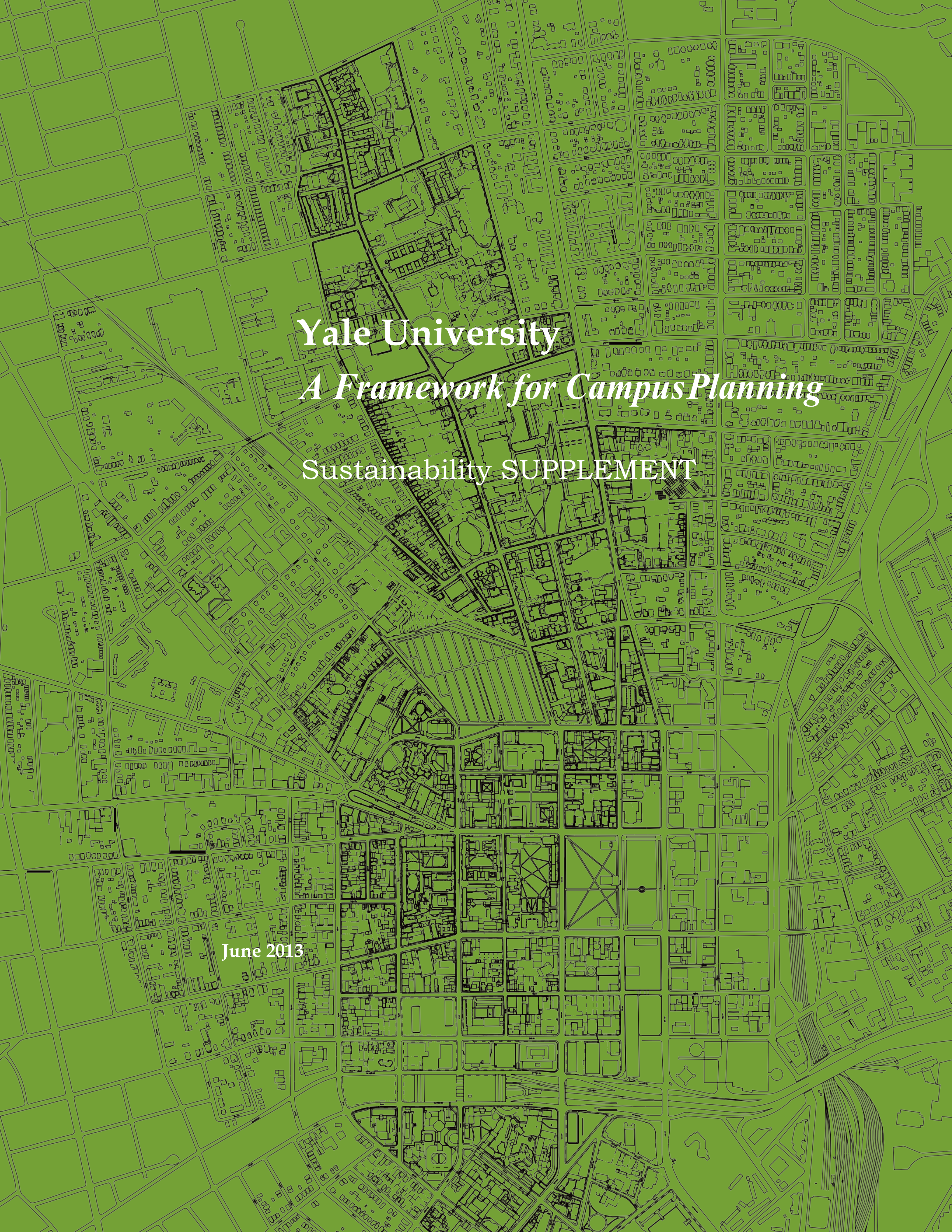

Yale University

A Framework for Campus Planning

Sustainability SUPPLEMENT

June 2013

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A Framework for Campus Planning
Sustainability Supplement

contents

1. INTRODUCTION

2001 The Advisory Committee on Environmental Management (ACEM) established

2003-2004 YSFP pilots fully seasonal, local, and sustainable menus at Berkeley College dining hall

