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Date: November 13, 2019

To: Rob Para, AIA

Co: Lamoureux-Pagano Assoc. Architects, Inc. (via email)

From: Kevin Seaman. P.E. LEED® AP

Re: Doherty High School: **Feasibility Study HVAC & Plumbing Narrative – No Build Option**

The following narrative describes the proposed scope of work pertaining to the heating, ventilation and air conditioning (HVAC) systems and the plumbing systems at the Doherty High School for the No Build Option. As noted in our earlier existing Mechanical conditions report, the systems in within the existing building vary in their age however, much of the hydronic heating and plumbing distribution systems are original and have exceeded their useful expected service life and as such we have proposed a replacement of a majority of the systems as described herein. In addition, many of the existing HVAC terminals, although not past their useful life, have no ability to cool the air and have poor acoustical performance to support a classroom environment making them undesirable for reuse within the existing building.

HVAC

Central Heating Plant:

1. The buildings heating boilers shall be replaced with high efficiency (93%+) gas-fired condensing hot water boilers. Pending final load calculations and system design, initially the boiler plant shall consist of three (3) gas-fired condensing fire-tube style boilers each with a gross input capacity of 7,500,000 BTUH similar to Lochinvar Crest or equal by Aerco or Viessman. Boilers shall be located within an existing lower level boiler room. Combustion air and flue venting for the new boilers shall run up the building to the roof level.

2. All heating piping shall be replaced with a 2-pipe hydronic hot water system complete with two (2) sets of tri-plex vertical in-line system pumps as manufactured by Armstrong, Grundfos or equal rated for the system flow for their respective building segments. Hydronic system shall connect to 2-pipe fan coil units, VAV terminals, unit heaters, hot water coils and fin-tube radiation located throughout the building. All terminals shall be designed to operate with a maximum water temperature of 140°F to maximize plant capacity. Pumps shall have premium efficient motors and be fitted with integral variable speed drives so that pump energy matches system flow demand.

3. Intermediate mechanical closets shall be provided on the upper level of the building and shall contain plate-frame heat exchangers and high efficiency pumps with variable speed ECM motors. These heat exchangers shall establish a water to glycol loop interface whereas all

packaged rooftop equipment shall be fed with a glycol water mix for improved freeze protection.

4. Phasing Comments:

   - We suggest the boiler plant be located within whichever area is considered the phase 1 area of renovation. In this way the boiler plant can be built and expanded (as applicable) using modular boilers to accept and support the future construction phases.

   - We recommend any temporary modular classroom structure be fitted with packaged HVAC electric heat pumps which do not rely on the main building boiler plant. Since the existing building has and will continue to undergo replacement of exiting unit ventilators with radiation as sections are renovated.

Central Cooling Plant:

Although the proposed presumes the use of packaged, refrigerant based, direct expansion (DX) cooling and dehumidification systems the design team shall review the possibility of using a central chilled water plant tied to chilled water coils in rooftop air handlers in lieu of DX coils and compressors in the rooftop equipment. Review during the design shall be done in conjunction with the energy modeler and the utility company to ascertain the various advantages and disadvantages of using such a system. Potential for use of a chilled beam system throughout the classroom areas may also be considered due to the existing tight floor to floor conditions and for improved energy performance.

Distribution and Ventilation:

1. Most of the buildings classroom areas are heated thru the use of fan coils or classroom unit ventilators with outdoor air louvers sealed off. Outdoor air for many classrooms is provided through the use of several roof mounted total energy recovery units. Although these units are currently within their projected useful service life they offer no ability to cool or dehumidify and as such are not desirable for reuse in a fully air conditioned structure.

   We propose new packaged rooftop units be provided which shall have total energy recovery wheels to utilize waste exhaust to temper incoming fresh air, hot water coils, DX coils (see note below) & hot gas reheat coils for cooling and dehumidification control. Units shall incorporate premium efficiency direct drive plenum fans on variable speed drives to optimize air delivery volumes based on space temperature and air quality demand as determined by CO_2 sensors. The units shall be as manufactured by Aaon, Daiken, Valent or equal. Note: The possibility of using a central chilled water plant in lieu of DX coils in the rooftop equipment shall be considered early on during the design and in conjunction with the energy modeler and the utility company.

