East Bay Municipal Utility District, Main Waste Water Treatment Facility, Administration and Laboratory Building

EBMUD

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THIS IS NOT THE BASIS OF DESIGN.

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Abbreviations

ACH	Air Changes Per Hour
AHU	Air Handling Unit
AL	Aluminum
APPROX	Approximate
ARCH	Architectural
BAS	Building Automation System
BHP	Brake Horsepower
BTU	British Thermal Unit
BTUH	British Thermal Unit / Hour
CAP	Capacity
CFM	Cubic Feet Per Minute
CH	Chiller
CHW	Chilled Water
CV	Constant Volume
DP	Differential Pressure
DDC	Direct Digital Control
EA	Each Or Exhaust Air
EBMUD	East Bay Municipal Utilities District
EF	Exhaust Fan
EXH	Exhaust
FD	Fire Damper
FE	Fume Exhaust
FH	Fume Hood
FLEX	Flexible
FPM	Feet Per Minute
FSD	Fire/Smoke Combination Damper
GALV	Galvanized
GE	General Exhaust
GPM	Gallons Per Minute
HC	Heating Coil
HD	Head (Feet Of Water)
HP	Horsepower
HHW	Heating Hot Water
HVAC	Heating Ventilation And Air Conditioning
HZ	Hertz (Cycles Per Sec)
IN (")	Inch Or Inches
LBS	Pounds
LDB	Leaving Dry Bulb Temperature
LWB	Leaving Wet Bulb Temperature
LWT	Leaving Water Temperature
MBH	1000 Btuh
OA	Outside Air
PSI	Pounds Per Square Inch
PSIG	Psi (Gauge)
SA	Supply Air
SS	Stainless Steel
SP	Static Pressure,
S/R	Supply/Return
TON	12,000 Btuh Of Cooling
TYP	Typical
TU	Terminal Unit
VAV	Variable Air Volume
VRF	Variable Refrigerant Volume
VD	Volume Damper
VFD	Variable Frequency Drive
WT	Volume
(E)	Existing
(N)	New
°F	Degree Fahrenheit

Revision History		
Revision Number	Issuance Date	Description
0	10/23/2023	Issued as 50% Design for EBMUD Comment

The following report was produced by Gayner Engineers. The staff members below worked on and prepared the information provided in this report.

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1 Executive Summary

The following document is Gayner Engineer's 50% Design BOD for the East Bay Municipal Utilities District Administration and Laboratory HVAC System upgrade. The intention of this BOD is to serve as a bridging document for the future MEP system designer to utilize in their design of the HVAC system in the upcoming Seismic Rehabilitation and HVAC improvement project.

The narrative includes description of the existing facility, the HVAC system and equipment, and perceived operational deficiencies. The narrative discusses improvements to the facility to improve temperature controllability and system reliability. The improvements for the laboratory spaces of the building involve replacement of existing rooftop air handling units and exhaust fans in conjunction with zone level control improvements. The intention of the new design is to provide the minimum necessary system improvements that will lower the risk of disruption to the facility in the event of equipment failure. In addition, the design is tailored to minimize disruption to the facility as a result of construction activities as the facility performs critical uninterruptable regulatory compliance work for the district.

In addition to the laboratory HVAC work, the narrative describes a more extensive upgrade to the office wing of the building to fully modernize the HVAC infrastructure. Two design alternatives for the office wing are additionally provided in order to best suit the buildings potential future use and the district's design preferences. As the work will ultimately be constructed as part of the district's upcoming Seismic Rehabilitation and HVAC improvement project, the system design determination will be the responsibility of the future MEP system designer.

2 Existing Building Description

The following assessment is based off observations made during site surveys, and review of Record drawings and As-Builts.

Assessment of the building mechanical systems is performed in reference to the following codes:

- 2022 California Building Code (CBC)
- 2022 California Mechanical Code (CMC)
- 2022 California Non-Residential Building Energy Efficiency Standards (Title-24)
- 2022 California Electrical Code (CEC)

2.1 General System Description

2.1.1 Overall

The laboratory and administration building at East Bay Municipal Utilities District (EBMUD) is an approximate 43,000 SF building located at the Main Waste Water Treatment Plant (MWWTP) facility. The building is a single story building that houses both laboratory and office facilities with a second floor mechanical penthouse located in the center of the building. The building is split with laboratory operations on the north wing of the building and administration / office facilities located on the south wing of the building. Per EBMUD building numbering scheme, the administration and office wing on the south end is referred to as W41 and the laboratory wing of the building is referred to as W42.

2.1.2 Project History

The building has undergone multiple renovations during its years of operation. The following is a list of the major projects undertaken listed by their Special District project number:

- SD-122A: Administration Center & Maintenance Center - 1978
  - Construction of the base building at approximately 19,000 Square Feet
- SD-152 – Laboratory Expansion - 1984
  - Construction of a laboratory expansion on the north west end of the existing building adding approximately 4000 additional square feet
- SD-185 – Laboratory Expansion
  - Construction of approximately 17,500 sq.ft laboratory expansion on the north end of the existing building and 1500 sq.ft of office area on the south end of the existing building. Project thoroughly renovated the existing facility with new MEP services throughout.
- SD-402 – MWWTP Admin Lab & Dewatering Building HVAC Improvements:
  - Replacement of existing air cooled chiller and associated pumps and hydronic accessories and complete replacement of existing roofing.

