3.3.3 PLUMBING SYSTEMS

3.3.3.1 Plumbing General Requirements

- Any requirements specified in this design manual that may exceed the minimum requirements of the governing code shall be adhered to unless prior approval is granted by Mason.
- Coordinate all plumbing service entrances including water, storm, sewer and natural gas with the corresponding site utility plans. Verify all sizes and inverts are coordinated.
- All equipment shall be installed with sufficient walk-around room to insure proper maintenance of equipment. Equipment shall be installed such that tube pull, filter replacement, ease of removal and replacement of strainers, ease of draining equipment, filter changes, convenience for service of parts, etc. can be achieved.

3.3.3.2 Meters and Gages

- Water meters shall be included in the contract and installed in accordance with the local water authority.
- Install an approved water meter on the city water make-up supply to evaporative cooling towers.
- Retail Space Utility Metering: Install an Onicon F-4200 Series clamp-on ultrasonic flow meter for the domestic water supply of each retail tenant. Install an Onicon F-5000 Series gas meter if natural gas is provided. For campus standardization purposes, substitutions to the Onicon models will not be accepted. Each flow meter shall be connected to the campus EMS system.

3.3.3.3 General-Duty Valves for Plumbing Piping

- Shut off (isolation) valves shall be provided on the inlet to each piece of plumbing equipment and on supply to each plumbing fixture not having stops on supplies.
- Sectional valves shall be provided close to the main on each branch and riser serving two (2) or more plumbing fixtures or equipment connections.
- Install valves on all lines that penetrate the floor from below.
- Drain valves shall be provided on each plumbing equipment and distribution riser located so as to allow drainage of equipment or riser for service and repair.
- Install valves on all lines at locations such that each floor can be isolated independent of main building.
- Provide automatic air relief valves at the tops of water risers.
- Any equipment such as showers, darkrooms, etc., requiring mixing of hot and cold water shall utilize a solid brass pressure compensated mixing valve rather than a temperature compensated mixing valve.
- Install control valves where they can be reached from the floor, where possible.

3.3.3.4 Hangers and Supports for Plumbing Piping and Equipment

- Provide calculations for pipeline flexibility. Anchor as needed. Conform to ASME Code for allowable stresses. Furnish calculations for spring hangers. For ductile iron/glass piping for sterilizer/autoclave uses ensure pipe hanger supports prevent any lateral movement.

- All piping with insulation shall be supplied with saddles and rigid insulation at pipe hanger locations.
- Seismic requirements must be considered as required.

3.3.3.5 Domestic Water Piping

- Provide di-electric couplings or unions between dissimilar pipe materials.
- Install flexible connectors between piping and connections to rotating or vibrating equipment.
- Provide unions at connections to equipment.

3.3.3.6 Domestic Water Piping Specialties

3.3.3.6.1 Backflow Prevention

- Each water service shall be provided with a service entrance backflow preventer sized for 100% demand load, ASSE 1013 type for domestic water. Where there is only a single water service to the building, backflow preventers on the service shall be arranged in parallel, sized to provide N+1 redundancy to allow for continuous water supply.
- In some cases, a bypass arrangement shall be permitted around a backflow preventer if the equivalent level of cross connection protection is installed in the bypass line.
- Backflow preventers shall have ready access for maintenance, replacement and testing. Backflow preventers shall not be installed where platforms, ladders or lifts are required for access. Backflow preventers shall be installed inside buildings in an area capable of maintaining a minimum temperature of 50 degrees Fahrenheit, except those approved for seasonal removal or replacement.
- Backflow preventers shall be installed in an area exclusively reserved for such assemblies or devices. Related appurtenances including valves, water meters, and fire pumps and sprinkler standpipes shall be permitted to share the same area, provided respective dimensional requirements can be maintained.
- Adequate sized floor drains are recommended for assemblies and devices with relief opening installed inside buildings. The relief port opening shall be installed with a manufacturer's air gap fitting and piped to a floor drain or receptor.
- A minimum of 30 inches of unobstructed space shall be provided in front of backflow assemblies or devices for maintenance and testing. A minimum of 12" of unobstructed space shall also be provided behind 3-inch and larger backflow assemblies or devices. A minimum of 6" of unobstructed space shall be provided behind 2" and smaller assemblies or devices. A minimum of 6'-0" of headroom shall be provided. An assembly or device may be installed in an alcove or under a counter provided it is within 12" of the opening and positioned in a serviceable manner.
- Backflow preventers designed to vent to atmosphere and potable system drainage valves (such as stop and waste or boiler drain type), shall not be installed in pits, vaults or similar submerged areas and shall not be installed in chemical or fume hood.
- In locations that have hard water (e.g. Prince William), a water softener shall be provided to protect specific pieces of equipment, such as water heaters, boilers, and autoclaves).
- Hose Bibs and Wall Hydrants: Hose bibs shall be provided within mechanical equipment rooms, kitchens, loading dock areas, and within planters for watering. Wall or yard hydrants shall be provided

outside the building to accommodate landscape watering, pavement/ sidewalk cleaning, and loading dock cleanup. All exterior hydrants shall be freeze-proof design. All hose bibs/hydrants shall be provided with integral hose bib vacuum breakers (see above), and shall be self-draining type where subject to freezing. Provide a hose bib with hot water on the same level as the exhaust fans serving kitchen hood exhaust system.

- Water Hammer Arrestors: Provide water hammer arresters in accordance with the recommendations in the American Society of Sanitary Engineers Standard 1010 “Water Hammer Arrestors.” Size and locate arrestors in accordance with the Plumbing Drainage Institute (PDI) Standard PDI-WH 201, Water Hammer Arrestors. Show water hammer arrestors on riser diagrams and/or on plans. Water hammer arrestors shall be installed with and inlet isolation valve.
- Provide frost proof wall hydrants every 50'-0” on exteriors of new buildings, with not less than one on each wall. Provide roof hydrants with 25’-0” of roof-mounted air handling equipment requiring periodic wash down maintenance.
- Roof Hydrants: Non-freeze post type hydrant. 1” (25mm) NPT inlet. Roof deck mounting system with cast iron underdeck flange and hydrant support with stainless steel fasteners. Galvanized steel pipe extension. EPDM flashing boot. Mounting shim for pitched roofs. 1/8” (3.2 mm) NPT drain hole. ASSE 1052 backflow preventer.

