face Area
Drain pan	RH galvanized	Coil type	W
Coil application	Cooling	Rows	10
Coil system type	Chilled water	Fin type	Prima flo H
Coil supply/cabinet side	Right	Fin material	Aluminum
External piping/service module	Std depth	Tube matl/wall thickness	.020" (0.508mm) copper
External pipe cabinet door	Yes	Turbulators	No
Coil casing	Galvanized	Coil coating	No
Apply ARI ranges	Yes	Face area	99.88 sq ft
Actual airflow	51500 cfm	Face velocity	516 ft/min
Elevation	0.00 ft	Air PD	1.32 in H2O
EDB	78.00 F	Coil module PD	1.32 in H2O
EWB	65.00 F	ARI 410-01 classification	ARI rated and certified
LDB	51.00 F	System type (old)	Chilled Water
LWB	50.90 F	Leaving fluid temp	66.42 F
Sensible capacity	1530.10 MBh	Fluid PD	9.84 ft H2O
Total capacity	2119.76 MBh	Fluid velocity	2.60 ft/sec
Fin spacing	136 Per Foot	Volume	128.99 gal
Max fluid PD	20.00 ft H2O	Reynolds number	9965.08 Each
ASP	0.00 in H2O	Coil installed weight	4680.5 lb
Entering fluid temp	40.00 F	Coil rigging weight	3602.3 lb
Fluid temp rise	26.42 F	Finned width top or single coil	51" (1295 mm)
Standard fluid flow rate	160.00 gpm	Finned width middle coil	51" (1295 mm)
Fouling factor	0.00000 hr-sq ft-deg F/Btu	Total cap ent coil type #1	1059.88 MBh
Fluid type	Water	Total cap ent coil type #2	1059.88 MBh
Averaging temperature sensor	Entering	Actual valve pressure drop	3.54 psig
Low limit switch	Leaving	Target CV rate	77.52 Each
Target valve pressure drop	4.00 psig	Electronic coil control valve size	3" NPT 85.0 CV 68 psig

Coil performance data is certified in accordance with ARI standard 410. Propylene glycol and calcium chloride, or mixtures thereof, are not covered under the scope of ARI 410.

Air-handling performance data is certified in accordance with ARI standard 430. Air handlers with Q-fans, air handlers with plenum fans, and vertical draw-thru air handlers where the coil is mounted immediately below the fan module are not covered under the scope of ARI 430.

Outdoor T-Series Climate Changer air handler

Fan

Module Position: 9

Fan [9]-1

Fan airflow	51500 cfm	Single or front discharge - 500 Hz	92 dB
Fan size and type	G100 - 40" AF	Single or front discharge - 1K Hz	88 dB
Fan discharge	Front - top	Single or front discharge - 2K Hz	86 dB
Drive location	Right	Single or front discharge - 4K Hz	83 dB
Motor HP	100	Single or front discharge - 8K Hz	77 dB
Motor voltage	460/3	Inlet and casing - 63 Hz	94 dB
ESP	3.50 in H2O	Inlet and casing - 125 Hz	96 dB
Total static pressure	7.36 in H2O	Inlet and casing - 250 Hz	98 dB
BHP	88.087 hp	Inlet and casing - 500 Hz	90 dB
Speed	1217 rpm	Inlet and casing - 1 kHz	85 dB
Module	Fan	Inlet and casing - 2 kHz	84 dB
Insulation	Solid dble wall	Inlet and casing - 4 kHz	77 dB
Access door	Right	Inlet and casing - 8 kHz	72 dB
Inlet location	Supply fan	Ducted inlet - 63 Hz	91 dB
Fan isolation	Spring	Ducted inlet - 125 Hz	93 dB
Motor class	ODP E+ motor	Ducted inlet - 250 Hz	97 dB
Motor frame type	T-frame	Ducted inlet - 500 Hz	89 dB
Cycle	60 cycle/sec	Ducted inlet - 1 kHz	84 dB
Drive service factor and type	1.5 fixed	Ducted inlet - 2 kHz	83 dB
Starter or VFD mounted and wired	Starter / disconnect	Ducted inlet - 4 kHz	77 dB
Elevation	0.00 ft	Ducted inlet - 8 kHz	71 dB
Min temperature	10.00 F	Casing - 63 Hz	90 dB
Design temperature	70.00 F	Casing - 125 Hz	92 dB
Bearing type	Standard heavy duty	Casing - 250 Hz	92 dB
Max BHP	99.342 hp	Casing - 500 Hz	84 dB
Fan module PD	4.24 in H2O	Casing - 1 kHz	78 dB
Unit controller	MP580 Unit Controller	Casing - 2 kHz	73 dB
Unit low limit	Unit Low Limit	Casing - 4 kHz	68 dB
Single or front discharge - 63Hz	93 dB	Casing - 8 kHz	64 dB
Single or front discharge - 125Hz	93 dB	Design sequence	L
Single or front discharge - 250 Hz	99 dB	Fan discharge loss PD	0.74 in H2O

Discharge plenum

Module Position: 10

Module	Discharge Plenum	Pressure drop - front	0.00 in H2O
Insulation	Solid dble wall	Pressure drop - right	0.00 in H2O
Discharge plenum - bottom opening	Yes	Pressure drop - left	0.00 in H2O
ASP - front	0.00 in H2O	Bottom discharge area	55.48 sq ft
ASP - right	0.00 in H2O	Pressure drop - bottom	0.03 in H2O
ASP- left	0.00 in H2O	Discharge loss - bottom	0.03 in H2O
Discharge airflow - bottom	51500 cfm	Total discharge plenum PD	0.03 in H2O
ASP - bottom	0.00 in H2O		