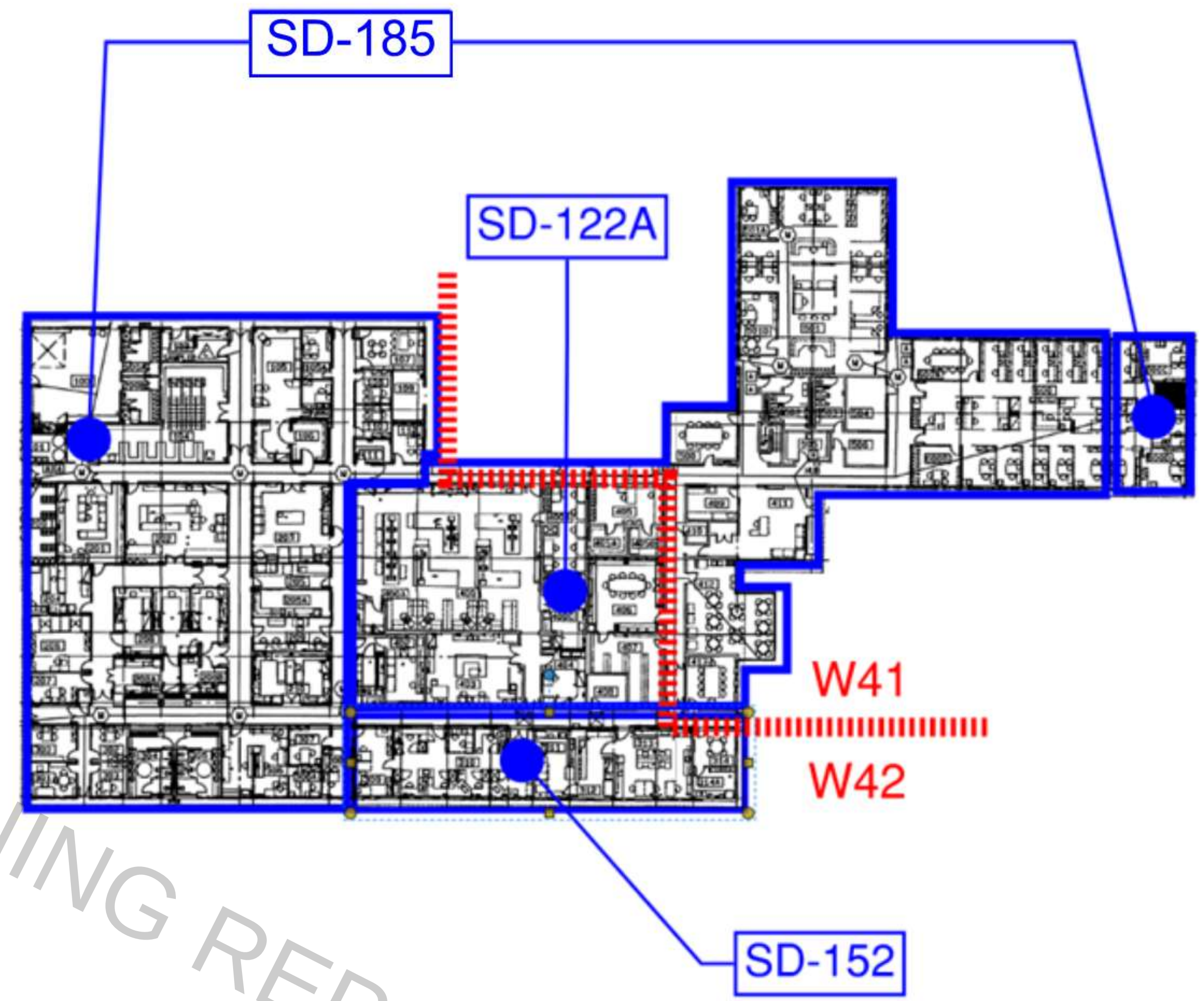

Figure 2–A: W41/W42 Project Addition History Map

2.2 HVAC System Overview

The HVAC system for the laboratory and administration wings of the building differs depending upon the nature of the spaces served. Overall, the system relies on an air-cooled chilled water plant for cooling generation and a natural gas burning boiler plant for heating. From a central cooling and heating generation standpoint, the building design does not separate laboratory and admin zones as airside HVAC equipment on both lab and admin wings received chilled and heating hot water from the heating and cooling plants.

In the laboratory spaces, 100% Outside Air (OA) constant volume rooftop AHUs provide filtered and tempered air into the zones to then be further conditioned by duct mounted heating and cooling coils located in a cased coil modules. Each zone is equipped with a coil module to provide individual temperature control per zone. The laboratory zones are additionally 100% exhausted by rooftop mounted exhaust fans which serve both general exhaust grilles as well as laboratory fume hoods. In the W41 office areas, the spaces are conditioned by roof mounted single zone constant volume AHUs configured in a return fan economizer configuration. The following provides more in depth information on each of the HVAC components.

2.3 Airside Components

2.3.1 Air Handling Units

The air handling units for the building are nineteen 19 separate AHUs originally installed during the last major reconstruction effort in 1989. Construction of the new facility was completed in 1994. The existing units were manufactured by PACE. The majority of units are 100% outside air units, which feature a single air tunnel with no return fan section. The units that serve Office areas have a separate return fan and economizer section. All units utilize double width double inlet (DWDI) belt driven supply fans controlled by motor starters. See table 2.3A below for description of existing units.

Table 2.3A – Existing AHU Configuration

Tag No.	CFM	Type.	Services
AHU-1	5400	100% O.A.	HHW,
AHU-2	6300	100% O.A.	HHW, CHW
AHU-3	4320	ECON	HHW, CHW
AHU-4	2600	ECON	HHW, CHW
AHU-5	4410	ECON	HHW, CHW
AHU-6	9620	ECON	HHW
AHU-7	3550	ECON	HHW, CHW
AHU-8	1480	100% O.A.	HHW
AHU-9	2480	ECON	HHW, DX Cooling
AHU-10	4160	ECON	HHW, DX Cooling
AHU-11	3870	100% O.A.	HHW, CHW
AHU-12	5210	100% O.A.	HHW
AHU-13	14200	100% O.A.	HHW, CHW
AHU-14	1445	100% O.A.	HHW
AHU-15	1505	100% O.A.	HHW
AHU-16	6220	100% O.A.	HHW
AHU-17	4445	ECON	None
AHU-18	5230	ECON	None
AHU-19	2875	100% O.A.	HHW

Observed Issues:

The air handling units have reached the end of their life expectancy and are due for replacement. Severe corrosion of the exterior cabinet was witnessed, which is causing pieces of the AHUs to flake off and fall apart in specific instances. The base rail of the units, where linking up with the roof curb shows severe signs of corrosion.

Figure 2–B: AHU-13

In some instances, the units have been refurbished by recoating the exterior and cleaning and repairing the interior of the units. However as is seen in the figure below, corrosion has been witnessed to be building up underneath the new coating.

Figure 2–C: Corrosion Under Unit Coating

Piping connections at each of the units have shown severe corrosion and many of the pipe assemblies are likely not functioning in their intended manner. The ferrous portions of the coil have severely rusted and are not capable of being reused. See Figure 2-C below. Many of the unions on the existing AHUs have threaded fittings which corrosion has seized permanently shut.

Condensate drain lines from each AHU are currently routed to roof storm drains. This is typically not allowed by most local jurisdictions; however, this depends on the local Authority Having Jurisdiction.

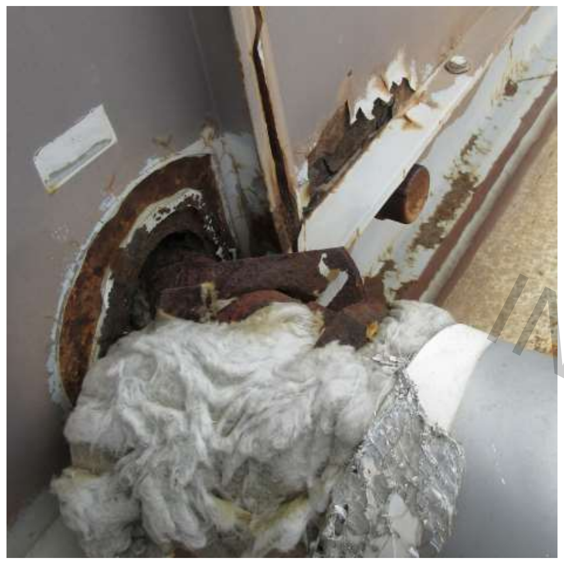

Figure 2–D: AHU-13 Heating Coil Connection

Figure 2–E AHU-12 Heating Coil Condition

The coils of each AHU are in a deteriorating condition due to continual exposure of corrosive air running through them. As seen in Figure 2E above, the coil has large amounts of corrosion on the fins. Heat transfer effectiveness is decreased by these conditions and the unit is likely not able to maintain supply air temperature during cold days. Additionally, given the condition, cleaning this coil to remove surface corrosion would not be possible without severely damaging the fins. Full replacement of the coil would be necessary if the AHU is intended to be reused.

Figure 2–F: AHU-16 OSA Intake Hood

The existing belt driven DWDI fans are selected to operate at constant speed and are controlled only utilizing motor starters. As such, the AHUs do not have any ability to compensate for filter loading. This has been causing the AHUs to deliver less airflow as the filters load and OA dampers become more restrictive. See Figure 2-E above. As the exhaust ductwork does not have any filters, the same phenomenon does not occur in the same way. Resultantly, the balance between supply and exhaust in each lab space within the building will get affected by this scenario. During site visits with the lab users, labs which were intended to be positive pressure were witness to be operating under negative pressure.

2.1.2 Exhaust Fans

All exhaust fans, and fume exhaust fans are belt driven utility set fans. The existing exhaust fans serving general lab exhaust are classified as "EF". The exhaust fans serving Fume Hoods are classified as "FEF". All fans are type BCV fans manufactured by Twin City. All exhaust fans utilize motor starters and operate in a constant volume operation. Some EFs are installed with fan mounted discharge stacks, see figure 2D below. EF-13, and FEF 13 were recently replaced as part of the SD-402 project with FRP construction VFD driven fans and FRP construction ductwork due to the extremely corrosive nature of the zones served by these fans.

The FEF fans serve the laboratory constant volume fume hoods located through the laboratory facility.. All Fumehood exhaust fans have separate field fabricated stacks mounted to extend the discharge of the fans a minimum of 10 feet to protect occupants from inhaling exhausted fumes. See figure 2d below for an example installation. The stacks are fitted with reducing nozzles at the discharges to accelerate the exit velocity of the fumes exhausted. The majority of the FEFs with the exceptions of FEF-3, FEF-6 and FEF 12 serve individual fume hoods. FEFs 3, 6, and serve multiple fume hoods in a manifold configuration.

