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The primary aspiration of the building design is to create conditions that foster innovation and effectiveness in research. By reconnecting with fundamental principles in nature, we are able to help researchers connect in new ways with the facility, each other and the community. Cutting edge facilities attract the best and brightest researchers and spur cutting edge research. The building design standards in this document are performance based standards drawn from leading global design solutions that represent best in class examples of high performance laboratories. Such projects and data can be found, in part, in the Labs21 program materials. In addition, each building will be expected to pursue 40% energy savings below ASHRAE 90.1-2007.

Unlike prescriptive standards, the use of performance standards allows the design team flexibility in addressing design issues in unique and innovative ways. The projects will be designed to meet the high levels of specified efficiency for energy, water, materials and indoor environmental quality, and also be measured to verify that they meet these performance standards. While this document will look at performance standards applicable to all occupancy types, the focus will be on research spaces. This is appropriate because more than seventy percent of the Innovation Square site will be devoted to research space. Furthermore, the energy impact of research laboratories is sometimes more than five times that of an equivalent office building. Energy-related design considerations will include such items as energy intensity, fan power, pressure drop, air change rates, lighting power densities, solar heat gain and equipment power densities. Performance requirements will be delineated for various categories of labs that can be broadly categorized as ventilation driven labs and heat gain driven labs. Specific strategies are provided to assist the design team in their approach, but are not explicitly required. A focus will also be centered in the healthfulness of the research environment, including access to daylight and views, healthy materials, and high levels of indoor air quality. Such a performance strategy will translate directly into operational savings for energy and water, and overall occupant satisfaction. Laboratory planning will be highly coordinated with the UFDC representatives to accommodate user needs and projected modifications to the space. Flexible lab design is used to minimize waste and time in laboratory reconfiguration. Over time, the environmental benefit of flexible and adaptable spaces can be large.
Research buildings are complex projects with myriad requirements for programming, spatial relationships, and technical requirements. They require an intensity and rigor in design and execution that is beyond most conventional buildings. And when these buildings are located collectively, in a district or park, the success of each is reinforced by the success of its neighbors.

More than any specific requirement or guideline is the notion that collaboration is critical to the successful operation of research buildings. There are many ways to foster this among the designers, constructors and users of the facilities. Buildings nowadays – especially research laboratories are complex pieces of machinery with many parts - some moving, some static, but all requiring careful attention. The design of these buildings requires different kinds of expertise – architectural, site planning, structural, HVAC and plumbing. Relying upon a multi-disciplinary and collaborative team, the Integrated Design Process provides a means to explore and implement sustainable design principles effectively on a project while staying within budgetary and scheduling constraints. The design of a successful research building should address the following:

- Collaboration and interaction
- Adaptability and flexibility
- Management process

COLLABORATION & INTERACTION

Interdisciplinary research is fundamental to the basic programming strategy of the research facilities. Labs and collaborative spaces should be designed to support human interaction and encourage cross-pollination among disciplines. Work areas should be flexible, inviting and provocative. Open spaces, rather than cubicles, should be filled with energy and activity.
Generous space and equipment are dedicated to collaborative work. Each floor features conference and seminar rooms, and a restaurant and coffee shop beckon interaction. At its core, each building design should recognize that gatherings in social settings are profoundly important science incubators.

ADAPTABILITY & FLEXIBILITY

Another key element of research buildings is adaptability. As the way research is conducted changes, laboratories need to be able to adapt to this change. The setting up of a flexible and adaptable framework for the research lab buildings will allow individual lab groups to rearrange their labs to suit their needs and will allow each lab space to be configured for plug-and-play operations. Researchers can reconfigure their labs with minimal effort and allow for lab floors to be subdivided and sublet with ease. The key to setting up Plug & Play Laboratories is:

- Create wet columns, run MEP vertical risers then plug in at each floor.
- Plan to allow for future MEP systems.
- Design at least 25% of the floor on grade for the most vibration sensitive equipment.
- Provide a zone on each floor with structural module of 21'-4" by 21'-4" to accommodate most vibration sensitive equipment but not necessarily the most sensitive equipment.

