ATTACHMENT A-1

DC DGS
Patricia Handy
HVAC Assessment

810 5th St NW, Washington, DC 20001

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Final Report

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1. EXECUTIVE SUMMARY

Setty Associates International, PLLC has conducted an in-depth study of Patricia Handy Building, located at 810 5th St. NW Washington DC 20001.

The purpose of this study was to examine the existing, recently installed heating, ventilation, and air conditioning (HVAC) system in order to determine the cause of recent mold findings throughout the building.

Setty engineers visited the site on three occasions, using instruments to take temperature and humidity measurements, as well as performing visual inspection of various areas for this study.

1.1 Issues and Recommendations

Items are listed below in order of temporary solutions (housekeeping and maintenance) to more involved changes potentially requiring formal documentation (design).

Issue	Location	Recommendation	Priority	Responsibility
#1: Open Windows	Dorm rooms, other spaces	Close all windows and secure to prevent from opening	High	Housekeeping
#2: Standing Water	Group showers	Frequent mopping of showers	Low	Housekeeping
#3: Poor Air Circulation	Storage rooms	Adjust common practices, shelving	Medium	Housekeeping
#4: Water Intrusion	Basement	Seal any openings and gaps	High	Maintenance
#5: AC Not Maintaining Setpoint	Dorm rooms, other spaces	Qualified professional to examine VRV units	Low	Maintenance
#6: Mop Basin Walls	Janitor closet	Remove damaged wall, replace with suitable materials	Low	Maintenance
#7: Accessible Unit On/Off Switches	Dorm rooms, other spaces	Provide tamper-proof switch covers	Medium	Maintenance
#8: Lack of Dehumidification	Group showers	Provide ceiling mounted dehumidifier	High	Maintenance/ Design
#9: Lack of Dehumidification	Basement	Provide ceiling mounted dehumidifier	High	Maintenance/ Design
#10: DOAS Investigation	Roof	Repair or upsize existing unit	High	Maintenance/ Design
#11: No Dropped Ceiling	Group showers	Add dropped ceilings	High	Design
#12: Exhaust Short Circuiting	Group showers	Provide exhaust extension to ventilate group showers	High	Design
#13: Lack of AC	Group showers	Relocate a fan coil unit from community room to shower room	Medium	Design
#14: Fresh Air Short Circuiting	Dorm rooms	Extend fresh air ductwork	Medium	Design
#15: Supply Duct Lining	Roof	Remove internally lined insulation, provide external	Medium	Design
#16: Isolated Shower Rooms	5th Floor Bathrooms	Provide transfer to connect shower with toilet exhaust	Medium	Design
#17: System Balancing	All rooms	Provide ABD's throughout	Medium	Design

2. PROJECT SCOPE AND EXISTING CONDITIONS

2.1 Project Scope and Background

Setty Associates International, PLLC has conducted an in-depth study of the Patricia Handy Building, located at 810 5th St. NW Washington DC 20001.

The purpose of this study was to examine the existing recently installed HVAC system in order to determine the root cause of recent mold findings throughout the building.

The building is a five story concrete structure with a full basement. The building was totally renovated in 2013, in which a new HVAC system was added to enhance the indoor air condition throughout the building.

Shortly following the renovation, mold and mildew began to appear in the group shower rooms as well as other areas, and became a cause of concern. To-date, one major cleanup, including the removal of the molded drywall, patching, and painting has been undertaken in order to clean up the mildew and restore the spaces.

2.2 Approach and Data Collection

Setty engineers visited the site on three occasions and met with the staff and DGS project manager. During the visits, Setty engineers visited the dorms, group shower rooms, roof areas, various storage rooms, single shower rooms, and community rooms in order to inspect their condition, look for signs of water damage, and examine the HVAC system up close.

Setty also used temperature and humidity data loggers, also referred to as HOBO pods. The loggers are manufactured by OnSet Inc. and were left at various areas in order to measure the temperature and humidity on a continuous basis. The loggers used by Setty are programmable and can be programmed to record data on a pre-schedule time basis. The data is stored locally in the loggers' memory during the observation period. Then, the loggers are collected, brought back to the office and connected to a computer where the data is downloaded and organized in a manner that can be accessed and observed for analysis.

Setty utilized 13 loggers for this test in total. Three loggers remained in the same position to gather temperature and humidity readings for the duration of the two week data gathering period: one logger was placed at the dedicated outdoor air system's (DOAS) air intake, one was located at the fresh air supply outlet in Common Room 300, and another was placed in Lobby 111.

Of these three, the loggers placed on the DOAS unit and on the fresh air supply outlet helped to determine a baseline that the other spaces could be compared with.

The remaining 10 loggers were distributed between selected floors for two, one-week measurement periods. One week after the initial placement of the loggers, Setty engineers revisited the site and relocated the loggers to the new areas. This method allowed Setty to measure the environmental conditions of additional rooms and enhance the data collection effort over the two week span.

The loggers were positioned in hallways, toilet rooms, group shower rooms, community rooms, dorm rooms, and other spaces suspected of high humidity conditions. The results of this effort are discussed in Section 3 of this report.

2.3 Findings and Recommendations

The following issues were observed below. Recommendations are provided with each issue description.

Issue #1: Open windows at community rooms and dorm rooms. Windows throughout the building are operable and can be opened by personnel and residents. There is no consistent effort to close the windows and keep them shut during unfavorable weather conditions. Currently, it is understandable that windows may be opened due the current DOAS supply conditions. However, when the windows are left open during unfavorable weather conditions, additional humid air from outside is allowed to enter the rooms. Due to the addition of moisture to the space, excess condensation builds up on the window frames and nearby air conditioning units. The existing cooling system is not adequately sized to handle the excess moisture due to the open windows, and consequently, comfortable space temperatures and humidity levels cannot be maintained.

Recommendation #1: Close and secure all windows during unfavorable weather conditions (especially high humidity). Windows can still be opened during periods of fair weather, but should be monitored to make sure they do not detrimentally affect the building conditions.

Issue #2: Standing water in the group shower rooms. The floors in the group shower rooms are not sloped to drains, allowing substantial amounts of standing water to collect right outside the shower stall. This water often remains there for a considerable amount of time before it is mopped up the following day.

Recommendation #2: Encourage mopping the shower rooms more frequently following the designated shower period to remove the standing water.

Issue #3: Lack of air circulation in storage rooms. Several storage rooms on the basement level are not provided with an adequate method of ventilation, meaning that whatever moisture enters the space is trapped in a confined area for an extended period of time. As a result, there are reports of mold and mildew in some of the storage rooms.

Recommendation #3: Provide the following:

1) Openings in the storage rooms to adjacent spaces to promote air circulation.
2) Provide an open mesh shelving system in lieu of solid surfaces.
3) Avoid placing cardboard boxes on storage room floors, and if possible remove unused cardboard from the storage rooms altogether.
4) Avoid placing clothing and cloth materials in storage rooms that lack air circulation.

We propose to add hi-low door or wall transfer grilles to smaller storage rooms. For larger storage rooms, provide a combination of a transfer fan with a low-wall transfer grille. Increasing air circulation to the storage areas will help to prevent a buildup of moisture in the spaces and discourage the occurrence of mold and mildew.

The current vertical storage shelving in several storage rooms utilize solid surface shelving. The shelves do not allow air to reach the underside of the boxes, providing a region for moisture to build up in. We propose to replace the current solid surface shelving with open wire mesh shelving, allowing air to reach the underside of the boxes. As an alternative approach, we suggest placing a spacer on the underside of the boxes so they can be partially separated from the solid shelf surface and receive some air circulation.

There are many empty cardboard boxes scattered in the storage rooms, some of which are resting on the floors. We recommend implementing a policy to discourage cardboard boxes from being left in the storage rooms altogether, and especially being removed from the floors. Cardboard boxes can be a large contributor to mold and mildew growth. The material is porous, and can easily absorb and trap any moisture that it comes into contact with, providing an ideal location for mold and mildew to grow. Any water that leaks into the space through nearby walls will eventually collect on the floor, meaning that cardboard left there is at a greater risk to contribute to mold and mildew growth.

Many items in the storage rooms, and in particular in the basement storage rooms, have become moldy and mildewed as a result of high humidity and lack of air flow. Among these is over a dozen emergency sleeping cots that are folded and stored very close to one another without adequate air flow. Thus the cots have absorbed moisture and become mildewed and moldy. These cots will need to be cleaned professionally, sanitized, allowed to dry and then stored in the open position to prevent the same occurrence. Also, efforts ought to be made to discourage the storage of clothing materials in the storage rooms since they are highly susceptible to mold and mildew as well as prone to damage by moths and other insects.

Issue #4: Water and air intrusion through basement roof slab and walls. Many of the outside air openings are not sealed sufficiently, and as a result water and humid air can enter the basement spaces, leading to mildew and mold issues.

Recommendation #4: Seal gaps and openings to outside. An outdoor sealant or caulk should be applied to the borders of the outside air openings found on the basement level, as well as any other points where water is infiltrating. This will help prevent water and humid air from being introduced, reducing the load on the AC and dehumidification system.

Issue #5: AC System Investigation. The building spaces are conditioned (cooled and heated depending on the season) through many fan coil units (FCU's) installed throughout the building. There are two main types of FCU's in this building: those that are mounted high on the walls (referred to as "high-wall" units) and those that are suspended from the ceiling (referred to as "cassette" or "ceiling cassette" units.

In many areas during the survey, the thermostats controlling the FCU's read a setpoint of 73°F, but the space temperatures were in the range of 75 to 81°F.

If the units were undersized this behavior would be expected, but Setty did a cursory review of the HVAC design and the capacity of the FCU's appear to be suitable for the intended spaces. The issue appears to be with the controls and a possible disconnect between the thermostat and the FCU not communicating properly.

Recommendation #5: AC System Investigation. Secure the services of a qualified HVAC company to examine the FCU's performance and confirm the thermostats are communicating properly with the units.

Issue #6: Janitorial Mop Basin Wall Surround. The basement janitorial closet contains a mop basin. The surrounding wall around the mop basin lacks a water proofing membrane such as a stainless steel guard. As a result, the dry wall is badly damaged and heavily soaked. The soaked wall is adversely contributing to the humidity levels in the basement.

Recommendation #6: Janitorial Mop Basin Wall Surround. Remove the damaged drywall and replace with new drywall suitable for a wet environment (Green Board). Provide a stainless steel guard on the wall surfaces in the proximity of the mop basin to prevent moisture from reaching the drywall.

Issue #7: Unit On/Off Switches Accessible. Multiple units were found to be in the off position due to accessible cut-out switches located close to the units. It is suspected that occupants turn the units on/off depending on comfort preferences.

Recommendation #7: Unit On/Off Switches Accessible. Provide tamper proof covers to the switches so that the units cannot be disturbed from scheduled operation.

Issue #8: Lack of dehumidification in the group shower rooms. There is currently a high humidity level in the group shower rooms. This is due to the lack of air flow during maximum use in the morning and evening showering periods.

Recommendation #8: Provide a horizontally mounted dehumidifier in the ceiling of the group shower rooms. The proposed dehumidification unit with supply and return ductwork will be mounted above the proposed suspended ceiling. It will dehumidify the air while recirculating it through the supply and return ductwork. The dehumidification units are rated based on pints of moisture removal per day and are available in 30, 50, 80, and 120 PPD capacities. We recommend a unit at approximately 30 to 50 PPD for each of the group shower rooms. The dehumidification units do add heat to the spaces they serve, thus the recommendation to relocate a cassette unit (Recommendation #13) is essential in order to prevent the rooms from overheating.

Issue #9: Lack of dehumidification in the basement. Many spaces in the basement lack proper dehumidification. Most times there are not enough people or high enough of an activity level in the basement multipurpose room to activate the HVAC system. As a result, the FCU's are usually off, allowing the humidity level to rise unchecked. There is a lot of evidence of moisture intrusion (buckets full of water from ceiling leaks) and evidence of potential efflorescence on the walls. Efflorescence is a condition in which paint delaminates from porous walls, especially exterior brick or concrete walls, due to mineral salt deposits that are leached out of the masonry after exposure to excess moisture.

Recommendation #9: Provide a horizontally mounted dehumidifier in the ceiling of the basement areas to remove the excess humidity buildup. FCU's are often not the right tool to manage humidity. Instead, we often rely on dedicated dehumidification units to remove a large amount of moisture from the air stream and manage humidity. Providing dedicated dehumidifiers in the basement areas will remove the buildup of humidity and will prevent mold and mildew growth on the exterior walls.

Issue #10: DOAS Investigation. The Dedicated Outside Air System (DOAS) is located on the roof level and supplies 100% outside air to the spaces below. The DOAS unit is the primary source of fresh air for the occupants in the building. The DOAS unit is supposed to condition the outside air year round and supply that air to spaces throughout. In the summer months, the DOAS is supposed to dehumidify the outside air by lowering the air temperature to about 56°F, effectively raising the relative humidity (RH) to 100% and allowing moisture to condense out of the air. The resulting air has a lower temperature and relative humidity, and is referred to as conditioned air. In the winter months, the cooler outside air should be heated to supply the spaces with 70 to 72°F air, and is referred to as neutral air.

To provide a complete evaluation of the existing DOAS unit, it is necessary to understand both the supply air conditions produced by the unit, as well as the amount of air that the unit is providing to ventilate the building. The supply air conditions were measured directly through the use of temperature and humidity sensors near the discharge and intake of the DOAS unit, while the overall capacity of the unit was evaluated by comparing documented values with code requirements for ventilation.

The complete review of the measured supply air conditions is provided in Section 3 of this report. The gathered data indicates that the supply air from the DOAS during the summer testing period was around 70°F or greater, with high humidity contents of 75 to 90% RH. This implies that the DOAS unit is not properly dehumidifying the air and in fact is contributing to the high level of moisture content in the building by continuously introducing humid air throughout. As mentioned before, this is of high importance since the DOAS unit is the primary source of dehumidification for the building, and the individual fan coil units (FCU's) will not be able to dehumidify the spaces independently.

Below is a summary of the existing facts and conditions that were used to evaluate the capacity of the existing DOAS unit.

Existing facts and conditions:

1) The Certificate of Occupancy for the building states the maximum occupancy to be 213 people, matching the number of beds at this facility.
2) The DOAS unit capacity was initially listed on the design drawing schedules as 4,000 CFM, and the manufacturer submittal was for 4,175 CFM (04-27-2015).
3) According to the latest testing and balancing (TAB) report (12-08-2015) the DOAS is providing 4,378 CFM of its designed 4,415 CFM (99%).
4) Setty's ventilation calculation amounts to 4,845 CFM of required outside air based on 457 people and <u>no changes to the existing spaces</u>.
5) Setty's ventilation calculation amounts to 4,285 CFM of required outside air based on 412 people <u>if Multipurpose Room 000 is repurposed into a conference room</u>.
6) On average, each group bedroom has about 10 occupants and requires approximately 90 CFM of outside air.

The main focus of investigating the ventilation capacity of the existing DOAS is to determine if a complete unit replacement was necessary in order to be code compliant. As listed above, the total ventilation requirement for the building without changing any spaces is calculated by Setty to be 4,845 CFM, making the current unit slightly undersized. However, the ventilation requirement for the building largely depends on the definition of Multipurpose Room 000, as it is accounting for 90 occupants requiring 910 CFM total. If the Multipurpose Room 000 is repurposed into a conference room, the occupancy would be reduced to about 45 people per code, and the OA requirement would drop to about 350 CFM for that space. Consequently, the total required OA would be reduced to 4,285 CFM, which is below the current performance of 4,378 CFM.

Overall, to address the deficiency of the DOAS unit there are essentially two main options to consider: repurposing the program space to alter the required ventilation rate, or upsizing the unit to meet the added capacity.

Recommendation #10A: Examine the DOAS unit and repurpose the multipurpose room. Secure the services of a qualified HVAC product repair team to examine the DOAS for service, functionality, and for trouble-shooting. Primarily, the capacity of the unit should be verified to produce 4,400 CFM. As the DOAS unit is fairly new, the DOAS could potentially be corrected to proper operation at a lower cost than replacing the unit entirely. If the unit is found to be deficient and cannot be repaired at a practical cost anyways, it may still need to be replaced, but with a similarly sized unit to that of the existing unit. By replacing the unit in kind, the existing electrical and structural conditions could remain unaltered. In addition to direct changes to the DOAS unit, Multipurpose Room 000 should either not be used as a gathering area or should be repurposed into a conference room, reducing the required OA for the space as discussed above.

Recommendation #10B: Upsize the DOAS unit. Alternatively, if the Multipurpose Room 000 stays as it is currently, the DOAS unit would need to be upsized to around a 5,000 CFM unit. The existing risers should be able to handle this additional airflow. Discussions with manufacturer representatives determined that a new 5,000 CFM unit matching the existing frame size would require breakers with a maximum overcurrent protection (MOCP) of 200 amps. The existing unit breaker is only rated for 110 amps MOCP, indicating that the electrical service would need to be substantially upsized to handle the new unit. Furthermore, the weight of the existing unit is around 2,700 lbs, while a new unit would weigh close to 3,100 lbs. The structural integrity of the roof would need to be approved for the added weight. Performing these updates would require the building to be shut down for approximately 3 months.

Issue #11: Lack of suspended ceiling system with vinyl faced tiles at all group shower rooms. The open ceilings of the group shower rooms leave the steel structure above exposed. When an excess of humid air builds up in the space, the piping, hangers, HVAC equipment, and fire proofing insulation are all adversely affected, and as a result are deteriorating rapidly.

Recommendation #11: Provide a suspended ceiling with vinyl-faced ceiling tiles in order to protect the ceiling and systems within it. It appears all group shower rooms can be fitted with an 8 foot ceiling. The proposed ceiling will contain the moisture to the areas under the ceiling and protect the structure and equipment from exposure to excess moisture.

Issue #12: Short circuiting of the bathroom exhaust and the resulting lack of exhaust from group shower rooms. The existing exhaust grille is intended to serve the group shower room as well as the toilet room, and is located halfway between the two rooms. The exhaust provides adequate ventilation for the toilet room, pulling in fresh air through the entry door. However, the fresh air takes the path of least resistance and is exhausted before reaching the shower rooms. As a result, the group shower rooms are isolated and moisture is allowed to build up, damaging various elements within the room.