3.3.3.7 Domestic Hot Water Piping

This section applies to both domestic hot water piping and first aid flushing water piping (i.e. tempered water, emergency water systems).

- Potable hot water systems are a known potential source of bacterial contamination including Legionella strains. Potential for legionella in potable water systems shall be considered and appropriately addressed based on facility risks and system application. Copper-silver ionization shall be considered for potable hot water systems in applications serving residence halls as these buildings may undergo extended periods of non-use and the risk of aspiration of bacteria in water systems via shower heads is greater. Copper-silver systems shall not serve food service areas, and redundancy need not be provided for such treatment equipment, and monitoring protocol shall be developed.
- Distribute domestic hot water to building fixtures at 124°F and incorporate required anti-scalding devices at points of use. Maintain distribution temperature through automatic pumped circulation back to the water heater(s) and master mixing valve(s).
- Do not install plastic hoses for domestic hot water and hot water return lines. Such material is known to harbor and encourage bacteria growth.
- Avoid the use of natural rubber washers, o-rings and gaskets.
- Mix hot and cold water as close to showerheads as possible.
- Minimize distribution piping dead legs. A dead-leg is any length of pipe with one open end connected to the distribution system and the other end terminating at a cap, closed valve, or fixture that is not ordinarily used at least once per day. Dead legs shall be limited to less than 10 feet.
- With the use of ultra-low flow, sensor operated lavatory faucets, hot water circulation to within 3’-0” of the faucet supply is necessary. This means that individual lavatories or a bank of lavatories must have a supply and return circuit extended to the wet wall or chase. Uncirculated branch feeds should not be used as the

carrying distance (i.e. displacement) in the supply piping is too short to reach the sensor faucet during its on cycle, resulting in complaints of "no hot water" at the fixture(s).

- Indicate required flow rates for each circuit on the design drawings (plans and/or riser diagrams) and calculate the estimated heat loss on the basis of the system operating temperature, ambient temperature, and insulation value. The minimum flow rate for any one circuit shall be not less than 0.5 gpm with a 1/2" pipe size.

- Hot water return piping shall not be run at the top floor ceiling above the level of the fixtures. This configuration can cause air pockets to form within the return header preventing circulation flow. Instead, always install hot water return headers at the ceiling of the floor below to allow the fixtures above to allow any entrained air to exit the piping system during normal use.

- Indicate the design temperature differential for the circulation system. Hot water return systems serving kitchens shall be sized for a 5°F temperature differential. General building areas shall be sized for a 7°F maximum differential, except that higher differentials (up to 15°F) may be used where justified by the specific application.

- Flushing water to safety showers and eyewash equipment will sit stagnant in the distribution piping if measures to purge the water are not employed. Legionellae, heterotrophic bacteria, and amoebae have been cultured from these piping systems. When these devices are used, aerosolization is expected.

- Regardless of the frequency of testing and flushing of the emergency shower and eyewash fixture, additional means of more frequent flushing shall be incorporated into the distribution system. The connection of the end run of the tempered water distribution system to one or more flushing fixtures (e.g. urinals and/or toilets) is a recommended option. The daily use of these fixtures will displace water through the system at least as much as would be expected from the domestic water system.

- Multiple sinks or similar fixtures may also be used, so long as they ensure sufficient turnover of the water supply.

- In cases where there is no suitable normally used cold water plumbing fixture on the floor served, provide a time clock-actuated line purge at the end of the supply main for the floor, which shall discharge to an indirect waste receptor at a rate of at least 15 gal/min or as necessary to provide a 2 fps velocity in the main for sufficient duration to turn over all contents in the water line on a bi-weekly basis.

- Piping serving emergency fixtures shall be of adequate size to supply the maximum quantity of emergency fixtures to be in simultaneous use, but not less than the flow rate of the single most demanding emergency fixture plus the total simultaneous flow of the flushing purge fixture. In most cases, this will require the distribution main to be 1-1/2 to 2 inch diameter, based on an emergency shower fixture of 20-30 gal/min and a flush-o-meter purge fixture flow rate of (20 to 35 gal/min).

- The minimum size branch line to a single emergency shower is 1-1/4", and a 1/2" branch shall be provided to serve each eyewash. Flow velocity under conditions of maximum design simultaneous use may be up to 6 ft/min in the main. However residual pressure at the outlet shall not be less than 30 psi. The maximum simultaneous use demand shall be considered in sizing of piping, equipment, and simultaneous pump capacity.

3.3.3.8 Domestic Water Pumps

- Booster pumps for the domestic water system of a building shall be provided when the minimum residual pressure requirements at the most hydraulically demanding fixture cannot be met.
- The Design Team shall substantiate the requirement of a booster pump by hydraulic calculations.
- Building water booster pump systems shall incorporate the following features:
  - Connected to building standby power.
  - Sized and quantity with capacity split for efficient operation under peak demands and minimum design flow.
  - N+1 redundancy of total demand, including simultaneous design load of emergency fixtures (if applicable; typically an allowance of 2 to 4 shower fixtures per building).
  - Sufficient capacity for at least one emergency shower (if applicable) plus peak load with any pump out of service.
  - Lead/Lag/Automatic Alternate with failure logic to maintain operation.
  - Arranged to permit service of single pump or controller with all remaining pumps in service.
  - A constant pressure bypass (with PRV control) shall be provided to ensure continuous service with the VFD or control panel out of service.
  - Where VFD’s are used, separate VFD for each pump.
  - Local control, alarms, and remote general fault alarm to building automation system shall be provided.
  - The use of a pressure accumulator tank should be avoided as the interior EPDM bladder becomes a source of bacteria growth.
- Hot water circulation pumps shall be all-bronze construction, duplexed for N+1 redundancy and controlled by an alternating duplex controller tied to an in-line aqua-stat to maintain distribution temperature. Distribution systems using master thermostatic mixing stations shall always incorporate an aqua stat controller as continuous circulation will result in thermal creep in the system during periods of non-use (i.e. overnight).

