DESIGNING FIRE STATIONS FOR THE HEALTH & WELLNESS OF FIREFIGHTERS & THEIR COMMUNITIES

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Designing Fire Stations For the Health & Wellness of Firefighters & Their Communities

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ABSTRACT:

Fire departments are making procedural and cultural changes due to the results of research regarding the health effects of carcinogens and firefighters' behavioral health but, where is the change in fire station design? Too many stations fail to control the spread of contaminants, disregard the overall wellbeing of building occupants, and lack sufficient space for firefighter personnel training and the use and care of vehicles within the apparatus bay. This leads to the question: How can the design of a fire station positively impact the overall health of not only firefighters, but their communities and the environment? Research has been conducted through interviews with first responders, discussions with architects and interior designers who have fire station design experience, analysis of fire stations and other building types that focus on the occupants' health, and through secondary sources of research conducted and released by the Federal Emergency Management Agency (FEMA) and National Fire Protection Agency (NFPA). With a functional, yet creative, approach, focused on the overall wellbeing of the station's occupants, a new design solution is proposed. This thesis argues that we must re-imagine fire station design to enhance the overall health, wellbeing, and safety of firefighters, their communities, and the environment.

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*NOTE: The term "Firefighters" is used here as a collective term for what in certain cases may also include other members of the emergency services, such as Emergency Medical Services (EMS) personnel.

INTRODUCTION

In February of 2020, the National Fire Protection Agency (NFPA) released their research[1] on fire departments in the United States for 2018. The key findings include: 29,705 fire departments and an estimated 1,115,000 career and volunteer firefighters. As first-responders, occupational conditions have physical and psychological effects on firefighters' lives. Between 2002 to 2018, 65 percent of firefighters deaths were related to occupational cancer.[2] Compared to 50 years ago, fires are burning hotter and faster due to the use of synthetic building materials and furniture, which release more toxic gases than natural materials. This means firefighters are dealing with far more toxic soot than they were in years past. That soot can seep into any area on a firefighters skin that may become exposed between their gear. Because it sticks to the firefighters' uniforms, it is transferred to their skin during the gear removal process.[3] The concept of coming out of a fire and being dirty used to be seen as a badge of honor, but with the growing amount of research being released on the health effects of carcinogens, firefighters have made a cultural shift. While firefighter culture and procedures are being updated, where is the update to fire station design?

In addition to physical health effects, behavioral health effects include[4]: fatigue, sleep disorders, substance use disorder, anxiety, depression, acute stress reactions, relationship and/or family problems, and suicidal symptoms. In 2018, a study[5] of 7,000 firefighters from across North America, conducted by the International Association of Fire Fighters (IAFF), NBC New York and NBC Bay Area, found that 65 percent of the respondents struggle with memories of difficult calls, while 59 percent have had family or relationship problems as a result of their jobs. Substance abuse issues were experienced by 27 perecnt of the respondents and 19% have had thoughts of suicide. There needs to be a better way to protect the overall health of firefighters that doesn't end once they leave the scene of a call. As designers, we can't affect what firefighters experience while responding to a call, but we can affect their physical and behavioral health while they're at the station. All of this information engenders the question, how can the design of a fire station positively impact the overall health of not only firefighters, but their communities and the environment?

PHYSICAL HEALTH EFFECTS

In a firefighting environment, there are close to 90,000 chemicals in use through building materials and furnishings. The byproducts of these materials after combustion are far more hazardous to the health of humans compared to the materials used in construction and furnishings 50 years ago.[6] There are three primary ways in which airborne harmful substances can make their way into firefighters bodies: inhalation, skin absorption, and orally. It has been shown[7] that the absorption rate for toxins increases 400 percent for every 5-degree increase in skin temperature. Despite wearing turnout gear, toxic chemicals can still penetrate through the gear and make contact with the firefighters skin. Although ingestion is a less common route of exposure, it does occur. When soot is on a firefighters hands, and if not washed, can be ingested through eating, drinking, and by accidently putting their hands in their mouth.[8] There are three major sources of contamination that are typically brought into the station:[9] personal protective equipment (PPE), fire and rescue equipment, and the apparatus (particularly interior cab). Gross decontamination should occur at the scene, with additional decontamination once returning to the station. It is important to mitigate the spread of carcinogens throughout the station because it is likely that accumulation of low levels of exposure over time (chronic effects) to carcinogens, which are any substances capable of causing cancer in living tissue,[10] leads to higher incidences of cancer in firefighters.

In addition to their concerns for cancer, firefighters also worry about cardiovascular diseases such as heart attacks and sudden cardiac death. An increased risk of cardiovascular diseases has been linked to circadian rhythm disorders.[11] The shift that a first responder works impacts the type of disturbance an individual experiences. Workers who start before 6:00 a.m. typically wake up outside of their natural circadian rhythm, resulting in sleep that isn't refreshing and is more difficult to wake up from.[12] There is also a link that circadian rhythm disruptions likely increased the risk for breast cancer and that the longer a person works the night shift, the greater their risk.[13] Short sleep, which is any cycle lasting between four and seven hours, is associated with an increased risk of coronary heart disease, stroke, type II diabetes, obesity and/or weight gain, depression, workplace accidents and mortality. There is data between

shift work and poor sleep, and between poor sleep and adverse health outcomes, but a concrete direct link between shift work and health outcomes is less clear.[14] One can presume, the physical health effects can overlap and even be caused by behavioral health effects and vise versa. The connection between children whose fathers are firefighters and congenital heart failure has already been proven,[15] running a three to six times higher risk of suffering from congenital heart defects compared to children with parents in other professions.[16] One area that lacks extensive and reliable empirical data concerns the fertility of firefighters connected to their exposure to hazardous substances, psychological stress and substances that are suspected to be, or have been established as, toxic to reproduction.[17]

BEHAVIORAL HEALTH EFFECTS

Firefighters across the country are responding to an increasingly high number of Emergency Medical Services (EMS) calls compared to fire calls. Firefights come across a wide variety of tragic situations while responding to hazardous materials incidents, assisting in natural disaster relief, and performing search and rescue missions. Firefighters respond to calls that play out in or around their homes, along highways, and in every other conceivable part of their communities.[18] With repeated exposures to trauma (RET), firefighters are at an increased risk for the development of post-traumatic stress disorder (PTSD), with prevalence estimates as high as 22.2 percent.[19] Frank Leto, from the FDNY Counseling unit said, "we are great at taking care of the public, but we are not so great at taking care of ourselves."[20] Only 20 percent of fire departments have a behavioral health program and only 27 percent have a basic firefighter fitness and health program. These numbers are from 2015, but a fifth needs assessment has been conducted and that data is set to be released in the second half of 2021.[21]

"Compassion fatigue" or "secondary trauma" are experienced by firefighters from repeated exposure to trauma.[22] Firefighters may suffer from symptoms such as sleep disorders, avoidance behaviors, and feelings of helplessness that are associated with post-traumatic stress disorder (PTSD) even if they may not be diagnosed with PTSD.[23] With prolonged periods of time at the station it is important firefighters have a place to relax and decompress, especially after returning from a tough call. A rest period between high-intensity shifts is necessary to maintain efficiency and mental alertness.[24] There needs to be places set up for someone to transition from a hyper-vigilant state, from the urgency of having run call after call, to a calmer state.

A study[25] of 6,933 firefighters from 66 U.S. fire departments found that 37 percent of those firefighters suffer from sleep disorders such as sleep apnea, insomnia, and work shift disorder. Firefighters with a sleep disorder were more likely to report a motor vehicle crash and were more likely to report falling asleep while driving than those who did not screen positive. Additionally, firefighters with sleep disorders were more likely to report having cardiovascular disease, diabetes, depression

and anxiety, and to report poorer health status, compared with those who did not screen positive.

The dormitory-style bunk rooms do not help in preventing sleep disturbances. Some firefighters may be more sensitive to light than others and some firefighters may snore, making it harder for the rest of the crew to fall and/or stay asleep. Some fire stations have separate bunk rooms, but will not have a solid wall between areas or a solid door between the room and hallway. This may allow for more privacy compared to the dormitory-style bunks, but this design decision does not help with noise control. While there may be an initial, construction cost saving in not having completely separate, walled off rooms with solid doors, the physical and emotional toll that is put on a firefighter comes at a far greater cost and should outweigh the initial, construction cost.

WHAT MAKES UP A FIRE STATION

Fire stations are typically broken down into three main architectural program areas. There is the apparatus bay with support rooms, the office area, and the living area. Data from a 2015 needs assessment of the United States fire service[26] relayed that almost half (43 percent) of all fire stations were more than 40 years old at the time. Older stations likely lack vehicle parking, space for equipment storage, living accommodations and space for the education and training required for today's modern fire service.[27] The apparatus bay houses the fire apparatus, emergency medical service vehicles, and other modes of transportation, such as a water rescue boat, the fire department might need to respond to a call. The apparatus bay support functions include: a turnout gear room, a room that houses the self-contained breathing apparatus (SCBA), a room for maintenance (also called a work room), a watch room, and a room for continued decontamination (for equipment, gear, and the firefighters). The office area consists of the main lobby, a reception, administrative offices, the I.T. room, and a training/meeting/ community room. The living area contains the dormitories (or also called bunk rooms), dayroom (which is like the living room of a home), kitchen, laundry room, and janitors closet. It is important to have restrooms and places for storage in each area (apparatus, office, and living).

Also important is the ability to have on-site training. To provide the best services to a community, firefighters must first understand what it is that they have to do. Keeping training on-site saves time and resources, but it also allows for more frequent training. Training enables firefighters to learn new skills and techniques in order to respond more efficiently and increase firefighter safety by learning how to function better as a team and enable members to function in different capacities within the crew.[28] The number of firefighter injuries and deaths are reduced because firefighters are confident they can apply the skills they learned during training to carry out their duties instinctively.

Different types of training require different types of spaces and there are a variety of ways to carry out fire rescue techniques. For example, in an enclosed room an obstacle course can be set up that simulates a floor collapse and the firefighter will declare Mayday (which is specifically for a firefighter, communicated over the radio, when firefighters are either lost, trapped, injured, or are missing/unaccounted for[29] and a window, 20-inches wide by 42-inches tall window, can be built to carry out the "Denver Drill" evolution.[30] The "Denver Drill" is an example of a training evolution for confined space rescue, but other types of training include: search, repelling, high/low rescue, forcible entry, hose advancement and stairwell evolutions, aerial apparatus and ground ladder evolutions,[31] to name a few. NFPA 1410, Standard on Training for Initial Emergency,[32] "establishes a baseline competency in training for fire suppression and rescue operations and offers general requirements for evaluations, emergency scene incident command, evolution preparation, and logistics" for fire departments to use. A training

tower, or also called a drill tower, not only allows for training that simulates multi-level structures, but also acts as a hose tower, which is a place to hang and dry the water hoses.

Tornado shelters are required to be built in fire stations, per the 2015 International Building Code (IBC).[33] In accordance with International Code Council (ICC), *ICC/NSSA Standard for the Design and Construction of Storm Shelters* (ICC 500),[34] fire stations shall have a storm shelter to withstand the speed of 250 MPH wind speeds.

DAILY LIFE

Shift schedules can vary per department and depending on if they are full time, part time, or volunteer firefighters. It is typical for a full time firefighter to be on duty for 24 hours, then remain off duty for 48 hours. It is a common belief that a firefighters' working day takes place at the chaotic scene of a fire or accident. Some of firefighters' work involves fighting fires and attending the scene of an accident, which is direct operative work, but in reality, a firefighters' typical workday is filled with completely different required activities. The rest of their duties include:[35] maintenance & cleaning around the building, vehicles, and equipment, prevention work and preparations for operative work, and educational and physical training. These tasks are important, but do not necessarily create positive impacts on someone's daily life.

LEARNING FROM OTHER BUILDING TYPES

The incorporation of nature to help with physical and behavioral health is used in hospitals, schools, and offices, but is almost nonexistent in fire station design. Robin Guenther, an architect at the firm Perkins + Will, said[36] that "one of the best ways to insult a building's architecture is to say that it looks institutional, that the terms implies a kind of lack of humanity." Guenther focuses on creating a balance between efficiency and improving the building occupants' environment to improve the way we feel inside the building, which can enhance a person's overall health. To accomplish this, Guenther promotes new buildings that are light on potentially harmful materials, heavy on natural light, go out of their way to be energy-efficient, and foster a connection between the building occupants and nature.[37] These principles should also be applied to fire station design. By incorporating therapy and healing gardens into fire station design, this idea can help foster connections between the firefighters, their communities, and nature.

Maggie Centers are a network of cancer support centers that aim to create comfortable spaces, located near but detached from hospitals, for anyone affected by cancer.[38] Located mainly throughout the United Kingdom, but also in Japan and Hong Kong, these buildings are designed specifically for cancer patients.[39] When designing a Maggie Center, there is a set of architectural requirements for the design of all future centers. These guidelines were created because the Maggie Centers were a new approach to cancer support.[40] Each architectural space is described in such a way that the obtained atmosphere is clear but no fixed solution is given. This allows for design freedom, while still maintaining the main concepts and principles. Apart from these contextual descriptions for specific spaces, there are also pointers for the architecture in general such as[41], "Centres and the way they are designed should raise your spirits, be safe and welcoming, but not too cozy and increase the sense of connectedness between people." Three major topics were identified: the emotional impact of building aspects, how users identify with the building and how the building supports social interaction at different levels.[42] Similarly, fire stations should have a specific design, in order to be as safe and functional as possible, for firefighters. Through learning from the Maggie Centers, there should be a set of guidelines for designing fire stations with a better approach to how the building can help improve firefighters' and their communities overall health. Scientific studies have proven the positive health effects of being

able to see nature. While this concept has been incorporated in other building types, it is rarely seen in fire stations. Physiological effects related to nature have been well-documented for years. By adding elements to fire stations such as water, plants, and increased daylight, Firefighter and EMS personnels' anxiety can be reduced. One study[43] found that subjects who walked through forest atmospheres had an average lower stress hormone concentration and less stress levels than subjects who walked through urban areas. This study found that relaxation levels increased by 56.1 percent. Having an interior or exterior garden that a firefighter could walk through can be implemented in any fire station design. Providing firefighters with an area to decompress during long shifts, especially after returning from a tough call, is important.

CURRENT STANDARDS & REGULATIONS

In August of 2014, Architect Paul Erickson of Lemay Erickson Willcox Architects published an article[44] named "Contain the Contaminants" in Firehouse Magazine. In this article he describes a strategy called "Hot Zone Design" where the fire station is zoned in three ways: The HOT Zone (red) for high hazard, TRANSITION Zone (yellow) for moderate hazard and COLD Zone (green) for low hazard. The purpose of "Hot Zone Design" is to help reduce the spread of contaminants throughout the fire station. The TRANSITION (yellow) Zones are airlocked, while the HOT (red) and COLD (green) Zones have separate HVAC systems. By doing this, positive-pressure airflow can help keep the spaces in the COLD (green) Zone area safe from toxic contaminants. He continues to publish articles and give presentations on this topic in order to help educate firefighters and designers on its importance. This strategy is the most recent design solution to the issue of contamination spread throughout the station.

In 2018 the U.S. Fire Administration (USFA), and entity of the Federal Emergency Management Agency (FEMA)[45] and National Fire Protection Association (NFPA) integrated Mr. Erickson's idea to 'Think In Zones' into their standards. NFPA 1500 is the *Standard on Fire Department Occupational Safety, Health, and Wellness Program*[46] and it impacts fire station design in areas including cancer prevention. In both the 2021 edition of NFPA 1500 and in the *Safety and Health Considerations for the Design of Fire and Emergency Medical Services Station*s, the concept of zoning is listed under the topic of contamination control inside fire stations. The different zones are designated as: red (hot zones), yellow (warm zones), and green (cold/clean zones)(reference Figure 1).