2002 Yale endorses Environmental Principles proposed by ACEM

2006 Sterling Hall of Medicine C3 Laboratory is first LEED CI certified lab in the US

2005 GHG Reduction Commitment signed by President Levin

2004 Hydrogen fuel cell receives award from the EPA

2005 Parking discount for carpoolers

2006 Buses begin to operate on 100% biodiesel fuel

2007 First solar installation at Fisher Hall

2007 Transportation Options created

2008 Athletics creates Bulldog Sustain-ability

2009 The Yale Community Carbon Fund launched

2009 Micro wind turbines installed on Becton Engineering and Applied Sciences Center

2011 Cogeneration facility at Sterling Power Plant is operational

2010 Building occupancy training program launched

2010 Department Zipcar share launched

2011 11.5% emissions reduction from 2005 achieved

2013 Zagster bike sharing program piloted

2012 Yale moves to single stream recycling

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013

2002 The Yale Sustainable Food Project (YSFP) is founded

2003 First annual Spring Salvage of dormitory furnishings

2005 Yale Office of Sustainability created

2005 Chemistry Research Building is Yale's LEED pilot project

2007 Zipcar program initiated

2007 Bike racks installed on Yale shuttles

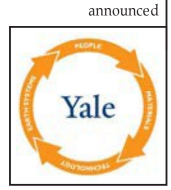
2007 Sculpture Building is Connecticut's first LEED platinum building

2008 Desk side recycling imple-mented

2009 All new construction & renovations mandated to meet LEED Gold or higher

2010 Composting food waste at all residential dining halls is launched

2010 Sustainability Strategic Plan 2010-2013 announced



2011 Compost Tea Study initiated

2012 University recognized as Connecticut's first bicycle friendly school

2012 First compressed natural gas vehicles purchased for fleet

2013 Sustainability Strategic Plan 2013-2016 announced

Sustainability Highlights 2001–2013

INTRODUCTION

Yale has made a significant commitment to sustainability in the past decade. In particular, Yale's pledge to reduce its campus greenhouse gas emissions 43 % below 2005 levels by 2020 is a primary driver for energy conservation and e∞ciency. Other examples of this commitment range from the University's increased recycling rates to the inclusion of sustainable food within its dining halls. Since campus planning helps define many aspects of the University's future function and feel, the adoption of this Sustainability Supplement to the Framework for Campus Planning is essential to guide a sustainable approach to the planning, building, and maintenance of Yale's campus. Further, this supplement supports and aligns with the Yale University Sustainability Strategic Plan.

This document together with the 2000 Framework for Campus Planning and the 2009 Supplement, is intended to be used by all those involved in the planning, design, and management of Yale's campus: planners, architects, engineers, consultants, and facilities sta≠. In addition, users are expected to review current Yale reference documents, such as the Sustainability Strategic Plan, for current institutional goals, and the Yale Design Standards for specific minimum requirements, preferred products, and materials (see Section7. References).

The supplement articulates seven interrelated Sustainability Planning Principles that apply to three Campus Framework Systems: Buildings, Landscape, and Utilities. The recommended sustainability approaches for each of these Campus Framework Systems are organized by six Areas of Focus: Energy, Air, Water, Land, Movement, and Materials. The "Precinct Considerations" section highlights the sustainability recommendations that are most applicable to each of the eight campus precincts. The precincts, which are based on geographic characteristics and programmatic needs, are the seven described in the 2000 Framework for Campus Planning plus the new West Campus precinct.

While this supplement describes a full range of sustainability concerns for Yale, the responsible management of energy and water is emphasized. To support the University's mission in the context of threats of environmental degradation, planning a resilient campus is paramount. To ensure resiliency, Yale prioritizes reduced energy consumption (and concomitant reductions in greenhouse gas emissions) and water management that reduces demand for potable water and improves water quality.