Building component dimensions are also critical to creating adaptable, efficient and highly operational lab environments, as well as for providing natural light and air for the researchers. Typically, the basic lab module size is 10'-8". It is recommended the building grid be based on lab module in north/south as well as east/west orientation for highest flexibility. This module should work for office and research space to allow for the building use to change over time with minimal cost. It is recommended the structural grid be based on the 10'-8" module in both orientations. This will allow casework to be laid out in more options and provide a more flexible laboratory facility. It is recommended core labs be located in highly visible locations that are seen from within and outside the building.

Along with the module dimension, the building depth is also critical. The dimensions below are assumed from center of column. To include exterior wall limits, assume 1'-8" (0.5m) beyond the centerline for dimensions in all directions. To estimate the penthouse area of a proposed research building, assume 12-14% of the total gross square feet (gsf) of the occupied floors.
32’ depth - 3 Lab Modules
This should allow for natural light through most of the building during most of the day time. This depth is very consistent to many European projects to encourage light and views for all spaces. A single corridor may be introduced if deemed necessary.

64’ depth - 6 Lab Modules
This is a fairly standard “western” floor depth. A single corridor is recommended at this depth.

96’ depth - 9 Lab Modules
This is a large depth primarily seen in the United States for projects built over the past 25 years because of efficiency and cost. Many times this depth requires at least two corridors. This divides researchers and creates space in the middle of the building with little or no views. The large “pancake” may be desirable for some research, but is only recommended in specific situations based on the type of research envisioned.

Most studies indicate a floor plate with 25,000 gsf or higher is very efficient for the mechanical systems, elevators, number of stairs, number of closets for data and electric and convenience to rest room facilities. When the floor plate becomes 35,000 gsf or larger, then many of the core services will need to be duplicated. Based on the best practices for widths, the length of the research floors is determined as follows:

- Building depth of 64’; recommend building length from 375 to 450 linear feet.
- Building depth of 96’; recommend building length from 255 to 355 linear feet.
- Building depth of 117’4”; recommend building length from 205 to 290 linear feet.

The recommended building height is a minimum of three floors to provide construction cost and operational cost efficiencies. Also two flights of stairs are usually considered the maximum for people to use on a daily basis. More floors may be acceptable depending on the location in the master plan and overall proposed site development. Depending on the type of research, the amount of toxic chemical may limit some research buildings or require labs above the fourth floor without chemicals.

A tight lower floor-to-floor height will be difficult to construct and then renovate during the life of the building. History has shown slightly higher floor-to-floor heights will be easier to construct and maintain for research buildings. To insure adaptability and usability, a minimum of 15 ft floor-to-floor height is recommended. Slightly higher floor-to-floor heights are acceptable and high bay spaces are acceptable as required.
LEAN MANAGEMENT PROCESS
The research industry is beginning to re-evaluate the way it works and is attempting to be more scientific in its research process. Some pharmaceutical companies, for example, are beginning to manage their research processes in the same way that they manage their manufacturing processes—the daily work flows are being studied, challenged, and simplified. There are several variations of the lean-management process that focus on improving the “science of science.” The following are some key points.

SORT AND THROW AWAY
The research team is asked to look over what is in their lab and determine if it is still necessary. If the supply is not necessary then it is thrown out with the intent of keeping the laboratory clean.

STORE, HAS A HOME, AND IS LABELED
What needs to be stored is determined and a place is found then labeled to help organize the lab. KanBan is a Japanese approach to managing supplies. A sign board lists all the necessary lab supplies along with the lowest acceptable amount before more supplies need to be ordered. This minimizes storage costs, wasted space, and clutter in the lab.

SUSTAIN
Manage and set up routines during the day and over the week to make effective use of people’s time. The research team evaluates work flow, then modifies the lab to support a more effective organization. If this process is done correctly then the research team should be able to work efficiently in the same area.

Innovation Square will have warehouse-storage facilities near the district to bring supplies in each day. Supplies in the labs will be stored only for short durations with off-site storage in close proximity. This means research buildings should be used more for research and less for storage. This also means less storage will provide more flexibility to change and accommodate the research programs.