Recommendation #12: Ductwork extension. The current ventilation system should be broken up into two systems to serve the toilet area and showers separately. In the toilet rooms, the existing exhaust register should be balanced to provide enough exhaust for the toilets alone, utilizing the entrance door to supply ventilation air for those spaces. To ventilate the showers, a ducted inline fan should be installed high in the space to transfer ventilation air from a nearby hallway to a supply air register located near the entrance of the shower area. Rather than just providing an air transfer from the hallway, a fan is necessary due to the comparatively large open area of the entrance door. Additionally, the exhaust for the showers would be accomplished by extending the ductwork from the existing riser to a new exhaust air terminal located at the back of the group shower room. The system should be properly balanced to verify that fresh air from the entrance door is exhausted through the existing exhaust register, and the ventilation air introduced at the entrance to the showers is exhausted through an exhaust register at the back of the showers.

Issue #13: Lack of cooling for the group shower rooms. As a result, the group shower rooms are warm, humid, and uncomfortable.

Recommendation #13: Relocate one of the four ceiling cassette units in the Community Room (with its associated thermostat) to the group shower room. There are four ceiling cassette units in each of the community rooms. Setty has checked with the HVAC manufacturer and it is not feasible to include an additional unit in the existing HVAC distribution system. However, four cassette units for the community rooms appears to be excessive and the rooms should be fine with three cassette units. The cassette unit at the far end of the community rooms can easily be relocated to the group shower rooms to condition the spaces.

Issue #14: The fresh air supply register locations are in close proximity to the dorm room entrances. This is preventing the fresh air supply from properly purging the rooms. The fresh air is supplied from a roof-mounted DOAS unit via vertical duct risers. The fresh air is then distributed to the spaces with the use of supply registers. However, many registers are located near the entry door where the air escapes into the hallway and consequently is exhausted from the bathrooms. The close proximity of the supply registers to the dorm room entrances results in ineffective ventilation in the dorm rooms, and leaves many parts of the rooms without a proper supply of fresh air.

Recommendation #14: Relocate the fresh air register to the opposite end of the room and connect it with an extension duct from the current fresh air register location to provide a full purging of the dorm room. The proposed branch duct can be installed up high and as tight to the slab as possible. By extending the supply to the opposite end of the room, the incoming fresh air will then tend to push the stale air out of the room, creating a healthier environment for the residents in the dorm rooms. Additionally, the lack of fresh air could explain why many residents are currently opening their windows and leaving them open in order to get fresh air and remove a buildup of odors.

Issue #15: The DOAS supply air duct appears to be internally lined with insulation. The first fifteen feet of the supply duct from the DOAS unit on the roof is shown on the design drawings to receive sound lining insulation. This is often done to reduce the noise generated from the unit and transmitted through the ductwork. However, the duct system is fabricated in sections connected by metal seams. The seams are initially caulked and taped shut, but over time will tend to open up or fail, allowing small amounts of water and moisture to enter the ductwork. The water that enters the duct cannot evaporate easily and can remain in the ductwork for an entire season if not the entire life of the ductwork. The water and moisture in the dark, cool duct provides ideal growing conditions for mold and mildew. Mold spores can be spread throughout the entire supply air system from this point and continuously feed interior spaces with mold spores, causing major health hazards.

Recommendation #15: Investigate the portion of the supply ductwork shown on the HVAC roof plan as having internally sound lined insulation and if found to exist, then remove the internal sound lining and insulate ductwork externally. We recommend to remove any sound lining that is installed on ductwork located on the exterior of the building that can harbor mold and mildew. All ductwork located outside of the building and exposed to the elements ought to be externally wrapped and insulated.

Issue #16: Isolated Shower Rooms. The exhaust for 5th floor bathrooms is placed in the toilet room. If the door to the toilet room is shut, the adjacent shower room is isolated from the exhaust grille, and humidity levels can increase unchecked.

Recommendation #16: Provide a wall mounted transfer grille high between the toilet and shower rooms to provide a clear path for the humid shower air to be exhausted from the space. The grille should be placed high in the space in order to be effective.

Issue #17: System Balancing. The system may not be providing sufficient amounts of OA to individual spaces. This was not specifically verified, but can be commonplace as systems are manually balanced, and may change over time depending on the performance of the unit. As a result, an area that was previously approved in a TAB report may no longer be supplying adequate airflow.

Recommendation #17: Provide automatic balancing dampers (ABD's) before each air terminal to ensure that the system is properly balanced and that each space is receiving the correct OA airflow rate. These devices are entirely mechanical, and operate independently without the need for electrical connections. Partially implementing this recommendation (adding some ABD's, not every air terminal) would help the system to be more easily balanced in the future.

3. DATA AND ANALYSIS

3.1 Surveyed Conditions

The Patricia Handy building was surveyed on July 8th, 16th, and 23rd. The visits involved an evaluation of individual rooms, as well as the positioning of data loggers in various spaces. A total of 13 data loggers were positioned to record both temperature and relative humidity from July 9th through the 16th. On July 16th, the loggers were repositioned in order to examine more spaces, and were later collected on July 23rd. This resulted in a total of 26 graphs of data, each displaying readings over a week long period. The results of data collection can be viewed in Figures 3-1 through 3-26 at the end of this section.

3.2 Data Logger Results

The data loggers provided a more complete picture of operating temperatures and humidity levels in the rooms by taking continuous readings throughout the day. As was previously mentioned, two notable loggers were left for the duration of the data collection period in the same locations: one logger was placed outside at the DOAS's air intake, and one logger was located at the fresh air supply outlet. All other loggers were placed throughout the building to record data for the shower and toilet areas, sleeping areas, corridors, and other common spaces.

Data logger results for the DOAS's outside air intake can be viewed in Figures 3-1 and 3-2. The outdoor conditions were recorded over the entire two week period and were used to cross reference possible explanations for peaks and troughs in the data of indoor space readings. Note that the highest temperature readings were recorded during the second week from Friday, July 19th through Monday, July 22nd, reaching a peak temperature of 104°F on Sunday, July 21st. The highest humidity readings occurred during the first week, primarily on Thursday, July 11th.

Figures 3-3 and 3-4 display the results for the logger placed on the fresh air supply outlet. The data logger was placed directly facing the supply register, reflecting the fresh air conditions supplied by the DOAS air handling unit. Compared to other graphs, the fluctuations in readings for this logger are most likely due to the fact that the device was pointed into the oncoming air stream. However, the average values of air supplied by the DOAS are still not as expected. The fresh air supply has peaks in the same locations as the outdoor air, as the DOAS unit attempted to condition the outside air. But these peaks and general magnitude are much higher than they should be, indicating that the DOAS is not performing properly. The fresh air supply does not appear to be properly dehumidified, as the relative humidity fluctuates between 75 to 90% RH on average. A properly operating DOAS should supply air at about 50% RH during the summer season. Furthermore, it appears that the DOAS currently provides room neutral air of around 70-72°F or even warmer air reaching up to 80°F. This means that the 'conditioned' air entering the building is already at a higher temperature and relative humidity than it should be, making it harder for spaces to cool properly or use this air for dehumidification.

<u>Basement Level</u>

Starting on the basement level, a data logger was placed in Janitor Closet 004 as there seemed to be significant water damage to the walls surrounding the mop sink. Results are given in Figure 3-5, and show that the space temperature and humidity levels track along with the supply air conditions introduced by the DOAS, although the extremes are less pronounced. The temperature fluctuates slightly, but not to unreasonable levels considering it is controlled indirectly by the adjacent Men's Toilet Room Staff 006 exhaust system. The humidity levels in the space are of larger concern, and are too high on average. If examined closely, it appears that the humidity profile for the Janitor Closet 004 trends in a similar manner to the DOAS, although at a lower overall magnitude.

The data obtained for Multipurpose Room 000 is given in Figure 3-6, and again shows a controlled space temperature with considerable peaks in relative humidity levels. Space temperature is more tightly controlled than the Janitor Closet 004, as it is on a dedicated cooling system. However, this cooling system is failing to control relative humidity levels, as it is not designed to perform significant dehumidification. The system is most likely being overwhelmed by humid supply air from the DOAS as well as any other infiltrating water sources along the walls of the space.

1st Floor

Corridor 003, shown in Figure 3-7, displays a fairly consistent space temperature with a high level of relative humidity. Humidity levels are not as high as some of the other spaces, but they are still well above the ideal range of about 40-50%.

Shower Room 105, displayed in Figure 3-8, reveals an expected pattern of two peaks of high relative humidity in both the morning and evening. The peaks fall in line with expected times of frequent shower usage. The humidity in the space spikes to greater than 90% RH in several cases. When not in use, the space is able to dry out to a more moderate relative humidity of around 55% RH, but overall the space is not able to regulate humidity levels effectively.

Lobby 111, shown in Figures 3-9 and 3-10, shares a similar description to other spaces in that the temperature is generally maintained but humidity levels are slightly high and uncontrolled.

Sleeping Room 109, shown in Figure 3-11, experienced more temperature fluctuation than would typically be desired. The space reached a maximum temperature of 77°F with an assumed setpoint of 73°F, but otherwise kept a fairly maintained temperature. Humidity levels were closer to an acceptable range in this space, reaching a slightly high max reading of about 60% RH, but in general staying just above the 50% RH on average.

Second Floor

Corridor 204, shown in Figure 3-12, maintains a consistent temperature reading with fluctuating humidity levels just above the preferred range of 40-50% RH.

Shower Room 205, shown in Figure 3-13, again displays a similar profile to the other shower rooms. The room temperature peaks during the same time that humidity spikes, and the exhaust system fails to control this behavior. Furthermore, you can see an influence on the adjacent Toilet Room 205, as shown in Figure 3-14. The peaks are slightly more distorted as some of the humidity is being exhausted, but in general the humidity peaks in Toilet Room 205 during the same morning and evening periods of heavy shower usage.

In Sleeping Room 208 and 212, shown in Figures 3-15 and 3-16 respectively, the temperature profiles are well controlled near the desired setpoint of 73°F. However, while Sleeping Room 212 has a typical profile of slightly high humidity, Sleeping Room 208 has some distinguished peaks around midday from Thursday, July 11th through Sunday, July 14th. The space sees a brief period of higher relative humidity just before and after lunch, which may be attributed to mopping the floors, etc. Whatever the cause, the current system does not have an effective means to dampen these higher humidity levels.

Sleeping Room 213, shown in Figure 3-17, has a less controlled temperature profile than would be desired. Temperatures are slightly higher in this space (assuming a 73°F setpoint), and climb to a maximum reading of about 79°F. However, this space has some of the lowest humidity readings recorded in this study, and fall within the ideal range on average of 40-50% RH.

Third Floor

The temperature readings for Corridor 303, shown in Figure 3-18, are slightly higher than the assumed setpoint, and reach a maximum temperature of about 80°F. Humidity levels in this space also peak more significantly than some of the other corridors measured. The increase may be caused by humid air escaping the showers during periods of heavy usage, or perhaps by the collection of wet towels in the hallway during those times.

Shower Room 304 and Toilet Room 304, shown in Figures 3-19 and 3-20, experience peak humidity levels typical to other shower and toilet rooms. The overall space temperatures do appear to be higher in these spaces though when compared to shower and toilet rooms on other floors. Notably the humidity sensors peaked on Shower Room 304 at 100% RH on multiple occasions, indicating the air was completely saturated.

Sleeping Room 307, shown in Figure 3-21, has a temperature profile that is typically a bit high with a maximum temperature reading of about 78°F. This unit does have an uncharacteristic dip in temperature where it could have perhaps been reset to a lower value on the night of Monday, July 15th, reaching a minimum temperature of about 73°F, before climbing back up to about 77°F. Humidity levels were generally uncontrolled and slightly high.

Fourth Floor

Sleeping Room 406, shown in Figure 3-22, displays a temperature and humidity profile that is uncharacteristically jagged. This behavior is most likely explained by the data logger being placed too closely to the nearby cooling unit. The switching of the unit on and off gives the graph a more varied profile than the ambient room experienced as a whole, but the average values can still be analyzed. Overall the room temperature was slightly higher than the temperature setpoint, reaching a maximum temperature of 82°F. Relative humidity was also higher than desired, averaging around 60% RH.

Shower Room 404 and Toilet Room 404, as shown in Figure 3-23 and 3-24, have typical peaks in relative humidity and temperature during periods of high usage. The peaks are notably smaller than some of the other floors, but still uncontrolled by the current exhaust system.

Corridor 403, shown in Figure 3-25, has a controlled temperature profile meeting the setpoint, with fluctuations in humidity levels slightly higher than desired. Overall, the floor should feel significantly more comfortable than other floors, which was noticed when surveying this space.

Fifth Floor

Toilet and Shower Room 512, shown on Figure 3-26, has a more irregular temperature and humidity profile than expected. Overall, this behavior may be attributed to the fact that the space is relatively small and so should be largely affected by the unit serving the space. The temperature generally stayed near setpoint, but the humidity in the space fluctuated rather significantly without defined peaks. The irregularity of the humidity levels is most likely because the space doesn't follow a schedule like the other combined showers do. Regardless, the shower rooms are experiencing an excess buildup of humidity levels.

3.3 Conclusion

This study uncovered several factors that contribute to high levels of humidity in the building, thereby leading to the generation of mildew and mold problems. Some of these factors include the exhaust layout of the shower rooms, the lack of a dropped ceiling in shower rooms, and insufficient fresh air conditions from the DOAS unit. The temperature and humidity data loggers confirmed suspicions of high humidity levels in the shower rooms, reflecting peaks in humidity levels that accurately matched the schedule of usage. Other plots highlighted specific areas that could benefit from improved air conditioning and dehumidification strategies. Furthermore, data for the fresh air supply brought attention to the performance of the existing DOAS unit, as the fresh air supply temperature and humidity levels were found to be higher than anticipated. Overall, the issues presented in this study should offer a clear explanation of the sources of problems in the Patricia Handy building, as well as potential solutions that can benefit the comfort and safety of the building occupants.

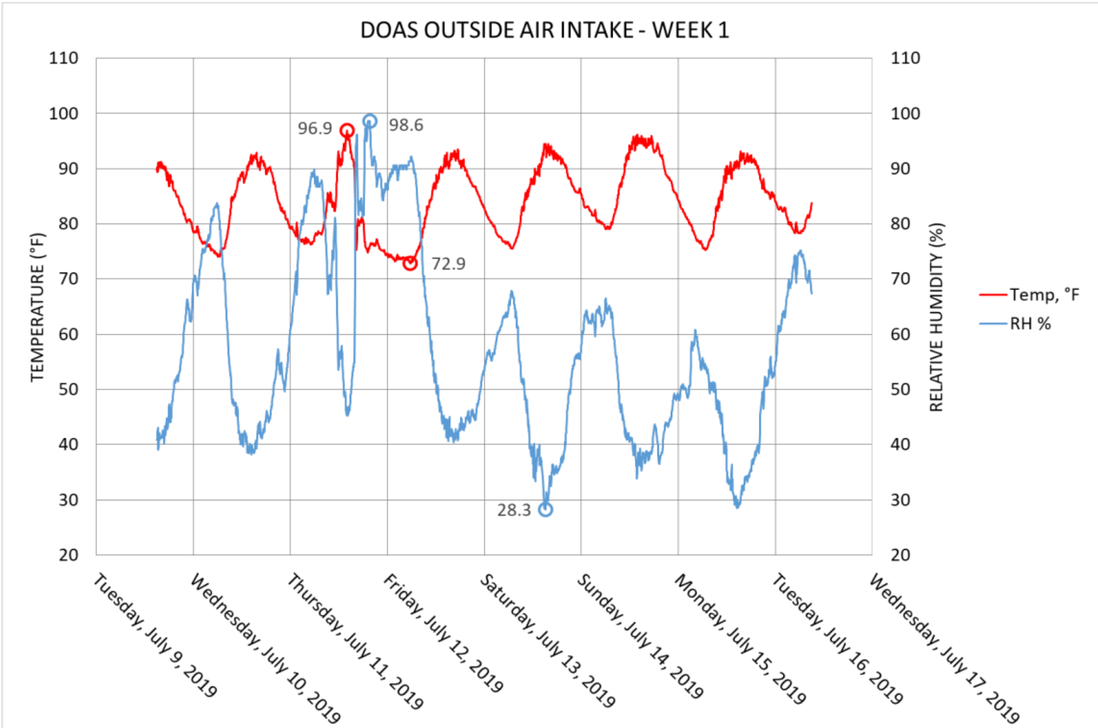


Figure 3-1

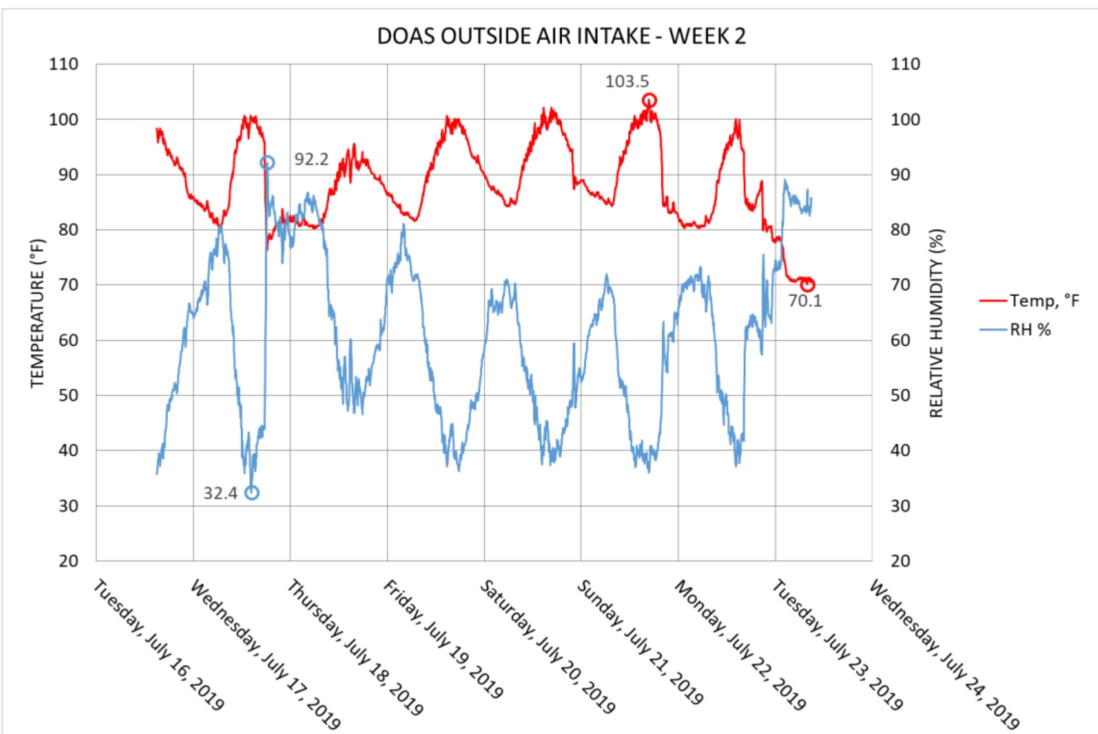
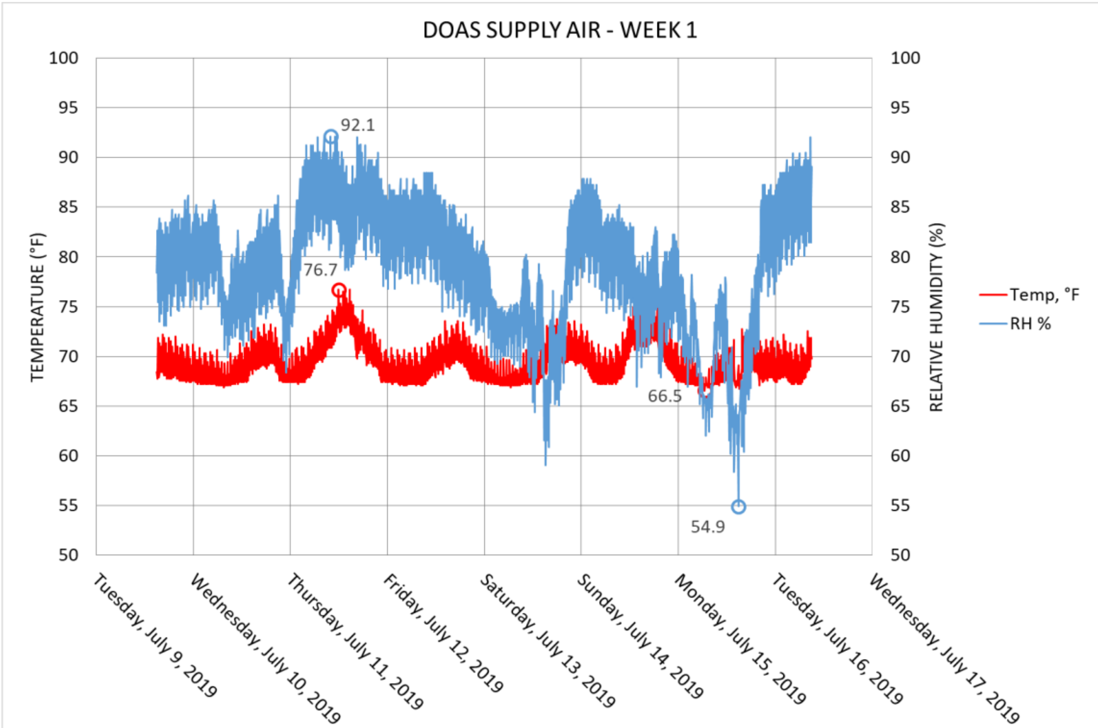