The Facilities O∞ce will review all its capital projects to assess the appropriate integration of recommendations set forth within this document. Design teams are expected to consider all recommendations herein, with implementation based on project-by-project feasibility and applicability. This supplement will periodically be reissued as Yale's current approach to sustainability will continue to be modified through an iterative process in the context of evolving sustainable technologies and campus accomplishments.

2. SUSTAINABILITY CAMPUS PLANNING PRINCIPLES


Yale University and the City of New Haven are inextricably woven together.

SUSTAINABILITY CAMPUS PLANNING PRINCIPLES

In the 2000 Framework for Campus Planning, Yale identified a set of shared values and beliefs that would inform all campus planning e≠orts:

- Yale's ability to fulfill its academic mission is enhanced by insistence upon excellence in its physical facilities and surroundings.
- Much of Yale's academic strength derives from the interconnections among schools, departments, and programs.
- Yale should be a faithful steward of its great architectural heritage and its new buildings should strengthen that heritage for future generations.
- The University and the City of New Haven are inextricably woven together in a vibrant urban tapestry. Their interdependency should be recognized and reinforced in future decisions to the benefit of both.

These values are rea∞rmed in this Sustainability Supplement to the Framework for Campus Planning, and form the foundation for the Sustainability Planning Principles guiding this supplement. Much has been learned since the publication of the original 2000 document and the 2009 Supplement. The Sustainability Planning Principles were formulated having recognized the importance of:

- Looking beyond borders: each project is nested within multiple, interlinked systems; from the project to Yale campus, to the specific neighborhood, to the City of New Haven, to the greater northeast region.
- Balancing economic viability with environmental and human health.
- Being a steward of campus natural resources based on an ecosystem services approach (see Appendix A).
- Embracing an integrated planning and design process.
- Managing and evaluating our actions using an adaptive and iterative process.
- Leveraging opportunities to create demonstration and learning projects on campus.

With the integration of these concepts, the Sustainability Planning Principles capture the strength of Yale's current planning e≠orts and provide direction for future development. Each principle should not be viewed in isolation, but should be taken as one piece of a vision to further motivate and focus work in campus planning. Moreover, Yale is committed to a thorough economic analysis of all the recommendations growing from these principles to ensure institutional fiscal responsibility. The Sustainability Planning Principles are as follows:

- **Harness Linkages**
- **Enhance Campus Access and Mobility**
- **Steward Natural Resources**
- **Plan for and Extend Life Cycle Use**
- **Incorporate Adaptive Management**
- **Ensure Collaborative Planning and Design**
- **Safeguard Human Health and Vitality**

Harness Linkages: ***Yale must plan its projects in a manner that acknowledges the interconnectedness of all campus systems and harnesses the beneficial linkages that exist beyond the project boundary.***

The recognition that all systems are linked together and thus influenced and a≠ected by one another is necessary to the development and management of a sustainable campus. The e≠ects and impacts of a project can reach far beyond project boundaries. Planning under a linkages-minded framework requires an understanding of the systems currently in place both on and o≠ the project site and the anticipation of the e≠ects a project will have on those systems. The systems that must be considered are unique to each project, but in a university setting they are likely to include familiar campus constructs, such as university buildings and campus transit; community systems, such as local roads, neighborhoods, and pedestrian tra∞c patterns; and environmental systems, including vegetation, stormwater, and natural habitats.

Enhance Campus Access and Mobility: ***Yale must plan for a pattern of circulation and campus navigation that supports long-term land use objectives, reduces traffic congestion and pollution, and enhances mobility options for nondrivers.***

As an urban campus, Yale benefits from a largely pedestrian-friendly street grid, as well as the proximity of several local and regional transit stations, yet without a cohesive circulation system, these benefits remain underutilized. The creation of a sustainable circulation system aims to reduce the number of miles traveled in a single-occupancy vehicle, particularly for trips within the campus. Safety is another primary goal, as the urban location of the campus necessitates safe, reliable, and convenient transportation 24 hours a day. This is particularly important given Yale's linear configuration, which results in on-campus destinations sometimes being far from one another. Yale's circulation plan will address each of these challenges as well as contribute to an overall improvement in campus life while reducing Yale's environmental impact.