The following tables lists the existing capacities of each fan.

Table 2.3B EF Capacities		Table 2.3C FEF Capacities		
Tag No.	**CFM**	**Tag No**	**CFM**	**Fume Hoods Served**
EF-1	2150	**FEF-1**	1250	FH 1
EF-2	1180	**FEF-2**	1250	FH 2
EF-3	4300	**FEF-3**	8420	FH 3-FH 8
EF-4	2750	**FEF-4**	760	FH 9
EF-5	300	**FEF-5**	1250	FH 10
EF-6	2000	**FEF-6**	2960	FH 11, FH 12
EF-7	2000	**FEF-7**	1710	FH 13
EF-8	2820	**FEF-8**	1000	FH 14
EF-9	2000	**FEF-9**	760	FH 15
EF-10	750	**FEF-10**	1000	FH 16
EF-11	1050	**FEF-11**	1250	FH 17
EF-13	600	**FEF-12**	1760	FH 18 FH 20
EF-14	1300	**FEF-13**	1000	FH 21
EF-15	2550	**FEF-14**	950	FH 22
EF-16	1000	**FEF-15**	1250	FH 23
		FEF-16	2500	FH 24

Observed Issues:

The exhaust fans show severe signs of rust and deterioration. Figure 2C shows the inside of a fan currently not in commission. It is assumed that other EFs are likely in a similar condition as they are of a similar age. All exhaust fans have served beyond their life expectancy. Many of the vibration isolators have rusted and failed likely causing transmission of vibration into the lab space.

Figure 2–G: Exhaust Fan EF-16

Figure 2–H: Exhaust Fan Stacks

2.1.3 Coil Modules

The duct mounted coil modules are located above ceiling at the zone level and contain both cooling and heating coils hydronic coils. Temperature control is accomplished by pneumatic actuated control valve which control the flow of CHW and HHW to maintain the space at temperature. The coils are equipped with condensate drain pans to collect condensate from the chilled water coil and gravity drain it to a waste receptor. The existing coils are manufactured by PACE.

Observed Issues:

The coil module in general show deterioration and are causing operational issues to the facility. The coils fins as seen in 2-I below show signs of corrosion and are discolored. This is likely diminishing the heat transfer effectiveness of the coils themselves. In many instances the coil casings have failed, and water has started to leak from the bottom of the modules. Mineral buildup is noticeable along the seam of the casing as seen in 2-I. Per discussion with maintenance staff, several coil modules have experience leaks over time, and many have been shut off at the isolation valves to prevent further leaks from occurring.

Coil Module Interior

Bottom of Coil Module

Figure 2–I: Duct Mounted Coil Modules

2.4 Water-side Components

2.2.1 Chillers

The main buildings central chilled water system is generated by a single 200-ton Daikin Air-Cooled Variable Speed Screw Compressor chiller. The chiller is located on the main building roof and is served by a set of variable speed chilled water pumps. The system is piped in a variable primary piping configuration. The installation of this chiller occurred in 2022 as part of the recently completed EBMUD's SD-402 project. The chiller is not presently known to have any operational issues.

Figure 2–J: 200 ton Daikin Chiller

2.2.3 Boilers

Heating hot water for the facility is provided by two natural draft, flex tube Parker Boilers each sized at 3 Million BTU/HR. The boilers are fed from purchased natural gas delivered to the site.

Observed Issues:

The casing and flues of the boilers are showing severe signs of rust and deterioration. See Figures below:

Figure 2–K: Boilers

According to feedback from the Honeywell service person, the existing boilers have experienced sludge buildup within the water tubes which has taken the boilers out of commission in the past. The boilers currently are not in compliance with BAAQMD regulations. Per BAAQMD Regulation 9-7, boilers over 2 Million BTU-HR must be Low-NOx emitting boilers. The current boilers are not equipped with burners capable of the Nox emission limits set by BAAQMD.

2.2.4 Boiler Pump Assemblies

Chilled water distribution for the facility is provided by field fabricated pumping assembly in a "Primary Only" configuration. Existing pumps are end suction type Bell and Gossett 1510 pumps each sized to 160 GPM. Pumps are configured in a reverse return configuration. VFDs are not provided for the pumps and pumps run at a constant speed. Air separators and chemical pot feeders are additionally provided.

Observed Issues:

The pumps have surface corrosion especially on the base frame the pumps are bolted to. The vibration isolators, appear to be rusted and fatigued. However, as these pumps are not above any occupied areas and are bolted to the slab, they likely are not transmitting any vibration into the space. Future renovations could consider removing the vibration isolation entirely and directly mounting the pumps to the concrete base. The inlet to the pumps do not look to have been provided with enough straight run, and no suction diffuser on the pumps is provided. Flex joints on the pump inlet and discharge are weathered and cracked. These could be a potential failure point in the future.

Figure 2–L: HHW Pump

Figure 2–M: HHW Rubber Bellows Joint

2.2.5 CHW Piping

Chilled water distribution for the facility is largely purposed for the duct mounted Coil Modules. Additionally some of the existing air handlers currently have CHW service as indicated by Table 2.3A above. Chilled water piping is mostly provided by threaded black steel piping. Larger connections approximately 2-1/2" and up utilizes flange connections. Insulation is fiberglass wrap with a paper jacketing on the straight pieces with PVC jacketing on the elbows. Control valves are provided with a Styrofoam Enclosures.

Observed Issues:

The chilled water piping has been the cause of many of the leaks that the facility has experienced. As the temperature of the chilled water, even with the elevated chilled water temp of 54°F, is below the dewpoint of the air, any exposed piece of piping produces condensate on it. As such there is a large amount of surface corrosion on all exposed piping components.

Figure 2–N: Rusted Coil Union

Figure 2–O: Closeup of piping connection

Figure 2–P: Coil Circuit Setter Showing Extreme Corrosion

Figure 2–Q: Threaded Black Steel Elbow underneath removed insulation

Additionally, as is shown above in figure 2-P, the packed fiberglass insulation of the fittings has done an improper job of preventing condensation from forming on the elbows. It is apparent that the insulation in many cases may be wet as is evident by the discoloration of the insulation in the pictures above. The figure above was taken after removing the jacket and insulation from one of the fittings. It is assumed that most other elbows are in a similar condition.

2.2.6 HHW Piping

Heating hot water distribution for the facility feeds both the duct mounted Coil Modules and several of the AHUs. HHW piping is mostly provided by threaded black steel piping. Larger connections approximately 2-1/2" and up utilizes flange connections. Insulation is fiberglass wrap with a paper jacketing on the straight pieces with PVC jacketing on the elbows. Exterior HHW piping is contained in aluminum jacketing. Control valves are provided with a Styrofoam Enclosures.

Observed Issues:

Overall the HHW piping is in much better condition that the CHW piping. As there is no condensation formation due to the temperature of the water, the majority of the components within the building do not show any rust. The jacketing for the HHW pipes outside of the building is still in good condition. The sections of pipe exposed to the environment have rusted. See Figures below.

Figure 2–R: HHW Piping Examples

3 New Work

3.1 Overall

The following design describes a replacement HVAC system that will allow better temperature, ventilation, and pressure control of the building in both laboratory and office areas while minimizing disruption to the facility. The new design will involve replacement of all rooftop air handling units, all rooftop exhaust fans, existing heating hot water boiler system and local control devices. In addition, multiple design options are presented for the W41 Administration and office wing. All options for the administration and office wing are more extensive in nature as it is our understanding that the district staff located in the building are capable of relocating to accommodate the construction.

3.2 New work – Central Systems

3.2.1 Boiler System

The existing boiler system will be demolished and removed. All exterior piping shall be demolished and removed.