   The possibility of using a central chilled water plant in lieu of DX coils in the rooftop equipment shall be considered early on during the design and in conjunction with the energy modeler and the utility company. With the chiller option the potential for use of a chilled beam system throughout the classroom areas shall also be considered due to the existing tight floor to floor conditions and for improved energy performance.

2. The existing duct distribution system serving most classrooms is not adequately sized to support air conditioning. As such we recommend much of the ductwork be removed and replaced with new ductwork supporting VAV terminals. Any existing ducts reused shall be internally cleaned, sealed and insulated.
3. If an all air system is selected (i.e. not chilled beam), most all classrooms shall be provided with ventilation and air conditioning through the use of displacement diffusers located low along the walls. This type of ventilation system improves indoor air quality, environmental conditions and energy efficiency in several ways some of which are:
    - Introduces fresh air down within the breathing zone (below 6 feet).
    - Reduces the amount of fresh air required to ventilate the space.
    - Limits the mixing of air contaminants within the space.
    - System noise is reduced with diffuser air velocities a fraction of that of most conventional mixed air systems.
    - Increases periods of economizer cooling (free cooling with outside air) by using higher supply air temperatures than most conventional mixed air systems.
    - Increases cooling equipment efficiency by having higher return air and supply air temperatures than most conventional mixed air systems.
4. Science lab units shall be configured for 100% OA with exhaust adjusting to maintain space under slight negative pressure with respect to school as well as to match any fume hood exhaust. The units shall be as manufactured by Valent, Aaon, Daikin or equal.
5. Throughout the building exterior perimeter areas provide fin-tube radiation to support a majority of the space heating load. VAV and/or fan powered VAV units shall be used in all interior area or where fin-tube radiation is not possible or practical.
6. The computer classrooms as well as the MDF room shall be cooled via high efficiency ductless split units (one per room) with fan coil mounted within ceiling and condensing unit on roof.
7. Automotive shop area, if applicable, shall include a dedicated packaged rooftop system. The unit shall have total energy recovery wheels, hot water coils, DX coils & hot gas reheat coils for cooling and dehumidification control. Unit shall incorporate premium efficiency direct drive plenum fans on variable speed drives to optimize air delivery volumes based on space temperature and air quality demand as determined by CO and NOx sensors. The unit shall be as manufactured by Valent, Aaon, Daikin or equal.
8. High plume style fume hood exhaust fan(s) shall be provided and connected to science lab fume hoods. Fan shall vary flow based on variable flow hood demand. Each hood shall be

fitted with sash airflow monitor and branch duct damper control as manufactured by TSI or Phoenix Controls to maintain flow at each hood based on open sash air velocity.

9. Provide kitchen hood system with energy saving smoke/heat detection systems coupled to variable speed exhaust fan. Provide new gas-fired make-up air system for the kitchen which shall have the ability to reset make-up air system volume in unison with kitchen hood exhaust demand control system. Outdoor make-up air shall be tempered heating only introduced directly in front of the kitchen hoods to minimize the need for cooling the air and impact on the room environment.
10. Locker rooms shall be provided with packaged rooftop units and supply and exhaust ductwork. The units shall have total energy recovery wheels and hot water coils and shall be configured for 100% OA ventilation during occupied periods. Units shall incorporate premium efficiency direct drive plenum fans on variable speed drives to optimize air delivery based on space temperature and air quality demand as determined by humidity and CO_2 sensors. The units shall be as manufactured by McQuay, Trane, Aaon or equal.
11. Restrooms (other than those in the locker room), Janitors closets, etc… shall be exhaust via roof mounted exhaust fans controlled by occupancy sensors located in the respective areas served.
12. Phasing Comments:

    - Most areas of the existing building shall be supported by roof mounted HVAC units serving multiple floors and as such the renovation approach should consider segmenting the building work into multi-story blocks.

    - We recommend any temporary modular classroom structures be fitted with packaged HVAC electric heat pumps which do not rely on the main building boiler plant.