Steward Natural Resources: ***Yale must protect and sustain the environmental integrity of its physical campus by conserving and creating ecosystem function that not only enhances campus quality of life, but also stewards the health of natural resources linking the University to the city and region beyond.***

Natural resources, on and o≠ campus, are essential to the health and productivity of the Yale community. By remaining mindful of the value of natural resources, Yale is better able to plan, develop, and manage its campus in a way that improves the quality of these resources and also helps campus users appreciate and enjoy them. By incorporating an ecosystem-services lens for Yale's campus planning, the University is better able to understand the role Yale's campus plays in the larger Long Island Sound and New England regions. Yale's policies will be influenced not only by goals internal to the Yale campus but also by larger regional considerations.

Plan for and Extend Life-Cycle Use: ***Yale must incorporate the concepts of life-cycle use and employ strategies that extend the life and improve the efficient performance of the built environment, ensure mindful consumption of natural resources, and preserve its historic building stock while ensuring it remains relevant to current needs.***

Yale's campus showcases many examples of buildings and open spaces that have served the University for hundreds of years, making it one of the most beautiful and beloved of all American college campuses. While some of these buildings have retained their original intended function, creative interventions have allowed many of these historic structures to adapt to 21st-century uses. By continuing to plan for changing needs over the course of a project's life cycle, Yale can both ensure the project remains relevant as needs change and extend the use of a project, thus reducing the need for resources and energy to build a replacement. This approach takes into consideration the impacts of construction, operation, adaptation, and evolution over the project's expected life span.

Incorporate Adaptive Management: ***Yale must adopt, through continual monitoring of campus projects, an iterative decision-making and planning process that responds to quantitative and qualitative data in an ongoing manner, and adapts dynamically to new information in a sustained feedback loop of analysis and action.***

Managing a campus is a dynamic and iterative process that requires adjustment to new information and lessons learned over the long term. Yale will pursue both passive and active adaptive management practices, preferring active management where possible. Target goals will continue to change as users learn more about the systems being studied and as technology continues to advance. Integrating adaptive management into the planning process will support Yale's stewardship of a sustainable campus.

Ensure Collaborative Planning and Design: ***Yale must integrate multiple disciplines and engage University and community stakeholders in campus planning and design to ensure that development responds to relevant academic, aesthetic, land use, transportation, health, infrastructure, operations, and utility initiatives.***

Collaborative planning is a key step in developing a sustainable campus. By engaging all stakeholders, including planners, end users, caretakers, and neighbors, the design process becomes a means of not only ensuring that the project meets and exceeds the desired outcomes but also generates innovative strategies over the life cycle of a project. Each stakeholder group brings a unique perspective and expertise to the project. Integrating representatives from across the campus can help identify potential challenges or opportunities early in the design process, allowing for changes to be made with minimal impacts on the overall project timeline or budget. Early collaboration among groups also generates a sense of ownership and excitement about a project, which will carry forward as the project becomes operational.

Safeguard Human Health and Vitality: ***Yale must balance the attributes of the natural and built environment to enhance human health, performance, vitality, and well-being as an integral part of all campus development.***

Sustainable design solutions recognize the human benefits of healthy green environments that provide opportunities for physical activity, restorative and aesthetic experiences, and social interaction. Healthy ecosystems are the source of less tangible but real benefits that humans derive from maintaining a relationship with nature—these benefits are especially important in an urban environment such as New Haven. Research by social scientists and psychologists shows that encounters with everyday nature—a green view from indoors, daylighting, and fresh air—restore the ability to concentrate, calm feelings of anxiety, and reduce aggression. Further, space making that orients users and improves visibility engenders safety and environmental awareness. Yale will create natural and built environments that have multiple positive e≠ects on human health, healing, worker satisfaction, productivity, and intellectual performance. These environments are inspiring to teach, learn, work, and live in.