Figure 3-2



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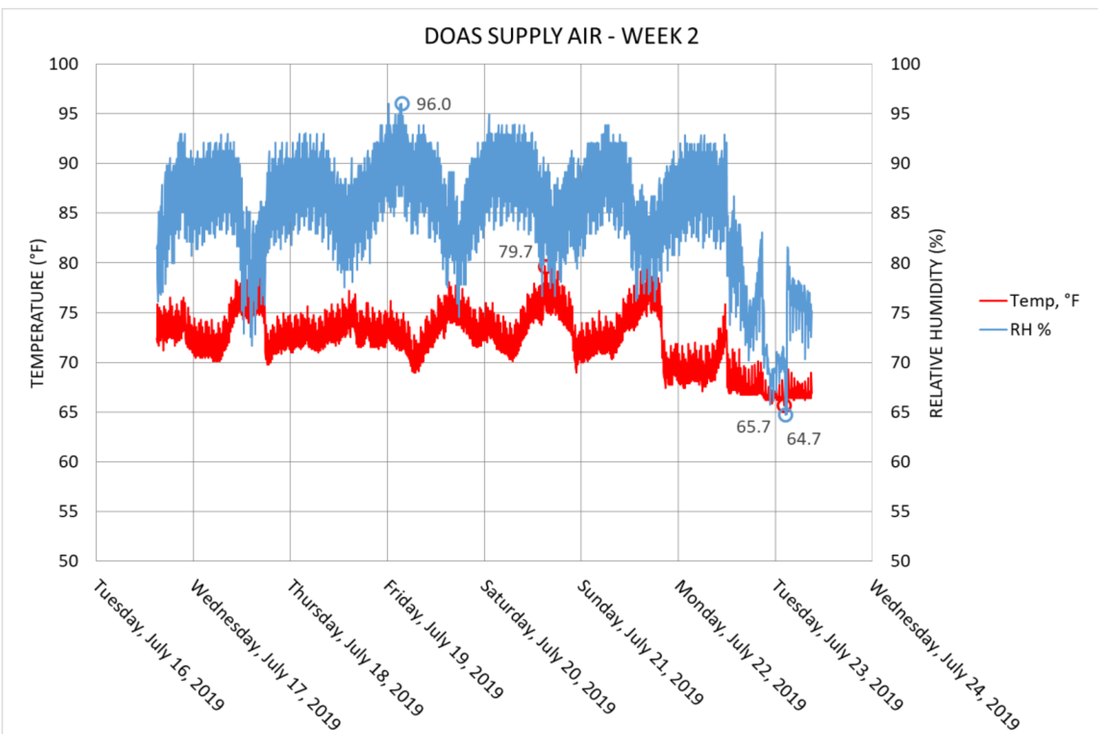

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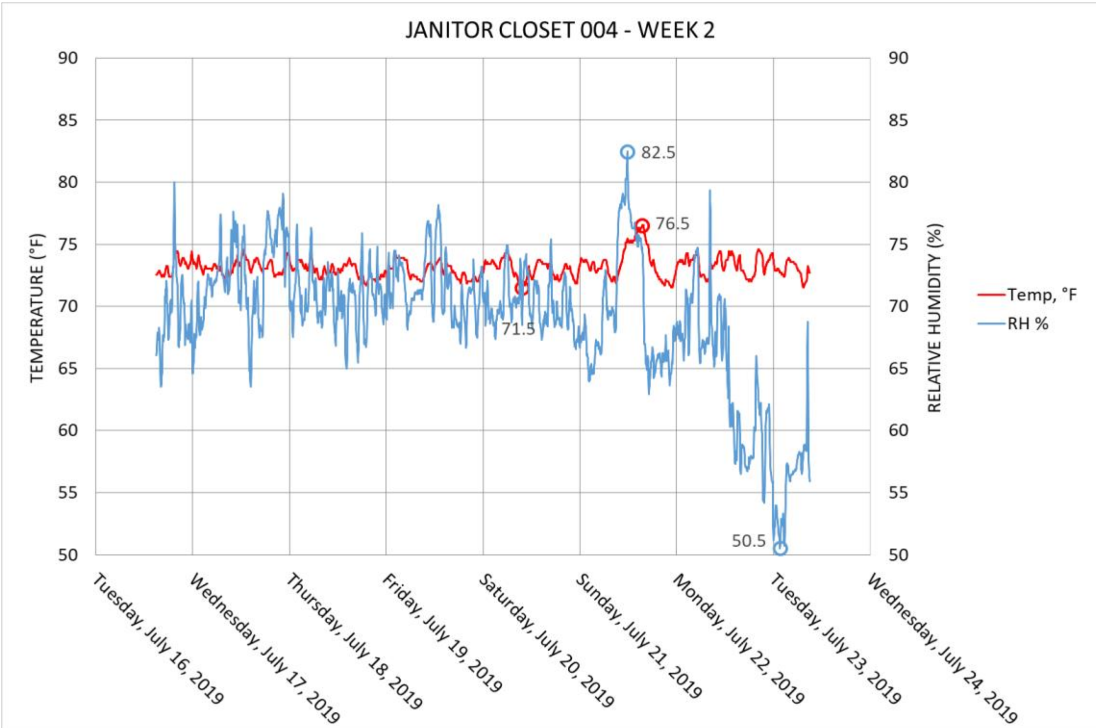

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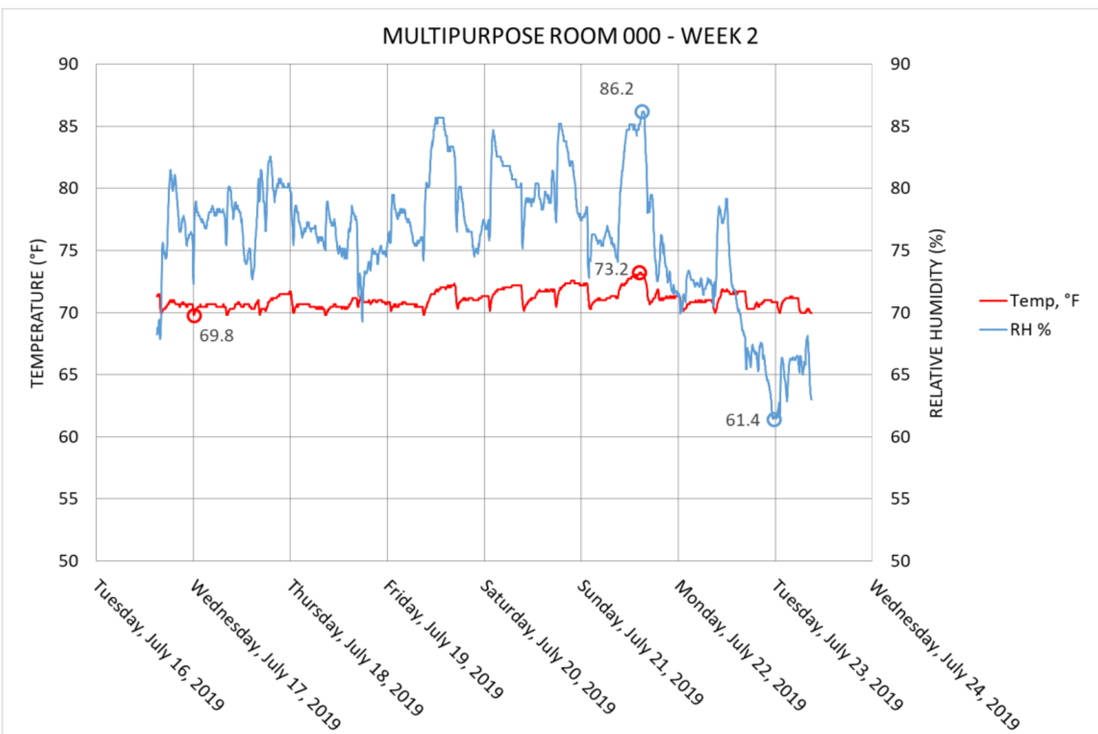

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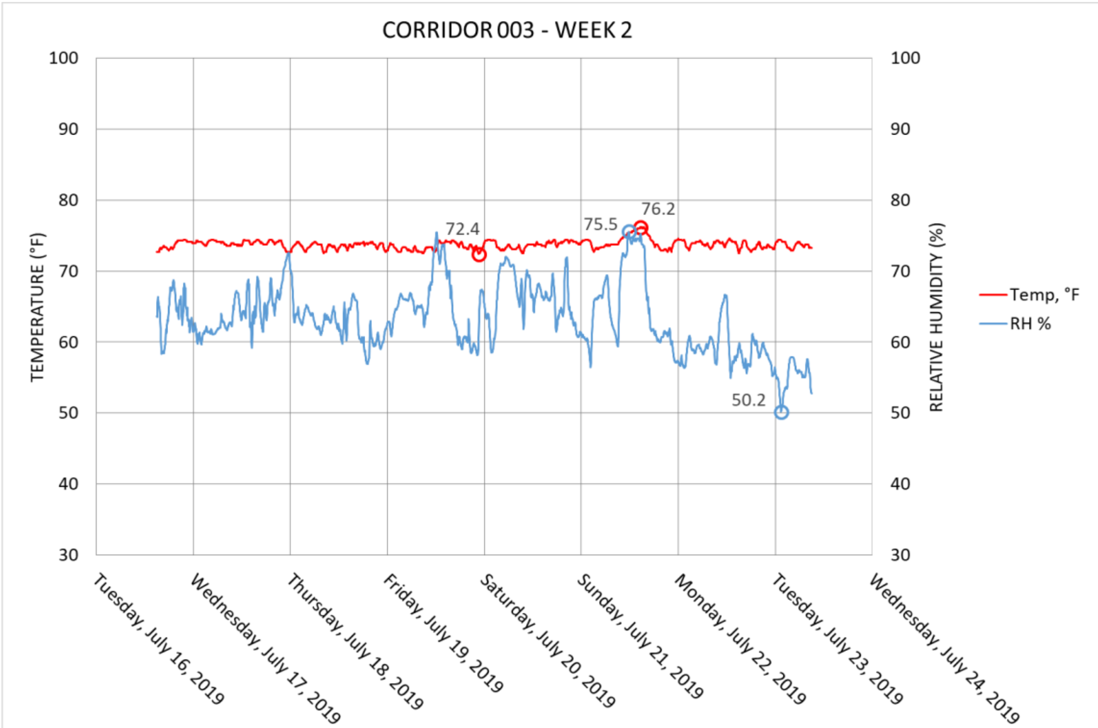

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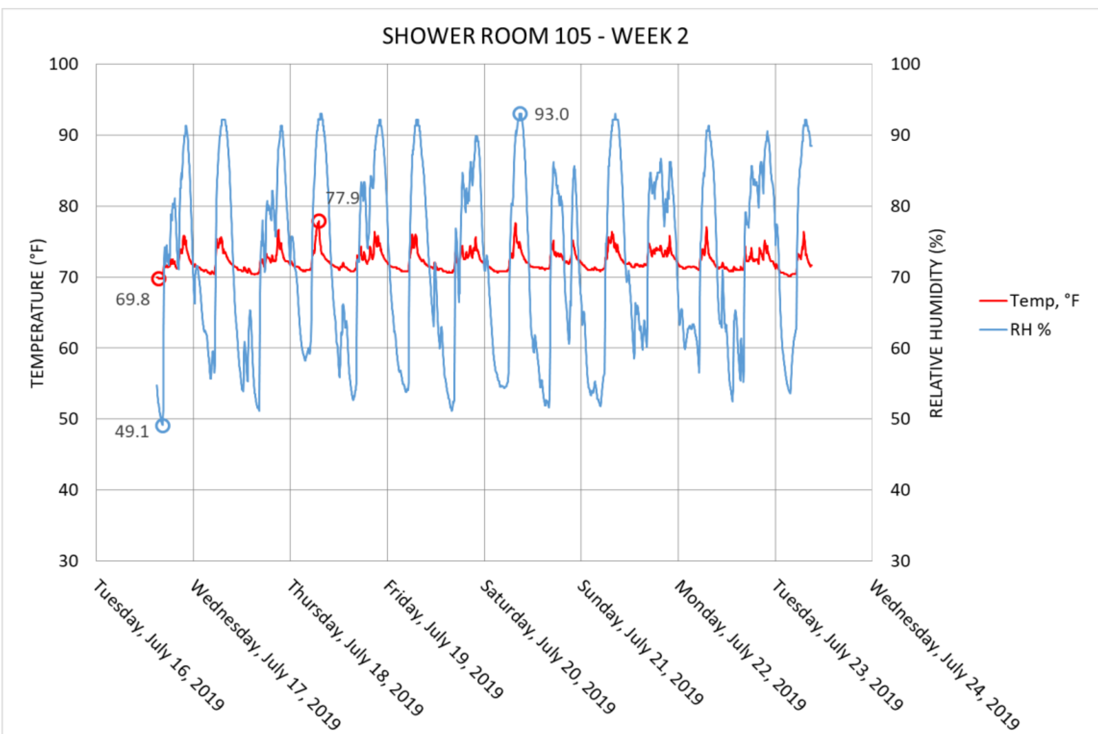

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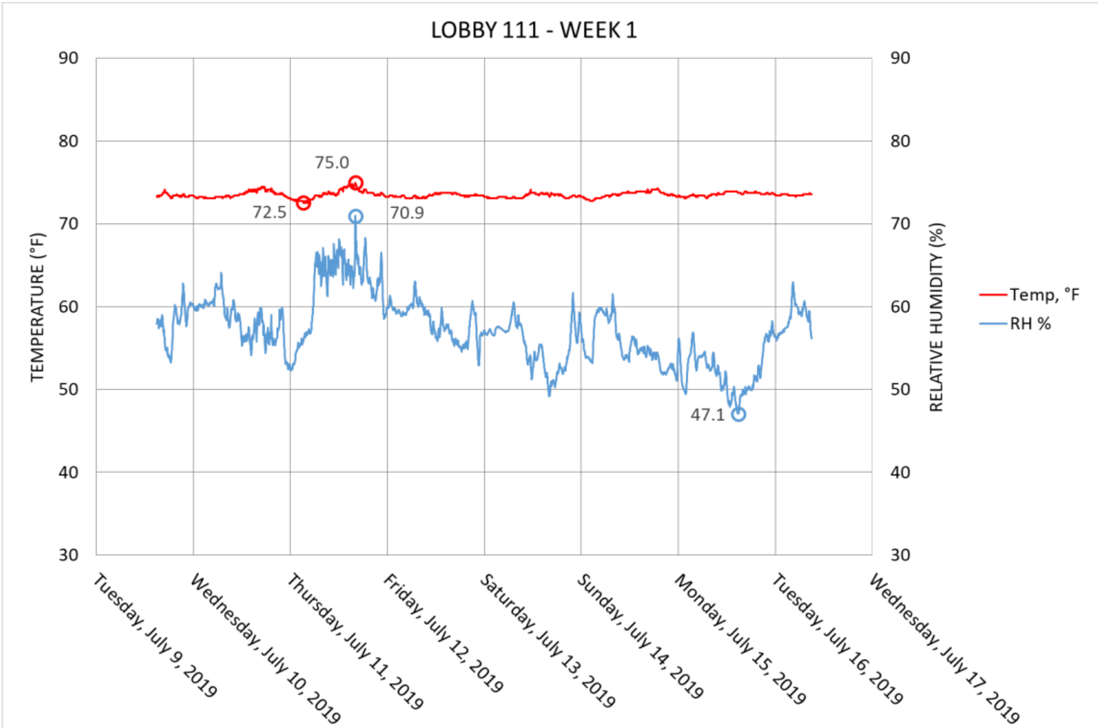