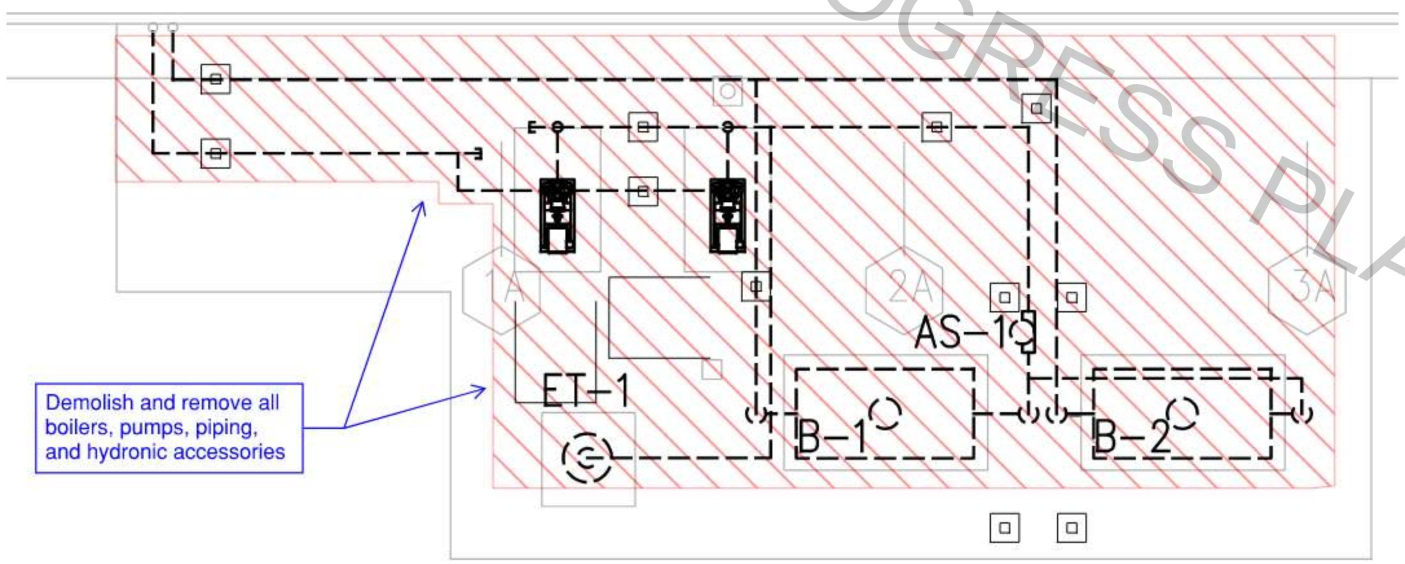

Figure 3–A: Boiler Yard Demolition Work

The new boiler system shall be a variable flow heating hot water plant with condensing boilers. The system will utilize two (2) 3,000 MBH natural gas forced draft condensing boilers capable of a minimum of 98% thermal efficiency. The new boilers shall be firetube in design and utilize duplex stainless steel heat exchangers. The new boilers will be located underneath the existing boiler canopy enclosure on the existing concrete pads. The new boilers shall be rated for outdoor installation and shall include a weatherproof enclosure over all electronics and controls components. The new boilers shall be fitted with 316 S.S. double wall flues. The new flues shall utilize the existing steel structure for support and seismic bracing of the new flue.

To serve the new boilers, new hydronic accessories including expansion tanks, air separators, and chemical pot feeders will be provided. Two (2) new end suction frame mounted heating hot water pumps will be provided in the same location of the existing pumps. The new pumps will be sized with N+1 redundancy. The new pumps will be VFD driven to allow variable flow to the building heating hot water loop. The system will be piped in a primary only configuration to maximize on the condensing efficiency of the hot water boilers. Primary secondary piping is unacceptable. All new piping will be insulated with Title 24 compliant insulation and exterior aluminum jacketing will be provided over all new piping and equipment insulation.

3.3 New Work – Laboratory Areas

In order to minimize disruption to the laboratory areas of the building the HVAC replacement scope will be limited to rooftop work and limited zone level improvements. The majority of above ceiling, below roof, equipment will remain with select improvements. The rooftop equipment will largely be replaced as this can be performed without relocation of any lab user equipment.

3.3.1 Air Handling Units

All air handling units serving laboratory areas shall be replaced. The new laboratory AHUs shall at a minimum include the following features:

- VFD driven direct drive supply fan array with N+1 Redundancy
- MERV 8 Prefilters
- MERV 13 Final Filters
- Stainless steel filter racks
- Pre-Heating Coils
- Cooling Coils
- Stainless steel coil casing
- Corrosion Resistant Construction

The new units shall be made by a custom AHU manufacturer in order to fit the exact width of the existing structural curbs and be capable of meeting the project criteria. Sizing of the new units shall be similar to that of the existing as the overall design intent is to replicate the original design airflow of the existing. The units shall additionally include 15% additional supply air capacity to allow for future zone level modifications. As listed above, the new units shall utilize a fan array with a minimum of two supply fans per unit. The supply fans shall be plenum type housed centrifugal fans with direct drive motors and backdraft dampers. The fan array shall be selected in a N+1 configuration allowing the unit to continue to operate in the event of a supply fan failure. All fans shall be VFD driven with individual VFDs provided per fan. The AHUs shall include a factory fabricated conditioned VFD enclosure to prevent exposure to environment to prevent premature wear on the electronic components. All fans will be internally vibration isolated to allow direct mounting of the AHU to the building without vibration isolators.

All new AHUs shall be equipped with preheat coils and chilled water coils to be capable of providing conditioned supply air to the building. This differs from the current design of the existing AHUs as several of the lab AHUs are provided with heating only to temper the incoming air while the remainder of the conditioning happens at the zone level cooling/heating coil modules. The intention of providing chilled water capabilities to the new AHUs is to allow the facility to adjust the incoming air temperature to the zone level heating and cooling equipment to aid in better controllability of overall zone temperature. In addition, by providing chilled water capacity at the roof mounted AHUs, the future zone level equipment can potentially be capable of being converted to a VAV-reheat system without subsequently replacing the AHUs.

As the costal environment in conjunction with the corrosive nature of the waste water plant subjects all equipment to an elevated level of corrosion, the new AHUs shall be designed with corrosion resistant construction to withstand the harsh environment. The units shall be designed to provide a suitable level of corrosion resistance while complying with weight and special limitations. At a minimum the units shall include a full stainless steel liner through the interior. Coils shall be aluminum fin construction with a 10,000 Hr ASTM Salt Spray epoxy coating. Coil casings and filter racks shall be constructed of 316 stainless steel. The exterior of the unit shall have a minimum of a 6000+ Hr ASTM Salt Spray rating coating.

During the SD-402 Project it was discovered that the record documentation does not accurately depict the dimensions of the equipment roof curbs of the equipment replaced as part of that project. Similarly, there is no record documentation of the existing roof curb dimensions for the existing AHUs. The design of the anchorage of the units will need to provide flexible provisions to expand or attach to the existing curb as required in order to sufficiently anchor the new units while maintaining anchor bolt edge distance requirements.

3.3.2 Exhaust Fans

The existing exhaust fans shall be replaced in kind. The new EFs shall be similar in size and capacity to that of the existing however be variable speed driven. Fans that are less than 1 HP shall utilize direct drive Electronically Commutated Motors (ECM) for variable speed control. The new exhaust fans shall be installed in a similar configuration to that of the existing and fume exhaust fans shall be installed with a discharge stack with a minimum height of 10 feet. All fans shall be stainless steel construction.

3.3.3 Zone Level Equipment

The zone level coil modules will not be replaced as doing so would cause significant disruption to the occupants. The zone level work will therefore be limited to providing new DDC controls and the associated modifications of the existing coils in order to provide more accurate control to the end users. In order to install the new DDC controls and actuator, demolition of the HHW and CHW branch piping feeding each coil module will be necessary.