3. SUSTAINABILITY AREAS OF FOCUS

All sustainability Areas of Focus are addressed in Kroon Hall's design.

SUSTAINABILITY AREAS OF FOCUS

The following six sustainability Areas of Focus—Energy, Air, Water, Land, Movement, and Materials—provide the lens through which recommendations for developing and managing the Yale campus will be presented. Each captures an overarching area of environmental concern that has impacts on a worldwide scale and at the scale of the Yale campus.

All areas of focus are considered important and have interrelated impacts, but Yale particularly emphasizes attention to Energy and Water. With regard to Energy, Yale expects projects to measurably reduce energy consumption and cost in support of the President's 2005 commitment to greenhouse gas emissions reduction. With regard to Water, Yale's stated water management goals for potable water conservation and stormwater runo≠ mitigation require careful consideration on all campus projects.

Cogeneration at Central Power Plant

Solar thermal panel creates domestic hot water for immediate use

ENERGY

Energy demand per person around the world is increasing at a rate of about 5% per year. The United States consumes a disproportionate amount of the world's energy, much of which is used by buildings.

The Department of Energy estimates that approximately 38.9% of U.S. energy consumption is attributable to building operations. The generation of this energy currently burns enormous quantities of nonrenewable fossil fuel resources, causing emissions to the atmosphere that foster climate change and contamination of vast quantities of process water. Energy conservation is vital.

Yale generates and provides energy to operate over 16.7 million square feet of facilities. The creation and distribution of energy represents the University's largest single expenditure, with the exception of salaries. Yale owns and operates four power plants: the Central Power Plant for the Main Campus, the Sterling Power Plant for the School of Medicine, the West Campus Power Plant, and the Central Campus Chiller Plant on Winchester Avenue serving Science Hill and the Central Campus. These are all natural gas-driven plants. The Central and Medical Plants cogenerate electric and thermal energy using gas turbines and heat recovery boilers, the Central Campus Chiller Plant provides chilled water only, and the West Campus Plant generates thermal energy while distributing electric power purchased from the grid. Yale produces and distributes steam and chilled water to provide heating and cooling for most of the main campus and the Medical School, with many outlying facilities depending on stand-alone mechanical systems. Thermal and electric energy produced by the plants and delivered to campus buildings is metered, monitored, and controlled centrally and continuously. Yale also purchases electricity from the United Illuminating Company, the electric utility company serving the city of New Haven, for supplemental electricity.

In 2005 Yale President Richard Levin committed to reducing Yale's greenhouse gas emissions 43% below 2005 levels by 2020. With this commitment, the reduction of energy consumption and greenhouse gas emissions is a priority concern for Yale. To accomplish this goal, Yale has embarked upon an ambitious energy program improving the e∞ciency of its power plants, updating buildings, utilizing emerging technologies, and searching for clean energy alternative sources as part of its energy use portfolio. These endeavors will enable Yale to optimize its energy consumption and control its energy demand as the campus grows and intensifies its space usage. Equally important are the patterns and habits of energy use by students, faculty, sta≠, and administrators. Campus faculty, sta≠, and students are taking active steps at the community level to accomplish this goal. These measures must be implemented to lessen the environmental stress that our energy consumption causes. Yale is committed to measurably reducing campus energy consumption.

Naturally ventilated space at Kroon Hall

Intersection of I-95 & I-91 in New Haven

AIR

Human activity is rapidly increasing the amount of greenhouse gases in the earth's atmosphere, which in turn is accelerating the greenhouse effect or the buildup of heat in the atmosphere. This causes ground-level ozone accumulation and depletes the upper-atmosphere ozone layer which is considered the main contributor to global warming. These gases consist primarily of carbon dioxide (CO2) due to burning fossil fuels, methane (CH4) due to landfills and livestock farming, nitrous oxide (N2O) due to fertilizers, and volatile organic compounds (VOC) or fluorinated gases such as hydrofluorocarbons (HFCs) and chlorofluorocarbons (CFCs) due to refrigerants and industrial processes. Particulate matter, or particle pollution, is another widespread health threat for both outdoor and indoor environments. It is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. Air pollution and global warming result in toxicity and climate change, which present considerable health, security, biodiversity, and sustainability risks.

