Property Evaluation Report

MODULAR BUILDING ASSESSMENT & CRITICAL REPAIRS

Project Number 2016-286

Tumwater, Washington

Washington State Department of Enterprise Services

by

EHM

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1 Executive Summary

EXECUTIVE SUMMARY

Introduction: Ehm Architecture was engaged by DES in March 2016 to perform a Building Assessment, to report on our findings and to make recommendations for emergency repairs. This assessment covers Architectural, Mechanical, Structural and Electrical Systems. Each recommended repair is listed as a separate line item, which includes estimated cost of repairs and priority level. The priority levels are offered for the benefit of DES, to assist with determination of which items will be included in its legislative funding request for its 10-year capitol plan.

Architectural: The original roof system was installed as part of the original building construction in 1980, was repaired in 1992 and was replaced in 2000. The roof repair has outlived its useful service life, and is recommended for full replacement. The exterior finish of the building has deteriorated over time, with minor damage to exterior insulating panels and failure of thermal and weatherproofing seals between panels. We recommend repair of damaged panels, replacement of panel seals and painting of the building exterior. Dock levelers have either outlived their useful service life, or require preventative maintenance and repair. Overhead rolling door assemblies have outlived their useful service life and need to be replaced.

Ship's ladders do not meet current building codes, and constitute a potential hazard to facility employees. They are therefore recommended for replacement. Concrete ramps, guardrails and Accessible Path of Travel at the building entry do not comply with ADA Accessibility and Building Code Regulations. They are recommended for replacement or reconstruction to achieve full compliance. Current site drainage and lack of storm drains in the parking lots result in ponding of water adjacent to the building and in the easterly parking lot. These conditions have significant potential to undermine the building foundation, and have accelerated degradation of the asphaltic parking lot. We recommend remedial grading with new paving at these areas.

Mechanical – Outside air is insufficient to control indoor fumes and odors from printing processes. Intake air volumes are recommended to be adjusted accordingly. Air handling units violate current State Energy Code, and are to be replaced. This replacement will require air terminal units and ductwork to be replaced as well. The cooling tower and hydronic system has outlived their useful service life, and should be replaced. Various components of the HVAC system are either in disrepair or are inadequate for their intended purpose. These items should be replaced. There are insufficient cleanouts for the main sewer line at the south side of the building and the four sewer laterals entering the building from the east, making inspection and maintenance difficult. We recommend installation of new cleanouts on the main sewer lines and laterals. Sanitary sewer main and lateral piping exhibit evidence of moisture and sedimentary intrusion at the joints. We recommend relining larger pipes and replacing smaller pipes. Some roof drain assemblies and rainwater leaders in the Low Bay area are not properly insulated, allowing heat loss through the piping. We recommend insulating those elements to improve overall energy efficiency.

Structural – The existing parapet is not adequate for fall protection and does not meet current building code for life safety. We recommend vertical extension of the parapet. Cooling tower fall restraint is inadequate, but this condition will be rectified through the planned replacement of the cooling tower with low-rise, roof-mounted cooling equipment. The mezzanine structural system is inadequate for posted loading capacity, so we recommend that the posted capacity be lowered to reflect the design capacity. Storage racks appear to be overloaded beyond their design capacities. We recommend limiting rack loading to maximum design capacity. The building's structural system is inadequate to resist code-prescribed lateral loading in a seismic event. Given the building use's importance in a significant, regional earthquake event and the State's need to keep it operational, we recommend structural retrofits to strengthen the building to code-prescribed levels.

Electrical – We recommend preventive maintenance of electrical equipment, to extend its useful service life and to prevent hot spots and overloads. Replacement of the power distribution system is not warranted at this time, and will continue to function with the system maintenance recommended. From among our recommended options to maintain, upgrade or replace the existing lighting system, DES has opted to maintain the existing lighting system.

2 Architectural

2. ARCHITECTURAL

I. INTRODUCTION

A. Ehm Architecture inspected architectural components of the Modular Building on April 26, 2016. The Scope of Work included assessment of building envelope (roof system, exterior finish and panel seals), overhead rolling doors, loading dock levelers, building code life safety issues, ADA compliance and deferred maintenance.

B. GENERAL DESCRIPTION OF THE EXISTING STRUCTURE

The Modular Building consists of a low-bay element to the north (photograph 1/AA-1), and a high-bay element to the south (photograph 2/AA-1). The high-bay Isabella Bush Records Center exists south of the Modular Building, and was excluded from this assessment at the direction of Department of Enterprise Services (DES) project management staff.

AGE: Built in 1980, the modular structure is approximately thirty-six years old.

CONDITION: The building is in good condition, with the exception of several items as further outlined herein.

ADEQUACY OF COMPONENTS: Adequacy of components varies according to individual components and their relationship to the assemblage as a whole. Individual building components are addressed in detail in the descriptions that follow this section.

REMAINING SERVICE LIFE: Through a program of preventive maintenance, and through critical repair and upgrade of building components and systems as outlined herein, this building should have a remaining service life of approximately fifty years. The remaining service lives of individual building components are listed in the corresponding sections of this report.

BUILDING ENVELOPE

Roof System

The original built-up roofing system, installed in 1980, was repaired in 1992. The building was completely re-roofed with the existing PVC membrane system in summer of 2000 (photographs 3/AA-2 and 4/AA-2). While no warranty information was obtained during our initial archives search, we are aware that a common warranty period for PVC membrane roofing systems typically ranges from 15 to 20 years. In that respect, it is reasonable to assume that the existing membrane roofing system has reached or is nearing the end of its useful and/or warranteed service life.

Our inspection of the roof system yielded issues and raised concerns which are consistent with those identified and quantified in the Inspection Report by Wayne's Roofing Inc. of October 2015 (Appendix A). It is not known to Ehm Architecture to what extent their recommended temporary repairs may have been made, but anything other than a warranteed application should be considered as strictly temporary.

The low bay roof supports two large air handlers (photograph 5/AA-3) and a cooling tower (photograph 6/AA-3). The high bay roof supports two large air handlers (photograph 7/AA-4), a roof hatch (photograph 8/AA-4), smoke ventilators (photograph 9/AA-5) and exhaust fans (photograph 10/AA-5). Both roof areas are bounded by parapets, which while ranging in height are inadequate to provide fall protection as required by code (photographs 11/AA-6 and 12/AA-6). The adjacent Isabella Bush Building, which is not within the scope of this assessment, features a guardrail which is code-compliant and which represents a good example of a potential design solution to the inadequate parapet height on the Modular Building roof (photograph 13/AA-7).

Exterior Finish

Typical exterior walls are finished with insulated metal panels (photograph 14/AA-7). Numerous areas of mold growth and discoloration are evident around the building (photograph 15/AA-8). Two areas of damage to insulated panels were noted, one on the east side of the building adjacent to the loading docks (photograph 16/AA-8).

Panel Seals
Panel seals were reported by facility maintenance staff to be largely in disrepair and/or failing. This issue is consistent with the age of the building and normal degradation of the building materials used to achieve panel seals when built.

Dock Levelers
Dock levelers were reported by Facilities Maintenance staff to be in various degrees of functionality and disrepair. Our inspection included an onsite evaluation by Industrial Hydraulics (IH) of Tumwater. Their report is included herein as Appendix B.

In summary, Leveler #1 was inoperable, so could not be evaluated. IH noted that the leveler appears to be original equipment, and not a replacement model as are some others. Leveler #2 (photograph 17/AA-9), which also appears to be original, is operational but in need of repair. Leveler #3 (photograph 18/AA-9) is newer in appearance and of a different configuration than Levelers # 1 and 2. In that sense, it appears to be a replacement model. It is in good working order. The appearance and configuration of Leveler #4 (photograph 19/AA-10) is similar to that of Leveler #3, suggesting that this may also be a replacement model. IH noted that the small cylinder which would operate the lip extender is not operational.

Overhead Rolling Doors
Overhead rolling doors (photograph 20/AA-10) have outlived their useful service life. Facility maintenance staff reports that broken springs and failing motors are a common occurrence.

Building Code Life Safety Issues
Ship's ladders to the Mezzanine (photograph 21/AA-11) have a riser height of 12 inches (photograph 22/AA-11), which significantly exceeds the current code maximum height of 9-1/2 inches. Further, current code only allows for ship's ladders to be used at areas not exceeding 250 square feet. The existing mezzanine areas far exceed 250 square feet.

SITE
Concrete Ramps at Entry
Disabled-access ramps adjacent to the westerly building entries (photograph 23/AA-12) are non-compliant with current ADA guidelines, which constitute a potential liability to the State of Washington. In particular, visual detection devices adjacent to the ramps and adjacent to parking areas are inadequate to inform vision-disabled individuals of existing hazards.

Guardrails at Entry
Under current code, guardrails for landings above 30 inches in height may have a maximum sphere spacing of 4 inches to prevent small children from slipping through or getting their heads stuck in vertical or horizontal members of guardrails. The existing guardrails (photograph 24/AA-12) have vertical members approximately 12 inches apart, which – although it may be unlikely for small children to access the entry areas – constitutes a hazard to such individuals, which could potentially expose the State to liability. The stair guardrails do not meet the handgrip requirement of a stair handrail, and the horizontal return at the bottom stair tread does not meet current code.

Path of Travel at Parking Lot
Visual detection devices are required under current code, at walking surfaces which are directly adjacent to parking areas. A ramp from the entry stair toe to the parking area is unprotected (photograph 25/AA-13), with no warnings to the visually-impaired that they are about to enter a vehicular way.

Site Drainage
Visual observation of the parking area east of the building revealed that the site does not have adequate stormwater drainage. Where one would normally expect to find catch basins (at the low point of paving slopes), none exist. The existing asphalt paving shows evidence of ponding, which was confirmed by facility maintenance staff. An aerial image from Google Earth also serves as evidence

in this regard. Such ponding accelerates deterioration of asphalt and potentially undermines it. It also renders parking spaces either unusable, and creates a potential nuisance by causing staff or visitors to unwittingly step into standing water during and after rain events. Such a nuisance could result in lost time for workers, as they would have to dry their shoes, socks and feet to safely and comfortably perform their duties. Water ponds at the west side of the building (photograph 26/AA-13), directly adjacent to the building foundation, which creates potential for settlement and/or undermining of building foundations.

C. CONSTRUCTION

- **BUILDING CODE**
  The building was built under the 1979 Edition of the Uniform Building Code by the International Conference of Building Officials, and the 1976 Uniform Fire Code.
  Occupancy Type: B-2
  Construction Type: V –N (NOTE: A fire alarm system was added in 2005).

- **EXISTING DRAWINGS**
  Record drawings were obtained from DES archives.

- **ORIGINAL PROJECT TEAM - 1979**

Original Owner:	Department of General Administration Division of Engineering & Architecture
Original Consulting Engineer/Planner:	Victor O. Gray & Company
Original Interior Space Planner:	Marvin Stein & Associates
Original Mechanical / Electrical Engineer:	Valentine, Fisher & Tomlinson
Original Soils Engineer:	Neil H. Twelker & Associates
Original Landscape Architect:	Richard Haag & Associates
Original Contractor:	Unknown

- **ROOF REPAIR PROJECT TEAM - 1992**

Architect:	The BJSS Group

- **ROOF REPLACEMENT PROJECT TEAM - 2000**

Architect:	Masini Sanford Gabrielse & Schoenfeldt
Contractor:	Roof Toppers

II. PROBLEMS TO BE CORRECTED AT THIS TIME

NOTE: See end of this section for listing and description of Priority Levels which are indicated below.

1. PUBLIC HAZARD

PROBLEM: Ramps at Entry

Visual detection devices are non-existent at the top of the main entrance ramps. While current code would only require ADA compliance if the building is modified, the lack of warning devices constitutes a hazard to the public – and a potential liability to the State - and should be corrected.

SOLUTION: Grind warning grooves into the concrete slab at the top of both ramps, or sawcut and replace slab as required to provide grooves.

QUANTITY: 8 linear feet x 12" wide

COST: $ 2,518

PRIORITY LEVEL: 1

PROBLEM: Guardrails at Entry

Under current code, guardrails for landings above 30 inches in height may have a maximum sphere spacing of 4 inches, to prevent small children from slipping through or getting their heads stuck in vertical or horizontal members of guardrails. This constitutes a hazard to the public – and a potential liability to the State - and should be corrected.

SOLUTION: Remove existing guardrails and install compliant guardrails

QUANTITY: 60 linear feet x 42" high

COST: $ 11,897

PRIORITY LEVEL: 1

PROBLEM: Path of Travel at Entry

Lack of visual warning devices at the entrance walkway leading to the parking lot constitutes a hazard to the public – and a potential liability to the State - and should therefore be corrected.

SOLUTION: Grind warning grooves into the concrete slab at the top of the ramp leading to the vehicular way, or sawcut and replace slab as required to provide grooves.

QUANTITY: 12 linear feet x 12" wide

COST: $ 793

PRIORITY LEVEL: 1

2. BUILDING REPAIR AND MAINTENANCE

PROBLEM: Damaged Insulated Panels

Two Insulated panels are damaged, allowing moisture intrusion and thereby compromising the integrity of the panels.

SOLUTION: Remove and replace damaged panels.

QUANTITY: 2 panels @ 30" wide x 17'-4" high

COST: $ 8,290

PRIORITY LEVEL: 2

PROBLEM: Insulated Panel Finish

Panels exhibit mold growth and discoloration. DES staff has requested inclusion of exterior painting in the critical repair scope of work.

SOLUTION: Clean, prime and paint existing insulated panels with elastomeric paint.

QUANTITY: x square feet

COST: $ 150,647

PRIORITY LEVEL: 3

PROBLEM: Failing Panel Seals

Panel seals are in disrepair and/or failing.

SOLUTION: Remove, clean adjacent surfaces and install new panel seals.

QUANTITY: 10,086 linear feet

COST: $ 46,665

PRIORITY LEVEL: 2

PROBLEM: Dock Levelers
Levelers #2, 3 and 4 require maintenance and/or repair, per the Inspection Report by Industrial Hydraulics (Appendix B).
SOLUTION: Perform maintenance and repair of dock levelers as recommended,
QUANTITY: Per Appendix B.
COST: $ 6,760
PRIORITY LEVEL: 1

PROBLEM: Overhead Rolling Door Failure
Overhead rolling doors have outlived their useful service life. Facility maintenance staff reports that broken springs and failing motors are a common occurrence.
SOLUTION: Remove and replace overhead rolling doors.
QUANTITY: (6) 11' wide x 12' high overhead coiling rolling doors complete with motors, hardware and operating devices.
COST: $ 65,435
PRIORITY LEVEL: 2

3. CONSULTANT RECOMMENDATIONS

PROBLEM: Aging Roof System
The 2000 reroofing system has outlived its useful service life, and should be replaced with a new PVC roofing system with 20-year warranty.
SOLUTION: Demo and replace existing roofing system. Repair damage to insulation and /or structural members below as necessary.
QUANTITY: 105,600 square feet
COST: $ 1,961,441
PRIORITY LEVEL: 3

PROBLEM: Inoperable Dock Levelers
Leveler #1 is inoperable, due to an electrical problem. The leveler appears to be original construction. As two other original docks have been previously replaced, Ehm Architecture recommends replacing Leveler #1.
SOLUTION: Remove and replace existing dock leveler.
QUANTITY: 1 leveler complete with hydraulics and electric motor.
COST: $ 11,194
PRIORITY LEVEL: 2

PROBLEM: Noncompliant Ship's Ladders
Ship's ladders are 33% steeper than required by current code, and service mezzanine areas which far exceed the current area allowed to be served by ship's ladders. For practicality and for the safety of facility staff, we recommend the replacement of two ship's ladders with compliant stairs.
SOLUTION: Remove and replace two ship's ladders with 42" wide code-compliant steel stairs with handrails and guardrails, one at each mezzanine.
QUANTITY: 2
COST: $ 18,507
PRIORITY LEVEL: 1

PROBLEM: Lack of Parking Lot Drainage
Lack of storm drainage facilities at the east and west parking lots creates ponding water. Water ponds at the west side of the building, directly adjacent to the building foundation.
SOLUTION: Remove asphalt, perform remedial grading to facilitate sheet drainage to adjacent retention ponds, repave and restripe parking lot.
QUANTITY: 82,200 square feet
COST: $ 580,849
PRIORITY LEVEL: 5

PRIORITY LEVEL DESCRIPTIONS

Level 1: Critical life safety and hazardous issues which should be addressed immediately, as emergency repairs.

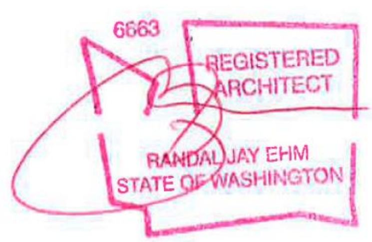
Level 2: Critical issues which, if not immediately repaired or replaced *would* continue to cause deterioration of or damage to the existing structure or building materials.

Level 3: Significant issues which, if not soon repaired or replaced (within one to two years) *may* continue to cause deterioration of or damage to the existing structure or building materials.

Level 4: Moderate issues which, if not soon repaired or replaced *may* continue to cause deterioration of or damage to the existing structure or building materials, but which could serve their intended purpose for a limited time (one to two years).

Level 5: Minor maintenance issues requiring preventative maintenance, cleaning and/or monitoring, or items which could be deferred beyond two years and/or as funding allows.

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME PERSONALLY, AND THAT I AM A DULY REGISTERED ARCHITECT IN THE STATE OF WASHINGTON.



Low Bay Section of Modular Building
PHOTOGRAPH 1

High Bay Section of Modular Building (Isabella Bush Building at right)
PHOTOGRAPH 2

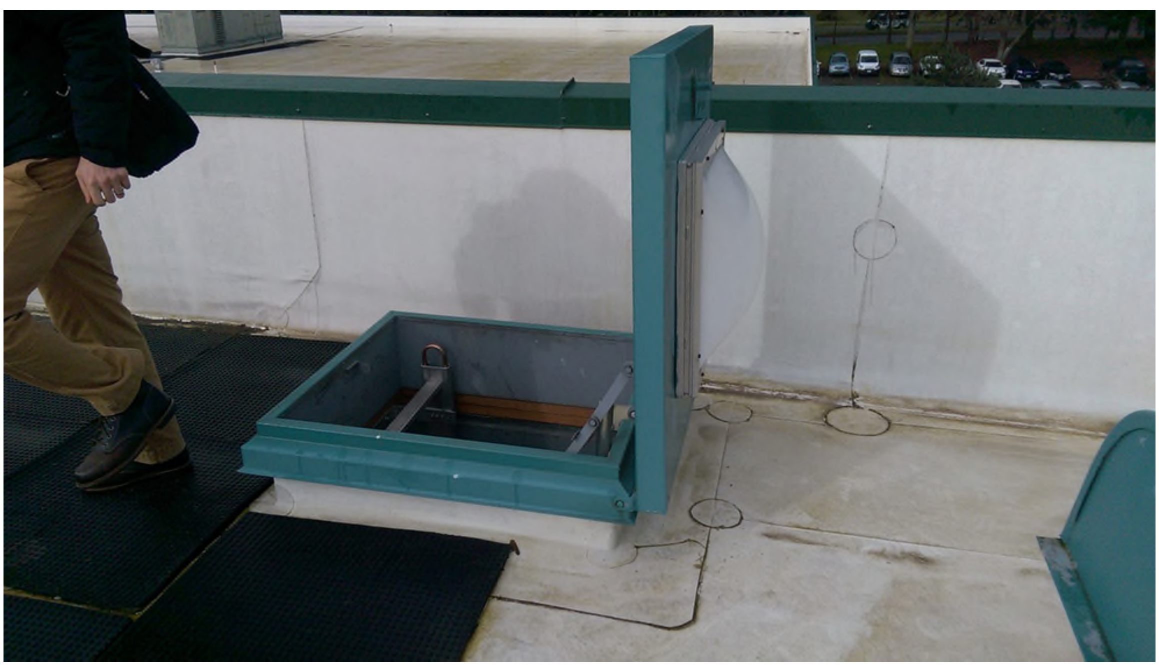
Low Bay Roof
PHOTOGRAPH 3

High Bay Roof
PHOTOGRAPH 4

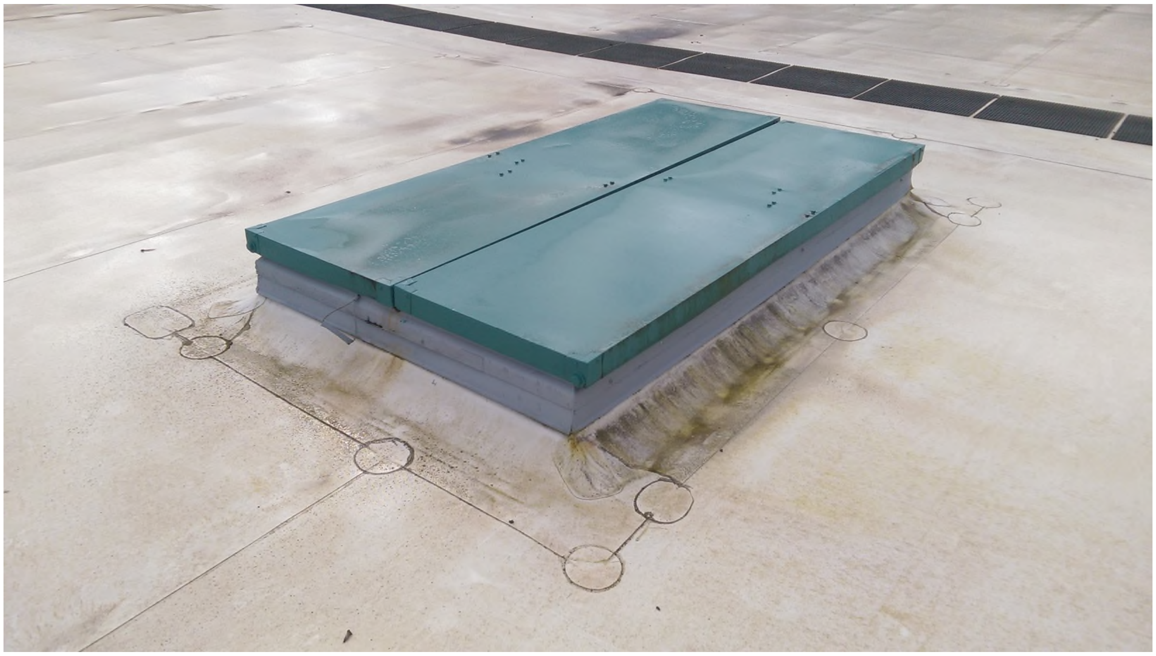
Low Bay HVAC Equipment
PHOTOGRAPH 5

Low Bay Cooling Tower
PHOTOGRAPH 6

High Bay HVAC Equipment
PHOTOGRAPH 7

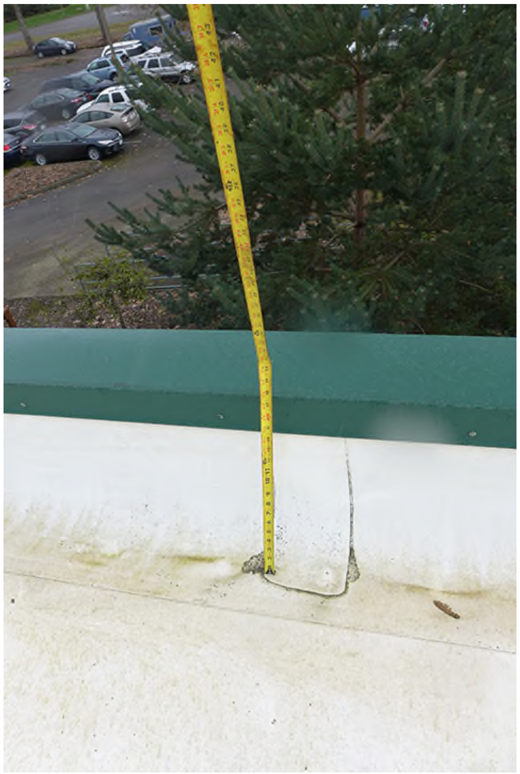


High Bay Roof Hatch
PHOTOGRAPH 8



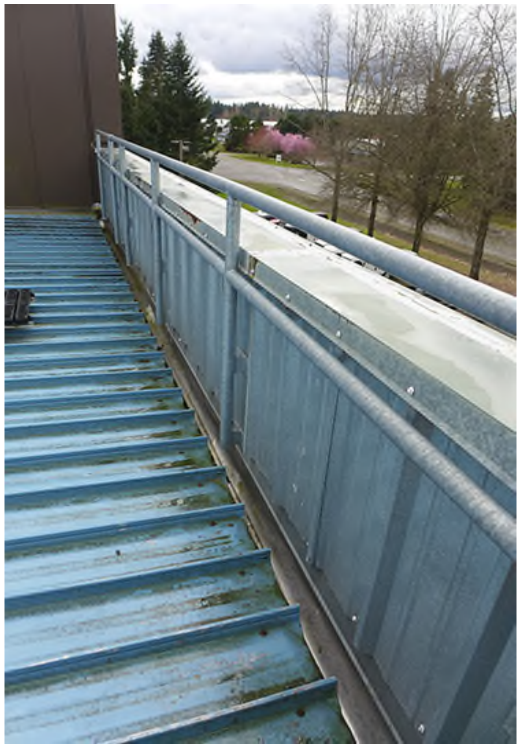
High Bay Ventilator
PHOTOGRAPH 9

High Bay Exhaust Fan
PHOTOGRAPH 10



Unsafe Parapet Height
PHOTOGRAPH 11

Unsafe Parapet Height
PHOTOGRAPH 12



Fall-Protection Guardrail at Adjacent Isabella Bush Building
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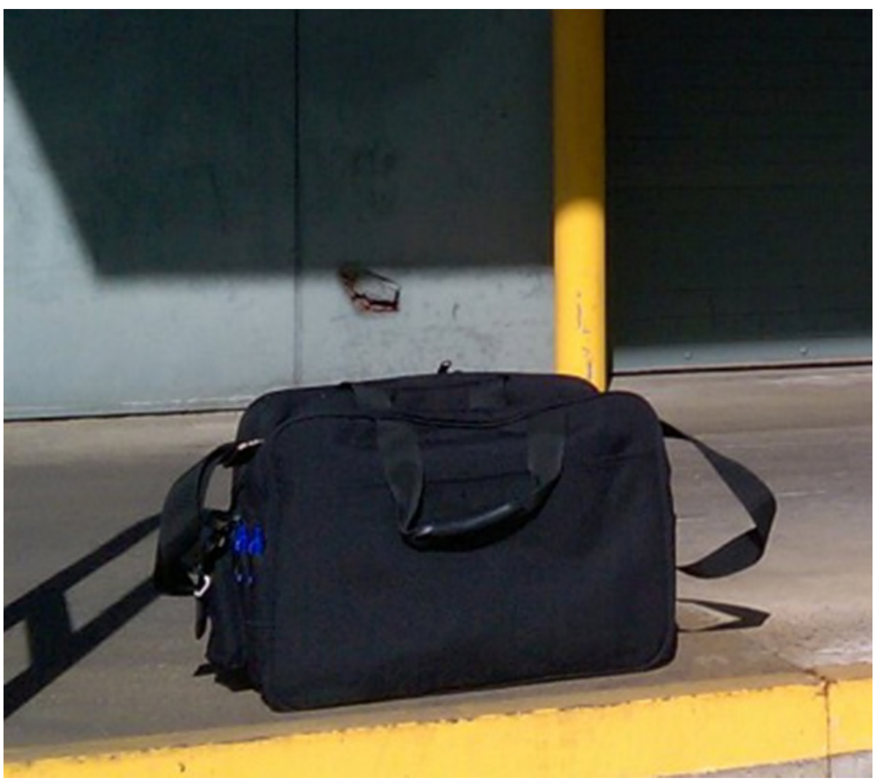
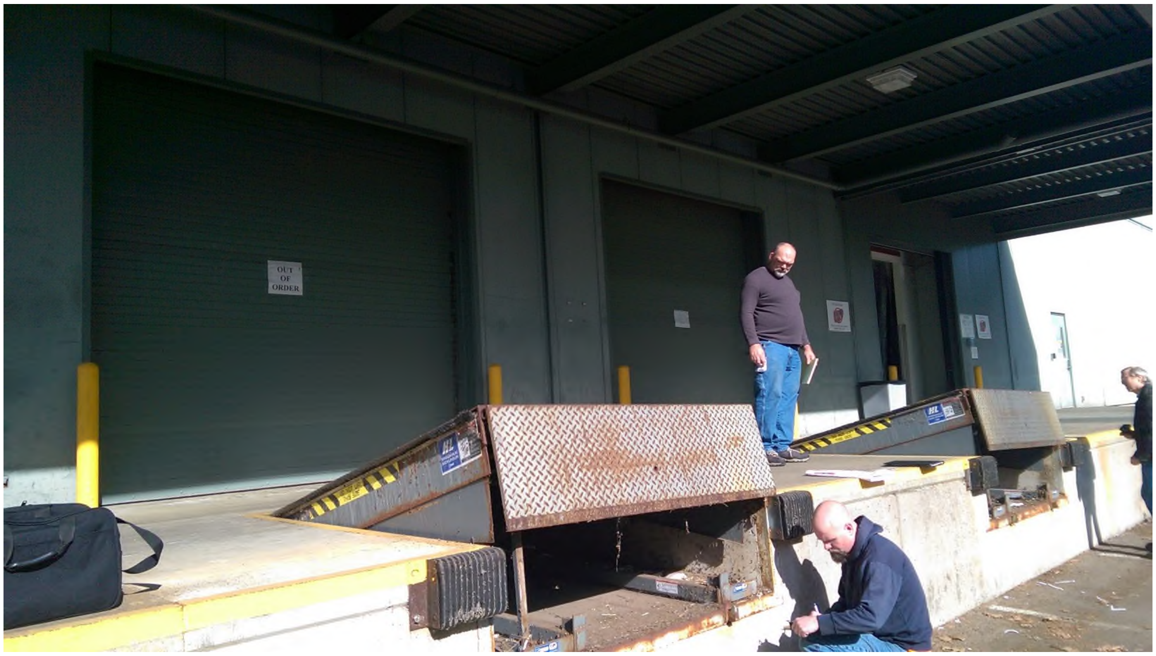
Insulated Panels at High Bay
PHOTOGRAPH 14

Insulated Panel Mold Growth and Discoloration
PHOTOGRAPH 15



Damaged Panel at Loading Dock
PHOTOGRAPH 16



Dock Leveler #2
PHOTOGRAPH 17

Dock Leveler #3
PHOTOGRAPH 18

Dock Leveler #4
PHOTOGRAPH 19

Overhead Rolling Door
PHOTOGRAPH 20

Ship's Ladder to Mezzanine
PHOTOGRAPH 21

Riser Dimension at Ship's Ladder
PHOTOGRAPH 22

Ramp at Entry
PHOTOGRAPH 23

Guardrail at Entry
PHOTOGRAPH 24

Path of Travel at Vehicular Way
PHOTOGRAPH 25

Ponding at Building Wall
PHOTOGRAPH 26

3. MECHANICAL

I. INTRODUCTION

A. The Greenbusch Group performed an inspection of the Modular Building mechanical systems on 4/26/16. On 5/4/16 and 6/1/16, Flohawks Plumbing and Septic conducted video inspections of the sanitary waste pipes for the building. The results of these inspections are included below.

B. GENERAL DESCRIPTION OF THE EXISTING FACILITY

AGE: Approximately 37 years

CONDITION: Several of the building's mechanical systems are deteriorating due to age, as detailed below.

ADEQUACY OF COMPONENTS: Adequacy of components varies according to individual components and their relationship to the assemblage as a whole. Individual mechanical components are addressed in detail in the descriptions that follow this section.

REMAINING SERVICE LIFE: A number of the building's mechanical systems have been partially or completely replaced at various stages in the history of the building. As a result, there is significant variability in the condition and life expectancy of the building's various pieces of mechanical equipment. The remaining service lives of individual mechanical components are listed in the corresponding sections of this report.

Specific problems, along with proposed solutions, approximate costs for addressing the issues, and the priority level of each item, are presented in the subsequent section, "Problems to be Corrected at This Time".

MECHANICAL SYSTEMS

Air Handlers

The facility is served by four rooftop air handling units (AHU's)—two for the High Bay and two for the Low Bay (photograph 01/MM-1). The air handlers are original to the building and employ dual-deck hydronic heating and cooling. This type of conditioning is not permitted under current energy code. The insulation and interior of the AHU's are deteriorating due to water infiltration. All of the AHU's are past their useful service lives at this point. However, all four air handlers have had their fan motors and variable frequency drives (VFD's) replaced recently (within the last one to two years) and, if salvaged, these components may have up to 20 years of service life remaining. However, the motors and VFD's may suffer shortened lifespans due to the noted water infiltration.

The low bay roof also houses two smaller air handling units (photograph 02/MM-1), which are dedicated to a secure section of the building. These units are relatively new and associated with a portion of the structure that is outside of the scope of this assessment.

Chiller and Cooling Tower

A centrifugal chiller (photograph 03/MM-2) and a cooling tower (photograph 04/MM-3) provide cold water to the cooling coils of the air handling units. The cooling tower has a chemical treatment system in place (photograph 05/MM-4). The existing chiller and cooling tower and their associated pumps were installed in 2001. The chiller has up to approximately 10 years of service life remaining, with proper maintenance. The cooling tower is having corrosion and leakage issues and is likely within its last five years of useful service.

Boilers and Circulation Pumps

Two hot water boilers (photograph 06/MM-5) are currently in place, providing heating water both to the unit heaters in the building and the AHU's on the roof. At the time of the inspection, one of the boilers was out of service for repairs. Both boilers date to the early 1990's but have newer model Honeywell controllers. The boilers are currently past their useful service life. The hot water circulation pumps (photograph 07/MM-5) associated with each boiler have motors that were replaced within approximately the last two years and should have another 15 years of life remaining.

Pipes and Distribution

A hydronic piping system (photograph 08/MM-6) distributes hot water from the boilers to the AHU's and unit heaters, and cold water from the chiller to the cooling tower and the AHU's. The hydronic piping suffers from poor sealing throughout the building and reportedly leaks in multiple locations if the water temperature is permitted to drop below 90 degrees Fahrenheit. Based on scaling and rust that is visible at fittings where leaks previously occurred, the interior condition of the piping is likely very corroded and deteriorated. The heating water piping is well past its useful service life and should be replaced.

As noted above, Flohawks Plumbing and Septic conducted video inspections of the sanitary waste pipes for the building. Appendix 7H includes record drawings of the exterior and interior below-grade waste pipes. The pipes that were inspected by video camera are indicated in red. Those not marked with red were either inaccessible for scoping or were found to be non-existent or decommissioned. Scoping of the sanitary waste piping shows that the main lines are a combination of cement pipes and PVC pipes, and the laterals are PVC pipe with glued joints. There are some signs of groundwater infiltration at the joints, as indicated by the volume of water that is in the pipes even when no fixtures are in use (photograph 09/MM-6, and photographs 10 and 11/MM-7). In addition, the inspection revealed that, over a 20 foot section of one of the lateral waste lines, the pipe slopes backward (into the building) at a grade of about .45 inches per foot (see Sanitary Waste Piping Map, Low Bay, Appendix-7H-2). This condition can hamper flow and contribute to blockages, creating a maintenance issue. However, barring any significant change in use for the building, The PVC waste piping is still expected to have a remaining useful service life of 20 years or more.

The local waste piping that connects the restroom fixtures to the lateral lines is composed of cast iron. These pipes show an expected amount of pitting and oxidation for their age, and some accumulation of refuse locations (photographs 12 and 13/MM-8). However, the inspection did not indicate the presence of immediate issues such as blistering, cracking, or significant buildup of rust. The cast iron piping should continue to serve for up to approximately 10 more years. It is recommended that the waste system be hydro-jetted approximately every two years to clear any accumulation and prevent blockages.

There is also a now-abandoned network of steam piping (photographs 14/MM-9 and 15/MM-10) throughout the facility. This piping is no longer in use but appears to be entirely iron, which has made its removal a difficult proposition.

Terminal Units and Ductwork

The facility contains a total of approximately 78 dual-deck air terminal units (photograph 16/MM-11) which are original to the building. These units have newer electronic controls and actuators. These units are not fan-powered; they modulate the hot and cold air volumes via motor-actuated dampers. The majority of the ductwork is original to the building and therefore somewhat leaky. Most of it is insulated sheet metal or flex duct, however many of the sections of rectangular duct that connect with the terminal units in the Low Bay area are reportedly constructed entirely of duct board, which makes them fragile. Left undisturbed, the terminal units and their associated ductwork could continue to serve for up to another 10 years. However, if the AHU's are upgraded, it will be necessary to replace the terminal units and ductwork as well, because their design capacity and layout are specific to the existing dual-deck HVAC system.

Unit Heaters and Pneumatic Valves

The facility contains seven horizontal unit heaters (photograph 17/MM-11) and seven vertically-discharging "heat curtain" style heaters (photograph 18/MM-12), all of which employ hot water heating coils and electric fans. The heaters should be capable of serving for another five years. However, the hot water valves for all of these units are controlled by pneumatic valve actuators supplied by a dedicated air compressor. The only other known pneumatic actuators in the facility are two valve actuators that are on hot water pipes in the boiler room. All of these pneumatic valves are past their useful service lives.

Humidification
There are seven Nortec Airfog humidification units installed in the High Bay area (photograph 19/MM-12). The units were installed in 2001 and have proven prone to leaking and breaking down. It is unlikely that their existing configuration is adequate to prevent microbial growth and their lack of dependability means the humidity level in the print shop is likely sporadic. These units are reportedly the property of the Print Shop and their replacement is therefore outside of the scope of this project. However, they are supplied with water by the domestic plumbing system and it is unknown if they currently have adequate backflow prevention in place.

As noted above, there is also a decommissioned steam system still in place which appears to have been formerly used for humidification. This includes a steam boiler, condensate trap, condensate pump, filtration system, and steam piping throughout the facility, all of which is currently unused. This system was most likely decommissioned in 2001 when the Nortec humidification units were installed.

Controls
The HVAC systems, with the exception of the unit heaters and humidifiers, are controlled by a Metasys Building Automation System (BAS), by Johnson Controls.

C. CONSTRUCTION

- **MECHANICAL CODE**
  The building was built under the 1979 Edition of the Uniform Mechanical Code.

- **EXISTING DRAWINGS**
  Record drawings from the original 1979 construction were obtained from the Owner, as well as control drawings from the boiler replacement.