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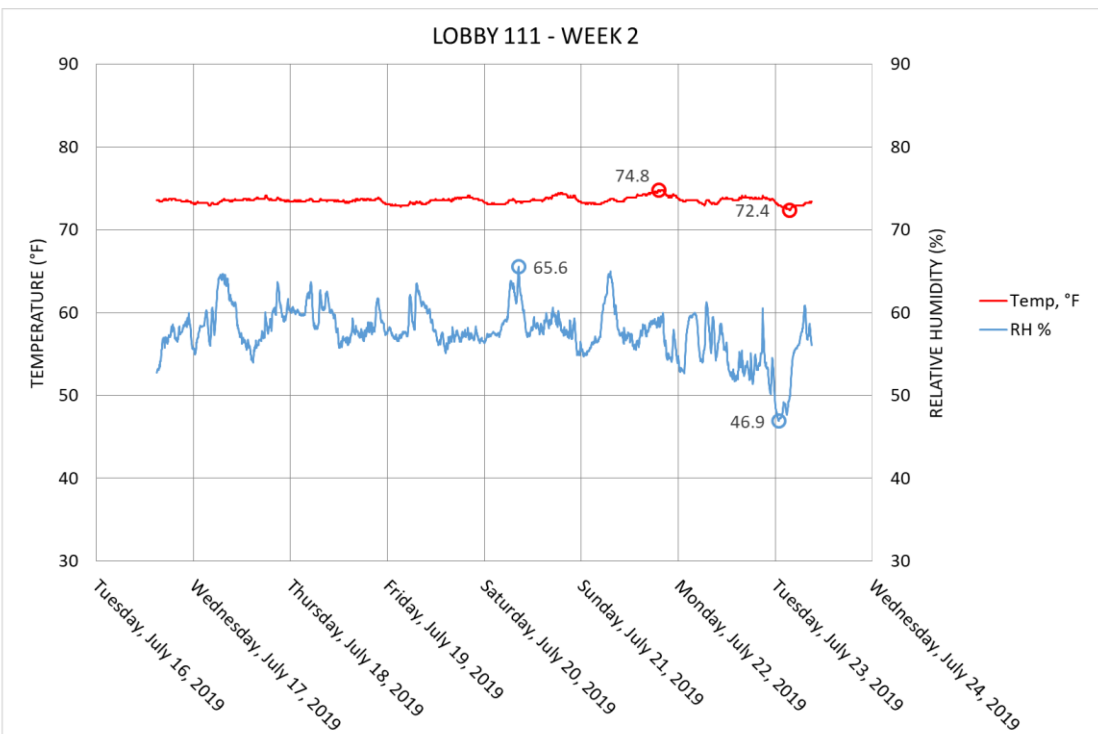

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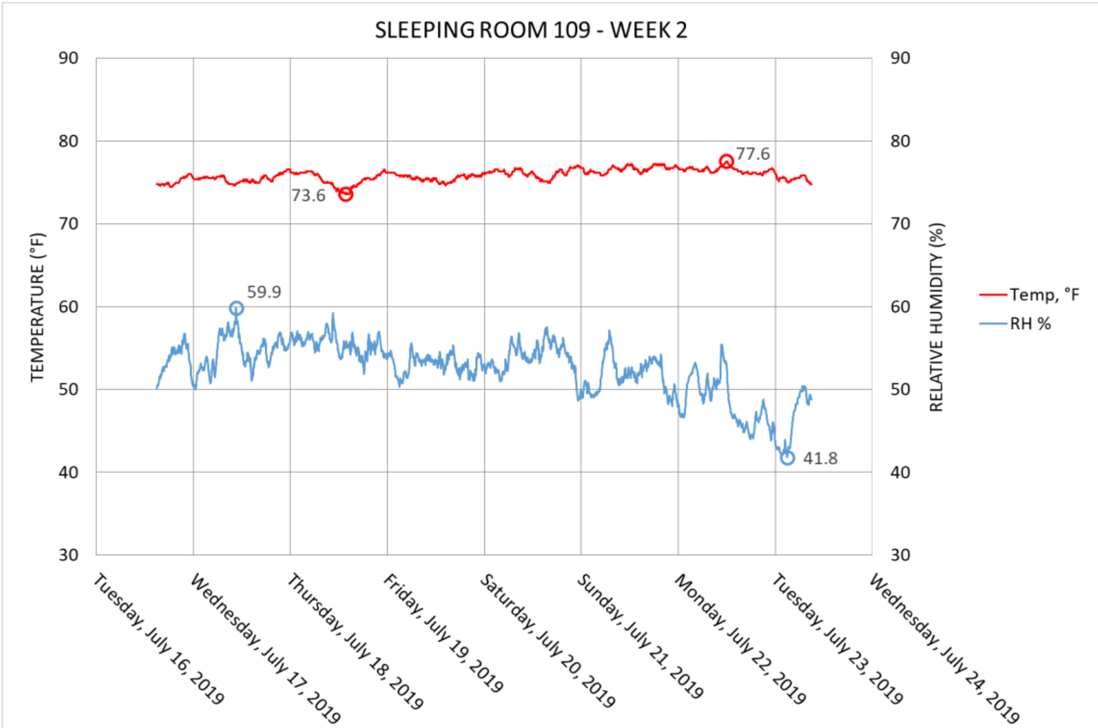

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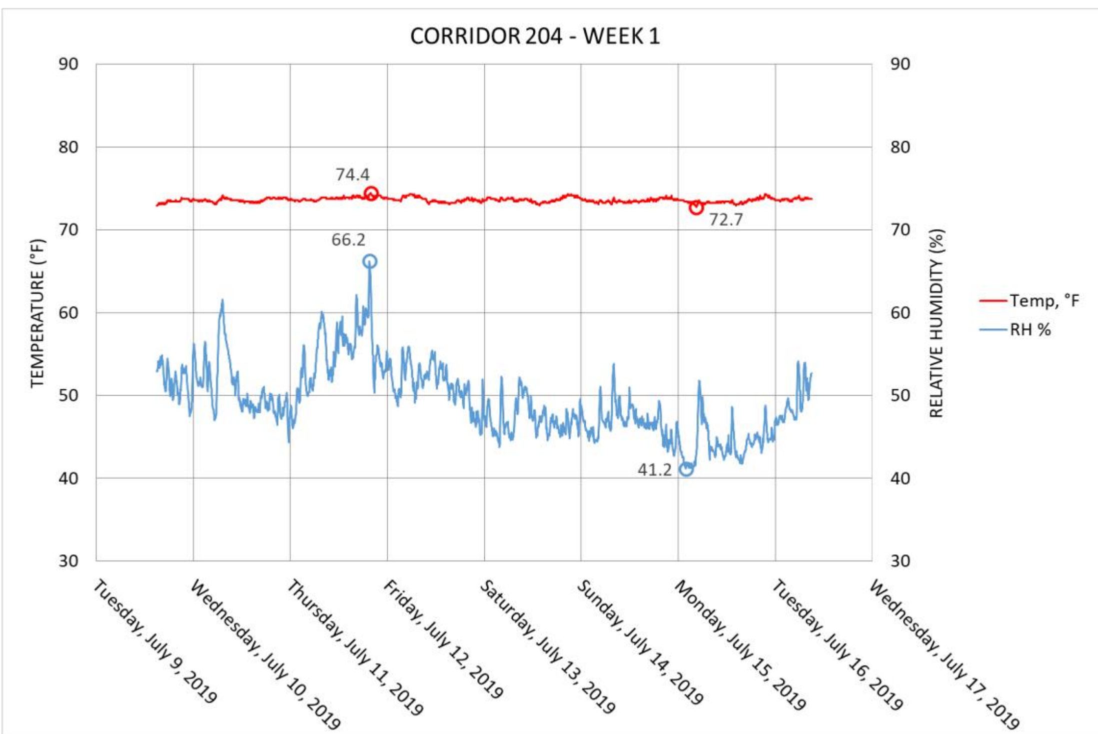

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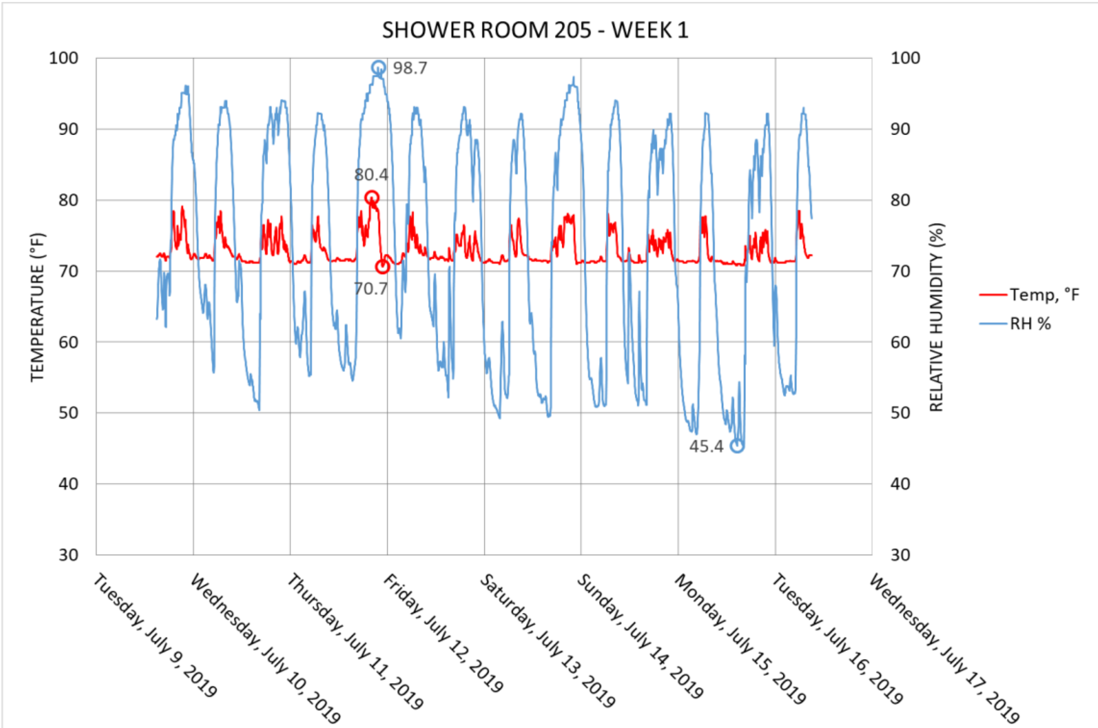

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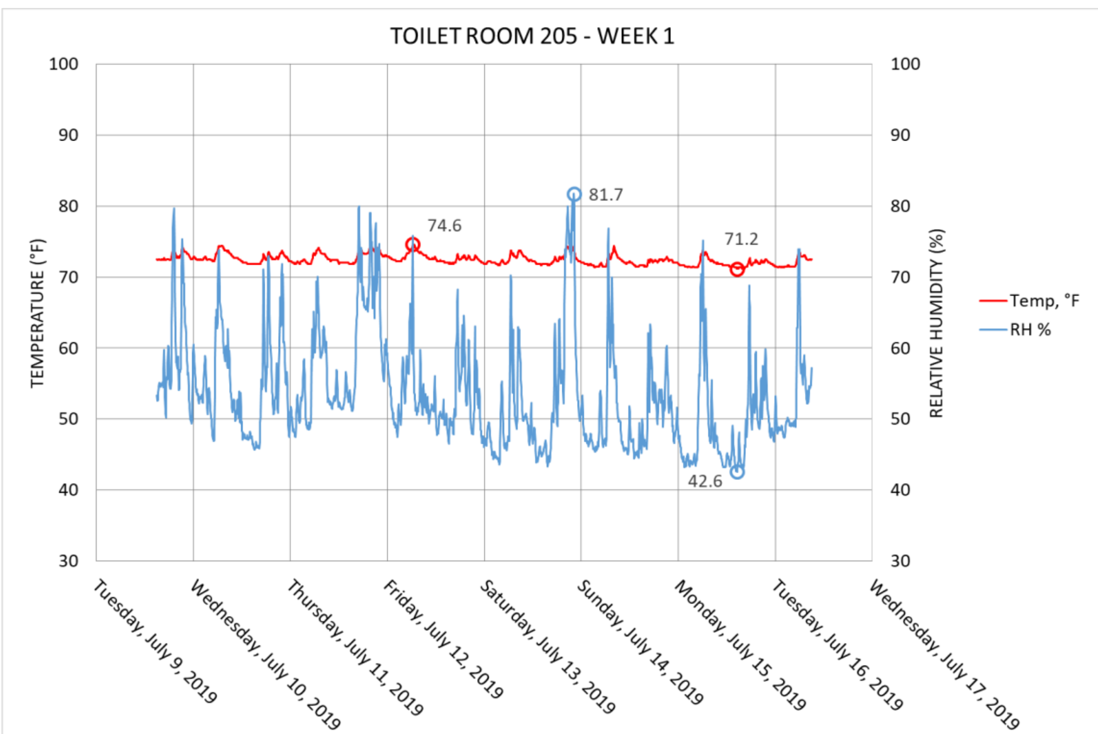

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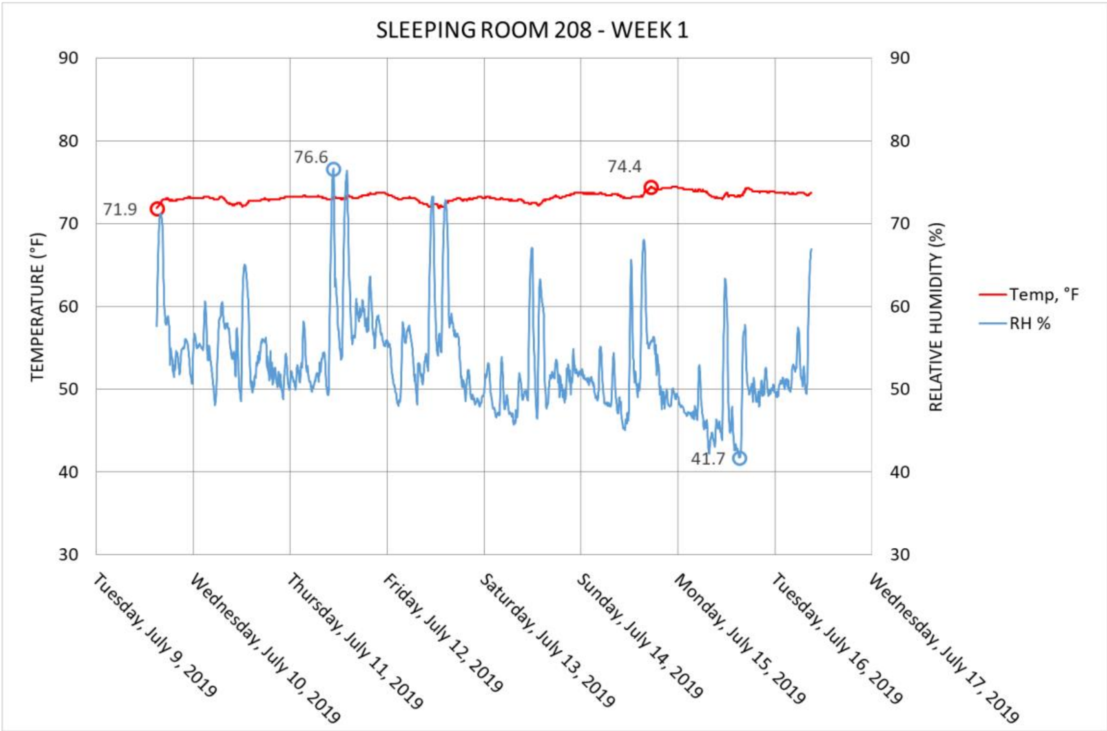

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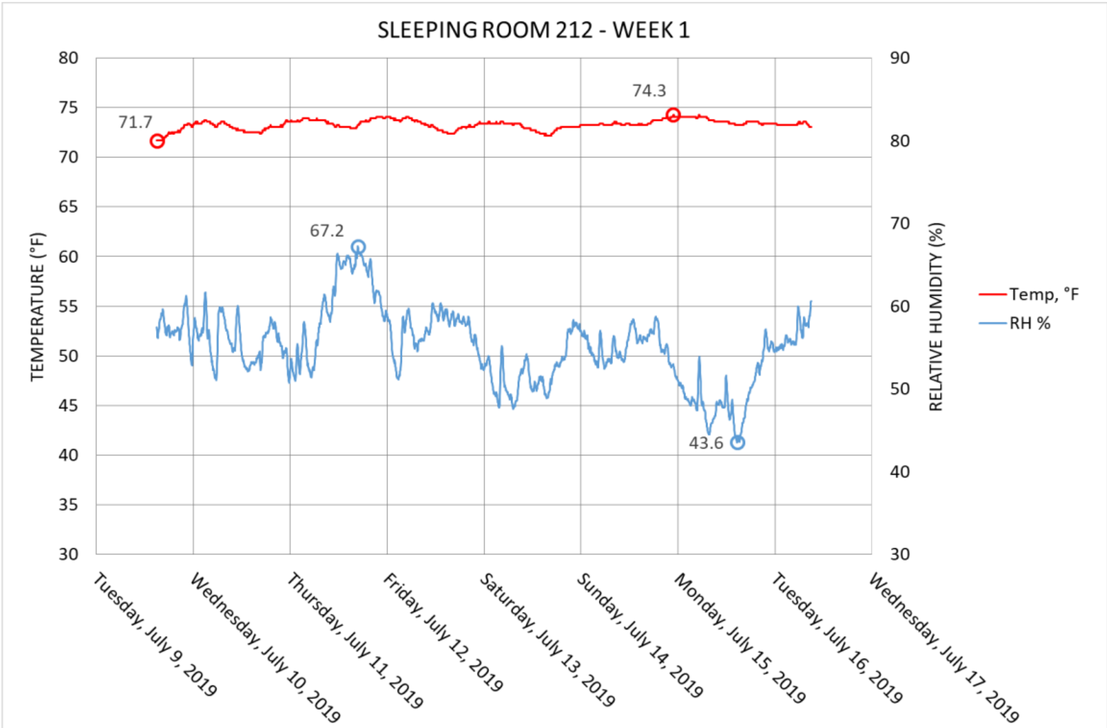