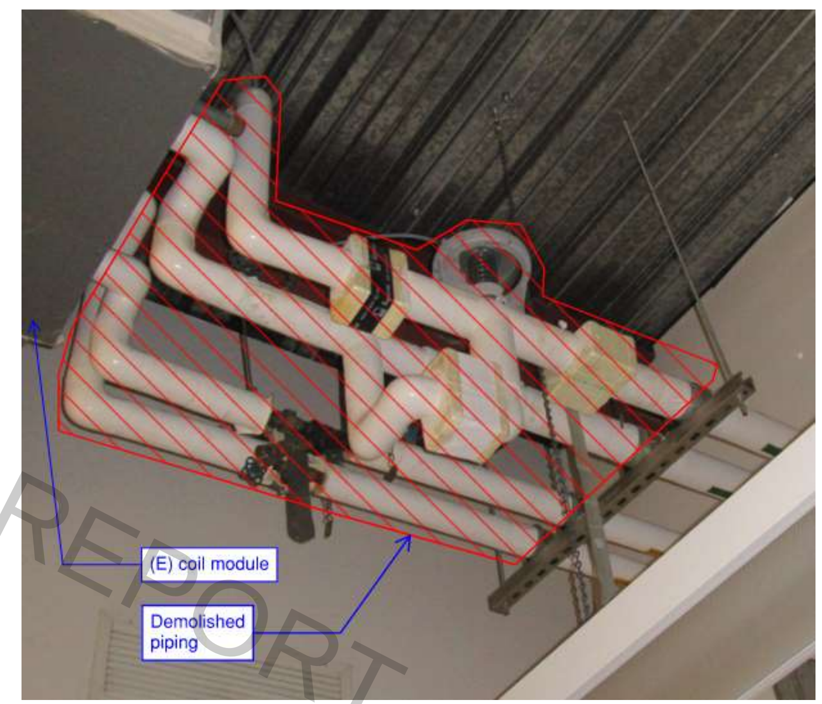

Figure 3–B: Coil Module Piping Demolition

After the existing piping is removed, a new piping segment with a circuit setter, shut off valves, Y-strainer and electronic DDC control valve will be installed at each coil module. This will be similar for both heating and chilled water piping. The new piping will be provided with new Armaflex closed cell insulation over all piping and control components.

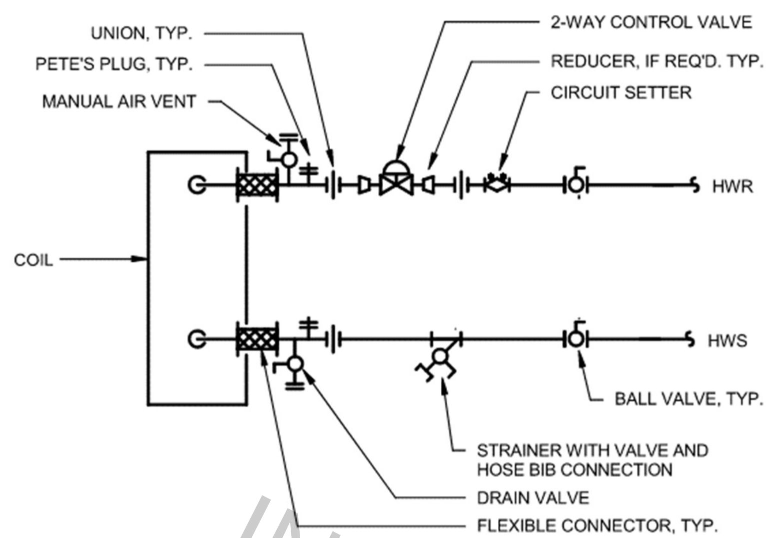

Figure 3–C: New Piping Connection

The demolition of the piping will require saw cutting the existing piping. To tap in the new piping, the contractor will need to weld on a new threaded coupling to allow for the new installation to occur. Alternatively a mechanical joining system such as Victaulic grooved couplings or Viega Megapress can be utilized to tie the new piping to the existing.

3.3.4 Direct Digital Controls (DDC)

The SD-402 project installed a new Alerton Ascent control system for control and monitoring of the new chilled water plant. The intent of this project is to expand upon this existing control system with new zone controls for the AHUs, EFs, and zone level devices.

All lab AHUs will be provided with a new BACnet IP based advanced equipment controller for direct control of the AHU operations. At the zone level, each zone will receive a new thermostat and a BACnet IP field level controller responsible for monitoring zone temperature and modulating the new DDC heating and cooling control valves.

3.3.5 Code Exceptions

The new work for the laboratory described above will in effect still operate the system in a constant volume configuration. Constant volume systems are not typically allowed for by Title 24 due to their high energy consumption. The nature of the system though which utilizes CHW and HHW coils at the zone level mitigates the excess energy consumption to an extent as no zone level reheat occurs. The following is an excerpt from **Title 24 2022 140.9-(C) – 1 – (C):**

> *"(c) **Prescriptive Requirements for Laboratory and Factory Exhaust Systems.***
>
> *1. **Airflow Reduction Requirements.** For buildings with laboratory exhaust systems where the minimum circulation rate to comply with code or accreditation standards is 10 ACH or less, the design exhaust airflow shall be capable of reducing zone exhaust and makeup airflow rates to the regulated minimum circulation rate, or the minimum required to maintain pressurization requirements, whichever is larger. Variable exhaust and makeup airflow shall be coordinated to achieve the required space pressurization at varied levels of demand and fan system capacity.*
>
> ***EXCEPTION 1 to Section 140.9(c)1:** Laboratory exhaust systems serving zones where constant volume is required by the Authority Having Jurisdiction, facility Environmental Health & Safety department or other applicable code.*
>
> ***EXCEPTION 2 to Section 140.9(c)1:** New zones on an existing constant volume exhaust system"*

As is stated above, the majority of the spaces would fall under the classification described by section 1 above which would require variable air volume control. For code compliance, the new system would be reliant upon Exception number 2 which allows for alterations of existing constant volume systems to remain constant volume.

3.4 New Work – Office Areas

The new work in the office areas is intended to provide a fully Title 24 compliant HVAC system. As described in section 2.2 above, from a central generation standpoint, the administration wing shares the same cooling and heating sources as the laboratory wing does. Per discussion with district staff, it is Gayner Engineers understanding that EBMUD may wish to explore systems that decouple the laboratory and office wings of the building to allow independent operation. As such two alternative systems are described below as well.

3.4.1 Base Design - VAV Reheat System with CHW/HHW AHUs

The base configuration for the building would be a VAV reheat system with rooftop AHUs fed by CHW and HHW. The CHW and HHW would be provided by the buildings chilled water and boiler plants and reuse existing piping mains feeding the existing units. At the zone level VAV reheat boxes would be provided.

3.4.1.1 Demolition Work

In this configuration all existing rooftop AHUs will be demolished and removed. In addition, at the zone level, selective demolition of the ductwork will be performed in order to accommodate the new HVAC zoning requirements.

3.4.1.2 Air Handling Units

The new AHUs will be in a relief fan economizer configuration. The existing units utilized a return fan configuration though given the short lengths of ductwork, and the return plenum nature of the building, a relief fan will offer greater overall system efficiency. The new units would share similar attributes to that of the proposed laboratory AHUs in order to provide a similar level of longevity and durability in the harsh EBMUD MWWTP environment. This will include the following at a minimum:

- VFD driven supply fan arrays
- VFD driven relief fans
- MERV 8 Prefilters
- MERV 13 Final Filters
- Stainless steel filter racks
- Pre-Heating Coils
- Cooling Coils
- Stainless steel coil casing
- Corrosion Resistant Construction

The supply fans will be direct drive VFD driven housed centrifugal plenum fans with a minimum of 2 fans per unit to provide 50% redundancy to the system. The relief fans will be mounted in the unit and will be ECM driven centrifugal plug fans. All fans will be internally isolated to allow direct mounting of the AHUs to the existing building without vibration isolators.

3.4.1.3 Zone Level Equipment

At the zone level, VAV-reheat terminal boxes will be provided to accomplish zone level temperature control. The terminal boxes will be provided with 2-row epoxy coated reheat coils to cope with the corrosive air experienced at the facility and prevent aluminum oxide formation on the coil fins. Zoning for the space will provide multiple HVAC zones within the open offices and individual VAV boxes for each private office.