II. PROBLEMS TO BE CORRECTED AT THIS TIME

1. CODE ISSUES

PROBLEM: The current volume of outside air being supplied to the High Bay area is not sufficient to control fumes and odors.
SOLUTION: Increase the minimum outside air settings for the Print Shop and confirm that the volume of exhaust air is sufficient for this facility.
COST: $6,750
PRIORITY LEVEL: 1

PROBLEM: The current air handling units are dual-deck systems which provide both hot and cold air, which is then mixed at the zone level to produce the desired supply air temperature. This system violates current Washington State Energy Code section C403.4.4 which restricts the heating of previously cooled air and/or the cooling of previously heated air.
SOLUTION: When the AHU's are replaced, a code-compliant single-duct system will need to be installed. This will also require replacement of all of the existing dual-deck air terminal units and associated ductwork throughout the facility.
COST: $1,000,927
PRIORITY LEVEL: 3

PROBLEM: The High Bay humidifiers are connected to the domestic water system and it is unknown if code compliant backflow prevention has been installed.
SOLUTION: Install backflow prevention in the humidification system per plumbing code, if it does not exist.
COST: $4,500
PRIORITY LEVEL: 2

2. PUBLIC HAZARD

PROBLEM: As noted under Code Issues, the current volume of outside air being supplied to the High Bay area is not sufficient to control fumes and odors.
SOLUTION: See Code Issue, item #1, above.
COST: See Code Issue, item #1, above.
PRIORITY LEVEL: 1

PROBLEM: All of the original AHU's have outside air louvers that are not wind-driven rain resistant and, as a result, rainwater is infiltrating the units and leaving standing water inside the AHU. This condition is causing corrosion and deterioration of the insulation and filters, as well as presenting an electrical hazard and the potential for indoor air quality issues such as mold (photograph 20/MM-13).
SOLUTION: Provide wind-driven rain protection until the air handlers are replaced with new units.
COST: $11,250
PRIORITY LEVEL: 1

3. BUILDING MAINTENANCE

PROBLEM: Hot water boiler H-2 is prone to false alarms in the controls system and randomly tripping faults which do not appear related.
SOLUTION: Check controls programming, wiring, and sensors for source of recurring issues.
COST: $7,500
PRIORITY LEVEL: 2

PROBLEM: The chiller capacitors are reportedly failing, though no specific issues were noted at the time of the inspection.
SOLUTION: Assess chiller capacitors with manufacturer's local representative and replace if needed.
COST: $7,500
PRIORITY LEVEL: 3

PROBLEM: AHU supply fans typically ramp up to a static pressure of 3" WC in response to a single call for cooling, regardless of other calls in the system.
SOLUTION: Adjust controls programming so that fans provide a more measured response to cooling calls.
COST: $30,000
PRIORITY LEVEL: 3

PROBLEM: There is some accumulation of effluent and silt in the waste pipes which can inhibit flow and eventually develop into blockages.
SOLUTION: Have the waste piping hydro-jetted to clear it of buildup.
COST: $69,300
PRIORITY LEVEL: 4

PROBLEM: Sanitary sewer piping main lines and laterals show some signs of groundwater and silt infiltration at the joints.
SOLUTION: Re-line the waste piping to eliminate infiltration.
COST: $33,750
PRIORITY LEVEL: 4

4. CONSULTANT RECOMMENDATIONS

PROBLEM: Heating water boilers H-1 and H-2 are past their useful service lives and prone to leaks.
SOLUTION: Replace boilers.
COST: $212,626
PRIORITY LEVEL: 2

PROBLEM: Hydronic system pipes and fittings show signs of rust, corrosion, and leakage. (photograph 21/MM-14) The boiler system has to be run at all times at a minimum of 90 degrees Fahrenheit in order to cause enough thermal expansion in the pipes and fittings to prevent leaks. The cooling tower is showing corrosion and has been repaired repeatedly due to leaks (photograph 22/MM-14).
SOLUTION: Replace the cooling tower, as well as hydronic piping, fittings, and seals throughout the facility.
COST: $841,896
PRIORITY LEVEL: 1

PROBLEM: Pneumatic valve actuators are still in use on unit heaters and two hot water pipes. Actuator components are becoming corroded (photograph 23/MM-15).
SOLUTION: Replace pneumatic actuators with electric motorized actuators, which will eliminate the need to keep and maintain the pneumatic system, as well as allowing the actuators to be monitored and controlled remotely via the building automation system, if desired.
COST: $27,000
PRIORITY LEVEL: 2

PROBLEM: Low Bay ductwork is prone to leakage and appears to have some portions that are constructed of duct board rather than sheet metal.
SOLUTION: Replace ductwork and fittings throughout the Low Bay.
COST: $411,262
PRIORITY LEVEL: 3

PROBLEM: There are not currently cleanouts on the sewer main at the south side of the building or the four lateral lines that enter the building from the east, making inspection and maintenance of the pipes difficult.
SOLUTION: Install cleanouts outside of the building on the main sewer lines and laterals.
COST: $2,400
PRIORITY LEVEL: 4

PROBLEM: One section of waste piping within the low bay slopes backward (into the building) for approximately 20 feet, at a grade of roughly .45 inches per foot. This condition can hamper flow and contribute to blockages, creating a maintenance issue.
SOLUTION: Re-grade the waste pipe so that it slopes downward toward where it exists the building.
COST: $ 26,400
PRIORITY LEVEL: 4

PROBLEM: Roof drain assemblies and rainwater leaders in some observed portions of the Low Bay are not insulated, which allows heat loss through the piping (photograph 24/MM-16).
SOLUTION: Insulate all roof drains and rainwater leaders to improve the energy efficiency of the space.
COST: $5,625
PRIORITY LEVEL: 4

Typical Air Handling Unit
PHOTOGRAPH 01

New Air Handling Unit
PHOTOGRAPH 02

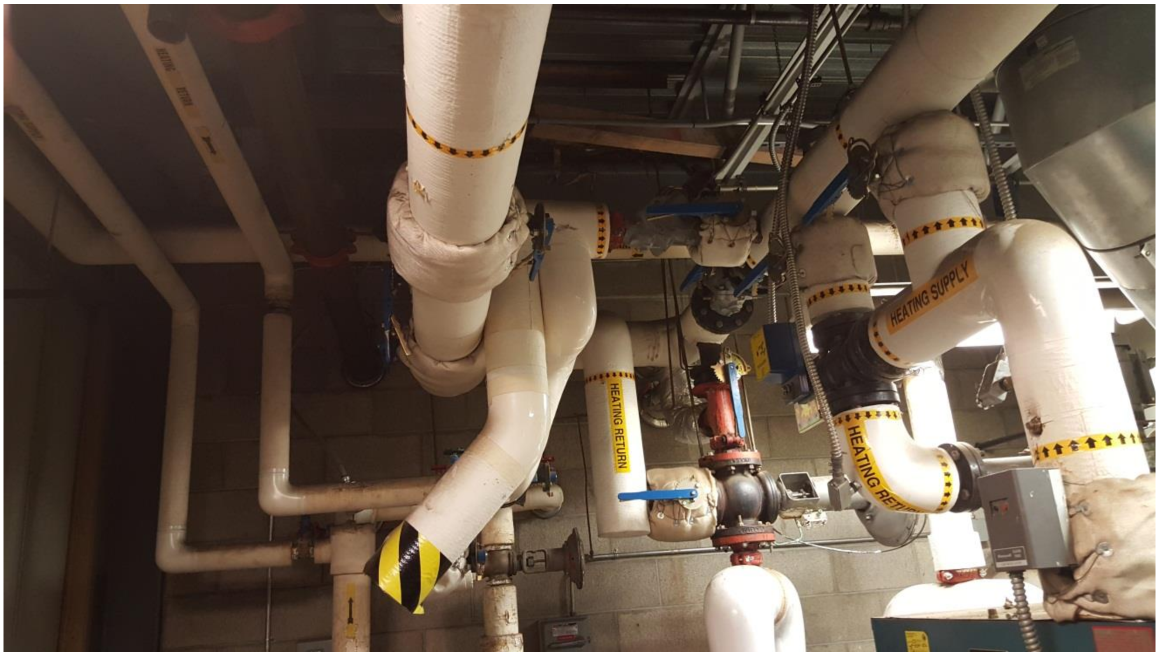
Centrifugal Chiller
PHOTOGRAPH 03

Cooling Tower
PHOTOGRAPH 04

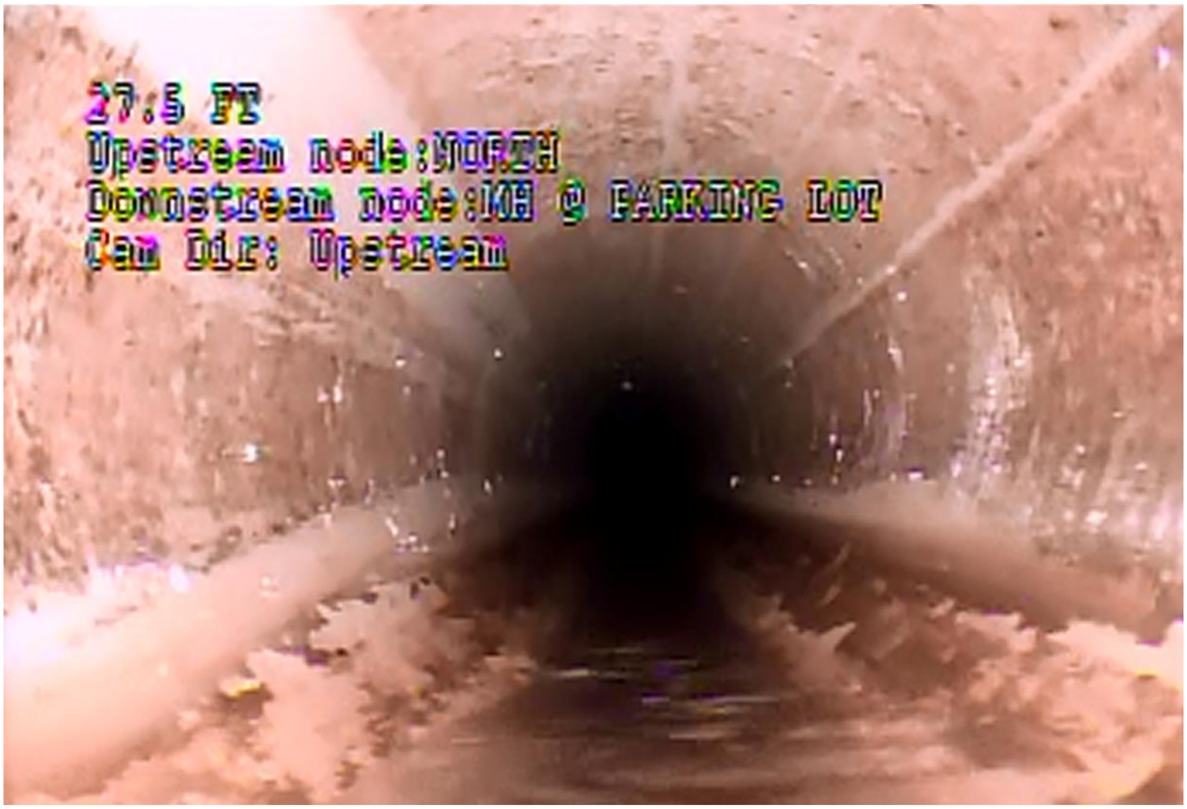
Cooling Tower Treatment System
PHOTOGRAPH 05

Heating Water Boiler
PHOTOGRAPH 06

Heating Water Circulation Pump
PHOTOGRAPH 07



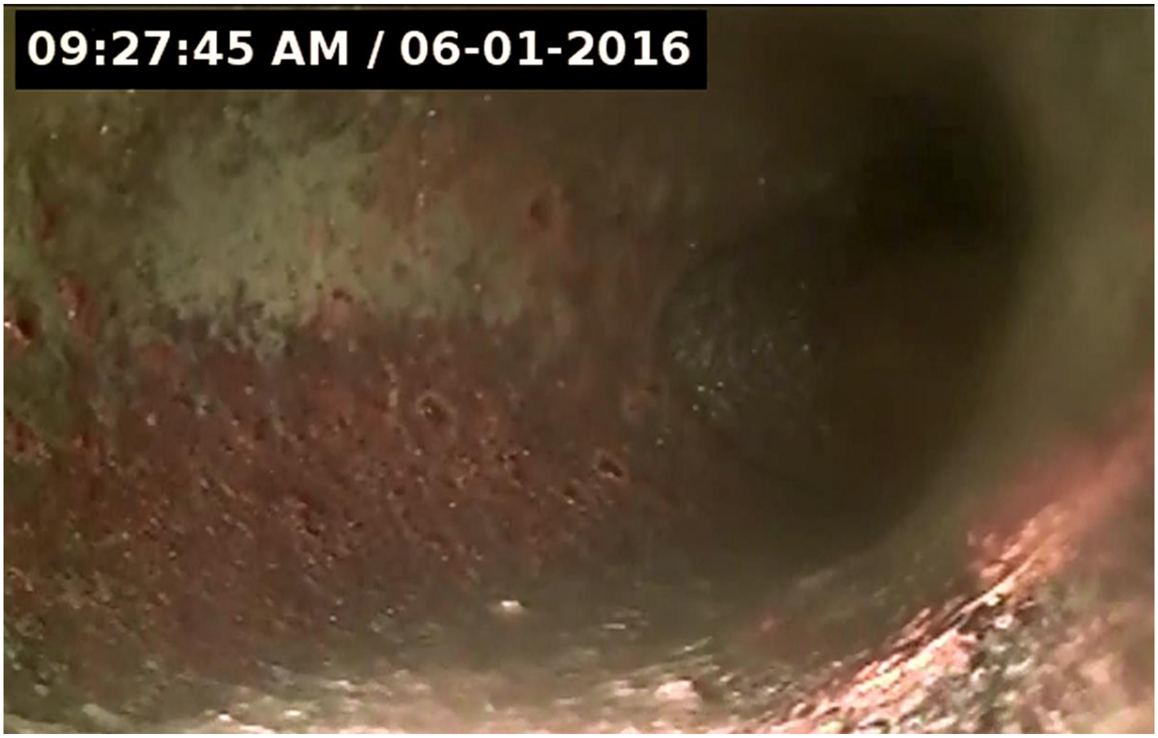
Hydronic Piping
PHOTOGRAPH 08



Sewer Main Line, PVC
PHOTOGRAPH 09

Sewer Main Line, Cement
PHOTOGRAPH 10

Sewer Lateral Line, PVC
PHOTOGRAPH 11



Waste Line, Cast Iron
PHOTOGRAPH 12

Waste Line, Cast Iron
PHOTOGRAPH 13

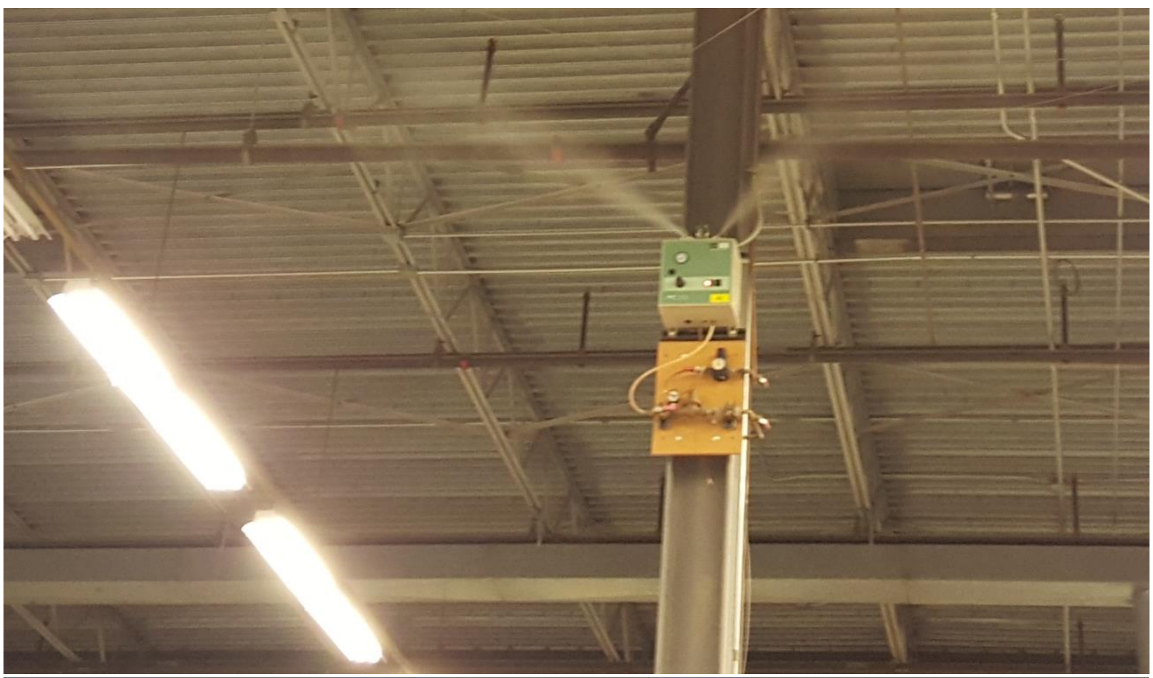
Abandoned Steam Piping
PHOTOGRAPH 14

Abandoned Steam Condensate System
PHOTOGRAPH 15

Air Terminal Unit
PHOTOGRAPH 16

Horizontal Unit Heater
PHOTOGRAPH 17

Vertically-Discharging Unit Heater
PHOTOGRAPH 18



Humidification Unit
PHOTOGRAPH 19

AHU Moisture Damage
PHOTOGRAPH 20

Signs of Rust and Scale in Pipes
PHOTOGRAPH 21

Cooling Tower Leak Damage and Patches (View of Bottom of Tank)
PHOTOGRAPH 22

Pneumatic Valve Actuator
PHOTOGRAPH 23

Roof Drain and Drain Piping, Uninsulated
PHOTOGRAPH 24

4. STRUCTURAL

I. INTRODUCTION

A. Peterson Structural Engineers (PSE) evaluated five locations/components of the Modular Building. PSE evaluated the following items:

- Fall Restraint for the Low and High Roof
- Cooling Tower Fall Restraint and Anchorage
- Mezzanine Loading and Access
- Storage Racks
- Building Seismic Analysis

B. GENERAL CONDITION OF THE EXISTING STRUCTURE

Fall Restraint for the Low and High Roof

The height of the building parapet (both high and low bay buildings) is not sufficient to prevent falls from the roof. The minimum height required to adequately prevent falls and be considered a railing is 42" vertical (IBC 2012 Section 1013). Current vertical parapet heights vary from 12" (at roof "ridge") to approximately 41" (at roof corners) and follow the slope of the roof (photograph 1/SS-1). PSE understands that maintenance workers or contractors doing work on the roof are required to wear fall protection harnesses regardless of where the work being performed is located on the roof with the current parapet configuration.

To correct this deficiency, the height of the parapet should be increased or a railing added to comply with fall protection requirements. PSE has identified four options to provide code-compliant fall protection. Of these options, extending the parapet vertically is the preferred option.

i. **Extend Parapet** – This option involves extending the parapet vertically using cold form steel stud in a fashion similar to the existing detail. The existing parapet is supported vertically by a structural steel channel which runs around the perimeter of the building and is located below the roof framing (photograph 2/SS-1 and 3/SS-2). The parapet cold form studs run outboard of the perimeter roof framing and form the parapet. The full parapet section includes exterior insulated metal panels, the steel channel studs, wood sheathing backing and the roof membrane.

To extend the parapet, new cold form steel studs would be placed back to back with the existing studs (photograph 4/SS-2). The new studs would have a height/length such that the 42-inch minimum for railings is satisfied. The option would require peeling back the roof membrane so a positive connection could be made between the structural steel roof framing and the parapet members. See sketch SSK-1 in Appendix A for a proposed detail.

ii. **New Pipe Railing** – Install a new conforming pipe railing inboard of the existing parapet. The base of this pipe railing would need to be welded or bolted to the top flange structural steel roof framing. This option is highly intrusive and requires penetrating the roof membrane. Constructability is also a concern as the connection to the top flange of the steel roof beam would be difficult to access. The roof beam would also likely need to be braced for torsion along its length with kickers to neighboring structure.

iii. **New Roof Anchor** - Install a new roof anchor to the top of an existing interior column to provide an engineered tie-off point for workers/maintenance staff on the roof. This option would still require workers to be tied off to the structure. This option also requires penetrating the roof membrane. It is viable from a structural perspective but does not change the need for workers to tie off when working on the roof.

iv. **Extend Perimeter Columns** – This option creates a new railing by extending the existing perimeter columns vertically so a beam can span between them. This option also requires the roof membrane to be penetrated. Besides an unappealing aesthetic, there are considerable constructability issues.

Cooling Tower Fall Restraint and Anchorage

The cooling tower (photograph 5/SS-3) requires scaffolding (photograph 6/SS-3) to access the upper portion of the equipment during maintenance. It is desired that permanent scaffolding and/or fall restraint could be added to the cooling tower so temporary scaffolding would not be required every time the equipment required maintenance. It was apparent during the site visits that it was not feasible or practical to add scaffolding or fall restraint to the existing equipment. Assuming the existing cooling tower is to remain, the temporary shoring still appears to be the best solution.

PSE was also tasked with determining the anchorage demands for lateral loading (wind and seismic) loading from the equipment that is transmitted to the structure below. The purpose of determining the anchorage demands was for evaluating the existing anchorage and support structure.

Four vertical pipe supports carry the weight of the cooling tower above. These pipes are welded to the joists located immediately below the cooling tower (photograph 7/SS-4). In addition to the four vertical pipes, the support frame utilizes four outriggers (photograph 8/SS-4) to widen the support at the base, increasing the lateral stability of the cooling tower support frame. The ends of the outriggers are not positively connected to the structure below and are not capable of transmitting any shear or tensile loads. They are only able to transmit vertical compressive loads to the structure (joist) during lateral events via direct bearing. Additionally, the cooling tower sits on four damping springs located at the corner of the base frame. It is assumed that these springs are included to damp out vibrations due to normal operation of the equipment. PSE conservatively considered these springs to be rigid when determining demands from wind and seismic loading.

The existing equipment and support structure was analyzed under current code level wind and seismic loading. Seismic loading was found to govern anchorage demands relative to wind loading. Seismic overturning demands were approximately 35% greater than wind demands. Detailed calculations can be found in Appendix B of this report.

Maximum shear load (EQ only) transferred by the pipe supports directly beneath the cooling tower is approximately 1,800 lbs. Maximum tensile load (EQ + DL) transferred by the pipe was approximately 1,300 lbs. and maximum compression (vertically downward) load (EQ + DL) was approximately 2,800 lbs. The welds at the base of the pipe were found to be sufficient to transfer the forces to the joist below. Maximum compression transmitted by the outriggers (vertically downward) was 2,700 lbs. As previously stated, the outriggers are not capable of transmitting shear or uplift forces.

Table S01 below summarizes the utilization ratios for the different directions of controlling seismic and wind loads. Note that four separate joists support reactions from the cooling tower. The utilization ratios presented below represent the single joist with the highest utilization ratio. "Uplift" loads represent cases all loads applied to the beam were uplift loads. Due to the support frame geometry this was only possible when the wind or seismic forces acted in the N/S direction. It was determined that maximum utilization ratios ranged from 0.16 to 0.61.

No corrective action is required or anticipated. The existing attachment of the equipment and supporting structure (joists) are adequate for the anticipated loads.

EAST-WEST DIRECTION			**NORTH-SOUTH DIRECTION**		
ITEM	**DIRECTION**	**UTILIZATION**	**ITEM**	**DIRECTION**	**UTILIZATION**
SEISMIC	UPLIFT	n/a	SEISMIC	UPLIFT	0.22
SEISMIC	DOWNWARD	0.61	SEISMIC	DOWNWARD	0.50
WIND	UPLIFT	n/a	WIND	UPLIFT	0.16
WIND	DOWNWARD	0.36	WIND	DOWNWARD	0.35

Table S01 – Cooling Tower Summary

Mezzanine Loading and Access

The mezzanine platform located in the high bay building is currently posted for 125-psf allowable storage load. PSE was tasked to confirm this posting or provide recommendations for lesser loading if appropriate (photographs 9/SS-5 and 10/SS-5). It was determined that the safe allowable loading for the mezzanine should be reduced to 100-psf. The loading was controlled by the capacity of the open web steel joist. Detailed calculations are included as part of Appendix C. Note that the calculated 100-psf loading supports the 100-psf design live load listed in the existing drawings general notes (DES 79-244 sheet S1).

The mezzanine is accessed by a stair way and a steep "ship's ladder" (photograph 11/SS-6). Building staff tasked PSE with evaluating the existing railings for compliance with current railing code requirements. Railings for both the stairs and ship's ladder (photograph 12/SS-6 and 13/SS-7) were evaluated under requirements found in the 2012 IBC Chapter 10 (Means of Egress) and OHSA 3124-12R 2003 (Stairways and Ladders, A Guide to OSHA Rules). Railings for both elements met the railing requirements for stairs and ladders, respectively. Detailed analysis can be found in Appendix D.

Storage Racks

Some minor cracking has been observed around the existing storage racks (photograph 14/SS-7) near the mezzanine in the high bay building. PSE evaluated the cracking around the storage racks and believes that the cracking observed is normal for a concrete slab of that age and construction. It should also be noted that the concrete slab was evaluated in 2014 by AHBL and the existing concrete slab was also found to be adequate to support the storage loads.

PSE conducted an independent evaluation of the rack anchorage to the concrete slab under seismic loading following procedures found in ASCE 7-10 (Minimum Design Loads for Buildings and Other Structures) and the Rack Manufacturer's Institute (RMI) "Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks". Assuming that each storage rack is anchored with (2) ½" diameter Hilti Kwik Bolt TZ expansion type anchors with 3.25-inch embedment (as PSE understands is common for these types of racks), the maximum product loading allowed per shelf is 85-psf or 2,640-lbs. The weight of the actual material being stored on the racks should be evaluated to confirm it is within the 2,640-lb per shelf limit. If the actual weight of product exceeds this load limit, the loads should either be reduced or the anchorage upgraded to comply with the increased demands. It should be noted that if the as-installed anchorage exceeds what has been assumed, additional product load capacity may be realized.

Whole Building Seismic Evaluation

PSE understands that no upgrades to the main lateral force resisting system (MLFRS) have been completed since the building was constructed in the early 1980's. The existing MLFRS utilizes a braced frame system with two braces typical on each side of the building. However, given the age and construction of the building, PSE anticipates that the detailing of these braces may not be adequate for current code prescribed loading (amongst other potential deficiencies).

As part of the building seismic evaluation, PSE performed both a Tier 1 and Tier 2 seismic screening per *ASCE/SEI 41-13: Seismic Evaluation and Retrofit of Existing Buildings* (ASCE 41). These two screenings involve following prescriptive procedures to evaluate potential issues with the MLFRS, diaphragms, and foundations.

The checklists in the ASCE 41 Tier 1 screening are differentiated by building type and are based on past observed performance of similar buildings. Each item in the checklist must be marked as "Compliant", "Noncompliant", "Not Applicable", or "Unknown". In accordance with ASCE 41, any checklist item that was identified as "Noncompliant" or "Unknown" was deemed deficient. A completed Tier 1 checklist is included as Appendix J of this report.

In order to consider the structural deficiencies determined during the Tier 1 screening in more detail, PSE also performed a Tier 2 evaluation. This evaluation was limited to the items identified as "noncompliant" during the Tier 1 evaluation. Detailed calculations produced for this portion of the evaluation are included as Appendix K.

For the Tier 1 screening, PSE considered the modular building as shown in the as-built documents (dated 04/07/1980 and revised 06/26/1981) provided by the client. PSE also performed two site visits (April 26th, 2016 and June 13th, 2016) to observe the existing condition of the MLFRS. The main lateral force resisting systems in all directions are concentrically braced steel chevron frames (photograph 15/SS-8). The building was analyzed in two different portions: northern and southern (low and high bay, respectively). Each wall of the building has two 20-foot bays which contain frames. The remaining bays have steel gravity only frames to resist gravity loads. The high bay portion of the modular building has two stories of frames while the northern portion of the building only has one. The roof diaphragms for each portion consist of Type B 1½"-deep, 20 gage metal decking. Since there is no concrete topping, the diaphragms were assumed to be flexible. Table S02 shows the pertinent design criteria for the screening performed on the subject building.

CRITERION	VALUE	LOCATION IN ASCE 41
Common Building Type	Steel Braced Frame (S2a)	Table 3-1
Structural Performance Level	Life Safety (S-3)	Section 2.3
Level of Seismicity	High $S_{D1} > 0.20g$	Table 2-5

Table S02 – Design criteria for seismic evaluation, per ASCE 41

From the table above, since the subject building has a MLFRS consisting of concentrically braced frames; it is defined by ASCE 41 as a common building type S2. The roof diaphragm is an untopped metal deck, which is defined as flexible in Table 3-1 of ASCE 41. This distinction means the building type is S2a, where the "a" indicates that the building has a flexible diaphragm.

A building that complies with the Life Safety structural performance level (given the designation S-3 by ASCE 41) may incur significant damage during a seismic event, but should not undergo partial or total collapse.

The level of seismicity was determined using site-specific acceleration data that was provided by the USGS Seismic Design Maps. This data was obtained by assuming Soil Site Class D (stiff soil). Table 2-5 of ASCE 41 requires the use of both design short-period spectral response acceleration, S_{DS}, and design spectral response acceleration at a one-second period, S_{D1}. Since the level of seismicity defined by S_{D1} controlled over the level defined by S_{DS}, this was the only value shown.

Per ASCE 41, a benchmark building is a building with a specific performance level that, if designed to a specific code, automatically complies with the Tier 1 screening procedure. According to the as-built documents, the subject building was designed according to the 1979 edition of the Uniform Building Code (UBC). However, for a building with steel concentrically braced frames and a Life Safety structural performance level, conformance to the 1997 edition (or later) of the UBC is required to satisfy the benchmark building requirement. The benchmark building criteria are given by Table 4-6 of ASCE 41.

The items listed below include the non-compliant or unknown statements from the requisite Tier 1 checklists provided in ASCE 41 and are updated with information from the Tier 2 study.

i. **SEPARATION BETWEEN ADJACENT BUILDINGS:** There are three distinct structures on site and are immediately adjacent to each other: the low and high bay modular buildings and the Isabella Bush Building located to the south of the modular buildings. The seismic joint between the low and high bay buildings (gridlines G & H) allows for 2" of movement between the two buildings (per sheet A9 of drawing set 79-244). The height to top of roof of the low bay building at grids G and H is 13'-7". ASCE 41 states that the distance between adjacent structures must be greater than 4% of the shorter building height to be considered compliant. Under this requirement, a

6.5-inch seismic joint is required. By inspection, the existing 2-inch seismic joint is undersized for a building of this height. While outside the scope of this evaluation, it is assumed that the joint between the high bay and Isabella Bush building is similarly undersized.

Providing a seismic joint which allows for the anticipated seismic movements appears to be the most desirable option to address the separation issue. This option would appear to be rather intrusive as approximately 240 linear feet of joint would need to be replaced to account for horizontal and vertical joints. Tying or linking the buildings together to behave as one structure is not realistic due to the discrepancy in building heights. Another option is to accept that damage to the buildings is likely to occur during a seismic event but that collapse is unlikely. For an S-3 performance level this would be acceptable as life safety is preserved.

ii. **SOIL LIQUEFACTION:** Per the Liquefaction Susceptibility Map for Thurston County (provided by the Washington State Department of Natural Resources), the subject building is located in an area that has a moderate susceptibility to liquefaction. Although the original construction documents state that existing soil be removed to a depth of ten feet and recompacted, and that another five feet of construction fill be placed on top of the recompacted native soil (DES 79-244 sheet C3), the Tier 1 requirement is that no liquefaction-susceptible soils be present within a depth of 50 feet.

There is no Tier 2 verification for the liquefaction requirement; however, ASCE 41 allows for the use of the liquefaction check in the Tier 3 evaluation (which is normally reserved for investigating the entire building). Per the geotechnical report included in the construction documents (DES 79-244 sheet C4), the underlying soil layer is medium dense, coarse to very coarse gravelly sand. This layer was present down to the maximum depth investigated, which was 24 feet below existing grade. The best-case estimated liquefaction susceptibility for this site is low. However, this site does not meet any of the criteria set forth in Section 8.2.2.2 of ASCE 41. These criteria dictate whether or not a site may be regarded as non-liquefiable.

Therefore, it is recommended that a new site-specific geotechnical investigation should be performed to confirm the liquefaction potential during a seismic event for this specific site. Future detailed retrofit design will require the consideration of the effects of liquefaction on the structure if liquefaction is likely.

iii. **DIAPHRAGM TRANSFER TO STEEL BEAMS**: During the follow-up site visit, PSE was able to determine that the existing detail between the steel beams and diaphragm is able to transfer seismic loads into the MLFRS. No retrofit is anticipated to this area.

iv. **BRACE CONNECTION STRENGTH:** Per the Tier 1 requirements, none of the brace connections have sufficient strength to develop the yield strength of the diagonal braces. Under the Tier 2 evaluation, demands for these connections were less stringent as they were based on limit-state analyses of the braced frames. None of these limit states were able to transmit a load large enough to cause the braces to yield. However, the demands on these connections were still greater than each connection's respective capacity.

Therefore, PSE recommends that brace frame connections be strengthened in order to increase their capacity. The connections may be strengthened by adding stiffener plates, anchor bolts, or welds, depending on the connection's specific configuration. A sample connection upgrade is shown in sketch SSK-2 in Appendix L**.**

v. **WALL OUT OF PLANE CROSS TIES:** During the follow-up site visit, PSE was able to determine that the connection of the roof diaphragm and the wall is adequate for transferring out of plane loads. No retrofit is anticipated to this area.

vi. **VERTICAL IRREGULARITY:** The original construction documents show two sets of stacked braced frames along each wall of the high bay building (DES 79-244 sheet S7). However, one of the lower braces on the east side of the building was moved north two bays to accommodate a new roll up door (photograph 16/SS-8). This resulted in braced frames that are not continuous to the foundation. This condition is non-compliant with the Tier 1 vertical irregularities provision.

ASCE 41 allows for vertical irregularities provided that the load can adequately be transferred from frame to frame and to the foundation. This means that not only must there be elements in place to transfer seismic force—struts to transfer shear and columns to transfer the overturning forces—but these elements must also have the capacity to resist the seismic force.

These support elements (beams and columns) were analyzed using Tier 2 limit-state analysis. This analysis involved determining the expected strength of the MLFRS and using the corresponding seismic load to analyze the whole system. From this analysis, the support columns were deemed to be adequate, but the W12x26 beam that spans the 20-foot bay between the upper and lower frames was determined to be an inadequate strut. Because seismic force cannot be adequately transferred between frames, PSE recommends that either the strut be upgraded to a section that can adequately transfer the seismic force or that the upper frame is moved so that it shares the same bay with the lower frame.

C. CONSTRUCTION

Building Code
The building was originally constructed in 1979 under the 1979 Edition of the Uniform Building Code (UBC) by the International Conference of Building Officials. Original Engineer of Record (EOR) was Victor O. Gray & Company.

A mezzanine was added in 1982 under the 1979 Edition of the UBC. The mezzanine is located between grids A &G and 1 & 3.

It appears that only minor structural upgrades and repairs have been completed since the original construction. It appears that a lateral brace was moved from its original location on the east wall of the high bay building to make room for new roll up doors.

Original Design Loadings (per DES 79-244 sheet S-1)

Dead (typical)	as required
Dead (future mezzanine)	60 psf
Live (mezzanine mech.)	150 psf
Live (roof)	25 psf
Live (hung equipment)	5 psf
Live (RTU's)	as required
Live (future mezzanine)	100 psf
Wind (UBC)	25 mph zone
EQ (UBC)	zone III
Allowable Soil Bearing	4,000 psf

II. PROBLEMS TO BE CORRECTED AT THIS TIME

1. PUBLIC HAZARD

PROBLEM: Fall Restraint at the Low and High Roof
The existing parapet is not compliant with current code to prevent falls from the roof. Maintenance staff or contractors performing work are currently required to wear a harness regardless of where they are working on the roof.

SOLUTION: Extend the parapet per sketch SSK-1,
QUANTITY: Approximately 1,320 LF of extended parapet
COST: $322,529
PRIORITY LEVEL: 2

PROBLEM: Cooling Tower Fall Restraint
Temporary scaffolding is required when performing maintenance on the cooling tower.
SOLUTION: Continue to provide access with temporary scaffolding or replace cooling tower with unit that incorporates improved maintenance access
QUANTITY: 1
COST: N/A (cooling tower to be replaced per DES – see Mechanical section of report)
PRIORITY LEVEL: 3

PROBLEM: Mezzanine Loading
The mezzanine between grids A & G and 1 & 3 is posted for 125 psf but is only adequate to support 100-psf.
SOLUTION: Evaluate the weight of the products being stored on the mezzanine and confirm that less the weight is less than 100-psf. If the product load exceeds this limit, the weight of the product stored on the mezzanine should be reduced. The mezzanine should also be posted for a 100-psf storage load limit.
QUANTITY: Two locations
COST: $1,200
PRIORITY LEVEL: 3

PROBLEM: Storage Rack Capacity
The storage racks may be overloaded depending on the weight of the products currently being stored.
SOLUTION: Evaluate the weight of the products being stored on the racks and confirm that less than 2,640-lbs are stored on any individual shelf. If the product load exceeds this limit, the weight stored per shelf should be reduced or the anchorage upgraded. Assuming no anchorage upgrades are made the storage racks should be posted for a 2,640-lb or 85-psf per shelf weight limit.
QUANTITY: Two locations
COST: $1,200
PRIORITY LEVEL: 3

PROBLEM: Separation Between Adjacent Buildings
The as-built seismic joint located between grids G and H allows for only 2-inches of movement and is undersized for the anticipated movement demands.
SOLUTION: Replace the seismic joint between the two buildings with a joint that can accommodate the anticipated seismic loads. The replacement joint should allow for 6½-inches of movement.
QUANTITY: 240 linear feet
COST: $44,994
PRIORITY LEVEL: 2

PROBLEM: Soil Liquefaction
It is unknown if the soils present at the building site are susceptible to liquefaction. If liquefiable soils are present, future detailed retrofit design will require the consideration of the effects of liquefaction on the structure.
SOLUTION: Conduct a site specific geotechnical investigation based on the constructed soil profile.
QUANTITY: n/a
COST: $20,000
PRIORITY LEVEL: 2

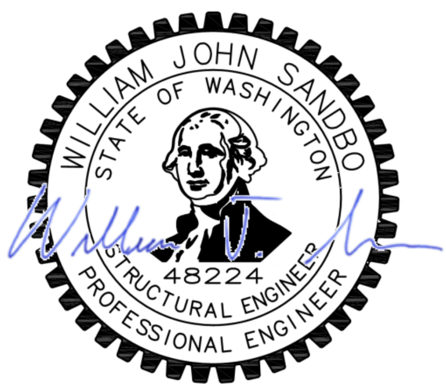
PROBLEM: Brace Connection Strength
The seismic braced frame connections are not adequate to transfer the anticipated seismic demand.
SOLUTION: Retrofit the brace frame connections to increase their capacity. The connections may be strengthened by adding stiffener plates, anchor bolts, or welds, depending on the connection's specific configuration. A sample connection upgrade is shown in sketch SSK-2**.**
QUANTITY: 72 connections
COST: $283,589
PRIORITY LEVEL: 2

PROBLEM: Vertical Irregularity
A vertical irregularity exists where a brace was moved to allow for installation of a new roll-up door on the east wall of the high bay building.
SOLUTION: Upgrade the W12x26 strut to a section that can adequately transfer the seismic force or move the upper braces north so it shares the same bay as the lower frame.
QUANTITY: 1 location
COST: $23,284
PRIORITY LEVEL: 2

2. **BUILDING MAINTENANCE**
Not applicable.

3. **CONSULTANT RECOMMENDATIONS**
Not applicable.

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT PERSONAL SUPERVISION AND THAT I AM A DULY LICENSED ENGINEER IN THE STATE OF WASHINGTON.



Parapet From Roof (at roof “ridge”)
PHOTOGRAPH 1

Parapet Base From Interior (from Mezzanine)
PHOTOGRAPH 2

MODULAR BUILDING ASSESSMENT

Parapet Base Detail (from roof access)
PHOTOGRAPH 3

Parapet Cavity
PHOTOGRAPH 4

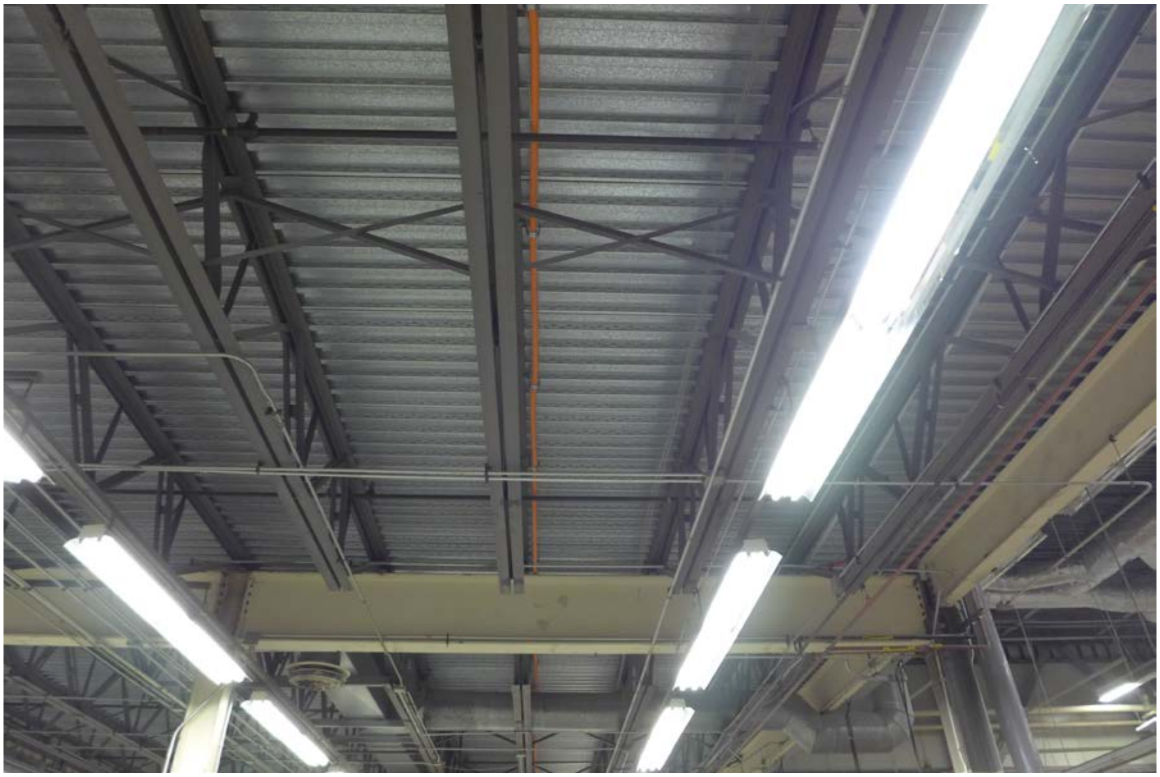
Cooling Tower
PHOTOGRAPH 5

Cooling Tower Scaffolding
PHOTOGRAPH 6

Cooling Tower Support Pipe Connection to Joist Below
PHOTOGRAPH 7

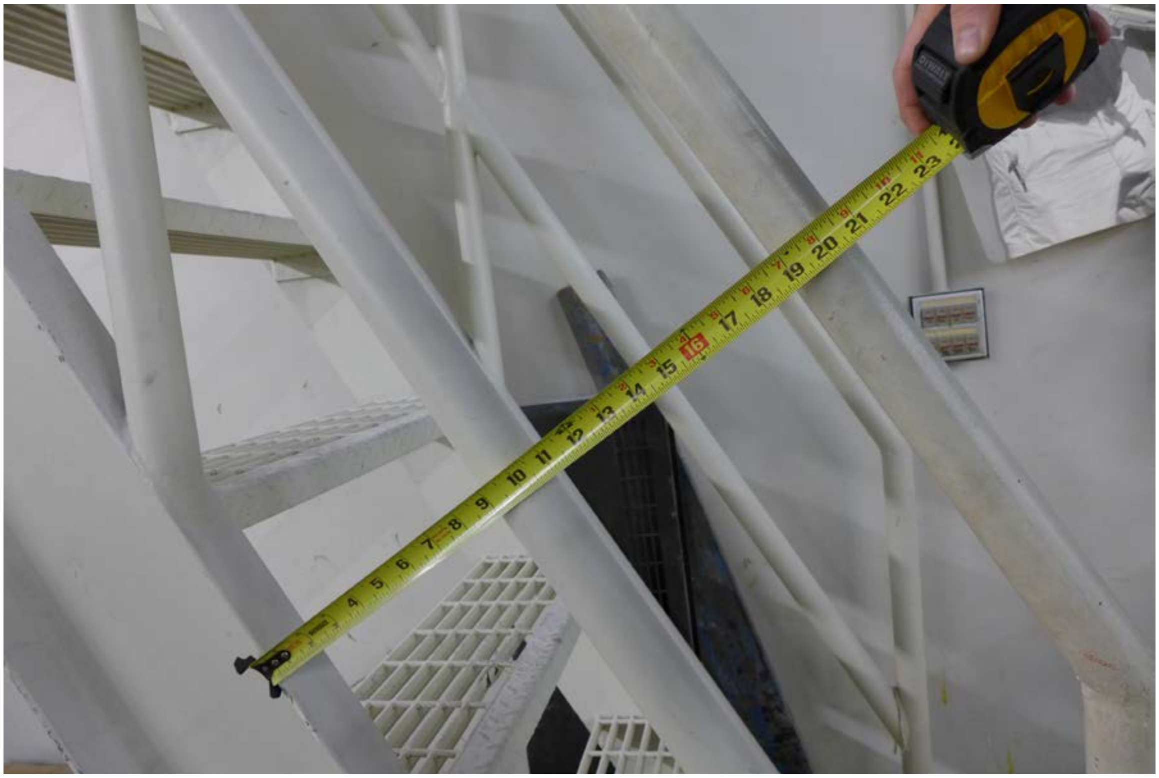
Cooling Tower Outrigger Detail
PHOTOGRAPH 8