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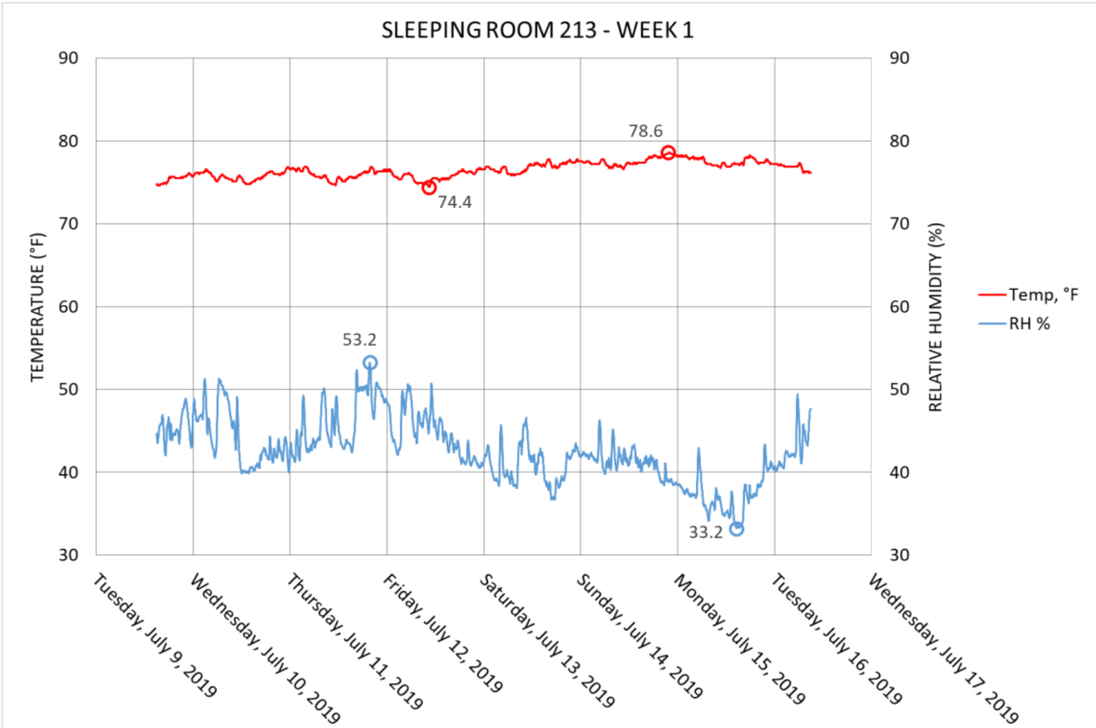

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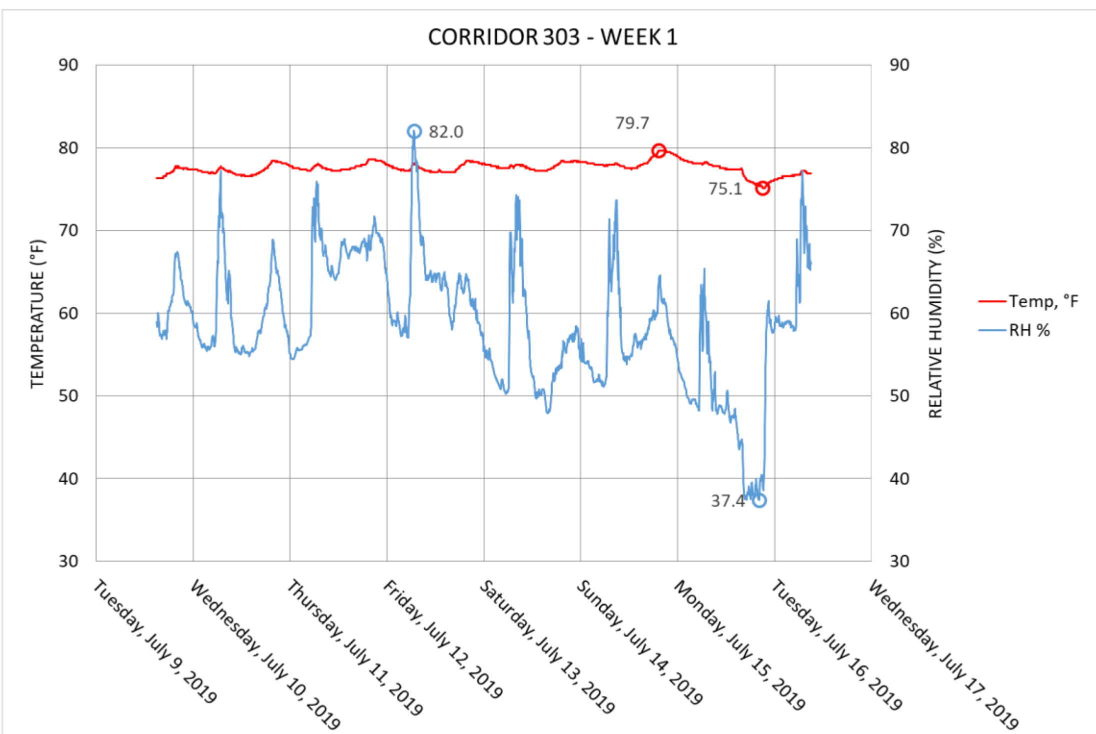

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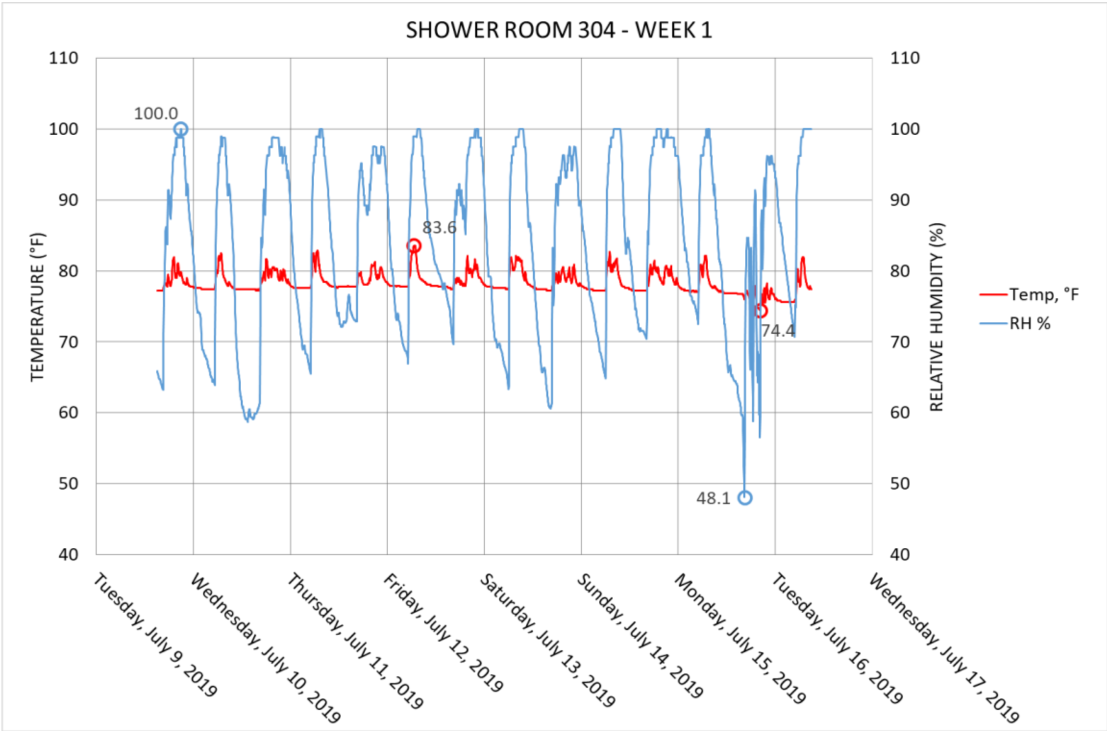

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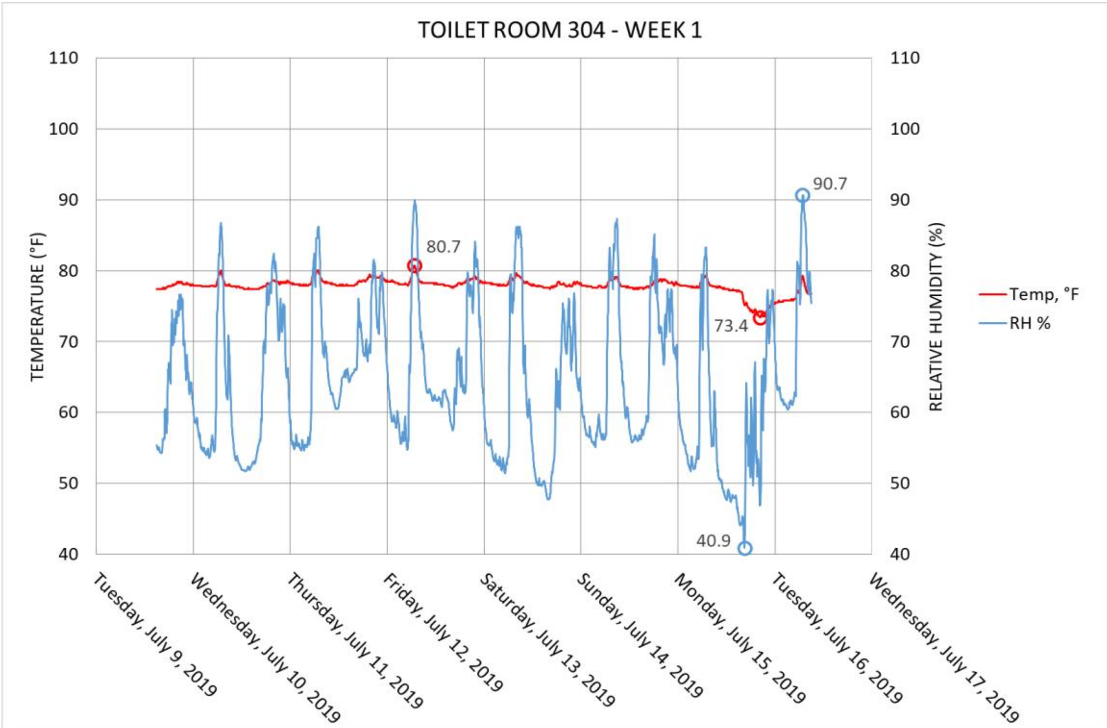

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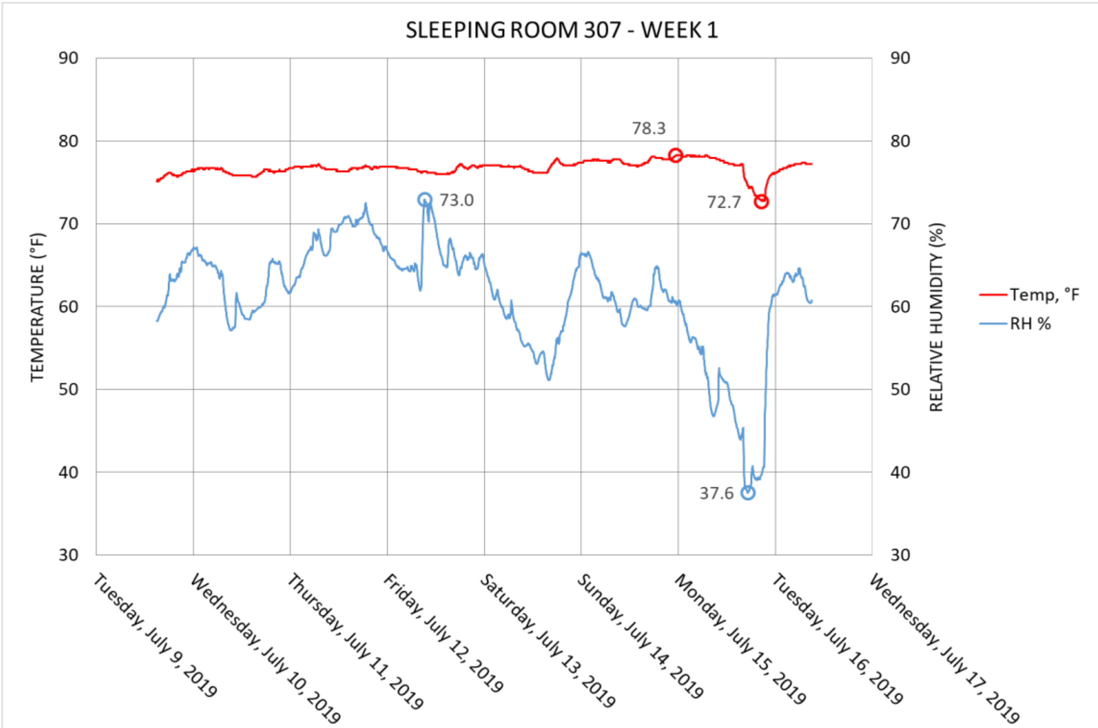

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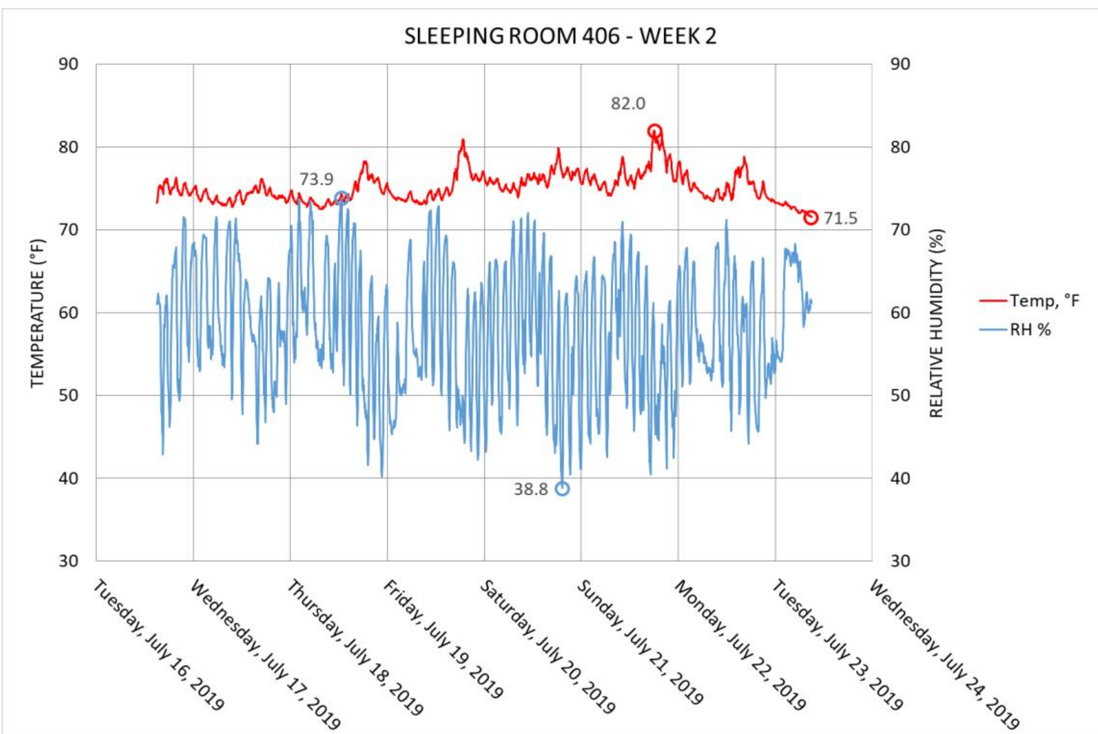

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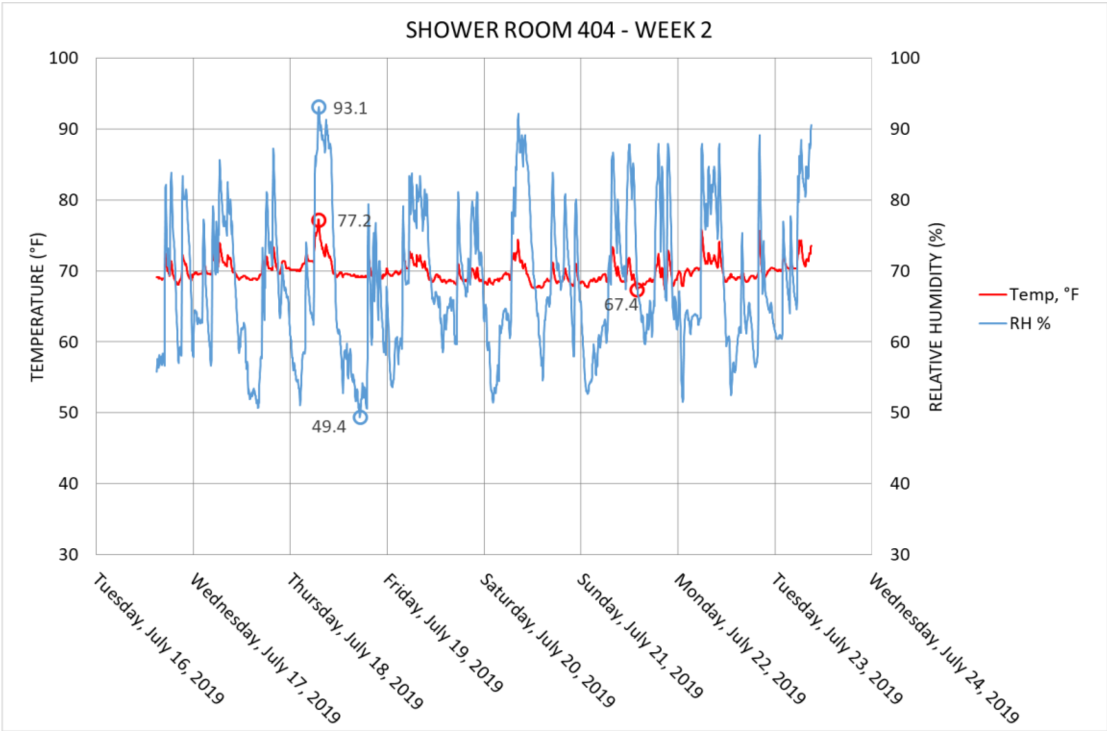

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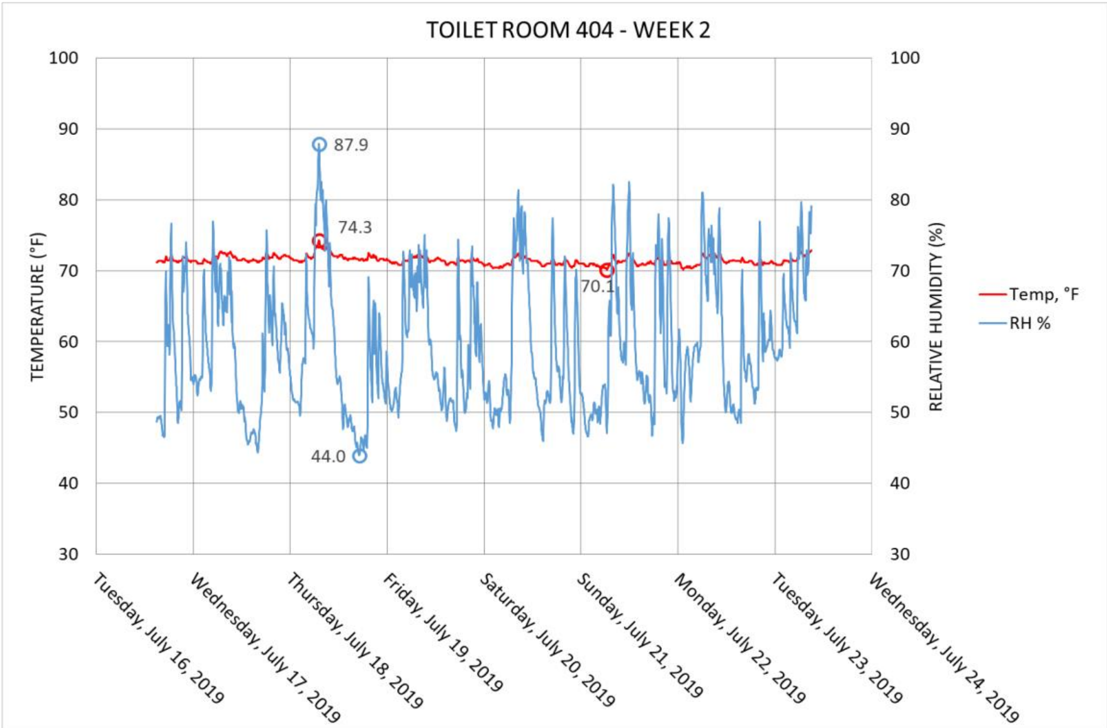