From an operational perspective, the projects should embrace cutting-edge management and technical processes. For example, the operating system for the high-throughput laboratory enables secure access worldwide, allows tests to be carried out in a flexible manner, schedules and performs numerous tests on a routine basis and deposits test results into large databases. The operating system permits scientists to connect to the high-throughput laboratory by way of the Internet or secure intranets. A set of process-control tools are then used to program and manage all the necessary steps for the design of tests, documentation of samples, submission of samples and the analysis of data. An extensive collection of samples can be achieved through a concerted worldwide effort. High-throughput laboratories and database networks will facilitate efforts taking place in public health, agricultural, emergency response, law enforcement and intelligence and national-security communities. Most spaces should be capable of being completely reconfigured within 24 hours.

All of these guidelines and recommendations lead to a vibrant and productive research environment, and further alivable district that supports the free exchange of ideas and the production of knowledge that will lead to innovations for the coming century.
To better understand the environmental impacts and recommend strategies we can look at labs in two broad typological categories: Ventilation Driven and Heat Gain Driven.
The principal sustainable design approach for Innovation Square should be to first study loads (ventilation, thermal, lighting etc) and address them. After that, the goal should be to meet the loads more efficiently, and lastly meet the remaining demand with sustainable energy sources.

To better understand the environmental impacts and recommend strategies we can look at labs in two broad categories: Ventilation Driven and Heat Gain Driven Labs.

**VENTILATION DRIVEN LABS**

These are labs where the ventilation loads in the lab dominate the energy usage and HVAC design. The quantity of air moved through these labs is a result of health and safety issues, and could either be driven by exhaust from lab equipment (like fume hoods and snorkels) or from minimum ventilation requirements to maintain health and safety in the lab.

**ISSUES AND POTENTIAL PROBLEMS**

- Occupied air change rates – question the norms.
- Duct airspeeds – higher air velocities in ducts cause noise disturbance as well as increase fan energy.
- System pressure drops – static pressure drops in ducts leads to high fan energy consumption. Care should be taken to reduce pressure drops in ductwork.
- Fumehood density – for a 10' ceiling, 8 linear feet of hood will give you more than 6 air changes per hour for a 32'x32' lab (9 modules).
- Treating large quantities of air creates high energy use.
- Larger air volumes create larger duct sizes.
- If the supply air temperature is not managed, there is potential for overcooling spaces and the need for reheat.
<table>
<thead>
<tr>
<th>STRATEGIES</th>
<th>VENTILATION DRIVEN LABS</th>
<th>HEAT GAIN DRIVEN LABS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contaminant sensors to allow for lower air change rates</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Use high performance, Low Flow Hoods</td>
<td>●</td>
<td>●</td>
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<tr>
<td>Underfloor Air Distribution</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Use Relief Air From Offices as Make Up Air</td>
<td>●</td>
<td>○</td>
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<tr>
<td>Zone For Heat Gain</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Chilled Beams</td>
<td>○</td>
<td>●</td>
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<tr>
<td>Radiant Ceilings</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Natural Ventilation</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Daylighting</td>
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</tr>
<tr>
<td>Night Temperature Setback</td>
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<td>○</td>
</tr>
<tr>
<td>Condensate Heat Recovery</td>
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<td>●</td>
</tr>
<tr>
<td>Energy Recovery &amp; Enthalpy Wheels</td>
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<td>●</td>
</tr>
<tr>
<td>Supply Air Temperature Reset</td>
<td>●</td>
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<tr>
<td>Solar Orientation and Shading</td>
<td>●</td>
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</tr>
<tr>
<td>Thermal Storage to Reduce Cooling Peak Loads</td>
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<tr>
<td>Cogeneration/ Tri Generation</td>
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<tr>
<td>Solar Energy (Thermal and Electric)</td>
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</tr>
<tr>
<td>Carbon Cap and Trade Between Tenants</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Bay Water Heat Rejection</td>
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<td>●</td>
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<tr>
<td>Waste Water Heat recovery</td>
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<tr>
<td>Purchasing Plans for High Efficiency Equipment</td>
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<td>●</td>
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<tr>
<td>Effluent Modeling</td>
<td>●</td>
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<tr>
<td>Measurement &amp; Verification to Inform Benchmarks</td>
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<td>●</td>
</tr>
<tr>
<td>Submetering for M&amp;V</td>
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</table>