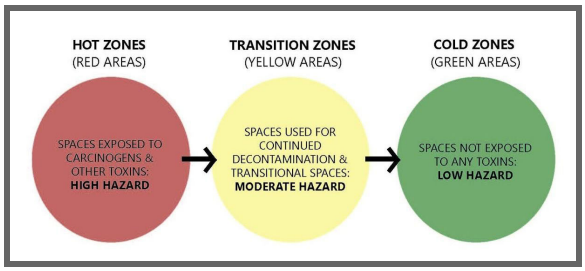


Figure 1: Zones Diagram [47]

Red zones are spaces likely to be exposed to contaminants or carcinogens, yellow zones are transition areas between contaminated areas and clean areas, and green zones are clean areas such for the living and office areas of the station.[48] Hot zones include: All spaces that house apparatus, tolls, equipment or personal protective equipment (PPE and also called turnout gear), EMS storage, the decontamination room, and wherever the extractor (washing machine for turnout gear) is located. Within the red zone, the decontamination of contaminated PPE and equipment shall take place. The Decontamination room is important because the ability to safely and effectively decontaminate firefighters and their equipment has come to the forefront of firefighter health and safety. All means must be taken to ensure both new and existing facilities are designed or renovated to allow for proper decontamination procedures to be conducted within them.[49] Transition zones include: dedicated showers, toilets, and sinks, separate and designated closet for cleaning and decontamination equipment and supplies, isolated HVAC (air-lock vestibule), and hand sanitizer

dispensers at all access to clean areas. Transition zones typically consist of very durable finishes for the ability to properly clean them. Fluid-applied epoxy floor finishes with integral coved base up the walls a minimum of 6 inches make the floor an easy wash.[50] Included in the cold zones are: the kitchen storage areas, locker room, the dayroom, kitchen, living quarters, offices, exercise area, offices, conference/training room, the main lobby, and any other area considered to be a regularly occupied living or working area. In the red zone, there is negative air pressure with a dedicated exhaust system to the outside and in the green zone, a separate HVAC system is used to create positive air pressure. Having separate HVAC systems for this purpose will help minimize the spread of toxins throughout the building. While these texts suggest what spaces should be in what zones, it does not specifically state which rooms should be next to each other within each zone.

METHODOLOGY

The thesis began development through research using secondary sources, such as research conducted and released by the Federal Emergency Management Agency (FEMA), National Fire Protection Agency (NFPA), and U.S. Fire Administration (USFA), reading about the health effects firefighters face, learning about firefighter culture, and researching sustainable design principles & strategies. By diagrammatically analyzing case studies of fire stations successes and failures, adapting design strategies from other building types to focus on the building occupants' health and wellbeing, were researched and examined to then design a next generation fire station and conclude clear, applicable design guidelines to fire station design. Primary research includes personal observation, interviewing over a dozen firefighter personnel including fire chiefs, assistant chiefs, and lieutenants, and discussions with the crew. There is no way, as a designer, for me to gain the experience and knowledge as these men and women; which is why interviews and discussions with firefighter personnel is critical.

CASE STUDIES

A few of the fire station case studies diagrammatically analyzed through highlighting the three different zones and highlighting the Sequence heading to (in blue) and returning (in orange) from a call include:The Salt Lake City Fire Station 14, Fire Station 20, The Tukwila Fire Station 51, and Lafayette Township Fire Station.

The Salt Lake City Fire Station 14, located in Utah, is an example of how a poor layout can affect firefighters. The floor plan of this station is diagrammatically analyzed through highlighting the three different zones and highlighting the Sequence heading to (in blue) and returning (in orange) from a Call. The Salt Lake City Fire Station 14 (reference Figure 2) is recognized as a leader in the optimization of energy reduction.

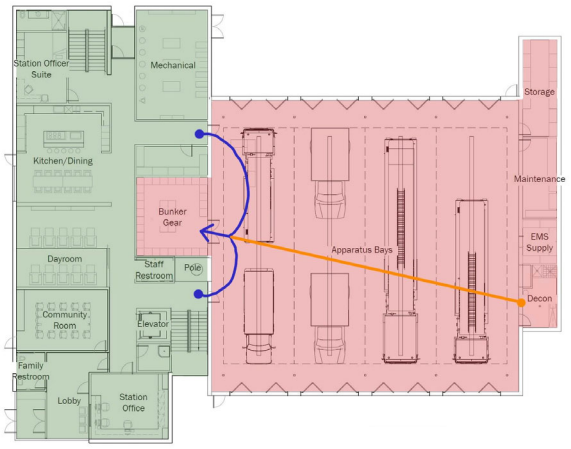


Figure 2: Diagram of Salt Lake City Fire Station 14 First Floor Plan [51]

The architects, TCA, were sought out by Salt Lake City in conjunction with Blalock and Partners to design this Zero Net Energy (ZNE) fire station to align with their "Climate Positive 2040" plan.[52] Although this all sounds very good, you can see the areas of improvement needed from the diagram. A large downfall to the design is that there are no itransition (yellow) zones between the hot (red) and cold (green) areas. The decontamination room is on

the opposite side of the apparatus bay and the only entrance to the turn gear room is from the apparatus bay. This means there is not much being done to mitigate the spread of contaminants throughout the fire station.

Fire Station 20 in Seattle is celebrated for its efficient layout. In High Performance Buildings (HPB) Magazine, author Eric Aman writes[53] that the design is based on maximizing efficiencies within the building while minimizing deployment time during emergency response. To enhance safety during nighttime deployment and minimize overall response time, bunk rooms are located on the first floor. One of the downfalls in the design is that a firefighter can only get to the turnout gear room through the apparatus bay, there is no access from the hallway or living/working area (reference Figure 3).

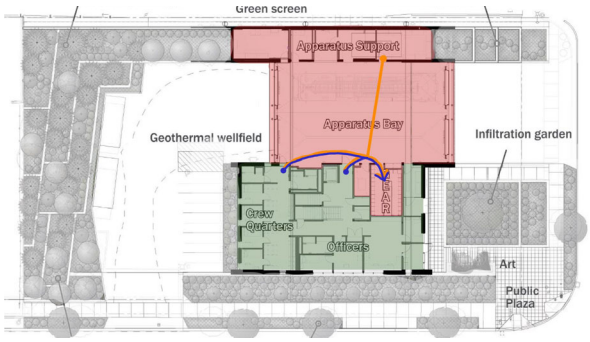


Figure 3: Diagram Over Fire Station 20 First Floor Plan [54]

A couple of features of the design that are intriguing are the public art plaza, which allows for public engagement, and the vegetable garden. A vegetable garden could not only be used to help feed the firefighters, but as an activity to engage with the community.

The Tukwila Fire Station 51 is located in Washington and is designed by Weinstein A+U. The design team used a metal structure with massive brick walls to emphasize the strength and stability of the fire department.[55] The floor plan[56] notes that the station has airlock corridors (reference Figure 3), but it seems that the floor plan falls short because a firefighter still has to re-enter the apparatus bay before entering or exiting the turnout gear room. With a few rotations and door adjustments, it seems like the flow could work a lot better. One design feature that stands out to me is the exterior courtyard. It is a place that allows firefighters to have a place outside to decompress, while also providing privacy from the public. Another design feature in the Tukwila Fire Station 51 is the use of four fold doors, which takes less than 7 seconds to open, compared to the traditional overhead doors that take about 14-17 seconds to open.[57]

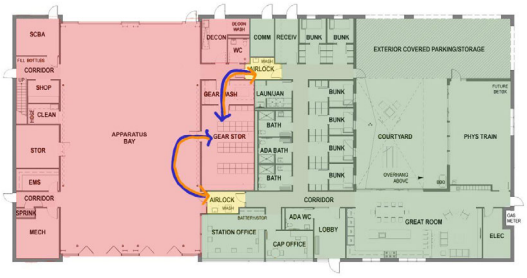


Figure 4: Diagram Over Tukwila Fire Station 52 Floor Plan [58]

Lafayette Township Fire Station, designed by McCall Sharp Architecture, has a few good design features to learn from; there is the ability to train on site with a training tower and a meeting room that can be shared with the community, with a separate entrance for community members (which acts as a security measurement). The downfall to this design is that the extractor room is on the opposite side of the apparatus bay from the decontamination room, so a firefighter is having to walk back and forth across the apparatus bay, instead of the rooms being next to one another. There are also no air-locked hallways in this design (reference Figure 5). If the corridor behind the turnout gear room was sealed and the wall from the decontamination room was extended, an air-locked hallway could be created. Then, the door to the watch room could be re-located off of that hallway, so a firefighter does not have to enter into the apparatus bay in order to get into the watch room.

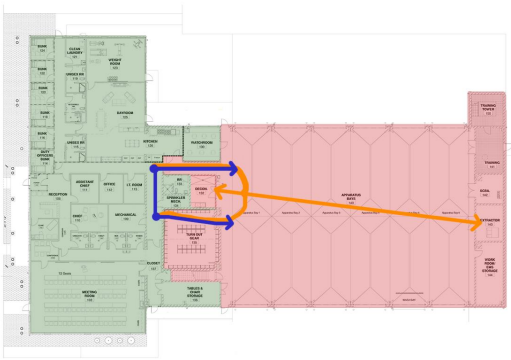


Figure 5: Diagram Over Lafayette Township Fire Station Floor Plan [59]

One design aspect that all four stations shared were having separate bunk rooms. This reinforces the research findings that individual bunk rooms are preferred over a dormitory-style bunk room. A similarity between all four stations is that an improvement of the sequence of circulation between spaces can be made so firefighters are not retracing their steps throughout zones.

PRE-DESIGN CONSIDERATIONS

The proposed fire station is located in Oxford, Ohio. By doing this I was able to work closely with the current Fire Chief, John Detherage, and learn the specific spatial needs for his department. Because the size of departments and number of people per shift vary, having a real life client created a baseline to determine the programmatic needs for the new, proposed station. Before designing a fire station it is important to figure out the specifics of the station, such as how many firefighters work per shift in order to figure out the number of gear storage lockers and bunk rooms are needed, will vary depending on the size of the department. Oxford's station currently has seven beds, but to plan for growth, a new design should have eight. A needs assessment for the current City of Oxford Fire Department Station 11 (Reference Figure 6) was created first. After researching the deficiencies of the current station, I worked with Chief Detherage to create a new architectural program. After the new baseline was set I then added the features from my research to enhance the architectural program. I sent the updated program to Chief Detherage for his review, and he approved the new programmatic additions. This process showed me that Oxford's station is just like the stations I had read about; not up to today's standards.

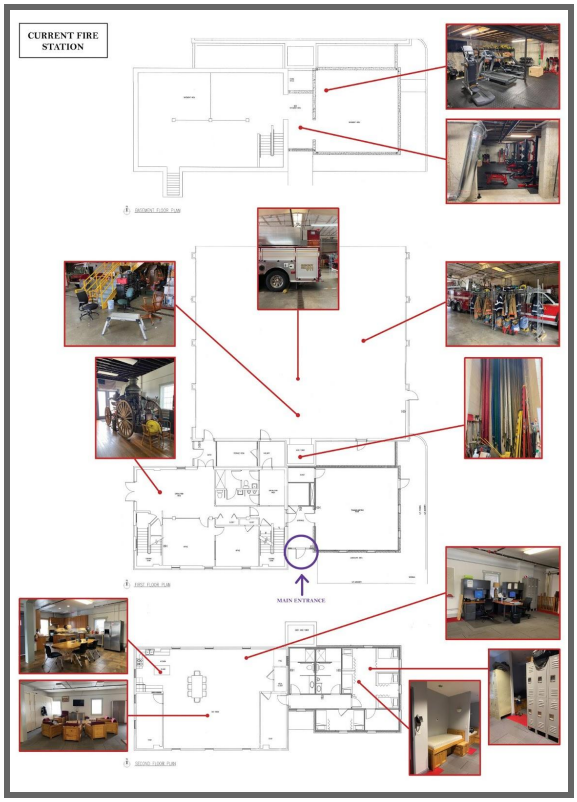


Figure 6: Needs Assessment Diagram for Oxford Fire Department Station 11 [60]

Site analysis began with a broad overview of the city of Oxford. I started by creating a response time map (Reference Figure 7), for where Oxford Fire Department (OFD) is currently located compared to the department's service limits, which covers 54 square miles. Next, a location analysis map was created (reference figure 8) that focused on the city of Oxford. The location analysis identifies where the current station, hospital, hot spots (areas visited at a high volume by the OFD), primary educational schools, parks, and railroad tracks are located within the city limits.

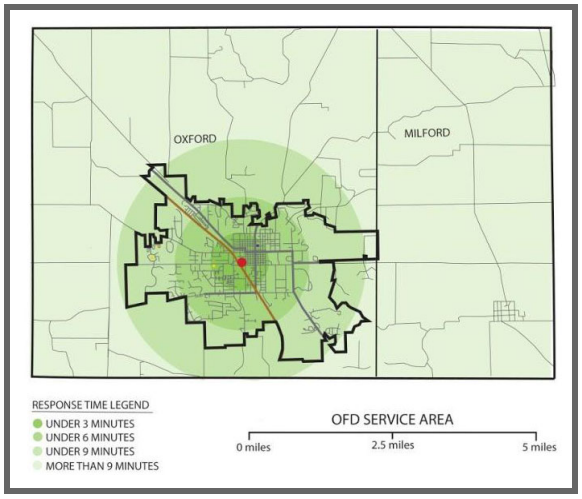


Figure 7: Response Time Map [61]

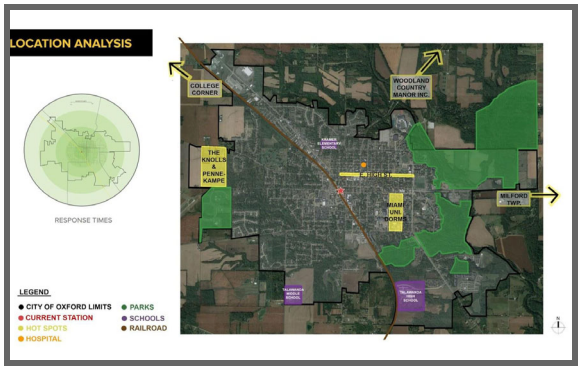


Figure 8: Location Analysis Map [62]

Typically a new fire station's location would be determined through a GIS map study. Under NFPA Standards 1710 (for full time stations) and 1720 (for part time stations) are the required response times. When firefighters leave the station they are supposed to reach their location within four minutes.[63] From the International Organization for Standardization (ISO) rating criteria, at a bare minimum, a fire station should be placed so that every part of the jurisdiction is within 5 miles of a fire station.[64] It was decided that if a second station would be built on the West side of the railroad tracks, to adhere to code requirements, the current station would still have to be renovated because it is already not up to today's standards. In order to fulfill governmental and community goals laid out in the City of Oxford's 2008 Comprehensive Plan,[65] part of the design proposal involved master planning. Under the Urban Design Goal to honor and preserve the historic character and quality of Oxford while embracing high quality which complements existing development, one of the objectives is to make uptown the civic center of the community. By moving the existing police and fire station, a new civic center was created (reference image 9). To fulfill NFPA and ISO requirements, part of the masterplan includes building a second fire station on the West side of the railroad tracks.

Additional objectives regarding the urban design goal are to: enhance the beauty and character of Oxford, integrate public art into the built environment, and preserve and enhance historic resources in the Mile Square including Uptown. An objective under the land use goal is to continue to manage growth, continue to enhance uptown, expand urban green space, and be a leader in environmental stewardship. In order to manage parking within the Mile Square, an objective regarding transportation goals, a parking garage is added in the masterplan design. This will also help serve the parking needs for the civic buildings.

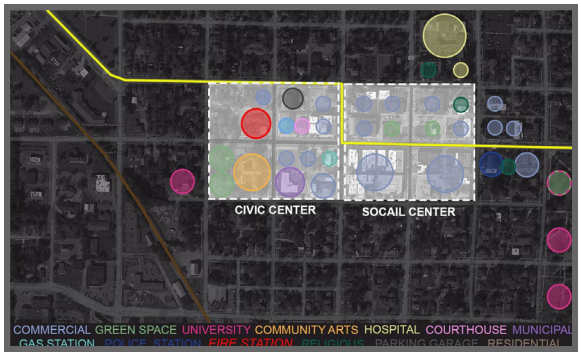


Figure 9: New Masterplan for the City of Oxford [66]

It is important to design a station that fits into the community's architectural language and is integrated into the urban fabric. The proposed design will use brick as at least one element of the exterior facade. Although Miami University is populated with brick buildings, that is not the reason for choosing brick. Historically, fire stations have used brick, but another factor in this decision are the existing civic buildings. All

of the civic buildings are constructed with brick as the main exterior facade. The Community Arts Building, which is the historic Women's College, also uses brick on its exterior facade (reference Figure 10). In addition, brick can be sourced locally (within 500 miles) and is a durable material. And finally, brick was chosen as an exterior finish because it helps characterize the city's strength and pride while simultaneously referencing a home-and-hearth refuge for the firefighters who are stationed there.