With regard to climate, Yale is situated in a region that historically has four distinct seasons. Precipitation is balanced among the seasons with large swings in daily and annual temperatures that generate diverse weather conditions over short periods of time. The prevalent seasonal airflow into Connecticut is both cold, dry air from the north and warm, humid, coastal air from the south. Over the last several years, it is evident that consequences from global warming are unbalancing the regional climate. We are now witnessing an extreme variation in weather patterns and stronger storm events during the summer, winter, and shoulder seasons. This has led to coastal flooding, biodiversity losses, and an increase in environmental health issues, among other impacts.

Air quality in New Haven is poor and the U.S. Environmental Protection Agency (EPA) classifies New Haven's air quality in the lowest 10% of the national standard. Most of New Haven's air pollution is caused by the close proximity of highly trafficked Interstates 95 and 91, and it is in close proximity to several major municipal power plants.

Yale is committed to air quality improvement and greenhouse gas reduction through energy demand management measures, efficient energy production, the implementation of renewable energy strategies, and policies that reduce fossil fuel-powered transportation. Additional Yale measures include techniques for carbon sequestration, such as preserving and creating natural landscapes for carbon storage in trees and soils, which also have the co-benefit of reduced heat islands on campus and water retention. Construction projects use erosion control techniques to prevent dust and particulates. Green cleaning standards and green product procurement programs prioritize the use of nontoxic, low-VOC-containing materials that improve indoor air quality and the health of Yale's building occupants. To minimize air pollution associated with energy generation, Yale strives to produce energy cleanly and purchase outside energy from environmentally responsible suppliers.


Green roof at Yale Health Center reduces stormwater runo≠


Wetlands located at West Campus naturally filter water as a part of the hydrologic cycle

WATER

Worldwide demand for water has resulted in exploitation and contamination of resources in many regions, while pollution degrades coastal areas and open oceans. Climate change is making communities increasingly vulnerable to water shortages and water quality degradation. The EPA reports that the commercial and institutional sector is the second largest consumer of publicly supplied water in the United States, which accounts for approximately 17% of the withdrawals from public water supplies.[1] Combined sewer overflow events, common to many U.S. industrial cities, including New Haven, result in large inputs of mixed sewage and stormwater into local surface bodies of water. Given Yale's proximity to major waterways and the Long Island Sound, campus water regulation, quantity, and quality are of major concern. The impacts of climate change will exacerbate the stormwater problem due to the increased intensity and frequency of storms.

Yale's campus currently consumes nearly 450 million gallons of potable water annually for domestic, process, and irrigation demand. The single largest demand for potable water is within the cooling towers of the central plants to generate chilled water for process and comfort cooling across campus. Domestic water use is the second largest demand and includes water used directly by people and equipment within academic, administrative, and residential buildings. Although Yale is in the biome of New England, where fresh water is currently an abundant resource, there are compelling reasons to carefully manage fresh water, including the energy embedded in water use, the infrastructure needed to provide and treat water, and the potential for fresh water to become less abundant with climate change.

The reduction of potable water demand and consumption and the sustainable management of campus stormwater are new priorities for Yale. To conserve water and increase water quality, Yale will strive to limit potable water to only those uses that explicitly require it, to treat and recycle gray water for secondary uses, and employ green infrastructure to capitalize on the ecosystem services of water filtration associated with bioswales, wetlands, green roofs, and other best-management practices such as leak detection and prevention programs. Yale is committed to being a model for sustainable water use and stormwater management.

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1 WaterSense, An EPA Partnership Program. "Types of Facilities Overview." EPA.gov. WaterSense, 21 Dec 2012. Web. 4 Feb 2013. *http://www.epa.gov/watersense/commercial/types.html#tabs*-office.