<table>
<thead>
<tr>
<th>BENCHMARKS</th>
<th>VENTILATION DRIVEN LABS</th>
<th>HEAT GAIN DRIVEN LABS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Use Intensity MJ/m²-yr (kBTU/ft²-yr)</td>
<td>2000-3500 (180-320)</td>
<td>2000-3500 (180-320)</td>
</tr>
<tr>
<td>Carbon Emission Intensity kg/m²-yr (lbs/ft²-yr)</td>
<td>225-375 (50-75)</td>
<td>225-375 (50-75)</td>
</tr>
<tr>
<td>Outside Air Changes per Hour (for a 10’ ceiling)</td>
<td>&gt;6 occupied, 2-4 unoccupied</td>
<td>&lt;4 occupied</td>
</tr>
<tr>
<td>Lighting Power Density - W/m² (w/ft²)</td>
<td>10.8 (1.0) - 11.8 (1.1)</td>
<td>10.8 (1.0) - 11.8 (1.1)</td>
</tr>
<tr>
<td>Equipment Power Density - W/m² (w/ft²)</td>
<td>10.8 (1.0) - 43 (4.0)</td>
<td>53.8 (5.0) - 161.4 (15.0)</td>
</tr>
<tr>
<td>Cooling Power Density - m²/Ton (ft²/Ton)</td>
<td>15 - 30 (150-300)</td>
<td>16 - 30 (150-300)</td>
</tr>
<tr>
<td>Fan Power Efficiency - kW/L-s (kW/cfm)</td>
<td>0.14 - 0.32 (0.3 - 0.6)</td>
<td>0.14 - 0.32 (0.3 - 0.6)</td>
</tr>
<tr>
<td>Total System Static Pressure - kPa (inches of Water)</td>
<td>1.25 (5)</td>
<td>1.25 (5)</td>
</tr>
</tbody>
</table>
DESIGN STRATEGIES

- Right size ventilation loads. Where fumehoods are not driving ventilation, consider reducing occupied air change rates to 4 air changes per hour during occupied mode and 2 air changes per hour during unoccupied mode with the use of air sampling technology (like the Aircuity system).

- Where fumehoods are driving up the ventilation loads, consider switching to low flow hoods and variable air volume hoods. With proximity sensors

- Reduce pressure drop in ducts by reducing duct airspeed. This could mean larger ceiling plenums.

- Supply air temperature supply at near neutral temperatures (68°F). Use chilled beams in labs that have a higher heat load.

- With high ventilation volumes in humid climates there is a large amount of energy that goes into dehumidification (around 7 times the sensible cooling load). The condensate from this process can be stored for toilet flushing. Before that however, it can be used to pre-cool incoming air.

- Relief air from the office areas could be cascaded as make up air into these spaces.

- Recover energy from general lab exhaust using dual wheel technologies (enthalpy wheel coupled with a sensible wheel for reheat).

LAB SPECIFIC BENCHMARKS

- Maximum air handler airspeed: 350 fpm
- Total system pressure drop: 5 inches of water
- Air Changes: 4 air changes per hour occupied, 2 air changes per hour unoccupied. This should be used only with contaminant detection systems like the Aircuity system.
- Alternatively, use Outside Air cfm/ ft² (this takes out the ceiling height from the equation). The benchmark is 0.67 cfm/ft² occupied, and 0.33 cfm/ft² unoccupied.
- Fan Power - kW/L-s: 0.14kW/L-s (0.3kW/ft²) - 0.32kW/ L-s (0.6kW/cfm).
- Lighting Power Density - Keep it under 1.1w/ft². High performance labs should keep it under 1.0w/ft². This number should include task lighting.
- Solar heat gain - keep below 1.0w/ft².
- Equipment power density - 1-4 w/ft². Anything higher will make internal heat gain the main driver in the lab and the lab will no longer fall into this category.

HEAT GAIN DRIVEN LABS

In these labs the HVAC loads are driven by internal heat gain from lights and equipment. Some of these labs need 100% outside air to prevent contamination of material in the labs, while others can use re-circulated air as they are similar to office spaces but with heavier equipment loads. In all these spaces the air change rate is driven by the cooling loads and not ventilation needs.