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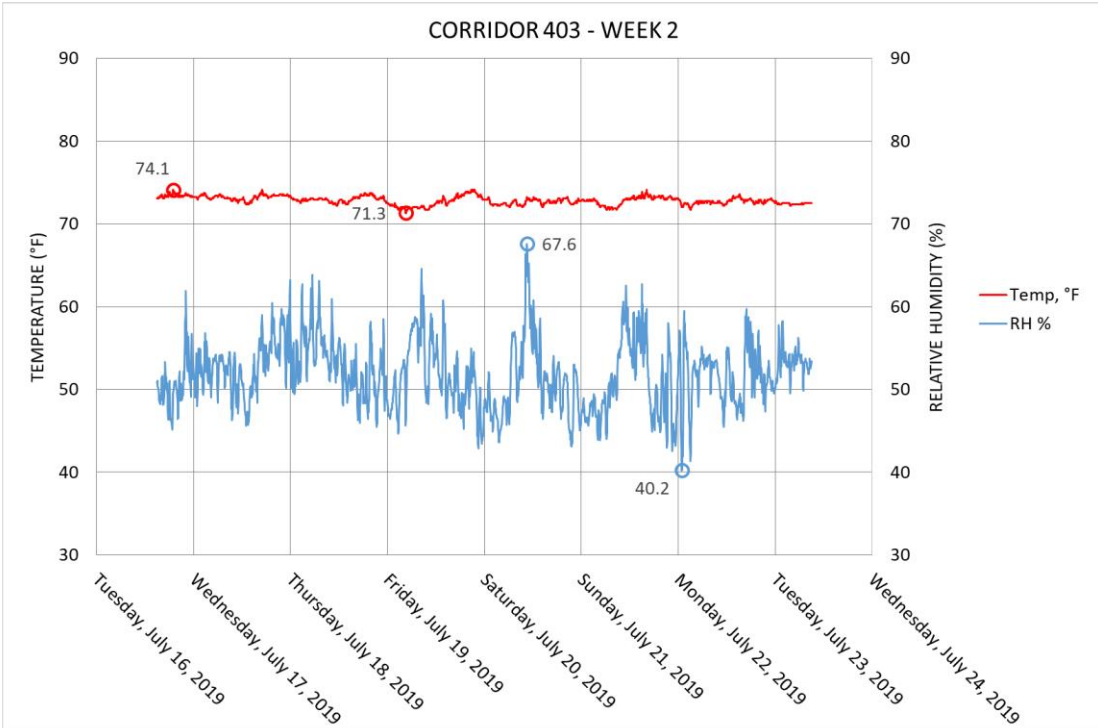

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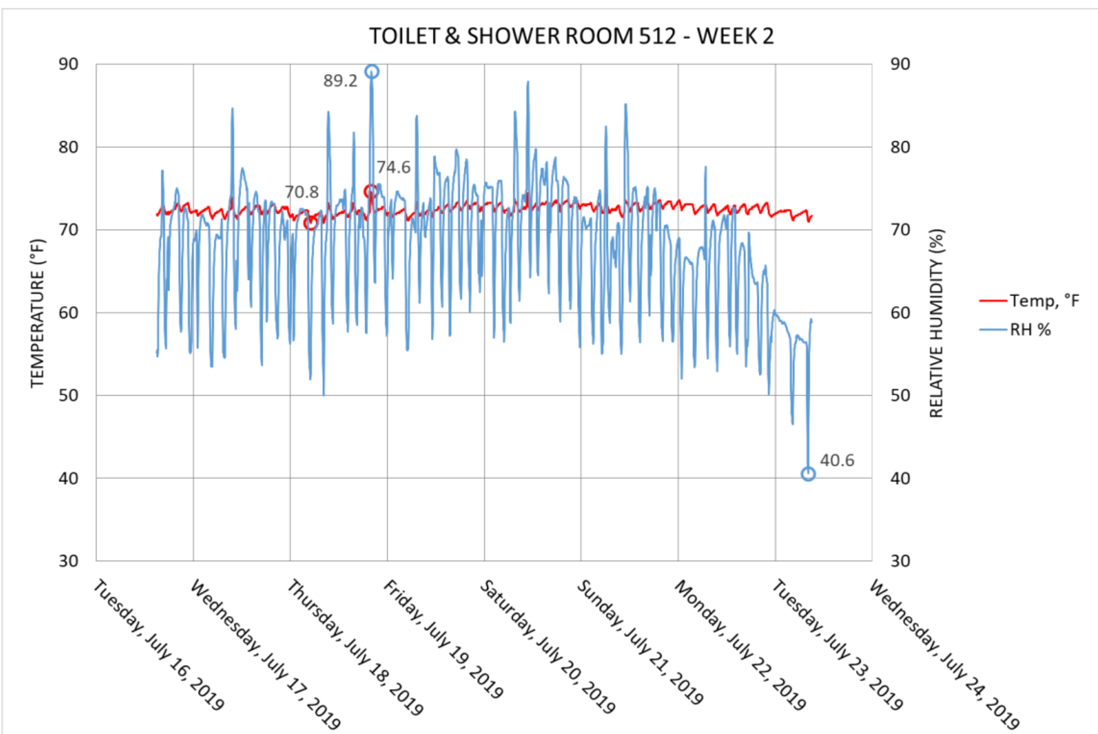
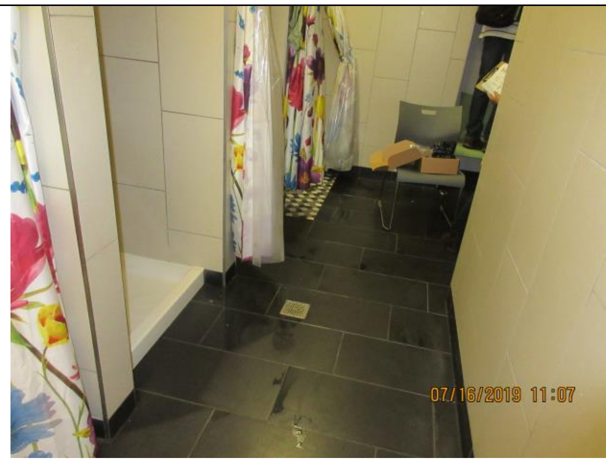


Figure 3-26

Description: A typical Fan Coil unit serving single bathrooms.

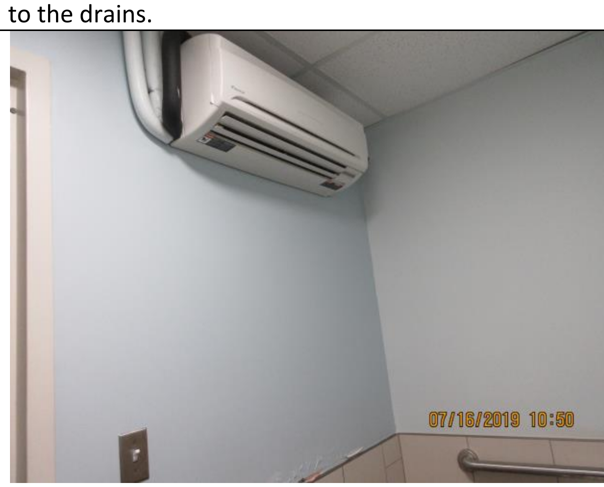
Description: Bathroom thermostat set to 73°F with room temp at 77°F.

Description: Typical fan coil serving dorm rooms.

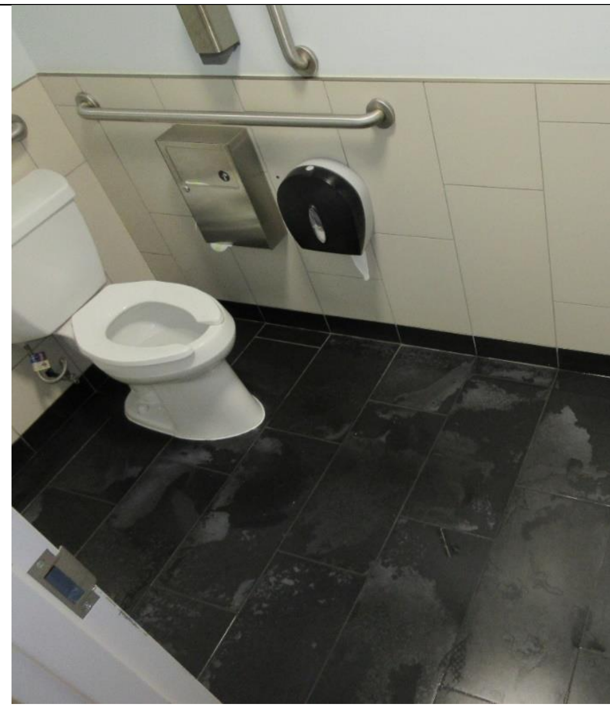


Description: No slope in the floor to allow water to flow to the drains.

Description: Damaged wall from leaking fan coil above.



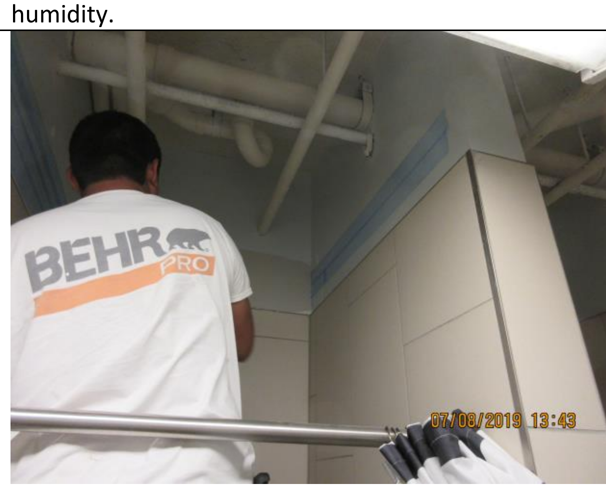
Description: Fan coil's drain pan is clogged and condensate is overflowing.

	
Description: 3096- T-Stat is hanging from ceiling.	Description: Wet floor from leaking fan coil above.
	
Description: T-Stat set to 73°F with room temp at 79°F.	Description: No slope in the floor to allow water to flow to the drains.

Description: no ceilings in the gang shower rooms.

Description: damaged pipe insulation due to high humidity.

Description: damaged pipe insulation due to high humidity.



Description: crew repairing damaged wall

Description: view of a dorm room with a fan coil unit.

Description: crew painting damaged wall boards.

Description: windows left open.

Description: piles of clothing and bathrobe contributing to high humidity levels.

Description: Metal shelves should be replaced with wired shelves and cardboard boxes should not be on the floor.

Description: T-Stat is set to 73°F with room temp at 80°F.

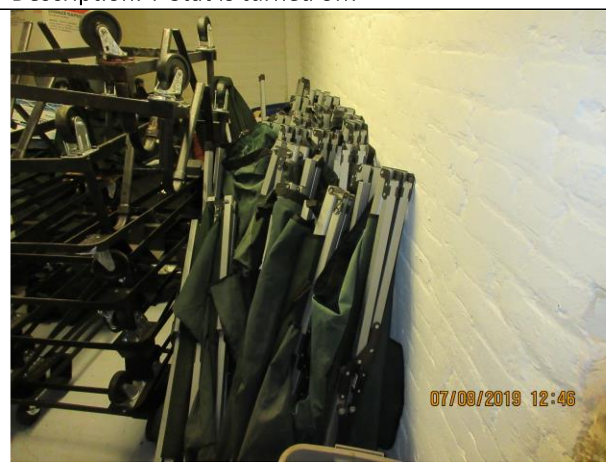
Description: T-Stat is set to 73 with room temp at 80°F.

Description: T-Stat is set to 73°F with room temp at 76°F.

Description: T-Stat is set to 73°F with room temp at 75°F.

Description: T-Stat is turned off.

Description: basement exterior walls effervescing.



Description: Mold on the foldable cots due to no ventilation in the storage room.

Description: water intrusion in basement.

Description: water leak from basement ceiling and damaged pipe.

Description: water intrusion at basement ceiling

Description: water intrusion at basement ceiling

Description: water intrusion at basement ceiling

Description: water intrusion at basement ceiling

Description: basement exterior walls effervescing.

Description: damaged drywall at the mop basin.

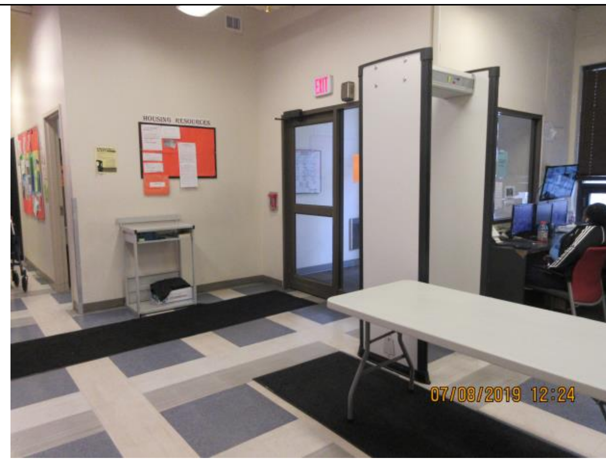
Description: exterior louver frame missing caulk.

Description: exterior louver frame missing caulk.

Description: exterior louver frame missing caulk.

Description: exterior louver frame missing caulk.

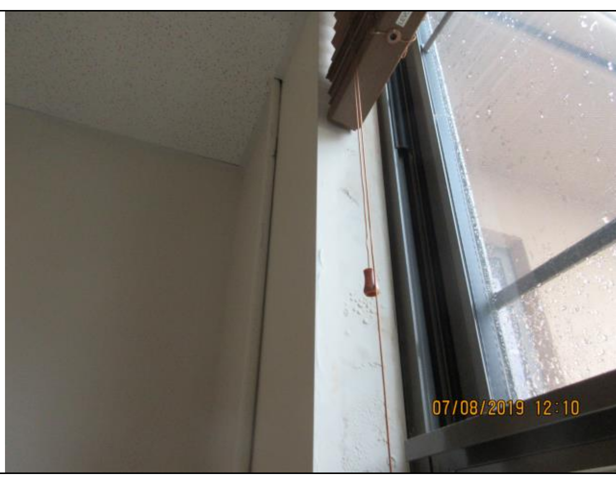
Description: Front entry foyer rug harboring water and dirt.



Description: Front entry.

Description: damage to window sill from water intrusion.

Description: damaged window frame from water intrusion.

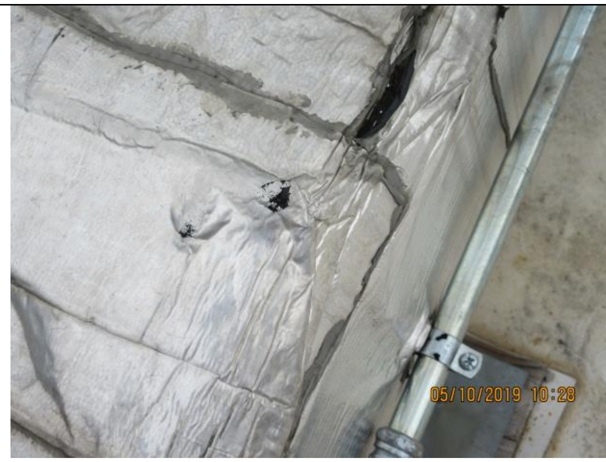


Description: damaged window frame from water intrusion.

Description: damage to window sill from water intrusion.

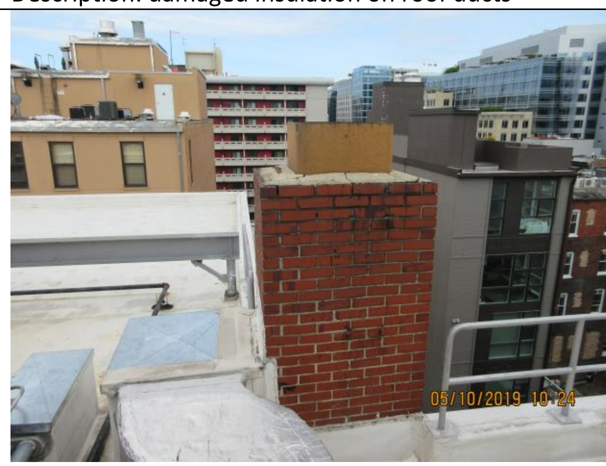
	
Description: T-Stat set at 73°F with room temp at 72°F.	Description: T-Stat set at 73°F with room temp at 78°F.
	
Description: a typical fresh-air supply air outlet	Description: T-Stat set at 73°F with room temp at 75°F.
	
Description: The Zapp Bug is directly under the T-Stat.	Description: gang shower rooms missing ceiling.

Description: ductwork on roof subject to damage.



Description: damaged insulation on roof ducts

Description: water collected under ducts.

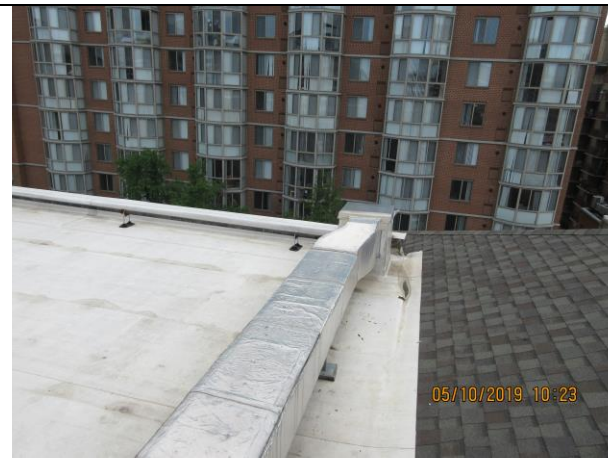


Description: masonry in need of repair.