Underside of Mezzanine
PHOTOGRAPH 9



Mezzanine Framing
PHOTOGRAPH 10

Mezzanine Ships Ladder
PHOTOGRAPH 11



Mezzanine Ships Ladder Railing Detail
PHOTOGRAPH 12

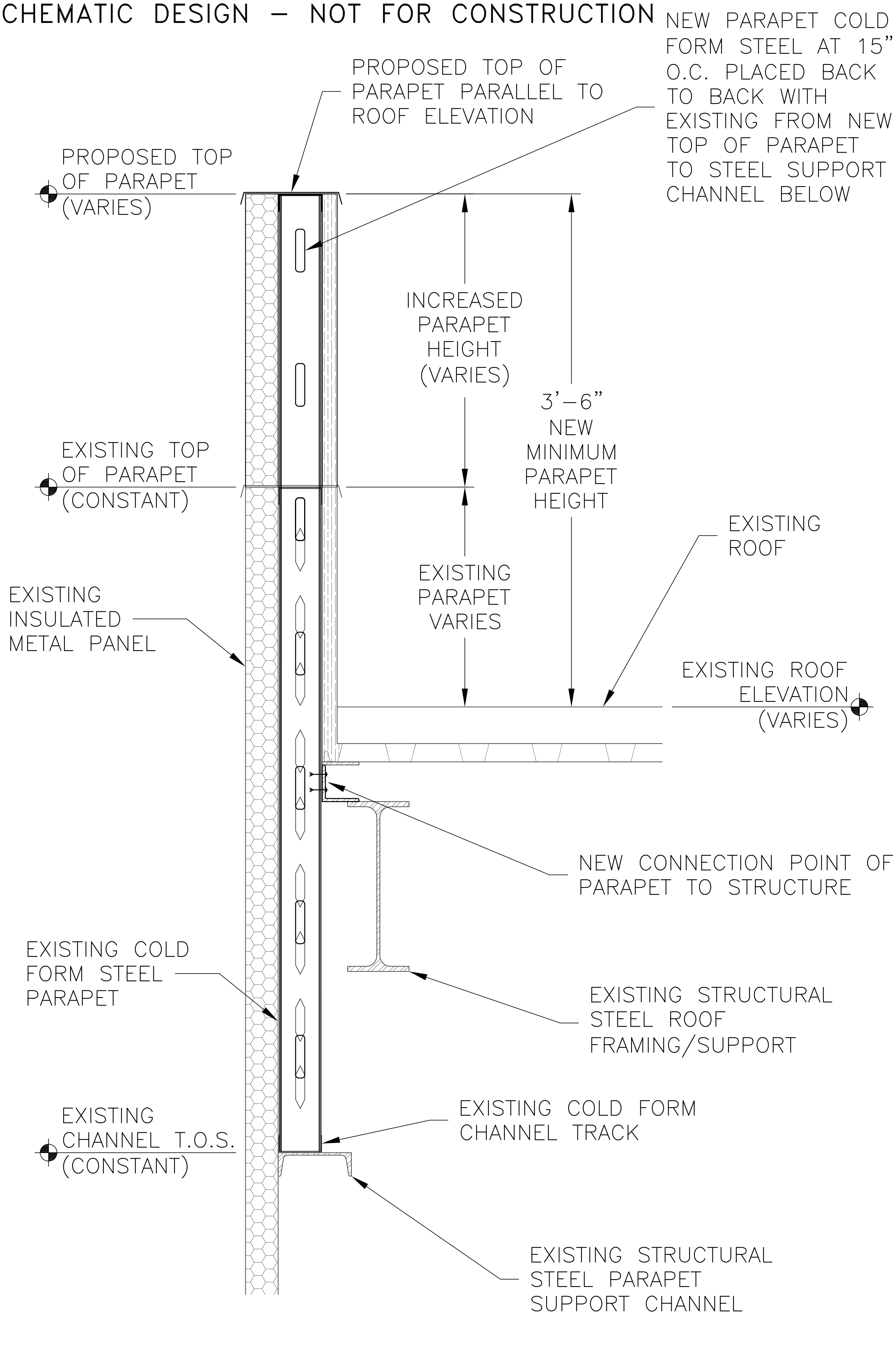
Mezzanine Stair Railing
PHOTOGRAPH 13

Storage Racks
PHOTOGRAPH 14

Typical Brace/Beam Connection
PHOTOGRAPH 15

Offset Braces Resulting in Vertical Irregularity
PHOTOGRAPH 16

SCHEMATIC DESIGN – NOT FOR CONSTRUCTION



NOTICE
0 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

PROGRESS PRINT – 5/11/16

PSE
Peterson Structural Engineers, Inc.
5319 S.W. Westgate Dr., Suite 215
Portland, Oregon 97221
(503) 292-1635

MODULAR BUILDING PARAPET

CLIENT INFO:
Ehm Architecture
1200 Fifth Avenue, Suite 1208
Seattle, WA 98101

PROJECT SITE:
WA State Print Shop
7580 New Market Street
Tumwater, WA 98501

SHEET CONTENT 16-150-01
PROPOSED PARAPET MODIFICATIONS FOR FALL PROTECTION

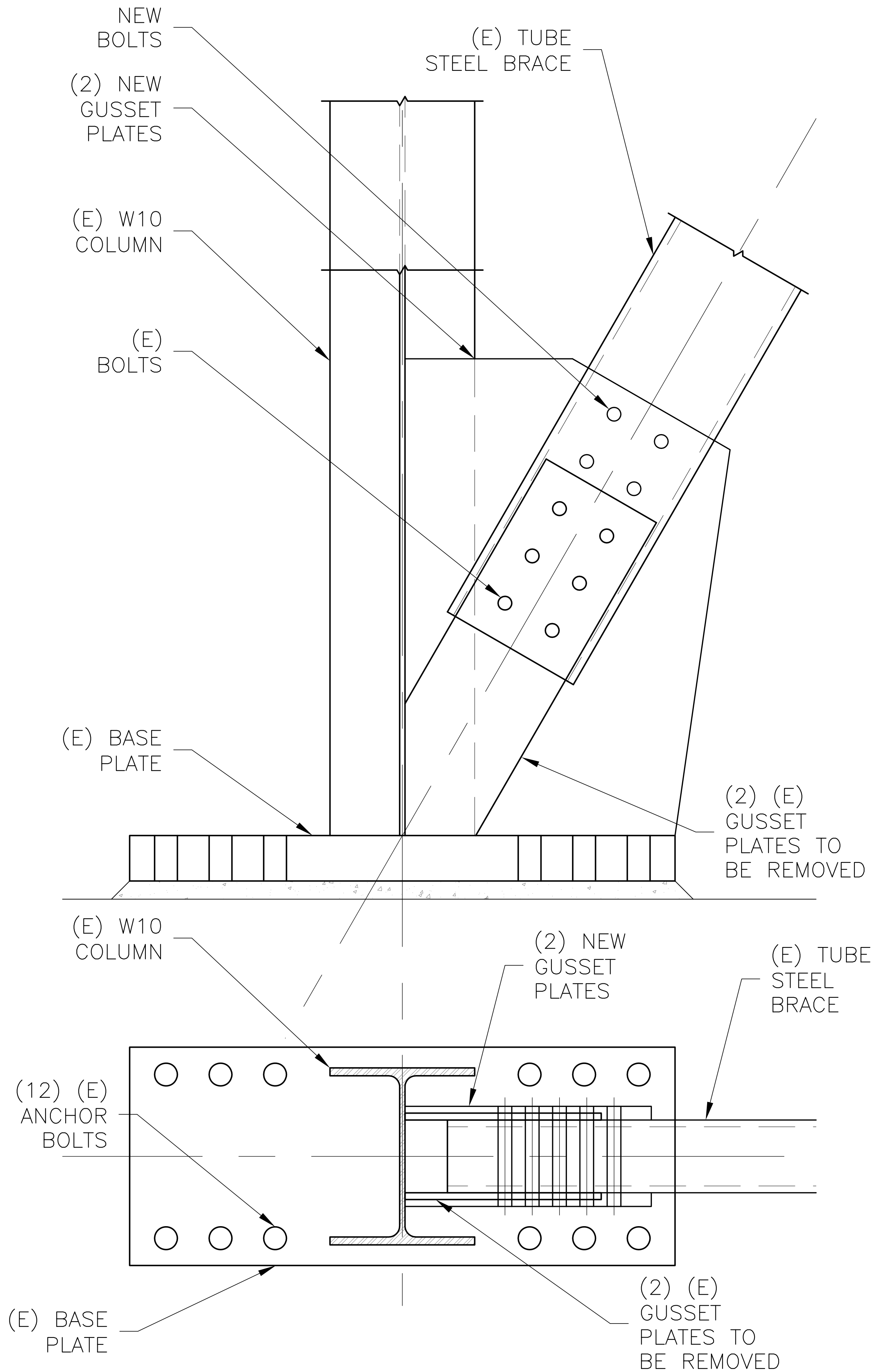
PSE JOB No. 16-150
DRAWN WJS
CHECKED TGM
DATE 5/11/16
REVISIONS
SHEET SSK-1

SCHEMATIC DESIGN – NOT FOR CONSTRUCTION

NOTICE

0 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE



PSE

Peterson Structural Engineers, Inc.
5319 S.W. Westgate Dr., Suite 215
Portland, Oregon 97221
(503) 292-1635

MODULAR BUILDING PARAPET

CLIENT INFO:
Ehm Architecture
1200 Fifth Avenue, Suite 1208
Seattle, WA 98101

PROJECT SITE:
WA State Print Shop
7580 New Market Street
Tumwater, WA 98501

SHEET CONTENT 16-150-01

PROPOSED TYPICAL BRACE CONNECTION RETROFIT

PSE JOB No.	16-150
DRAWN	WJS
CHECKED	TGM
DATE	6/30/16
REVISIONS	
SHEET	SSK-2

5. ELECTRICAL

I. INTRODUCTION

A. Elcon Associates, Inc. personnel inspected electrical components of the Modular Building on April 8 and April 26, 2016. The Scope of Work included assessment of building power distribution system, interior lighting, and loading dock levelers. The Scope of Work also included a review of a 2012 ESCO Audit and update of associated costs.

B. GENERAL DESCRIPTION OF THE EXISTING ELECTRICAL SYSTEMS
The power distribution and interior lighting systems are mostly original, with a few minor upgrades and modifications apparent.
AGE: Built in 1980, the modular structure's electrical systems are approximately thirty-six years old.
CONDITION: The building electrical components are in good to fair condition, as further outlined herein.
ADEQUACY OF COMPONENTS: The building power distribution and lighting systems are adequate to their current use. There are no significant anticipated changes to the building that would exceed the system capacity.
REMAINING SERVICE LIFE: Through a program of preventive maintenance, the power distribution and lighting system should have a remaining service life of approximately twenty years.

BUILDING ELECTRICAL COMPONENTS
Electrical Distribution
The existing electrical distribution system consists of an incoming 480/277volt, 1500kVA Utility transformer that supplies a 480/277volt, 2500amp (approximately 2000kVA rated) fused switchboard (photograph 01/EE-1) loaded to 500kVA (600amps) or one-third of the Utility transformer. The Main Switchboard feeds four (4) 800amp 480/277volt switchboards (photograph 02/EE-1). A recently installed 250kW generator located outside next to the Utility transformer provides backup power for lighting, and payroll and check printers.

The electrical serviceable life is dependent on how hot the panels and circuit breakers have been due to electrical loading, also on the number of operations (on/off cycles) the circuit breaker/switch have been subjected to. Another item in determining serviceable life is the environment; is the equipment installed outside, inside, in dirty or clean location, and if there is condensing moisture, based on the ambient temperate.

The exposure to excessive heat shortens the life span of electrical equipment, unless the equipment has been too hot to touch, aging due to high temperatures is not an issue.

Another aspect of equipment aging is the number of operations (on/off cycles) the circuit breaker, fused switch, contactor, etc. has been subject to. A typical UL listed circuit breaker is tested for approximately 10,000 operations (27 years if cycled once per day, 365 days per year, 7 days a week); 6,000 operations at fully rated current and voltage, and additional 4,000 operations without current. A contactor or relay is typically rated for 100,000 electrical operations. Contactors are used in motor controllers and some lighting control panels.

The last set of items is environment and maintenance in determining aging factors for equipment. The building is clean and heating and ventilation keeps moisture out of equipment limiting corrosion. The cleanliness of the building also keeps contaminates out of equipment preventing arcing and tracking in the electrical equipment causing equipment failures.

Lighting
The lighting system is functioning normally, and there are no apparent immediate wholesale repair needs. Lighting levels are below recommended levels at printing stations. Light fixtures are mature, and appear to be at the point where components are reaching end of life and needing frequent replacement. See Audit discussion below.

Dock Levelers

The load dock levelers (photograph 03/EE-2) are powered at 480volts 3-phase power. The dock leveler controllers (photograph 04/EE-2) are located inside the building next to each respective rollup door. Electrically the dock levelers are functional except for the North load dock, where power is disconnected, and it was not possible to verify if the dock leveler was functional. See related report by Industrial Hydraulics in Appendix B.

C. AUDIT

Review

The University Mechanical 11/27/2012 Investment Grade Audit for the State Modular Building Energy Upgrades' sole electrical consideration was the building interior lighting system. It discussed only possible energy reduction measures. It did not include any review of lighting levels, glare, color rendering, or other light quality or maintainability considerations. The audit proposed lighting retrofits or replacements for 1,199 fixtures out of 1,254 fixtures. The audit proposed adding 7 new occupancy controls. The audit identified $4,383 design cost, $87,650 construction cost, $13,500 utility energy rebate, and a $6,543 annual savings in energy use and operational savings. No defect was found in our review of the Audit costs identified, for the time they were issued.

QUANTITY: 1,199 replaced or retrofitted fixtures,
7 occupancy sensors

COSTS: $4,383 design cost
$87,650 construction cost
($13,500) utility energy rebate
($6,543) annual savings

Update

The audit recommendations were not examined exhaustively in the field. It appears some the recommendations have already been implemented such as replacement of mercury-vapor lighting in lobby areas with compact fluorescent. The U.S. Inflation Rate has increased by 4.2% between 2012 and 2016. The 2012 Washington State Energy Code went into effect in July 2013, and its requirements were not reflected in the Audit costs. The 2015 Washington State Energy Code is scheduled to be in effect as of July 1, 2016, and is assumed applicable to any lighting work proposed. The Energy Code updates compel implementation of more lighting controls and attendant design than were included in the Audit. The 2016 update decreases the allowed energy use for lighting by approximately 20%, making LED fixtures the only viable solution for some applications. The Energy Code requirements dilute the potential utility rebate, since the utility will only pay for energy efficiency measures above and beyond what the Energy Code compels. .

QUANTITY: 1,199 replaced or retrofitted fixtures,
Whole building lighting control system per Code

COSTS: $32,000 design cost
$212,000 construction cost
($7,000) utility energy rebate
($7,500) annual savings

The approach taken in the Audit was directed purely at lighting changes to achieve energy savings that resulted in a 9.8 year simple payback. An alternative lighting design approach is one driven by operational needs - insuring appropriate lighting levels and quality are provided for the tasks performed. This design approach includes lighting measurements and calculations. Minimizing the energy use and construction cost is a secondary consideration. Cost estimating for this traditional design approach typically includes capital costs, and life-cycle costs when identified in the project scope. The lighting industry is shifting more and more to LED fixtures. Life-cycle cost evaluation typically finds that LED fixtures are a more appropriate solution in occupied facilities (~ 40 hrs/week). Fluorescent fixtures still are utilized, but are pretty much relegated to seldom used spaces such as storage closets where there isn't enough usage of the lighting to achieve payback of the additional cost for an LED solution.

D. CONSTRUCTION

Existing Drawings
Drawings were obtained from the Owner for most of the building elements. However, some minor building components do not appear on the available drawings.

Changes Required by Current Electrical Codes
Our inspection supports an assessment that the lighting and power distribution systems are be compliant with the Code in effect at the time of installation. As such, these systems are 'grand-fathered' and are not required to be updated to meet current Code requirements. The factors which would trigger Code related updates are changes in use or occupancy of the building, and modification of the lighting or power distribution systems. The extent of Code required upgrades would depend on the good judgment of the engineer, the electrician, and the electrical inspector.

Any major remodel or re-lamping and re-ballasting will trigger current Washington State Energy Code and the modified lighting system would need to be brought into compliance with current energy limits and control requirements for lighting.

E. RECOMMENDATIONS

Preventive Maintenance
Perform regular maintenance of electrical equipment in accordance with NEMA, NFPA 70B, or other industry standard, to include annual infrared scanning (imaging) be done to locate any hot spots caused by loose connections, overloads, or dirty contacts in circuit breakers or fused switches. Regular maintenance of equipment ensures reliable facility operation, protects personnel and equipment from catastrophic failure of deteriorated equipment, and eliminates owner liability for preventable accidents.
Cost: $ 2,400/Year
Priority Level: 3

Power Distribution
Wholesale replacement of the building power distribution system is not warranted at this time. The system is expected to provide relatively trouble-free operation for at least the next five years with regular maintenance. As the system exceeds its design life, component repair and replacement needs will become more common. At some point the cost/benefit of continuing with spot repairs and declining reliability versus system replacement will motivate a building-wide refurbishment of the electrical distribution system.
Cost: $ 572,880
Priority Level: 5

Lighting
The recommended approach, depends on the objective. Three different recommendations are provided below to suit different objectives.

1 - Continue to maintain the existing lighting system on an as-needed basis. This is the least capital cost solution, and is appropriate for a maintenance-only budget, with a financial outlook of 10 years or less. Costs will be similar to those currently experienced in the facility.

OPTION 1 COST: $54,000 annual maintenance (parts and labor)

2 – Perform an ESCO type lighting upgrade focused on retrofit or replacement of existing fixtures with lower wattage alternatives with a reasonable cost/benefit payback period. This would be an updated version of the 2012 Audit approach. Due to Code compelled increases in the controls and design costs, simple payback for this alternative is estimated at 12 years. Costs are noted in the Audit – Update section above.

OPTION 2 COST: $229,500 net, see Audit Update for details

3 – Perform a complete building lighting system replacement with full design. This is a best management approach for a facility whose operation is expected to continue for the next 20 years or more. It ensures appropriate lighting for all the building operations, and replaces the existing lighting system, which is at the end of its design life. This is a capital equipment/building renovation project that it is not feasible under a maintenance budget that has limited dollars and many building systems to maintain.

OPTION 3 COST: $344,000

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME PERSONALLY, AND THAT I AM A DULY REGISTERED ENGINEER IN THE STATE OF WASHINGTON.

Elect Rm 704 - Main Switchboard 2500Amps
PHOTOGRAPH 01

Elect Rm 704 – Switchboard ‘HA’ 800Amps
PHOTOGRAPH 02

MODULAR BUILDING ASSESSMENT

Electrical EE-1

Load Dock Leveler
PHOTOGRAPH 03

Load Dock Leveler Controller
PHOTOGRAPH 04

6 Cost Estimate

Modular Building Building Assessment Cost Matrix

Project No. 2016-286

ROEN ASSOCIATES | EHM

		PRIORITY LEVEL				
		1 - Critical Life Safety Issue	2 - Critical Issue	3 - Significant Issue	4 - Moderate Issue	5 - Minor Maintenance
2	**Architectural**					
	Repair Damaged Insulated Panels		$8,290			
	Paint Insulated Panels			$150,647		
	Replace Failing Panel Seals		$46,665			
	Repair Dock Levelers	$6,760				
	Replace Overhead Rolling Doors		$65,435			
	Replace Inoperable Dock Levelers		$11,194			
	Remediate Parking Lot Drainage					$580,849
	Replace Aging Roof System			$1,961,441		
	Modify Ramps at Entry	$2,518				
	Replace Guardrail at Entry	$11,897				
	Modify Path of Travel at Entry	$793				
	Replace Noncompliant Ship's Ladders	$18,507				
3	**Mechanical**					
	Increase Minimum Outside Air Settings	$6,750				
	Replace AHU / Ductwork			$1,000,927		
	Backflow Prevention at Humidification System		$4,500			
	Wind/Rain Protection at AHU	$11,250				
	Check Controls Programming for False Alarms		$7,500			
	Replace Cooling Tower/Piping/Fittings/Seals	$841,896				
	Replace Pneumatic Actuators with Electric		$27,000			
	Assess Chiller Capacitors			$7,500		
	Replace Ductwork in Low Bay			$411,262		
	Adjust Controls Programming			$30,000		
	Install Cleanouts on Main Sewer Lines/Laterals				$2,400	
	Insulate All Roof Drains				$5,625	
	Reline Waste Piping to Eliminate Infiltrations				$33,750	
	Re-grade Twenty Foot Section of piping within the Low Bay section of the building				$26,400	
	Hydro jet the waste piping				$69,300	
	Replace hydronic heating boilers (2 boilers)		$212,626			
4	**Structural**					
	Parapet Extension		$322,529			
	Cooling Tower Fall Restraint			$0		
	Mezzanine Load Posting			$1,200		
	Storage Rack Load Posting			$1,200		
	Replace Seismic Joint		$44,994			
	Obtain Geotechnical Report		$20,000			
	Retrofit Braced Frames		$283,589			
	Address Vertical Irregularity of Brace		$23,284			
5	**Electrical**					
	Continue to Maintain Existing Lighting				$54,000	
	Esco Lighting Upgrade			$229,500		
	Complete Lighting Upgrade			$344,000		
	Preventive Maintenance			$2400 per year		
	Replace Power Distribution Systems					$572,880
	TOTAL	**$900,371**	**$1,077,606**	**$4,137,677**	**$191,475**	**$1,153,729**

Qualifications on Pricing

Pricing includes Construction Costs only, and excludes all Soft Costs (Design, Sales Tax, Furnishings, Impact Fees).

Pricing Include applicable General Conditions, Supervision, Fee, Escalation in all all items

Contractor Markup/FEE/General Conditions change per item based on whether project is handled by prime subcontractor or managed by General Contractor

7 Appendix

Appendix A - Roof Inspection Report

7A

Inspection Report

Facility: Modular Building High Bay

Address: 7580 New Market Street,
Tumwater, WA 98501

Customer: Department of Enterprise Services

Address: PO Box 41475,
Olympia, WA 98504

Prepared By:

Wayne's Roofing Inc.
13105 Houston Rd. E.,
Sumner, Washington 98390-9208

Tel: (253) 863-4455   **Fax:** (253) 863-8311

www.waynesroofing.com

Inspection Date: Friday, September 18, 2015

Roof Condition Summary

Building	Roof	SF	Roof System	Condition Rating
Imported Roofs	A -	170	White - PVC	Fair
Imported Roofs	B	304	White - PVC	Fair
Imported Roofs	C	885	White - PVC	Fair
Imported Roofs	D	1,202	White - PVC	Fair
Imported Roofs	E	3,147	Standing Seam - Metal	Fair
Imported Roofs	Bay	57,840	White - PVC	Fair
Imported Roofs	Bay	38,104	White -PVC	Fair

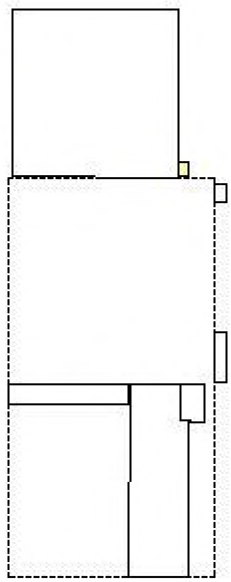
Inspection Report

Department of Enterprise Services, Tumwater, WA

Work Order #: 35198

Inspection Date: 10:30:00 AM

Roof: A -   Building: Imported Roofs



Roof System: White - PVC

Install Date: 1998 - Estimated

Roof Deck: Metal

Roof SF: 170

Elevation: 15'

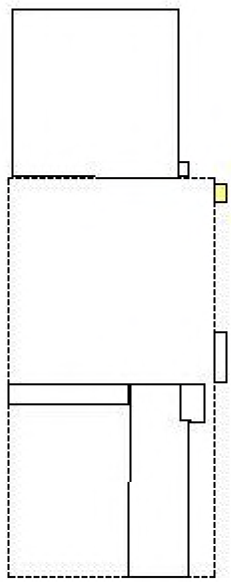
Interior Sensitivity: 0 - None

Warranty:

Condition Assessment: 50 - Fair

Roofs in fair condition. Minor debris were noted at this time. No visual problems noted during our inspection.

Roof: B Building: Imported Roofs



Roof System:	White - PVC
Install Date:	1998 - Estimated
Roof Deck:	Metal
Roof SF:	304
Elevation:	15'
Interior Sensitivity:	0 - None
Warranty:	

Condition Assessment: 50 - Fair

Roofs in fair condition. No visual problems noted during our inspection.

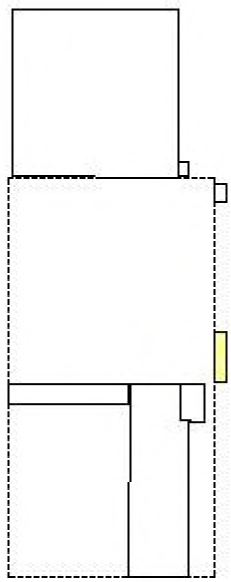
Inspection Report

Department of Enterprise Services, Tumwater, WA

Work Order #: 35198

Inspection Date: 10:30:00 AM

Roof: C | **Building: Imported Roofs**

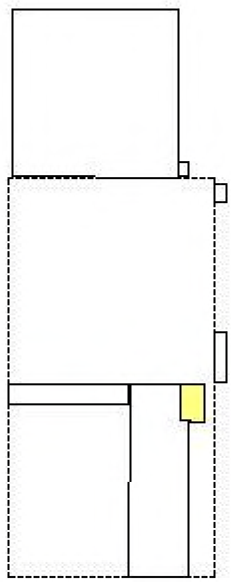


Roof System:	White - PVC
Install Date:	1998 - Estimated
Roof Deck:	Metal
Roof SF:	885
Elevation:	18'
Interior Sensitivity:	0 - None
Warranty:	

Condition Assessment: 50 - Fair

Roofs in fair condition. No visual problems noted during our inspection.

Roof: D | **Building: Imported Roofs**



Roof System:	White - PVC
Install Date:	1998 - Estimated
Roof Deck:	Metal
Roof SF:	1,202
Elevation:	18'
Interior Sensitivity:	0 - None
Warranty:	

Condition Assessment: 50 - Fair

Roofs in fair condition. No visual problems noted during our inspection.

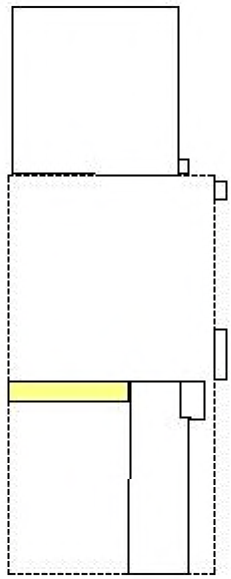
Inspection Report

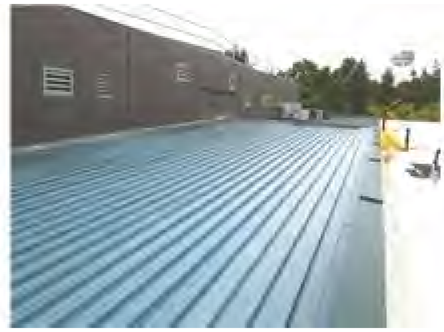
Department of Enterprise Services, Tumwater, WA

Work Order #: 35198

Inspection Date: 10:30:00 AM

Roof: E | Building: Imported Roofs



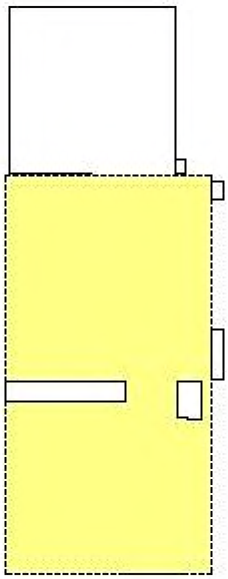


Roof System:	Standing Seam - Metal
Install Date:	- Unknown
Roof Deck:	Plywood
Roof SF:	3,147
Elevation:	30'
Interior Sensitivity:	2 - Medium
Warranty:	

Condition Assessment: 50 - Fair

Roofs in fair condition. No visual problems noted during our inspection.

Roof: Modular - High Bay | **Building: Imported Roofs**



Roof System:	White - PVC
Install Date:	1998 - Estimated
Roof Deck:	Unknown
Roof SF:	57,840
Elevation:	32'
Interior Sensitivity:	2 - Medium
Warranty:	

Condition Assessment: 50 - Fair

Roofs in fair condition at this time.

Condition: 004- Debris on roof
Severity: 2 - Secondary Repair
Qty: SF: 1 LF: 4 EA: 1

Minor debris noted around the drainage areas. Drainage areas should always be keeped clear for proper drainage of the roof.

Condition: EG - 204 - Condensation Lines
Severity: 2 - Secondary Repair
Qty: SF: 1 LF: 4 EA: 1

The condensation lines are lying directly on the roof surface. This detail could cause the PVC line to rub through the field membrane with back and forth movement. Recommend lifting and supporting the PVC lines up off of the roof surface. (2 locations - approximately 150 LF each)

Condition: EG-224 - Improper Installation

Severity: 2 - Secondary Repair

Qty: SF: 1 LF: 4 EA: 1

Current access stairs installed on this roof section should have a protection walkpad installed to protect the field membrane from wear. (3'x5' walkpad)

Condition: F-112 Field Membrane- temporary repair

Severity: 2 - Secondary Repair

Qty: SF: 1 LF: 4 EA: 1

The patch currently installed is designed to be temporary. A permanent repair is recommended as soon as possible.

Condition: PP-152 Penetration - Sealant failure

Severity: 2 - Secondary Repair

Qty: SF: 1 LF: 4 EA: 1

During our inspection we noted the caulking at this penetration is failing and needs to be resealled.

Condition: PP-152 Pitch Pan- Sealant failure

Severity: 2 - Secondary Repair

Qty: SF: 1 LF: 4 EA: 1

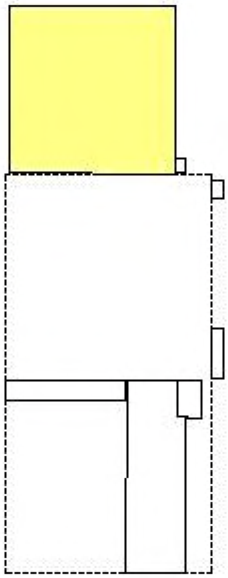
Sealant should be removed and replaced to prevent water entry.

006

Condition: 006- Ponding
Severity: 1 - Monitor
Qty: SF: 2 LF: 8 EA: 2

Ponding can add weight to the roof, and can cause many undesirable problems. If the roof membrane is damaged in a ponded area, the water may drain into the roof system and potentially into the building. We will continue to monitor these areas for any potential problems.

Roof: Modular - Low Bay | Building: Imported Roofs



Roof System:	White -PVC
Install Date:	1998 - Estimated
Roof Deck:	Unknown
Roof SF:	38,104
Elevation:	25'
Interior Sensitivity:	2 - Medium
Warranty:	

Condition Assessment: 50 - Fair

Roofs in fair condition.

Condition:	F-100 Field Membrane- deteriorated		
Severity:	3 - Immediate Action		
Qty:	SF: 25	LF: 24	EA: 2

The roof membrane is deteriorated and should be replaced to avoid further degradation and the potential for leaks. Approximately a 4'x8' section.

Condition:	D-206 Drain- vegetation build up		
Severity:	2 - Secondary Repair		
Qty:	SF: 1	LF: 4	EA: 1

Minor debris noted around the drainage areas. Drainage areas should always be keeped clear for proper drainage of the roof.

Condition: 026 - Staining
Severity: 1 - Monitor
Qty: SF: 2 LF: 8 EA: 2

Membrane is stained from natural weathering.

Condition: EG - 212 - New Equipment
Severity: 1 - Monitor
Qty: SF: 3 LF: 12 EA: 3

New Equipment, perimeter tie-in at new membrane flashings appear to have been stripped in using PS tape & sealant instead of heat welding the details?

Appendix B - Dock Leveler Report

7B

INDUSTRIAL Hydraulics Inc.

Aberdeen *Chehalis* *Tumwater*
(360) 533-7070 *(360) 748-7878* *(360) 956-7070*

Ehm Architecture / Washington State Department of Enterprise Services

Assessment and recommendations for dock leveler hydraulic systems at Department of Printing and Imaging

To: Randal Ehm

From: Brady Sweeney

Phone: Office 206-763-1481 Ext 306
Cell 206-719-0771

Email: randal@ehmarch.com **Date:** 5-10-16

Leveler #1: This system had an electrical problem when we were on site so we were unable to run it to get a look at the system under the platform. From the looks of the platform and the concrete, this system is an original and has not been updated. We are unable to provide an assessment at this time.

Leveler #2: This system also seems to be original. When we ran the system the pump was cavitating at the end of the stroke. We observed oil on the exterior of the tube for the main lift cylinder which indicates a leak that has diminished the oil level in the reservoir, causing the cavitation. In order to remedy this leak the main cylinder would need to be removed and brought into the shop to be rebuilt. The rebuild of the cylinder can vary greatly from a basic hone, polish and repack to a more extensive rebuild including machining new parts as needed. This system also lacks a brace to hold the platform up during maintenance.

Estimate For Repair $3200.00

Includes

Remove, basic rebuild, and reinstall cylinder
Fabricating support brace
Basic cleaning and inspection, and top-off hydraulic fluid

*Any repairs or machining of parts for the main cylinder beyond a basic reseal would have to be quoted upon tear down. Any worn parts found upon further inspection would be quoted at that time (including bad hoses and fittings)

Leveler #3: This system looks newer than the first two and looks to be in good working order upon the initial inspection.

Estimate For Repair $400.00

<u>Includes</u>

Basic cleaning and inspection

*Any worn parts found upon further inspection would be quoted at that time (including bad hoses and fittings).

<u>Leveler #4:</u> This system also looks newer than the first two. Upon initial inspection there did not seem to be any apparent leaks. The main cylinder lifts the platform fine but the small cylinder to lift the lip does not extend. The lip cylinder is controlled by a sequence valve that is supposed to open when the main cylinder reaches the end of its stroke and the set pressure is reached. The lack of this function working could be caused by something as simple as the pressure setting being wrong on the sequence valve or by a bad sequence cartridge. We would need to trouble shoot the system further to find the cause of the problem.

Estimate For Repair $800.00

<u>Includes</u>

Basic cleaning and inspection

Trouble shoot issue with lip cylinder and adjust sequence valve

*If a bad sequence valve is found upon trouble shooting new parts would be quoted at that time. Any worn parts found upon further inspection would be quoted at that time (including bad hoses and fittings).

<u>Comments:</u> For the purpose of numbering, leveler #1 is the northernmost and #4 is the southernmost. Leveler #2 is the only one being used at this time so it should be the highest priority for repair.

As stated above these are estimates and only include the scope of work laid out. Any further repairs would be quoted upon further inspection.

7C

Appendix C - Cooling Tower Calculations

Reactions on the building by the cooling tower

I/ Loads on the cooling tower:

1. Dead load:

Total weight of the structure: $D \simeq 8{,}000$ lbs

2. Seismic load: Chapter 13 ASCE 7-10

Importance factor: $I_p = 1.0$

Amplification factor: $a_p = 2.5$

Response mod. factor: $R_p = 3.0$

$$\frac{z}{h} = 1$$

$$S_{DS} = 0.869$$

$$W_p = 8{,}000 \text{ lbs}$$

$$\Rightarrow F_p = \frac{0.4\, a_p\, S_{DS}\, W_p}{\left(\frac{R_p}{I_p}\right)} \left(1 + 2\frac{z}{h}\right)$$

$$= \frac{0.4 \cdot 2.5 \cdot 0.869 \cdot 8{,}000}{3.0}(1+2) = \underline{\underline{6952 \text{ lbs}}}$$

$$F_{p\,max} = 1.6\, S_{DS}\, I_p\, W_p = 1.6 \cdot 0.869 \cdot 1.0 \cdot 8{,}000 = 11{,}123.2 \text{ lbs}$$

$$F_{p\,min} = 0.3\, S_{DS}\, I_p\, W_p = 0.3 \cdot 0.869 \cdot 1.0 \cdot 8{,}000 = 2\,085.6 \text{ lbs}$$

Vertical component: $F_v = \pm 0.2\, S_{DS}\, W_p = \pm 0.2 \cdot 0.869 \cdot 8{,}000$
$= \underline{\underline{\pm 1\,390.4 \text{ lbs}}}$

USGS Design Maps Summary Report

User–Specified Input

Report Title Modular Building Assessment Project
Thu April 28, 2016 17:42:02 UTC

Building Code Reference Document 2012 International Building Code
(which utilizes USGS hazard data available in 2008)

Site Coordinates 46.97832°N, 122.9131°W

Site Soil Classification Site Class D – "Stiff Soil"

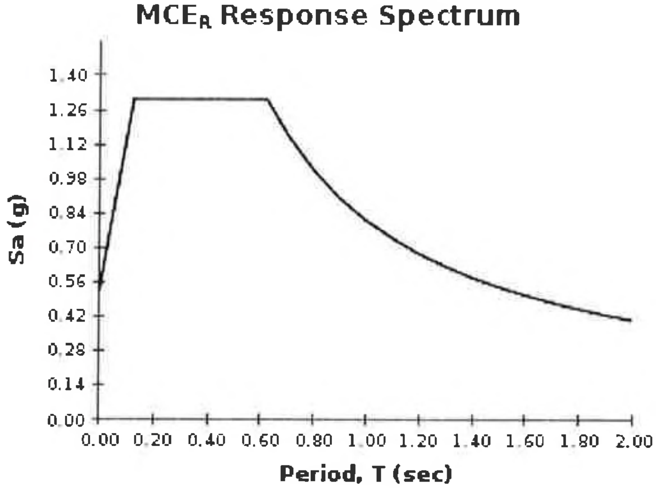
Risk Category I/II/III

USGS–Provided Output

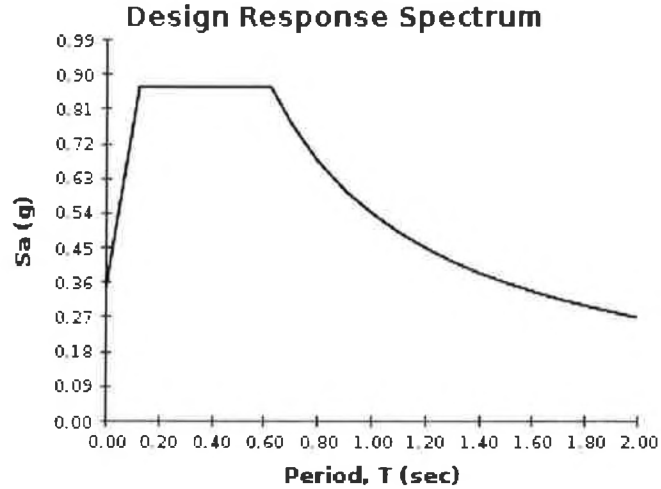
S_S =	1.303 g	S_{MS} =	1.303 g	S_{DS} =	0.869 g
S_1 =	0.540 g	S_{M1} =	0.809 g	S_{D1} =	0.540 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.

MCE_R Response Spectrum



Design Response Spectrum



3. Wind load: Chapter 25 Section 29.5 ASCE 7-10

Risk Category : II (of the building)

$\Rightarrow V_{ult} = 110$ mph

$K_d = 0.85$

Exposure Category C

$K_{zt} = 1.0$

$G = 0.85$

$K_h = 0.96$ ($h = 27.5$ ft)

$q_h = 0.00256 \, K_h K_{zt} K_d V^2$

$= 0.00256 \cdot 0.96 \cdot 1 \cdot 0.85 \cdot 110^2$

$= 25.3$ psf

$GC_r = 1.9$

$\Rightarrow$ Wind pressure on the cooling tower:

horizontal : $p_h = q_h (GC_r) = \underline{48 \text{ psf}}$

uplift : $p_{VL} = q_h (GC_r) = \underline{48 \text{ psf}}$

$$A_{f\,N\text{-}S} = \frac{(140'' \times 86'')}{12^2} = 83.6 \text{ ft}^2$$

$$A_{f\,E\text{-}W} = \frac{(140'' \times 108'')}{12^2} = 105 \text{ ft}^2$$

$$A_r = \frac{(86'' \times 108'')}{12^2} = 64.5 \text{ ft}^2$$

$\Rightarrow F_{h\,N\text{-}S} = 48 \cdot 83.6 = \underline{4013 \text{ (lbs)}}$

$F_{h\,E\text{-}W} = 48 \cdot 105 = \underline{5040 \text{ (lbs)}}$

$F_{VL} = 48 \cdot 64.5 = \underline{3096 \text{ (lbs)}}$

ATC
Applied Technology Council
WINDSPEED BY LOCATION

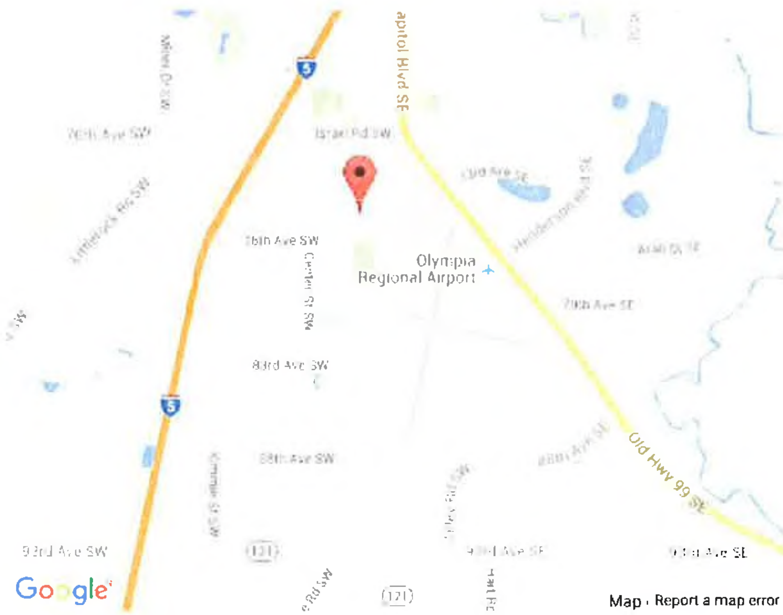
Search Results

Query Date: Thu Apr 28 2016
Latitude: 46.9791
Longitude: -122.9125

ASCE 7-10 Windspeeds
(3-sec peak gust in mph*):

Risk Category I: 100
Risk Category II: 110
Risk Category III-IV: 115
MRI 10-Year:** 72
MRI 25-Year:** 79
MRI 50-Year:** 85
MRI 100-Year:** 91

ASCE 7-05 Windspeed:
85 (3-sec peak gust in mph)
ASCE 7-93 Windspeed:
75 (fastest mile in mph)



*Miles per hour
**Mean Recurrence Interval

Users should consult with local building officials to determine if there are community-specific wind speed requirements that govern.

Print your results

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II/ Structural Analysis:

Load Combinations:

1. $1.4\ D$
2. $(1.2 + 0.2\ S_{DS})\ D + E$
3. $(0.9 - 0.2\ S_{DS})\ D + E$
4. $0.9D + W$

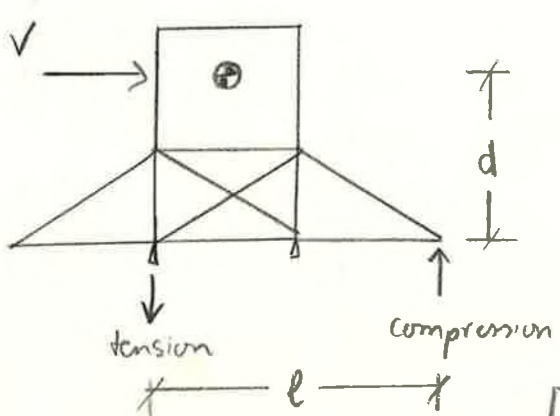
Vertical load analysis:

Based on the configuration of the supporting structure for the cooling tower, all the vertical load will be resisted by the round pipes @ the 4 corners.

Assume a vertical force P acting on the structure, @ the base of each round pipe, the reaction is $\boxed{R = \frac{P}{4}}$

Lateral load analysis:

Based on the configuration of the supporting structure for the cooling tower, when a seismic force is applied to the tower, the whole structure will rotate about one of the steel pipe.