Figure 10: Buildings Surrounding Site [67]

FEMA suggests that one way to look at the overall design of a fire station is from a performance perspective. They list ten performance goals that are useful to help formulate goals and keep the design focused on the "big picture." In order, starting with the most important, these goals are: Response, training, health and safety, evaluations (ISO, Accreditation, etc.), culture (camaraderie, special functions (may not be applicable for every facility), technology, durability, sustainability, and aesthetics.[68] Once a person understands the specific functions that a fire station requires, it is important to then re-think how these spaces can be designed.

DESIGN PROPOSAL: FIREFIGHTER HEALTH & WELLNESS

It is stated in the Firefighter Cancer Support Network's white paper, *Taking Action Against Cancer in the Fire Service*[69] and reiterated in *Safety and Health Consideration for the Design of Fire and Emergency Medical Services Stations*[70] that "The design of fire stations, whether for new construction or renovation, must include such standard design features as state-of-the-art equipment and systems for adequate air flow, removal and capture of carcinogens and particulates, appropriate location and ventilation of storage rooms for contaminated PPE and other equipment, washer-extractor and gear drying equipment, as well as clear separation of living quarters from the apparatus floor. In short, architects should be working to design cancer out of fire stations. Responsible elected and appointed officials should require this type of expertise when hiring design professionals for fire stations." The idea to design cancer out of fire stations is echoed/ magnified in the goal to improve firefighters physical health. The apparatus bay and apparatus support rooms, which includes the turnout gear room, are currently identified by the NFPA and FEMA as hot (red) zones. It is zoned this way because not every department owns two sets of gear for their firefighters (which is not to blame individual departments, but rather the overall lack of funding and resources available and distributed to fire departments). To ensure the physical health of firefighters, every department should have two sets of gear so while one set is being cleaned, another one is available to use. This makes sure no contaminated gear is placed in the apparatus bay or in the turnout gear room. While every department does not currently have this, in the hopes of this becoming the new normal, the zone of the turnout gear room can be re-examined and be zoned as a Transition (yellow) zone.

Designers can't control what happens outside of the station, but we can control how fast we can get firefighters out of the station & headed to the mission. This is achieved by having the best flow as possible in the sequence of circulation when heading to a call. When Firefighters consider getting from Point A to B, it's at a walk, not a run. Therefore it is important to understand what can add time to their response. The easiest way to decrease response time is to provide direct access to the turnout gear room and the apparatus bay.

Bends and turns in hallways will slow the firefighters down and can create hazards. When entering the transitional spaces door swings need to be designed so that firefighters will not open a door into another firefighter's path of travel. In multi-story stations, poles can reduce response times from an upper level by 50 percent or more,[71] but safety features need to be included on both levels to prevent falls and hard landings. Some departments have even banned the use of poles in the stations.[72]

When returning from a structure fire, a firefighter will travel from the hot zone to the transition zone and then finally return to the cold zone of the fire station. While "thinking in zones" is important, the next step is for there to be a linear transition between zones. The sequence of circulation firefighters go through when heading to and returning from a structure fire is very important. When returning from a structure fire, the continued decontamination process should begin in the decontamination room (where there is a foot pedal sink to clean equipment, a shower to scrub down and clean larger equipment and turnout gear, a barrel to place turnout gear that cannot fit into the extractor, and the extractor). After placing their gear in the barrel or extractor, firefighters would be able to grab a clean set of clothes out of lockers, ener a restroom to undress, place their dirty clothes in a bin to be washed, shower and put their clean set of clothes on, then head back into the living/office areas of the station. During the design process a space adjacency exercise, or what space is going to be next to, is helpful in creating a well-designed, efficient fire station. Similar to every other type of situation that is dealt with in the fire service, a well thought-out and developed pre-plan is essential to the overall success of a project.

The decontamination process is the same idea as a surgical suite would be designed, allowing a surgeon to go through a specific process to sanitize before surgery. That precise procedure only works if the fire staff follow the design intent and not avoid the system.[73] To ensure firefighters are not retracing their steps between zones, the continued decontamination process needs to be a linear transition between spaces to mitigate the spread of contaminants. Through a space adjacency diagram the best sequence of circulation between rooms is created (Reference Figure 11). While this design strategy is one way to protect firefighters' physical health, taking steps to improve firefighters' behavioral health can also protect their physical health.

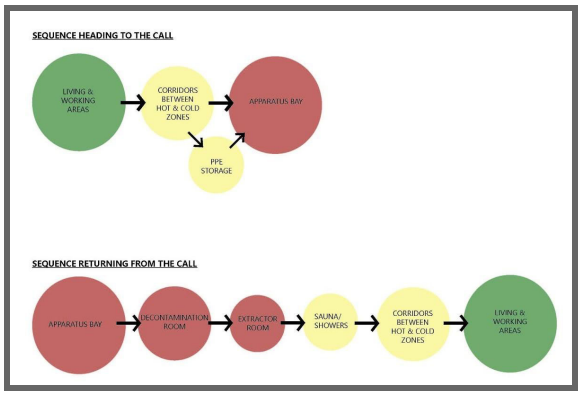


Figure 11: Sequence of Circulation when Heading to and Returning From a Call [74]

As human beings, stress and anxiety are a natural part of our lives. Everyone can relate to this. Firefighters are no different. But learning how to decompress and deal with stress and anxiety may be even more important for firefighters since it not only affects their emotional wellbeing, but how they perform their job (and therefore help others). When on a call, proper breathing can mean life or death. During a blaze, firefighters use a mask and a self contained breathing apparatus (SCBA), such as a Scott Air-Pak, for their air supply, but these units only contain a certain amount of air. This means the ability to regulate and control proper breathing can help ensure they have as much oxygen as they need and that heavy, stressed-out breathing doesn't jeopardize their limited air supply.[75] On top of that, when firefighters are called to action, there is a charge in their sympathetic nervous system. A parasympathetic crash follows, which can leave firefighters feeling exhausted, apathetic, and even irritable. This is where the importance of breathing becomes crucial.

Proper and focused breathwork bridges the connection between the mind and body.[76] When we focus on our breath, we inhale, creating expansion; and each exhale is an opportunity to release and let go of tension, tightness, and stress. Exercise has been promoted for years, and now it's well known as part of our wellbeing, but meditation (mindfulness) has not gained as much attraction. Very often, we do not really take the time to notice how the body feels. Everyone can gain from taking a few minutes out of their day to meditate, but imagine how helpful this can be for firefighters who are dealing with trauma. Of course meditation can happen anywhere, but providing a quiet space for this to happen is ideal. By dedicating an area as a calm room in a fire station, it provides a physical space that acts as a reminder for the firefighters to take the time to check in with one's self and decompress.

In addition to calm rooms, it is important to incorporate other ways for firefighters to decompress. One design strategy is to include a game room. As firefighters are hitting a ping pong ball back and forth, or shooting pool, they may open up to one another about a rough call they experienced. This not only serves as a way for firefighters to decompress, but also grow firefighter camaraderie. Simply talking to one another, especially in this day and age when everyone is glued to their phones, can go a long way in helping a person's behavioral health. Decompressing and growing firefighter camaraderie traditionally happen in the fitness room, dayroom, and kitchen, however, providing additional spaces, such as the game and calm rooms, stresses the importance of these activities. These additional spaces create an environment that may make it easier for someone to let their guard down and communicate what's on their mind, and what they may be struggling with, to another firefighter. Another new way to facilitate these activities is through the redesign of the watch room. Watch rooms are typically located off of the apparatus bay and are used for writing reports, working on other jobs, and/or studying, and may have mail slots for firefighters to receive paperwork. Instead of having one, enclosed room off of the apparatus bay, the watch room can be relocated to bridge the gap between the civic, office area of a fire station, to the domestic, home-like setting within the fire station. Inspired by the atmosphere created in cafes, flexible seating options and views to an exterior garden create a more pleasant place for firefighters to accomplish their work. But just like how people go to a cafe to work, they also go there to socialize. By re-imaging how the watch room is designed, more opportunities for decompression and firefighter camaraderie are created. The use of wood and indoor vegetation within this space soften civic formality toward an impression of authenticity and informality, emphasizing that a city's fire station is not just a civic building, but a home to the firefighters.

With the remembrance that a fire station is not only a civic building where firefighters work, but also their home due to their long shifts, it is important that the station is designed to promote healthy sleep. Although it is thought that camaraderie is grown by having a dormitory-style bunk room, I believe it is more important to make sure firefighters can get a good night's rest, without any unnecessary sleep disturbances, and focus on growing camaraderie in the areas previously listed. By having individual bunk rooms, with doors that close to help keep the bunk room a quiet place, a few of the unnecessary sleep disturbances are eliminated. In order to improve the time it takes to fall asleep (sleep latency) and enhance the quality of sleep (sleep efficiency) firefighters experience, full sized beds should be provided in their bunk rooms. If the bunk rooms are designed a little bit larger than the standard size, to fit a full sized bed instead of twin sized bed, this could help firefighters' ability to fall and stay asleep. In every fire station researched for this thesis, there are twin size beds provided for the firefighters. With research showing the negative physical and behavioral health effects of anyone getting under 6-7 hours of sleep, shouldn't every step in a design decision help

facilitate healthy sleep? By allowing more room for someone to move around and find a comfortable position, and not feeling squished into a tiny bed, this small change could make a large overall impact in helping a firefighter's ability to fall and stay asleep. In the proposed station's design, all of the doors to the bunk rooms, and rooms nearby, would be fitted with jamb silencers to prevent slamming, including the lockers located in each bunk room. The last design solution is to have a rolling blackout shade in each bunk room window. The rolling blackout shades, which run in tracks or channels at the window jambs, preventing light spillage around the edges. This allows someone to take a nap in their bunk room anytime of the day.

By providing circadian lighting systems, color-adaptive fixtures that use LED technology, echo the subtle color variations that natural sunlight goes through each day, from cool, blue tones in the morning to warmer, red tones in the evening, extra environmental cues to begin the body's journey towards a restful night's sleep. Providing better access to daylight during the day also serves to align a person's internal clock.[77] This is why on top of providing dimming switches for precise light level controls, there is also ample amount of natural light delivered throughout the station. One inch thick insulated glass is used on the four-fold apparatus bay doors, clerestory glass windows, and storefront window glazing systems used throughout the building to provide great visibility and natural day lighting to all essential areas.

Another solution to mitigate unnecessary sleep disturbances is to have an alerting system that only turns on lights specific to the crews that are responding to the call instead of for the entire station. These alerting systems would also be ramped (noises that start soft and gradually increase and lights that begin dim and gradually increase) alerting systems to reduce the audible and visual shocks to a firefighters body. This reduces the anatomical shock to a person's body that the sudden loud tones and bright lights cause.[78] Sleep education sessions should be implemented as well to reiterate the understanding that being well rested optimizes job performance. From a study[79] published in 2016, almost 1,200 firefighters participated in a randomized sleep study. Implementation of the education and sleep disorders screening program reduced the percentage of firefighters who filed an injury report by 12 percent. It also reduced reported injuries by 10 percent per annum, reducing the percentage of firefighters injured by 17 percent and was accompanied by a 46 percent decrease in the utilization of paid disability time among firefighters. In addition to the considerable human toll of injuries, there are also financial costs. Firefighter injuries in the United States cost an estimated $4.70 to $11.73 billion annually, which adds substantially to the $43.81 billion in direct expenditures paid each year for fire protection. In a department of approximately 1,200 active firefighters, and not including the medical costs and human suffering associated with injury and disability, such a reduction in disability day usage translates into an estimated annual savings of $2.1 million.[80]

DESIGN PROPOSAL: COMMUNITY HEALTH & WELLNESS

City services buildings such as police and fire stations, libraries, and city halls are important touchpoints for the communities they serve. In some respects, they define the character of the government and color the interactions between citizens and public servants. One of the main architectural challenges of designing buildings for the public sector is designing buildings that embrace the community through their public-facing functions while maintaining the security, functionality, and financial stewardship expected by administrators and taxpayers.[81] When designing a fire station, it is important to make sure the community feels like they are not forgotten. This is why part of my research involved creating a community survey. Although the community survey was not released, it is important that if any master planning is being conducted within a city, a survey is created and distributed in order to

adhere to the community's wants and needs. One of the main community design goals was to create opportunities on the site and within the building for the community to grow their relationship with the firefighters and one another.

One way to achieve this goal is for the station's overall design concept to include opportunities that would help take care of the behavioral and physical health of community members. A walk-in clinic is designed in the main lobby of the station. Providing this space in my station's design allows a person to come in and get medical attention, such as getting their blood checked, in a private area. Within the Safe-haven laws, fire stations are places where a person can leave an unharmed infant so that the child may become a ward of the state.[82] Some people may not know this information, so as a way to educate the community of this law and reinforce the idea that the fire station looks out for its community beyond fighting fires and providing emergency medical service, I have added a Safe Haven Baby Box to the design of my proposed station. A Safe Haven Baby Box[83] is a safety device that legally permits a mother in crisis to safely, securely, and anonymously surrender their newborn if they are unable to care for their baby.These devices are typically installed in an exterior wall at the end of an apparatus bay.[84] This location is not ideal, but is located here because the Safe Haven Baby Boxes are added to existing stations. With this in mind during design. The baby box is located in an exterior wall that connects to the interior of the walk-in clinic.

On the proposed station's site is a historic building, the Dr. William S. Alexander House, which is registered under the National Register of Historic Places (NRHP).[85] The building is currently empty, but through further research, I discovered that a coffee shop will be located on the first floor, with a church located on the second floor. Part of the Masterplan is to keep the coffee shop on the first floor, but to turn the second floor into a museum about the history of firefighters and specifically, the City of Oxford's fire departments history. The museum preserves and enhances historic resources in the Mile Square including Uptown, but it also covers a design goal of this thesis, which is growing community education through interaction. A community room is provided inside the station that would seat up to 40 people. Educational drills such as "stop, drop, and roll" can be conducted on the playground. The playground serves as a place for children to positively impact their physical and behavioral health. For adults, an outdoor fitness area, half basketball court, and path through a memorial garden is provided.

Places to watch firefighters' activities can draw people to the site. The balcony on the second floor of the historic Alexander house can be used as a viewing deck to watch the firefighters train on the training tower and/or watch them wash the apparatus on the front apron. Another space for this is provided by built-in seating in front of the station. Solid concrete planes offer a place for the community to eat lunch or chat, while also protecting the building from vehicular ramming. As community members pass the station, they should be able to identify the fire station that services their city. The height of the training tower allows for the tower to act as a beacon within the community. It helps people identify where the fire station is located from far away and can help with wayfinding within the city. At the top of the training tower is also where the emergency alerting system would be located. A transparent façade allows passers-by to look in on a historic element, an 1895 5th size Ahrens pumper, that is located in the lobby of the station. At night, the space is illuminated, creating a lantern effect. Seeing history on display in such an inviting setting helps draw a person into the fire station lobby to get a closer look and see what else the station has to offer. Upon entering the lobby, the visitor is greeted with a quote that is dear to the Oxford Fire Department, with an exterior view toward the sky and rooftop vegetation. With the use of Low-sunlight, low-water plants, visitors are led from the exterior of the station to the interior lobby. The visitation window is

straight ahead, located in a person's line of sight. To the right, just passed a glass-enclosed display case, are the doors to the right lead into the community room and on the left is the entrance into the walk-in clinic and entrance to a public restroom. In the lobby, built-in seating is provided for visitors waiting to tour that station or waiting to enter the clinic or community room.

To quote Daniel Yudchitz from an article he wrote titled *Making Public Facilities More Public,*[86] "At its simplest level, a city provides a service. The better public servants can connect with the people they serve, the better the community will function. Architecture facilitates those connections in many ways – by giving city governments a physical identity, by creating inviting settings for citizens to participate in public life, and by communicating, in ways big and small, the values we live by. The designer's fundamental role is to deliver a functional, efficient facility, but it goes beyond that. Our real challenge is to deliver more value without adding more cost, creating spaces that embrace, and are embraced by, the communities that fund and use them". Bridging the gap between firefighters and the community helps people know who their first responders are. Visibility and engagement are important to remind the community that the fire department is there for them, looking out for the community's health and wellness, without their first interaction involving an emergency.