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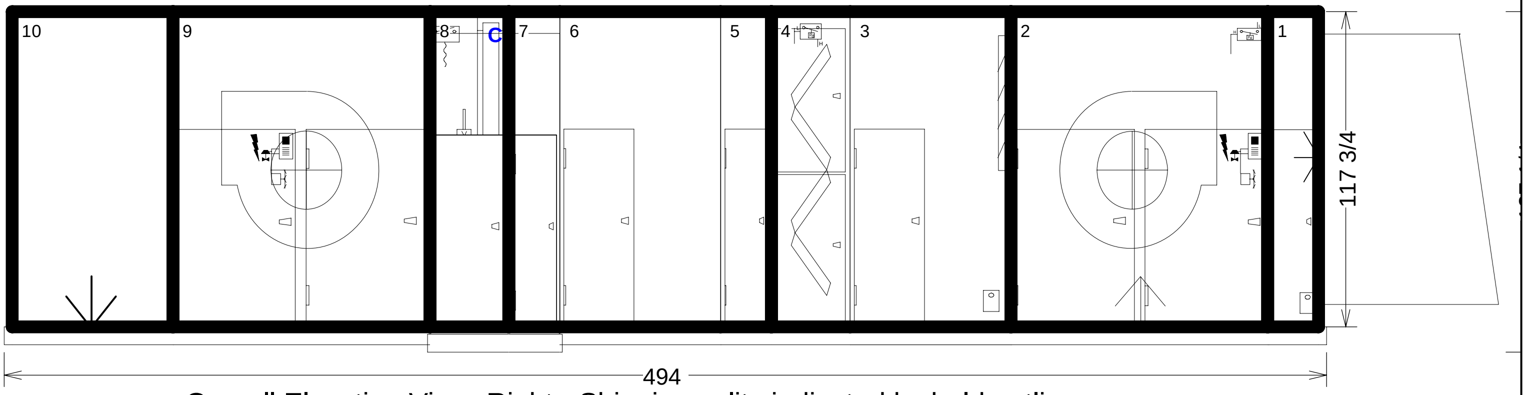
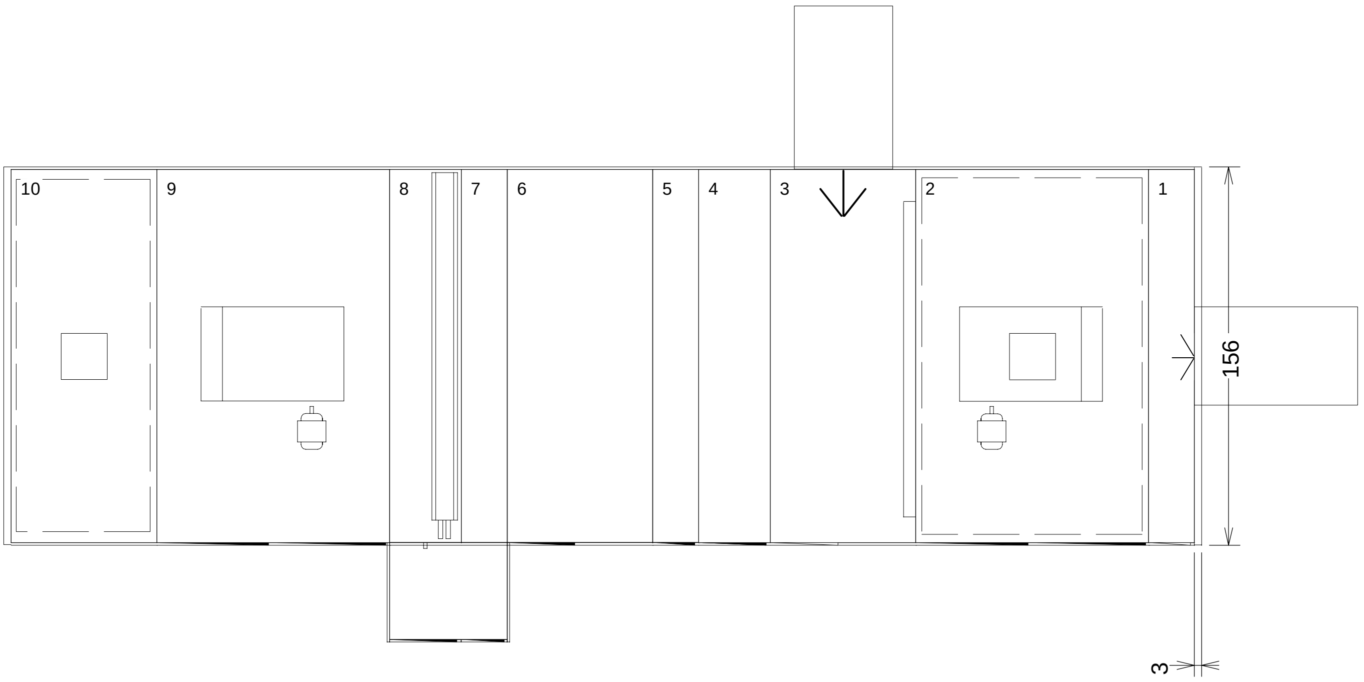


Overall Elevation View: Right - Shipping splits indicated by bold outline. - Measurements in inches

Pos #	Module	Length	Weight
1	Exhaust dampers	19	1565.00
2	Fan	96	5457.40
3	Mixing	60	1803.00
4	Flat or angled filters	29 1/2	1162.33
5	Access	19	516.00
6	Access	60	1137.00
7	Access	19	966.00
8	Horizontal coil	29 1/2	6184.12
9	Fan	96	6509.40
10	Discharge plenum	60	1753.00

Installed Unit Weight 27053.25 lbs



Overall Plan View: Top - Measurements in inches