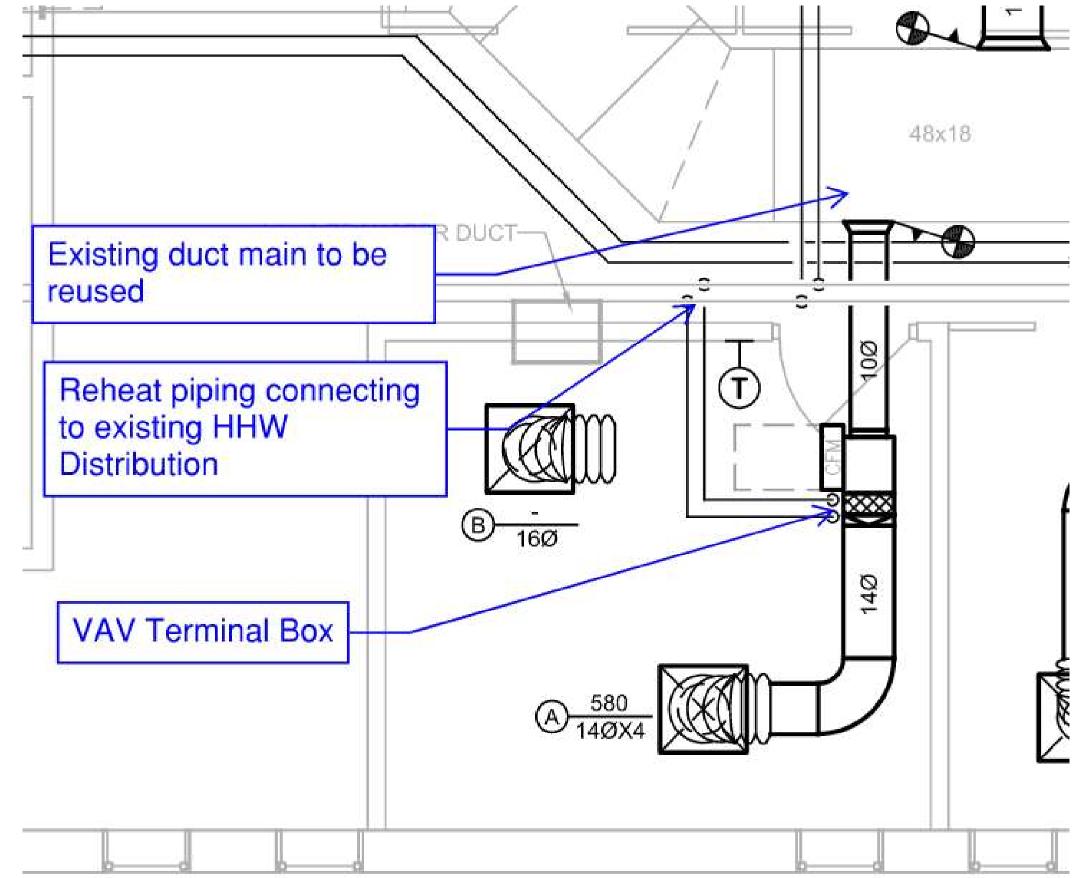

Figure 3–D: Zone VAV Terminal Unit

3.4.1.4 DDC Controls

The new AHUs will be provided with a BACnet IP based advanced equipment controller typing into the existing Alerton control system provided during SD-402. The new VAV boxes will additionally be fitted with BACnet IP field level controllers. The new AHUs and VAV boxes will be programmed with ASHRAE Guideline 36: Best in class HVAC Control Sequences to maximize energy efficiency and temperature controllability.

3.4.2 Alternative 1 – Variable Refrigerant Flow System

In order to divorce the admin wing from the central heating and cooling systems serving the rest of the building, a viable alternative would be to provide a Variable Refrigerant Flow (VRF) system with DOAS units. This system utilizes a central outdoor condensing unit paired with multiple indoor fan coil units. The below diagram gives a diagrammatic view of the system architecture.

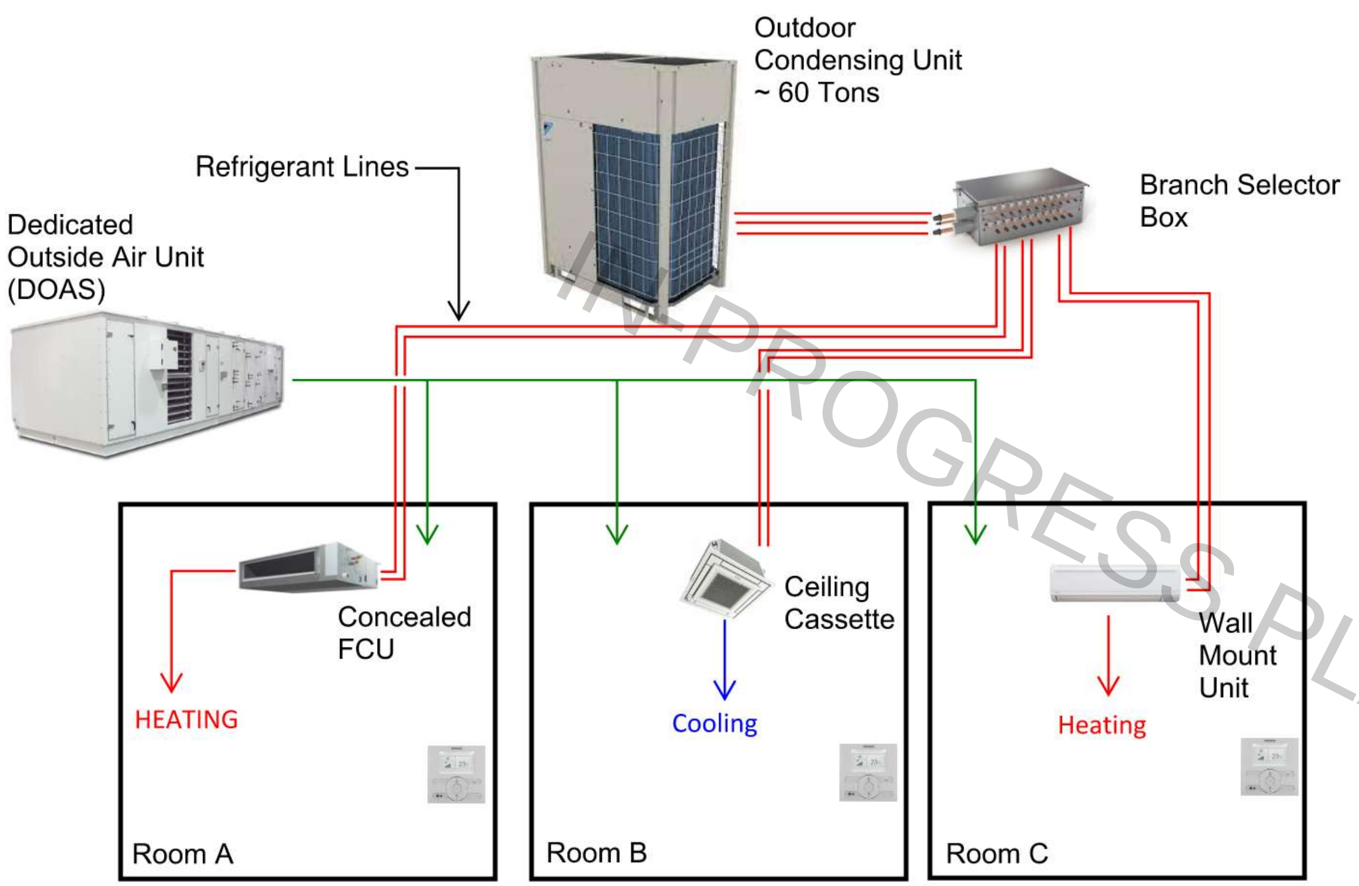

Figure 3–E: Simplified VRF System Diagram

3.4.2.1 Condensing Units

The system utilizes a central condensing unit to reject and source heat from the ambient air. As the total capacity of the office wings will equal to approximately 60 refrigeration tons, (3) separate 20 ton condensing unit section will be utilized. The condensing units will be heat recovery type to allow for simultaneous heating and cooling at the zone levels. The condensing units will be located on the previous location of the existing AHUs as the new system will necessitate much smaller and fewer AHUs for ventilation air supply. The condensing unit will be epoxy coated from the factory and be further coated with an aftermarket coating to prevent corrosion generation from the ambient air.