DESIGN PROPOSAL: ENVIRONMENTALLY RESPONSIBLE DESIGN

A city tells a story that represents community and governmental values which are displayed through their civic buildings. When a fire station is designed to positively affect the environment, that value of caring for the environment is represented. In addition to passive building solutions, using industry standards such as Leadership in Energy and Environmental Design (LEED), Cradle to Cradle Products Innovation Institute (Cradle to Cradle), and the WELL Building Standard (WELL) can help guide any person or public entity planning on renovating or building a new fire station. LEED, Cradle to Cradle, and WELL are rating systems, but the strategies used in their certification requirements can be used to design a sustainable fire station. Using these three standards as design guidelines can be beneficial to both people and the environment.

The LEED v4 system goals include:[87] Reduce contribution to global climate change, enhance individual human health, protect and restore water sources, protect and enhance biodiversity and ecosystem services, promote sustainable and regenerative material cycles, build a green economy, and enhance community quality of life. On the LEED v4 for BD+C: New Construction and Major Renovation, the rating scorecard[88] covers eight different categories: Location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, and regional priority. Included in LEED v4 is use of cradle to cradle certified products, which is a multi-attribute assessment of materials. The Cradle to Cradle Products Innovation Institute sets a global standard through the Cradle to Cradle Products Program. The assessment[89] of products includes the examination of material health, material reutilization, renewable energy, water stewardship and social fairness. The toxicity of chemicals inside a product are examined under the material health category. The use of non-toxic materials is also a concept the WELL Building Standard takes into account under the materials category.[90]

The WELL Building Standard is a good reference for how to design with the health of the building occupants in mind. The WELL Building Standard certification[90] requires on-site assessment and performance testing by a third party . Building performance is measured by having monitoring features of the built environment that impact human health and wellbeing, through air, water, nourishment, light, movement, thermal comfort, sound, materials, mind, and community. Under these

seven categories are a variety of subcategories such as toxic material reduction, thermal comfort, air quality, low-glare workstation design, noise levels, and activity incentive programs, to name a few. The WELL reference guide has a precondition, titled 'Biophillia I – Qualitative,' which incorporates the support of human-nature connections through design elements. Biophilic design[91] emphasizes human adaptations to the natural world, depends on repeated and sustained engagement with nature, and integrates design interventions that connect with the overall setting or space. Biophilic design ecomposses direct experiences of nature (such as light, air, water, plants animals, and natural landscapes and ecosystems), indirect experience of nature (such as images of nature, natural materials, natural colors, naturalistic shapes, forms, and patterns, and biomimicry), and experience of space and place (such as prospect and refuge).[92] Biophilia influences the moment-to-moment physical and sensory elements found within interiors. It impacts our emotions, health, and overall feeling.[93] A successful application of biophilic design can be achieved by employing direct and indirect strategies to help create space and place. Biophilic design is implemented into the proposed fire station's design through the use of large windows and clearstories to allow natural light to flood the interior and create views to nature. In addition to creating views to nature, a firefighter can be immersed in nature on the rooftop garden over the apparatus bay and interact with nature in a small vegetable garden on the outdoor patio. The use of engineered wood floors and interior plants to connect to the natural world. Sick Building Syndrome is a phenomenon where the occupants of a building experience acute health problems that seem to be linked directly to the time spent inside the building where they felt symptoms that may be localized in a particular room, area, or may be widespread throughout the building and there is no specific illness or cause that can be identified.[94] Using biophilic design and having the ability to go outside of the building, while staying close to the station, would help prevent Sick Building Syndrome.

Sustainable building strategies are also used in the proposed fire station's design. Harvesting rainwater, using permeable surface materials, and having a vegetated roof can help reduce rainwater runoff. Water can be saved through the use of greywater. Greywater is defined as[95] untreated wastewater that has not been affected by infectious, contaminated, or unhealthy bodily wastes. The proposed station would use two different greywater systems. One cistern would collect and reuse greywater from water used for training and washing the apparatus. A trench drain system would collect the water runoff, of water used during training, from outside of the building, funneling it to a separate harvest treatment system with a hose bib connection for fire personnel to use for vehicle washing.[96] The second cistern would collect rainwater that falls on non-driving surfaces on the site to reuse for irrigation. Another strategy is to use radiant heat flooring in the apparatus bay, which allows for more efficient heat recovery from the cold air that may enter into the apparatus bay when a bay door opens. Extending the in-floor radiant heat three feet beyond the bay doors is a safety measure that will help melt ice during the winter months. Geothermal wells are located beneath the playground to use for the station's heating and cooling needs. Additional benefits to designing an environmentally responsible fire station are the positive impacts to individuals physical and behavioral health. This mutualistic relationship adds value to the fire department and entire community.

CONCLUSION

In short, the main goal of this thesis is to raise the standards of fire stations design to go beyond meeting building code requirements to improve the physical and behavioral health of firefighters and their communities. Firefighter physical health can be improved by creating a linear sequence of circulation, particularly concerning the continued decontamination process, to mitigate the spread of toxins throughout the building. To improve firefighters behavioral health, the programmatic addition of a calm room reiterates the need for

firefighters to decompress. Learning from other building types can help re-imagine how spaces, such as the lobby and watch room, can be designed. The design of fire stations should go beyond concern for firefighters health and wellness. Improving the community's physical and behavioral health should be a key factor in fire station design. As a public safety facility, health and wellness concerns should extend beyond the firefighters and include members of the community. Providing opportunities for the community to improve their physical and behavioral health at the fire station aligns community and departmental values. The alignment of values includes environmental concerns. To build an environmentally responsible fire station, using building standards such as LEED, WELL, and Passive House, can help guide any person or public entity planning on renovating or building a new fire station. Whether it is a fire station or a relationship, it is critical to build on a strong foundation. A building does not leave its users, or the environment, unaffected. It either has a negative, neutral or positive impact. Positively impacting individuals, and the environment, can be achieved by applying the design strategies laid out in this thesis.

BIBLIOGRAPHY

[1] Evarts, Ben, and Gary P. Stein. "US Fire Department Profile 2018." *Research*, National Fire Protection Association (NFPA), Feb. 2020, https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/osfdprofile.pdf

[2] "Taking Action Against Occupational Cancer." *International Association of Fire Fighters*, International Association of Fire Fighters, 27 Mar. 2019, https://www.iaff.org/news/taking-action-against-occupational-cancer/

[3] Shaffer, Ryan. "Cancer Leading Cause of Death in Firefighters." *Worksite Medical*, 11 Jan.2019, https://www.worksitemed.com/firefighter-cancer/

[4] NFPA 1500™: Standard on Fire Department Occupational Safety, Health, and Wellness Program, 2021 Edition. Chapter 12, Section 12.1.1 and Section 12.2.3.4. In *NFPA National Fire Codes & Standards Online*. Retrieved from https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1500

[5] Stulberger, Evan, et al. "I-Team: National Data Shows Firefighters' Mental, Emotional Health Not Getting Enough Attention." *NBC New York*, NBC New York, 19 Mar. 2018, https://www.nbcnewyork.com/news/local/firefighters-mental-health-survey-ptsd/1809926/

[6] Wieder, Michael A., editor. U.S. Fire Administration (USFA), 2018, *Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations*, https://www.usfa.fema.gov/downloads/pdf/publications/design_of_fire_ems_stations.pdf.

[7] Ibid.

[8] *Exposure to Carcinogens*, International Association of Fire Fighters. https://www.iaff.org/wp-content/uploads/FFCancer_Exposure.pdf

[9] Wieder, Michael A., editor. U.S. Fire Administration (USFA), 2018, *Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations*, https://www.usfa.fema.gov/downloads/pdf/publications/design_of_fire_ems_stations.pdf.

[10] Merriam-Webster.com Dictionary, s.v. "carcinogen," accessed March 12, 2020, https://www.merriam-webster.com/dictionary/carcinogen

[11] Magnusson, Stefan, and David Hultman. Healthy Firefighters – the Skellefteå Model Improves the Work Environment. Swedish Civil Contingencies Agency (MSB), 2014, The Swedish Civil Contingencies Agency (MSB), <https://www.msb.se/siteassets/dokument/publikationer/english-publications/healthy-firefighters-the-skelleftea-model-improves-the-work-environment.pdf>.

[12] Ibid.

[13] Counts, Catherine R. "Sleep Disruption, Shift Work Threatens Firefighter Health." FireRescue1, 6 Feb. 2017, https://www.firerescue1.com/health/articles/sleep-disruption-shift-work-threatens-firefighter-health- O6URPLAtX6sT6vwe/

[14] Ibid.

[15] Aronson, K.J., Dodds, L.A., Marrett, L. and Wall, C. (1996), Congenital anomalies among the offspring of fire fighters. Am. J. Ind. Med., 30: 83-86. https://doi.org/10.1002/(SICI)1097-0274(199607)30:1<83::AID-AJIM14>3.0.CO;2-4

[16] Mari, M. A., Cascudo, M. M., & Alchieri, J. C. (2016). Congenital Heart Disease and Impacts on Child Development. *Brazilian journal of cardiovascular surgery*, *31*(1), 31–37. https://doi.org/10.5935/1678-9741.20160001

[17] Magnusson, Stefan, and David Hultman. Healthy Firefighters – the Skellefteå Model Improves the Work Environment. Swedish Civil Contingencies Agency (MSB), 2014, The Swedish Civil Contingencies Agency (MSB), <https://www.msb.se/siteassets/dokument/publikationer/english-publications/healthy-firefighters-the-skelleftea-model-improves-the-work-environment.pdf>.

[18] Jahnke, S A. (2016). *Firefighting and mental health: experiences of repeated exposure to trauma*. Work: Vol 53 (4) February 2016. doi:10.3233/WOR-162255

[19] Corneil, W., Beaton, R., Murphy, S., Johnson, C., & Pike, K. (1999). Exposure to traumatic incidents and prevalence of posttraumatic stress symptomatology in urban firefighters in two countries. *Journal of Occupational Health Psychology, 4*(2), 131–141. https://doi.org/10.1037/1076-8998.4.2.131.

[20] IAFF Staff. "Silent Suffering: Firefighting and Depression." *IAFFRecoveryCenter.com*, IAFF Center of Excellence for Behavioral Health Treatment and Recovery, 31 May 2017, www.iaffrecoverycenter.com/blog/silent-suffering-firefighting-depression/#:~:text=The%20first%20step%20is%20often,at%20taking%20care%20of%20ourselves.%E2%80%9D.

[21] "Fourth Needs Assessment of the U.S. Fire Service." National Fire Protection Association (NFPA), Nov. 2016. https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/Needs-Assessment/OSFourthNeedsAssessment.ashx

[22] Jahnke, S A. (2016). *Firefighting and mental health: experiences of repeated exposure to trauma*. Work: Vol 53 (4) February 2016. doi:10.3233/WOR-162255

[23] Ibid.

[24] Berard,Yamil. "New Shift Schedule Triggers Backlash at Ga. EMS." EMS1, 17 Jan. 2020, https://www.ems1.com/labor-issues/articles/new-shift-schedule-triggers-backlash-at-ga-ems-wvDSya6Uz5PpD4Dc/

[25] Barger LK, Rajaratnam SM, Wang W, O'Brien CS, Sullivan JP, Qadri S, Lockley SW, Czeisler CA, Harvard Work Hours, Health and Safety Group. Common sleep disorders increase risk of motor vehicle crashes and adverse health outcomes in firefighters. *J Clin Sleep Med* 2015;11(3):233–240. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4346644/.

[26] "Fourth Needs Assessment of the U.S. Fire Service." National Fire Protection Association (NFPA), Nov. 2016. https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/Needs-Assessment/OSFourthNeedsAssessment.ashx

[27] Friese, Greg. "Editor's Note." *HOW TO BUILD A FIRE STATION*, 2017, p. 3. https://publications.firerescue1.com/2017/Fire-Chief-Digital-Edition-Summer-2017.pdf.

[28] Rogers, Kara. "Biophilia Hypothesis." *Encyclopedia Britannica Online*. Encyclopedia Britannica, 26 May 2016. Web. 10 Oct. 2016. https://www.britannica.com/science/biophilia-hypothesis

[29] Van der Feyst, Mark. "Firefighter Basics: Calling the Mayday." *Fire Engineering*, Fire Engineering, 30 Nov. 2020, www.fireengineering.com/firefighter-training/firefighter-basics-calling-the-mayday/#gref.

[30] Taft, Gregory. "Remembering Our Fallen (Mark Langvardt)." *Denver Fire Online*, Denver Fire Department, 26 Sept. 2014, denverfireonline.com/remembering-fallen/#:~:text=The%20only%20window%2C%20was%2020,trapped%20and%20low%20on%20air.

[31] Firefighter Nation Content Directors. "Back-to-Basics Truck Training." *Firefighter Nation*, Firefighter Nation, 23 May 2012, www.firefighternation.com/firerescue/back-to-basics-truck-training/#gref.

[32] "NFPA 1410, Standard on Training for Initial Emergency Scene Operations." *NFPA Catalog*, National Fire Protection Association (NFPA),catalog.nfpa.org/NFPA-1410-Standard-on-Training-for-Initial-Emergency-Scene-Operations-P1428.aspx#:~:text=2015%20NFPA%201410.-,NFPA%201410%2C%20Standard%20on%20Training%20for%20Initial%20Emergency%20Scene%20Operations,using%20available%20personnel%20and%20equipment.

[33] *International Code Council. (2000). International building code. Falls Church, Va. :International Code Council.*

[34] "Highlights of ICC 500-2014, ICC/NSSA Standard for the Design and Construction of Storm Shelters." FEMA Building Science Branch, Sept. 2015.

[35] Magnusson, Stefan, and David Hultman. Healthy Firefighters – the Skellefteå Model Improves the Work Environment. Swedish Civil Contingencies Agency (MSB), 2014, The Swedish Civil Contingencies Agency (MSB), <https://www.msb.se/siteassets/dokument/publikationer/english-publications/healthy-firefighters-the-skelleftea-model-improves-the-work-environment.pdf>.

[36] Maunz, Shay. "Health Care Centers Take a Smarter, Greener Approach to Healing." *Green Building & Design*, 2018, pp. 44–45.

[37] Ibid.

[38] Raskin, Laura. "How Maggie's Centres Help Cancer Patients Find Strength from Within." *Metropolis*, Metropolis, 15 Oct. 2019, www.metropolismag.com/interiors/healthcare-interiors/maggies-centres/.

[39] Daryl Martin, Sarah Nettleton, Christina Buse, Affecting care: Maggie's Centres and the orchestration of architectural atmospheres, Social Science & Medicine, Volume 240, 2019, 112563, ISSN 0277-9536, <https://doi.org/10.1016/j.socscimed.2019.112563>.

[40] Annemans, Margo & Audenhove, Chantal & Vermolen, Hilde & Heylighen, Ann. (2012). What makes an environment healing? Users and designer about the Maggie's Cancer Caring Centre London. https://www.researchgate.net/publication/237044596_What_makes_an_environment_healing_Users_and_designer_about_the_Maggie's_Cancer_Caring_Centre_London

[41] Ibid.

[42] Ibid.

[43] *Park, B. J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., & Miyazaki, Y. (2010). The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. Environmental health and preventive medicine, 15(1), 18–26. https://doi.org/10.1007/s12199-009-0086-9*

[44] Erickson, Paul. "HOT ZONE Design: Contain the Contaminants." *FIREHOUSE SUPPLEMENT: STATION DESIGN*, Aug. 2014, pp. 4–8. <https://cdn.officer.com/files/base/FHC/document/2016/11/StationDesign-Aug2014.pdf>.

[45] "About the U.S. Fire Administration." *U.S. Fire Administration*, U.S. Fire Administration, 14 Apr. 2021, www.usfa.fema.gov/about/.

[46] NFPA 1500™: Standard on Fire Department Occupational Safety, Health, and Wellness Program, 2021 Edition. Chapter 12, Section 12.1.1 and Section 12.2.3.4. In *NFPA National Fire Codes & Standards Online*. Retrieved from https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1500

[47] McCall, Katie. "Zones Diagram." Digital graphic, 2020.

[48] Wieder, Michael A., editor. U.S. Fire Administration (USFA), 2018, *Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations*, https://www.usfa.fema.gov/downloads/pdf/publications/design_of_fire_ems_stations.pdf.

[49] Wieder, Michael A., editor. U.S. Fire Administration (USFA), 2018, *Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations*, https://www.usfa.fema.gov/downloads/pdf/publications/design_of_fire_ems_stations.pdf.