3.3.3.9 Sanitary Waste Piping Specialties

3.3.3.9.1 Floor Drains

- Floor drains are required where water may likely accumulate and create a hazard, and also where intensive wet cleaning operations are required, including the following areas:
  - Food preparation kitchen areas, including serving lines
  - Mechanical equipment rooms
  - Toilet rooms with two or more flushometer operated fixtures or water closets
  - Shower or tub room, including area outside ADA shower stalls

- Laundry rooms

- With the exception of toilet rooms, showers, and kitchens, floor drains shall include sediment buckets. Floor drain grates shall be sized and traffic rated for the application, with grates that are fixed or set so as not to slip or deform with anticipated traffic, including consideration of cages, carts, etc. The entire drain shall be corrosion-resistant, smooth, and contiguous with the floor.

- Floor drains shall have minimum 3” diameter outlets, except that drains in loading dock, and kitchens shall have 4” outlets.

- Floor drains in kitchens and other areas where sanitation is paramount shall be constructed of stainless steel.

- Floor drains, floor sinks, and similar penetrations through wet areas above grade shall be protected with a water-proofing membrane and clamping collar, except where floors are otherwise protected with a membrane or approved water proofing system.

- Trap seal primers: Provide automatic solenoid trap seal primers for unattended drain traps where the water trap seal may evaporate over time and allow sewer gases to enter the building. Trap seal primers shall comply with ASSE 1018 or ASSE 1044. Flapper style trap guards such as Proset “Trap Guard” shall not be specified as a substitute for an automatic trap primer. Typical floor drain locations requiring trap guards include:

  - Residential units (to prevent evaporative losses during extended breaks).
  - Mechanical room general drains.
  - Laundry room drains.
  - Floor drains in public restrooms.

- For toilet, locker and shower rooms, general service floor drains shall be cast iron body with flashing collar and adjustable strainer head. Nickel bronze strainer. Round top. For slab on grade, provide gasketed outlet. For above grade, provide no-hub outlet. Provide optional trap primer connection or field connected trap primer to drain tailpiece.

- General service mechanical room floor drains shall be cast iron body with flashing collar. Cast iron ADA grate and slotted cast iron sediment bucket. For slab on grade, provide gasketed outlet. For above grade, provide no-hub outlet. Provide optional trap primer connection or field connected trap primer to drain tailpiece.

- The use of pumping systems shall be avoided. Drainage systems shall be designed to flow by gravity wherever possible.

- Building areas that are sufficiently elevated above the sewer to not require discharge through a pumping system shall be routed independently to discharge by gravity.

- Arrange plumbing systems to prevent sewage backflow into the building due to a stoppage in the exterior sewer by providing relief outside the building through sewer manhole covers.

- Backwater valves shall be provided outside the building for any drainage main that serves fixtures or equipment whose flood level rim is not at least 9” above the elevation of the exterior manhole cover serving the system, or above the next upstream manhole.

- Drains with flood level rim elevations higher than the above reference point shall not be combined with lower level mains upstream of the backwater valve.

- The backwater valve shall be located at the connection with the manhole, or with similar accessible means, to permit access for sewer rodding, or other service.

- Sufficient venting shall be provided to serve the building sewer either through stacks that do not discharge through the backwater valve or by provision of a relief vent.

- The use of individual backwater valves at fixtures is not permitted.

- Where possible, the use of backwater valves that are full-way, normally open type (or devices located at the manhole) are preferred as they are less susceptible to damage or problems related to cable drain cleaning operations.

3.3.3.10 Sanitary Waste Interceptors

- Grease abatement systems shall be provided to prevent the discharge of Fats, Oil, Grease (FOG), and other substances harmful or hazardous to the building drainage system, the public sewer, the private sewage disposal system or the sewage treatment plant or processes.

- Grease abatement systems shall apply to Food Service Establishments (FSE) where food is served to or provided for the public, with or without charge, including, but not limited to restaurants, cafeterias, school kitchens, bars, or any other commercial operation that has the potential to discharge grease laden wastewater.

- Fixtures and equipment shall include, but not be limited to pot sinks; pre-rinse sinks; soup kettles or similar devices; fresh meat cutting and prepping; wok stations; floor drains; floor sinks; automatic hood wash units; and dishwashers.

- Food Waste Disposers shall not be installed on any fixture that requires grease abatement.

- Provide solids interceptors upstream of grease interceptors at fixtures that may discharge solid food waste.

- All grease abatement systems shall receive only stabilized flow from gravity-flow grease waste collection systems and shall not receive pressurized discharge such as from sewage pumps or lift stations. Where pumping is required, grease must be separated prior to the lift station.

- Waste from bathrooms or similar fixtures conveying human waste shall connect directly to the building sanitary drain, and shall not connect through any grease abatement system.

- In general, volume-based grease interceptors shall be located below grade outdoors; or above grade indoors where listed for such applications and within a conditioned space.

- Grease interceptors shall be sized and selected in accordance with the regulations of the Authority Having Jurisdiction.

- Laundries: Laundry facilities not installed within an individual dwelling unit or intended for individual family use shall be equipped with an interceptor with a wire basket or similar device, removable for cleaning, that prevents passage into the drainage system of solids 0.5 in (12.7 mm) or larger in size, string, rags, buttons or other materials detrimental to the public sewage system.

3.3.3.11 Indirect Waste

- Indirect waste connections shall be provided for all plumbing fixtures/equipment that is of public health concern, as well as for equipment drainage as required.

- Food preparation, dishwashing, and ware-washing equipment, autoclaves, ice machines, and similar equipment shall discharge with an appropriate air gap to an approved indirect waste receptor.