Controls:

1. The current school already incorporates a direct digital control (DDC) energy management system (EMS) as supplied and service by Automated Building Systems, Inc. This system shall be extended to include all new systems and incorporate further energy saving and monitoring features. The system monitors and controls the HVAC equipment for efficient use and for proper indoor air quality and temperatures. The system is designed on PC based architecture and adjustments are made on a graphics based presentation of building systems. The system also supports maintenance and record keeping needs of the facility. Occupancy of the school is based on the standard school year with occupied/unoccupied conditions based on current school day practice. This is an adjustable feature that can be made to reflect additional operating needs and use of the school building by staff or others.

2. The HVAC systems are generally operated on a school day basis coinciding with the occupied/unoccupied schedule of the standard 180-day school year. Adjustments can be

made through the DDC system to allow for usage during periods other than the usual school operating periods.

3. Space temperature is monitored by individual space sensors that transmit data to the central monitoring and control station. Space conditions are adjustable through DDC system and can be modified to meet individual needs. Local control of space conditions is limited to predefined adjustments in space temperature and to facilitate a 3-hour occupied override feature.

4. All classroom systems shall incorporate space occupancy sensors to reset ventilation levels when room is unoccupied during a regularly scheduled occupied period. Systems serving high occupancy areas such as the cafeteria and gymnasium also include carbon dioxide (CO_2) indoor air quality (IAQ) sensors which optimize the fresh outdoor air ventilation levels in response to variations in space occupancies.

5. The system shall incorporate many energy-saving features such as 1) hot water temperature reset controls, 2) static pressure reset controls, 3) occupancy based controls and 4) ventilation reset controls to name just a few.

6. The building shall be connected to emergency power source for operation of heating boilers and pumps during loss of primary power. Systems on emergency power may include MDF and IDF rooms as well as areas deemed critical by the Owner.

7. Phasing Comments:

    - The existing building control system can be easily expanded to support the building in renovation segments through the use of networked unitary controls. We do not suggest the modular classrooms be connected to this system due to their temporary nature.

Sustainable Opportunities:

Many of the proposed system and control sequences noted above minimize energy consumption however, further optimization may be obtained by investigating the use of either high efficiency air cooled water chillers of water cooled cooling equipment which has an inherent better energy performance than air cooled equipment. A life cycle evaluation must be performed as size and length of cooling system run time will impact overall value.

In addition to the water cooled cooling option, consideration could also be given to a geothermal based option. A geothermal chiller/heater could support building cooling loads in the summer as well as provide supplemental heating to the building by preheating both the heating water and domestic hot water thereby reducing the demand on the building fossil fuel boilers. A geothermal well field analysis as well as a life cycle cost would need to be performed to verify economic viability.

Two solar based options to consider would be passive solar wall design using air passing through a wall assembly facing South to preheat air and/or vacuum tube thermal solar panels mounted on the roof to directly supplement the building heating and domestic hot water systems.

Plumbing

Distribution & Conveying Systems

The water distribution system is more than 40 years of age and most likely has some lead containing piping, fittings and/or solder as well as thinning pipe walls. As such, we suggest the entire domestic water distribution system be replaced in its entirety. The new distribution system would consist of copper piping with lead-free fittings and products.

All sanitary sewer and rain water conductors located above the grade floor slab shall be replaced in their entirety unless examined and found to be in good condition. Underground waste piping shall be examined via camera inspection and if found to be in good condition shall be retained and reused. All sanitary sewer and rain water conductors shall be constructed of cast iron. An acid waste system consisting of acid rated piping and a neutralizing system shall be provided for the science labs.

All waste from the kitchen(s) shall be piped to a large (1,500 gallon+/-) exterior grease trap prior to discharge to the municipal sewer system.

Any modular classroom buildings should be equipped with adequate student and staff restrooms to support the population of the modular. These restrooms should be fed with potable cold water from the existing building. Sanitary sewer lines should tie into site sanitary sewer mains. All water and sanitary drain lines located outside the heated envelope shall be heat traced and insulated where located above grade or less than 4 feet below grade.

Domestic Hot Water

High efficiency (93%+) gas-fired condensing boiler/water heaters and tanks shall be used to replace the existing water heaters and support the buildings domestic hot water needs. In addition, this system shall be coupled to the heat output of thermal solar panels, if selected. The use of these supplemental systems will be dependent on their life cycle cost and require further study.

Dual water tempering valve stations shall be provided at the water heater to maintain water heater temperatures above 140°F to prevent bacterial growth in the tank while delivering 125°F water to service fixtures for sanitation and 110°F hot water to public lavatory sinks and other student and public use fixtures to prevent scalding.