Assume a lateral force V acting @ the centroid of the cooling tower. the shear force on each steel pipe is $\boxed{\frac{V}{4}}$

Tensile force @ base of the pipe = compressive force @ base of the truss sp = $\boxed{R = \frac{V}{2} \cdot \frac{d}{\ell}}$

Lateral load analysis (Cont.):

- For V in N-S direction:

$\ell = 244''$ $d = 139''$

$\Rightarrow R = \frac{139}{244} \frac{V}{2} = 0.285V$

- For V in E-W direction:

$\ell = 182''$ $d = 139''$

$\Rightarrow R = \frac{139}{182} \frac{V}{2} = \underline{0.382\ V}$ control

★ Combination no. 1 : 1.4D

$\Rightarrow P = 1.4 \cdot 8{,}000 = 11{,}200$ lbs

$V = 0$

$\Rightarrow$ compression force @ the base of the pipe $= \frac{11{,}200}{4} = \underline{2{,}800\ lbs}$

shear force " $= 0$

★ Combination no 2: $(1.2 + 0.2 S_{DS})D + E$

$\Rightarrow P = (1.2 + 0.2 \cdot 0.869) \cdot 8{,}000 = 10{,}990$ lbs

$V = F_p = 6{,}952$ lbs

$\Rightarrow$ Compression force @ the base of the truss supports

$C = 0.382\ V = 0.382 \cdot 6{,}952 = \underline{2{,}656\ (lbs)}$

Tension force @ the base of the pipe:

$T = -\frac{P}{4} + 0.382\ V = -\frac{10{,}990}{4} + 0.382 \cdot 6{,}952 = \underline{-92\ (lbs)}$

no uplift

Combination no 2 : $(1.2 + 0.2 S_{DS}) D + \Omega_0 Q_E$

Shear force @ the base of the pipe :

$$S = \frac{V}{4} = \frac{6{,}952}{4} = 1{,}738 \text{ (lbs)}$$

★ Combination no. 3 : $(0.9 - 0.2 S_{DS}) D + \Omega_0 Q_E$:

$\Rightarrow P = (0.9 - 0.2 \cdot 0.869) \cdot 8{,}000 = 5766.4$ lbs

$V = F_p = 6{,}952$ lbs

$\Rightarrow$ Compression force @ the base of the truss supports:

$C = 0.382 \cdot V = 2{,}656$ (lbs)

Tension force @ the base of the pipe.

$$T = -\frac{P}{4} + 0.382 V = -\frac{5766.4}{4} + 0.382 \cdot 6{,}952 = 1214 \text{ (lbs)}$$

Shear force @ the base of the pipe

$$S = \frac{V}{4} = 1{,}738 \text{ (lbs)}$$

★ Combination no. 4 : $0.9D + 1.0W$:

$P = 0.9 \cdot 8{,}000 - 3096 = 4104$ (lbs)

$V = 5040$ (lbs)

$\Rightarrow$ Compression force @ the base of the truss supports:

$C = 0.382 \cdot V = 0.382 \cdot 5040 = 1925.3$ (lbs)

Tension force @ the base of the pipe.

$$T = -\frac{P}{4} + 0.382 V = -\frac{4104}{4} + 0.382 \cdot 5{,}040 = 899.3 \text{ (lbs)}$$

Shear force @ the base of the pipe :

$$S = \frac{V}{4} = \frac{5040}{4} = 1260 \text{ (lbs)}$$

Summary:

- **Steel pipes:**

  Max shear : $V_{max} = 1,738$ lbs (EQ controls)

  Max tension : $T_{max} = 1,214$ lbs (EQ controls)

  Max compression : $C_{max} = 2,800$ lbs (DL)

- **Supports of the truss:**

  Max compression : $C_{max} = 2,656$ lbs (EQ controls)

Appendix D - Mezzanine Storage Capacity Calculations

7D

Mezzanine Capacity evaluation

To evaluate the capacity of the mezzanine, we will evaluate each structural member one by one, and which one has the lowest capacity for Live load will be the controlling capacity of the whole structure:

1. Concrete on Metal deck.
2. Open web steel joist.
3. Steel beam (interior) W 24 x 84
4. Column.
5. Steel beam (Edge) W 21 X 50

1. Concrete on metal deck:

$2\frac{1}{2}$" normal weight concrete topping w/ W2.9XW2.9-6X6 W.W.F Reinf. over type "13-30" $1\frac{1}{2}$" deep 18 gauge metal deck.

spanning 4'-0"

Deck weight = 2.76 psf
Concrete weight = 36.25 psf } total deck weight = 39 psf

From ASCSD page 113:

Maximum Superimpose load for this deck is:

$1.6 L_{allowed} = 1358$ psf

$\Rightarrow L_{allowed} = 849$ psf

So, the capacity of the deck is **849psf** ✓

ASC STEEL DECK

BH-36 Composite Deck 4.4

4" Total Slab Depth

Normal Weight Concrete (145 pcf)

Concrete Volume 0.931yd^3/100ft^2

Maximum Unshored Span (in)

Gage	Single	Double	Triple
22	6' - 3"	6' - 8"	7' - 5"
20	7' - 6"	8' - 2"	8' - 10"
18	8' - 6"	10' - 1"	10' - 8"
16	9' - 2"	11' - 4"	11' - 4"

GA	Vertical Load Span (in)	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
22	ASD & LRFD - Superimposed Load, W (psf)															
	ASD, W/Ω	663	543	451	380	324	279	241	211	185	163	144	128	114	102	91
	LRFD, ϕW	1060	868	722	609	518	446	386	337	295	261	231	205	183	163	146
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Diaphragm Shear, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3124	3061	3008	2979	2939	2905	2875	2848	2825	2815	2795	2777	2761	2747	2733
	PAF Base Steel ≥ .25"	2809	2774	2745	2736	2714	2695	2678	2663	2649	2649	2637	2627	2618	2609	2602
	PAF Base Steel ≥ 0.125"	2784	2752	2724	2717	2696	2678	2662	2648	2636	2636	2625	2615	2607	2599	2591
	#12 Screw Base Steel ≥ .0385"	2762	2731	2705	2700	2680	2663	2648	2635	2623	2624	2614	2605	2596	2589	2582
	Concrete + Deck = 38.2 psf	I_{cr} = 25.4 in^4/ft						M_{no}/Ω = 27.1 kip-in/ft					V_n/Ω = 2.26 kip/ft			
	$(I_{cr}+I_u)/2$ = 39.42 in^4/ft	I_u = 53.4 in^4/ft						ϕM_{no} = 41.5 kip-in/ft					ϕV_n = 3.40 kip/ft			

GA	Vertical Load Span (in)	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
20	ASD & LRFD - Superimposed Load, W (psf)															
	ASD, W/Ω	780	640	533	450	384	331	287	251	221	195	173	155	138	124	112
	LRFD, ϕW	1248	1024	853	720	614	529	459	402	353	312	277	247	221	198	179
	L/360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRFD - Diaphragm Shear, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3273	3195	3130	3099	3050	3008	2971	2939	2910	2900	2876	2854	2834	2816	2799
	PAF Base Steel ≥ .25"	2888	2845	2810	2803	2776	2752	2731	2712	2696	2698	2684	2671	2659	2649	2639
	PAF Base Steel ≥ 0.125"	2859	2819	2785	2781	2755	2732	2713	2695	2680	2682	2669	2657	2646	2636	2627
	#12 Screw Base Steel ≥ .0385"	2834	2796	2765	2762	2737	2716	2697	2681	2666	2669	2657	2645	2635	2625	2617
	Concrete + Deck = 38.5 psf	I_{cr} = 28.8 in^4/ft						M_{no}/Ω = 31.7 kip-in/ft					V_n/Ω = 2.26 kip/ft			
	$(I_{cr}+I_u)/2$ = 42 in^4/ft	I_u = 55.2 in^4/ft						ϕM_{no} = 48.5 kip-in/ft					ϕV_n = 3.40 kip/ft			

GA	Vertical Load Span (in)	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
18	ASD & LRFD - Superimposed Load, W (psf)															
	ASD, W/Ω	906	814	680	575	491	424	369	324	286	253	217	187	163	143	126
	LRFD, ϕW	1358	1235	1087	919	786	679	591	518	457	405	361	323	290	262	237
	L/360	-	-	-	-	-	-	-	-	-	253	217	187	163	143	126
	LRFD - Diaphragm Shear, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3581	3474	3385	3352	3284	3226	3174	3129	3089	3082	3048	3017	2990	2964	2941
	PAF Base Steel ≥ .25"	3053	2995	2945	2946	2907	2874	2845	2819	2796	2804	2784	2766	2750	2735	2721
	PAF Base Steel ≥ 0.125"	3015	2960	2913	2916	2880	2848	2821	2796	2774	2784	2765	2748	2732	2718	2705
	#12 Screw Base Steel ≥ .0385"	2988	2935	2891	2896	2861	2831	2804	2780	2760	2770	2752	2735	2720	2706	2694
	Concrete + Deck = 39.8 psf	I_{cr} = 34.6 in^4/ft						M_{no}/Ω = 40.0 kip-in/ft					V_n/Ω = 2.26 kip/ft			
	$(I_{cr}+I_u)/2$ = 46.4 in^4/ft	I_u = 58.2 in^4/ft						ϕM_{no} = 61.3 kip-in/ft					ϕV_n = 3.40 kip/ft			

GA	Vertical Load Span (in)	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
16	ASD & LRFD - Superimposed Load, W (psf)															
	ASD, W/Ω	906	823	755	695	595	514	448	384	323	275	236	204	177	155	136
	LRFD, ϕW	1358	1235	1132	1045	952	823	717	630	557	495	442	396	357	323	292
	L/360	-	-	-	-	-	-	-	384	323	275	236	204	177	155	136
	LRFD - Diaphragm Shear, ϕS_n (plf / ft) 36/4 Attachment Pattern															
	Arc Spot Weld 1/2" Effective Dia	3910	3772	3657	3626	3538	3461	3395	3336	3283	3282	3237	3197	3161	3127	3097
	PAF Base Steel ≥ .25"	3230	3154	3091	3103	3053	3009	2970	2936	2906	2924	2898	2874	2852	2832	2814
	PAF Base Steel ≥ 0.125"	3157	3087	3029	3046	3000	2959	2924	2893	2865	2885	2861	2839	2818	2800	2783
	#12 Screw Base Steel ≥ .0385"	3169	3100	3042	3059	3012	2972	2936	2905	2877	2898	2873	2851	2830	2812	2795
	Concrete + Deck = 39.2 psf	I_{cr} = 39.8 in^4/ft						M_{no}/Ω = 48.0 kip-in/ft					V_n/Ω = 2.26 kip/ft			
	$(I_{cr}+I_u)/2$ = 50.4 in^4/ft	I_u = 61.1 in^4/ft						ϕM_{no} = 73.5 kip-in/ft					ϕV_n = 3.40 kip/ft			

LRFD - Diaphragm Shear, ϕS_n (plf / ft) for all vertical load spans, WWF Designation or Area of Steel per foot width

All Gages	3/4" Welded Shear Studs	6x6 W1.4xW1.4 A_s = 0.028 in^2/ft	6x6 W2.9xW2.9 A_s = 0.058 in^2/ft	6x6 W4.0xW4.0 A_s = 0.080 in^2/ft	4x4 W4xW4 A_s = 0.120 in^2/ft	4x4 W6xW6 A_s = 0.180 in^2/ft
	6 in o.c.	3700	5050	6040	7840	10540
	12 in o.c.	3700	5050	6040	7840	10540
	18 in o.c.	3700	5050	6040	7840	8790

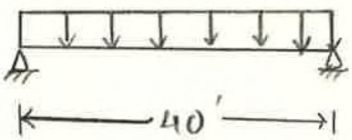
B PANELS

2. <u>Open-web Steel joist:</u>

28 LH 12 steel joist @ 4'-0" O.C

spanning 40'.

Approximate weight 27 plf



$\Rightarrow D = 27\ plf + 39\ psf \cdot 4' = 143\ plf$

$1.2D = 171.6\ plf$

<u>Strength capacity:</u> $1.6L = 1105 - 171.6 = 933.4\ (plf)$

(SJI page 113)

$\Rightarrow L_{allowed} = \dfrac{933.4}{1.6} = 583\ (plf)$

$\Rightarrow W_{LL\ allowed} = \dfrac{583}{4} = \underline{145\ psf}$ for 50ksi steel

$= \underline{104\ psf}$ for 36ksi steel

<u>Deflection capacity:</u> $L_{allowed} = 408 \cdot \dfrac{360}{240} - 143 = 469\ (plf)$

$\left(\begin{array}{c} \Delta \le L/240 \\ \text{for } D+L \end{array}\right)$

$\Rightarrow W_{LL\ allowed} = \dfrac{469}{4} = \underline{117\ psf}$

$\left(\begin{array}{c} \Delta \le L/360 \\ \text{for } L \text{ only} \end{array}\right)$ $L_{allowed} = 408\ plf$

$\Rightarrow W_{LL\ allowed} = \dfrac{408}{4} = \underline{102\ psf}$ controls

So the capacity of the steel joist is <u>102 psf</u>

STANDARD LRFD LOAD TABLE

LONGSPAN STEEL JOISTS, LH-SERIES

Based on a 50 ksi Maximum Yield Strength
Adopted by the Steel Joist Institute May 1, 2000
Revised to May 18, 2010 – Effective December 31, 2010

The **BLACK** figures in the Load Table give the TOTAL safe factored uniformly distributed load-carrying capacities, in pounds per linear foot, of **LRFD** **LH**-Series Steel Joists.

The approximate joist weights, in pounds per linear foot, given in the Load Table may be added to the other building weights to determine the unfactored DEAD load. In all cases the factored DEAD load, including the joist self-weight, must be deducted from the TOTAL load to determine the factored LIVE load. The approximate joist weights do not include accessories.

The RED figures in the Load Table represent the unfactored, uniform load, in pounds per linear foot, which will produce an approximate joist deflection of 1/360 of the span. This load can be linearly prorated to obtain the unfactored, uniform load for supplementary deflection criteria (i.e. an unfactored uniform load which will produce a joist deflection of 1/240 of the span may be obtained by multiplying the RED figures by 360/240). In no case shall the prorated, unfactored load exceed the unfactored TOTAL load-carrying capacity of the joist as given in the Standard ASD Load Table for Longspan Steel Joists, **LH**-Series.

The Load Table applies to joists with either parallel chords or pitched top chords. Joists can have a top chord pitch up to 1/2 inch per foot. If the pitch exceeds this limit, the Load Table does not apply. When top chords are pitched, the load-carrying capacities are determined by the nominal depth of the joists at the center of the span. Sloped parallel-chord joists shall use span as defined by the length along the slope.

Where the joist span is in the RED **SHADED** area of the Load Table, the row of bridging nearest the mid span shall be diagonal bridging with bolted connections at chords and intersections. Hoisting cables shall not be released until this row of bolted diagonal bridging is completely installed. The RED **SHADED** area extends up through 60'–0".

Where the joist span is in the **BLUE** **SHADED** area of the Load Table, all rows of bridging shall be diagonal bridging with bolted connections at chords and intersections. Hoisting cables shall not be released until the two rows of bridging nearest the third points are completely installed. The **BLUE** **SHADED** area starts after 60'–0" and extends up through 100'–0".

The approximate gross moment of inertia (not adjusted for shear deformation), in inches^4, of a standard joist listed in the Load Table may be determined as follows:

$I_j = 26.767(W)(L^3)(10^{-6})$, where W= RED figure in the Load Table, and
L = (span – 0.33) in feet.

Loads for span increments not explicitly given in the Load Table may be determined using linear interpolation between the load values given in adjacent span columns.

*The safe factored uniform load for the spans shown in the SAFE LOAD Column is equal to (SAFE LOAD) / (span). The TOTAL safe factored uniformly distributed load-carrying capacity, for spans less than those shown in the SAFE LOAD Column are given in the MAX LOAD Column.

To solve for an unfactored RED figure for spans shown in the SAFE LOAD Column (or lesser spans), multiply the unfactored RED figure of the shortest span shown in the Load Table by (the shortest span shown in the Load Table – 0.33 feet)^2 and divide by (the actual span – 0.33 feet)^2. In no case shall the calculated unfactored load exceed the unfactored TOTAL load-carrying capacity of the joist as determined from the Standard ASD Load Table for Longspan Steel Joists, **LH**-Series.

LRFD

STANDARD LOAD TABLE FOR LONGSPAN STEEL JOISTS, LH-SERIES

Based on a 50 ksi Maximum Yield Strength - Loads Shown In Pounds Per Linear Foot (plf)

Joist Designation	Approx. Wt in Lbs. Per Linear Ft. (Joists only)	Depth in inches	Max Load (plf)	SAFELOAD* in Lbs. Between		SPAN IN FEET														
			< 29	29-33		34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
24LH03	11	24	601	17430		513 235	508 226	504 218	484 204	460 188	439 175	418 162	400 152	382 141	366 132	351 124	336 116	322 109	310 102	296 96
24LH04	12	24	737	21360		628 288	597 265	568 246	540 227	514 210	490 195	468 182	447 169	427 158	409 148	393 138	376 130	361 122	346 114	333 107
24LH05	13	24	789	22890		673 309	669 297	660 285	628 264	598 244	570 226	544 210	520 195	496 182	475 171	456 160	436 150	420 141	493 132	387 124
24LH06	16	24	1061	30780		906 411	868 382	832 356	795 331	756 306	720 284	685 263	655 245	625 228	598 211	571 197	546 184	522 172	501 161	480 152
24LH07	17	24	1166	33810		997 452	957 421	919 393	882 367	847 341	811 320	774 297	736 276	702 257	669 239	639 223	610 208	583 195	559 182	535 171
24LH08	18	24	1243	36060		1060 460	1015 447	973 416	933 388	895 362	858 338	817 314	780 292	745 272	712 254	682 238	652 222	625 208	600 195	576 184
24LH09	21	24	1464	42450		1248 552	1212 530	1177 501	1146 460	1096 424	1044 392	994 363	948 337	903 313	861 292	822 272	786 254	751 238	720 223	690 209
24LH10	23	24	1547	44850		1323 596	1284 559	1248 528	1213 500	1182 474	1152 439	1105 406	1053 378	1002 351	955 326	912 304	873 285	834 266	799 249	766 234
24LH11	25	24	1630	47280		1390 624	1350 593	1312 555	1276 523	1243 498	1210 472	1180 449	1152 418	1101 388	1051 361	1006 337	963 315	924 294	885 276	850 259
			< 34	34-41		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
28LH05	13	28	623	21180		505 219	484 205	465 192	445 180	429 169	412 159	397 150	382 142	367 133	355 126	342 119	330 113	319 107	309 102	298 97
28LH06	16	28	828	28140		672 289	643 270	618 253	592 238	568 223	546 209	525 197	505 186	486 175	469 165	451 156	436 148	421 140	406 133	393 126
28LH07	17	28	934	31770		757 326	726 305	696 285	667 267	640 251	615 236	591 222	568 209	547 197	528 186	508 76	490 166	474 158	457 150	442 142
28LH08	18	28	1001	34020		810 348	775 325	744 305	712 285	684 268	657 252	630 236	604 222	580 209	556 196	535 185	516 175	496 165	478 155	462 148
28LH09	21	28	1232	41880		1000 422	958 400	918 375	879 351	844 329	810 309	778 291	748 274	721 258	694 243	669 228	645 216	622 204	601 193	580 183
28LH10	23	28	1347	45810		1093 466	1056 439	1018 414	976 388	937 364	900 342	864 322	831 303	799 285	769 269	742 255	715 241	690 225	666 215	643 204
28LH11	25	28	1445	49140		1170 498	1143 475	1104 448	1066 423	1023 397	982 373	943 351	907 331	873 312	841 294	810 278	781 263	753 249	727 236	702 223
28LH12	27	28	1587	53970		1285 545	1255 520	1227 490	1200 476	1173 454	1149 435	1105 405	1063 383	1023 361	984 340	946 321	913 303	880 285	849 270	819 256
28LH13	30	28	1654	56250		1342 569	1311 543	1281 513	1252 495	1224 472	1198 452	1173 433	1149 415	1126 396	1083 379	1041 352	1002 332	964 314	930 297	897 281
			< 39	39-46	47-49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
32LH06	14	32	647	25230	25230	507 211	489 189	472 169	455 179	441 163	426 161	412 153	399 145	385 136	373 131	363 125	351 119	340 113	330 108	321 104
32LH07	16	32	728	28380	28380	568 225	549 223	529 211	511 200	493 189	477 178	462 170	447 162	432 154	418 146	406 140	393 133	381 127	370 121	360 116
32LH08	17	32	790	30810	30810	616 255	595 242	574 229	553 216	535 205	517 194	499 184	483 175	468 167	453 159	439 151	426 144	412 137	400 131	388 125
32LH09	21	32	992	38670	38670	774 319	747 302	720 285	694 270	670 256	648 243	627 230	606 219	586 208	568 198	550 189	534 180	517 172	502 164	487 157
32LH10	21	32	1096	42750	42750	856 352	825 332	796 315	768 297	742 282	717 267	693 254	667 240	645 228	624 217	603 206	583 196	564 186	546 178	529 169
32LH11	24	32	1201	46830	46830	937 385	903 363	870 343	840 325	811 306	783 292	757 277	732 263	709 251	687 239	664 227	643 216	624 206	604 196	585 187
32LH12	27	32	1409	54960	54960	1101 450	1068 428	1032 406	996 384	961 364	928 345	897 327	867 311	838 295	811 281	786 267	762 255	738 243	715 232	694 222
32LH13	30	32	1572	61320	61320	1225 500	1201 480	1177 461	1156 444	1113 420	1072 397	1035 376	999 354	964 336	931 319	900 304	871 289	843 275	816 262	790 249
32LH14	33	32	1618	63120	63120	1264 515	1239 495	1215 476	1192 455	1170 440	1149 417	1107 395	1069 374	1032 355	997 337	964 321	933 304	903 290	874 276	846 264
32LH15	35	32	1673	65250	65250	1305 532	1279 511	1255 492	1231 473	1207 454	1186 438	1164 422	1144 407	1125 393	1087 374	1051 355	1017 338	984 322	952 306	924 292
			< 43	43-46	47-56 57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
36LH07	16	36	590	25350	25350	438 177	424 168	411 160	399 152	387 146	376 140	366 134	355 128	345 122	336 117	327 112	318 107	310 103	301 99	294 95
36LH08	18	36	649	27900	27900	481 194	466 185	453 175	439 168	426 160	414 153	402 146	390 140	379 134	369 128	358 123	349 118	340 113	331 109	322 104
36LH09	21	36	832	35760	35760	616 247	597 235	579 224	561 214	544 204	528 195	513 186	499 178	484 171	471 163	459 157	445 150	433 144	423 138	412 133
36LH10	21	36	916	39390	39390	681 273	660 260	639 248	619 236	601 225	583 215	567 206	550 197	535 188	520 180	507 173	492 165	480 159	466 152	454 146
36LH11	23	36	1000	42990	42990	742 297	720 283	697 269	676 257	657 245	637 234	618 224	601 214	583 205	567 196	552 188	537 180	522 173	508 166	495 159
36LH12	25	36	1197	51450	51450	889 351	862 338	835 322	810 307	784 292	762 279	739 266	717 255	696 243	675 232	655 222	636 213	618 204	600 195	583 187
36LH13	30	36	1407	60510	60510	1045 415	1012 395	981 378	951 362	922 342	894 327	868 312	843 298	819 285	796 273	774 262	753 251	732 240	712 231	694 222
36LH14	36	36	1551	66690	66690	1152 455	1132 434	1093 412	1059 392	1024 372	991 354	961 337	931 323	903 309	876 295	850 283	826 270	802 259	780 247	757 237
36LH15	38	36	1635	70320	70320	1213 480	1192 464	1171 449	1153 434	1116 413	1081 394	1047 375	1015 358	984 342	955 327	927 312	900 299	874 286	850 274	826 263

STANDARD ASD LOAD TABLE

LONGSPAN STEEL JOISTS, LH-SERIES

Based on a 50 ksi Maximum Yield Strength
Adopted by the Steel Joist Institute May 25, 1983
Revised to May 18, 2010 – Effective December 31, 2010

The **BLACK** figures in the Load Table give the TOTAL safe uniformly distributed load-carrying capacities, in pounds per linear foot, of ASD **LH**-Series Steel Joists.

The approximate joist weights, in pounds per linear foot, given in the Load Table may be added to the other building weights to determine the DEAD load. In all cases the DEAD load, including the joist self-weight, must be deducted from the TOTAL load to determine the LIVE load. The approximate joist weights do not include accessories.

The RED figures in the Load Table represent the uniform load, in pounds per linear foot, which will produce an approximate joist deflection of 1/360 of the span. This load can be linearly prorated to obtain the uniform load for supplementary deflection criteria (i.e. a uniform load that will produce a joist deflection of 1/240 of the span may be obtained by multiplying the RED figures by 360/240). In no case shall the prorated load exceed the TOTAL load-carrying capacity of the joist.

The Load Table applies to joists with either parallel chords or pitched top chords. Joists can have a top chord pitch up to 1/2 inch per foot. If the pitch exceeds this limit, the Load Table does not apply. When top chords are pitched, the load-carrying capacities are determined by the nominal depth of the joists at the center of the span. Sloped parallel-chord joists shall use span as defined by the length along the slope.

Where the joist span is in the RED **SHADED** area of the Load Table, the row of bridging nearest the mid span shall be diagonal bridging with bolted connections at chords and intersections. Hoisting cables shall not be released until this row of bolted diagonal bridging is completely installed. The RED **SHADED** area extends up through 60'–0".

Where the joist span is in the **BLUE SHADED** area of the Load Table, all rows of bridging shall be diagonal bridging with bolted connections at chords and intersections. Hoisting cables shall not be released until the two rows of bridging nearest the third points are completely installed. The **BLUE SHADED** area starts after 60'–0" and extends up through 100'–0".

The approximate gross moment of inertia (not adjusted for shear deformation), in inches^4, of a standard joist listed in the Load Table may be determined as follows:

$I_j = 26.767(W)(L^3)(10^{-6})$, where W= RED figure in the Load Table, and
L = (span – 0.33) in feet.

Loads for span increments not explicitly given in the Load Table may be determined using linear interpolation between the load values given in adjacent span columns.

*The safe uniform load for the spans shown in the SAFE LOAD Column is equal to (SAFE LOAD) / (span). The TOTAL safe uniformly distributed load-carrying capacity, for spans less than those shown in the SAFE LOAD Column are given in the MAX LOAD Column.

To solve for a RED figure for spans shown in the SAFE LOAD Column (or lesser spans), multiply the RED figure of the shortest span shown in the Load Table by (the shortest span shown in the Load Table – 0.33 feet)^2 and divide by (the actual span – 0.33 feet)^2. In no case shall the calculated load exceed the TOTAL load-carrying capacity of the joist.

A S D

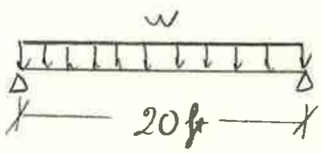
STANDARD LOAD TABLE FOR LONGSPAN STEEL JOISTS, LH-SERIES
Based on a 50 ksi Maximum Yield Strength - Loads Shown In Pounds Per Linear Foot (plf)

Joist Designation	Approx. Wt in Lbs. Per Linear Ft (Joists only)	Depth in inches	Max Load (plf)	SAFELOAD* in Lbs. Between			SPAN IN FEET														
			< 29	29-33			34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
24LH03	11	24	401	11620			342	339	336	323	307	293	279	267	255	244	234	224	215	207	199
							235	226	216	204	186	175	162	152	141	132	124	116	109	102	96
24LH04	12	24	491	14240			419	398	379	360	343	327	312	298	285	273	262	251	241	231	222
							288	265	246	227	210	195	182	169	158	148	138	130	122	114	107
24LH05	13	24	526	15260			449	446	440	419	399	380	363	347	331	317	304	291	280	269	258
							308	297	285	264	244	226	210	196	182	171	160	150	141	132	124
24LH06	16	24	708	20520			604	579	555	530	504	480	457	437	417	399	381	364	348	334	320
							411	382	356	331	306	284	263	245	228	211	197	184	172	161	152
24LH07	17	24	777	22540			665	638	613	588	565	541	516	491	468	446	426	407	389	373	357
							452	421	393	367	343	320	297	276	257	239	223	208	195	182	171
24LH08	18	24	829	24040			707	677	649	622	597	572	545	520	497	475	455	435	417	400	384
							480	447	416	388	362	338	314	292	272	254	238	222	208	196	184
24LH09	21	24	976	28300			832	808	785	764	731	696	663	632	602	574	548	524	501	480	460
							562	530	501	460	424	393	363	337	313	292	272	254	238	223	209
24LH10	23	24	1031	29900			882	856	832	809	788	768	737	702	668	637	608	582	556	533	511
							596	559	528	500	474	439	406	378	351	326	304	285	266	249	234
24LH11	25	24	1087	31520			927	900	875	851	829	807	787	768	734	701	671	642	616	590	567
							624	588	556	526	498	472	449	418	388	361	337	315	294	276	259
			< 34	34-41			42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
28LH05	13	28	415	14120			337	323	310	297	286	275	265	255	245	237	228	220	213	206	199
							219	205	192	180	169	159	150	142	133	126	119	113	107	102	97
28LH06	16	28	552	18760			448	429	412	395	379	364	350	337	324	313	301	291	281	271	262
							289	270	253	238	223	209	197	186	175	166	156	148	140	133	126
28LH07	17	28	623	21180			505	484	464	445	427	410	394	379	365	352	339	327	316	305	295
							326	305	285	267	251	236	222	209	197	186	176	166	158	150	142
28LH08	18	28	667	22680			540	517	496	475	456	438	420	403	387	371	357	344	331	319	306
							348	325	305	285	268	252	236	222	209	196	185	175	165	156	148
28LH09	21	28	821	27920			667	639	612	586	563	540	519	499	481	463	446	430	415	401	387
							428	400	375	351	329	309	291	274	258	243	228	216	204	193	183
28LH10	23	28	898	30540			729	704	679	651	625	600	576	554	533	513	495	477	460	444	429
							466	439	414	388	364	342	322	303	285	269	255	241	228	215	204
28LH11	25	28	964	32760			780	762	736	711	682	655	629	605	582	561	540	521	502	485	468
							493	475	448	423	397	373	351	331	312	294	278	263	249	236	223
28LH12	27	28	1058	35980			857	837	818	800	782	766	737	709	682	656	632	609	587	566	546
							545	520	496	476	454	435	408	383	361	340	321	303	285	270	256
28LH13	30	28	1103	37500			895	874	854	835	816	799	782	766	751	722	694	668	643	620	598
							569	543	518	495	472	452	433	415	396	373	352	332	314	297	281
			< 39	39-46	47-49		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
32LH06	14	32	431	16820	16820		338	326	315	304	294	284	275	266	257	249	242	234	227	220	214
							211	199	189	179	169	161	153	145	138	131	125	119	114	108	104
32LH07	16	32	485	18920	18920		379	366	353	341	329	318	308	298	288	279	271	262	254	247	240
							235	223	211	200	189	179	170	162	154	146	140	133	127	121	116
32LH08	17	32	527	20540	20540		411	397	383	369	357	345	333	322	312	302	293	284	275	267	259
							255	242	229	216	205	194	184	175	167	159	151	144	137	131	125
32LH09	21	32	661	25780	25780		516	498	480	463	447	432	418	404	391	379	367	356	345	335	325
							319	302	285	270	256	243	230	219	208	198	189	180	172	164	157
32LH10	21	32	731	28500	28500		571	550	531	512	495	478	462	445	430	416	402	389	376	364	353
							352	332	315	297	282	267	254	240	228	217	206	196	186	178	169
32LH11	24	32	801	31220	31220		625	602	580	560	541	522	505	488	473	458	443	429	416	403	390
							385	363	343	325	308	292	277	263	251	239	227	216	206	196	187
32LH12	27	32	939	36640	36640		734	712	688	664	641	619	598	578	559	541	524	508	492	477	463
							450	428	406	384	364	345	327	311	295	281	267	255	243	232	221
32LH13	30	32	1048	40880	40880		817	801	785	771	742	715	690	666	643	621	600	581	562	544	527
							500	480	461	444	420	397	376	354	336	319	304	288	275	262	249
32LH14	33	32	1079	42080	42080		843	826	810	795	780	766	738	713	688	665	643	622	602	583	564
							515	495	476	458	440	417	395	374	355	337	321	304	290	276	264
32LH15	35	32	1115	43500	43500		870	853	837	821	805	791	776	763	750	725	701	678	656	635	616
							532	511	492	473	454	438	422	407	393	374	355	338	322	306	292
			< 43	43-46	47-56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
36LH07	16	36	393	16900	16900		292	283	274	266	258	251	244	237	230	224	218	212	207	201	196
							177	168	160	153	146	140	134	128	122	117	112	107	103	99	95
36LH08	18	36	433	18600	18600		321	311	302	293	284	276	268	260	253	246	239	233	227	221	215
							194	185	176	168	160	153	146	140	134	128	123	118	113	109	104
36LH09	21	36	554	23840	23840		411	398	386	374	363	352	342	333	323	314	306	297	289	282	275
							247	235	224	214	204	195	186	179	171	163	157	150	144	138	133
36LH10	21	36	611	26260	26260		454	440	426	413	401	389	378	367	357	347	338	328	320	311	303
							273	260	248	236	225	215	206	197	188	180	173	165	159	152	146
36LH11	23	36	667	28660	28660		495	480	465	451	438	425	412	401	389	378	368	358	348	339	330
							297	283	269	257	246	234	224	214	205	196	188	180	173	166	159
36LH12	25	36	798	34300	34300		593	575	557	540	523	508	493	478	464	450	437	424	412	400	389
							354	338	322	307	292	279	267	255	243	232	222	213	204	195	187
36LH13	30	36	938	40340	40340		697	675	654	634	615	596	579	562	546	531	516	502	488	475	463
							415	395	376	359	342	327	312	298	285	273	262	251	240	231	222
36LH14	36	36	1034	44460	44460		768	755	729	706	683	661	641	621	602	584	567	551	535	520	505
							456	434	412	392	373	356	339	323	309	295	283	270	259	247	237
36LH15	36	36	1090	46880	46880		809	795	781	769	744	721	698	677	656	637	618	600	583	567	551
							480	464	448	434	413	394	375	358	342	327	312	299	286	274	263

3. Steel beam (interior):

W 24 X 84 @ 40' center spanning 20 ft

braced @ 4 ft by the steel joists.



Weight of the beam: 84 plf

$\Rightarrow D = 84\,plf + 39\,psf \cdot 40' + 27\,plf \cdot \frac{40'}{4'} = 1914\,(plf)$

$\Rightarrow 1.2D = 2296.8\,plf$

Strength Capacity:

For W24X84: $L_p = 6.89\,ft$ (AISC Table 3-2)

$\phi_b M_{px} = 840\,kip\text{-}ft$

$L_b = 4\,ft < L_p = 6.89\,ft$

$\Rightarrow \phi_b M_{nx} = 840\,kip\text{-}ft$

$\Rightarrow w' = \frac{840\,kip \cdot ft \cdot 8}{(20\,ft)^2} = 16.8\,kip/ft = 16{,}800\,plf$

$\Rightarrow L_{allowed} = \frac{16{,}800 - 2{,}296.8}{1.6} = 9\,064.5\,(plf)$

$\Rightarrow w_{LL\,allowed} = \frac{9064.5}{40} = \underline{226.6\,psf}$

Deflection Capacity:

For W24x84: $I_x = 2370 \text{ in}^4$

$$\Delta = \frac{5wl^4}{384EI_x}$$

$\Delta \le \frac{L}{240}$ for D+L

$\Delta \le \frac{L}{360}$ for L alone

$$\frac{L}{240} = \frac{20 \cdot 12}{240} = 1 \text{ in} \qquad \frac{L}{360} = \frac{20 \cdot 12}{360} = \frac{2}{3} \text{ in}$$

$w_{D+L} = 1914 \text{ plf} + L_{allowed} = 159.5 \text{ lbs/in} + L_{allowed}$

$$\frac{5(159.5 + L_{allowed}) \cdot (20 \cdot 12)^4}{384 \cdot 29{,}000{,}000 \cdot 2370} = 1$$

$\Leftrightarrow L_{allowed} = 1431.5 \text{ lbs/in} \Rightarrow w_{LLallowed} = \underline{429 \text{ psf}}$

$$\frac{5 \cdot (L_{allowed}) \cdot (20 \cdot 12)^4}{384 \cdot 29 \cdot 10^6 \cdot 2370} = \frac{2}{3}$$

$\Rightarrow L_{allowed} = 1060 \text{ lbs/in} \Rightarrow w_{LLallowed} = \underline{318 \text{ psf}}$

$\Rightarrow$ So, the capacity of the Interior beam is $\underline{\underline{226.6 \text{ psf}}}$

4/ Steel column:

W10x39

$A_g = 11.5\ in^2$

$r = 1.98\ in$

$F_y = 50\ ksi$

$E = 29,000\ ksi$

height $h = 15'-10\frac{1}{2}'' = 15.875\ ft$

brace @ each end

to be conservative, assume the column is pin-pin

$\Rightarrow K = 1$

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = \frac{\pi^2 \cdot 29000}{\left(\frac{15.875 \cdot 12}{1.98}\right)^2} = 30.92\ (ksi)$$

$$\Rightarrow \frac{F_y}{F_e} = \frac{50}{30.92} = 1.62 \leq 2.25$$

$$\Rightarrow F_{cr} = \left[0.658^{F_y/F_e}\right] F_y = 0.658^{1.62} \cdot 50 = 25.41\ (ksi)$$

$$\Rightarrow \phi P_n = 0.9\ F_{cr} A_g = 0.9 \cdot 25.41 \cdot 11.5 = \underline{263\ (kips)}$$

Weight of the column $= 39 \cdot 15.875 = 619.13\ (lbs)$

Tributary area of the column, $A_T = 20' \times 40' = 800\ (ft^2)$

Deck weight on the column $= 39\ psf \cdot 800 = 31,200\ (lbs)$

Joist weight on the column $= 5 \cdot (27\ plf \cdot 40') = 5,400\ (lbs)$

Beam weight on the column $= 20' \cdot 24 = 480\ (lbs)$

$\Rightarrow$ Total dead load, $D = 37,080\ (lbs)$

$\Rightarrow 1.2D = 44,496\ (lbs)$

$\Rightarrow 1.6\ L_{allowed} = 263,000 - 44,496 = 218,504\ (lbs)$

$$\Rightarrow W_{allowed} = \frac{218,504}{1.6 \cdot 800} = 171\ psf$$

So, the capacity of the column is $\underline{\underline{171\ psf}}$

5. Steel beam (edge):

W 21 X 50 support 20 ft deck and span 20 ft. unbraced.

weight of the beam: 50 plf

$$D = 50plf + 39\,psf \cdot 20' + 27\,plf \cdot \frac{20'}{4'} = 965\,(plf)$$

$$\Rightarrow 1.2\,D = 1158\,plf$$

Strength Capacity:

For W21 X 50 : $L_{px} = 4.59\,ft$

$\phi_b M_{px} = 413\,kip\text{-}ft$ (AISC Table 3-2)

$$L_b = 4\,ft < L_{px}$$

$$\Rightarrow \phi_b M_{nx} = \phi_b M_{px} = 413\,kip\text{-}ft$$

$$\Rightarrow w = \frac{413 \cdot 8}{20^2} = 8{,}26\,(kip/ft) = 8{,}260\,plf$$

$$\Rightarrow L_{allowed} = \frac{8{,}260 - 1{,}158}{1.6} = 4{,}438.75\,(plf)$$

$$\Rightarrow W_{L\,allowed} = \frac{4{,}438.75}{20} = 222\,(psf)$$

Deflection Capacity:

For W21X50 : $I_x = 984 in^4$

$\Rightarrow \frac{5wl^4}{384EI_x}$ $\quad \Delta \leq \frac{L}{240} = 1 in$ for D+L

$\Delta \leq \frac{L}{360} = \frac{2}{3} in$ for L alone

$W_{D+L} = 965 plf + L_{allowed} = 80.417 lbs/in + L_{allowed}$

$$\frac{5(80.417 + L_{allowed}) \cdot (20.12)^4}{384 \cdot 29 \cdot 10^6 \cdot 984} = 1$$

$\Rightarrow L_{allowed} = 580 lbs/in \Rightarrow W_{allowed} = \underline{348 psf}$

$$\frac{5(L_{allowed})(20.12)^4}{384 \cdot 29 \cdot 10^6 \cdot 984} = \frac{2}{3}$$

$\Rightarrow L_{allowed} = 440 lbs/in \Rightarrow W_{allowed} = \underline{264 psf}$

$\Rightarrow$ So, the capacity of the edge beam is $\underline{\underline{222 psf}}$

Conclusion:

The capacity of the steel joists controls the capacity of the mezzanine plat form.

Assume the weight of lightings & mechanical ducts as 2psf.

⇒ The capacity of the mezzanine is **100 psf.**

Retrofit concept for mezzanine stair / ladder

I / Stair @ ④ on A6 of 82-111:

The slope of the stair is max
$$\begin{cases} \tan^{-1}\left(\dfrac{7'\text{-}3\,^{15}/_{16}''}{9'\text{-}7\tfrac{1}{2}''}\right) = 37.3^\circ \\ \tan^{-1}\left(\dfrac{8'\text{-}6\,^{9}/_{16}''}{11'\text{-}4\,^{1}/_{2}''}\right) = 36.9^\circ \end{cases}$$

=> the slope is $37.3^\circ < 50^\circ$

According to OSHA 3124-12R 2003 page 14 & 15:

- The handrail must be in between 30 inches and 37 inches from the upper surface of the handrail to the surface of the tread.

The actual handrail height is $2'\text{-}8\frac{3}{8}'' = 32.375''$

=> It meets the requirement from OSHA.

II / Ladder on A7 of 82-111:

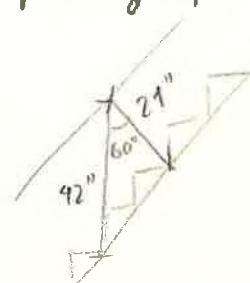
The slope of the ladder $= 60^\circ > 50^\circ$

According to OSHA 3124-12R 2003 page 9:

- the side rail for the ladder must be at least 42" vertically.

According to the drawing and the site visit photograph:
height of the side rail = 42"

=> It meets the requirement from OSHA.



G AT NEW COL.