[50] Krzyzanowski, Robert. "A Case Study in Decontamination." Firehouse, Endeavor Business Media, LLC., 1 May 2019, https://www.firehouse.com/stations/building-components/cleaning-laundry/article/21071984/a-case-study-in-fire-station-decontamination

[51] McCall, Katie. "Diagram over Salt Lake City Fire Station 14 First Floor." Digital graphic, 2020.

[52] "Salt Lake City Fire Station 14." TCA Architecture, <www.tca-inc.com/salt-lake-city-fire-station-14

[53] Aman, Eric. "Fire Station 20, Seattle." *HPB Magazine*, ASHRAE.org, 5 Dec. 2017, https://www.hpbmagazine.org/fire-station-20-seattle/.

[54] Mithun & McCall, Katie. "Diagram Over Fire Station 20 First Floor Plan." Digital graphic, 2020.

[55] "Fire Station 51." *Swenson Say Fagét*, Swenson Say Fagét, 14 Sept. 2020, https://ssfengineers.com/fire-station-51/.

[56] "Public Safety Plan." *City of Tukwila*, 10 Nov. 2020, www.tukwilawa.gov/departments/mayors-office/key-city-plans-and-projects/public-safety-plan/.

[57] "Fire Station Doors." *Clear Fold - Opening Doors to New Solutions*, Clear Fold Door Inc., https://www.clearfold.com/portfolio/fire-station-doors/

[58] Diagram by Katie McCall. Floor plan provided by the City of Tukwila at www.tukwilawa.gov/departments/mayors-office/key-city-plans-and-projects/public-safety-plan/.

[59] McCall Sharp Architecture, LTD. & McCall, Katie. "Diagram over Salt Lake City Fire Station 14 First Floor." Digital graphic, 2020.

[60] McCall, Katie. "Needs Assessment Diagram for Oxford Fire Department Station 11." Digital graphic, 2020.

[61] McCall, Katie. "Response Time Map." Digital graphic, 2020.

[62] McCall, Katie. "Location Analysis Map." Digital graphic, 2020.

[63] "NFPA 1710." *National Fire Protection Association*, National Fire Protection Association (NFPA), www.nfpa.org/Codes-and-Standards/ARCHIVED/Safer-Act-Grant/NFPA-1710.

[64] Richardson, David. "Evaluating Fire Station Locations." *Emergency Reporting*, Emergency Reporting, 15 June 2020, https://emergencyreporting.com/blog/evaluating-fire-station-locations/.

[65] ACP Visioning+Planning Development Economics. "Comprehensive Plan." City of Oxford, Ohio, 4 Nov. 2008.

[66] McCall, Katie. "New Masterplan for the City of Oxford." Digital graphic, 2021.

[67] McCall, Katie. "Buildings Surrounding Site." Digital graphic, 2021.

[68] Wieder, Michael A., editor. U.S. Fire Administration (USFA), 2018, *Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations*,

https://www.usfa.fema.gov/downloads/pdf/publications/design_of_fire_ems_stations.pdf.

[69] "Taking Action Against Cancer in the Fire Service." Firefighter Cancer Support Network (FCSN), Aug. 2013. https://mfsi.me.edu/wp-content/uploads/2018/11/Taking-Action-Against-Cancer-In-The-Fire-Service.pdf

[70] Wieder, Michael A., editor. U.S. Fire Administration (USFA), 2018, *Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations*, https://www.usfa.fema.gov/downloads/pdf/publications/design_of_fire_ems_stations.pdf.

[71] Matthews, Peter. "Station Design: Integrating NFPA Standards into Your Fire Station." *Firehouse*, Firehouse, 26 June 2018, www.firehouse.com/stations/architects/news/21011092/station-design-integrating-nfpa-standards-into-your-fire-station.

[72] Newcomb, Tim. "Sorry, Kids. Fire Stations Are Ditching Fire Poles." *TIME.com*, Time Inc., 23 Dec. 2010, https://web.archive.org/web/20101225031330/http://www.time.com/time/nation/article/0,8599,2039352,00.html

[73] Krzyzanowski, Robert. "A Case Study in Decontamination." Firehouse, Endeavor Business Media, LLC., 1 May 2019, https://www.firehouse.com/stations/building-components/cleaning-laundry/article/21071984/a-case-study-in-fire-station-decontamination

[74] McCall, Katie. "Sequence of Circulation when Heading to and Returning From a Call." Digital graphic, 2020.

[75] Fenton, Crystal. "3 Lessons I've Learned Teaching Yoga to NYC Firefighters." *Yoga Journal*, 21 Aug. 2018, https://www.yogajournal.com/practice-section/yoga-poses-for-firefighters/.

[76] Ibid.

[77] Carter, Craig. "Better Sleep at the Station." *FIREHOUSE*, Endeavor Business Media, LLC, 1 May 2018, https://www.firehouse.com/stations/article/20994413/better-sleep-at-the-fire-station.

[78] Erickson, Paul. "Fire Station Design: Better Sleep for Behavioral Health." *FIREHOUSE / 2020 Fire Service Health & Safety Report*, 1 Sept. 2020, https://cdn.firehouse.com/files/base/cygnus/fhc/document/2020/08/NFFF_2020_Health_and_Safety.5f49c3c7c7a9d.pdf.

[79] Sullivan, J. P., O'Brien, C. S., Barger, L. K., Rajaratnam, S. M., Czeisler, C. A., Lockley, S. W., & Harvard Work Hours, Health and Safety Group (2017). Randomized, Prospective Study of the Impact of a Sleep Health Program on Firefighter Injury and Disability. *Sleep*, *40*(1), zsw001. <https://doi.org/10.1093/sleep/zsw001>..

[80] Ibid.

[81] Yudchitz, David. "Making Public Facilities More Public." *Leo A Daly*, Leo A Daly, 6 Nov. 2019, https://leoadaly.com/perspectives/making-public-facilities-more-public/.

[82] "Safe-Haven Law." *Wikipedia*, Wikimedia Foundation, 9 Feb. 2021, https://en..wikipedia.org/wiki/Safe-haven_law.

[83] *Safe Haven Baby Boxes*, Safe Haven Baby Boxes, https://shbb.org

[84] Ibid.

[85] "Dr. William S. Alexander House." *Wikipedia*, Wikimedia Foundation, 29 Mar. 2021, https://en.wikipedia.org/wiki/Dr._William_S._Alexander_House

[86] Yudchitz, David. "Making Public Facilities More Public." *Leo A Daly*, Leo A Daly, 6 Nov. 2019, https://leoadaly.com/perspectives/making-public-facilities-more-public/

[87] Horwitz-Bennett, Barbara. "LEED: The Next Generation." *Continuing Education Center*, BNP Media / ClimateMaster, Inc., https://continuingeducation.bnpmedia.com/courses/climatemaster-inc/leed-the-next-generation/

[88] "Checklist: LEED v4 for Building Design and Construction." *U.S. Green Building Council*, U.S. Green Building Council, 5 Apr. 2016, https://www.usgbc.org/resources/checklist-leed-v4-building-design-and-construction.

[89] "What Is Cradle to Cradle Certified®? ." *Cradle to Cradle Products Innovation Institute*, Cradle to Cradle Products Innovation Institute, https://www.c2ccertified.org/get-certified/product-certification.

[90] "WELL v2: The next Version of the WELL Building Standard." International WELL Building Institute, Pcb., 2020.

[91] Kellert, Stephen R. "What Is and Is Not Biophilic Design?" *Metropolis*, Metropolis, 26 Oct. 2015, https://www.metropolismag.com/architecture/what-is-and-is-not-biophilic-design/

[92] Ibid.

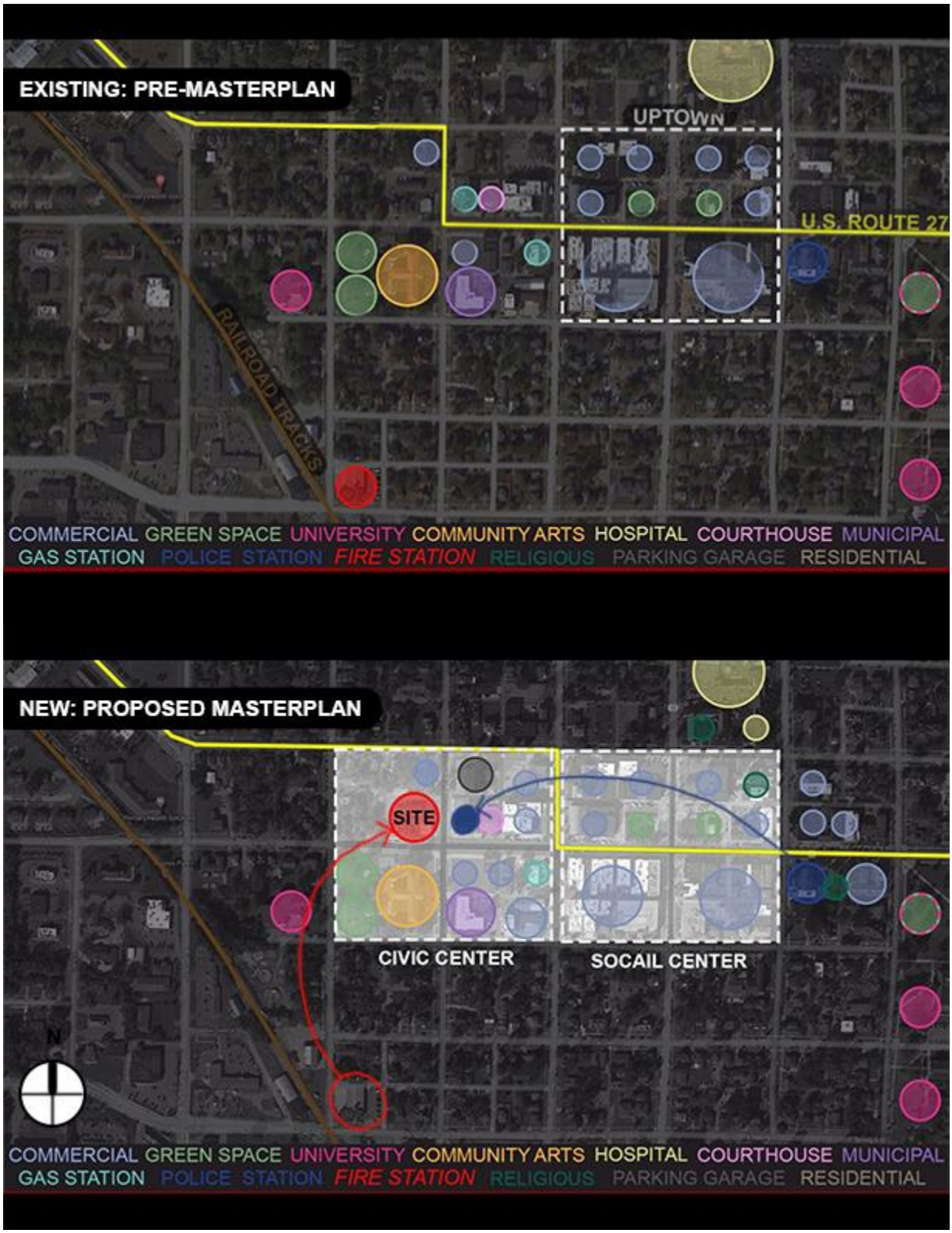
[93] Baldwin, Eric. "Biophilia: Bringing Nature into Interior Design." *ArchDaily*, ArchDaily, 1 Sept. 2020,https://www.archdaily.com/935258/biophilia-bringing-nature-into-interior-design?ad_source=search&ad_medium=search_result_all.

[94] Rogers Fire Department. "Minimum Company Standards: Denver Drill." *The City of Rogers*. July 2014. https://www.rogersar.gov/DocumentCenter/View/20358/Standardized-Skill-Denver-Drill?bidId=

[95] City of San Diego Development Services Department. "Specifications for Gray Water Systems." City of San Diego, Sept. 2018. https://www.sandiego.gov/sites/default/files/gray_water_systems.pdf

[96] Fox, Andrea. "4 Uses for Municipal Reclaimed Water (Greywater)." *Gov1 By Lexipol*, Lexipol, 3 Aug. 2018, https://www.gov1.com/public-safety/articles/4-uses-for-municipal-reclaimed-water-greywater-cXV91s8eJpx1JZI3/