For the temporary modular structures, provide local electric tank type water heaters to support the restroom lavatory and Janitor sink fixtures.

Fixtures

Planned renovations will most likely require removal of the existing fixtures. Once removed the fixtures should be replaced with code compliant water conserving fixtures. In addition, to achieve improved LEED® compliance and further water savings we recommend ultra-low flush water closets and urinals be utilized. The ultra low flush water closets use 1.28 gallons per flush as opposed to the 1.6 gallon per flush allowed by today's code and the urinals use 1 pint (0.13 gallons) per flush as opposed to the current 1 gallon per flush allowed. The combination of these two can result in substantial savings overtime. However, these fixtures should only be used when connecting to new well pitched (more than code minimum) sewer lines as the low flow fixtures do have a tendency to result in line blockages if the sewer line pitch or conditions is not good.

Lavatory faucets shall be of the low flow metered type controlled by either a wired or battery powered sensor operated faucet. Use of these faucets promotes good hygiene as well as water conservation.

Natural Gas Service:

The existing gas service to the building currently supports the heating boilers, domestic water heaters and many of the rooftop units. The projected new load, gas-fired heating boilers, water heaters and cooking equipment is expected to be near the same as the current load and may be less due to proposed building thermal improvements as well as more efficient heating and hot water boilers.

Sustainable Opportunities:

Many of the proposed fixtures and control sequences noted above minimize water usage and conserve energy however, further optimization may be obtained by investigating the use of storm water recovery systems. These systems collect, filter and utilize storm water to supply water to water closets and urinals throughout the building. A life cycle evaluation must be performed to ascertain the initial first costs, annual operating costs and projected savings associated with such a system.

Use of vacuum tube thermal solar panels shall be further considered, if desired, as part of a life cycle study analysis.

End of HVAC & Plumbing Narrative

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From: Kevin Seaman. P.E. LEED® AP

Re: Doherty High School: **Feasibility Study HVAC & Plumbing Narrative – Addition & Renovation Option**

The following narrative describes the proposed scope of work pertaining to the heating, ventilation and air conditioning (HVAC) systems and the plumbing systems at the Doherty High School for the Addition & Renovation Option. As noted in our earlier existing Mechanical conditions report, the systems in within the existing building vary in their age however, much of the hydronic heating and plumbing distribution systems are original and have exceeded their useful expected service life and as such we have proposed a replacement of a majority of the systems as described herein. In addition, many of the existing HVAC terminals, although not past their useful life, have no ability to cool the air and have poor acoustical performance to support a classroom environment making them undesirable for reuse within the existing building.

<u>HVAC</u>

Central Heating Plant:

1. The buildings heating boilers shall be replaced with high efficiency (93%+) gas-fired condensing hot water boilers. Pending final load calculations and system design, initially the boiler plant shall consist of four (4) gas-fired condensing fire-tube style boilers each with a gross input capacity of 12,000,000 BTUH similar to Lochinvar Crest or equal by Aerco or Viessman. Boilers shall be located within an existing lower level boiler room. Combustion air and flue venting for the new boilers shall run up the building to the roof level.

2. All heating piping shall be replaced with a 2-pipe hydronic hot water system complete with two (2) sets of tri-plex vertical in-line system pumps as manufactured by Armstrong, Grundfos or equal rated for the system flow for their respective building segments. Hydronic system shall connect to 2-pipe fan coil units, VAV terminals, unit heaters, hot water coils and fin-tube radiation located throughout the building. All terminals shall be designed to operate with a maximum water temperature of 140°F to maximize plant capacity. Pumps shall have premium efficient motors and be fitted with integral variable speed drives so that pump energy matches system flow demand.

3. Intermediate mechanical closets shall be provided on the upper level of the building and shall contain plate-frame heat exchangers and high efficiency pumps with variable speed ECM motors. These heat exchangers shall establish a water to glycol loop interface whereas all

packaged rooftop equipment shall be fed with a glycol water mix for improved freeze protection.

4. Phasing Comments:

   - We suggest the boiler plant be located within whichever area is considered the phase 1 area of Addition. In this way the boiler plant can be built and expanded (as applicable) using modular boilers to accept and support the future construction phases.