Urban meadows are an example of green infrastructure approach

Courtyards provide vital green spaces throughout campus

LAND

A healthy landscape can provide the desired aesthetic and recreational qualities of a campus environment while also ensuring the quantifiable ecological benefits such as shade and heat island effect mitigation, air quality improvement, biodiversity enhancement, and stormwater management. As the natural benefits of vegetation and permeable land are lost to logging, agriculture, and building development, communities must embrace new approaches to development of the built environment, utility, and transportation infrastructures to preserve and restore vital green space. An ecosystem services approach expands the role of landscapes to include key elements of overall ecosystem and environmental function. The ecosystem services framework offers fruitful design approaches to both promote a healthy, vibrant landscape as well as reduce the environmental impact of the campus's open spaces.

Yale is situated within a relatively dense and historic city setting, based on an original nine-square plan dating back more than 375 years. Adjoining the New Haven Green, Yale's semi-urbanized campus covers over 1,100 acres of maintained and natural landscapes that range from college courtyards, quadrangles, and designated garden areas to sports fields, a golf course, and a nature preserve. Within the Yale campus it is possible to expand the definition of land to include the open space that can support vegetation such as rooftops, streetscapes, and walls. Many of Yale's landscapes contain historic trees, the care of which is critical to the University's identity and experiential quality. Beyond the central New Haven campus, Yale has land holdings at the Athletic fields, West Campus in West Haven and Orange, and various properties in the New England region.

Over the centuries, Yale has focused considerable financial and human resources on the aesthetic, social, and recreational facets of its open space. Far from merely interstitial spaces between buildings, the campus's open spaces not only provide distinctive places for a variety of academic and recreational activities, but form the cohesive fabric of the University's unique campus. While Yale benefits from urban density in terms of close proximity among buildings and efficiencies in utility and transportation infrastructure, it will need to balance intensified development with the need to preserve vital green space and reduce the burden on New Haven's wastewater infrastructure.

Yale is committed to environmentally responsible and restorative land management practices that can have significant impact on water use, greenhouse gas emissions, and outdoor air quality. Yale's forests are sustainably managed and harvested. New landscape designs are executed with native or adapted species to minimize irrigation and fertilization needs and to encourage biodiversity. Attention to developing contiguous landscapes helps with soil retention, site resiliency, stormwater runoff control, and tree health. An ecosystem services approach (see Appendix A) is the basis for the development of campus-specific landscape design, construction, and management strategies. Green infrastructure approaches are encouraged, such as use of temporary storage and infiltration of stormwater using structured landscape features and natural attenuation strategies.

Multimodal circulation is encouraged at Yale

Pedestrian paths provide access throughout the Yale campus

MOVEMENT

The world's population circulates globally, regionally, and locally in ways that cause documented adverse impacts on the environment. Fossil fuel-powered transportation increases greenhouse gas emissions, air pollution, tra∞c congestion, noise pollution, and extensive infrastructure.

On a typical day, Yale has over 25,000 students, faculty, sta≠, and visitors who move around campus by foot, bicycle, shuttle bus, city bus, taxi, and personal vehicle, creating a complex and dynamic circulation. Yale's circulation system includes surface parking lots and parking structures, as well as transit stops and hubs connecting to local and regional train stations and other transfer points.

Over 7,000 people drive to Yale's campus daily, generating greenhouse gas emissions, and congesting local streets, resulting in lost productivity and a≠ecting the basic quality of life. The average peak-hour commuter delay in New Haven is 28 hours per year, according to the Texas A&M Transportation Institute 2011 Urban Mobility Report. This is the equivalent of more than 3.5 full workdays stuck in tra∞c. This commuter tra∞c is a major reason why Connecticut does not meet two of six pollutant criteria as determined by the EPA. This presents a health risk for the people who live in the New Haven area.[1]