APPENDIX: DESIGN WORK



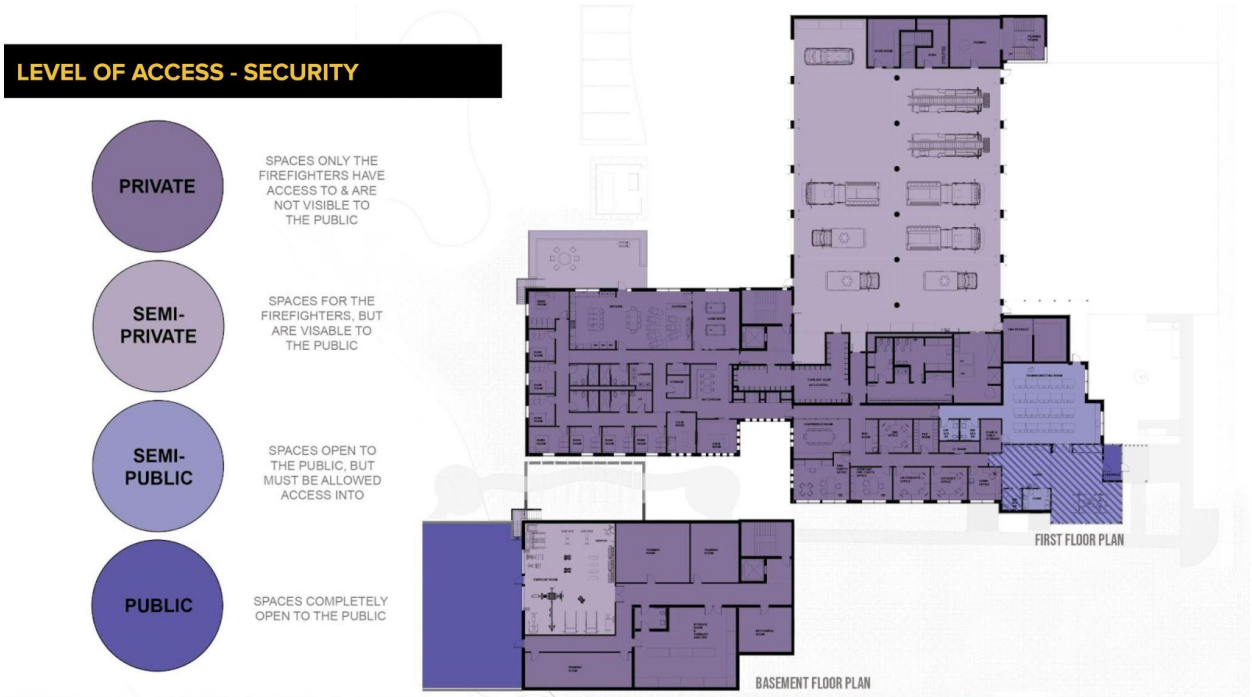
SITE ANALYSIS

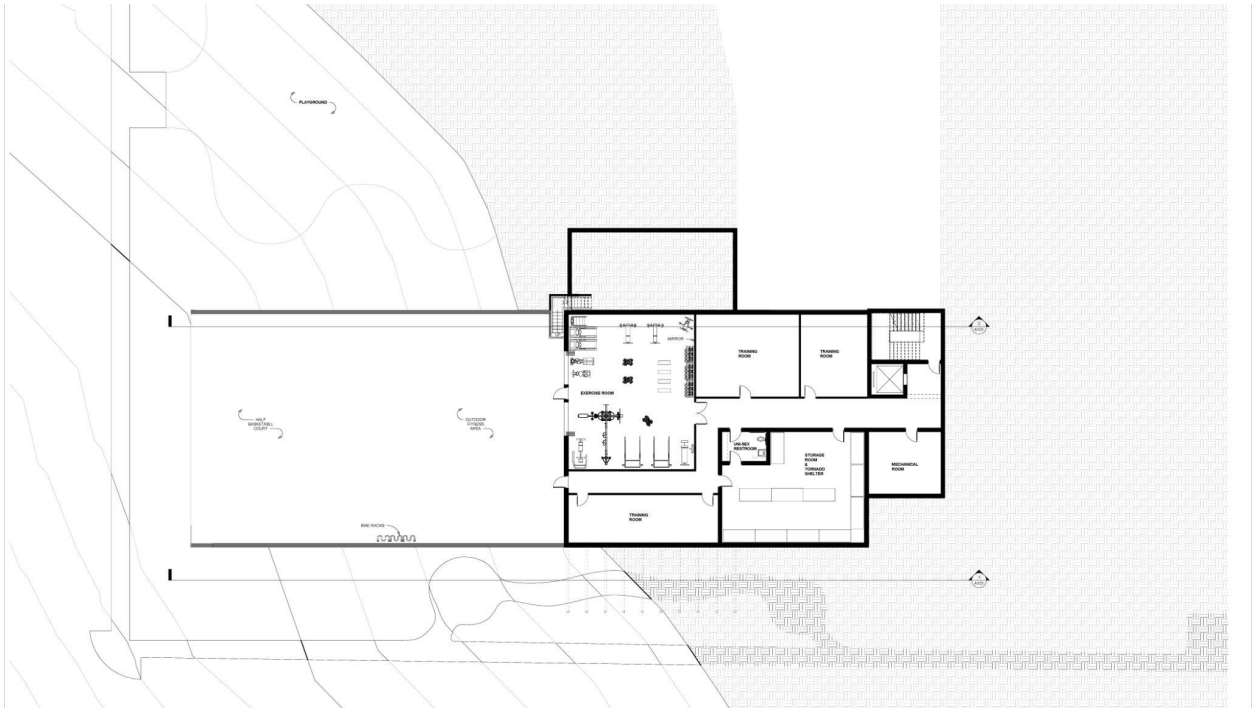
SITE ANALYSIS

SITE PLAN

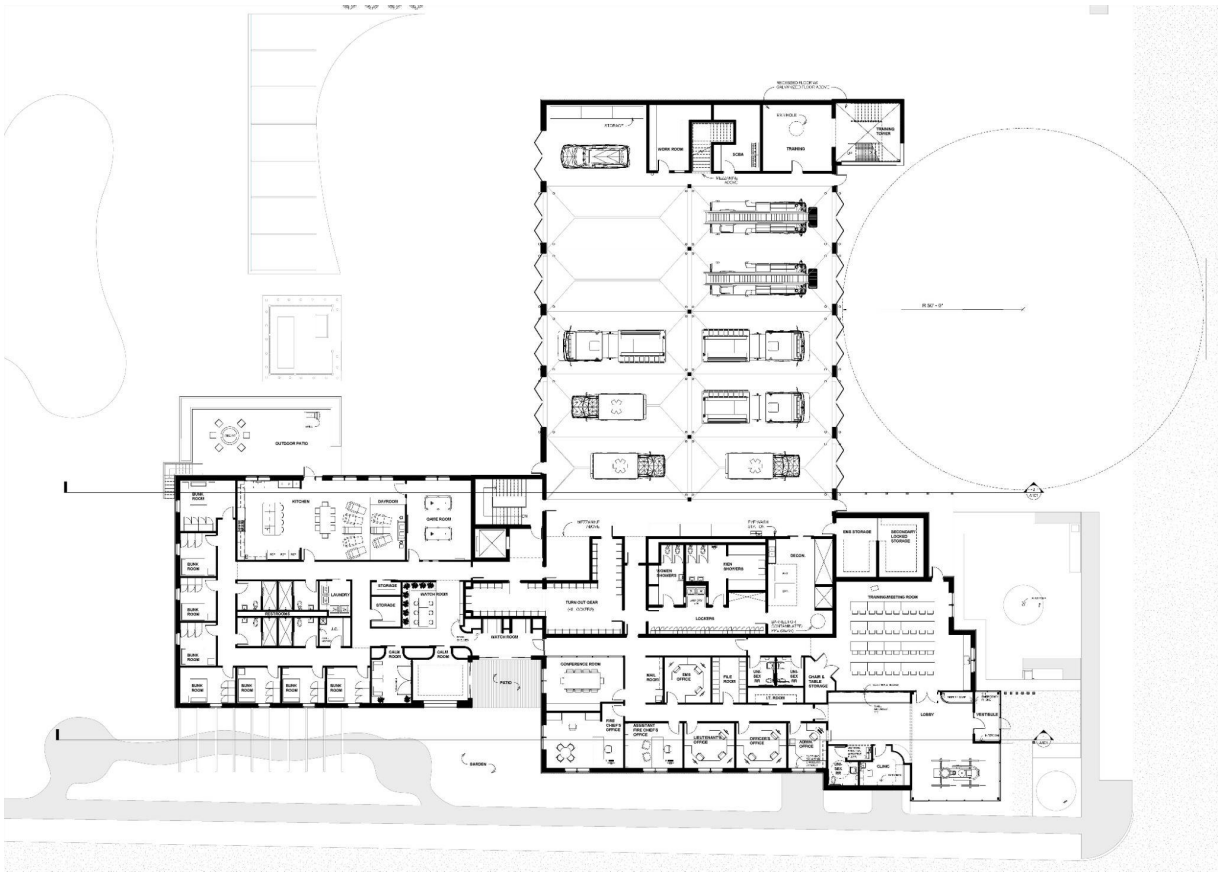
STATION BREAKDOWN INTO THREE PARTS

STATION BREAKDOWN + WATCH ROOM TRANSITION ZONE HIGHLIGHTED



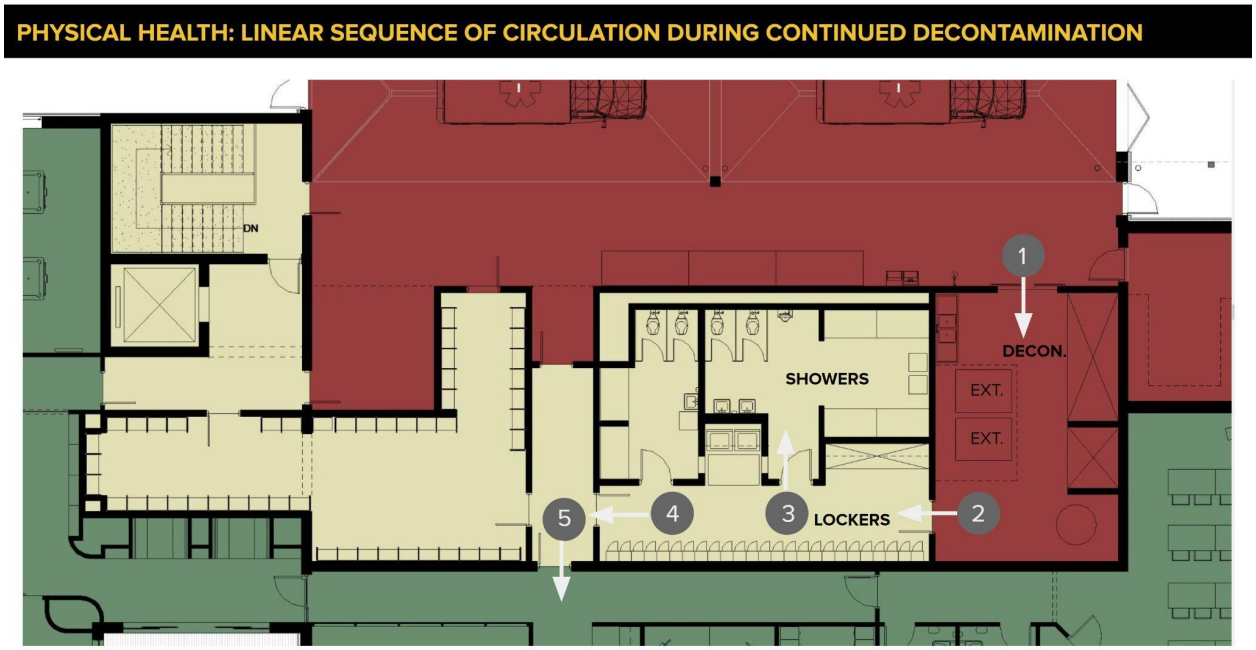


BASEMENT FLOOR PLAN



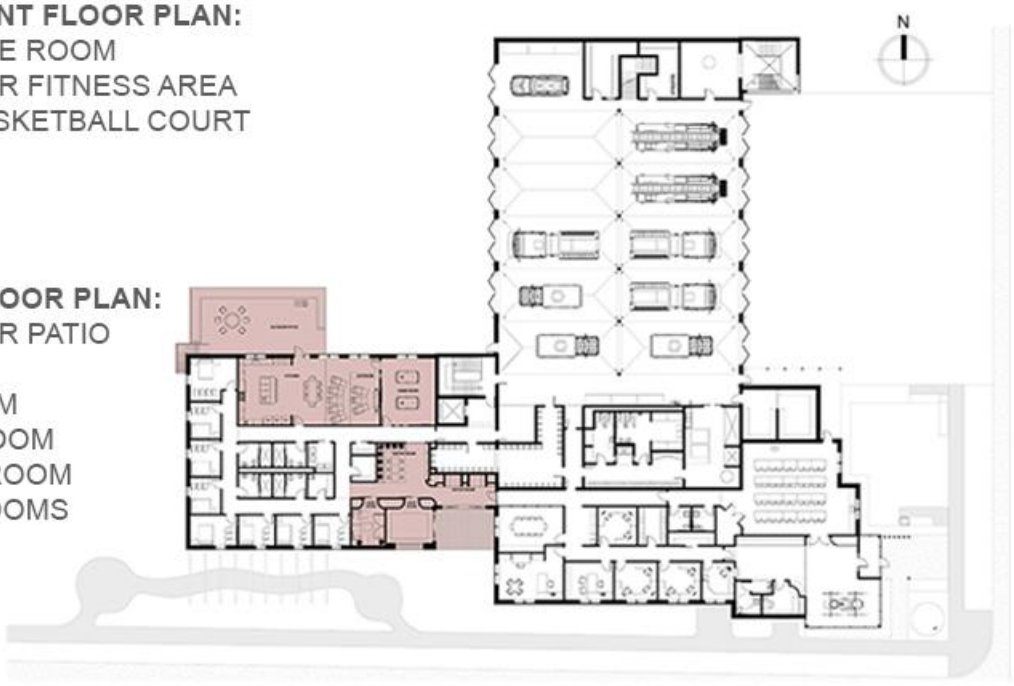
FIRST FLOOR PLAN

HOT ZONE DESIGN

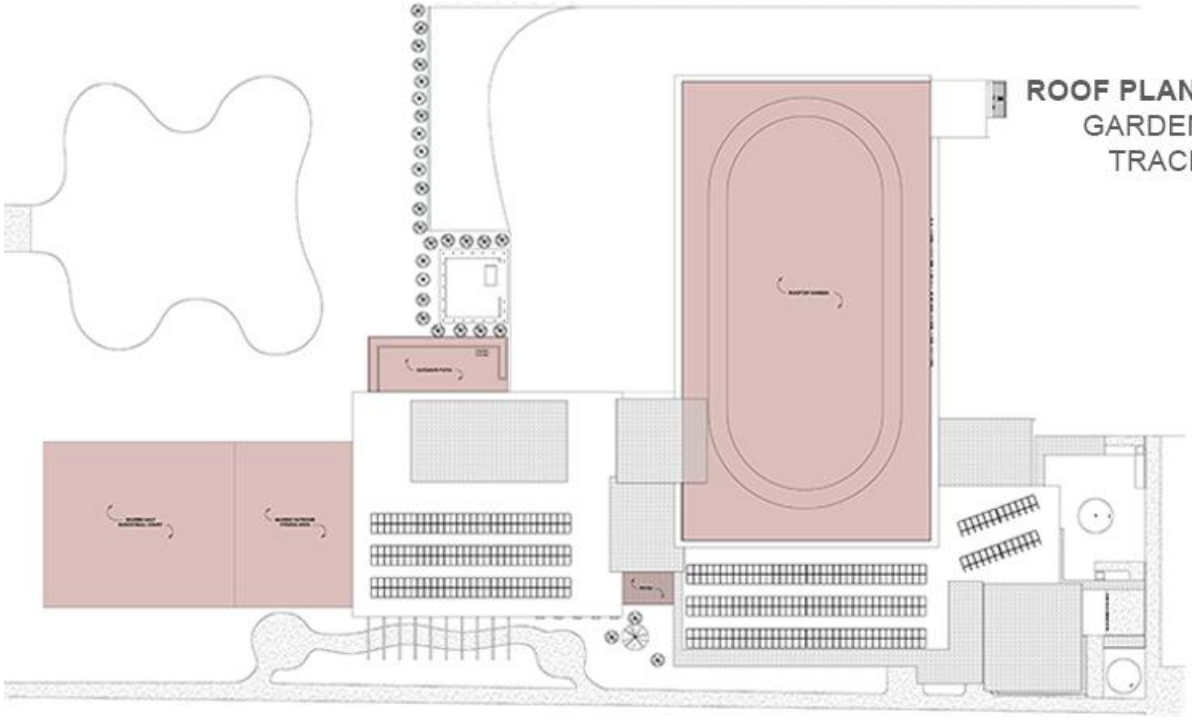


SPACES FOR DECOMPRESSION & GROWING FIREFIGHTER CAMARADERIE

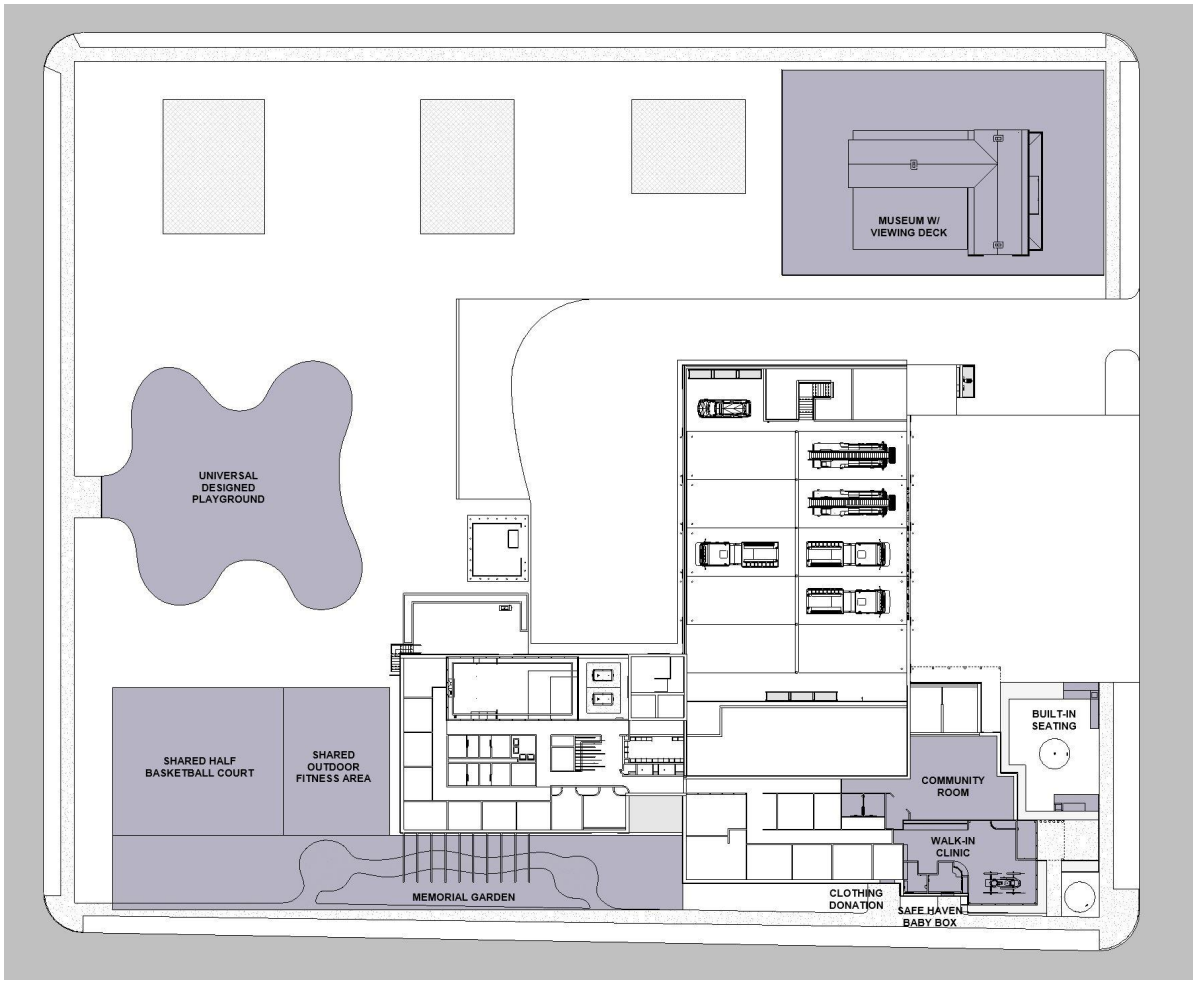
BASEMENT FLOOR PLAN:
EXERCISE ROOM
OUTDOOR FITNESS AREA
HALF BASKETBALL COURT



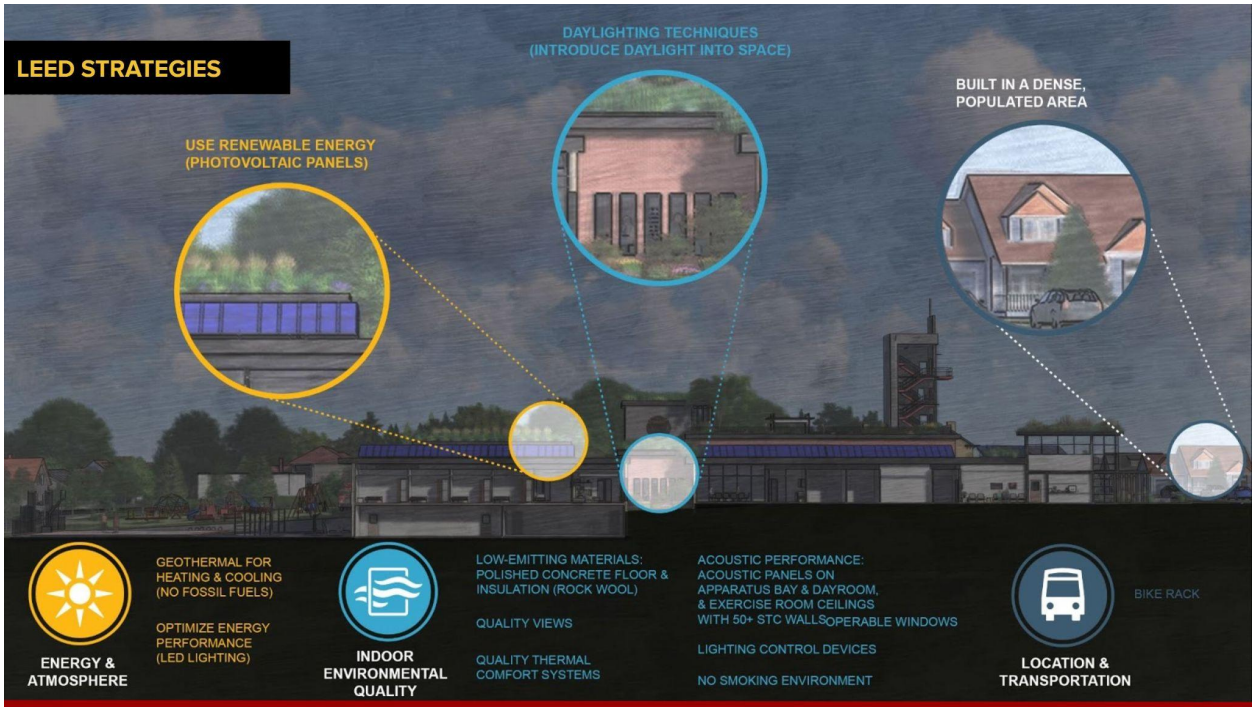
FIRST FLOOR PLAN:
OUTDOOR PATIO
KITCHEN
DAYROOM
GAME ROOM
WATCH ROOM
CALM ROOMS

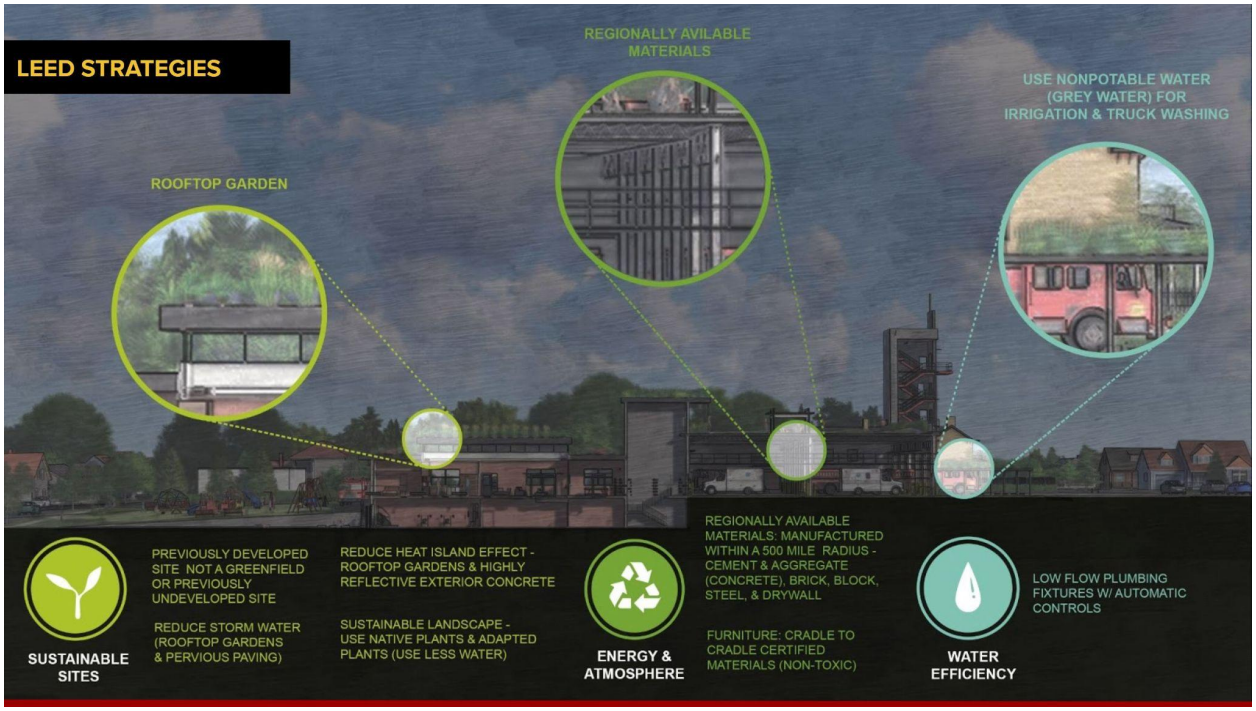


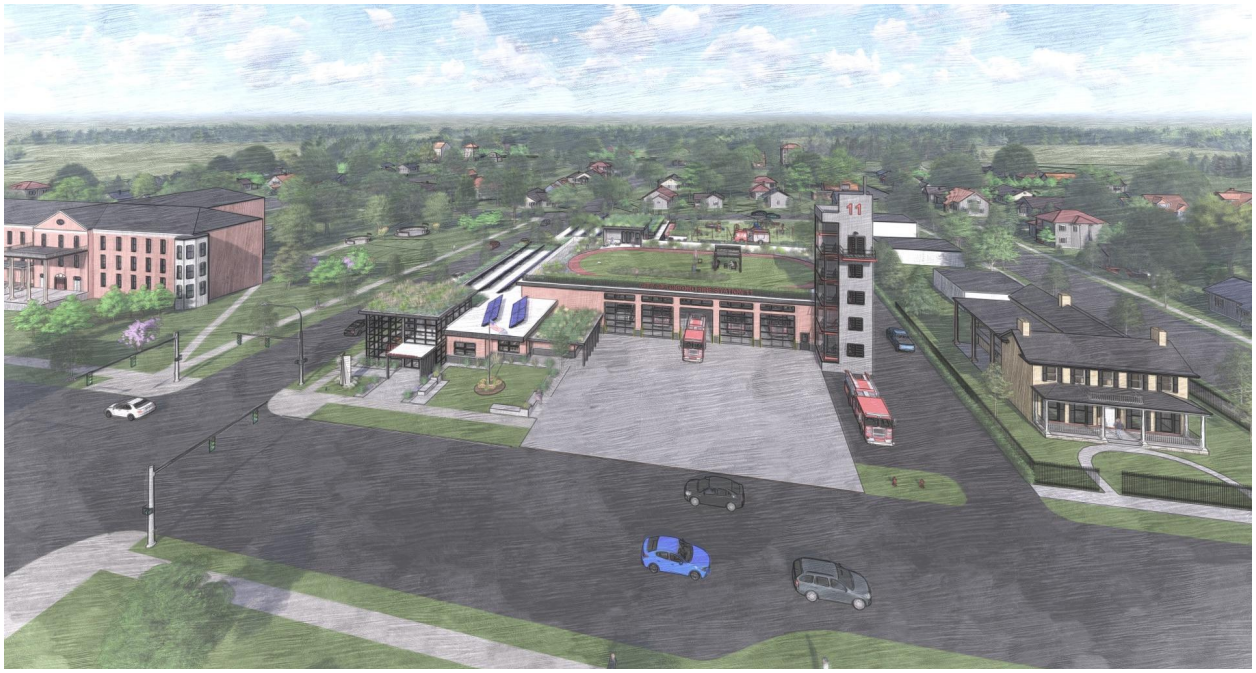
ROOF PLAN:
GARDEN
TRACK



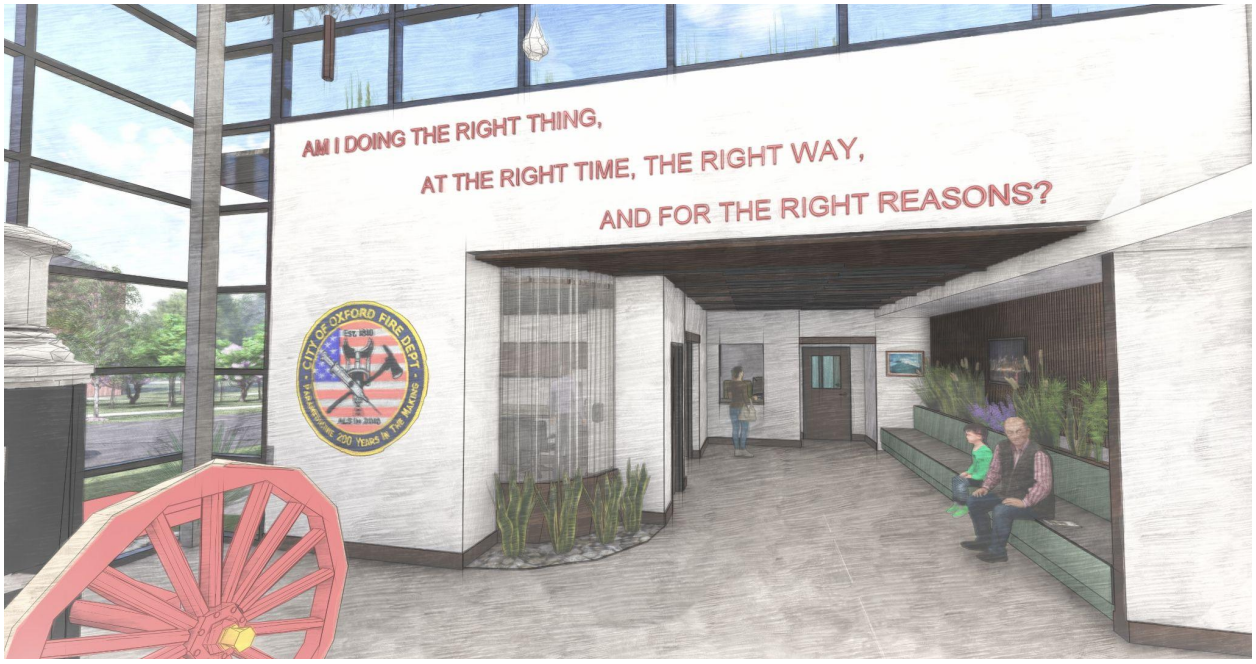
Community Health & Wellness


LEED STRATEGIES
DAYLIGHTING TECHNIQUES (INTRODUCE DAYLIGHT INTO SPACE)
USE RENEWABLE ENERGY (PHOTOVOLTAIC PANELS)
BUILT IN A DENSE, POPULATED AREA
GEOTHERMAL FOR HEATING & COOLING (NO FOSSIL FUELS)
OPTIMIZE ENERGY PERFORMANCE (LED LIGHTING)
ENERGY & ATMOSPHERE
LOW-EMITTING MATERIALS: POLISHED CONCRETE FLOOR & INSULATION (ROCK WOOL)