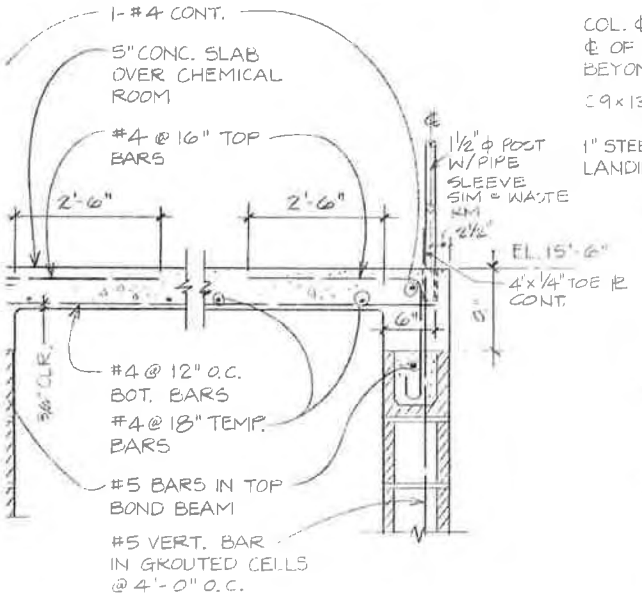
-0" (ALTERNATE #1)

8 EXIST. FOOTING

SCALE 1"=1'-0" (ALTERNATE #1)

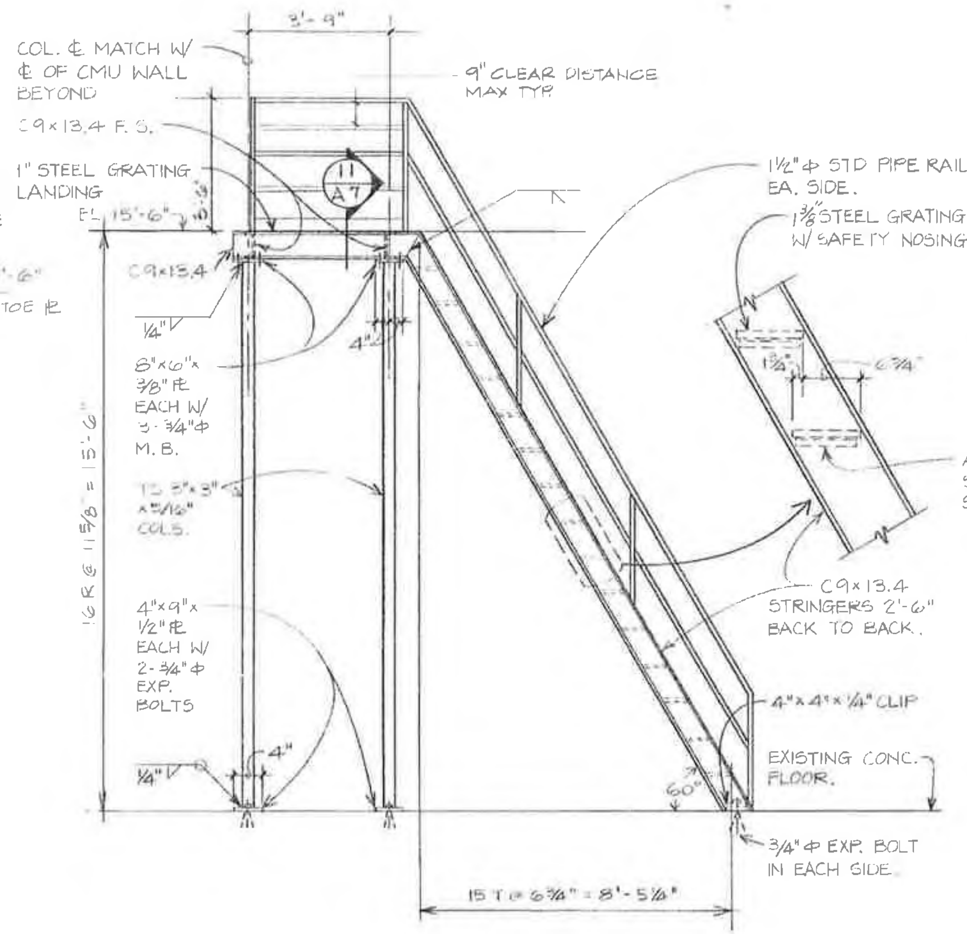
9 BRACING TO NEW BEAM CONN.

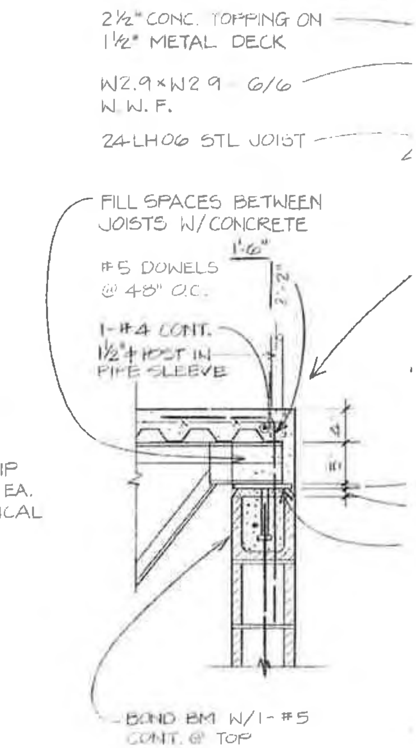
SCALE 1"=1'-0" (ALTERNATE #1)



N AT CHEMICAL STORAGE

1'-0"





13 TYPICAL SHIPS LADDER

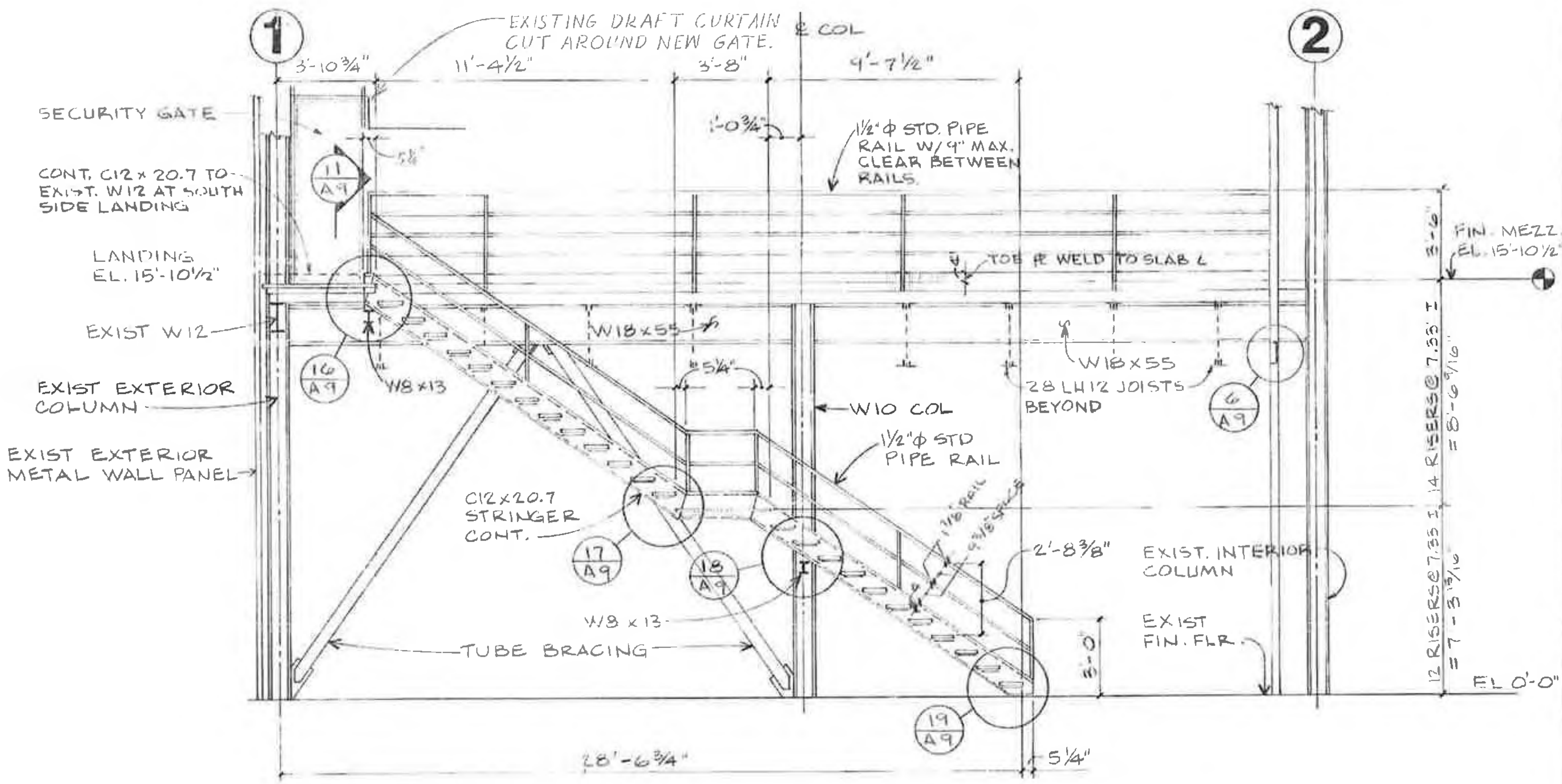
(3- REQUIRED)

SCALE ⅜" = 1'-0"

14 TYPICAL C.M

SCALE ½" = 1'-0"

DW - 3⅝" x 20 STUDS



SECTION AT MEZZANINE STAIR

4

1/4" = 1'-0"

(ALTERNATE #1)

Drawn

Appendix F - Modular Building Racks Memorandum

7F

PROJECT MEMO

To: Janet Knoblach, AIA/ Engineering and Architectural Services Architect

From: Joseph Simon, P.E./ AHBL Structural Engineers

AHBL Office: Tacoma, WA (253) 383-2422

Date: 9/30/2014

Project: Modular Building New Storage Rack Installation

AHBL No.: 2130191.29

Subject: Floor Load Capacity Study

Janet, AHBL was retained to evaluate the capacity of the existing concrete slab on grade to support and anchor new storage racks to be installed in the portion of the Record Center Building currently housing a printing operation. To aid my efforts, I received foundation drawings and rack loading and dimension information from your office. I also contacted Mr. Tom Tate with Northwest Handling Systems to get information pertaining to their standard practices regarding rack installation.

Based on our investigation, it appears that the existing floor slab is adequate to support the proposed racks for load combinations including gravity and seismic forces. Furthermore, the existing slab is sufficiently thick to develop anchorage against seismically induced lateral and uplift forces.

Based on information I received, I understand that the new storage racks will match the width and shelf length of the existing rack system in an adjacent space (5'-4" wide, 10'-0" long shelf length) except that the proposed racks will be about 23'-4" tall to the highest shelf. The proposed racks are to have eleven shelves and each shelf is to support as much as 2160 pounds.

In talking with Mr. Tate, I understand that it is typical for each leg of the rack system to be anchored with two ½ inch diameter Hilti Kwik Bolt TZ expansion-type anchors with 3.25 inches of embedment. Based on our calculations, this means of anchorage appears to be acceptable. However, the rack manufacturer/supplier/installer should perform engineering calculations in accordance with the IBC detailing and justifying the actual means of anchorage.

I hope this information is helpful. Feel free to call with any questions.

Sincerely,

Joseph Simon, P.E.

Appendix G - Investment Grade Energy Audit

7G

ENERGY SERVICES PROPOSAL

INVESTMENT GRADE AUDIT
FOR THE STATE MODULAR BUILDING
ENERGY UPGRADES

PREPARED BY
UNIVERSITY MECHANICAL CONTRACTORS, INC.
November 27, 2012

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

University Mechanical Contractors, (UMC), is pleased to have the opportunity to present this Investment Grade Audit for the State Modular Building Energy Upgrades. The scope of this project is focused on reducing energy usage and improving the heating and cooling systems serving the facility. After performing a complete audit and analysis of the boiler plant and the chiller plant, we have worked directly with the state of WA Department of Enterprise Services to develop an energy conservation and facility upgrade program. When implemented, this program will provide the following benefits.

Energy and Water Conservation Benefits:

1. **Estimated annual savings include 12,227 therms natural gas and 100,647 kWh (1,566 million Btus)*. This equates to $21,881 / year at current utility rates.**
2. **Estimated PSE conservation incentives of $13,500**
3. **Estimated Annual Operational Savings of $1,667**

Notes: * (The savings shown here are estimated savings. See Section 6.1 for guaranteed energy savings)

Atmospheric Benefits:

This Project will eliminate 197,660 lbs CO_2 / Year from the atmosphere

This is the Equivalent of Planting 4,416 Trees

...Or...Removing 13 Cars from the Road

Facility Infrastructure Benefits:

1. **Upgrades lighting system with new lamps and fixture replacements in select locations.**
2. **Replaces all remaining pneumatic control devices in the facility with DDC. This includes the large pneumatic HW valves located in the boiler room.**
3. **Improves ventilation air quality supplied to printing area.**

UMC is pleased to provide this project that meets the initial goals and provides substantial benefits for the State Modular Building. The estimated project investment; estimated utility incentive; and guaranteed utility consumption savings resulting from the project's implementation are shown in the following table.

Savings and Investment Summary

Utility Conservation & Facility Upgrade Measures	Resulting Annual Savings [1] $	Estimated Operational Savings $	Potential Utility Rebate [2] $	Guaranteed Project Cost $	Simple Payback Yrs
	$ -	$ -	$ -	$ -	
UCM 1: Lighting & Lighting Controls Upgrades	$ 6,043	$ 1,500	$ 13,500	$ 87,650	9.8
	$ -	$ -	$ -	$ -	
	$ -	$ -	$ -	$ -	
UCM 2: HVAC Controls Upgrade	$ 1,156	$ -	$ -	$ 101,332	87.7
	$ -	$ -	$ -	$ -	
	$ -	$ -	$ -	$ -	
UCM 3: Energy Based Re-Commissioning	$ 9,717	$ -	$ -	$ 87,448	9.0
	$ -	$ -	$ -	$ -	
Subtotal	**$ 16,916**	**$ 1,500**	**$ 13,500**	**$ 276,430**	**14.3**
				$ -	
Bond				**$ 4,146**	
Project Supervision (on-site)				**$ -**	
Subtotal - Construction	**$ 16,916**	**$ 1,500**	**$ 13,500**	**$ 280,576**	**14.5**
Additional Project Development and Implementation Costs					
Investment Grade Audit				$ 10,875	
Mechanical Design				$ 13,215	
Lighting Design				$ 4,383	
Project Management				$ 16,586	
M&V (Years 2 & 3)				TBD	
Overhead				$ 27,643	
Profit				$ 22,114	
Total Construction Cost - (All Measures / Excluding Tax)	**$ 16,916**	**$ 1,500**	**$ 13,500**	**$ 375,392**	**19.7**
Construction Contingency				$ 20,732	
				$ -	
Subtotal				**$ 396,124**	
Construction Allowance for B&G					
WA State GA Project Management Fee					
WA State GA M&V Fee (Years 2 & 3 total)					
Estimated Tax (@ 8.7%)				$ 32,659	
Total Installed Cost (Including Contingency)				**$ 428,783**	**22.5**

Notes:
(1) Annual utility savings ($) are based on current utility rate schedule
(2) Rebates & Incentives are estimated, but not guaranteed
(3) Estimated Tax applies to Total Constuction Cost, excluding contingency

We are excited to be the Energy Service Company (ESCO) partnering with Washington State, and will continue to work collaboratively in planning, developing and implementing a seamless project that achieves the financial, facility, engineering, and operational objectives.

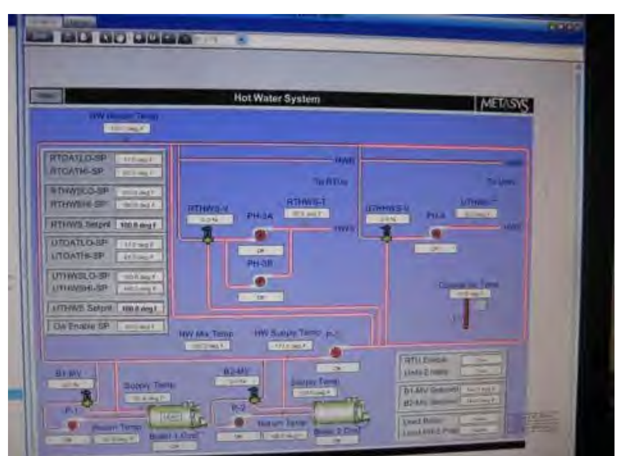
2.0 EXISTING CONDITIONS

2.1 Facility Description & Overview

Overview:
The State Modular Building is a 97,600 square foot, production, warehouse & office facility. The facility was constructed in two phases. The first phase, constructed in 1979, consists of a 40,000 sqft low bay area currently used for printing, storage and fulfillment and a 57,600 sqft high bay area that houses the printing equipment and production department. The second phase, implemented in 1983, consisted of tenant improvement in the high bay section. This facility is located directly adjacent to the Isabella Bush Records Center in Tumwater. This facility is currently occupied by the state printing department. There is currently some question as to the long term utilization of this facility and whether it will be modified to serve a different function in the near term.

HVAC System:
The HVAC system consists of four (4) rooftop mounted dual duct VAV units. There are two units (S-1 & S-2) that are located on the low bay section of the facility and two (S-3 & S-4) that are located on the high bay section. Each of these RTUs utilize HW and CHW from the central systems to heat & cool the respective hot/cold deck of each system. These units provide air to DD terminal boxes located throughout the facility.

Hot Water System:
Heating for the facility is provided by two (2) standard efficiency Burnham boilers located in a second floor mechanical room. The heating HW is distributed to the facility via a primary/secondary pumping system. There are two secondary loops, one of which serves the RTUs while the second serves ceiling hung unit heaters that are located at roll-up doors throughout the facility.



Chilled Water System:
A 300 ton Carrier water cooled centrifugal chiller (installed in 1999) is utilized to generate CHW for the facility. This system utilizes a BAC cooling tower (located on the roof) to reject heat. The CHW circulation system distributes CHW to the four RTUs.

Domestic Hot Water:
Domestic hot water (DHW) requirements are provided through small electric DHW heaters.

Energy Management Systems:
The majority of the facility is controlled via a Johnson Control Metasys DDC system.

Lighting:
The lighting for this facility is comprised primarily of a combination of 4’ fluorescent fixtures with T8 32 watt lamps in a majority of the facility and 8’ fluorescent fixtures with T12 HO lamps throughout the high bay production area.

Water Fixtures:
Water fixtures serving the facility are primarily high flow fixtures, consisting of 3.5 gpf water closets, 1.0 gpf urinals and 2.2 gpm faucets.

3.0 FACILITY AUDIT & ANALYSIS

3.1 Utility Data Analysis

Utility Suppliers

The individual utility suppliers are listed below.

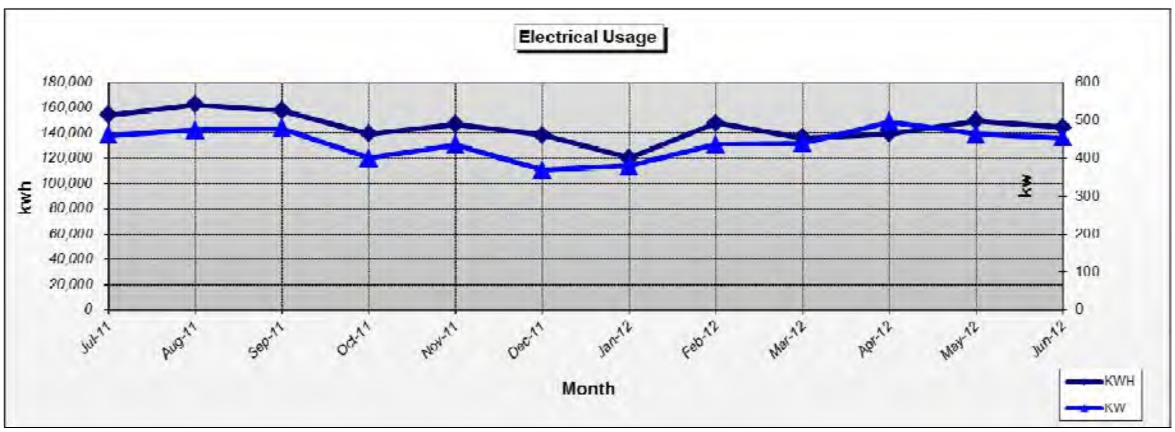
Electricity & Natural Gas

Puget Sound Energy provides electricity and Natural Gas for the facility. The observed electrical blended rate over the last 12 months is $0.096/kwh. The average natural gas rate during this same time frame was $1.065/therm. The detailed baseline utility rate is shown in Section 6.

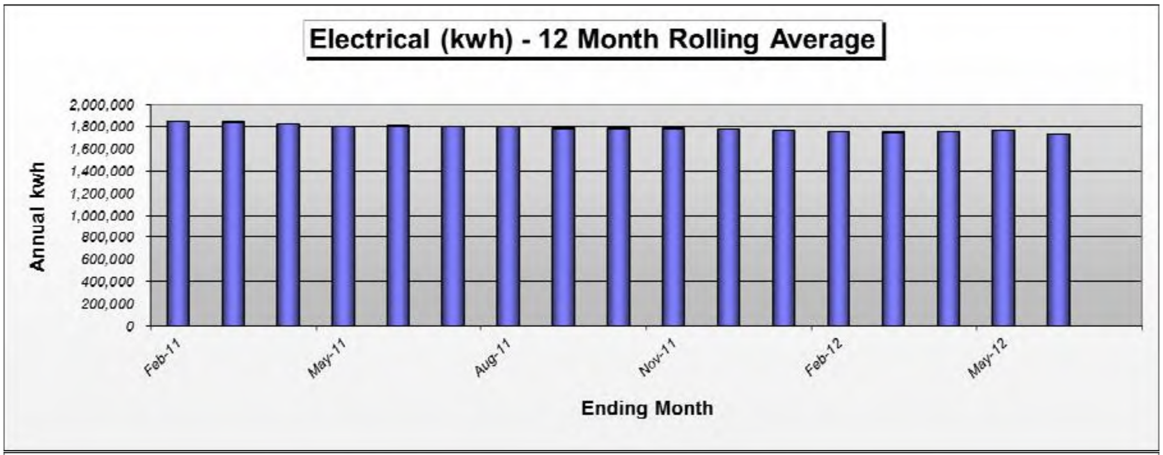
Electric Utility Data

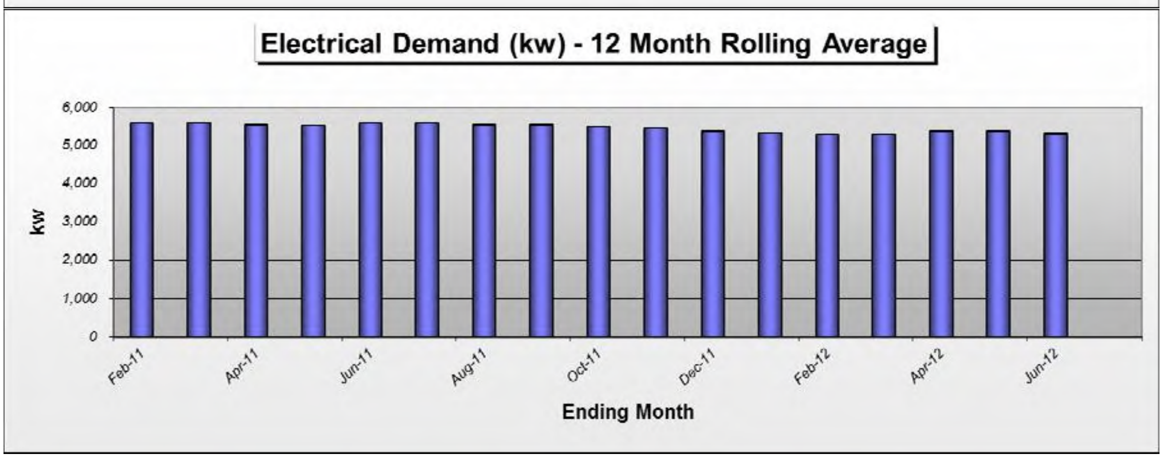
Throughout the period starting June 2011 and ending May 2012, the facility consumed 1,736,800 kWh of electricity. The annual electric demand for the same period was 5,289 kW, with a monthly peak of 496 kW in April of 2012 and a monthly low of 369 kW in December.

The following charts shows historical electric consumption and demand during this period.



One method, to illustrate the upward or down ward trend of utility usage over a long period of time is through the use of a 12-month rolling average chart (shown below). Each bar on the following charts represents the total kW or kWh for the previous 12 months (including the month noted on the x-axis).



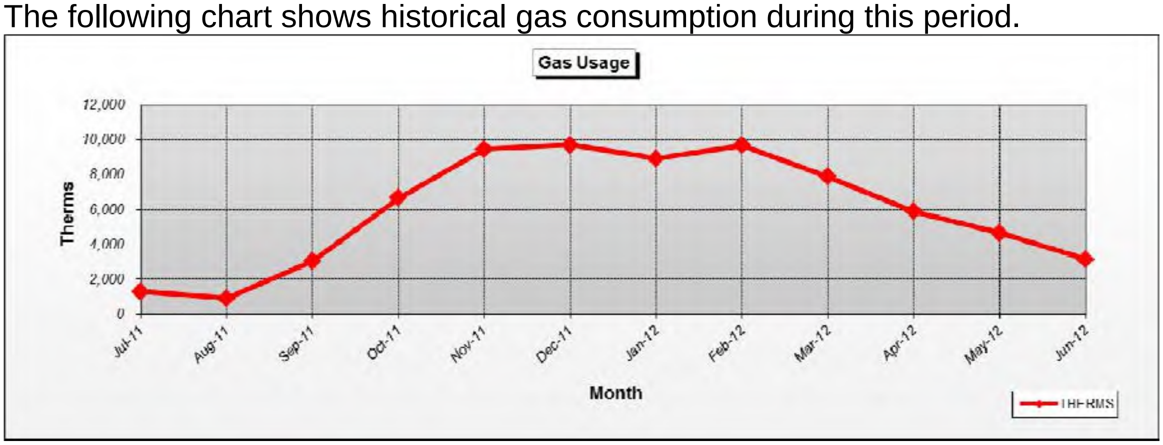


As illustrated in the chart above, the electrical usage and demand have both remained fairly consistent over the recent past. .

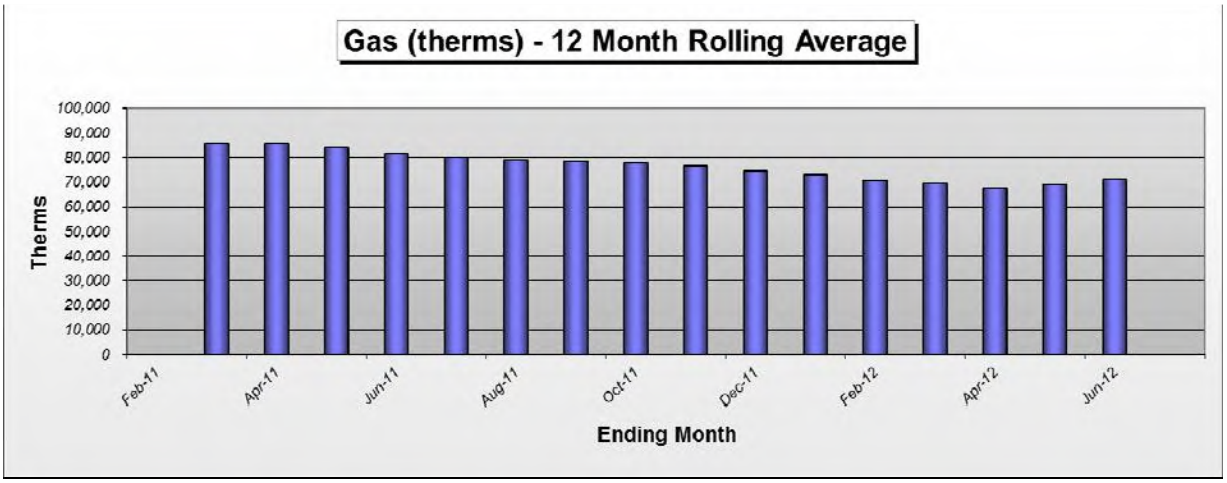
Natural Gas Utility Data

Throughout the period starting June 2011 and ending May 2012, the facility consumed 71,120 therms of gas, with a monthly peak of 9,704 therms in December of 2011 and a monthly low of 893 therms in August of 2011.

The following chart shows historical gas consumption during this period.



As illustrated in the following chart, there has been a slight downward trend in annual gas usage since March of 2011. This could be due primarily to weather fluctuations, but most likely there has been some effect from the recent controls commissioning that has been implemented by L&I.



<u>Energy Use Index</u>

The Energy Use Index (EUI) is a method used to compare the energy usage between similar facilities in geographic regions throughout the United States. This EUI is a measure of the total energy usage (in British Thermal Units – Btu) divided by the total square footage of the facility. <u>The EUI for the State Modular Building is 133,603 Btu/sqft/yr</u>. This facility is very hard to benchmark against other facilities due to its unique and varied usage characteristics.

3.2 Building Baselines

For the purposes of this project, the proposed utility usage Baseline consumption for the State Modular Building is provided below.

State Modular Building – Proposed Utility Usage Baseline

MONTH	ELECTRICAL KWH	DEMAND KW	ELECTRICAL ($)	GAS THERMS	GAS ($)	UTILITY TOTAL ($)
Jul-11	154,400	460	$14,073	1,287	$1,488	**$15,561**
Aug-11	162,400	475	$14,737	893	$1,053	**$15,790**
Sep-11	157,600	478	$14,601	3,031	$3,411	**$18,012**
Oct-11	139,600	401	$13,883	6,651	$7,330	**$21,213**
Nov-11	146,800	435	$14,721	9,454	$9,957	**$24,679**
Dec-11	138,400	369	$13,475	9,704	$10,220	**$23,695**
Jan-12	120,000	380	$12,083	8,911	$9,388	**$21,471**
Feb-12	148,000	437	$14,805	9,672	$10,187	**$24,992**
Mar-12	136,000	440	$13,582	7,871	$8,289	**$21,870**
Apr-12	139,600	496	$13,011	5,876	$6,159	**$19,169**
May-12	149,600	464	$13,749	4,632	$4,899	**$18,648**
Jun-12	144,400	454	$13,414	3,138	$3,342	**$16,756**
Subtotals	**1,736,800**	**5,289**	**$166,133**	**71,120**	**$75,723**	**$241,856**

<u>Baseline Adjustment</u>

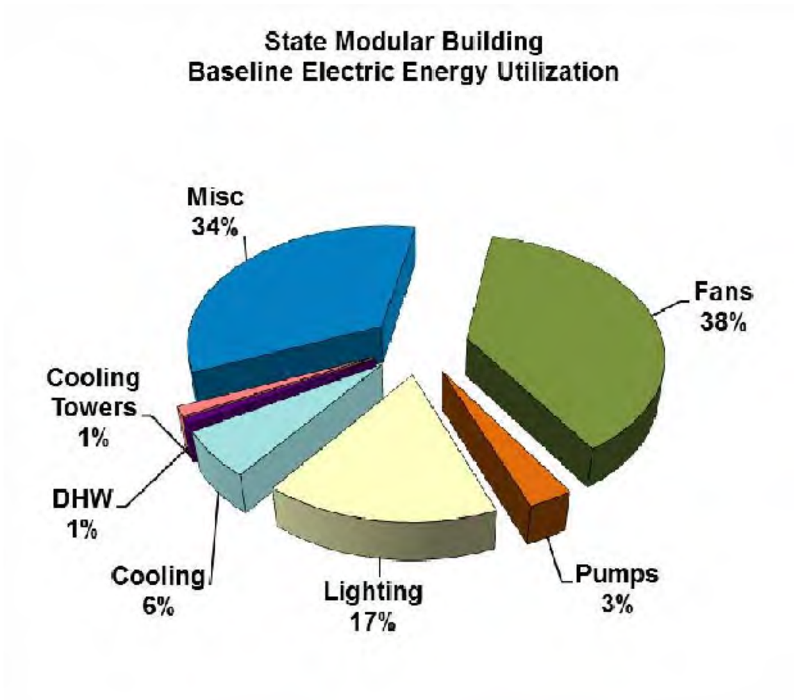
The implementation of UCM-3 Energy Base Re-Commissioning will result in an increased amount of ventilation air being supplied to the facility throughout the year. This air will have to be conditioned, and as a result there will be an increase in the baseline energy usage to account for this newly conditioned air. This additional energy usage has been estimated using a BIN weather analysis (provided in the appendix). This baseline adjustment will result in the following increased utility usage.

Adjusted Annual Electrical Energy Usage:
1,736,800 kWh + 25,344 kWh (adjustment) = 1,762,144 kWh

Adjusted Annual Electrical Energy Usage:
71,120 therms + 2,603 therms (adjustment) = 73,723 therms

Baseline Operating Practices

The operating practices during the Baseline period determine the utility consumption shown in the Tables shown above. The information in the following tables outlines the operating characteristics that were in effect during the Baseline period, as determined during the Investment Grade Audit.



EQUIPMENT	DESCRIPTION		QTY	HP	KW	OPERATING HRS/YR	ANNUAL KWH	ANNUAL COST
Fans								
	Supply Fans							
S-1	Low Bay North		1	15.00	6.8	8,760	59,771	$5,720
S-2	Low Bay South		1	20.00	9.1	8,760	79,695	$7,627
S-3	High Bay West		1	25.00	11.4	8,760	99,618	$9,533
S-4	High Bay East		1	30.00	13.6	8,760	119,542	$11,440
	Return Fans				-		-	$0
R-1	Low Bay North		1	5.00	2.3	8,760	19,924	$1,907
R-2	Low Bay South		1	7.50	3.4	8,760	29,885	$2,860
R-3	High Bay West		1	15.00	6.8	8,760	59,771	$5,720
R-4	High Bay East		1	20.00	9.1	8,760	79,695	$7,627
	EXHAUST FANS						-	
EF-1	Dark rm		1	0.08	0.1	4,680	284	$27
EF-2	Plate rm		1	0.10	0.3	4,680	1,193	$114
EF-3	Dark rm		1	0.10	0.3	4,680	1,193	$114
EF-4	Dark rm		1	0.10	0.4	4,680	2,059	$197
EF-5	chem stor		1	0.10	0.1	8,760	638	$61
EF-6	locker rm		1	0.10	0.1	4,680	341	$33
EF-7	waste paper		1	30.00	21.8	4,680	102,184	$9,779
EF-8	Ludlow Machine		1	0.10	0.1	4,680	341	$33
E-8	Media Processing		1	0.75	0.5	4,680	2,555	$244
	Relief Fans						-	$0
Ref-1	Office Area		1	0.25	0.2	4,160	757	$72
Ref-2	Office Area		1	0.25	0.2	4,160	757	$72
H-8	109		1	0.05	0.0			
H-9	Lunchroom		1	0.05	0.0			
H-10	101		1	0.05	0.0			
H-11	107		1	0.05	0.0			
H-12	Corridor		1	0.03	0.0			
H-13	Receiving #125		1	0.17	0.1			
H-14	Receiving #125		1	0.17	0.1			
H-15	Receiving #125		1	0.17	0.1			
H-16	Receiving #125		1	0.17	0.1			
H-17	Maint. Grnds Entry		1	0.13	0.1			
H-18	Blr Rm		1	0.05	0.0			
H-19	Chlr Rm		1	0.04	0.0			
H-20	Mezz. Storage		1	0.04	0.0			
H-21	Mezz. Storage		1	0.04	0.0			
Boiler 1			1		1.9			
Boiler 2			1		1.9			
	Subtotal				91.2		660,201	$63,181
Pumps							-	
	Circulation Pumps						-	
R-3	CHW(Armstroing)		1	25.00	18.2	500	9,098	$871
R-4	CNDW Pump		1	20.00	14.6	250	3,639	$348
R-5	CNDW Pump		1	20.00	14.6	250	3,639	$348
H-3	RTU Pump		1	5.00	3.6	4,160	15,138	$1,449
H-4	Cab htrs & Unit htrs		1	2.00	1.5	4,160	6,055	$579
H-5	Blr H-1 Recirc Pump		1	2.00	1.5	4,160	6,055	$579
H-6	Blr H-2 Recirc Pump		1	2.00	1.5	4,160	6,055	$579
	HHW Primary Loop Pump		1		3.0	1,820	5,481	$525
	Subtotal				58.3		55,161	$5,279
Cooling							-	
R-6	CRCU		1	0.50	0.4	4,160	1,514	$145
R-7	Air Cooled Condenser		1	0.33	0.2	4,160	999	$96
CH-1	Chiller (York 300 Centrifugal w/ vfd)		1		210.0	500	105,000	$10,049
	Subtotal				210.6		107,513	$10,289
Cooling Towers							-	
CT-1	Fan		1	20.00	14.6	500	7,278	$697
	Fan		1	20.00	14.6	500	7,278	$697
	Pan Heater		1		7.0	50	350	$33
	Subtotal				36.1		14,906	$1,427
Lighting							-	
Percentage of Annual Electrical Usage							-	$0
Watts per Square Foot						4,472	283,235	$27,106
Percent Lights On at any one time		75%					-	$0
Building Occupancy %		100%					-	$0
	Subtotal				-		283,235	$27,106
DHW							-	
A-2	40 Gal 2 Element		1		6.0	900	5,400	$517
A-3	30 Gal 2 Element		1		5.0	900	4,500	$431
A-4	80 Gal 2 Element		1		10.0	900	9,000	$861
A-5	20 Gal 1 Element		1		3.0	900	2,700	$258
	Subtotal				24.0		21,600	$2,067
Misc							-	
Plug Load w/sqft		2				3,640	142,106	$13,600
Avg Load % On		20%					-	$0
Building Occupancy %		100%					-	$0
							-	$0
Printing/Copying Equipment							384,000	$38,280
							-	$0
R-8	Controls Air Compressor		1	3.00	2.2	200	437	$42
	Printer Air Compressor		1	30.00	26.9	1,500	40,335	$3,860
	Mezzanine Printer Air Compressor		1		14.6	1,501	21,849	$2,091
	Air Dryer (Dominick-Hunter)		1		1.3	1,502	1,993	$191
	Subtotal				45.0		590,719	$58,063
Total					**465.2**		**1,733,336**	**$167,411**

Existing Operating Characteristics

Existing Equipment Annual Operating Hours Annual Operating Hours =				
Day of Week	Run Hours (HVAC Equipment)			
Monday	24 hrs/day			
Tuesday	24 hrs/day			
Wednesday	24 hrs/day			
Thursday	24 hrs/day			
Friday	24 hrs/day			
Saturday	24 hrs/day			
Sunday	24 hrs/day			
Holiday	24 hrs/day			

Existing Heating/Cooling Operating Set Point Temperatures				
Day of Week	Office Space Occupied Degree F (Heating/Cooling)	Office Space Unoccupied Degree F (Heating/Cooling)		
Monday	68 / 72	68 / 72		
Tuesday	68 / 72	68 / 72		
Wednesday	68 / 72	68 / 72		
Thursday	68 / 72	68 / 72		
Friday	68 / 72	68 / 72		
Saturday	68 / 72	68 / 72		
Sunday	68 / 72	68 / 72		
Holiday	68 / 72	68 / 72		

4.0 PROPOSED SCOPE OF WORK

4.1 Scope of Work

The following is a detailed description of each Utility Conservation Measure (UCM) that is being recommended as part of this proposal.

UCM-1 Lighting and Control Upgrades
Overview of Current Situation
The current lighting systems utilize a combination of fixture types including: • 4’ T8 32 watt fluorescent • 4’ & 8’ T12 HO fluorescent fixtures (printing area) • Mercury Vapor lamps • 2 Lamp F32 T8 U-Tube Lamps, NBF Ballast
Recommendations
• Retrofit the existing 4’ & 8’ T12 HO fixtures with T8, 28 watt lamps, reflectors and HBF ballasts. • Retrofit existing 4’ T8, 32 watt fixtures with T8, 28 watt lamps • Retrofit existing 2 Lamp F32 T8 U-Tube Lamps with Troffer Kit with Reflector 2' w 2 F17 17 watt Lamp NBF • Replace exiting interior mercury vapor lamps with CFL • Install occupancy sensors in select areas and restrooms to turn fixtures off when the space is unoccupied.
Benefits (Including Occupant Health & Safety)
• Reduces electrical energy usage • Improves lamp life and reduces annual lamp replacement costs

UCM-2: HVAC Controls Upgrade

Overview of Current Situation

The existing controls system for the Modular Building consists of a JCI DDC front end with E/P transducers used to control pneumatic end controllers. There are also several fully pneumatic control valves still in operation on the HW distribution system. There is a requested desire by DES to completely remove any remaining pneumatic controls from the facility and replace with DDC.

Recommendations

- Replace remaining pneumatic control valves with new DDC controlled valves (located in boiler mechanical room & at unit heaters near roll-up doors).
    - (2) HW control valves located in boiler room
    - (7) HW control valves serving unit heaters at each roll-up door
    - (7) HW control valves serving unit heaters located throughout the facility
- Replace remaining pneumatic devices with new full DDC control that includes the following
    - Up to twenty (20) pneumatic thermostats located in low bay VAV boxes.

Advantages/Benefits

- Improve operating efficiency of HVAC control system
- Solve operational issues
- Improve energy efficiency
- Improve occupant comfort

Supporting Documentation

UCM-3: Energy Based Re-Commissioning
Overview of Current Situation

The existing HVAC system serves the space heating, cooling & ventilating requirements of the facility adequately, but could be improved from an overall efficiency standpoint. During the course of the audit the following items were noted.

- There is a lack of control over the RA/OA dampers that limits the controllability of the ventilation air supplied by the 4 rooftop DD VAV units. This is especially prevalent with the 2 RTUs serving the high bay print area. The RA fan currently supplies excess air pressure such that it over-pressurizes the MA plenum and prevents sufficient ventilation air from entering the area served by these units. This operation also has the effect of inadvertently lowering the EUI baseline due to the reduced requirement of heating/cooling the OA that would otherwise be entering the RTU for ventilation purposes.
- Trends indicate that the issues with the lack of ventilation air occurs primarily during the occupied (daytime) periods for the facility. During the unoccupied (nighttime) periods, the ventilation air increases. This is actually the opposite of preferred operation for these units. As a result of the current mode of operation, the increase in OA at night results in a decrease in the MA temperature and also a significant increase in the Hot Deck temperature (as this is required to heat the MA and maintain the facility setpoint). During the daytime (when the RA over-pressurizes the MA plenum) the MA becomes the same temperature as the RA (~72F).
- In certain areas (low bay copy center, etc) there are some thermostats that control 2 DD boxes.
- The high bay print shop often leaves the rollup loading dock door open throughout the day. This may be a result of odors indoors due to poor IAQ and makes humidity/temperature control difficult.
- The humidity control has been upgrades from a central steam system to stand alone ultrasonic humidity controllers located on columns throughout the print shop.

Recommendations

Implement a Re-commissioning effort for the facility HVAC system. Targeted improvements would include:

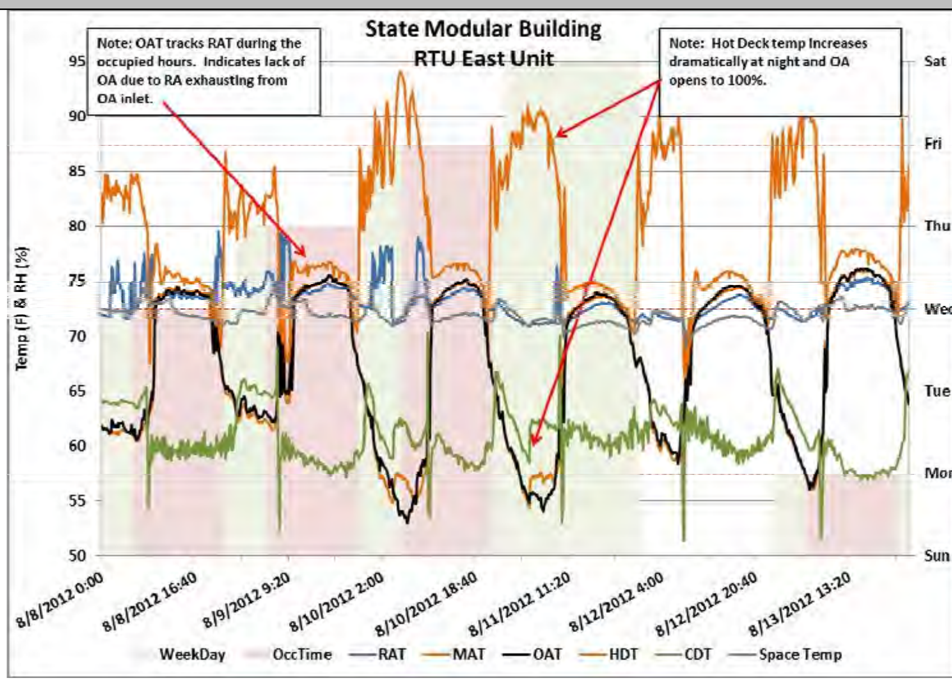
- Efficient modification of control sequencing issues (as applicable).
- Optimization of the RTUs, Heating System, Cooling System & Unit Heaters.
- Modify control sequencing on RTU's to improve ventilation air control. This could help with economizer efficiency and odor control in the print shop.
- Control DHW pump to turn unit off when the facility in unoccupied.
- Implement Optimum Start/Stop schedule for all systems.
- Optimize unit heater operating sequence at dock doors to prevent unnecessary operation.
- Reduce ventilation air during typically unoccupied periods to reduce nighttime heating requirements.
- Pre & Post Testing and Air Balancing (TAB).