- Indirect receptors for food preparation areas and equipment shall be stainless steel floor sinks with appropriate capacity, and with the proper part grate design to eliminate splashing. An internal dome strainer or sediment bucket shall be provided.

- Effluent from autoclaves shall discharge indirectly to a floor drain or floor sink connected to sanitary sewer. Autoclave effluent does not go to waste neutralization treatment.

- Cast-iron floor sinks may be provided in mechanical rooms and similar unfinished areas.

- Floor drains with funnel tops may be used for limited flow applications, such as from ice machines.

- Stainless steel wall outlet boxes connected to a 2” minimum diameter concealed standpipe may be used for various equipment drainage, provided the box is not concealed or inside casework.

- Floor drains and floor sinks shall be installed with their top grate flush to 1/8” below the finished floor, with the finished floor slightly tapered to drain toward the receptor. The installation of floor sinks with rims installed above the floor is not permitted. The only time waste receptors shall be installed with rims above the floor is where specifically necessary to preclude floor drainage from entering the system, such as where a receptor is installed to direct clear water waste to the storm system, or in limited cases where a standpipe receptor/ hub drain is permitted.

- Indirect waste shall not terminate at other plumbing fixtures, including janitor mop sinks, but rather to the appropriate waste receptor.

- Indirect waste shall never terminate over culinary plumbing fixtures or similar applications where use or sanitation is impinged in any manner.

- The use of hub drains and standpipe receptors is not allowed in finished areas because of the potential for trash and debris to enter the drainage system, as well as their unsanitary nature. The interior of these devices is not readily cleanable, and projections above the floor present both sanitation and safety hazards. Such devices, however, may be appropriate in certain mechanical room applications receiving clean wastes, as well as when connected to wall waste outlet boxes.

- Indirect waste receptors shall be installed in readily accessible, normally occupied spaces and shall not be located in toilet rooms, crawl spaces, casework, closets, or any concealed spaces. The one exception is that floor sinks may be located in dedicated walk-in utility connection areas adjacent to sterilizers and similar equipment where such configuration is consistent with the normal equipment installation.

- In locating floor sinks and other indirect waste receptors, the Design Team considers the potential for a waste line stoppage to result in overflow, and ensures the location permits cleanup, constant visual monitoring, and is not likely to cause damage to the building, sanitation issues, or hazard to occupants.
- The placement of indirect waste receptors shall permit removal and cleaning of the sediment bucket or dome strainer and cleaning and mechanical rodding of the device in the event of a stoppage.
- Special care should be applied in locating floors sinks and drains in pits serving lab equipment to ensure accessibility.
- Indirect waste receptors shall be located in the same room as the fixture served, and to minimize the length of indirect waste piping.
- Waste receptors shall be of sufficient depth, and shall be selected to prevent splashing and accommodate peak discharge conditions.
- Undercounter glasswashers and similar equipment shall terminate to adjacent sink wye-branch tailpieces where possible, or may terminate to an accessible unconcealed wall outlet box, or if necessary a funnel top drain or if needed a floor sink.
- Food waste disposers and similar equipment shall not be permitted to discharge through indirect waste receptors, but rather shall be directly connected to the sanitary drainage system.
- As with other drainage systems, the Design Team shall be careful to specify floor sink and floor drain outlet connections that are compatible with the selected waste piping material.
- Floor sinks and floor drains shall be installed to be readily visible, with at least ½ of the grate exposed and removable.
- Floor sinks and floor drains may be fully concealed below equipment only where equipment is readily mobile and elevated over the drain top at least 4”.
- The use of gravity indirect waste lines (including food service and air handling condensate piping) less than 1” diameter shall be avoided, as smaller lines have proven difficult to maintain due to stoppages.
- Plumbing connections to laboratory, vendor designed, and food service equipment shall be included in plumbing documents after coordination with the respective vendor/ consultant.

3.3.3.12 Sanitary Sewerage Pumps

- Only fixtures located below the crown level of the exterior sewer shall be pumped. Where pumped systems are required, equipment is of the duplex type, each capable of discharging 100% of the incoming peak flow in the event of a pump failure.
- Sewage ejectors shall be fed from stand-by power.
- Sewage ejector control panels shall include a dry contact for remote alarm connection to the EMS.
- Pumps shall be commercial grade, submersible type, and provided with lift rail, lead-lag-alternate controls, and designed to preclude single point failure.
- Pumps shall be capable of passing not less than 2 inch diameter solids.

- Basins shall be industrial grade plastic sump of either high density polypropylene or fiberglass construction.

3.3.3.13 Storm Drainage Piping Specialties

- The building storm drain shall extend outside the building and connect to the campus storm sewer system.
- The number and sizes of drains shall be adequate to convey storm water from areas being drained at the same rate as water is collected in those areas. At least two drainage points shall be established for each roof or areaway drainage area, and no roof drain shall have a drain outlet smaller than 3 inches in diameter.
- Roof and deck areas 500 square feet and smaller may be provided with a single drain, provided overflow or other approved relief provisions are incorporated to prevent build-up of water in the event of failure of the primary drain.
- A dedicated secondary emergency roof drainage overflow system shall be provided to serve flat roof areas, except where such roof areas are provided with appropriately sized overflow scuppers. The overflow drain system shall consist of overflow drains installed alongside each roof drain, with a weir 2” to 3” above the roof low point. The system shall be piped independently to discharge through downspout nozzles spilling to the exterior, approximately 12” to 18” above grade. A stainless steel rain cap shall be specified over the top of the overflow roof drain dome grate to prevent intrusion of rainfall during normal conditions.
- Storm drainage leaders (including overflow drains) shall be located in permanent shafts or at building columns. Vertical piping shall be routed as straight as practical, with minimal offsets. An expansion joint or acceptable horizontal offset (swing joint) shall be provided at connections to each roof and overflow drain.
- Drain leaders shall not be located in interior partitions.
- The system design shall avoid placement of horizontal piping above conference spaces, offices, electrical rooms, or other critical areas.
- Where drains are located less than 9” above the elevation of the exterior storm water relief point (e.g. manhole or catch basin grate), automatic backwater valves shall be provided.
- General purpose roof drains shall be cast iron body with nominal 15” outer diameter, combination flashing ring with gravel stop, bottom outlet, extension collar as roof conditions require, under-deck clamp, sump receiver plate and polyethylene leaf guard dome.