Description: roof level ducts exposed to elements.

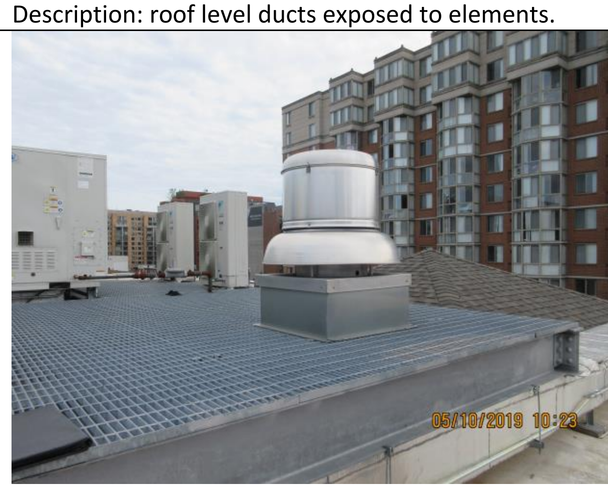
Description: roof level ducts exposed to elements.

Description: roof level ducts exposed to elements.

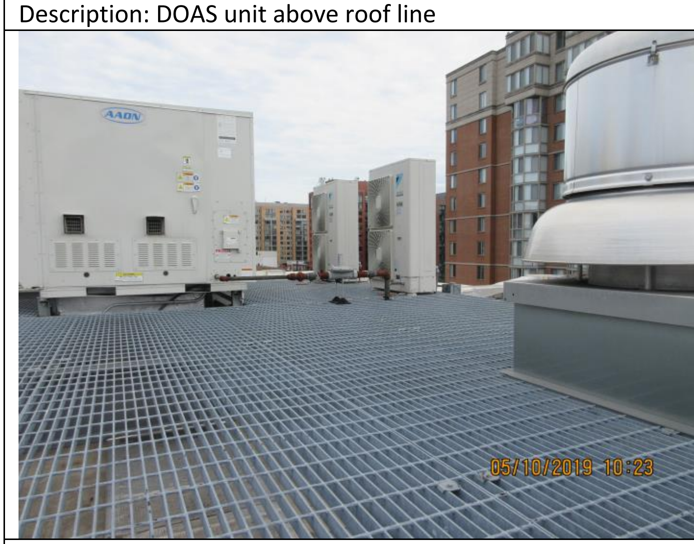


Description: roof level ducts exposed to elements.

Description: DOAS unit above roof line



Description: Shower room exhaust fan above roof line.

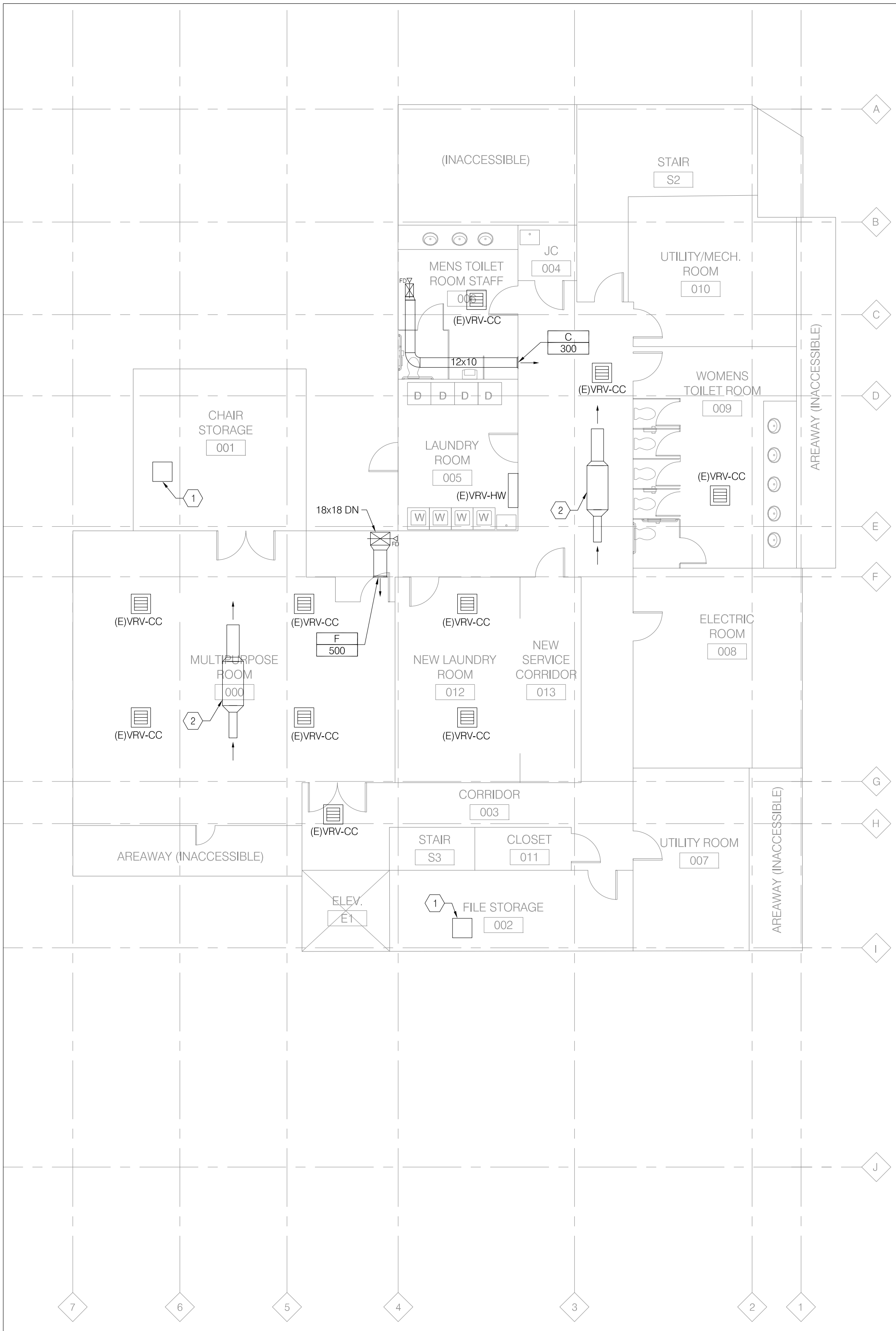


Description: Condensing units above roof line

Description: T-Stat set to 73°F with room temp at 77°F.

APPENDIX A

Abbreviations	Description
ABD	Automatic Balancing Damper
AC	Air-Conditioning
CFM	Cubic-Feet per Minute; a measure of the flow-rate of air
DOAS	Dedicated Outdoor Air System; the system is responsible for providing ventilation air at "neutral conditions", and is largely responsible for dehumidifying the air introduced to the space.
FCU	Fan Coil Unit
HVAC	Heating, Ventilation, and Air Conditioning
OA	Outdoor Air
PPD	Pints Per Day; the rate of water condensed out of the air
RH	Relative Humidity
T-Stat	Thermostat
TAB	Testing and Balancing
VRV	Variable Refrigerant Volume; an air-conditioning system that relies on varying the amount of refrigerant between an outdoor condensing unit and individual indoor units to heat or cool as required.



1 BASEMENT FLOOR PLAN
M100
SCALE: NTS

NEW WORK KEY NOTES

1. PROVIDE FLOOR MOUNTED DEHUMIDIFIER (TYP.)
2. PROVIDE CEILING MOUNTED DEHUMIDIFIER (TYP.)

SYMBOLS & ABBREVIATIONS

VRV	VARIABLE REFRIGERANT VOLUME
VRV-CC	VARIABLE CEILING CASSETTE UNIT
VRV-HW	HIGH-WALL VRV UNIT
FD	FIRE DAMPER
VD	VOLUME DAMPER

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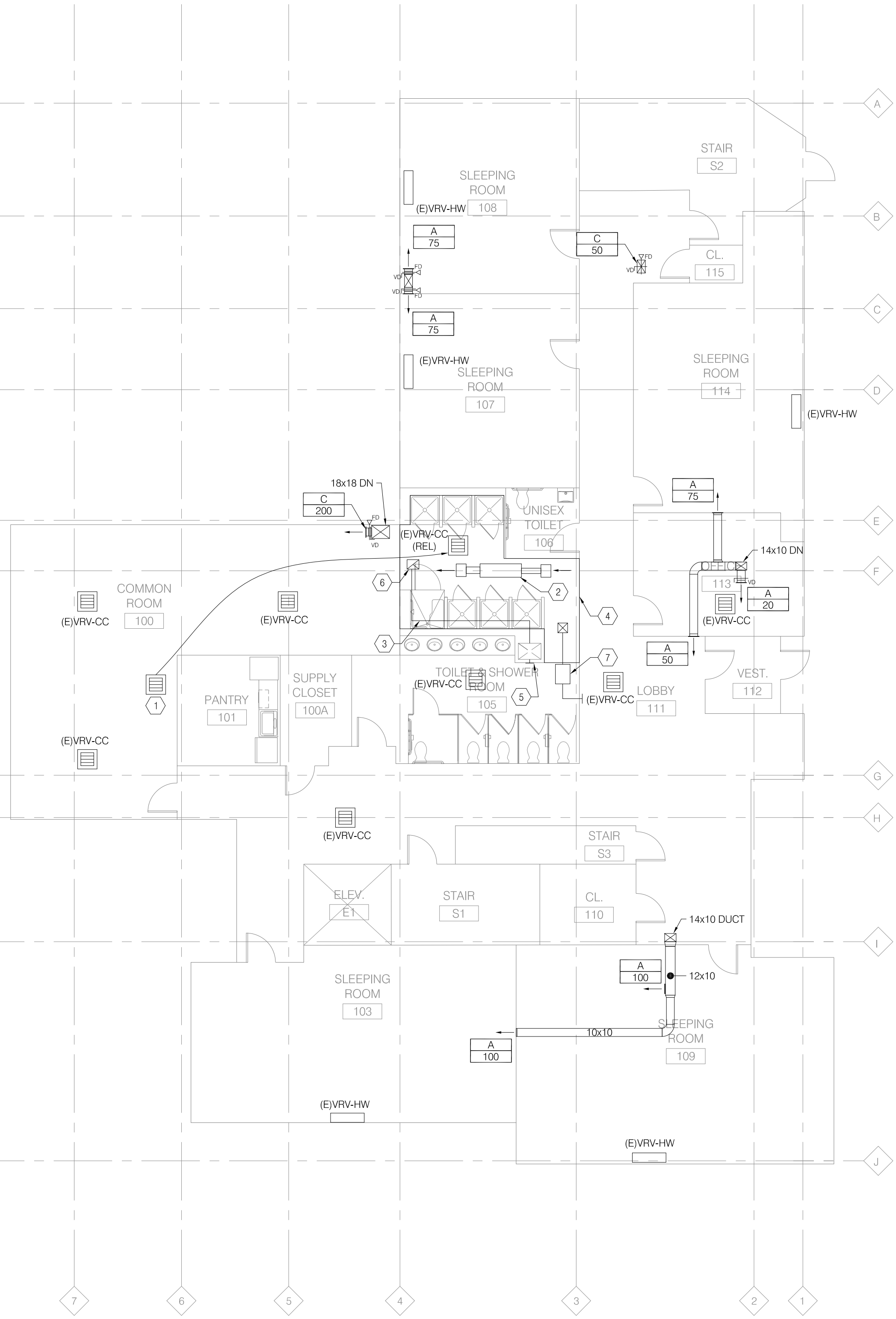
PROJECT:
DC DGS PATRICIA HANDY HVAC ASSESSMENT
810 5TH STREET. NW
WASHINGTON DC 20001

DATE: 09/23/2019
BY: SHS
SKETCH NO: M100

ISSUED FOR: ISSUE
PROJECT NO: SIPX192029.00
SCALE: NTS



1 M101 FIRST FLOOR PLAN

SCALE: NTS

NEW WORK KEY NOTES

1. RELOCATE CEILING CASSETTE VRV UNIT TO SHOWER ROOM.
2. PROVIDE CEILING HUNG DEHUMIDIFIER WITH SUPPLY AND RETURN DUCTWORK AND CEILING GRILL.
3. NEW EXHAUST DUCT EXTENDED TO THE SHOWER ROOM.
4. NEW DROPPED CEILING AT 8' HIGH WITH VINYL FACED 2X2 TILES.
5. BALANCE OUTLET TO REDUCE AIRFLOW.
6. NEW EXHAUST GRILL AT SHOWER ROOM.
7. PROVIDE DUCTED INLINE FAN AT CEILING TO SUPPLY VENTILATION AIR FOR GROUP SHOWER ROOMS. TRANSFER DUCT SHALL CONNECT TO NEAREST HALLWAY.

SYMBOLS & ABBREVIATIONS

VRV	VARIABLE REFRIGERANT VOLUME
VRV-CC	VARIABLE CEILING CASSETTE UNIT
VRV-HW	HIGH-WALL VRV UNIT
FD	FIRE DAMPER
VD	VOLUME DAMPER

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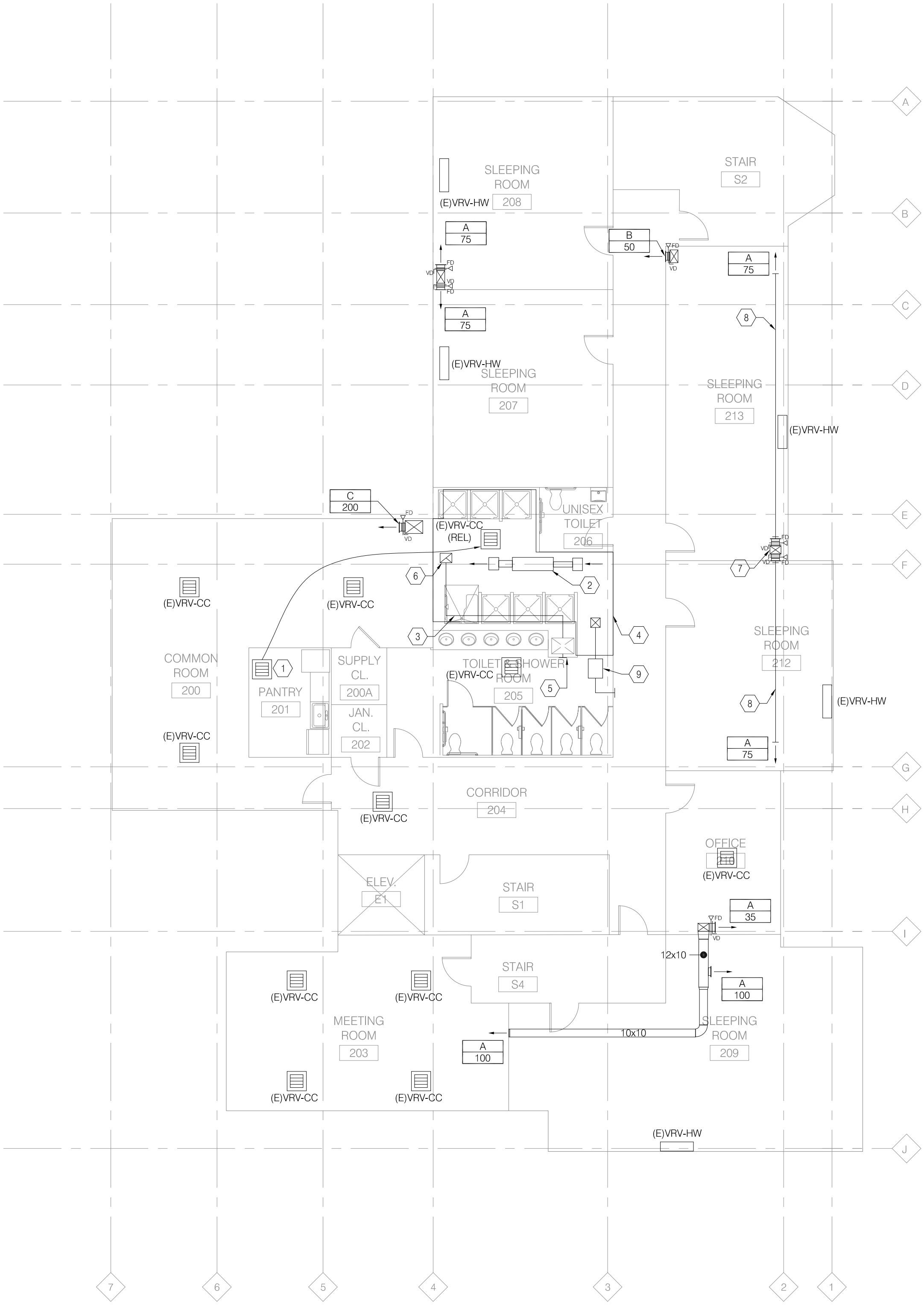
SCALE: NTS

DATE: 09/23/2019

BY: SHS

SKETCH NO: M101



1 M102 SECOND FLOOR PLAN

SCALE: NTS

NEW WORK KEY NOTES

1. RELOCATE CEILING CASSETTE VRV UNIT TO SHOWER ROOM.
2. PROVIDE CEILING HUNG DEHUMIDIFIER WITH SUPPLY AND RETURN DUCTWORK AND CEILING GRILL.
3. NEW EXHAUST DUCT EXTENDED TO THE SHOWER ROOM.
4. NEW DROPPED CEILING AT 8' HIGH WITH VINYL FACED 2X2 TILES.
5. BALANCE OUTLET TO REDUCE AIRFLOW.
6. NEW EXHAUST GRILL AT SHOWER ROOM.
7. THE FRESH AIR SUPPLY DUCT EXTENSION TO IMPROVE VENTILATION AND MINIMIZE SHORT CYCLING OF THE FRESH AIR.
8. PROVIDE DUCT EXTENSION TO IMPROVE VENTILATION.
9. PROVIDE DUCTED INLINE FAN AT CEILING TO SUPPLY VENTILATION AIR FOR GROUP SHOWER ROOMS. TRANSFER DUCT SHALL CONNECT TO NEAREST HALLWAY.