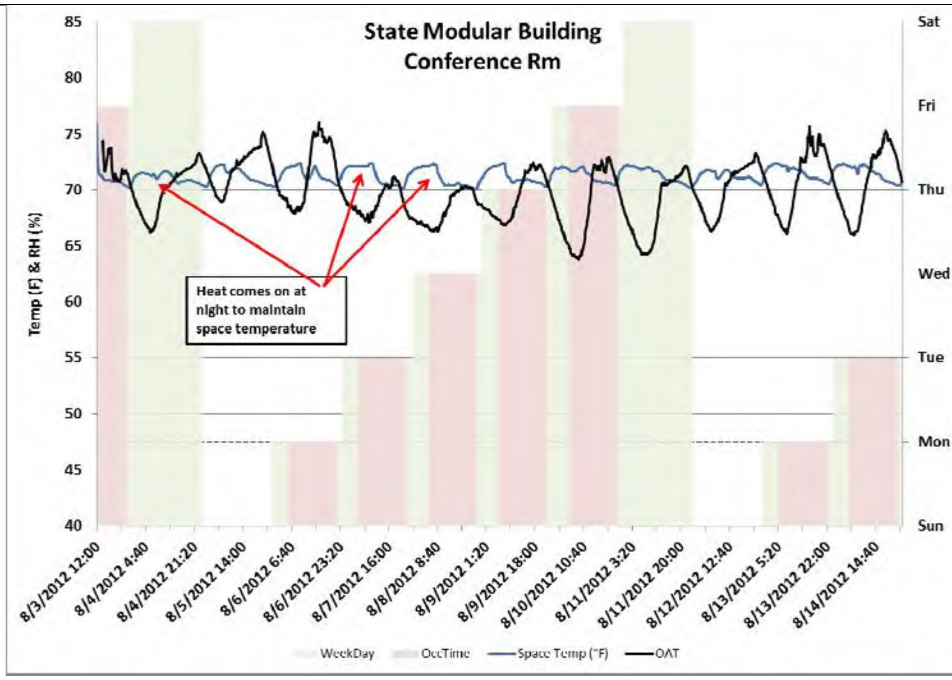
Advantages/Benefits

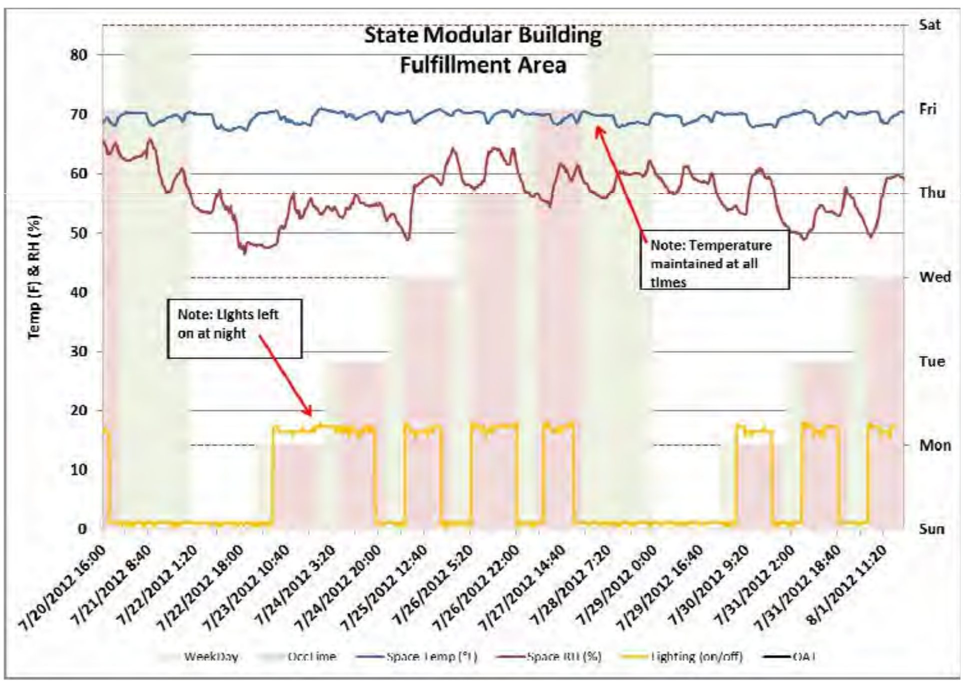
- Improve operating efficiency of HVAC control system
- Solve operational issues
- Improve energy efficiency
- Improve occupant comfort

(Note: The proposed modification to the RTU control that will result in improved ventilation to the space will also result in an increase in the heating/cooling required to condition this increase in outside air. As a result, a baseline modification to the energy use baseline is being proposed.)

Supporting Documentation







4.2 Project Notations/Clarifications/Exclusions

1. Adequate space will be provided for the staging of materials.
2. Owner shall provide access as required per the coordinated schedule.

3. This project does not include any hazardous material identification, material handling, removal and disposal, which may be found during construction of this project.
4. This project does not include any asbestos testing or abatement.
5. This project does not allow for cost associated with working in hazardous or confined spaces.
6. This project does not include hazardous material identification, material handling or removal & disposal that may be found during construction. This includes mold remediation.
7. This project does not include any upgrades to the existing electrical system due to load or code requirements at facility.
8. This project does not include any upgrades to the existing fire protection system.
9. This proposal does not include the repair or replacement of existing damaged lighting fixtures, hardware and lenses/fixture enclosures.
10. This project does not include any costs for temporary construction utilities other than temporary heating.
11. This project does not include any costs for structural upgrades.
12. This project excludes architectural sheet metal
13. This project excludes sound consultant or acoustical engineering
14. All work as proposed is expected to be done during normal working hours.
15. Boiler Replacement and Upgrade assumes that there are no unforeseen issues with the existing vertical chase when installing the proposed new, stainless steel exhaust stack. There are sections of this chase that were not accessible during the development of this IAG.

4.3 Conservation Measures Not Included in Current Proposal

1. Upgrade HW Boiler System:
    - The existing HW boilers (2) are standard efficiency boilers and are nearing the end of their useful life.
    - The HW distribution piping must be maintained at a constant temperature at all times to prevent leaks that occur at gaskets/joints throughout the facility. The requirement to maintain temperature 24/7 causes the system to be extremely inefficient.
    - The HW piping located within the boiler room is extremely complex, making it difficult to efficiently control HW distribution efficiently.
    - The pumping system is constant volume.

    UMC recommends replacing the existing boilers and upgrading the piping system throughout the facility, improving the piping distribution/layout within the boiler room and upgrading the pumping distribution system to variable volume. If this ECM were incorporated with the boiler replacement being recommended at the Records Center, there may be an opportunity to combine the two separate systems into one. This would reduce the initial capital cost and the ongoing operations/maintenance costs.

2. Replace the four existing rooftop units:
    - The existing RTUs are well past there useful life.
    - The DD/VAV system currently serving this facility is inefficient for this type of operation.

    UMC recommends redesigning the existing HVAC air site system and replacing the DD rooftop units with more a more efficient system for this facility.

3. Implement water conservation upgrades throughout the facility

4. Install VFD on cooling tower fan motor

5. Review opportunities for improving weatherization around loading dock doors.

5.0 PROJECT FINANCIALS

This section provides an overview of the financial impact provided through implementation of this program. We have attempted to convey this information in a manner that identifies the costs, savings, fees, rates and structures along with a cash flow analysis.

5.1 Project Cost Structure

For development and performance of the Work described in this proposal, the Washington State Department of Enterprise Services shall pay to University Mechanical Contactors, Inc. the Contract Sum of $375,392 - (excluding estimated WA State Sales Tax, contingency and, estimated WA State GA Project Management Fees). The following table outlines all of these costs, including UMC's fees and compensation.

CATEGORY		COST ($)		% OF CONSTRUCTION COST
CONSTRUCTION COST (MTRL & LBR)		$	276,430	
	PERFORMANCE & PAYMENT BOND	$	4,146	1.5%
	PROJECT SUPERVISION (ON-SITE)	$	-	
	Subtotal	**$**	**280,576**	
PROJECT DEVELOPMENT				
	INVESTMENT GRADE AUDIT	$	10,875	
	VAV BOX AUDIT	$	-	
	Subtotal	**$**	**10,875**	
PROJECT IMPLEMENTATION				
	MECH DESIGN (CONSTRUCTION DOCUMENTS)	$	13,215	7.0%
	LIGHTING DESIGN	$	4,383	5.0%
	PROJECT/CONSTRUCTION MANAGEMENT	$	16,586	6.0%
	Subtotal	**$**	**34,183**	
PERFORMANCE MEASUREMENT & VERIFICATION				
	MEASURMENT & VERIFICATION (YRS 2 & 3)	excluded		
	Subtotal	**$**	**-**	
OTHER PROJECT COSTS				
	OVERHEAD	$	27,643	10.0%
	PROFIT	$	22,114	8.0%
	Subtotal	**$**	**49,757**	
TOTAL PROJECT COST - (EXCLUDING TAX)		**$**	**375,392**	
CONSTRUCTION CONTINGENCY		**$**	**20,732**	
SUBTOTAL (WITH CONTINGENCY)		**$**	**396,124**	
CONSTRUCTION ALLOWANCE FOR B&G		**$**	**-**	
WA STATE GA PROJECT MANAGEMENT FEE		**$**	**-**	
WA STATE GA M&V FEE (YEARS 2 & 3)		**$**	**-**	
ESTIMATED TAX (@ 8.7%)		**$**	**32,659**	
SUBTOTAL (WITH CONTINGENCY)		**$**	**428,783**	
Notes:	Mechanical design fee is % of mechanical construction cost only			
	Lighting design fee is % of lighting construction cost only			
	Project Management, bond and O&P fees are % of total construction cost			
	Estimated Tax applies to Total Project Cost (excluding contingency)			

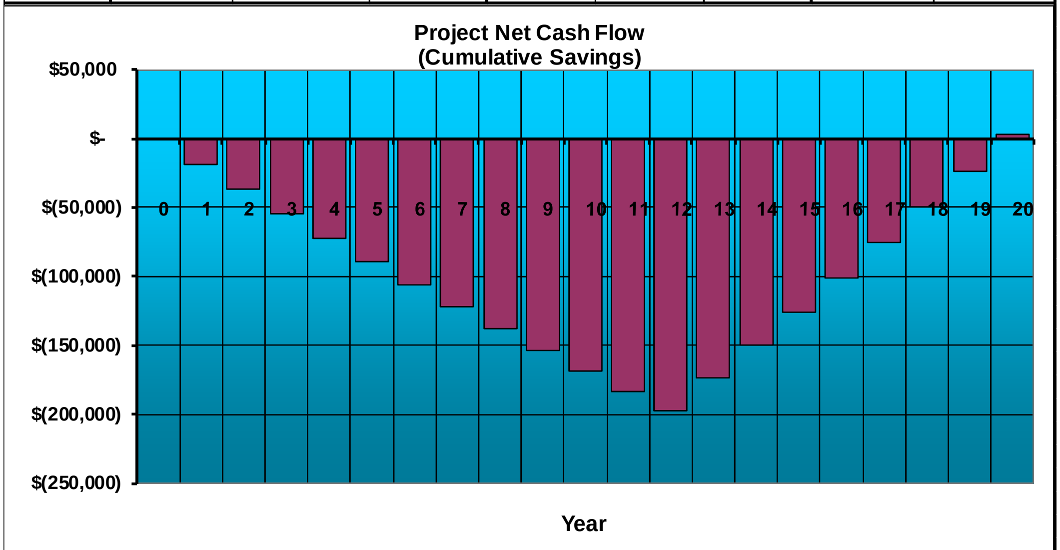
5.2 Project Cash Flow Analysis

The following table provides a sample cash flow analysis for this project.

State Modular Building — **Projected Cash Flow Analysis**

Project Data		Loan Data	
Project Implementation Cost*	$ 375,392	Interest Rate (annual)	2.0%
Sales Tax	$ 32,659	Loan Period	12
Grant or Capital Contribution	$ -	Payments per Year	12
Utility Incentives, Rebates, Tax Credits	$ 13,500	Total Interest Paid	$ 49,565
Resultant Project Amount to be Financed	$ 394,551		
Amount Financed	**$ 394,551**		
		Escalation Rates	
Ongoing Support Services		Utility Escalation Rate	2.0%
		Operational Cost Escalation Rate	2.0%
Utility Savings (annual)	$ 16,916		
Operational Savings (annual)	$ 1,500	*excludes contingency cost	

	Project Savings			Project Costs			Cashflow	
Year	Utility	Operational	Project	Principal & Interest	Ongoing Support	Program	Annual Net	Cumulative Net
0	$ -	$ -	**$ -**	$ -	$ -	**$ -**	**$ -**	**$ -**
1	$ 16,916	$ 1,500	**$ 18,416**	$ (37,010)	$ -	**$ (37,010)**	**$ (18,594)**	**$ (18,594)**
2	$ 17,254	$ 1,530	**$ 18,784**	$ (37,010)	$ -	**$ (37,010)**	**$ (18,225)**	**$ (36,819)**
3	$ 17,599	$ 1,561	**$ 19,160**	$ (37,010)	$ -	**$ (37,010)**	**$ (17,850)**	**$ (54,669)**
4	$ 17,951	$ 1,592	**$ 19,543**	$ (37,010)	$ -	**$ (37,010)**	**$ (17,466)**	**$ (72,135)**
5	$ 18,310	$ 1,624	**$ 19,934**	$ (37,010)	$ -	**$ (37,010)**	**$ (17,076)**	**$ (89,211)**
6	$ 18,677	$ 1,656	**$ 20,333**	$ (37,010)	$ -	**$ (37,010)**	**$ (16,677)**	**$ (105,888)**
7	$ 19,050	$ 1,689	**$ 20,739**	$ (37,010)	$ -	**$ (37,010)**	**$ (16,270)**	**$ (122,158)**
8	$ 19,431	$ 1,723	**$ 21,154**	$ (37,010)	$ -	**$ (37,010)**	**$ (15,855)**	**$ (138,014)**
9	$ 19,820	$ 1,757	**$ 21,577**	$ (37,010)	$ -	**$ (37,010)**	**$ (15,432)**	**$ (153,446)**
10	$ 20,216	$ 1,793	**$ 22,009**	$ (37,010)	$ -	**$ (37,010)**	**$ (15,001)**	**$ (168,447)**
11	$ 20,621	$ 1,828	**$ 22,449**	$ (37,010)	$ -	**$ (37,010)**	**$ (14,561)**	**$ (183,008)**
12	$ 21,033	$ 1,865	**$ 22,898**	$ (37,010)	$ -	**$ (37,010)**	**$ (14,112)**	**$ (197,119)**
13	$ 21,454	$ 1,902	**$ 23,356**	$ -	$ -	**$ -**	**$ 23,356**	**$ (173,763)**
14	$ 21,883	$ 1,940	**$ 23,823**	$ -	$ -	**$ -**	**$ 23,823**	**$ (149,940)**
15	$ 22,320	$ 1,979	**$ 24,300**	$ -	$ -	**$ -**	**$ 24,300**	**$ (125,641)**
16	$ 22,767	$ 2,019	**$ 24,786**	$ -	$ -	**$ -**	**$ 24,786**	**$ (100,855)**
17	$ 23,222	$ 2,059	**$ 25,281**	$ -	$ -	**$ -**	**$ 25,281**	**$ (75,574)**
18	$ 23,686	$ 2,100	**$ 25,787**	$ -	$ -	**$ -**	**$ 25,787**	**$ (49,787)**
19	$ 24,160	$ 2,142	**$ 26,303**	$ -	$ -	**$ -**	**$ 26,303**	**$ (23,485)**
20	$ 24,643	$ 2,185	**$ 26,829**	$ -	$ -	**$ -**	**$ 26,829**	**$ 3,344**



This cash flow analysis has been estimated based on the best information available at this time. The variables (taxes, interest rate, utility incentive, etc) are subject to change and will be re-evaluated at the time of proposal acceptance & contract completion.

5.3 Investment Summary

Investment Grade Audit (IGA)
The Cost for the IGA is per Contract Agreement No. 20101-004 A (1) between the WA State Department of Enterprise Services and University Mechanical Contractors

Labor and Materials
Details of the Scope of Work associated with the Labor and Material Costs are provided in the Section 4.0.

Construction Contingency
Construction Contingency consists of three parts (1) Latent Conditions, (2) Owner Directed Contingency and (3) Design Contingency.

1) Latent Conditions Contingency is an allowance provided within the contract on the assumption that latent or unknown conditions do exist related to existing systems, facilities or the facility sites. The discovery of these latent conditions could not have been reasonably known prior to construction. Furthermore, the owner has disclosed all adverse conditions that are known or could be reasonably known prior to construction. These conditions may include, but are not limited to: defects, malfunctions or obsolescence in systems being modified or in supporting systems; systems and conditions required to be upgraded to meet current or new building or safety codes; defective structures; discovery of hazardous materials including asbestos; buried utilities or underground obstructions; etc. In addition, UMC reserves the right to use the contingency to fund unforeseen cost-to-capital costs. Such conditions when uncovered shall be dealt with in the course of the project and the project responses to the unknown conditions shall be treated as Change Orders.

2) Owner Contingency is an allowance to accommodate adjustments to scope directed by the Owner through change orders as outlined below:

    a) Change Orders for Latent Conditions and for Owner Directed Changes requiring price adjustments, if any, shall be funded first from the Construction Contingency Allowance less the Design Contingency part to the extent of the available allowance budget and then from additional funds added to the Contract Price targeted to the Construction Contingency Allowance through the Change Order process.

b) In addition, such changes may delay the Contract Schedule or contiguous tasks or both. The contractor shall be entitled to equitable adjustments to the schedule. Such schedule adjustments and the resultant price of such adjustments shall be included in the Change Order.

3) Design Contingency Allowance is used to provide small project adjustments to contract costs due to minor errors, happenstance or minor circumstances. These contingency funds are separate from all other contingency funds and are accessible solely by change order.

4) Increased mobilization cost associated with implementing the project in two separate phases.

5) Potential increases in the cost of labor & materials for the measures that will be implemented in subsequent years.

Re-commissioning Contingency

Re-commissioning Contingency is provided to allow for repair/replacement of control & operational issues identified during the re-commissioning process. This contingency is wholly Owner Directed.

Mechanical, Electrical and Plumbing Design Costs:

The following items and tasks are included in the fee:

- ✓ Conduct Design Analysis
- ✓ Evaluate Design Alternatives
- ✓ General Project Engineering
- ✓ Preliminary and Final design submittal and review
- ✓ Design documentation
- ✓ Review and selection of materials and systems

Construction Management / Administration:

The following items and tasks are included in the construction management / administration fee:

- ✓ General Quality Oversight
- ✓ Project Progress Reports
- ✓ Permitting Process
- ✓ Coordination with civic, county and/or federal code officials
- ✓ Subcontractor Contract Development
- ✓ Construction Administration
- ✓ Coordination with Client
- ✓ Project Accounting and Invoicing
- ✓ Commissioning Co-ordination
- ✓ Project Logs and Records
- ✓ MEP Redlines and As-Built Development
- ✓ Project Close-Out
- ✓ Release of Purchase Orders

- ✓ Site General Conditions
- ✓ Start-up of Systems
- ✓ Performance Testing
- ✓ Training Administration/Coordination with factory representatives
- ✓ Onsite Subcontractor/Discipline Coordination
- ✓ Quality Assurance/Quality Control
- ✓ Inventory of materials and equipment received
- ✓ Site Safety Administration
- ✓ Punch list Development/Resolution

The following table summarizes the total investment summary per UCM.

UCM Summary

Utility Conservation & Facility Upgrade Measures	Resulting Annual Savings [(1)] $	Estimated Operational Savings $	Potential Utility Rebate [(2)] $	Guaranteed Project Cost $	Simple Payback Yrs
	$ -	$ -	$ -	$ -	
UCM 1: Lighting & Lighting Controls Upgrades	$ 6,043	$ 1,500	$ 13,500	$ 87,650	9.8
	$ -	$ -	$ -	$ -	
	$ -	$ -	$ -	$ -	
UCM 2: HVAC Controls Upgrade	$ 1,156	$ -	$ -	$ 101,332	87.7
	$ -	$ -	$ -	$ -	
	$ -	$ -	$ -	$ -	
UCM 3: Energy Based Re-Commissioning	$ 9,717	$ -	$ -	$ 87,448	9.0
	$ -	$ -	$ -	$ -	
Subtotal	**$ 16,916**	**$ 1,500**	**$ 13,500**	**$ 276,430**	**14.3**
				$ -	
Bond				**$ 4,146**	
Project Supervision (on-site)				**$ -**	
Subtotal - Construction	**$ 16,916**	**$ 1,500**	**$ 13,500**	**$ 280,576**	**14.5**
Additional Project Development and Implementation Costs					
Investment Grade Audit				$ 10,875	
Mechanical Design				$ 13,215	
Lighting Design				$ 4,383	
Project Management				$ 16,586	
M&V (Years 2 & 3)				TBD	
Overhead				$ 27,643	
Profit				$ 22,114	
Total Construction Cost - (All Measures / Excluding Tax)	**$ 16,916**	**$ 1,500**	**$ 13,500**	**$ 375,392**	**19.7**
Construction Contingency				$ 20,732	
				$ -	
Subtotal				**$ 396,124**	
Construction Allowance for B&G					
WA State GA Project Management Fee					
WA State GA M&V Fee (Years 2 & 3 total)					
Estimated Tax (@ 8.7%)				$ 32,659	
Total Installed Cost (Including Contingency)				**$ 428,783**	**22.5**

Notes:

(1) Annual utility savings ($) are based on current utility rate schedule

(2) Rebates & Incentives are estimated, but not guaranteed

(3) Estimated Tax applies to Total Constuction Cost, excluding contingency

6.0 MEASUREMENT & VERIFICATION

6.1 Summary of Total Guaranteed Savings

The tables in this section illustrate the total savings in 2012 dollars and extended over a 20 year life span. The actual savings guarantee will be in units of energy (kwh, demand kw, and gallons water). The dollars shown in these tables are calculated by applying the current rates (as shown in Section 6) to the guaranteed units of energy saved. An annual escalation rate has been applied equal to 2% for utility rates and 2% for operational costs (this is for projecting estimated annual savings only - escalation is not included in any guarantee).

Year	Annual Utility Savings	Annual Operational Savings	Cummulative Project Savings
Construction			
1	$16,916	$1,500	$18,417
2	$17,255	$1,530	$37,202
3	$17,600	$1,561	$56,363
4	$17,952	$1,592	$75,907
5	$18,311	$1,624	$95,842
6	$18,677	$1,656	$116,175
7	$19,051	$1,690	$136,916
8	$19,432	$1,723	$158,071
9	$19,820	$1,758	$179,649
10	$20,217	$1,793	$201,659
11	$20,621	$1,829	$224,109
12	$21,034	$1,865	$247,008
13	$21,454	$1,903	$270,365
14	$21,883	$1,941	$294,189
15	$22,321	$1,980	$318,489
16	$22,767	$2,019	$343,276
17	$23,223	$2,060	$368,558
18	$23,687	$2,101	$394,346
19	$24,161	$2,143	$420,650
20	$24,644	$2,186	$447,479

The following Table summarizes the first year savings of the Total Guaranteed Savings (Total Guaranteed Savings Summary) in Guarantee Type categories. **<u>All guarantees are based on units of energy (not dollars)</u>**.

Proposed M&V Type				
Energy Conservation Measure	**Measurement & Verification Option Proposed**			
	Option A Partially Measured Retrofit Isolation	**Option B** Retrofit Isolation	**Option C** Whole Facility	**Option D** Calibrated Simulation
UCM 1: Lighting & Lighting Controls Upgrades	X			
UCM 2: HVAC Controls Upgrade				X
UCM 3: Energy Based Re-Commissioning	X			

The following Table illustrates the total guaranteed savings in units of energy.

Utility Conservation & Facility Upgrade Measures	Guaranteed Energy/Utility Savings				
	Electric		Natural Gas	Water / Sewer	
	kW/yr	kWh/yr	therms	Usage gal/yr	Sewer gal/yr
	-	-	-	-	-
UCM 1: Lighting & Lighting Controls Upgrades	216	61,200	-	-	-
	-	-	-	-	-
	-	-	-	-	-
UCM 2: HVAC Controls Upgrade	-	-	1,100	-	-
	-	-	-	-	-
	-	-	-	-	-
UCM 3: Energy Based Re-Commissioning	-	22,853	7,704	-	-
	-	-	-	-	-
Subtotal	**216**	**84,053**	**8,803**	**-**	**-**

6.2 Energy Guarantee

UMC is prepared to guarantee the performance of the installed measures to reduce energy consumption. The table shown in section 6.1 provides the specific energy guaranteed consumption savings for each utility conservation measure. Savings calculations are based upon both baseline operating characteristics and proposed operation criteria. These target energy savings are dependent upon the stipulated conditions as defined in the individual UCM M&V plans.

The measurement & verification plan provides the specific on-going reporting tasks that will be performed in order to verify that the UCMs are performing as specified. The intent is to measure and verify key indicators on which the energy savings are based. <u>Once these key indicators are verified to be in accordance with the proposed criteria, the savings due to the performance of the equipment or measure shall be deemed as met</u>. The proposed measurements for each UCM are defined in Section 6.3.

Baseline: The "baseline" refers to the current operating characteristics of the facility, system or equipment prior to the implementation of the conservation measures identified in this audit. All parties acknowledge that the baseline characteristics as identified in this audit and as associated with specific measures have been determined based on the following:

- Actual operating information gathered during this audit through field observation, site measurements, occupant interviews, trending or owner operational log books. In certain situations, this information has been used to determine stipulated factors such as occupancy schedules, typical equipment operating hours, operational expenditures, light fixture burn-hours, etc.
- Owner provided information.
- In certain instances, a modified baseline may have been developed and discussed with the owner. A modified baseline is instituted when the pre-retrofit conditions do not reflect a system that is operating per current code or per owner's desired normally anticipated operating conditions.

Proposed: The proposed operating criteria, including system performance and operational expenditures, which were used for savings calculations are provided in Section 6 of this IGA. Systems must be operated per the proposed criteria to ensure energy cost savings are realized. UMC will provide the initial start-up and commissioning of the system to ensure that the UCMs operate per the proposed operating criteria. **The Owner acknowledges responsibility to ensure that these criteria are maintained and associated energy savings are realized. Energy Savings Guarantees are predicated based upon Owner maintaining their responsibilities as provided below in "Owner Responsibilities."**

6.3 Measurement and Verification Plan

Guarantee Savings Types

The IPMVP protocol includes four guarantee options to measure and verify savings: Option A – Partially Measured Retrofit Isolation, Option B – Retrofit Isolation, Option C – Whole Facility, and Option D – Calibrated Simulation. The following table describes these options in more detail.

M&V Option	How Savings Are Calculated	Typical Applications
Option A. Partially Measured Retrofit Isolation This approach is intended for Facility Improvement Measures where a one-time measurement for specific equipment or systems instantaneous baseline energy use, and a one-time measurement for specific equipment or systems instantaneous post-implementation energy	Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied; separate from the energy use of the rest of the facility. Measurements may be either short-term	Lighting retrofit where power draw is measured periodically. Operating hours of the lights are assumed to be one half hour per day longer than store

use can be measured. Baseline and Post energy consumption is calculated by multiplying the measured end use instantaneous capacity (i.e. – kW, Gal/hr, BTU/hr) by stipulated hours of operation for each mode of operation (i.e. – hours, week, month).	or continuous. Partial measurement means that some but not all parameter(s) may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Careful review of ECM design and installation will ensure that stipulated values fairly represent the probable actual value. Stipulations should be shown in the M&V Plan along with analysis of the significance of the error they may introduce.	open hours.
Option B. Retrofit Isolation This approach is intended for Facility Improvement Measures where continuous periodic measurements for specific equipment or systems baseline energy use, and continuous periodic measurements for that equipment or systems post-implementation energy use can be measured.	Savings are determined by field measurement of the energy use of the systems to which the ECM was applied; separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the base year this meter is in place for a week to verify constant loading. The meter is in place throughout the post-retrofit period to track variations in energy use.
Option C. Whole Facility This approach is intended for measurements of the whole-facility where specific meter baseline energy use and measurements of whole-facility or specific meter post-implementation energy use can be measured.	Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.	Multifaceted energy management program affecting many systems in a building. Energy use is measured by the gas and electric utility meters for a twelve month base year period and throughout the post-retrofit period.
Option D. Calibrated Simulation This approach is intended for Facility Improvement Measures where the end use capacity or operational efficiency; demand, energy consumption or power level; or	Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must	Multifaceted energy management program affecting many systems in a building but where no

manufacturer's measurements, industry standard efficiencies or operating hours are known in advance, and used in a calculation or analysis method that will calculate the outcome.	be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in understanding facility interactions and in calibrated simulation. Factors that are stipulated should be shown in the M&V Plan.	base year data are available. Post-retrofit period energy use is measured by the calibrated simulation using a model (usually Excel or whole facility model such as Trane Trace). Base year energy use is determined by simulation using a model calibrated by the post-retrofit period utility data.

The following information outlines are applicable for this contract:

<u>Measurement and Verification (M&V) methods provided under this Article</u>**:**

Option A – Partially Measured Retrofit Isolation
Option B – Retrofit Isolation
Option C – Whole Facility
Option D – Calibrated Simulation

General Overview:

The purpose of the Measurement and Verification (M&V) Section is to identify the methods, measurements, procedures and tools that will be used to verify the savings for each ECM. Savings have been determined by comparing prior usage, consumption or efficiencies defined as the Baseline to the selected ECMs being implemented against the resulting post ECM implementation usage, consumption or efficiencies.

The baseline usage, consumption and equipment efficiencies associated with this facility is defined as the Contracted Baseline. The utility baseline for the facility and the baseline operating practices are defined in Section 3. The operating characteristics pertaining to specific equipment, systems and/or operating practices that have been used to determine the estimated savings associated with individual ECMs is described in the following M&V plan for each measure.

The actual guaranteed savings associated with this Program is outlined in the tables provided in Section 6.1.

UCM 1.00 – Lighting & Controls Upgrade

Proposed M&V Method – Option A: Partially Measured Retrofit Isolation

<u>M&V Procedure</u>

All M&V activities associated with the Project will be conducted by UMC.

An audit has been performed to determine the total number of existing fixtures at the facility, as well as identifying the type of fixture and the corresponding usage.

Pre-Installation Measurements: Measurements will be made of the energy usage of selected representative existing lighting systems for connected load prior to implementation of retrofit work. The wattages of these fixtures will be measured using a calibrated kW meter. This measurement will occur once prior to retrofit work.

Baseline Key Parameters	Quantity	Measured (Y/N)	Verification Method
Existing Annual Burn Hours (ABH_{exist})	See spreadsheet in Appendix	N	Stipulated (Estimated based on typical warehouse hours of operation and trend information)
Existing Fixture Demand (kW)	See spreadsheet in Appendix	Y	• Measure 1 circuit serving high bay 8' T12 fixtures • Measure 1 circuit serving typical low bay 4' T8 32 watt fixtures
Existing Number of fixtures	See spreadsheet in Appendix	N	Stipulated (Counted during lighting audit)

Post-Installation Measurements: One-time post-retrofit energy usage measurement will be made on the same or similar fixtures as the pre-retrofit measurements. The wattages of these fixtures will be measured using a calibrated kW meter. This measurement will occur once after completion of retrofit work.

Whenever there is a discrepancy between the energy usage (kW) utilized in the energy savings calculations and that measured in the pre- and post-retrofit measurements then either more circuits will be measured, or the difference in the energy usage will be applied to all similar fixtures that were not measured.

Annual % savings associated with reduced annual burn hours due to the implementation of lighting controls will be stipulated.

Operational savings are based on material savings only (cost of labor has not been included). These operational savings take into account the reduction in lamp & ballast replacements that will be a direct result of this UCM. Operational Savings associated with this measure will be stipulated.

Proposed Key Parameters	Quantity	Measured (Y/N)	Verification Method
Proposed Annual Burn Hours ($ABH_{proposed}$)	See spreadsheet in Appendix	N	Stipulated (Estimated based on typical warehouse hours of operation and trend information)

New Fixture Demand (kW)	See spreadsheet in Appendix	Y	• Measure same high bay circuit as during pre-measurement • Measure same low bay circuit as during pre-measurement
Proposed Number of fixtures	See spreadsheet in Appendix	N	Counted during lighting audit and confirmed during commissioning
Reduction in Annual Burn Hours due to Installation of Lighting Controls	20%	N	Stipulated
Operational Savings due to Reduced Lamp/Ballast Replacements (material savings only)	See spreadsheet in Appendix	N	Stipulated

End of Year One M&V: None proposed

Calculations

All calculations associated with the estimated pre & post energy usage will be made according to standard engineering practice. All savings estimates are provided in the Appendix for review.

UCM 2.00 – HVAC Controls Upgrade

Proposed M&V Method – Option D: Calibrated Simulation (all savings associated with this measure will be stipulated)

M&V Procedure

All M&V activities associated with the Project will be conducted by UMC.

Pre-Installation Measurements: Confirm baseline operating schedules via BAS system. The existing baseline operating characteristics of the State Modular Building HVAC have been documented in Section 3 and in the savings calculation spreadsheet provided in the appendix.

Baseline Key Parameters	Quantity	Measured (Y/N)	Verification Method
Existing HVAC system operating schedule	See Section 3 Baseline Operating Practices (all systems currently operate 8760hrs/yr)	Y	Confirmed during pre-construction monitoring through review of current BAS operating schedule - stipulated

***Post-Installation Measurements**:* There will be no post-installation measurements made. All savings associated with this measure are based on an industry standard savings percentage for the type of work implemented.

Proposed Key Parameters	Quantity	Measured (Y/N)	Verification Method
Proposed HVAC system operating schedule	Same as Baseline (see Section 3)	N	Schedule will be confirmed during project commissioning - stipulated
Annual Savings associated with Facility Heating	2.0% of total baseline heating usage	N	Stipulated

***End of Year One M&V**:* None Proposed.

Calculations
All calculations associated with the estimated pre & post energy usage will be made according to standard engineering practice. Following final inspection and commissioning, a verification of the original savings estimate will be performed to confirm savings based on the actual installation. Savings presented in the contract documents will be stipulated throughout the duration of the contract. All savings estimates are provided in the Appendix for review.

UCM 3.00 – Energy Based Re-Commissioning

Proposed M&V Method – Option A: Partially Measured Retrofit Isolation

M&V Procedure
All M&V activities associated with the Project will be conducted by UMC.

***Pre-Installation Measurements**:* The existing baseline operating characteristics of the State Modular Building heating system have been documented in Section 3 and in the savings calculation spreadsheet provided in the appendix. Specific variables have been measured and documented during the IGA. These variables will be stipulated for the course of the project. There are no additional measurements that will be made.

Baseline Key Parameters	Quantity	Measured (Y/N)	Verification Method
Existing HVAC system operating schedule	See Section 3 Baseline Operating Practices	Y	Confirmed during pre-construction monitoring through review of current BAS operating schedule - stipulated
Average Annual RTU	S1=6,175cfm	N	Estimated based on 50% of Design

Airflow	S2=8,550cfm		Airflow - stipulated
Average Annual RTU Airflow	S3=19,725cfm S4=23,340cfm	N	Estimated based on 75% of Design Airflow - stipulated
% Average RTU Airflow Supplied to HD when OAT < 60F	25%	N	Estimated based Design Airflow - stipulated
Average % OA for RTUs S1 & S2 from 10:00pm to 10:00am	40%	Y	Calculated based on trended RA/OA/MA temperatures obtained during IGA - stipulated
Average % OA for RTUs S3 & S4 from 10:00pm to 10:00am	80%	Y	Calculated based on trended RA/OA/MA temperatures obtained during IGA - stipulated
Average Space Temperature during Heating Mode	72	Y	Trended during IGA - stipulated
Average % OA provided by RTUs from 10:00am to 10:00pm	Between 0% & 5%	Y	Estimated based on trended information obtained during IGA - stipulated

***Post-Installation Measurements**:* Short term monitoring/trending (2-4 weeks) of select system operating characteristics will be implemented to confirm that the HVAC airside system is operating as anticipated. The operating characteristics to be measured will include the following.

- Monitor RAT, OAT & MAT serving three (2) RTUs to confirm OA reduction during unoccupied periods (10 minute intervals)

In addition to the short term trending of facility operating characteristics, additional M&V will consist of confirmation/documentation of system commissioning to implement all proposed operating requirements. Future savings will be calculated with the Excel spreadsheet models that have been developed to estimate energy savings (these are included in the appendix). Proposed operating schedules (if included) have been reviewed and agreed to by the owner and will be stipulated for future operation.

Proposed Key Parameters	Quantity	Measured (Y/N)	Verification Method
Proposed HVAC system operating schedule	Same as Baseline (see Section 3)	N	Schedule will be confirmed during project commissioning - stipulated
Average Annual RTU Airflow	S1=8,028cfm S2=11,115cfm S3=17,095cfm S4=20,228cfm	N	Estimated based on 65% of Design Airflow - stipulated
% Average RTU Airflow Supplied to HD when OAT	25%	N	Estimated based Design Airflow - stipulated

< 60F			
Average % OA for RTUs from 10:00pm to 10:00am	5%	Y	Confirmed via post-construction monitoring of OA, RA & MA for 2 of 4 RTUs
Average Space Temperature during Heating Mode	68	N	Stipulated
Annual Savings associated with RTU Fan Energy Usage	27,397 kWh (5% of total baseline SF & RF motor usage)	N	Stipulated
Annual Savings associated with Chiller Energy Usage	5,250 kWh (5% of total baseline chiller usage)	N	Stipulated

End of Year One M&V: None Proposed.

Calculations
All calculations associated with the estimated pre & post energy usage will be made according to standard engineering practice. Following final inspection and commissioning, a verification of the original savings estimate will be performed to confirm savings based on the actual installation. Savings presented in the contract documents will be stipulated throughout the duration of the contract. All savings estimates are provided in the Appendix for review.

6.4 Utility Rate Structure and Escalation Rates

Utility costs used for savings calculations will be based on the utility rate in effect for the predominant bill or the utility rate in effect for the corresponding period of the Baseline period, whichever is greater. The rate, in effect during the Baseline period, will be designated the floor price, and is shown below for each utility.

Electricity		
Tariff Number or Designation:	Schedule 26 Large Demand General Service	
Utility Name:	Puget Sound Energy	
Rate Structure:	$ 104.46	Basic Charge
Electricity	$ 0.066949	$ per kWh
Demand (Oct – Mar)	$ 8.94	$ per kW
Demand (Apr – Sep)	$ 5.96	$ per kW
	6%	City of Tumwater Tax Rate
Total Elect Rate (including Tax)	**$ 0.070966**	**$ per kWh**
	$ 9.48 / $ 6.32	**$ per kW**
Blended Rate	$ 0.0957 kWh	Average $ per kwh[1]

1. Based on baseline load profile

Natural Gas		
Tariff Number or Designation:	Schedule 31	
Utility Name:	Puget Sound Energy	
Rate Structure:	$ 33.32	Basic Charge
	$ 0.32599	Delivery Charge - $ per therm
	$ 0.60040	Cost of Gas - $ per therm
	$ 0.04028	Gas Conservation Charge - $ per therm
	6%	City of TumwaterTax Rate
	$ 1.0247	**Total Gas Cost - $ per therm**

6.5 Applicable Codes

Federal, State, and Local codes or regulations are applicable to the use and operation of the facility. All work installed under this project will meet the requirements of the following codes:

- The International Building Code and appendices thereto pertaining to building accessibility, not including the adoption of the incorporated electrical codes, plumbing codes, fire codes or property maintenance codes other than specifically referenced subjects or sections of the International Fire Code, but including the incorporated International Residential Code; International Mechanical Code; International Fuel Gas Code; International Energy Conservation Code.
- The Washington State Energy Code
- The Uniform Mechanical Code
- The Uniform Code for Building Conservation
- The Safety Code for Elevators and Escalators (ASME/ANSI A 17-.1)
- The NEC
- The NFPA Fire Alarm Systems
- The NFPA 13 Fire Sprinkler Systems
- The Uniform Plumbing Code
- The Washington State Ventilation and Indoor Air Quality Code
- All applicable local city codes

UMC is not responsible for the code compliance of systems not installed under this project.

6.6 M&V Costs

The cost for the first 12 months of M&V reporting is included in the project implementation cost.

The owner has the option to continue M&V and associated energy guarantees for the subsequent years at the prices shown below (including a labor escalation rate of 4%). To elect this option owner shall provide written notification to UMC one month after the end of the prior period. In the event this option is not elected for a particular year, it may not be elected in subsequent years. UMC's ongoing fee for M&V for years 2 through 4 is shown below.

Year	Annual M&V Cost
1	(1)
2	$4,600
3	$4,784
4	$4,975

(1) Included in project cost

6.7 M&V Reporting

UMC will provide a commissioning report to the Owner within 90 days of completion of the project.

At the completion of the 12 months of energy savings, UMC will provide the first year of reporting within 90 days of this date.

Ongoing M&V reporting beyond year one is not included as part of this proposal. The annual cost for the continued M&V is shown above and can be opted for continuation by the Owner. The savings guarantee associated with this project will only continue past year one as long as the Owner includes the continuation of M&V services as defined herein.

6.8 Owner Responsibilities

This section details the responsibilities the Owner, in connection with the management and administration of the Performance Guarantee. UMC is not responsible for increased energy or operational issues that result from items beyond its control or in the event that the Owner fails to comply with the following requirements.

- The Owner will provide a representative at each facility to coordinate work and provide required data described below. Owner will provide access to all spaces required for pre measurement and post measurement. At the Owner's discretion, one representative will witness all pre and post measurements. UMC will provide calibration reports on all meters as required by the Owner.

- The Owner will provide UMC with accurate facility operating information, as defined below, and in the Contracted Baseline article of this Section during each Annual Period, as soon as such information becomes available to the Owner.

- Owner will provide UMC with copies of utility bills within 7 days of receipt by Owner or provide access to utility vendor information.

- Owner will provide telephone/data remote access as UMC reasonably requests. All charges related to telephone/data line installation, activation and communication services are the responsibility of the Owner.

- Owner will be responsible for notification of UMC regarding schedule changes of the air handling systems associated with this measure. Owner will be responsible for maintaining proposed schedules and setback temperatures. If, for any reason, schedules or setback temperatures must change, Owner will be responsible to make UMC aware of the change.