ISSUES & POTENTIAL PROBLEMS

- Occupied air change rates –question the norms. Often more air is circulated through labs than is necessary to maintain a good indoor air quality.

- Supplying 100% outside air for cooling purposes is inefficient
Solar heat gain and electric lights will add to the heat loads.

Natural ventilation is not possible because of potential contamination.

If these labs share an air handler with other labs, they will likely drive the supply air temperature down – causing reheat in other labs.

Heat loads in these labs can sometime drive air changes up to 15 air changes per hour – requiring the treatment of large quantities of outside air just for cooling.

Increased duct and fan energy to supply air to cool these spaces.

In retrofit labs if there is an increase in internal heat gain, sometimes there is not enough room to expand ductwork.

**DESIGN STRATEGIES**

- Right size ventilation loads and meet the heat loads hydronically. Chilled beams are a good way to do this. Other strategies include fan coils and radiant ceilings.
- Reduce lighting power densities – additional heat gain makes the problem worse. Reduce lighting loads further with daylight sensors.
- Reduce solar heat gain with good orientation and shading strategies. Keep peak solar gain to below 1.0w/ft² peak.
- Incorporate purchasing plans for equipment that favor high efficiency lab equipment.
- Labs should have a +/- 4.5°F degree temperature tolerance. Set back temperatures at night.
- Zone for heat gain.
- Design cooling for coincident peak loads factoring in scheduling and equipment diversity.

**BENCHMARKS**

- Lighting Power Density - Keep it under 1.1w/ft². High performance labs should keep it under 1.0w/ft². This number should include task lighting.
- Solar heat gain - keep below 1.0w/ft².
- Equipment power density - 5-15 w/ft².

**DESIGN STRATEGIES & BENCHMARKS COMMON TO ALL LABORATORIES**

**DESIGN STRATEGIES**

- Right size ventilation loads and meet the heat loads hydronically. Chilled beams are a good way to do this. Radiant Ceilings and Fan coils are another alternative.
- Waste water heat recovery - use it to preheat incoming water.
- Use condensate for pre-cooling incoming air.
- Use energy recovery from lab exhaust. Where possible, use dual wheel technology to maximize energy recovered.
- Use thermal storage (chilled water/ice) to reduce peak loads at the central plant. This might not necessarily save energy overall, but it could be useful to reduce peak loads and possibly reduce chiller sizes.
- Study the feasibility of cogeneration and trigeneration.
These are good strategies to reduce carbon emissions by using the waste heat from the electricity generation process to produce chilled water and hot water. Absorption chillers could also be run off solar thermal energy.

- One strategy to encourage innovation with tenants is to set carbon caps per tenant to create a small-scale localized cap and trade program within the facility.

- Effluent modeling: Use either mathematical or physical models to assure design compliance with OSHA standards.

- Provide extensive commissioning services for the project including in-situ commissioning of fume hoods.

- Measurement & Verification: While this is not explicitly a design strategy, measurement and verification is an important tool to be used to inform the design process - especially project benchmarks. The measurement and verification process should cover at least one year of post-occupancy and should include a plan for corrective action if the anticipated energy targets are not met. When buildings are designed to be sub-let, each tenant space should be submetered. The energy model should be recalibrated based on the M&V results and the recalibration should be used to inform future models.

- Shades: Addressing issues of shade is critical to the success of the project. Shading is essential for both thermal and visual comfort. Interior spaces in buildings should be shaded carefully. Direct sun strikes increase thermal loads on spaces, and also increase glare - reducing the potential for day lighting. All buildings should minimize direct sun strikes to the interior in the summer but utilize diffused sunlight for day lighting with sun shades and light shelves. Some spaces can use winter sun for passive solar heat gain.

BENCHMARKS

- Energy Use Intensity: 2000-3500 MJ/m²-yr (180-320 kBTU/ft²-yr)
- Carbon Emission Intensity (measured in Kg of CO2 equivalent per square foot per year). Recommended range: 225-375 kg/m²-yr (50 -75 lbs/ft²).
- Lighting Power Density - Keep it under 11.8 w/m² (1.1w/ft²). High performance labs should keep it under 10.8 w/m² (1.0w/ft²). This number should include task lighting.
- Solar heat gain - keep below 10.8 w/m² (1.0w/ft²).