QUALITY VIEWS
QUALITY THERMAL COMFORT SYSTEMS
INDOOR ENVIRONMENTAL QUALITY
ACOUSTIC PERFORMANCE: ACOUSTIC PANELS ON APPARATUS BAY & DAYROOM, & EXERCISE ROOM CEILINGS WITH 50+ STC WALLS
OPERABLE WINDOWS
LIGHTING CONTROL DEVICES
NO SMOKING ENVIRONMENT
BIKE RACK
LOCATION & TRANSPORTATION


LEED STRATEGIES
REGIONALLY AVILABLE MATERIALS
USE NONPOTABLE WATER (GREY WATER) FOR IRRIGATION & TRUCK WASHING
ROOFTOP GARDEN
PREVIOUSLY DEVELOPED SITE NOT A GREENFIELD OR PREVIOUSLY UNDEVELOPED SITE
REDUCE STORM WATER (ROOFTOP GARDENS & PERVIOUS PAVING)
SUSTAINABLE SITES
REDUCE HEAT ISLAND EFFECT - ROOFTOP GARDENS & HIGHLY REFLECTIVE EXTERIOR CONCRETE
SUSTAINABLE LANDSCAPE - USE NATIVE PLANTS & ADAPTED PLANTS (USE LESS WATER)
REGIONALLY AVAILABLE MATERIALS: MANUFACTURED WITHIN A 500 MILE RADIUS - CEMENT & AGGREGATE (CONCRETE), BRICK, BLOCK, STEEL, & DRYWALL
FURNITURE: CRADLE TO CRADLE CERTIFIED MATERIALS (NON-TOXIC)
ENERGY & ATMOSPHERE
LOW FLOW PLUMBING FIXTURES W/ AUTOMATIC CONTROLS
WATER EFFICIENCY


11


11



PUBLIC LOBBY

PUBLIC LOBBY

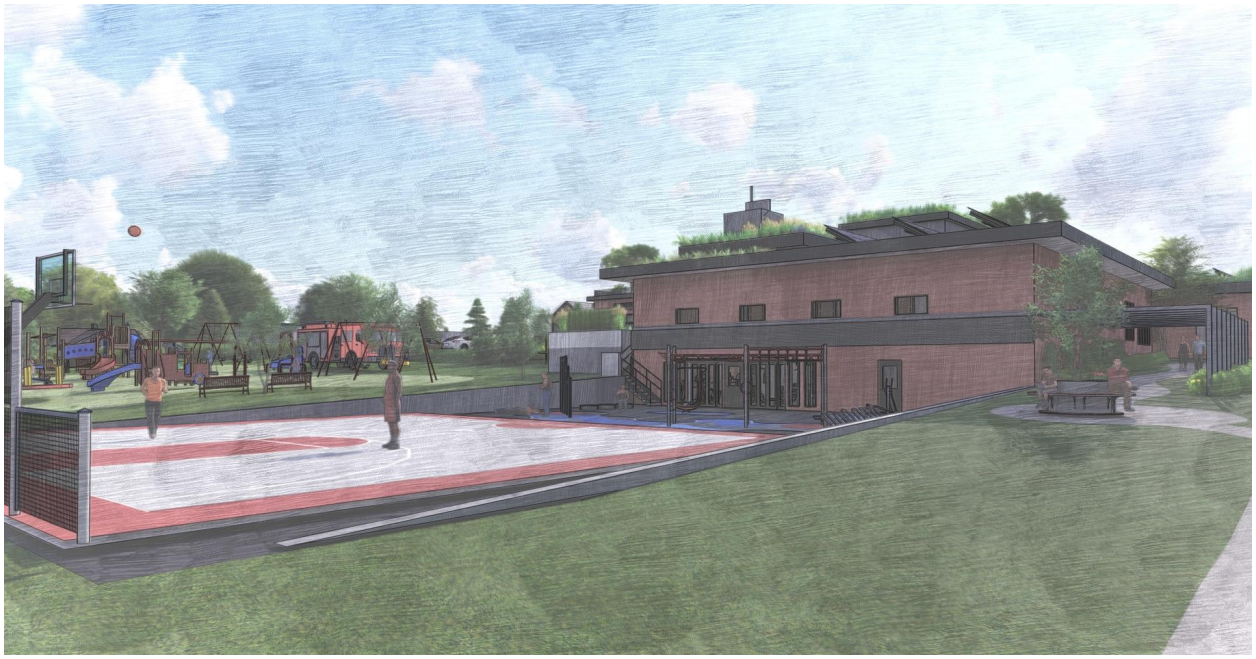
WAITING AREA IN PUBLIC LOBBY

TRAINING/COMMUNITY ROOM

VIEWING AREA FROM BUILT-IN SEATING

VIEWING AREA FROM THE MUSEUM'S DECK

MEMORIAL GARDEN & VIEW TO OUTDOOR PATIO
(SHOWING THAT THERE IS SOME PRIVACY)