3.3.3.14 Rainwater Harvesting Systems

- Rainwater harvesting is permitted for the purposes of flushing water closets and urinals; landscape irrigation systems, and other water handling systems to the extent such rainwater harvesting systems are feasible, reasonable and consistent with the agency mission, program, functionality, and project budget.
- The capturing, harvesting, collection, storage, and filtering of rainwater for the purpose of flushing water closets and urinals shall be designed in accordance with the guidelines of 2007 Virginia Rainwater Harvesting Manual presented by the Cabell Brand Center, Salem, VA; the ASPE/ARCSA Design Handbook or a similar nationally recognized standard. The minimum design standards include the following:
    - The rainwater collected is classified as non-potable and is limited to supplying water closets and urinals only;

  - The installation of the harvesting and reclamation system shall comply with all applicable sections of the VUSBC;
  - The rainwater shall be collected solely from hard surfaced roofs; collection from green or vegetated roofs is not acceptable due to long term water quality problems;
  - Connection to exterior hose bibbs or faucets is prohibited;
  - The collection storage system shall be covered, and preferably underground;
  - The rainwater shall be filtered through a minimum 6 micron filter before supplying to the water closets and urinals;
  - The effluent and first flush from these systems shall be discharged to a storm sewer system;
  - Overflow from tanks shall be connected to the storm water system;
  - The piping systems conveying the rainwater from the system shall be separated from all other piping systems and clearly identified; and
  - The supply rainwater itself shall be colored blue or green with a non-toxic biodegradable dye.

- Rainwater delivered to indoor plumbing fixtures shall meet the minimum water quality standard of limiting fecal coliform to a number less than 2 of a most probable number (MPN) per 100ml and pH levels between 6.5 SU and 7.9 SU.

- Treatment may be required to ensure the quality of the rainwater meets the standards herein. The Design Team shall make the determination as to the required treatment equipment and methods at the onset of the project, but any system shall include the provision for a residual content of a dissolved disinfectant by either chlorination, brominating, hydrogen peroxide solutions or some other accepted disinfectant

- Signage shall be posted in a conspicuous location in each room where rainwater is used. Signage shall be as follows:

NON-POTABLE WATER
RAINWATER USED TO FLUSH
WATER CLOSETS AND URINALS

- The harvesting of rainwater for the sole use in landscape irrigation systems or cooling tower make-up is permitted. Each supplemental potable water supply connection to the irrigation system or cooling tower system shall be protected from backflow in accord with the VUSBC. Any connection to exterior hose bibbs or faucets is prohibited. When rainwater is used for irrigation or cooling tower make-up, the then no dye-marking coloration is required.

3.3.3.15 Emergency Plumbing Fixtures

- Emergency fixture equipment, location and application shall comply with the George Mason University Environmental Health and Safety Office (Mason's EHS) Laboratory Safety Manual.

- Emergency eyewash and shower fixtures shall be provided in pH treatment rooms, hazardous material and chemical storage areas, and other areas where hazardous chemicals are utilized or otherwise deemed necessary through consultation with Mason's EHS.

- In spaces where a significant hazard exists and it is likely a user may be present without supervision, a flow alarm shall be provided to indicate emergency shower operation. Locations where this may be necessary shall be determined through Mason's EHS, and may include areas such as chemical storage and pH treatment system rooms.

- Emergency shower and eyewash equipment shall be fed potable water tempered to a range of 70°F to 90°F, with a recommended setpoint of 85°F which is a few comfortable degrees below average human skin temperature.

- The use of tempered water shall be assessed by Mason's EHS in applications where the chemical exposure my react either chemically or open skin pores and increase the risk of injury. In such cases, cold potable water may be used.

- Tempered water should be generated through semi-instantaneous heat exchangers for the potable hot water supply. When emergency showers are connected, the domestic water heaters shall have a minimum capacity of 2 to 4 showers running (i.e. 40 to 80 gpm tempered, approximately 25 to 50 gpm from the heaters).

- Tempered water supply temperature shall be maintained by an ANSI Z358.1 thermostatic mixing valve. Mixing valves may be centrally located for multiple fixtures, or located at each fixture, whichever suits the building design. Allowable thermostatic mixing valve manufacturers are Lawler, Watts, Bradley or Apollo.

- Where point of use mixing valves are used and supplied by the building potable hot and cold water system, the risers and mains feeding the emergency equipment shall be sized to include the operation of the equipment (20 to 30 gpm).

3.3.3.16 Facility Natural Gas Piping

- Natural gas systems shall be designed per NFPA Standard 54/ANSI Z-223.1, National Fuel Gas Code and 2009 Virginia Fuel Gas Code (2009 IFGC).

- Fuel gas piping distribution systems that serve laboratories shall be low-pressure systems, operating at 7 inches w.c.

- Welded medium pressure natural gas distribution systems of 2 to 5 psi may be used to serve the inlet pressure regulator in food service and mechanical equipment, where justified by the gas load, equipment gas train requirements, and installed in full compliance with 2009 IFGC and serving gas supplier requirements, including proper over-pressure protection.

- Gas services to kitchen appliances shall not exceed 2 psi unless specifically required by individual equipment.

- Commercial kitchen automatic gas shut-off valves shall be interlocked in accordance with applicable codes with Type 1 kitchen hood fire suppression system and shall be labeled.

- Gas distribution systems to food service areas and mechanical equipment shall be separated from the laboratory gas distribution piping starting at the service entrance.

- For laboratories, the volume flow rate required shall be determined from the manufacturer's input ratings.

- Laboratory turret outlets shall be 5 cubic feet per hour and standard diversity factors may be used, but equipment shall be considered at 100% use factor.