- <u>Owner will maintain all proposed operating schedules as defined in this proposal and as discussed during training. UMC cannot be responsible for excess energy usage that occurs due to atypical operating hours that are the result of equipment overrides, failure to maintain vacation/holiday scheduling or changes in building use or operating characteristics beyond that as identified during the development of the IGA</u>.

- <u>Owner will provide equipment service and preventative maintenance to keep all equipment installed as part of this project operating efficiently. This includes all service & maintenance as defined in equipment O&M & warranty documents and as discussed during training. Equipment must be maintained in peak operating condition to provide ongoing efficient operation in a manner to meet the savings estimates set forth in this document. Unless otherwise contracted, UMC will provide no additional equipment maintenance or repairs outside of the warranty period</u>

- <u>Owner agrees that the existing operating schedules and equipment conditions, as provided in this IGA, are complete and correct. If, for any</u>

reason, the Owner requires that the equipment be operated in excess of the proposed schedules, UMC will not be responsible for resulting increased energy usage.

- During the performance guarantee period, any post-retrofit changes made by the Owner that may affect the baseline data (i.e., new construction, additional electrical loads, manual control of automatic devices, etc.) shall be reported to UMC so that adjustments can be made to reflect the changes and proper adjustments to the savings guarantees can be made.

- UMC will provide an operations and maintenance manual. Upkeep of the equipment installed as part of this project is the responsibility of the Owner's maintenance personnel. Any loss of efficiency that occurs to the installed equipment caused by a lack of ongoing maintenance or upkeep shall be taken into account and appropriate impact to annual savings adjusted.

- Owner must make every effort to make sure that all appropriate personnel attend equipment/system training provide by UMC during the implementation of this project. These training sessions will be scheduled with the Owner to make sure they are held during a period when appropriate personnel can attend.

Section 6.9 On-Going Space Operating Conditions

The following section provides the space conditions that Owner must maintain to ensure the comfort of the building occupants. These conditions also provide the basis upon which all energy savings calculations have been made. Deviations beyond these conditions that are made at the discretion of the Owner could negatively affect the ongoing savings performance of this project.

HVAC Operating Criteria: Heating, ventilating, and air conditioning (HVAC) systems provided as a part of this project will provide space conditions in accordance with the Standards of Comfort described below. This standard will pertain only to buildings and areas of buildings that are directly affected by measures implemented in this project and under which this HVAC equipment has direct control over space comfort conditions. HVAC comfort conditions cannot be guaranteed when operable windows or doors are open.

Space Conditions:
Occupied:

- Office:
  - Heating Set Point - 68 degrees F
  - Cooling Set Point - 78 degrees F (where mechanical cooling systems are employed)
- Warehouse:

- Heating Set Point - 65 degrees F
- Cooling Set Point - 70 degrees F (where mechanical cooling systems are employed)
- 30% - 50% RH (as capable of being maintained with current HVAC system)

Unoccupied:

- Office:
    - Minimum - 55 degrees F
    - Maximum - 90 degrees F (where mechanical cooling systems are employed)
- Warehouse:
    - Minimum - 65 degrees F
    - Maximum - 70 degrees F (where mechanical cooling systems are employed)
    - 30% - 50% RH (as capable of being maintained with current HVAC system)

Minimum outside air per occupant:

- In accordance with ANSI/ASHRAE Standard 62.1-2007, standards and the International Mechanical Code as adopted by the Washington State Building Code Council effective July 1 2010.

HVAC Equipment Operating Hours:

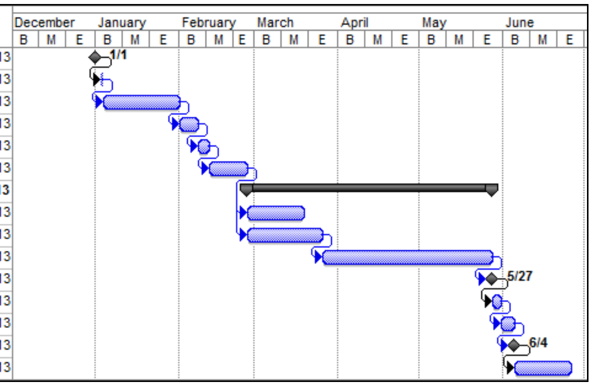
- The operating schedules for the equipment installed as a part of this project will remain the same as the original baseline operating schedule unless schedule changes have been proposed and implemented as a part of this project.

7.0 IMPLEMENTATION PLAN

7.1 Project Schedule

A preliminary project schedule for the State Modular Building ESPC project milestones is shown below.

ID	Indicators	Task Name	Duration	Start	Finish
1		**Notice to Proceed**	0 days	Tue 1/1/13	Tue 1/1/13
2		Kick-Off Meeting	1 day	Thu 1/3/13	Thu 1/3/13
3		Engineering Begins	20 days	Fri 1/4/13	Thu 1/31/13
4		Submittals	5 days	Fri 2/1/13	Thu 2/7/13
5		Site Mobilization	2 days	Fri 2/8/13	Mon 2/11/13
6		Demolition and Prep	10 days	Tue 2/12/13	Mon 2/25/13
7		**Installation**	**65 days**	**Tue 2/26/13**	**Mon 5/27/13**
8		UCM-1 Lighting & Controls Upgrade	15 days	Tue 2/26/13	Mon 3/18/13
9		UCM-2 Controsl Upgrades	20 days	Tue 2/26/13	Mon 3/25/13
10		UCM-3 Energy Based RCx	45 days	Tue 3/26/13	Mon 5/27/13
11		Substantial Completion	0 days	Mon 5/27/13	Mon 5/27/13
12		Punch List	3 days	Tue 5/28/13	Thu 5/30/13
13		Post Measurements Complete	3 days	Fri 5/31/13	Tue 6/4/13
14		Project Complete	0 days	Tue 6/4/13	Tue 6/4/13
15		O&M and M&V Reports	15 days	Wed 6/5/13	Tue 6/25/13



8.0 APPENDIX

UCM 1.0 Lighting & Lighting Controls Upgrades - Energy Savings Estimates

Project Name	State Modular Building		
Address	7580 New Market St SW		
City	Tumwater		
State	Washington	Tax Rate	0.00%
County	Thurston	Zip Code	98501

Facility Contact	Scott Locke UMC		
Phone	(206) 295-3214	Ext.	
Building Contact			
Phone		Ext.	
Facility Type		Heat	
Sq. Feet		AC	

Auditor(s)	Mike Campbell	NWE Contact Phone	(509) 680-3963		
Audit Date		Office Phone #	(425) 806-9200		
Last Revised	8/15/12	Office Fax #	(425) 806-7455		
Utility	Puget Sound Energy	kWh Rate		Demand Rate	
Lamp Replace		Ballast Replace		Second Tier Start Level	0.0000
Group Spot		PCB / Percent		Maint. Rate	

ECM #		Location	Fixture Qty	Fixture ID	Existing / Proposed Fixture Description	Lamp Wat	Fixture Wat	Fixture Heig	Hours/ Da	Days/ Wee	FC	Sensor Qty	Sensor / Power Pac	Energy Save	Sensor Heig	Survey Notes
1	E	Entry / Reception	3	EFMV100	Existing Fixture Mercury Vapor 100 watt Lamp	100	125		9	5						use 841 lamps unless specified
	P	Entry / Reception	3	CFLR32	Retrofit HID with 32 watt CFL Lamp and Ballast	32	32		9	5						
2	E	Entry / Reception	12	ECFL32	Existing 32 watt CFL Lamp	32	32		9	5						leave as is
	P	Entry / Reception	12	ECFL32	Existing 32 watt CFL Lamp	32	32		9	5						
3	E	Entry / Reception	2	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						3L ballast. existing has one lamp removed
	P	Entry / Reception	2	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
4	E	Entry / Reception	1	ET2217N	Existing Troffer 2x2 2L F17 T8, NBF Ballast	17	33		9	5						relamp for color
	P	Entry / Reception	1	RL217N	Relamp with 2 F17 T8 Lamps	17	33		9	5						
5	E	Conf 115	7	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	Conf 115	7	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
6	E	101 Office	7	ET4332N	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	101 Office	7	TK4228N	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
7	E	Shop Area - Under Mezz	34	ES8432N	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112		16	5	35					850. lots of end caps missing. 11 burned out lamps
	P	Shop Area - Under Mezz	34	LB428N	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, NBF Ballast	28	96		16	5						
8	E	Production Manager Office	5	EW4332N	Existing Wrap T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5		1.00	WSDPDT2PI	20%		
	P	Production Manager Office	5	WK4228NP	Wrap Kit with Reflector 4' 2L F32 T8 28 watt Lamps, PRS NBF Ballast	28	48		9	5				20%		
9	E	Closet	1	EW4232N	Existing Wrap T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	Closet	1	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		2	5						
10	E	Mezzanine	29	ES8232N	Existing Strip T8 8' w 2 F32 32 watt Lamp, NBF Ballast	32	58		16	5						850
	P	Mezzanine	29	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		16	5						
11	E	Rest of Production Area	152	ES8432N	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112	25.0 ft	16	5						217 lamps burned out. 850
	P	Rest of Production Area	152	LB428N	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, NBF Ballast	28	96	25.0 ft	16	5						
12	E	Rest of Production Area - Over Machine	5	ES8432N	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112	14.0 ft	16	5						
	P	Rest of Production Area - Over Machine	5	LB428H	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, HBF Ballast	28	130	14.0 ft	16	5						
13	E	Rest of Production Area - Over Machine	4	ET4332N	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		16	5						850
	P	Rest of Production Area - Over Machine	4	TK4228H	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, HBF Ballast	28	65		16	5						
14	E	Rest of Production Area - Over Machine	8	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		16	5						
	P	Rest of Production Area - Over Machine	8	LB228H	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, HBF Ballast	28	65		16	5						
15	E	Rest of Production Area - Over Machine	31	ES8296H	Existing Strip 8' 2 Lamp F96 T12 HO Ballast	95	221		16	5						850
	P	Rest of Production Area - Over Machine	31	SKR8428H4	Strip Kit with Reflector 8' w 4 F32 28 watt Lamp, HBF Ballast 4.25" Brackets	28	130		16	5						
16	E	Rest of Production Area - Over Machine	1	EW4432N	Existing Wrap T8 4' w 4 F32 32 watt Lamp, NBF Ballast	32	112		16	5						850. no cover
	P	Rest of Production Area - Over Machine	1	WK4228H	Wrap Kit with Reflector 4' 2L F32 T8 28 watt Lamps, HBF Ballast	28	65		16	5						
17	E	Rest of Production Area	4	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		16	5						
	P	Rest of Production Area	4	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		16	5						
18	E	Rest of Production Area	2	ET2217N	Existing Troffer 2x2 2L F17 T8, NBF Ballast	17	33		16	5						
	P	Rest of Production Area	2	RL217N	Relamp with 2 F17 T8 Lamps	17	33		16	5						
19	E	Rest of Production Area	6	ES8432N	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112	14.0 ft	16	5						850. against wall - walkway
	P	Rest of Production Area	6	LB428N	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, NBF Ballast	28	96	14.0 ft	16	5						

20	E	Room 209 - Press Supervisor	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	Room 209 - Press Supervisor	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
21	E	208 Bindery Office	4	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	208 Bindery Office	4	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
22	E	207 Office	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	207 Office	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
23	E	301 Electrical	2	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	301 Electrical	2	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		2	5						
24	E	302 Telephone Room	2	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	302 Telephone Room	2	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		2	5						
25	E	119 Womens RR	5	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5		1.00	WSDPDTI	20%		
	P	119 Womens RR	5	**LB228LP**	Lamp and Ballast Retrofit 2L F32 T8 28 watt Lamps, PRS LBF Ballast	28	42		9	5				20%		
26	E	201 Office	4	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	201 Office	4	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
27	E	202 Server Room	6	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	202 Server Room	6	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		2	5						
28	E	305 Electrical	4	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	305 Electrical	4	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		2	5						
29	E	210 Press Room	8	**ES4248H**	Existing Strip 4' 2 Lamp F48 T12 HO Ballast	60	133		16	5						850
	P	210 Press Room	8	**NVS4328H**	New V-Strip Fixture 4' 3L F32 T8 28 watt Lamps, High BF Ballast	28	99		16	5						
30	E	210 Press Room	3	**ES8296H**	Existing Strip 8' 2 Lamp F96 T12 HO Ballast	95	221		16	5						850
	P	210 Press Room	3	**SKR8428H4**	Strip Kit with Reflector 8' w 4 F32 28 watt Lamp, HBF Ballast 4.25" Brackets	28	130		16	5						
31	E	210 Press Room	1	**ES8432N**	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112		16	5						850
	P	210 Press Room	1	**LB428N**	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, NBF Ballast	28	96		16	5						
32	E	Mezzanine	9	**ES8432N**	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112		16	5						850
	P	Mezzanine	9	**LB428N**	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, NBF Ballast	28	96		16	5						
33	E	307 Vault	8	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	307 Vault	8	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
34	E	Mezz Above Vault	3	**ES8432N**	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112		9	5						
	P	Mezz Above Vault	3	**LB428N**	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, NBF Ballast	28	96		9	5						
35	E	Chemical Room	1	**EINC100**	Existing Incandescent 100 watt Lamp	100	100		9	5						explosion proof
	P	Chemical Room	1	**CFLR32**	Retrofit HID with 32 watt CFL Lamp and Ballast	32	32		9	5						
36	E	309 Area	7	**ES8232N**	Existing Strip T8 8' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5	25					850
	P	309 Area	7	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
37	E	313 Locked Room	2	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	313 Locked Room	2	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
38	E	312 Locked Room	2	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	312 Locked Room	2	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
39	E	311	4	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	311	4	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						

40	E	Mezz in this Area	8	ES4232N	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						850
	P	Mezz in this Area	8	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
41	E	212A	4	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	212A	4	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
42	E	212B	7	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	212B	7	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
43	E	308	1	ES8432N	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112		9	5						850
	P	308	1	LB428L	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, LBF Ballast	28	84		9	5						
44	E	310	4	ES8432N	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	32	112		9	5						
	P	310	4	LB428N	Lamp And Ballast Retrofit w 4 F32 28 watt Lamp, NBF Ballast	28	96		9	5						
45	E	206 Hall and Open Area back by Womens RR	9	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						850
	P	206 Hall and Open Area back by Womens RR	9	LB228H	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, HBF Ballast	28	65		9	5						
46	E	206 Hall and Open Area back by Womens RR	2	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						850
	P	206 Hall and Open Area back by Womens RR	2	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
47	E	206 Hall and Open Area back by Womens RR	6	ET2232N	Existing Troffer 2x2 2L F32 T8 U-Tube Lamps, NBF Ballast	32	58		9	5						850
	P	206 Hall and Open Area back by Womens RR	6	TK2217N	Troffer Kit with Reflector 2' w 2 F17 17 watt Lamp NBF	17	31		9	5						
48	E	118 RR in 206	5	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5		1.00	WSDPDT2PI	20%		
	P	118 RR in 206	5	LB228LP	Lamp and Ballast Retrofit 2L F32 T8 28 watt Lamps, PRS LBF Ballast	28	42		9	5				20%		
49	E	120 First Aid	1	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	120 First Aid	1	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
50	E	Hot Water Room in 206	1	ES4232N	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	Hot Water Room in 206	1	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		2	5						
51	E	Old Dark Room	11	EINC60	Existing Incandescent 60 watt Lamp	60	60		9	5						drop ceiling. 850
	P	Old Dark Room	4	NT4228H	New Troffer Fixture 4' w 2 F32 28 watt Lamp, HBF Ballast	28	65		9	5						
52	E	Old Dark Room	2	ES8260N	Existing Strip 8' 2 Lamp F96 60 watt Lamp T12 Standard Ballast	60	138		9	5						850
	P	Old Dark Room	2	NT4228H	New Troffer Fixture 4' w 2 F32 28 watt Lamp, HBF Ballast	28	65		9	5						
53	E	Next Section with Maps on Wall	15	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						850
	P	Next Section with Maps on Wall	15	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
54	E	204 Hall	5	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	204 Hall	5	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
55	E	204 Hall	9	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	204 Hall	9	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
56	E	Open Area / Cubes	19	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	Open Area / Cubes	19	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
57	E	Office 201	5	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	Office 201	5	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
58	E	Office / Storage off of 201	4	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	Office / Storage off of 201	4	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
59	E	Office 203	4	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	Office 203	4	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						

60	E	1104D	4	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	1104D	4	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
61	E	200 Facilities Office	2	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	200 Facilities Office	2	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
62	E	Telephone Room	1	**ES4132N**	Existing Strip T8 4' w 1 F32 32 watt Lamp, NBF Ballast	32	32		2	5						
	P	Telephone Room	1	**LB128L**	Lamp And Ballast Retrofit w 1 F32 28 watt Lamp, LBF Ballast	28	22		2	5						
63	E	100	105	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						62 lamps burned out
	P	100	105	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
64	E	109 HR Office	4	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	109 HR Office	4	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
65	E	108 Conf	6	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	108 Conf	6	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
66	E	107 Office	4	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	107 Office	4	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
67	E	106 Office	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	106 Office	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
68	E	105 Office	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	105 Office	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
69	E	104 Office	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	104 Office	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
70	E	103 Office	4	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	103 Office	4	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
71	E	102 Office	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	102 Office	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
72	E	101 Office	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	101 Office	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
73	E	300 Admin Supply	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		2	5						
	P	300 Admin Supply	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		2	5						
74	E	113 Office	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	113 Office	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
75	E	114 Office	2	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	114 Office	2	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
76	E	Front of Main Shop - Halls	41	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	Front of Main Shop - Halls	41	**LB228L**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
77	E	Front of Main Shop - Halls	10	**ET2217N**	Existing Troffer 2x2 2L F17 T8, NBF Ballast	17	33		9	5						
	P	Front of Main Shop - Halls	10	**RL217N**	Relamp with 2 F17 T8 Lamps	17	33		9	5						
78	E	Front of Main Shop - Halls	6	**ECFL32**	Existing 32 watt CFL Lamp	32	32		9	5						can light
	P	Front of Main Shop - Halls	6	**ECFL32**	Existing 32 watt CFL Lamp	32	32		9	5						
79	E	Front of Main Shop - Halls	3	**EFMV100**	Existing Fixture Mercury Vapor 100 watt Lamp	100	125		9	5						can light
	P	Front of Main Shop - Halls	3	**CFLR32**	Retrofit HID with 32 watt CFL Lamp and Ballast	32	32		9	5						

80	E	Telephone Room	1	**ES4132N**	Existing Strip T8 4' w 1 F32 32 watt Lamp, NBF Ballast	32	32		2	5						
	P	Telephone Room	1	**LB128L**	Lamp And Ballast Retrofit w 1 F32 28 watt Lamp, LBF Ballast	28	22		2	5						
81	E	Main Telephone Room	1	**ES4232N**	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	Main Telephone Room	1	**LB228L**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		2	5						
82	E	Main Electrical	2	**ES4232N**	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	Main Electrical	2	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		2	5						
83	E	705 Sprinkler Room	1	**ES4232N**	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	705 Sprinkler Room	1	**LB228L**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		2	5						
84	E	507 Mens RR	4	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5		1.00	WSDPDTI	20%		
	P	507 Mens RR	4	**LB228LP**	Lamp and Ballast Retrofit 2L F32 T8 28 watt Lamps, PRS LBF Ballast	28	42		9	5				20%		
85	E	702 Fire Alarm Room	2	**ES4232N**	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	702 Fire Alarm Room	2	**LB228L**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		2	5						
86	E	506 Womens RR	4	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5		1.00	WSDPDTI	20%		
	P	506 Womens RR	4	**LB228LP**	Lamp and Ballast Retrofit 2L F32 T8 28 watt Lamps, PRS LBF Ballast	28	42		9	5				20%		
87	E	504 Cafeteria	12	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	504 Cafeteria	12	**LB228L**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		9	5						
88	E	707 Conf	12	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	707 Conf	12	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
89	E	708 6A Storage	10	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	708 6A Storage	10	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		2	5						
90	E	Telephone Room	1	**ES4132N**	Existing Strip T8 4' w 1 F32 32 watt Lamp, NBF Ballast	32	32		2	5						
	P	Telephone Room	1	**LB128L**	Lamp And Ballast Retrofit w 1 F32 28 watt Lamp, LBF Ballast	28	22		2	5						
91	E	Mech to left	1	**ES4232N**	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	Mech to left	1	**LB228L**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		2	5						
92	E	710 Fulfillment	135	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	710 Fulfillment	135	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
93	E	710 Fulfillment	29	**ET2217N**	Existing Troffer 2x2 2L F17 T8, NBF Ballast	17	33		9	5						
	P	710 Fulfillment	29	**RL217N**	Relamp with 2 F17 T8 Lamps	17	33		9	5						
94	E	710 Fulfillment	58	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	710 Fulfillment	58	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
95	E	715	6	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	715	6	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
96	E	714 in 710	6	**ET4332N**	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	32	85		9	5						
	P	714 in 710	6	**TK4228N**	Troffer Kit with Reflector 4' w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
97	E	Telephone Room A back in Hall	1	**ES4132N**	Existing Strip T8 4' w 1 F32 32 watt Lamp, NBF Ballast	32	32		2	5						
	P	Telephone Room A back in Hall	1	**LB128L**	Lamp And Ballast Retrofit w 1 F32 28 watt Lamp, LBF Ballast	28	22		2	5						
98	E	500 Info Doc Service	113	**ET4232N**	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						850, except 4 over cubes get 841
	P	500 Info Doc Service	113	**LB228N**	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
99	E	500 Info Doc Service	8	**ET2217N**	Existing Troffer 2x2 2L F17 T8, NBF Ballast	17	33		9	5						
	P	500 Info Doc Service	8	**RL217N**	Relamp with 2 F17 T8 Lamps	17	33		9	5						

100	E	501 Office	6	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	501 Office	6	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
101	E	502 Mens RR (back in hall)	3	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5		1.00	WSDPDTI	20%		
	P	502 Mens RR (back in hall)	3	LB228LP	Lamp and Ballast Retrofit 2L F32 T8 28 watt Lamps, PRS LBF Ballast	28	42		9	5				20%		
102	E	503 Womens RR	3	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5		1.00	WSDPDTI	20%		
	P	503 Womens RR	3	LB228LP	Lamp and Ballast Retrofit 2L F32 T8 28 watt Lamps, PRS LBF Ballast	28	42		9	5				20%		
103	E	700 State Library	110	ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		9	5						
	P	700 State Library	110	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		9	5						
104	E	700 State Library	1	ET2217N	Existing Troffer 2x2 2L F17 T8, NBF Ballast	17	33		9	5						
	P	700 State Library	1	RL217N	Relamp with 2 F17 T8 Lamps	17	33		9	5						
105	E	700A Electrical	2	ES4232N	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	700A Electrical	2	LB228N	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, NBF Ballast	28	48		2	5						
106	E	700B Custodian	1	ES4232N	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	32	58		2	5						
	P	700B Custodian	1	LB228L	Lamp And Ballast Retrofit w 2 F32 28 watt Lamp, LBF Ballast	28	42		2	5						
	E	**Existing Fixture Total**	**1,254**													
	P	**Proposed Fixture Total**	**1,247**								**Sensor Total**	**7**				

Project Analysis for State Modular Building

Energy Analysis

Existing System Baseline 283,234 kWh / Yr.

Energy Efficient System 215,256 kWh / Yr.

Energy Reduction 24.00%

Annual Energy Savings 67,978 kWh / Yr.

Maintenance Savings Calculations

Code	Description	Qty	Lamps	Type	Lamp Watts	Input Watts	Lamp Life	Annual Hours	Lamp Changes Per Year	Retail Price	Lamps x Cost	Year 1 Lamp Replacement Costs	Year 2 Lamp Replacement Costs	Year 3 Lamp Replacement Costs	Year 4 Lamp Replacement Costs	Year 5 Lamp Replacement Costs
ECFL32	Existing 32 watt CFL Lamp	**18**	1	CFL	32	32	10,000	2,340	4.21	$5.00	$5.00	$21.06	$21.69	$22.34	$23.01	$23.70
ET2217N	Existing Troffer 2x2 2L F17 T8, NBF Ballast	**51**	2	T8	17	33	20,000	2,340	5.97	$4.00	$8.00	$47.74	$49.17	$50.64	$52.16	$53.73
ET2232N	Existing Troffer 2x2 2L F32 T8 U-Tube Lamps, NBF Ballast	**6**	2	T8	32	58	20,000	2,340	0.70	$4.00	$8.00	$5.62	$5.78	$5.96	$6.14	$6.32
ES4248H	Existing Strip 4' 2 Lamp F48 T12 HO Ballast	**8**	2	F	60	133	20,000	4,160	1.66	$4.00	$8.00	$13.31	$13.71	$14.12	$14.55	$14.98
ES8260N	Existing Strip 8' 2 Lamp F96 60 watt Lamp T12 Standard Ballast	**2**	2	F	60	138	20,000	2,340	0.23	$4.00	$8.00	$1.87	$1.93	$1.99	$2.05	$2.11
ES8296H	Existing Strip 8' 2 Lamp F96 T12 HO Ballast	**34**	2	F	95	221	20,000	4,160	7.07	$4.00	$8.00	$56.58	$58.27	$60.02	$61.82	$63.68
EINC60	Existing Incandescent 60 watt Lamp	**11**	1	INC	60	60	1,000	2,340	25.74	$2.00	$2.00	$51.48	$53.02	$54.62	$56.25	$57.94
EINC100	Existing Incandescent 100 watt Lamp	**1**	1	INC	100	100	1,000	2,340	2.34	$2.00	$2.00	$4.68	$4.82	$4.97	$5.11	$5.27
EFMV100	Existing Fixture Mercury Vapor 100 watt Lamp	**6**	1	MV	100	125	20,000	2,340	0.70	$23.00	$23.00	$16.15	$16.63	$17.13	$17.64	$18.17
ES4132N	Existing Strip T8 4' w 1 F32 32 watt Lamp, NBF Ballast	**4**	1	F	32	32	20,000	520	0.10	$4.00	$4.00	$0.42	$0.43	$0.44	$0.45	$0.47
ES4232N	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	**19**	2	F	32	58	20,000	520	0.49	$4.00	$8.00	$3.95	$4.07	$4.19	$4.32	$4.45
ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	**608**	2	F	32	58	20,000	2,340	71.14	$4.00	$8.00	$569.09	$586.16	$603.75	$621.86	$640.51
ET4332N	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	**228**	3	F	32	85	20,000	2,340	26.68	$4.00	$12.00	$320.11	$329.72	$339.61	$349.80	$360.29
EW4232N	Existing Wrap T8 4' w 2 F32 32 watt Lamp, NBF Ballast	**1**	2	F	32	58	20,000	520	0.03	$4.00	$8.00	$0.21	$0.21	$0.22	$0.23	$0.23
EW4332N	Existing Wrap T8 4' w 3 F32 32 watt Lamp, NBF Ballast	**5**	3	F	32	85	20,000	2,340	0.59	$4.00	$12.00	$7.02	$7.23	$7.45	$7.67	$7.90
EW4432N	Existing Wrap T8 4' w 4 F32 32 watt Lamp, NBF Ballast	**1**	4	F	32	112	20,000	4,160	0.21	$4.00	$16.00	$3.33	$3.43	$3.53	$3.64	$3.75
ES8232N	Existing Strip T8 8' w 2 F32 32 watt Lamp, NBF Ballast	**36**	2	F	32	58	20,000	2,340	4.21	$4.00	$8.00	$33.70	$34.71	$35.75	$36.82	$37.93
ES8432N	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	**215**	4	F	32	112	20,000	2,340	25.16	$4.00	$16.00	$402.48	$414.55	$426.99	$439.80	$452.99
												$1,558.78	$1,605.54	$1,653.71	$1,703.32	$1,754.42

Code	Description	Qty	Ballasts	Type	Lamp Watts	Input Watts	Ballast Life	Annual Hours	Ballast Changes Per Year	Retail Price	Ballasts x Cost	Year 1 Ballast Replacement Costs	Year 2 Ballast Replacement Costs	Year 3 Ballast Replacement Costs	Year 4 Ballast Replacement Costs	Year 5 Ballast Replacement Costs
ECFL32	Existing 32 watt CFL Lamp	**18**	1	CFL	32	32	50,000	2,340	0.84	$20.00	$20.00	$16.85	$17.35	$17.87	$18.41	$18.96
ET2217N	Existing Troffer 2x2 2L F17 T8, NBF Ballast	**51**	2	T8	17	33	60,000	2,340	1.99	$11.00	$22.00	$43.76	$45.07	$46.42	$47.82	$49.25
ET2232N	Existing Troffer 2x2 2L F32 T8 U-Tube Lamps, NBF Ballast	**6**	2	T8	32	58	60,000	2,340	0.23	$11.00	$22.00	$5.15	$5.30	$5.46	$5.63	$5.79
ES4248H	Existing Strip 4' 2 Lamp F48 T12 HO Ballast	**8**	2	F	60	133	60,000	4,160	0.55	$25.00	$50.00	$27.73	$28.57	$29.42	$30.30	$31.21
ES8260N	Existing Strip 8' 2 Lamp F96 60 watt Lamp T12 Standard Ballast	**2**	2	F	60	138	60,000	2,340	0.08	$25.00	$50.00	$3.90	$4.02	$4.14	$4.26	$4.39
ES8296H	Existing Strip 8' 2 Lamp F96 T12 HO Ballast	**34**	2	F	95	221	60,000	4,160	2.36	$25.00	$50.00	$117.87	$121.40	$125.04	$128.80	$132.66
EFMV100	Existing Fixture Mercury Vapor 100 watt Lamp	**6**	1	MV	100	125	60,000	2,340	0.23	$65.00	$65.00	$15.21	$15.67	$16.14	$16.62	$17.12
ES4132N	Existing Strip T8 4' w 1 F32 32 watt Lamp, NBF Ballast	**4**	1	F	32	32	60,000	520	0.03	$11.00	$11.00	$0.38	$0.39	$0.40	$0.42	$0.43
ES4232N	Existing Strip T8 4' w 2 F32 32 watt Lamp, NBF Ballast	**19**	2	F	32	58	60,000	520	0.16	$11.00	$22.00	$3.62	$3.73	$3.84	$3.96	$4.08
ET4232N	Existing Troffer T8 4' w 2 F32 32 watt Lamp, NBF Ballast	**608**	2	F	32	58	60,000	2,340	23.71	$11.00	$22.00	$521.66	$537.31	$553.43	$570.04	$587.14
ET4332N	Existing Troffer T8 4' w 3 F32 32 watt Lamp, NBF Ballast	**228**	3	F	32	85	60,000	2,340	8.89	$11.00	$33.00	$293.44	$302.24	$311.31	$320.65	$330.26
EW4232N	Existing Wrap T8 4' w 2 F32 32 watt Lamp, NBF Ballast	**1**	2	F	32	58	60,000	520	0.01	$11.00	$22.00	$0.19	$0.20	$0.20	$0.21	$0.21
EW4332N	Existing Wrap T8 4' w 3 F32 32 watt Lamp, NBF Ballast	**5**	3	F	32	85	60,000	2,340	0.20	$11.00	$33.00	$6.44	$6.63	$6.83	$7.03	$7.24
EW4432N	Existing Wrap T8 4' w 4 F32 32 watt Lamp, NBF Ballast	**1**	4	F	32	112	60,000	4,160	0.07	$11.00	$44.00	$3.05	$3.14	$3.24	$3.33	$3.43
ES8232N	Existing Strip T8 8' w 2 F32 32 watt Lamp, NBF Ballast	**36**	2	F	32	58	60,000	2,340	1.40	$11.00	$22.00	$30.89	$31.81	$32.77	$33.75	$34.76
ES8432N	Existing Strip T8 8' w 4 F32 32 watt Lamp, NBF Ballast	**215**	4	F	32	112	60,000	2,340	8.39	$11.00	$44.00	$368.94	$380.01	$391.41	$403.15	$415.25
												$1,459.07	$1,502.84	$1,547.93	$1,594.37	$1,642.20
											Year	**1**	**2**	**3**	**4**	**5**
											Annual Savings =	**$3,017.85**	**$3,108.39**	**$3,201.64**	**$3,297.69**	**$3,396.62**

UCM 2.0 HVAC Controls Upgrade - Energy Savings Estimates

Energy Savings Estimate

Overview:

Implement RCx on primary HVAC systems (HW, CHW, RTUs)

Notes:

Savings Calculations

	Baseline Operation			Annual Savings	
	Annual kWh	Annual Therms	% Savings	kWh	Therms
HW Heating		61120	2%	-	1,222
				-	-
Subtotal	-			-	1,222

Assumptions:

HVAC system currently operates 24/7.
Unoccupied setback is not currently occupied in any location within the facility
RCx commissioning will result in a minimum average savings of 5% of current usage on chillers
RCx commissioning will result in a minimum average savings of 5% of current usage on fan motor operation of all 4 RTUs

Estimated Annual Savings:

Gas Savings =	**1,222**	**therms**
Elect Savings =	**-**	
Water Savings =		
Sewer Savings =		
Cost Savings ($) =	**$ -**	

Utility Information:

Electrical Cost ($/kwh) = Water Cost ($/kgal) =
Heating Cost ($/therm) = Sewer Cost ($/kgal) =

UNIVERSITY MECHANICAL CONTRACTORS, INC. We Build Value

Project:	**State Modular Building**	**Job #:**	
		Date:	**10/30/2012**
Subject:	**ECM-2: HVAC Controls Upgrade**	**By:**	**SRL**
		Page:	

UCM 3.0 Energy Based Re-Commissioning - Energy Savings Estimates

Energy Savings Estimate

Overview:

Implement RCx on primary HVAC systems (HW, CHW, RTUs)

Notes:

Modify control sequence to reduce OA at night to minimum OA at all times. The RTUs currently modulate to full OA during these periods.

Savings Calculations

OAT	Annual Hours	Existing Annual Heating (therms)	Proposed Annual Heating (therms)	Estimated Annual Savings (therms)
57.5	774	1,528	109	1,418
52.5	816	2,165	155	2,010
47.5	781	2,604	187	2,418
42.5	641	2,575	184	2,390
37.5	391	1,835	131	1,704
32.5	140	750	54	697
27.5	35	209	15	194
22.5	15	98	7	91
17.5	11	78	6	72
12.5	2	12	1	11
Subtotal	**3,602**	**11,854**	**849**	**11,005**

Assumptions:

HVAC system currently operates 24/7.
Unoccupied setback is not currently occupied in any location within the facility
Total Avg Annual RTU cfm (total of 2 High Bay RTUs) = 43,065 cfm
Total Avg Annual RTU cfm (total of 2 Low Bay RTUs) = 14,725 cfm
% Avg RTU cfm supplied to HD = 25%

High Bay Units:			High Bay Units:	
RTU control dampers currently modulate to	80%	OA at ~ 10:00pm each night	Design cfm (total 2 HB RTUs) =	57,420
Amount of OA provided by RTUs during daytime	0%	OA at ~ 10:00am each morning	Average VFD Speed =	75%
Low Bay Units:			Low Bay Units:	
RTU control dampers currently modulate to	40%	OA at ~ 10:00pm each night	Design cfm (total 2 HB RTUs) =	29,450
Amount of OA provided by RTUs during daytime	0%	OA at ~ 10:00am each morning	Average VFD Speed =	50%

Average Space Temperature (heating) = 72 F
Heating System Efficiency = 80%

RTU control dampers proposed to modulate to 5% OA during unoccupied periods (night) — Minimum Design OA (all 4 RTUs) = 10,700

Estimated Annual Savings:

Gas Savings = **11,005** **therms**
Elect Savings =
Water Savings =
Sewer Savings =

Cost Savings ($) =** **$ -

Utility Information:

Electrical Cost ($/kwh) = | Water Cost ($/kgal) =
Heating Cost ($/therm) = | Sewer Cost ($/kgal) =

UNIVERSITY MECHANICAL CONTRACTORS, INC.
We Build Value

Project:	**State Modular Building**	**Job #:**	
		Date:	**10/30/2012**
Subject:	**ECM-3: Energy Based Re-Commissioning**	**By:**	**SRL**
		Page:	

Energy Savings Estimate

Overview:

Implement RCx on primary HVAC systems (HW, CHW, RTUs)

Notes:

Savings associated with main RTU average fan speed reduction & redulting reduction in chiller operation.

Savings Calculations

	Baseline Operation			Annual Savings	
	Annual kWh	Annual Therms	% Savings	kWh	Therms
RTU Fans	547,901		5%	27,395	-
Chillers	105,000		5%	5,250	-
Subtotal	652,901			32,645	

Assumptions:

HVAC system currently operates 24/7.
Unoccupied setback is not currently occupied in any location within the facility
RCx commissioning will result in a minimum average savings of 5% of current usage on chillers
RCx commissioning will result in a minimum average savings of 5% of current usage on fan motor operation of all 4 RTUs

Estimated Annual Savings:

Gas Savings =	**-**	**therms**
Elect Savings =	**32,645**	
Water Savings =		
Sewer Savings =		
Cost Savings ($) =	**$ -**	

Utility Information:

Electrical Cost ($/kwh) = Water Cost ($/kgal) =
Heating Cost ($/therm) = Sewer Cost ($/kgal) =

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We Build Value

Project:	**State Modular Building**	**Job #:**	
		Date:	**10/30/2012**
Subject:	**ECM-3: Energy Based Re-Commissioning**	**By:**	**SRL**
		Page:	

Baseline Adjustment Calculation Associated with the Implementation of UCM 3.0 (Increased ventilation air during occupied periods)

Baseline Adjustmnet

Overview:

Baseline Adjustment calculations applied to allow for required ventilation air during occupied hours

Notes:

Modify OA/RA damper operation & RA fan speed to provide minimum OA during occupied operation

Savings Calculations

OAT	Annual Hours	Existing Annual Heating (therms)	Proposed Annual Heating (therms)	Estimated Baseline Adjustment (therms)
57.5	650	-	359	359
52.5	662	-	492	492
47.5	686	-	641	641
42.5	516	-	580	580
37.5	266	-	350	350
32.5	74	-	111	111
27.5	23	-	38	38
22.5	11	-	20	20
17.5	5	-	9	9
12.5	2	-	3	3
Subtotal	**2,893**	**-**	**2,603**	**2,603**

OAT	Annual Hours	Existing Annual Cooling kWh	Proposed Annual Cooling kWh	Estimated Baseline Adjustment kWh
97.5	1	-	8,848	8,848
92.5	4	-	7,236	7,236
87.5	20	-	5,676	5,676
82.5	64	-	2,891	2,891
77.5	128	-	781	781
72.5	250	-	20	20
67.5	412	-	(54)	(54)
62.5	607	-	(53)	(53)
Subtotal	**1,484**	**-**	**25,344**	**25,344**

Assumptions:

HVAC system currently operates 24/7.