   - We recommend any temporary modular classroom structure be fitted with packaged HVAC electric heat pumps which do not rely on the main building boiler plant. Since the existing building has and will continue to undergo replacement of exiting unit ventilators with radiation as sections are renovated.

Central Cooling Plant:

Although the proposed presumes the use of packaged, refrigerant based, direct expansion (DX) cooling and dehumidification systems the design team shall review the possibility of using a central chilled water plant tied to chilled water coils in rooftop air handlers in lieu of DX coils and compressors in the rooftop equipment. Review during the design shall be done in conjunction with the energy modeler and the utility company to ascertain the various advantages and disadvantages of using such a system. Potential for use of a chilled beam system throughout the classroom areas may also be considered due to the existing tight floor to floor conditions and for improved energy performance.

Distribution and Ventilation:

1. Most of the buildings existing classroom areas are heated thru the use of fan coils or classroom unit ventilators with outdoor air louvers sealed off. Outdoor air for man classrooms is provided through the use of several roof mounted total energy recovery units. Although these units are currently within their projected useful service life they offer no ability to cool or dehumidify and as such are not desirable for reuse in a fully air conditioned structure.

   We propose new packaged rooftop units be provided which shall have total energy recovery wheels to utilize waste exhaust to temper incoming fresh air, hot water coils, DX coils (see note below) & hot gas reheat coils for cooling and dehumidification control. Units shall incorporate premium efficiency direct drive plenum fans on variable speed drives to optimize air delivery volumes based on space temperature and air quality demand as determined by CO_2 sensors. The units shall be as manufactured by Aaon, Daiken, Valent or equal. Note:

   The possibility of using a central chilled water plant in lieu of DX coils in the rooftop equipment shall be considered early on during the design and in conjunction with the energy modeler and the utility company. With the chiller option the potential for use of a chilled beam system throughout the classroom areas shall also be considered due to the tight floor to floor conditions and for improved energy performance.

2. The existing duct distribution system serving most existing classrooms is not adequately sized to support air conditioning. As such we recommend much of the ductwork be removed and replaced with new ductwork supporting VAV terminals. Any existing ducts reused shall be internally cleaned, sealed and insulated.
3. Most all classrooms shall be provided with ventilation and air conditioning through the use of displacement diffusers located low along the walls. This type of ventilation system improves indoor air quality, environmental conditions and energy efficiency in several ways some of which are:
   - Introduces fresh air down within the breathing zone (below 6 feet).
   - Reduces the amount of fresh air required to ventilate the space.
   - Limits the mixing of air contaminants within the space.
   - System noise is reduced with diffuser air velocities a fraction of that of most conventional mixed air systems.
   - Increases periods of economizer cooling (free cooling with outside air) by using higher supply air temperatures than most conventional mixed air systems.
   - Increases cooling equipment efficiency by having higher return air and supply air temperatures than most conventional mixed air systems.
4. Science lab units shall be configured for 100% OA with exhaust adjusting to maintain space under slight negative pressure with respect to school as well as to match any fume hood exhaust. The units shall be as manufactured by Valent, Aaon, Daikin or equal.
5. Throughout the building exterior perimeter areas provide fin-tube radiation to support a majority of the space heating load. VAV and/or fan powered VAV units shall be used in all interior area or where fin-tube radiation is not possible or practical.
6. The computer classrooms as well as the MDF room shall be cooled via high efficiency ductless split units (one per room) with fan coil mounted within ceiling and condensing unit on roof.
7. Automotive shop area, if applicable, shall include a dedicated packaged rooftop system. The unit shall have total energy recovery wheels, hot water coils, DX coils & hot gas reheat coils for cooling and dehumidification control. Unit shall incorporate premium efficiency direct drive plenum fans on variable speed drives to optimize air delivery volumes based on space temperature and air quality demand as determined by CO and NOx sensors. The unit shall be as manufactured by Valent, Aaon, Daikin or equal.
8. High plume style fume hood exhaust fan(s) shall be provided and connected to science lab fume hoods. Fan shall vary flow based on variable flow hood demand. Each hood shall be fitted with sash airflow monitor and branch duct damper control as manufactured by TSI or Phoenix Controls to maintain flow at each hood based on open sash air velocity.
9. Provide kitchen hood system with energy saving smoke/heat detection systems coupled to variable speed exhaust fan. Provide new gas-fired make-up air system for the kitchen which

shall have the ability to reset make-up air system volume in unison with kitchen hood exhaust demand control system. Outdoor make-up air shall be tempered heating only introduced directly in front of the kitchen hoods to minimize the need for cooling the air and impact on the room environment.