SUSTAINABLE PROJECT DELIVERY

After establishing appropriate goals and big picture strategies in Stage One, the design team will continue to develop, monitor and integrate these goals throughout project delivery. The integrated design approach will continue through each project phase and should include at the minimum, the following milestones:

SCHEMATIC DESIGN

- Conduct design charrettes to set project vision and goals
- Review initial sustainable design concepts and strategies
- Identify synergies between design strategies and disciplines
• Prepare preliminary energy model to test and inform design strategies
• Prepare preliminary carbon assessment and identify opportunities
• Prepare preliminary daylight analysis
• Optimize key district systems – chilled water, steam/hot water, energy, graywater and wastewater
• Where applicable, review LEED documentation and certification process with the UFDC and design team
• Develop sustainable construction plans for recycled, regional and other materials

DESIGN DEVELOPMENT
• Develop detailed design strategies for mechanical and electrical systems
• Engage Commissioning Agent
• Run energy efficiency measures in energy model to improve design and confirm strategies
• Perform lifecycle analysis on energy efficiency measures. All measures with simple paybacks below 10 years are highly encouraged and ones with payback periods below 15 years should be considered.
• Continue to develop daylight analysis to inform the design
• Identify specific manufacturers and suppliers of green products
• Where applicable, monitor progress of LEED documentation and update checklist
• Identify areas of opportunity or challenge
• Ensure contractor is positioned to deliver sustainable construction practices

CONSTRUCTION DOCUMENTS
• Where applicable, ensure LEED credit requirements and reference standards are embedded within the project specifications and construction documents. Continue credit documentation and submit LEED Design Phase credits for review
• Contractor will have an erosion and sedimentation control plan, construction waste management plan, plans to achieve regional, recycled, FSC and low-VOC material targets, air quality management plans, and if applicable, a fundamental commissioning plan in place at the onset of construction.

POST OCCUPANCY
The first step towards understanding building performance metrics and consumption patterns is to measure performance and consumption. Innovation Square should be designed with this in mind. A comprehensive metering program should be put in place to measure the following:
• Individual buildings should be metered for electricity, water, chilled water, hot water and fuel consumption.
• In addition, individual labs should be metered for all process consumption including process (equipment) electricity, process water, and process chilled water.
• Metered data should be stored in an archive database on a monthly basis to enable the extrapolation of monthly and seasonal consumption trends.
WATER MANAGEMENT, RESEARCH BUILDING GUIDELINES.
Historically clean and plentiful water resources were the foundation stones of civilization – whether it was the Nile Valley, Tigris or the Indus valley. This simple truth holds true even today – water is fundamental to our development, and how we handle our water resources is key to our future. Water issues are even more pertinent in the Southeast United States with a recent study at Columbia University tying the shortage to population growth. We cannot have population and economic growth in the region without addressing our need for water.

According to the Lawrence Berkeley National Laboratories, approximately 3 percent of total U.S. electricity is used in the municipal water and wastewater sector. As much as one-quarter to one-half of the electricity used by most U.S. cities is consumed at municipal water and wastewater treatment facilities. A significant portion of this energy is devoted to pumping water from the treatment facility to the point of use.

Because of the scarcity of available water resources and the energy intensity of transporting water, it makes economic and environmental sense to minimize the amount of water used. This can be addressed by demand control – using low flow fixtures inside the buildings, and minimizing irrigation needs for landscaping. The water issue should also be addressed on the supply side – collecting rainwater and graywater locally and supplying it to buildings for non-potable uses like flushing and irrigation. One of the potential issues with using graywater for flushing is that the utilities typically base the sewage charges off potable water usage and so a separate method of billing will need to be devised for a situation where graywater is used for flushing. In the proposal for Innovation Square the graywater supply will also be a utility and as such can also be metered, so this should not be a problem for this project.

Recognizing the regional scarcity of water and the available, cost effective, technologies for appropriate water management, water should be considered throughout the design.
In general, water can be divided into multiple categories depending on the required use of the water, including potable water, grey water and black water.

Potable water is cleaned to the highest standard and will be used for drinking, lavatories, showers and research laboratories. Higher standards for research water will be considered on a building basis depending on research demands.