Unoccupied setback is not currently occupied in any location within the facility

Total Avg Annual RTU cfm (total of all 4 RTUs) = 56,466 cfm

Design cfm (total all 4 RTUs) = 86,870

% Avg RTU cfm supplied to HD = 25%

Average VFD Speed = 65%

RTU control dampers currently modulate to 0% OA at ~ 10:00am each morning

Minimum Design OA (all 4 RTUs) = 10,700

RTU control dampers currently modulate to 80% OA at ~ 10:00pm each night

Average Space Temperature (heating) = 72 F

Heating System Efficiency = 80%

Estimated chiller efficiency = 0.70 kW/ton

Average Space Temperature (cooling) = 72 F

% Avg RTU cfm supplied to CD = 75%

Proposed Operation:

RTU control dampers proposed to modulate to 5% OA during unoccupied periods (night)

RTU control dampers proposed to modulate to 20% OA during occupied periods (7:00am to 10:00pm)

Estimated Baseline Adjustment:

Gas Adjustment = 2,603 therms

Elect Adjustment = 25,344

Utility Information:

Electrical Cost ($/kwh) =

Heating Cost ($/therm) =

Water Cost ($/kgal) =

Sewer Cost ($/kgal) =

UNIVERSITY MECHANICAL CONTRACTORS, INC.
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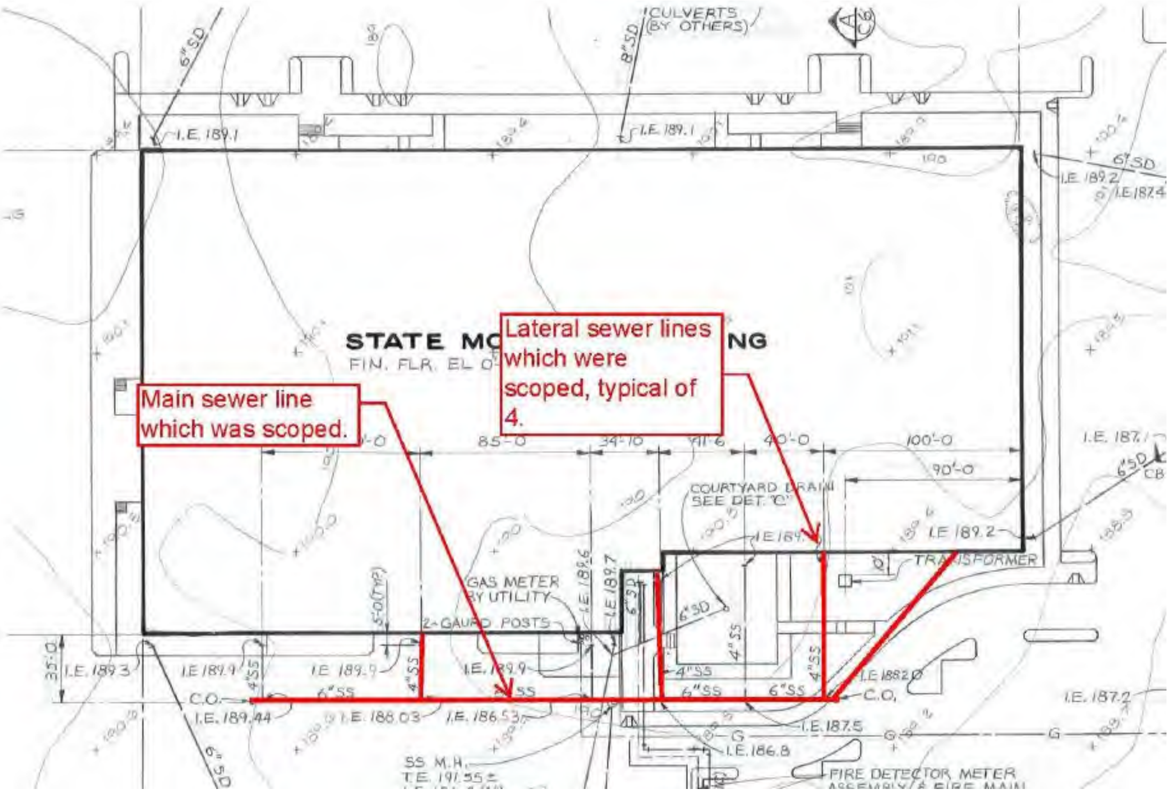
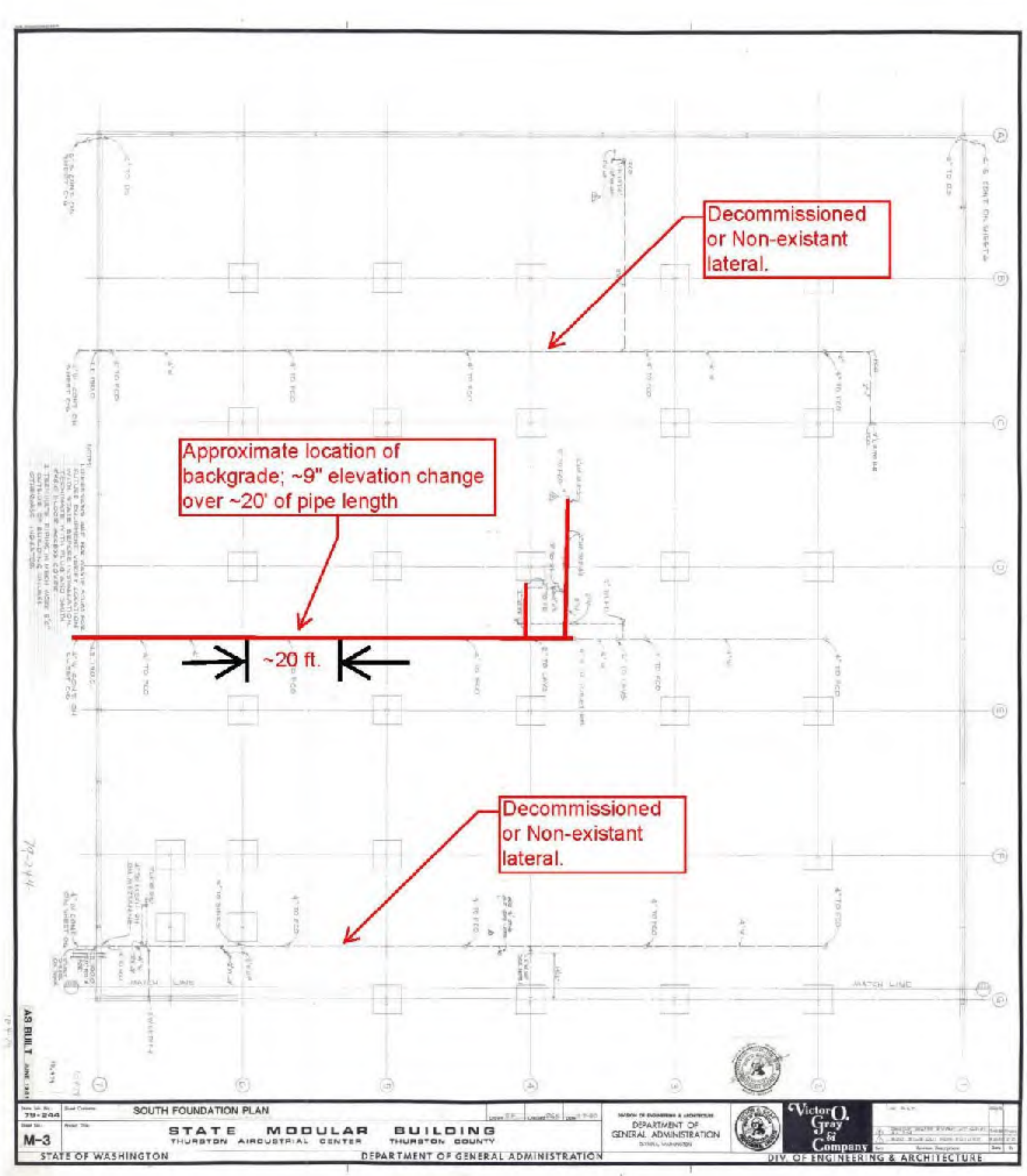
Project:	**State Modular Building**	**Job #:**	
		Date:	**10/30/2012**
Subject:	**Baseline Adjustment associated with UCM-3**	**By:**	**SRL**
		Page:	

Appendix H - Sewer Piping Maps

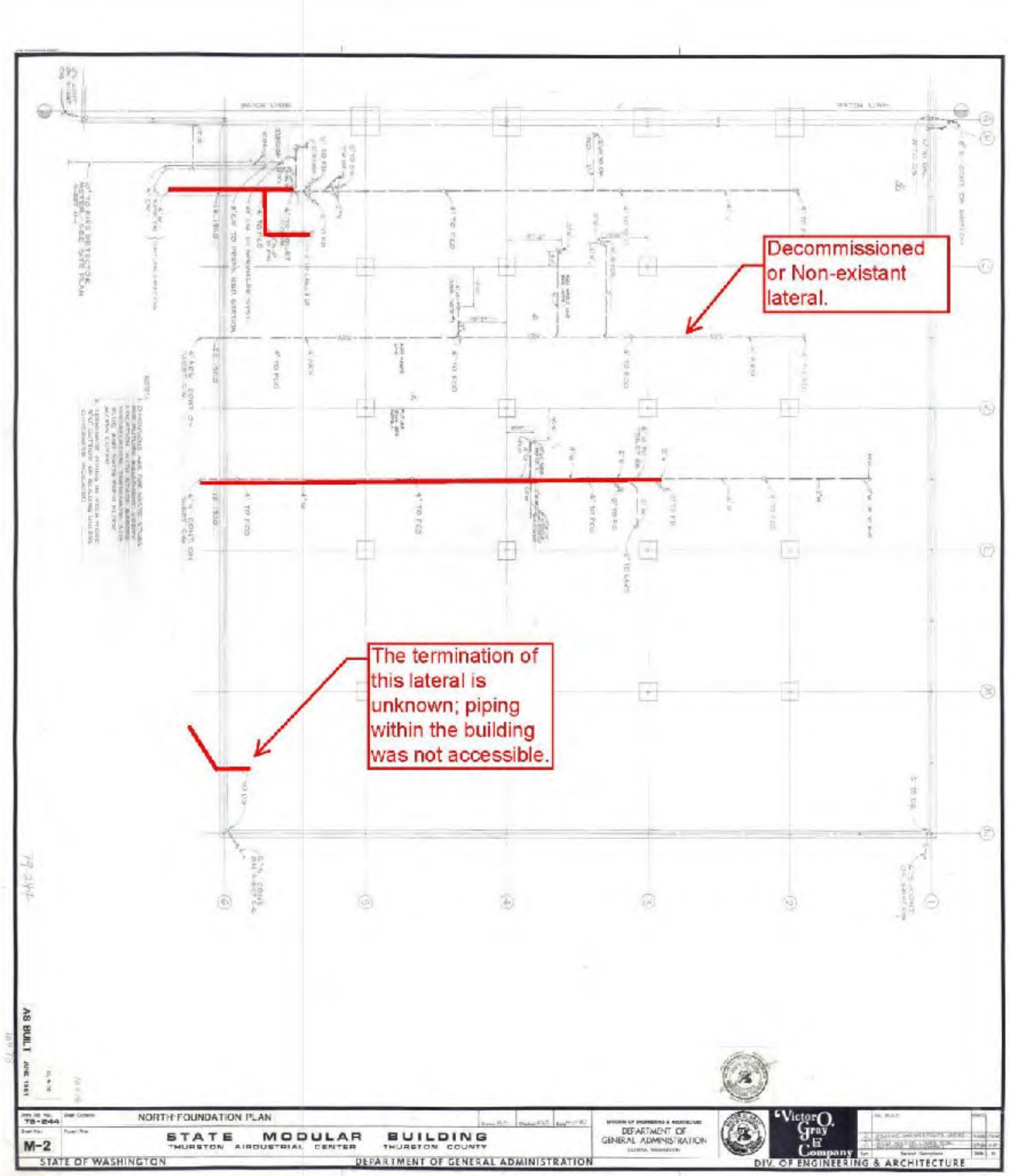
7H



Sanitary Waste Piping Map, Exterior Site Plan
Appendix-1-01



Sanitary Waste Piping Map, Low Bay
Appendix-1-02



Sanitary Waste Piping Map, Exterior Site Plan
Appendix-1-03

Appendix J - Tier 1 Seismic Study Checklist

7J

Project: 16-150 Location:

Completed by: JSG Date:

Note
C - complies
NC - non-compliant
N/A - not applicable
U - unknown

16.1.2LS LIFE SAFETY BASIC CONFIGURATION CHECKLIST

Low Seismicity

Building System

General

(C) NC N/A U LOAD PATH: The structure shall contain a complete, well defined load path, including structural elements and connections, that serves to transfer the inertial forces associated with the mass of all elements of the building to the foundation. (Commentary: Sec. A.2.1.1. Tier 2: Sec. 5.4.1.1)

C (NC) N/A U ADJACENT BUILDINGS: The clear distance between the building being evaluated and any adjacent building is greater than 4% of the height of the shorter building. This statement shall not apply for the following building types: W1, W1a, and W2. (Commentary: Sec. A.2.1.2. Tier 2: Sec. 5.4.1.2)

(C) NC N/A U MEZZANINES: Interior mezzanine levels are braced independently from the main structure or are anchored to the seismic-force-resisting elements of the main structure. (Commentary: Sec. A.2.1.3. Tier 2: Sec. 5.4.1.3)

Building Configuration

C NC (N/A) U WEAK STORY: The sum of the shear strengths of the seismic-force-resisting system in any story in each direction is not less than 80% of the strength in the adjacent story above. (Commentary: Sec. A2.2.2. Tier 2: Sec. 5.4.2.1)

C NC (N/A) U SOFT STORY: The stiffness of the seismic-force-resisting system in any story is not less than 70% of the seismic-force-resisting system stiffness in an adjacent story above or less than 80% of the average seismic-force-resisting system stiffness of the three stories above. (Commentary: Sec. A.2.2.3. Tier 2: Sec. 5.4.2.2)

C (NC) N/A U VERTICAL IRREGULARITIES: All vertical elements in the seismic-force-resisting system are continuous to the foundation. (Commentary: Sec. A.2.2.4. Tier 2: Sec. 5.4.2.3)

(C) NC N/A U GEOMETRY: There are no changes in the net horizontal dimension of the seismic-force-resisting system of more than 30% in a story relative to adjacent stories, excluding one-story penthouses and mezzanines. (Commentary: Sec. A.2.2.5. Tier 2: Sec. 5.4.2.4)

(C) NC N/A U MASS: There is no change in effective mass more than 50% from one story to the next. Light roofs, penthouses, and mezzanines need not be considered. (Commentary: Sec. A.2.2.6. Tier 2: Sec. 5.4.2.5)

(C) NC N/A U TORSION: The estimated distance between the story center of mass and the story center of rigidity is less than 20% of the building width in either plan dimension. (Commentary: Sec. A.2.2.7. Tier 2: Sec. 5.4.2.6)

Moderate Seismicity: Complete the Following Items in Addition to the Items for Low Seismicity.

Geologic Site Hazards

C (NC) N/A U LIQUEFACTION: Liquefaction-susceptible, saturated, loose granular soils that could jeopardize the building's seismic performance shall not exist in the foundation soils at depths within 50 ft under the building. (Commentary: Sec. A.6.1.1. Tier 2: 5.4.3.1)

(C) NC N/A U SLOPE FAILURE: The building site is sufficiently remote from potential earthquake-induced slope failures or rockfalls to be unaffected by such failures or is capable of accommodating any predicted movements without failure. (Commentary: Sec. A.6.1.2. Tier 2: 5.4.3.1)

(C) NC N/A U SURFACE FAULT RUPTURE: Surface fault rupture and surface displacement at the building site are not anticipated. (Commentary: Sec. A.6.1.3. Tier 2: 5.4.3.1)

High Seismicity: Complete the Following Items in Addition to the Items for Low and Moderate Seismicity.

Foundation Configuration

(C) NC N/A U OVERTURNING: The ratio of the least horizontal dimension of the seismic-force-resisting system at the foundation level to the building height (base/height) is greater than $0.6S_a$. (Commentary: Sec. A.6.2.1. Tier 2: Sec. 5.4.3.3)

(C) NC N/A U TIES BETWEEN FOUNDATION ELEMENTS: The foundation has ties adequate to resist seismic forces where footings, piles, and piers are not restrained by beams, slabs, or soils classified as Site Class A, B, or C. (Commentary: Sec. A.6.2.2. Tier 2: Sec. 5.4.3.4)

Project: 16-150 Location:

Completed by: JSG Date:

16.5LS LIFE SAFETY STRUCTURAL CHECKLIST FOR BUILDING TYPES S2: STEEL BRACED FRAMES WITH STIFF DIAPHRAGMS AND S2A: STEEL BRACED FRAMES WITH FLEXIBLE DIAPHRAGMS

Low Seismicity

Seismic-Force-Resisting System

(C) NC N/A U COLUMN AXIAL STRESS CHECK: The axial stress caused by gravity loads in columns subjected to overturning forces is less than $0.10F_y$. Alternatively, the axial stress caused by overturning forces alone, calculated using the Quick Check procedure of Section 4.5.3.6, is less than $0.30F_y$. (Commentary: Sec. A.3.1.3.2. Tier 2: Sec. 5.5.2.1.3)

(C) NC N/A U BRACE AXIAL STRESS CHECK: The axial stress in the diagonals, calculated using the Quick Check procedure of Section 4.5.3.4, is less than $0.50F_y$. (Commentary: Sec. A.3.3.1.2. Tier 2: Sec. 5.5.4.1)

Connections

(C) NC N/A U TRANSFER TO STEEL FRAMES: Diaphragms are connected for transfer of seismic forces to the steel frames. (Commentary: Sec. A.5.2.2. Tier 2: Sec. 5.7.2)

(C) NC N/A U STEEL COLUMNS: The columns in seismic-force-resisting frames are anchored to the building foundation. (Commentary: Sec. A.5.3.1. Tier 2: Sec. 5.7.3.1)

Moderate Seismicity: Complete the Following Items in Addition to the Items for Low Seismicity.

Seismic-Force-Resisting System

(C) NC N/A U REDUNDANCY: The number of lines of braced frames in each principal direction is greater than or equal to 2. The number of braced bays in each line is greater than 2. (Commentary: Sec. A.3.3.1.1. Tier 2: Sec. 5.5.1.1)

(C) NC N/A U CONNECTION STRENGTH: All the brace connections develop the buckling capacity of the diagonals. (Commentary: Sec. A.3.3.1.5. Tier 2: Sec. 5.5.4.4)

(C) NC N/A U COMPACT MEMBERS: All brace elements meet compact section requirements set forth by AISC 360, Table B4.1. (Commentary: Sec. A.3.3.1.7. Tier 2: Sec. 5.5.4)

(C) NC N/A U K-BRACING: The bracing system does not include K-braced bays. (Commentary: Sec. A.3.3.2.1. Tier 2: Sec. 5.5.4.6)

High Seismicity: Complete the Following Items in Addition to the Items for Low and Moderate Seismicity.

Seismic-Force-Resisting System

(C) NC N/A U COLUMN SPLICES: All column splice details located in braced frames develop 50% of the tensile strength of the column. (Commentary: Sec. A.3.3.1.3. Tier 2: Sec. 5.5.4.2)

(C) NC N/A U SLENDERNESS OF DIAGONALS: All diagonal elements required to carry compression have *Kl/r* ratios less than 200. (Commentary: Sec. A.3.3.1.4. Tier 2: Sec. 5.5.4.3)

C (NC) N/A U CONNECTION STRENGTH: All the brace connections develop the yield capacity of the diagonals. (Commentary: Sec. A.3.3.1.5. Tier 2: Sec. 5.5.4.4)

(C) NC N/A U COMPACT MEMBERS: All brace elements meet section requirements set forth by AISC 341, Table D1.1, for moderately ductile members. (Commentary: Sec. A.3.3.1.7. Tier 2: Sec. 5.5.4)

(C) NC N/A U CHEVRON BRACING: Beams in chevron, or V-braced, bays are capable of resisting the vertical load resulting from the simultaneous yielding and buckling of the brace pairs. (Commentary: Sec. A.3.3.2.3. Tier 2: Sec. 5.5.4.6)

(C) NC N/A U CONCENTRICALLY BRACED FRAME JOINTS: All the diagonal braces shall frame into the beam–column joints concentrically. (Commentary: Sec. A.3.3.2.4. Tier 2: Sec. 5.5.4.8)

Diaphragms (Stiff or Flexible)

(C) NC N/A U OPENINGS AT FRAMES: Diaphragm openings immediately adjacent to the braced frames extend less than 25% of the frame length. (Commentary: Sec. A.4.1.5. Tier 2: Sec. 5.6.1.3)

Flexible Diaphragms

C NC N/A U CROSS TIES: There are continuous cross ties between diaphragm chords. (Commentary: Sec. A.4.1.2. Tier 2: Sec. 5.6.1.2)

C NC N/A U STRAIGHT SHEATHING: All straight sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered. (Commentary: Sec. A.4.2.1. Tier 2: Sec. 5.6.2)

C NC N/A U SPANS: All wood diaphragms with spans greater than 24 ft consist of wood structural panels or diagonal sheathing. (Commentary: Sec. A.4.2.2. Tier 2: Sec. 5.6.2)

C NC N/A U DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 40 ft and aspect ratios less than or equal to 4-to-1. (Commentary: Sec. A.4.2.3. Tier 2: Sec. 5.6.2)

C NC N/A U OTHER DIAPHRAGMS: The diaphragm does not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Commentary: Sec. A.4.7.1. Tier 2: Sec. 5.6.5)

7K

Appendix K - Tier 2 Seismic Study Structural Calculations

TIER 1 QUICK CHECKS

COLUMN AXIAL STRESS CHECK (WORST-CASE)

ROOF LOADS:

$DL_R = 20$ psf
$LL_R = 25$ psf

MEZZANINE LOADS:

$DL_M = 20$ psf + 3"/12"/ft (150 pcf) = 57.5 psf
$LL_M = 125$ psf (POSTED)

TYP. T.A. = 200 ft^2

P_{max} (SOUTH) = (ΣDL + ΣLL) T.A. = 45.5 KIPS

P_{max} (NORTH) = ($DL_R + LL_R$) T.A. = 9.0 KIPS

SOUTH COLUMN => W10x33, A = 9.71 in^2

NORTH COLUMN => W6x15, A = 4.43 in^2

P/A (SOUTH) 4.69 ksi < $0.1 F_y$ = 5 ksi, OK

P/A (NORTH) = 2.03 ksi < $0.1 F_y$ = 5 ksi, OK

TIER 1 QUICK CHECKS (CONT.)

BRACE AXIAL STRESS CHECK

$$f_j^{AVE} = \frac{1}{M_S}\left(\frac{V_j}{sN_{br}}\right)\left(\frac{L_{br}}{A_{br}}\right)$$

L_{br}: AVG LENGTH OF BRACE = VARIES

N_{br} = 2 BRACES/FRAME

s = 20ft

A_{br}: SEE TABLE TO RIGHT

V_j = SEE BELOW

M_S = SEE TABLE TO RIGHT

TABLE 4-10

d/t	M_S
14.79	6.0
31.24	3.0

LOCATION	d/t*	M_S	A_{br}
SOUTH, TOP TS 6x4x1/4	22	4.69	4.30 in^2
SOUTH, BOT TS 8x4x3/8	14.33	5.17	7.58 in^2
NORTH 6x3x3/8	14	6.0	5.48 in^2

* CALCULATED PER AISC 360 TABLE B4.1

STORY SHEAR FORCES (V_j)

NORTH BUILDING:

$V_j = C S_a W$

W = WALL WEIGHT + ROOF WEIGHT

WALL WEIGHT = 10psf × 100 ft × 1/2 $\left(\frac{15.58 + 13.5}{2}\right)$ = 7.27 KIPS

ROOF WEIGHT = 20psf × 100ft² = 200 KIPS

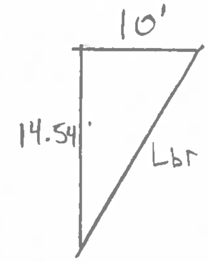
W = 207 KIPS / BRACE

$S_a = S_{XS}$ = 0.674 g (SH.5)

C = 1.4 (TABLE 4-8)

V_j = 196 KIPS

TIER 1 QUICK CHECKS (CONT.)



$L_{br} = 17.65 ft$

$f_j^{AVG} = \frac{1}{6}\left(\frac{196}{20\times2}\right)\left(\frac{17.65}{5.48}\right)$

$f_j^{AVG} = 2.62 ksi < 0.5F_y = 18.5 ksi$, OK

SOUTH BUILDING:

$F_x = \frac{w_x h_x^k}{\sum w_i h_i^k} V$; $K = 1.0$ $(T < 1s)$

ROOF WEIGHT, $W_r = 20 psf \times 120 ft \times 120 ft = 288$ KIPS

2ND STORY WALL WEIGHT; $W_{w2} = 10 psf \times 120 ft \times 1/2\left(\frac{30+27.5}{2} - 17.79\right)$

$W_{w2} = 6.58$ KIPS

MEZZANINE T.A. = $40 ft \times 120 ft = 4{,}800 ft^2$

MEZZANINE WEIGHT, $W_M = (4{,}800 ft^2)(57.5 psf + 0.25 \times 125 psf) = 426$ KIPS

1st STORY WALL WEIGHT, $W_{w1} = 10 psf \times 120 ft \times 1/2\left[17.79 + \left(\frac{30+27.5}{2} - 17.79\right)\right]$

$W_{w1} = 17.25$ KIPS

STORY	W_i (KIPS)	h_i (ft)	$W_i h_i$	$\frac{W_x h_x}{W_i h_i}$	F_x (KIPS)
2ND (ROOF)	295	28.75	8,481	0.518	314
1st	443	17.79	7,881	0.482	292
GROUND	10.7	0	0	–	–
$\sum$	749		16,362	1	606

$V = C S_a W$, $C = 1.2$

$V = (1.2)(0.674)(749) = 606$ KIPS/BRACE

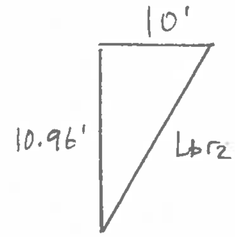
TIER 1 QUICK CHECK (CONT.)

V_2 = 314 KIPS/BRACE

L_{br_2} = 14.84 ft

$f_2 = \frac{1}{4.69}\left(\frac{314}{20 \times 2}\right)\left(\frac{14.84}{4.3}\right)$

f_2 = 5.78 ksi < $0.5F_y$ = 18.5 ksi, OK.

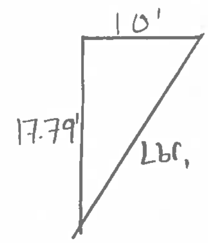


V_1 = 606 KIPS/BRACE

L_{br_1} = 20.41 ft

$f_1 = \frac{1}{5.17}\left(\frac{606}{20 \times 2}\right)\left(\frac{20.41}{7.58}\right)$

f_1 = 7.89 ksi < $0.5F_y$ = 18.5 ksi, OK



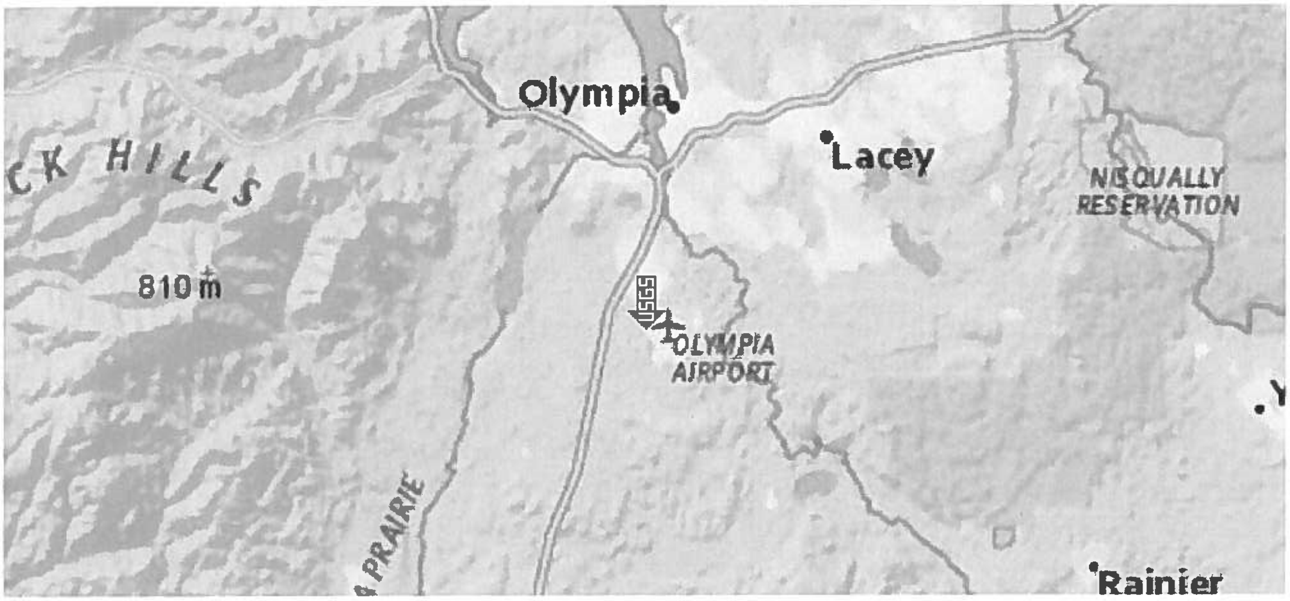
USGS Design Maps Summary Report

User–Specified Input

Building Code Reference Document ASCE 41-13 Retrofit Standard, BSE-1E
(which utilizes USGS hazard data available in 2008)

Site Coordinates 46.97832°N, 122.9131°W

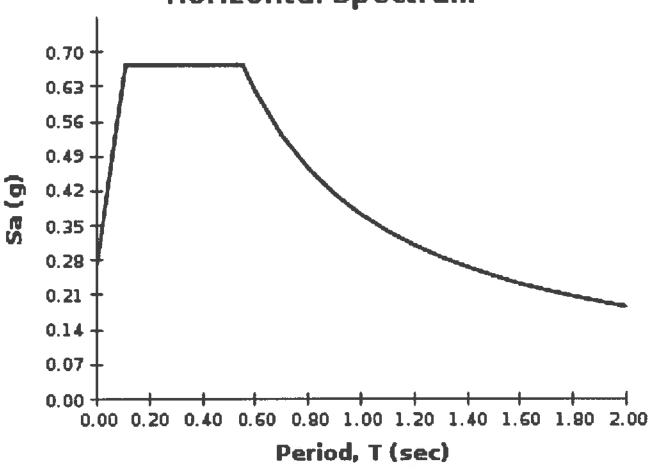
Site Soil Classification Site Class D – "Stiff Soil"



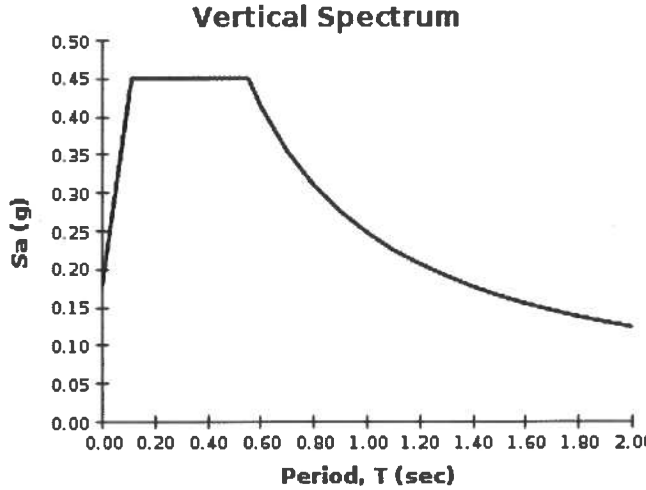
USGS–Provided Output

$S_{S,20/50}$	0.475 g	$S_{XS,BSE-1E}$	0.674 g
$S_{1,20/50}$	0.178 g	$S_{X1,BSE-1E}$	0.372 g

Horizontal Spectrum



Vertical Spectrum



CONNECTION STRENGTH

TENSION LOADS

BRACE	L_{BR} (ft)	A_{BR} (in^2)	F_yA_{BR} (KIPS)
TS 6x3x3/8	17.65	5.48	203
TS 6x4x1/4	14.84	4.30	159
TS 8x4x3/8	20.41	7.58	280

BRACE BUCKLING LOADS

TS 6x3x3/8:

P_n = 42 KIPS (INTERPOLATED, TABLE 4-3, AISC 360)

TS 6x4x1/4:

P_n = 82 KIPS (INTERPOLATED, TABLE 4-3, AISC 360)

TS 8x4x3/8:

P_n = 82 KIPS (INTERPOLATED, TABLE 4-3, AISC 360)

CONNECTION CAPACITIES (BRACE YIELDING)

TS 8x4x3/8:

(6) 3/4" ϕ BOLTS (A325) PER AS-BUILTS

V_{BOLTS} = (6) 17.9/ϕ = 143 KIPS < F_yA_{BR}, N.G

TS 6x4x1/4:

(4) 3/4" ϕ BOLTS (A325)

T = 159 (10.96/14.84) = 117.4 KIPS

V = 159 (10/14.84) = 107.1 KIPS ; F_{rv} = V / (4)0.442 = 60.6 KSI/BOLT

BY OBSERVATION, BOLTS FAIL IN SHEAR (BEFORE BRACE YIELDS), N.G.

V_{BOLTS} = 95 KIPS

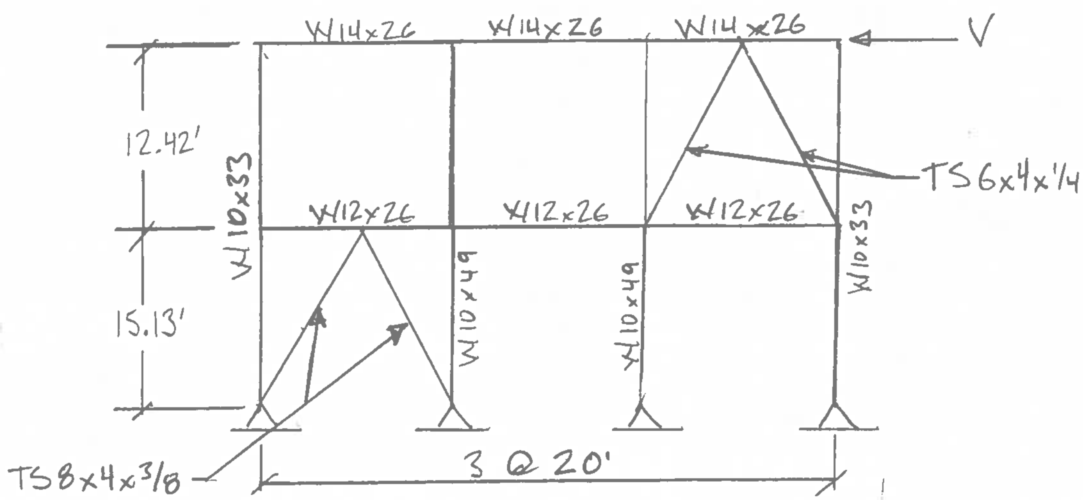
CONNECTION STRENGTH (CONT.)

TS 6x3x3/8:

(3) (3/4") ϕ BOLTS (A325)

$V_{BOLTS} = (3)(17.9)/\phi = 72$ KIPS < $F_y A_{32} = 203$ KIPS, N.G.

VERTICAL IRREGULARITIES



SOUTHERN BRACED FRAMES ALONG EAST WALL LINE

MEMBER SIZES PER AS BUILTS

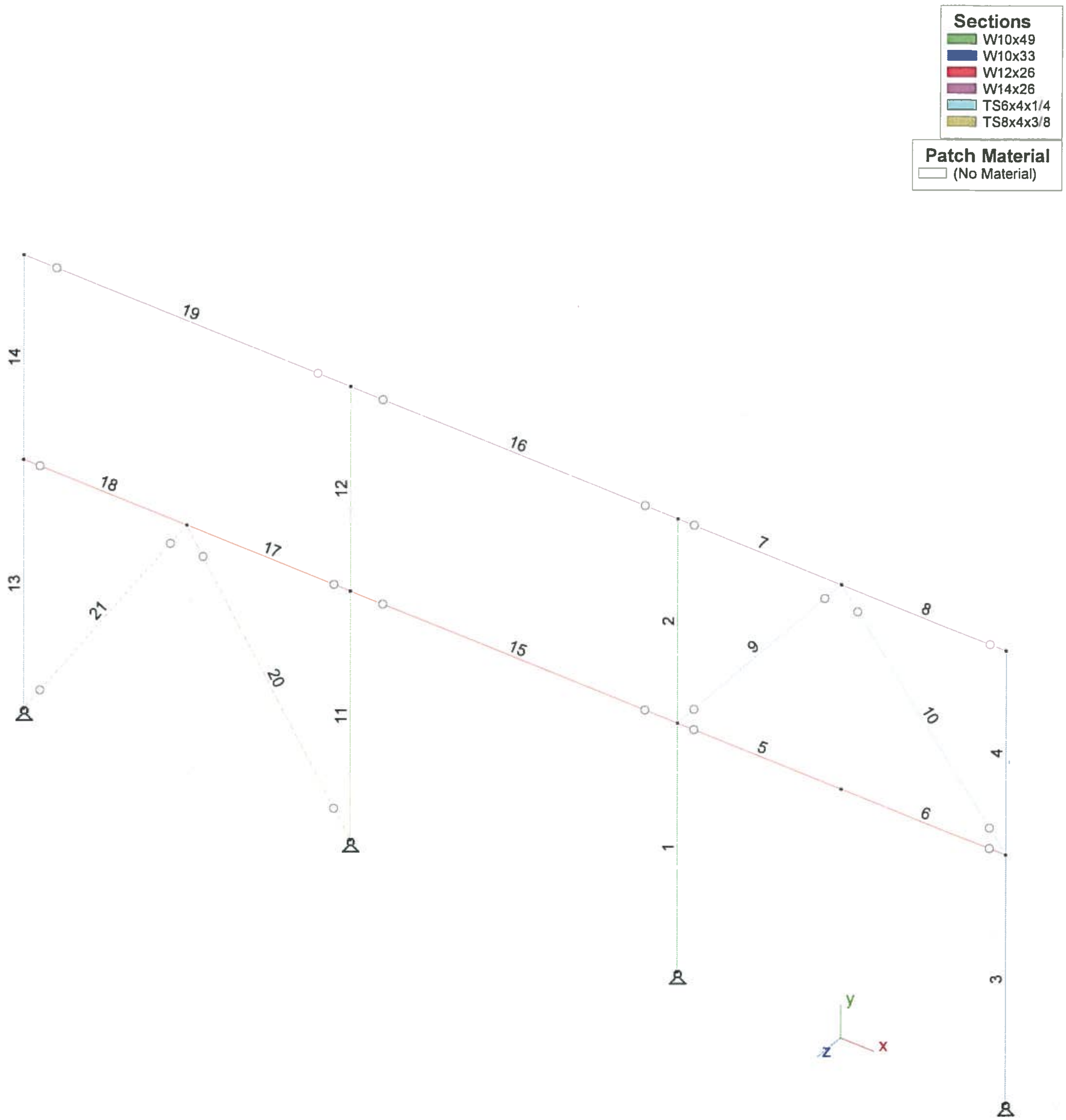
1) CHECK LOAD REQUIRED FOR BRACE BUCKLING

2) ALL CONNECTIONS PINNED

3) CHECK UTILIZATION OF SUPPORTING MEMBERS WHEN BRACE UTILIZATION IS @ 100%

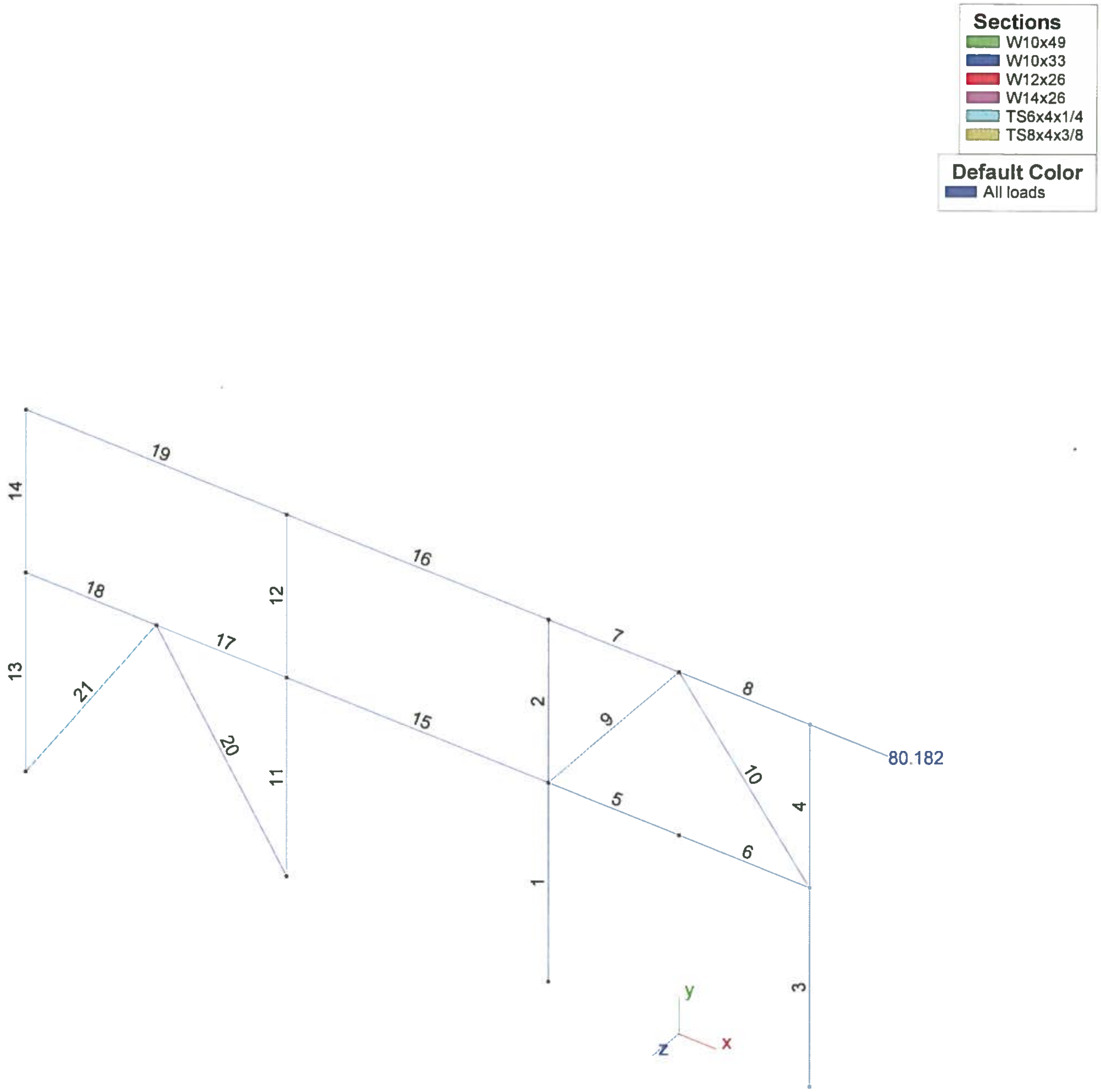
FROM SH. 11:

CENTER BEAM FAILS BEFORE BRACES CAN BUCKLE; ∴ CORRECTIVE ACTION NEEDED


Sections
W10x49
W10x33
W12x26
W14x26
TS6x4x1/4
TS8x4x3/8
Patch Material
(No Material)
19
14
16
18
12
13
17
7
21
2
8
15
9
20
11
10
5
4
6
1
y
z
x
3

Sh. 9

Frame


Sections
W10x49
W10x33
W12x26
W14x26
TS6x4x1/4
TS8x4x3/8
Default Color
All loads
19
14
16
18
12
17
7
13
21
8
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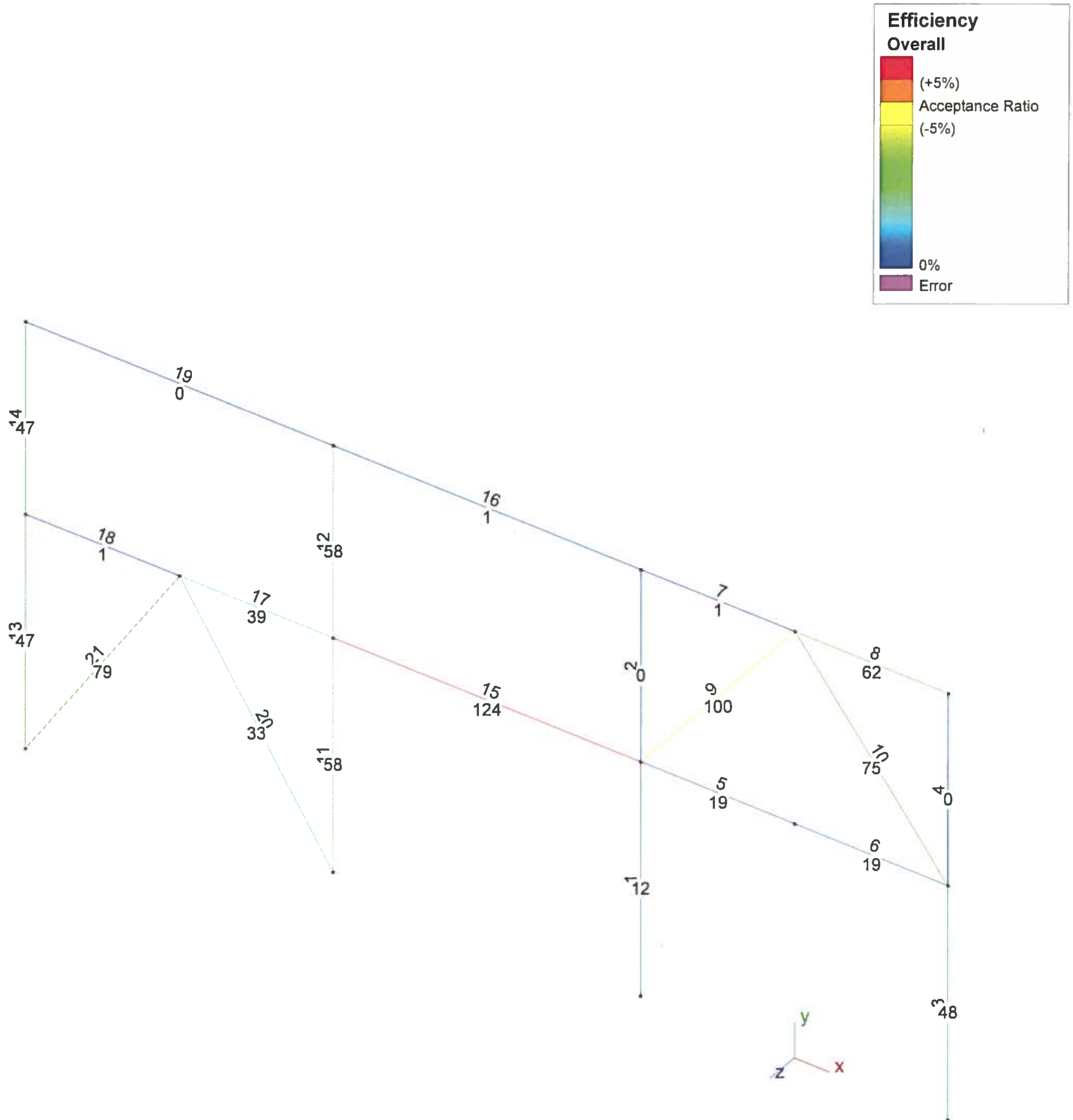
15
80.182
20
11
10
5
4
6
1
y
3
x
z

SH. 10



SH 11

Plot View - Overall Efficiency