SYMBOLS & ABBREVIATIONS

VRV	VARIABLE REFRIGERANT VOLUME
VRV-CC	VARIABLE CEILING CASSETTE UNIT
VRV-HW	HIGH-WALL VRV UNIT
FD	FIRE DAMPER
VD	VOLUME DAMPER

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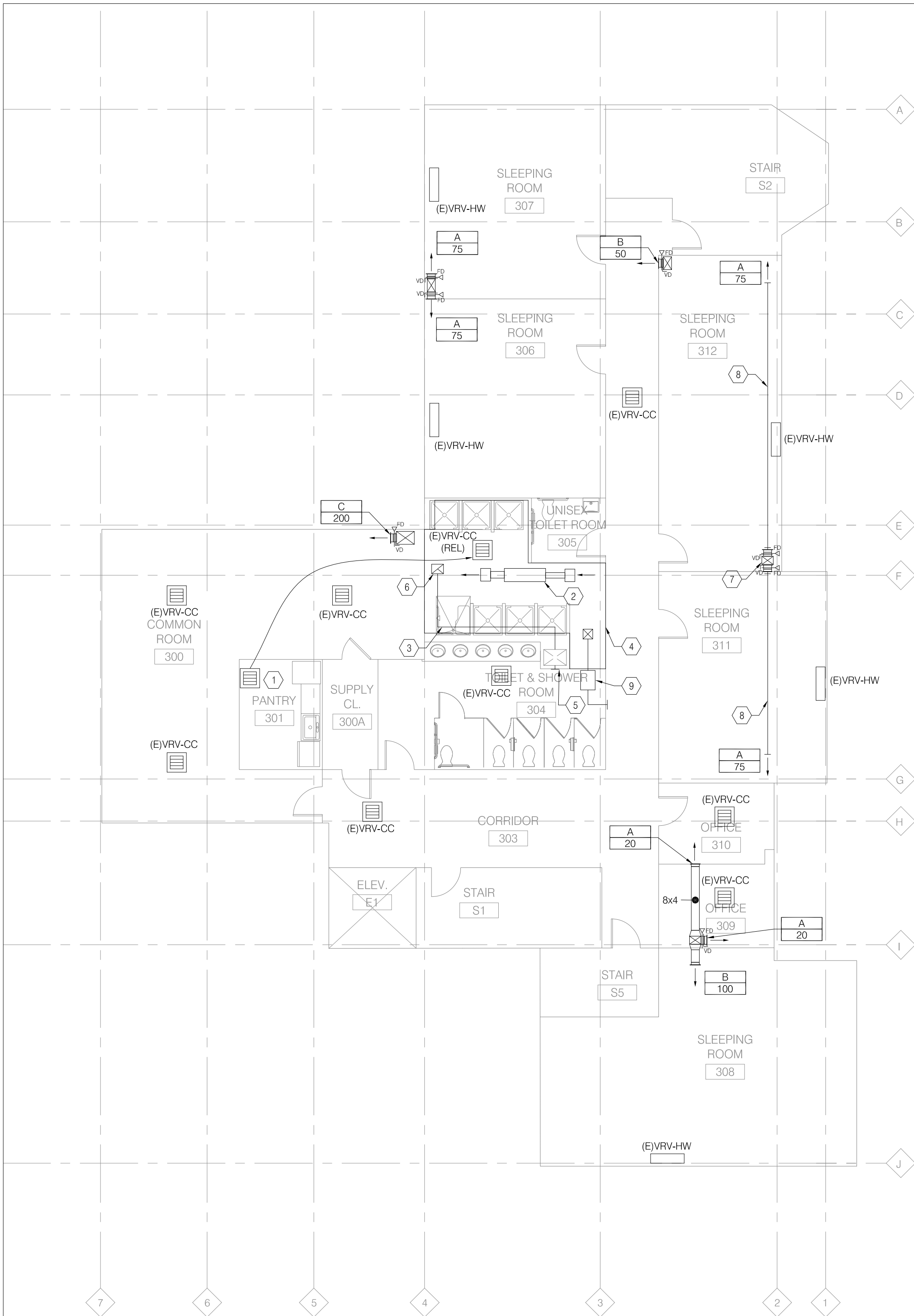

NEW WORK KEY NOTES

1. RELOCATE CEILING CASSETTE VRV UNIT TO SHOWER ROOM.
2. PROVIDE CEILING HUNG DEHUMIDIFIER WITH SUPPLY AND RETURN DUCTWORK AND CEILING GRILL.
3. NEW EXHAUST DUCT EXTENDED TO THE SHOWER ROOM.
4. NEW DROPPED CEILING AT 8' HIGH WITH VINYL FACED 2X2 TILES.
5. BALANCE OUTLET TO REDUCE AIRFLOW.
6. NEW EXHAUST GRILL AT SHOWER ROOM.
7. THE FRESH AIR SUPPLY DUCT EXTENSION TO IMPROVE VENTILATION AND MINIMIZE SHORT CYCLING OF THE FRESH AIR.
8. PROVIDE DUCT EXTENSION TO IMPROVE VENTILATION.
9. PROVIDE DUCTED INLINE FAN AT CEILING TO SUPPLY VENTILATION AIR FOR GROUP SHOWER ROOMS. TRANSFER DUCT SHALL CONNECT TO NEAREST HALLWAY.

SYMBOLS & ABBREVIATIONS

VRV	VARIABLE REFRIGERANT VOLUME
VRV-CC	VARIABLE CEILING CASSETTE UNIT
VRV-HW	HIGH-WALL VRV UNIT
FD	FIRE DAMPER
VD	VOLUME DAMPER

1 M103 THIRD FLOOR PLAN

SCALE: NTS

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SCALE: NTS

DATE: 09/23/2019

BY: SHS

SKETCH NO: M103

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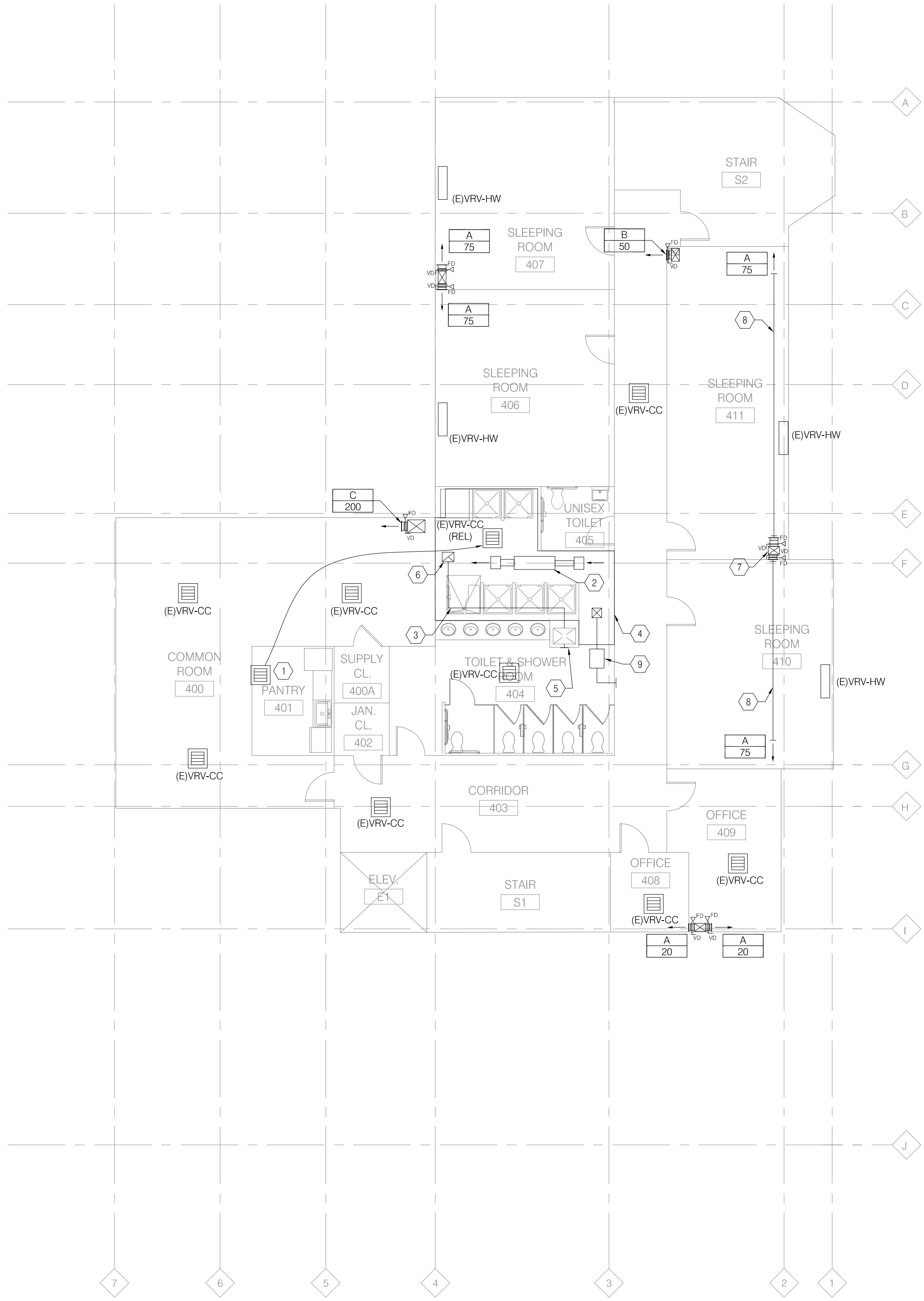
NEW WORK KEY NOTES

1. RELOCATE CEILING CASSETTE VRV UNIT TO SHOWER ROOM.
2. PROVIDE CEILING HUNG DEHUMIDIFIER WITH SUPPLY AND RETURN DUCTWORK AND CEILING GRILL.
3. NEW EXHAUST DUCT EXTENDED TO THE SHOWER ROOM.
4. NEW DROPPED CEILING AT 8' HIGH WITH VINYL FACED 2X2 TILES.
5. BALANCE OUTLET TO REDUCE AIRFLOW.
6. NEW EXHAUST GRILL AT SHOWER ROOM.
7. THE FRESH AIR SUPPLY DUCT EXTENSION TO IMPROVE VENTILATION AND MINIMIZE SHORT CYCLING OF THE FRESH AIR.
8. PROVIDE DUCT EXTENSION TO IMPROVE VENTILATION.
9. PROVIDE DUCTED INLINE FAN AT CEILING TO SUPPLY VENTILATION AIR FOR GROUP SHOWER ROOMS. TRANSFER DUCT SHALL CONNECT TO NEAREST HALLWAY.

SYMBOLS & ABBREVIATIONS

VRV	VARIABLE REFRIGERANT VOLUME
VRV-CC	VARIABLE CEILING CASSETTE UNIT
VRV-HW	HIGH-WALL VRV UNIT
FD	FIRE DAMPER
VD	VOLUME DAMPER



1 M104 FOURTH FLOOR PLAN

SCALE: NTS

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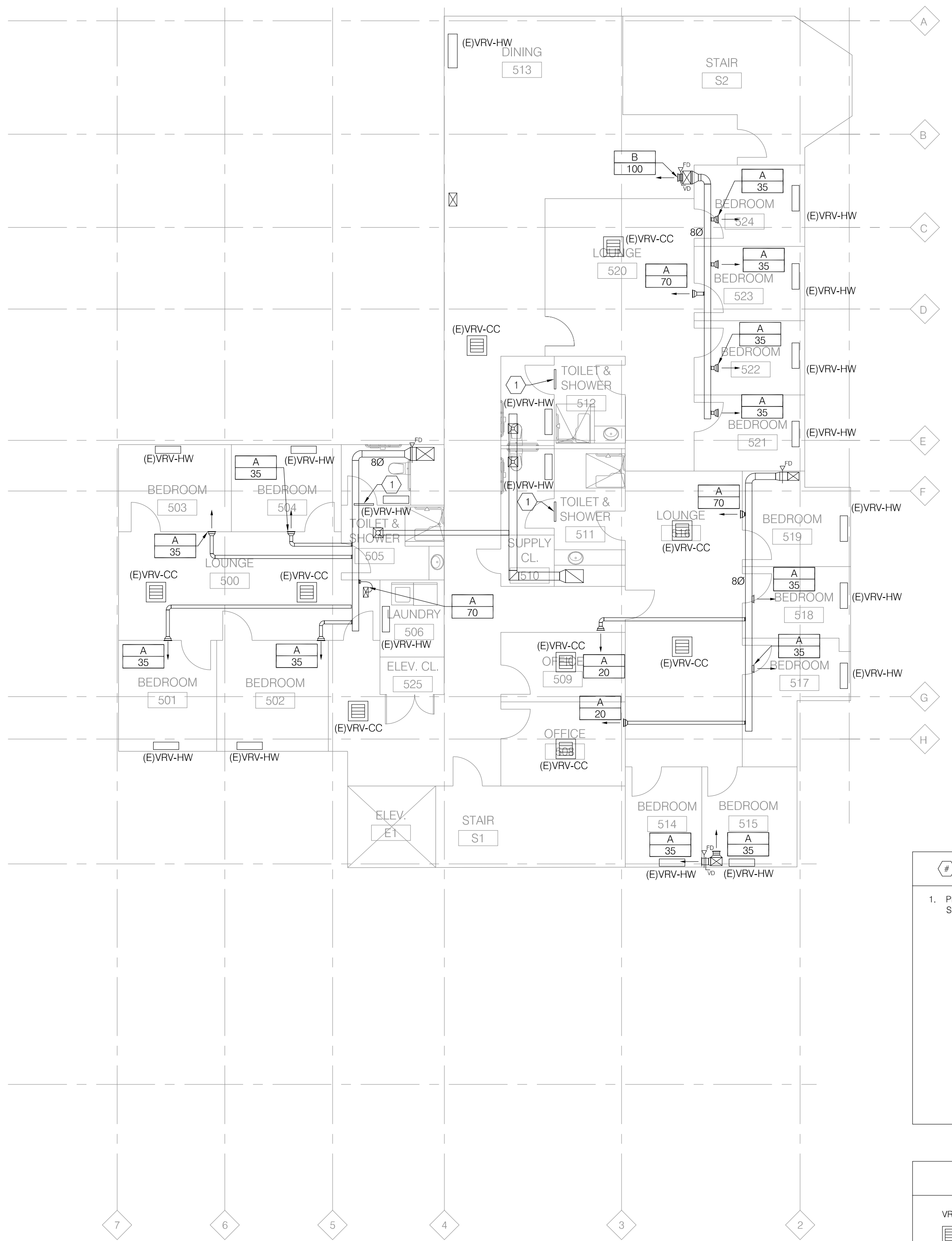
SKETCH NO: M104



NEW WORK KEY NOTES

1. PROVIDE WALL TRANSFER GRILLE HIGH BETWEEN TOILET ROOM AND SHOWER ROOM.

SYMBOLS & ABBREVIATIONS

VRV	VARIABLE REFRIGERANT VOLUME
VRV-CC	VARIABLE CEILING CASSETTE UNIT
VRV-HW	HIGH-WALL VRV UNIT
FD	FIRE DAMPER
VD	VOLUME DAMPER

1 / M105 FIFTH FLOOR PLAN

SCALE: NTS

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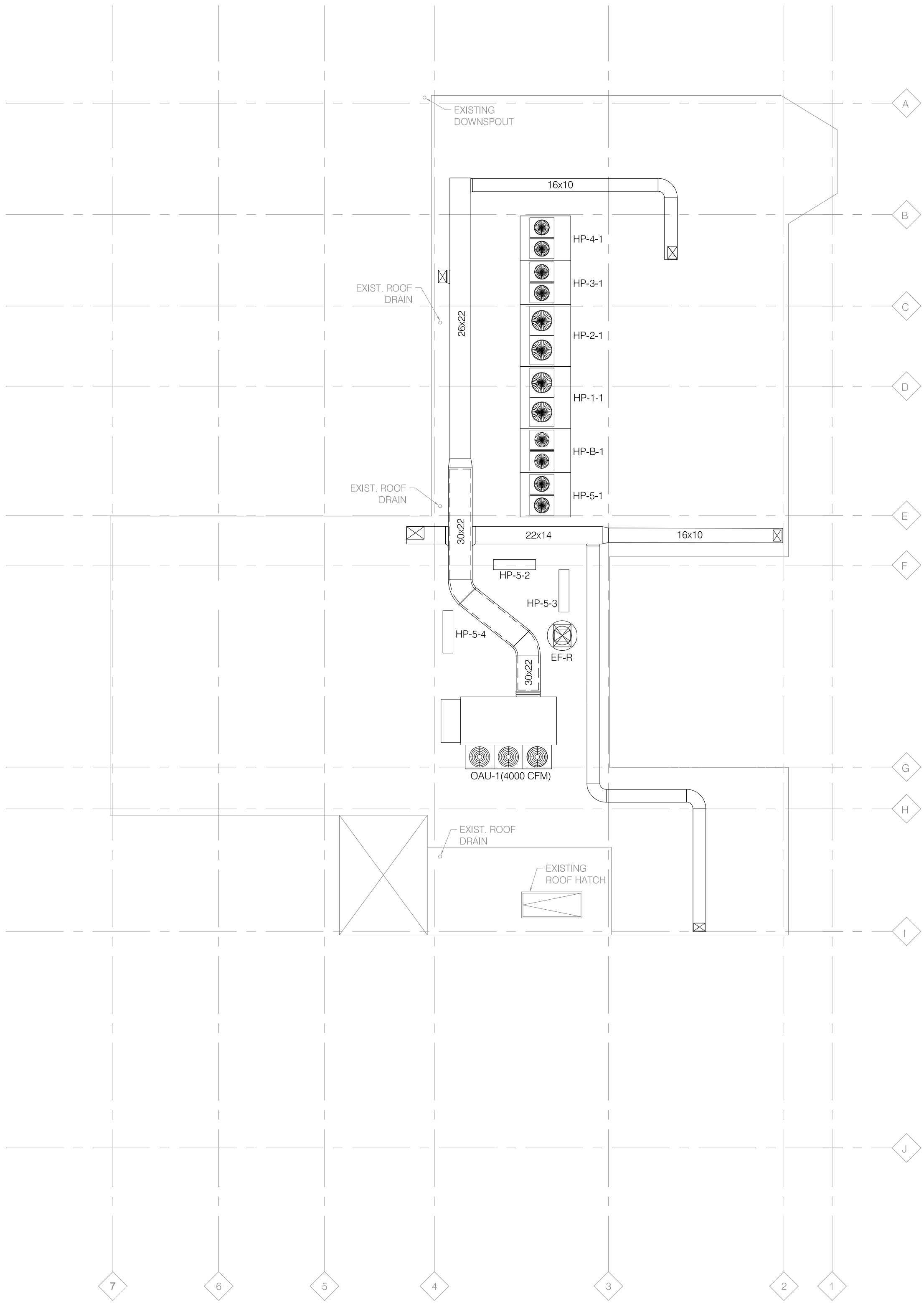

1 | M106

ROOF FLOOR PLAN

SCALE: NTS

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