- Food service equipment loads shall not be diversified.
- Primary equipment loads shall not be diversified.
- The design pressure loss in the gas piping system shall be such that the supply pressure at any piece of equipment is greater than the minimum pressure required for proper equipment operation.
- A pressure drop of 0.3 inches of water column during periods of maximum design flow is to be used for sizing low-pressure gas installations.
- Pressure drop in medium pressure systems should not exceed 10% of the design distribution pressure.
- Natural gas piping entering laboratories shall first drop down to a local emergency shut-off valve located at the laboratory entrance. This emergency shut-off valve should include the following features:
  - NEMA 1 rated enclosure.
  - A UL listed solenoid valve designed to fail closed on the loss of electrical power.
  - Enable/disable key switch to shut off natural gas to the lab(s) when not occupied.
  - Resettable panic button mounted on panel front.
  - Remote signal to the building fire alarm system upon activation of the panic button.
  - Fire alarm activation signal to the controller to shut down the natural gas to the lab(s) upon activation of the fire alarm.
- Whenever equipment is on wheels or intended to be movable for regular cleaning or usage, the gas connection shall be made with a UL/ AGA listed epoxy-coated stainless steel commercial type gas connectors that is especially designed for movable equipment applications and includes a quick disconnect with integral shut-off and a properly assembled restraining device.
- All connectors shall be properly sized for the required flow rate based on equipment input requirements and maximum allowable pressure drop.
- Gas connections to laboratory equipment and fixed equipment shall be hard-piped, and unions shall not be permitted in concealed, unventilated spaces, including above ceilings.
- The final gas connection below the ceiling to laboratory fume hoods may be made with ASTM A539 welded steel tubing specifically designed for fuel gas lines; however, compression fittings shall not be utilized at any point in a fuel gas system, and joints shall be permitted only at each end.

3.3.3.17 Compressed Air Piping

- Risers for compressed air systems shall be provided as high pressure nominal 100 psi pressure systems, so that laboratories may utilize either high-pressure or low pressure distribution via local pressure-reducing valves at the riser take-offs for each floor to deliver the necessary local or zone low pressure condition.
- Even where high pressure air is not initially required, valved and capped provisions shall be provided at the distribution space or riser take off for each floor, with forethought in system sizing to permit future connections.

- An adequate number of valves shall be provided so as to facilitate maintenance; and to isolate systems for renovations and unexpected emergencies without affecting operation of adjacent spaces. Valves shall be provided as follows:
  - At the source equipment (master shut-off),
  - At the base of each riser,
  - At each riser connection on each floor,
  - At branch piping to each laboratory (generally outside and above the entry door to the lab),
  - At equipment requiring maintenance.
- Compressed air distribution piping shall be OXY/MED copper tubing, ASTM B-819, Type L with BCuP series brazed joints and shall meet the quality requirements established in NFPA 99 for medical oxygen. ACR copper tubing is not allowed due to incompatibilities in pipe and fitting dimensions.
- High-pressure distribution piping systems shall be sized to limit pressure drop to 10% of the system operating pressure. Downstream of local pressure reducing valves, 40 psig laboratory air is distributed to turrets and is sized to limit pressure drop to 3 psi at design demands to the farthest outlet.
- Velocities shall not exceed 4000 ft/min.
- Conventional lab turrets shall provide a flow of 1 cfm at every outlet station. Use standard diversity charts to determine peak loads.
- High pressure air is sized based on projected demand requirements, and detailed programming.
- Special attention should be applied to sizing of systems with regards to quantity and type of high purity gas generators, air tables, and similar equipment which may have high consumption rates and not allow significant application of diversity.

3.3.3.18 Compressed Air Equipment

- A central laboratory compressed air system is typically required for laboratory teaching and research facilities.
- Air compressors shall be of the oil-less or oil-free design with no lubricating oil in contact with the air end of the compressor element.
- Equipment redundancy shall be N+1 and the capacity splits shall be selected to appropriately match the profile demand for maximum energy efficiency. This may include the selection of triplex or quadruplex arrangements of smaller compressors, rather than a duplex set of large compressors at 100% capacity each.
- All compressors shall include an automatic exerciser built into the on-board controller to start and stop the compressor not less than once a week to prevent equipment from sitting idle.
- Compressed air equipment shall tie to the EMS to indicate general/summary fault alarm status.
- In general, air compressors may draw inlet air from the space they are located. Air compressors shall include inlet filters as supplied by the manufacturer.

- The requirement for optional standby power shall be evaluated on an individual program basis, but is typically not required for teaching laboratory systems.

- Provide condensate drainage for intercoolers and aftercoolers over to an adjacent floor drain.

- The discharges from the air compressors shall header together and connect to an ASME rated air receiver sized for 4 to 5 gallons per peak scfm load. For example, an air compressor set sized to provide 150 scfm shall tie to a receiver of 600 to 750 gallons nominal.

- Air receivers shall be provided with a factory applied corrosion resistant coating.

- Air receivers shall be equipped with an ASME pressure relief valve, a pressure indicator, and an automatic drain valve piped over to an adjacent floor drain. In addition, a pressure transducer shall be provided either within the master compressor control panel, a sequencing control panel or on the receiver itself to provide start/stop control to the compressors to maintain system pressure on demand.

- Provide a three valve bypass around the air receiver.

- Provide 3.0 micron pre-filters, 98% efficiency after the receiver. The filters shall be duplexed in parallel for N+1 redundancy. Filter shall be sized for full flow rate at a maximum pressure drop not to exceed 3 psi.

- Provide refrigerated dryers, duplexed in parallel for N+1 redundancy to reduce the pressure dewpoint to a maximum of +40°F.

  - If a lower dewpoint for the central compressed air system is required, provide heat-less desiccant dryer towers duplexed in parallel for N+1 redundancy to achieve a pressure dewpoint of -40°F.

  - In lieu of refrigerated dryers, heat of compression dryers may be considered to reduce purge losses and maximize energy efficiency.