**DESIGN STRATEGY**
- The district plan will maintain the natural hydrology of the site.
- Stormwater will be managed appropriately on site so as to not increase the amount of stormwater that runs off the site. Stormwater from roads and parking lots will be appropriately treated to reduce any potential contaminants.
- Irrigation will be minimized through strategic plantings, the use of adapted and native plants, high efficiency irrigation system, and the use of non-potable treated water.
- Domestic water demand will be reduced through the use of high performance, low-flow domestic lavatory faucets, toilets and showers. Such fixtures are standardized and widely available.
- Condensate should be collected in all buildings and used for flushing toilets and irrigation.
- No once through water for cooling on any scale; building or district.
- Any wash equipment should utilize efficient rinse cycles.
- RO discharge will be captured and combined with grey water or condensate.
- No garbage disposals.
- Reduce process water by 20%.
- Reduce the use of bottled water by providing a quality drinking water system across district.
- Ensure measurement and verification systems are in the design to collect data and monitor water use across district. All water data should be collected and made public.

**BUILDING WATER BENCHMARKS**
- The total domestic water use should achieve a minimum of 75% efficiency below the LEED 2009 Water Efficiency Credit 3.
- EPA WaterSense Standards will be used:
  - Water closets (gpf): 1.28
  - Urinals (gpf): 0.13
  - Showerheads (gpm): 1.5-2
  - Private lavatory faucents (gpm): 1.5
- UPC/IPC Standards will be used:
  - Public lavatory (gpf): 0.5
  - Public metering lavatory faucets (gpc): 0.25
  - Kitchen and janitor sink faucets (gpm): 2.2
  - Metering faucets (gpc): 0.25
- 20% process water reduction measured against LEED 2009 Water Efficiency Credit 4.

*EPA water sense is 0.5 spf, but 0.13 is available and practical.*
Indoor environmental quality will be considered a major aspect of the design and construction of the facilities. Researchers will have comfortable and inviting spaces in which they can conduct research. Occupant comfort is widely accepted to increase productivity, health, and wellbeing for researchers, and foster innovation in research. Indoor environmental quality will be addressed through indoor air quality, controllability of systems, and daylighting of the spaces. Smoking will be prohibited on the campus.

**INDOOR AIR QUALITY**

Indoor air quality will be emphasized through improved ventilation, CO2 monitoring, and architectural and systems design that appropriately manages indoor pollutants such as dust & pollen through an in-track system at entryways, and the appropriate ventilation of areas that contain potential air quality hazards including cleaning supplies, chemical storage, and high volume copying.

In addition, only healthful low-VOC materials will be used in construction, including:

- Adhesives & sealants in accordance with LEED 2009 IEQ Credit 4.1
- Paints & coatings in accordance with LEED 2009 IEQ Credit 4.2
- Carpet systems in accordance with LEED 2009 IEQ Credit 4.3
- Composite wood & agrifiber products in accordance with LEED 2009 IEQ Credit 4.4

Beyond LEED requirements required for the above, it is also recommended that the projects pursue the Living Building Challenge Petal 11 for Materials Red List (https://lbi.org/lbc/Standard-Documents/LBC2-0.pdf). With few exceptions for which there are no alternatives,
the projects and all building materials and projects should NOT contain any of the following materials or chemicals:

- Asbestos
- Cadmium
- Chlorinated Polyethylene and Chlorosulfonated Polyethylene
- Chlorofluorocarbons (CFCs)
- Chloroprene (Neoprene)
- Formaldehyde (added)
- Halogenated Flame Retardants
- Hydrochlorofluorocarbons (HCFCs)
- Lead (added)
- Mercury
- Petrochemical Fertilizers and Pesticides
- Phthalates
- Polyvinyl Chloride (PVC)
- Wood treatments containing Creosote, Arsenic or Pentachlorophenol

Entryways must have an external sand and dirt track-in system and an internal sand and dirt track-in system contained within a separate entry space. All kitchens, bathrooms, copy rooms, janitorial closets and chemical storage spaces must be separately ventilated and exhaust directly to outside air.

CONTROLABILITY OF SYSTEMS
To accommodate the individual comfort parameters of researchers, the buildings will be designed with a high controllability of systems. All researchers will have access
to lighting controls in each office, multi-occupant space and work station. Task lighting will be provided accordingly and its use will result in lower ambient levels of lighting.