HALF BASKETBALL COURT & MEMORIAL GARDEN

OUTDOOR FITNESS AREA

PLAYGROUND

EXTERIOR VIEW

OUTDOOR PATIO

KITCHEN

DAYROOM

GAME ROOM

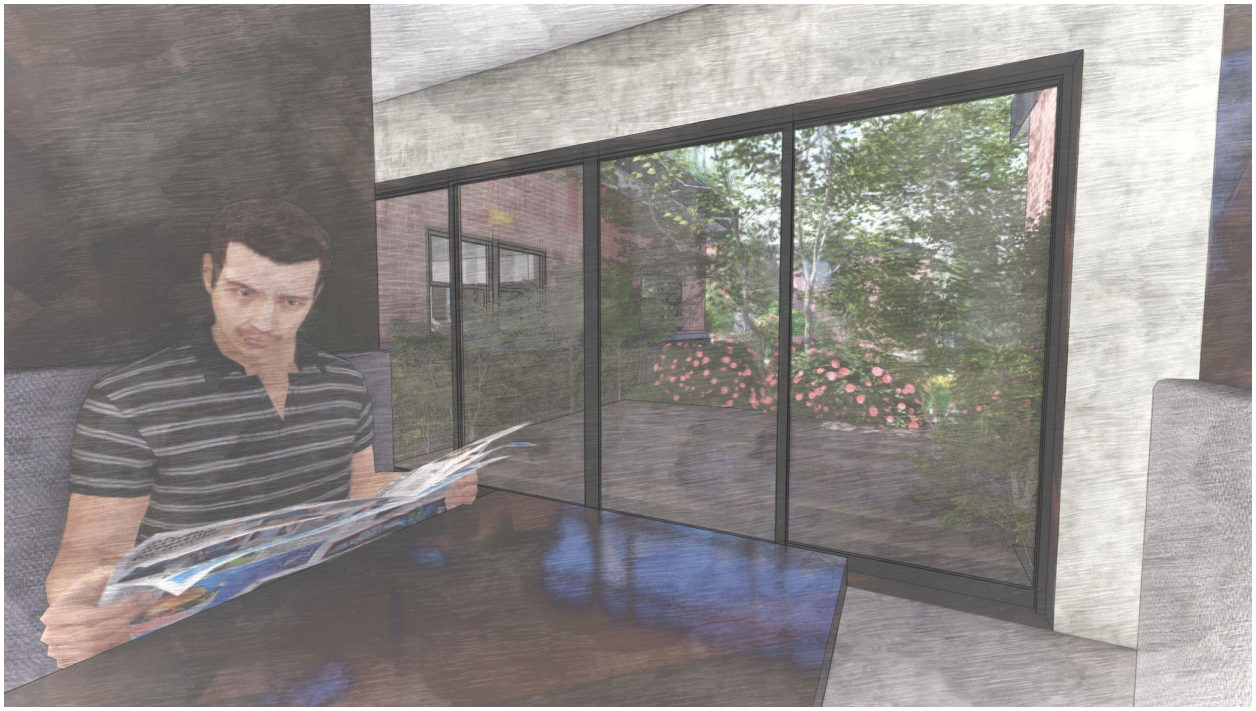
GAME ROOM

WATCH ROOM - BAR TOP SEATING

WATCH ROOM - BAR TOP SEATING

WATCH ROOM - BAR TOP SEATING

WATCH ROOM - BOOTH SEATING



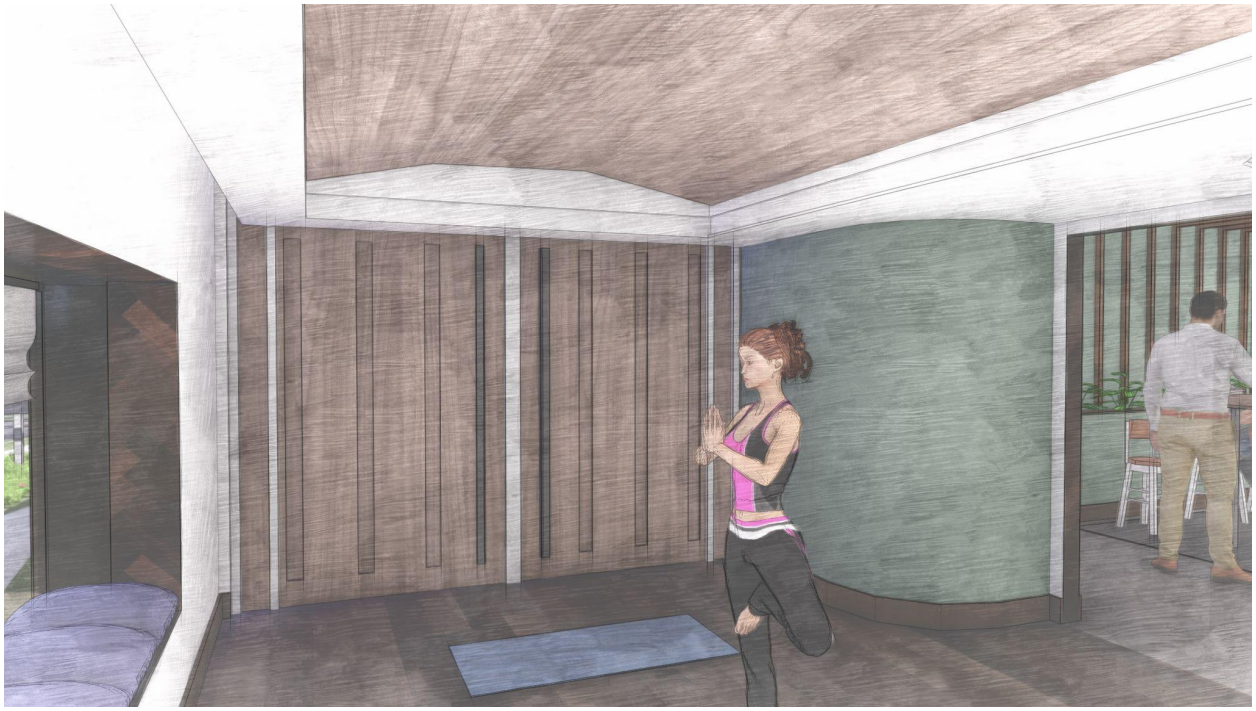
WATCH ROOM - BOOTH SEATING

WATCH ROOM

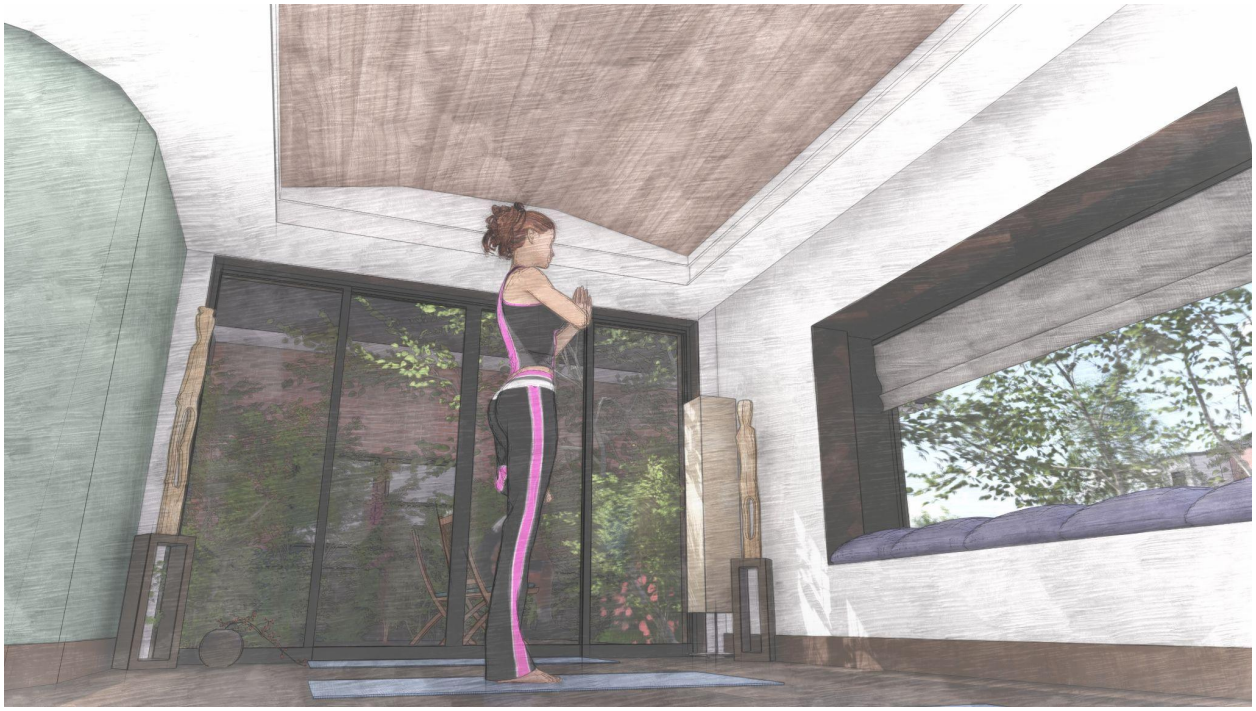
OUTDOOR PATIO

VIEW FROM OUTDOOR PATIO

VIEW FROM OUTDOOR PATIO INTO CALM ROOM 1



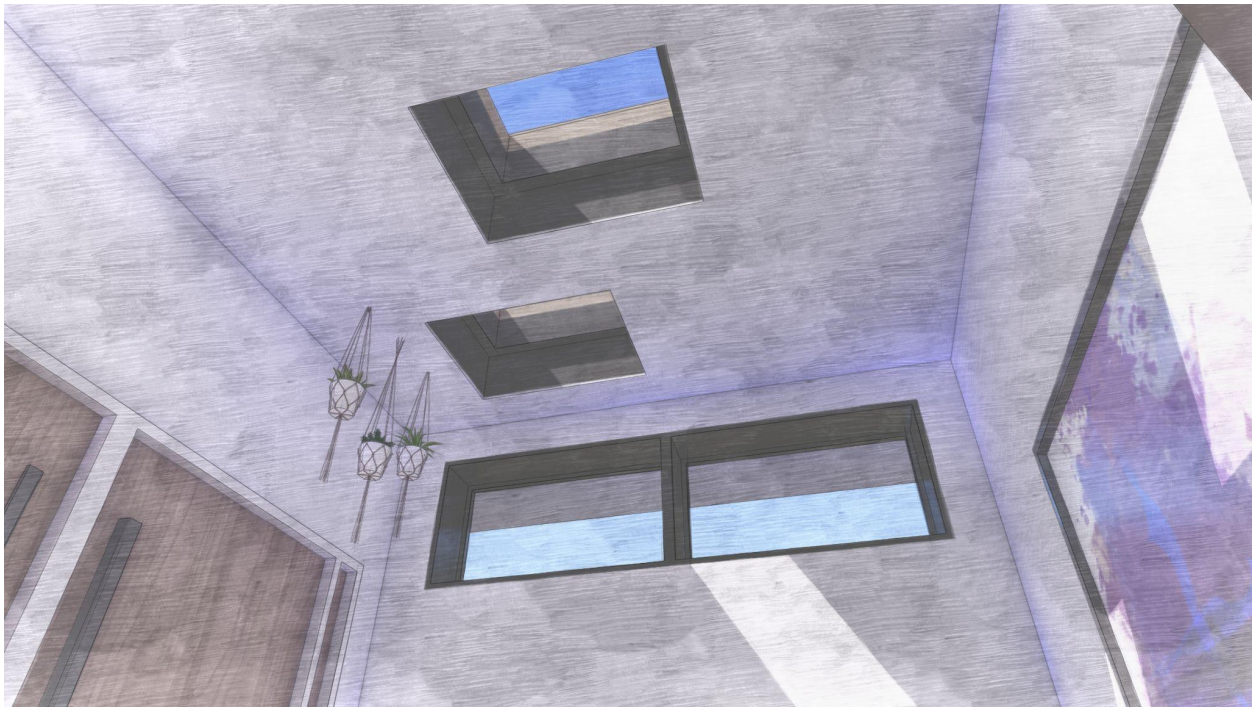
CALM ROOM 1



CALM ROOM 1

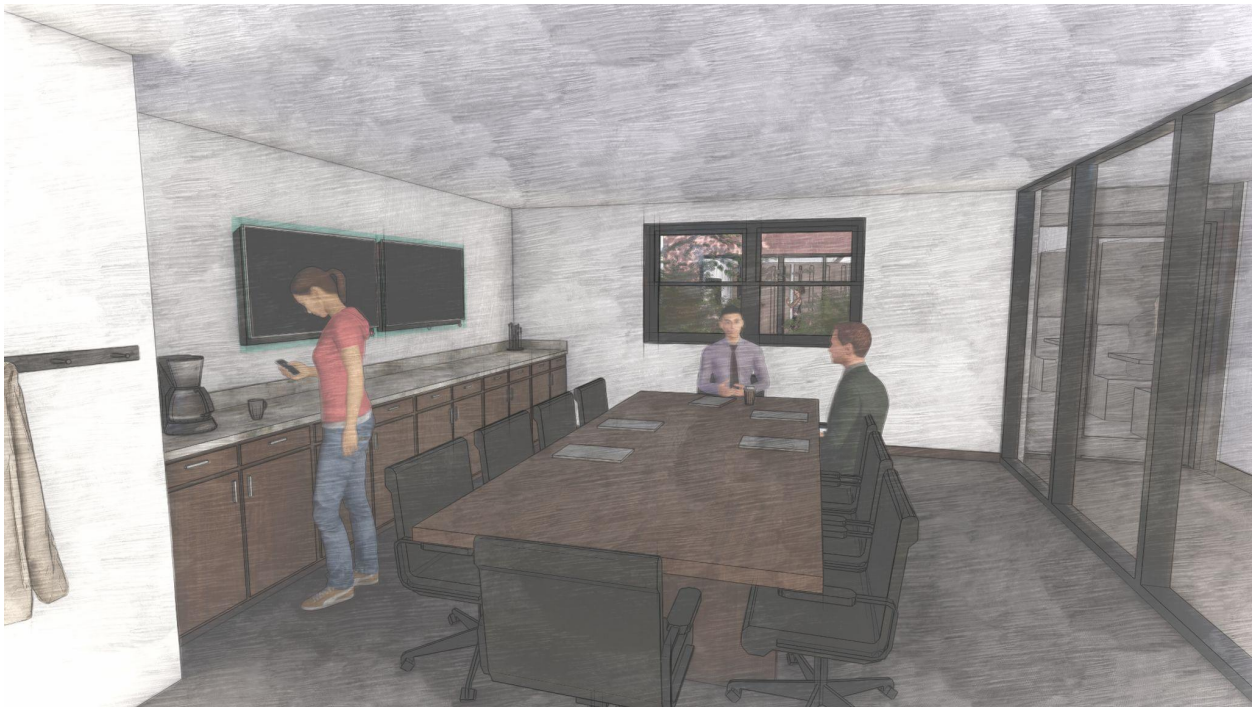
EXTERIOR VIEW LOOKING TOWARDS THE CALM ROOMS
(SHOWING THAT THERE IS SOME PRIVACY)

CALM ROOM 2



CALM ROOM 2

BUNK ROOM



CONFERENCE ROOM

CHIEF'S OFFICE

CHIEF'S OFFICE

ROOFTOP GARDEN

ROOFTOP GARDEN

EAST ELEVATION (MAIN ENTRY)

EAST ELEVATION (MAIN ENTRY)