10. In all options if atriums are employed that freely open to three or more floors, smoke evacuation systems shall be employed which reject smoke from the top of the atrium and introduce outside make-up air at the lowest levels. A 3rd party reviewer shall be employed to perform specialized CFD modeling to optimize system design as well as to perform code required peer review and testing.
11. Any building segment considered to be high rise shall incorporate stair tower pressurization in the egress stairs. In addition, in floors which do not have sufficient exterior windows for smoke evacuation the HVAC system shall be configured for use as a smoke evacuation system during clean-up by the fire department after a fire. This shall be not construed as a floor smoke control system.
12. Locker rooms shall be provided with packaged rooftop units and supply and exhaust ductwork. The units shall have total energy recovery wheels and hot water coils and shall be configured for 100% OA ventilation during occupied periods. Units shall incorporate premium efficiency direct drive plenum fans on variable speed drives to optimize air delivery based on space temperature and air quality demand as determined by humidity and CO_2 sensors. The units shall be as manufactured by McQuay, Trane, Aaon or equal.
13. Restrooms (other than those in the locker room), Janitors closets, etc… shall be exhaust via roof mounted exhaust fans controlled by occupancy sensors located in the respective areas served.
14. Phasing Comments:

    - Most areas of the existing building shall be supported by roof mounted HVAC units serving multiple floors and as such the renovation approach should consider segmenting the building work into multi-story blocks.

    - We recommend any temporary modular classroom structures, if used, be fitted with packaged HVAC electric heat pumps which do not rely on the main building boiler plant.

Controls:

1. The current school already incorporates a direct digital control (DDC) energy management system (EMS) as supplied and service by Automated Building Systems, Inc. This system shall be extended to include all new systems and incorporate further energy saving and monitoring features. The system monitors and controls the HVAC equipment for efficient use and for proper indoor air quality and temperatures. The system is designed on PC based architecture and adjustments are made on a graphics based presentation of building systems. The system also supports maintenance and record keeping needs of the facility. Occupancy

of the school is based on the standard school year with occupied/unoccupied conditions based on current school day practice. This is an adjustable feature that can be made to reflect additional operating needs and use of the school building by staff or others.

2. The HVAC systems are generally operated on a school day basis coinciding with the occupied/unoccupied schedule of the standard 180-day school year. Adjustments can be made through the DDC system to allow for usage during periods other than the usual school operating periods.

3. Space temperature is monitored by individual space sensors that transmit data to the central monitoring and control station. Space conditions are adjustable through DDC system and can be modified to meet individual needs. Local control of space conditions is limited to predefined adjustments in space temperature and to facilitate a 3-hour occupied override feature.

4. All classroom systems shall incorporate space occupancy sensors to reset ventilation levels when room is unoccupied during a regularly scheduled occupied period. Systems serving high occupancy areas such as the cafeteria and gymnasium also include carbon dioxide (CO_2) indoor air quality (IAQ) sensors which optimize the fresh outdoor air ventilation levels in response to variations in space occupancies.

5. The system shall incorporate many energy-saving features such as 1) hot water temperature reset controls, 2) static pressure reset controls, 3) occupancy based controls and 4) ventilation reset controls to name just a few.

6. The building shall be connected to emergency power source for operation of heating boilers and pumps during loss of primary power. Systems on emergency power may include MDF and IDF rooms as well as areas deemed critical by the Owner.

7. Phasing Comments:

   - The existing building control system can be easily expanded to support the building additions and renovations in segment phases through the use of networked unitary controls. We do not suggest the modular classrooms, if used, be connected to this system due to their temporary nature.

Sustainable Opportunities:

Many of the proposed system and control sequences noted above minimize energy consumption however, further optimization may be obtained by investigating the use of either high efficiency air cooled water chillers of water cooled cooling equipment which has an inherent better energy performance than air cooled equipment. A life cycle evaluation must be performed as size and length of cooling system run time will impact overall value.