  - When desiccant dryers are used, add 15% of the calculated peak load to the compressor capacity to account for purge losses.

- Provide 1.0 micron final-filters, 98% efficiency after the dryers. The filters shall be duplexed in parallel for N+1 redundancy. Filter shall be sized for full flow rate at a maximum pressure drop not to exceed 3 psi.

- Coordinate heat rejection loads of air cooled equipment with HVAC to ensure adequate ventilation rates. Where water cooled compressors are used, coordinate heat rejection loads as well as required flow rates, temperature rise and operating temperatures with HVAC central chilled water.

- Optional: A final “dry” receiver may be placed after the final filters to serve as a volume of stored energy as well as to moderate the flow through the dryer and filter equipment.

- Final system pressure to the building distribution shall be a nominal 100 psig.

3.3.3.19 Vacuum Piping

- A central laboratory vacuum system is typically required for laboratory teaching and research facilities.

- An adequate number of valves shall be provided so as to facilitate maintenance; and to isolate systems for renovations and unexpected emergencies without affecting operation of adjacent spaces. Valves shall be provided as follows:

- At the source equipment (master shut-off),
- At the base of each riser,
- At each riser connection on each floor,
- At branch piping to each laboratory (generally outside and above the entry door to the lab),
- At equipment requiring maintenance.

- Where valves are located above ceilings, thorough coordination of piping services shall be required to ensure proper access for valve operation.
- Run-outs from horizontal piping serving drops to inlets shall be taken off above the centerline of the main or branch pipe and rise vertically at an angle of not less than 45° from vertical.
- Vacuum piping shall be sized based on an inlet flow of 0.5 scfm using standard diversity factors and an overall system pressure drop not to exceed 3 inches Hg from the furthest inlet to the vacuum source equipment.
- Vacuum distribution piping shall be ASTM B 88 copper water tube, Type L with lead free solder joints.

3.3.3.20 Vacuum Equipment

- Prior to selection of vacuum pumps, evaluate the substance being evacuated and compatibility of the system with any potential chemicals.
- Pumps, whenever possible, shall be of the single-stage, fully recirculating, liquid ring type, designed for use in chemical laboratory or chemical processing, constructed of stainless steel with corrosion resistant mechanical seals and elastomers compatible with laboratory chemical process vapors.
- Oil recirculation vacuum pumps may be used in lieu of liquid ring pumps if the expected ingestion of chemical vapors or liquids is compatible with the seal oil without causing oil viscosity break-down or polymerization.
- The vacuum system should be insensitive to occasional ingestion of liquid slugs as may occur from improper trapping and use at vacuum inlets.
- The system design criteria shall be for 100% of the system peak load to remain upon failure of any one pump. All pumps shall alternate in the appropriate lead-lag sequence and include a pump exerciser function.
- Pump sizing shall be based on an inlet flow of 0.5 scfm using standard laboratory inlet diversity factors.
- Vacuum receivers shall be corrosion resistant and have automatic drain traps to remove moisture from the system.
- The determination to provide standby power shall be made on a per project basis. Local control systems with system operating status and alarm condition readout shall be provided at the equipment, and lead-lag-alternate-minimum run functions shall be included.
- A remote signal-to-building automation system shall be limited to a general fault alarm for each system source.

- The laboratory vacuum system shall be capable of maintaining a vacuum of 19 inches Hg at the inlet terminal farthest from the central vacuum source under peak demand. If deeper vacuums are required, they shall be generated locally with special vacuum pumps in the laboratory or laboratory support area. The system or pumps shall be selected for an operational range of 22 inches to 24 inches Hg.

- Vacuum pumps shall include water resistant HEPA filters at the suction side of the vacuum receiver. The exhaust from vacuum pumps shall be discharged outdoors above the roof and at a minimum distance of 25 feet from air intakes, operable windows or other openings and areas where people may congregate. Exhausts shall be protected from entry of insects, debris or water, typically by turning down the exhaust 180 degrees and installing a bird and insect screen.

3.3.3.21 Pressurized Gas Systems

- Pressurized gas systems for laboratories include nitrogen, carbon dioxide, argon, helium, oxygen and other species of gas required for a particular laboratory program. These systems may fall within one of the three following categories:

  - Point-of-use local cylinder(s) with single stem mounted regulator or panel mounted manifold.

  - Central cylinder bank with automatic switchover manifold assembly.

  - Central cryogenic bulk supply with vaporizer(s) and reserve and switchover manifold assembly.

- The primary supply of central system should typically provide not less than two weeks consumption and at least 3 weeks consumption for bulk systems.

- The reserve supply of bulk systems should be sized for a minimum three days' average consumption or for the period of time required for the gas supply vendor to respond to an unscheduled delivery.

- Point of use cylinders are sized according to the specific program requirements as determined by the user or use group.

- Pressurized gas system shall be distributed at 100 psig and regulated down to local required outlet pressures within the labs or at equipment.

- In general and unless noted otherwise, maximum velocity in distribution systems shall not exceed 4000 feet per minute (fpm), and pressure drop shall not exceed 10% for systems operating above 55 psi, and shall not exceed 3 psi for systems operating below 55 psi.

- An adequate number of valves shall be provided so as to facilitate maintenance; and to isolate systems for renovations and unexpected emergencies without affecting operation of adjacent spaces. Valves shall be provided as follows:

  - At the source equipment (master shut-off),

  - At the base of each riser,

  - At each riser connection on each floor,

  - At branch piping to each laboratory (generally outside and above the entry door to the lab),

  - At equipment requiring maintenance.

- Where valves are located above ceilings, thorough coordination of piping services shall be required to ensure proper access for valve operation.

- All laboratories, art studios and scene shops using or storing gas cylinders must have cylinder storage mounts, racks or floor stands for each cylinder. Mounts must be located at a height that allows for the restraining chain to be placed 3/4 of the way up the cylinder. Cylinders shall comply with 29 CFR 1910.101.