The condensing units scroll type compressors which are a high pressure refrigerant system. Currently the only refrigerant commercially available for the scroll compressors in VRF systems is R410A. Recent California legislation passed by California Air Resource Board (CARB) under their Significant New Alternatives Policy (SNAP) has banned the use of refrigerants with a Global Warming Potential (GWP) of greater than 750. R410A has a GWP of approximately 2088 and therefore would be prohibited by these new policy. The legislation however has established a timeline for different types of refrigeration equipment. Chillers and Packaged heat pumps have an earlier timeline and will be phased out by the end of 2024 and 2025 respectively. VRF on the other hand has the latest phaseout deadline of January 1st of 2026 and is therefore still being sold utilizing R410A. If the project delivery will happen after this date, the future build out designer will need to select a VRF system that utilizes a more environmentally friendly refrigerant and the resulting design implications that arise.

3.4.2.2 Air Handling Units

By nature, the VRF system locates the cooling at the zone level and the central AHUs do not have to deliver full design cooling/heating airflow to the facility. Resultingly, the AHUs can be substantially downsized as they will only be used to provide the minimum amount of ventilation air needed to each space. This will be determined by Title 24 minimum ventilation requirements. As the system will be tasked with delivering substantially less air than the existing (approximately 80% less) fewer rooftop AHUs are required.

The new AHUs will be combined supply and exhaust fan units to supply 100% OSA to the building and satisfy ventilation loads. The units will be equipped with heat recovery core heat exchangers to allow for tempering of the outside air prior to entering the building. Heat recovery for the DOAS units is required due to Title 24 2022 changes which now requires economizers on indoor units of less than 33,000 BTU/hr as opposed to the previous 54,000 BTU/hr limit. It is anticipated that indoor units may exceed 33,000 BTU/hr of cooling capacity and installation of an economizer on these units would not be practical.

3.4.2.3 Indoor Units

As is shown above in Figure 4-E, the system can support multiple types of indoor units. The open office areas will be installed with ducted concealed FCUs which will duct to and supply ceiling diffusers. Private offices will be fitted with ceiling cassette style units which mount into the existing T-Bar ceiling grid. Where not practical to install either of these types of units, an exposed wall mounted unit can also be utilized. As there are several types of fan coil units available, the system overall has a high degree of system flexibility and can provide a higher granularity of individual temperature control. As these systems place evaporator DX coils indoors, condensate drain lines will need to be ran from each unit to an appropriate condensate disposal location. This may require installation of additional condensate drainage pumps as the administration wing has a large horizontal footprint without sanitary sewar lines near the extremities.

3.4.2.4 Controls

The VRF system will be controlled by a central control system that is provided by the VRF system manufacturer. Direct control of the VRF system through the building's existing Alerton system which will be utilized in the labs is not possible. The VRF system will be capable of speaking native BACnet and will be capable of integrating with the Alerton system for monitoring and scheduling only. The Alerton system will control the new DOAS units on the roof which provide ventilation air to the space. These units will be provided with BACnet IP advanced equipment controllers.

3.4.3 Alternative 2 – Packaged Heat Pumps

Another alternative that can separate the cooling and heating generation of the W41 side of the building from W42 would be to utilize multiple packaged rooftop heat pumps in the place of the existing rooftop AHUs. This system would utilize a packaged Dx Refrigeration cycle built into the AHUs to generate heating and cooling for the zones served by each AHU.

3.4.3.1 Rooftop Equipment

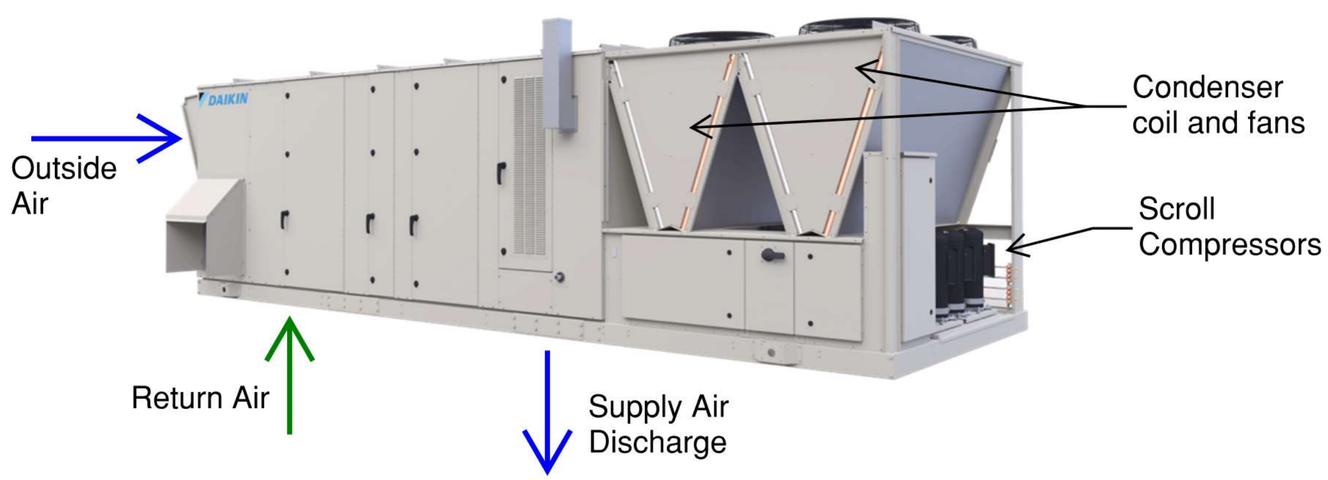

Figure 3–F: Packaged Unit Example

The packaged heat pump as picture above contains a "packaged" Direct Expansion (DX) refrigeration circuit built onto the unit. This routes refrigerant between a DX coil and the condenser section pictured on the right side of the figure above. These units will additionally be specified as "Heat Pump" models which feature a reversing valve in the refrigerant circuit allowing the unit to function in heating as well as cooling. This permits the unit to change from heating to cooling depending upon the zone demand and outside air conditions.

In order to not necessitate a substantial seismic redesign of the building and require additional framing reinforcements, the new units ideally should be similar to the weight of the existing. As the rooftop equipment in this design alternative requires the condenser section in addition to the same features of a standard air handling unit, there is overall more equipment packed into each unit. As a result, compromises will need to be made to the construction of the unit to meet the weight requirements of the existing facility. The packaged unit will need to be designed with a higher coil face velocity and be constructed with lighter gauge sheet metal in order to lessen the overall weight of the unit.

In addition to making the units lighter, the packaged units are typically intended for light commercial applications and do not have as much customizability as standard AHUs do. Resultingly, the units will come in standard catalog sizes and configurations without the potential for modification to meet specific jobsite constraints. As a result, more extensive modification of the existing curbs will be necessary as the new units will not be the same exact footprint as the existing. Modifications may involve installation of steel members on top of the existing AHU curbs to align the mounting points to the new units.

The construction characteristics of the units in addition will not have as many configurable options as a fully custom AHU will and resultingly will not be capable of being built to a high degree of corrosion resistance. The sheet metal gauges of the units will be limited by the standard offerings of the unit manufacturers and custom materials such as aluminum and stainless steel will not be an option. This will lead to an overall shorter equipment lifespan as compared to that of a custom unit optimized to the EBMUD MWWTP environment. For additional corrosion protection after market coatings of the coils and unit casings will be required.

3.4.3.2 Zone Level Control

As the intent of this alternate is to separate the cooling and heating generation of the system from the remainder of the building, the system will not utilize the heating hot water of the boiler plant. Resultingly no zone level reheat terminal boxes will be provided. The effect of this is that the areas served by each packaged heat pump will need to be entirely in either heating or entirely in either cooling at one time. The system will not allow a singular zone to be in a different mode than the adjacent zones around it. Below is an image of the current zoning layout of the existing AHUs.