In addition to the water cooled cooling option, consideration could also be given to a geothermal based option. A geothermal chiller/heater could support building cooling loads in the summer as well as provide supplemental heating to the building by preheating both the heating water and domestic hot water thereby reducing the demand on the building fossil fuel boilers. A geothermal well field analysis as well as a life cycle cost would need to be performed to verify economic viability.

Two solar based options to consider would be passive solar wall design using air passing through a wall assembly facing South to preheat air and/or vacuum tube thermal solar panels mounted on the roof to directly supplement the building heating and domestic hot water systems.

Plumbing

Distribution & Conveying Systems

The water distribution system is more than 40 years of age and most likely has some lead containing piping, fittings and/or solder as well as thinning pipe walls. As such, we suggest the entire domestic water distribution system be replaced in its entirety. The new distribution system would consist of copper piping with lead-free fittings and products throughout both the renovation and addition.

All sanitary sewer and rain water conductors located above the grade floor slab shall be replaced in their entirety unless examined and found to be in good condition. Underground waste piping shall be examined via camera inspection and if found to be in good condition shall be retained and reused. All sanitary sewer and rain water conductors shall be constructed of cast iron. An acid waste system consisting of acid rated piping and a neutralizing system shall be provided for the science labs.

All waste from the kitchen(s) shall be piped to a large (1,500 gallon+/-) exterior grease trap prior to discharge to the municipal sewer system.

Any modular classroom buildings should be equipped with adequate student and staff restrooms to support the population of the modular. These restrooms should be fed with potable cold water from the existing building. Sanitary sewer lines should tie into site sanitary sewer mains. All water and sanitary drain lines located outside the heated envelope shall be heat traced and insulated where located above grade or less than 4 feet below grade.

Domestic Hot Water

High efficiency (93%+) gas-fired condensing boiler/water heaters and tanks shall be used to replace the existing water heaters and support the buildings domestic hot water needs. In addition, this system shall be coupled to the heat output of thermal solar panels, if selected. The use of these supplemental systems will be dependent on their life cycle cost and require further study.

Dual water tempering valve stations shall be provided at the water heater to maintain water heater temperatures above 140°F to prevent bacterial growth in the tank while delivering 125°F water to service fixtures for sanitation and 110°F hot water to public lavatory sinks and other student and public use fixtures to prevent scalding.

For the temporary modular structures, provide local electric tank type water heaters to support the restroom lavatory and Janitor sink fixtures.

Fixtures

Planned renovations will most likely require removal of the existing fixtures. Once removed the fixtures should be replaced with code compliant water conserving fixtures. In addition, to achieve improved LEED® compliance and further water savings we recommend ultra-low flush water closets and urinals be utilized. The ultra low flush water closets use 1.28 gallons per flush as opposed to the 1.6 gallon per flush allowed by today's code and the urinals use 1 pint (0.13 gallons) per flush as opposed to the current 1 gallon per flush allowed. The combination of these two can result in substantial savings overtime. However, these fixtures should only be used when connecting to new well pitched (more than code minimum) sewer lines as the low flow fixtures do have a tendency to result in line blockages if the sewer line pitch or conditions is not good.

Lavatory faucets shall be of the low flow metered type controlled by either a wired or battery powered sensor operated faucet. Use of these faucets promotes good hygiene as well as water conservation.

Natural Gas Service:

The existing gas service to the building currently supports the heating boilers, domestic water heaters and many of the rooftop units. The projected new load, gas-fired heating boilers, water heaters and cooking equipment will most likely exceed the current load due to increase in building size. Once loads are confirmed a review with the local gas utility (Eversource) shall take place to confirm adequate supply.

Sustainable Opportunities:

Many of the proposed fixtures and control sequences noted above minimize water usage and conserve energy however, further optimization may be obtained by investigating the use of storm water recovery systems. These systems collect, filter and utilize storm water to supply water to water closets and urinals throughout the building. A life cycle evaluation must be performed to ascertain the initial first costs, annual operating costs and projected savings associated with such a system.

Use of vacuum tube thermal solar panels shall be further considered, if desired, as part of a life cycle study analysis.

End of HVAC & Plumbing Narrative