Each space for which occupant control of another indoor environmental parameter is possible, should be designed for the occupant to have control. This includes potential controls for temperature, radiant temperature, humidity, or air speed. This is generally achieved through the provision of thermostatic controls in office spaces. Operable windows may be explored for appropriate spaces and if used, should be connected to the mechanical system to optimize the design.

**DAYLIGHTING**

Daylight and views will be provided to the greatest extent possible to areas in which occupants would benefit from receiving daylight. Through the use of advanced daylight modeling programs, daylight will be optimized with the use of appropriately sized glazing and transparency, ceiling height and interior and exterior solar and daylight controls. The extent of daylight will in part be balanced with potential energy implications including solar heat gain, and reduction in electrical lighting use. Laboratories will foster transparency through interior glazing and open labs. The use of façade glazing should be used appropriately and shouldn’t exceed 45%. Daylight will penetrate from the north and south roughly 25-30 feet with proper controls.
Materials considerations are broken down into four general sections; materials handling and use during operations, materials for construction, and recycling during construction and operation. Each of these has considerable design and construction implications and provides an opportunity to create a healthy and effective research environment.

**MATERIALS HANDLING & USE DURING CONSTRUCTION**

**Just In Time Inventory**

By centralizing the storage of dry good within each building and the district as a whole, more effective purchasing may be implemented. The benefits to this approach include:

- A reduction in purchasing costs with central bulk purchasing
- Reduced energy use in labs as materials can be stored in designated areas rather than highly ventilated laboratories – thereby allowing researchers more bench room.
- With centralized purchasing, it makes it easier for researchers and lab managers to purchase preferred recycled content and regional materials to support the local economy. Without centralized purchasing, each lab manager would have to spend time researching preferred vendors.

The challenge to developing a district wide inventory system will be to address the needs of multiple owners and tenants. It is recommended to develop centralized storage on a tenant by tenant basis after examining the chemical inventory for the tenant.

**Chemical Management**

Through the use of chemical tracking tools, chemicals can be managed more effectively to reduce purchasing costs, enhance safety, and reduce potentially hazardous and costly waste streams.

The MIT Green Chemical Alternatives Purchasing Wizard is a tool used for researching and
purchasing less hazardous chemical alternatives. http://ehs.mit.edu/greenchem/

The U.S. Environmental Protection Agency has also summarized key green chemistry resources http://www.epa.gov/greenchemistry/pubs/tools.html

In addition, a commitment to green chemistry can reduce the number of fume hoods required in a laboratory, thereby reducing capital and operational expenditures, as well as allow for increased daylighting in the space, sightlines across the lab, and reduced storage and disposal costs for chemicals.

MATERIALS FOR CONSTRUCTION

Construction materials will be considered with green materials in mind. The contractor will give preference to regional and recycled content materials and also pursue the use of FSC certified wood products if it is deemed feasible.

While the LEED Green Building Rating System offers credit for regional, recycled content, FSC and low VOC materials, healthy research environments can move to eliminate a large range of toxins and associated materials impacts from the built facility through materials selection.

- A minimum of 30% recycled content materials will be used on the project.
- A minimum of 30% regional materials will be used on the project.
- Interior finishes will consist of rapidly renewable and certified wood sources where feasible and appropriate. All interior finishes can be expected to meet stringent indoor air quality standards for VOC emissions.
- Over 75% of construction waste will be recycled as a base construction activity. Recycling will continue as the building is operational through the use of provided recycling receptacles throughout the building design.
- Recycling during Construction and operation
- Major construction materials should be in part considered through a lens of total embodied energy to determine relative carbon footprint of the materials. Such a consideration will set the stage for comprehensive carbon inventory of the district and potential trading schemes among tenants.

The Perkins+Will Precautionary List outlines substances for which there is sufficient evidence that they are detrimental to human and environmental health.( http://transparency.perkinswill.com/)

The Living Building Challenge also outlines a “red list” of materials: http://ilbi.org/the-standard/LBC2-0.pdf. The Living Building Challenge is a forward thinking design standard that aims to position all design and construction activities as beneficial to human and environmental health.