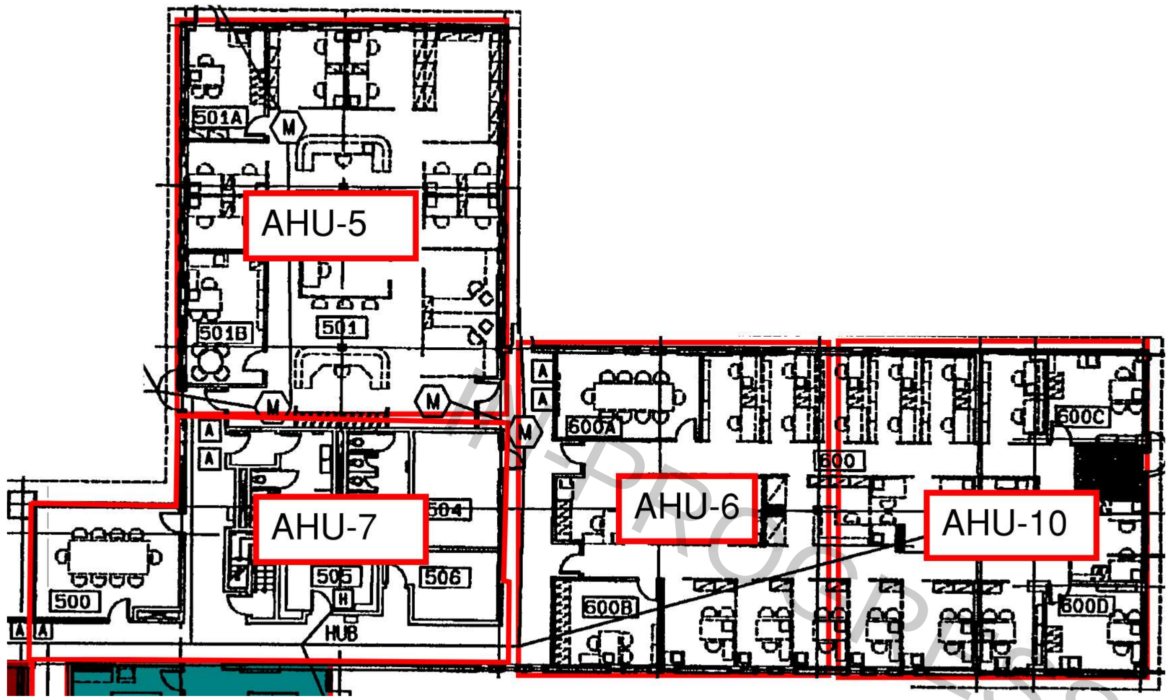

Figure 3–G: Office Wing AHU Zoning

The above map represents the current zoning of the existing air handling units. As the new units will be connecting to the existing ductwork, the zoning will be similar to that of the existing. To provide a further granularity in the conditioning of the spaces, an alternative that can be utilized is VAV diffusers. These diffusers replace the existing air grilles that are located at the ceiling and can individually vary the amount of air delivered through it:

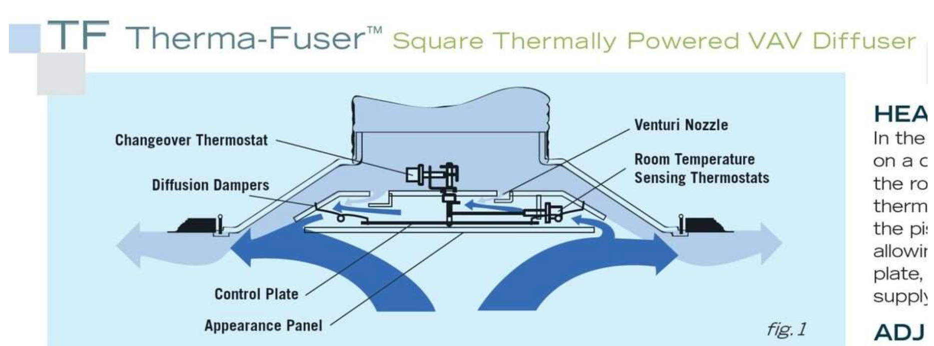

Figure 3–H: VAV Diffuser Diagram

These diffusers will correspond to a zone level thermostat to allow variability of air delivery into each space. This allows each diffuser to prevent a space from becoming overly heated or overly cooled depending upon the mode of operation of the packaged heat pump. While this will still permit some additional zoning capabilities, this will not let a zone act entirely independently of the remainder of the system

3.4.4 System Comparison

The following weight factor analysis chart highlights various key characteristic in each type of system.

Office HVAC System Comparison - Weight Factor Analysis										
		Base System - VAV Reheat w/ Hydronic AHUs			Alternative 1 – VRF System			Alternative 2 - Packaged Heat Pump System		
	Weight (1-5)	Description	Score (1-10)	Weighted Score (1-50)	Description	Score (1-10)	Weighted Score (1-50)	Description	Score (1-10)	Weighted Score (1-50)
First Cost	5	• Requires less overall system modification as no increase in overall building cooling capacity occurs • Utilizes existing CHW system, no gross capacity addition • Highest ductwork modification cost • Higher control cost	6	30	• Higher equipment cost due to additional capacity being added to the system ~ 60 Additional tons • More ductwork modification required • More electrical amperage required • Requires addition of condensate drain lines • Less overall ductwork installation and smaller AHUs required	3	15	• Lowest cost • Light commercial grade equipment in lieu of custom AHUs and controls • Minimal ductwork modifications • Less overall equipment control devices • Adds overall refrigeration capacity to building	4	20
System Reliability	5	• Highest reliability due to highest construction quality HVAC equipment • Less distrusted components • Readily available component replacement • Less cooling redundancy due to reliance on existing chiller and boiler plant	7	35	• Less than base system due to more working components and additional equipment quantity • Improved corrosion resistance of indoor units due to limited outdoor air delivery	6	30	• Least Reliable • Light commercial application units will not hold up as well in corrosive EBMUD environment	4	20
Energy Performance	2	• Highest, cooling is sourced from higher efficiency screw chiller from SD-402 • Allows for full economizer operation	9	18	• Worst, does not allow for full economizer operation • System is reliant upon Scroll compressors which are inherently less efficient than the variable speed screw compressors of the existing CHW system	1	2	• Higher than alternative 1 though less than Base system.	3	6
Environmental Consideration	2	• Does not install more refrigerant to the building • Requires natural gas for heating	6	12	• Utilizes R410A Refrigerant • Fully electric / Eliminates natural gas • Allows greater utilization of EBMUD cogeneration energy	4	8	• Utilizes lower GWP R454b or R32 refrigerant though still increases overall refrigerant quantity at building • Eliminates natural gas • Allows greater utilization of EBMUD cogeneration energy	5	10
Temperature Control	3	• Highest controllability due to DDC Controls • Allows for fully optimized ASHRAE Guideline 36 SOO implementation • Allows for greater flexibility and tunability of existing system	10	30	• Similar controllability to Base system. • Allows more individual zoning flexibility with less upfront cost • Requires multiple control systems which adds complexity	8	24	• Least controllability due to lack of zoning flexibility of existing duct runs.	2	6
Installation Impact	2	• More impactful than Alt-2 but better than Alt-1. Requires replacement of existing AHUs and extensive ductwork modifications.	6	12	• Most impactful, requires significant reconfiguration of rooftop equipment and installation of indoor FCUs.	4	8	• Least impactful. Existing ductwork can largely be reused with the main component being replaced being the diffusers	10	20
		Total Weighted Score:		137	Total Weighted Score:		87	Total Weighted Score:		82

Note* The above scores represent Gayner Engineer's opinion of each category. We highly recommend that EBMUD staff weigh in on these criteria to best grade each system

Note** Red text represents negative qualities while black text represents positive or neutral qualities

3.5 Waterproofing – New Work

The SD-402 project installed a new modified bitumen roofing system throughout the entire roof. For all existing units, the new roofing system did not replace any existing flashing as doing so would require lifting the new mechanical units. This during the design was deemed impractical due to the shutdown requirements and potential damage to the existing installation. The project did provide additional sealing over the existing flashing to improve the waterproofing capabilities of the existing flashing.

Figure 3–I: Existing AHU Flashing

As the new unit installation may necessitate modification to the existing curbs, the newly provided roofing will need to be removed as necessary to facilitate the new installation. All new units will require flashing and waterproofing to be designed to mate with and tie into the newly provided roofing.