- Cylinders containing oxidizers shall be placed an adequate distance away from flammable gases (a minimum of 25 feet) unless one or both is stored in an approved ventilated cylinder cabinet(s).

- Gas distribution piping shall be OXY/MED copper tubing, ASTM B-819, Type L with BCuP series brazed joints and shall meet the quality requirements established in NFPA 99 for medical oxygen. ACR copper tubing is not allowed due to incompatibilities in pipe and fitting dimensions.

- Cylinder and liquefied gas (e.g. Dewar) interior storage areas shall be monitored by an oxygen depletion sensor(s) if determined to be necessary by Mason’s EHS.

3.3.3.22 Chemical Waste Systems

- Laboratory waste or other special waste and vent systems shall be separate from the general use sanitary system and shall be designed in accordance with the general drainage design considerations (i.e. sizing and venting) for sanitary waste systems.

- This section provides additional system specific requirements. The Design Team shall carefully evaluate sizing of laboratory waste systems. Many items of equipment do not directly correspond to flow rates and values of common Hunter’s Curve fixture unit tables, as the tables are based around flow discharge characteristics of domestic plumbing fixtures and water closets.

- The Design Team shall specify mechanical joint traps under laboratory sinks and fume hoods.

- Borosilicate glass piping is not permitted for direct connections to darkrooms or for vent penetrations through the roof.

- Laboratory waste drainage and vent pipe and fittings, above grade shall be Schedule 40 fire retardant polypropylene (PPFR), ASTM D 4101. Molded fittings per manufacturer system, ASTM D F1412. Heat fusion socket assembly. DWV pattern. Heat fusion method in accordance with ASTM D 2657 and manufacturer’s written instructions.

- Laboratory waste drainage and vent pipe and fittings, below grade shall be either Schedule 40 fire retardant polypropylene (PPFR) or non-fire retardant, ASTM D 4101. Molded fittings per manufacturer system, ASTM D F1412. Heat fusion socket assembly. DWV pattern. Heat fusion method in accordance with ASTM D 2657 and manufacturer’s written instructions.

- In areas requiring plenum rated materials, laboratory waste and vent pipe and fittings shall be either borosilicate glass, ASTM C 1053 or Schedule 40 PVDF, ASTM F 1673.

- Floor drains shall not be located inside laboratories, unless required for the indirect discharge from equipment.

- Floor drains shall not be located at emergency showers.

- All laboratory waste shall be treated through an approved pH adjustment system designed by a licensed professional engineer.

3.3.3.23 Processed Water Systems

- The water quality parameters for central purified systems (i.e. DI, RODI, etc.) shall be established by the users, use group, Design Team consultant and Facilities Management.

- At a minimum, central pure water systems to labs shall be generated at a quality equal to ASTM D 1193 "Standard Specification for Reagent Water," Type III.

- The use of reverse osmosis bulk treatment followed by either electro-deionization or mixed bed deionization will typically achieve ASTM Type III water minimum resistivity of 4.0 megOhm-cm (maximum conductivity of 0.25 µS/cm). However, when this purified water comes into equilibrium with air (most significantly atmospheric carbon dioxide) it typically assumes a conductivity of around 1.0 to 0.7µS/cm without further polishing. Therefore, distribution of purified water at this conductivity range is acceptable as dissolve carbon dioxide is not considered a contaminant of concern.

- Point of use polishing equipment is typically used in individual laboratories to achieve the required grade of high purity water for specific needs.

- In general when central purified water systems are provided they shall consist of the following basic components:

  - Inlet reduced pressure backflow preventer connected to the building potable water system.
  - Pretreatment particulate filtration, regenerative softeners and service carbon filters.
  - 1 micron RO pre-filter.
  - Two-pass reject staged reverse osmosis (RO) skid with a minimum recovery rate of 75% and a rejection rate of 95% to 99%.
  - Post-RO mixed bed deionization or electro-deionization (CEDI).
  - Storage tank with sub-micron hydrophobic vent filter and return spray ball.
  - Distribution pump(s).
  - 245 nm ultraviolet light for microbial control.
  - Sub-micron final filter(s).
  - Return line conductivity cell.
  - Main PLC controller with compatible communication protocol connectivity to the building EMS.

- In general it is not necessary or desired to feed tempered water to the RO system. Elevated temperature promotes formation of biofilm and encourages microbial growth in the system.

- The extent of equipment redundancy shall be determined on a case-by-case basis to meet laboratory user needs.

- Storage tanks should be sized to hold an average 24 hours' supply.

- RO system should be sized to produce the average 24 hours' supply with 8 hours, but shall not have a capacity of less than 1.0 gpm (480 gallons per 8 hour production window).

- Purified water systems shall be of the constantly circulating type, designed such that a minimum velocity corresponding with a turbulence Reynolds Number (Re) of not less than 10,000 is achieved under all conditions, including peak design demand. Higher scouring velocities may be required in some applications, but typically 10,000 to 20,000 Re is adequate.

- The system shall be designed to provide a minimum use pressure of 25 psig at outlets (after polishers), and maximum system pressure shall not exceed 80 psi. Pressure requirements at polisher inlets shall be verified and is typically at least 35 psig.

- For segments of distribution loops where system pressure exceeds 55 psig, a flow control valve prior to the outlet(s) is recommended. A Plast-O-Matic Series FC flow control valve with 1/2" port size set for a flow of 1.0 gpm is a recommended basis of design.

- Dead legs in distribution and return piping shall be minimized to 6 pipe diameters when possible.

- A rotameter and sanitary diaphragm-type valve shall be provided in the return line from each laboratory floor to permit proper balancing and visual indication of flow.

- The piping system distribution on each floor shall be independent of other floors to the connection with the main supply and return riser. Appropriate sampling and sanitation ports shall be provided.

- Distribution pipe material shall be pigmented polypropylene, ASTM D 4101, Type II co-polymer, SDR 11 wall thickness. Socket fusion joints using heat fusion procedures in ASTM D 2657.

- The entire system shall be designed to be chemically cleaned and sanitized.