Yale has committed to mitigate the impacts of circulation to and around its campus by embracing a Sustainable Transportation Plan that promotes safe and attractive alternatives to single-occupancy vehicular access. The plan is organized around a set of established sustainable transportation principles recognized nationally and internationally. The basic principles are Access, Health and Safety, Individual Responsibility, Integrated Planning, Pollution Prevention, and Fuller Cost Accounting. The plan ranks transportation modes in a hierarchy of; pedestrian, cyclist, transit rider, and single-occupant vehicle as the least preferable. This is the same hierarchy set forth in the City of New Haven Complete Streets Design Manual[2] and is consistent with best practices in the sustainability field. More cities and campuses are giving priority to walkers and cyclists, and seeking to create options such that commuters will have safe choices that allow alternatives to driving alone. Conscious planning for e∞cient access, movement, and circulation is an essential contribution toward overall campus environmental performance. Planners and designers are expected to integrate these principles in new infrastructure and building projects.

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1 United States. Environmental Protection Agency. Nonattainment Status for Each County by Year for Connecticut Including Previous 1-Hour Ozone Counties. GreenBook. 23 April 2013. *http://www.epa.gov/oar/oaqps/greenbk/anayo_ct.html*.

2 City of New Haven. "City of New Haven Complete Streets Design Manual." CityofNewHaven.com. 7 Sept 2010, 4 Feb 2013, 7 Sept 2010, 4 Feb 2013. *www.cityofnewhaven.com/Engineering/pdfs/CS-Manual-FINAL.pdf*

Wood used for Kroon Hall was sustainably sourced from the Yale Forest

Construction and demolition waste properly sorted for recycling

MATERIALS

Enormous amounts of raw and processed material are procured, consumed, and disposed of annually, much of it to support the construction and renovation of buildings and infrastructure. This includes metals, minerals, earth, fossil fuels, and forest products. The chain of environmental impacts of materials relates to the original location and source, processing and manufacturing, product mass and volume, transportation and delivery methods, and final consumption and disposal. The complex ecological and health consequences of the materials, products, and waste associated with the development of the built environment must be taken into account as Yale's campus grows.

In its ongoing operations, Yale handles large amounts of organic, processed, and manufactured material annually. In addition, building construction and renovation projects use considerable amounts of structural, mechanical, electrical, plumbing, cladding, and interior finish materials each year.

Recognizing the environmental impact of Yale's procurement and disposal of material, Yale has been a leader in implementing material reduction, waste avoidance, and recycling programs to minimize adverse e≠ects. Yale's comprehensive single-stream recycling program handles glass, plastics, metals, cardboard and paper waste. Clean wood and scrap metals are also recycled. Surplus furniture, equipment, and building products are stored and redistributed around campus. Discarded electronics and batteries are collected and properly recycled. Organic food waste is diverted from the municipal solid waste stream. Procurement policies favor environmentally preferable materials with recycled and recyclable content as well as reduced packaging. Yale continues to increase its current 40% rate of waste diversion from the municipal solid waste stream.

With regard to buildings, Yale invests in the adaptive reuse of existing structures whenever possible. All major construction and renovation projects follow LEED Gold certification guidelines, which prioritize the use of salvaged, reused, recycled, and locally sourced materials. Yale's standards require a minimum 90% diversion rate from the municipal solid waste stream for construction and demolition waste on all comprehensive renovations and new buildings and a minimum of 75% diversion rate on all other construction projects. Campus-generated municipal solid waste has decreased over the past decade and continues to decrease with ongoing waste reduction campaigns and system changes. This commitment to material and waste reduction will continue to evolve as material science produces viable lighter-weight, lower-mass, waste-free, and environmentally preferable alternatives to consider.

4. SUSTAINABILITY RECOMMENDATIONS BY CAMPUS FRAMEWORK SYSTEM

Buildings: An array of building types and architectural styles from many eras presents environmental performance opportunities and challenges.

Landscape: A blend of hardscape and softscape characterize the Yale campus

Utilities: Installation of underground conduit on Core Campus

SUSTAINABILITY RECOMMENDATIONS BY CAMPUS FRAMEWORK SYSTEM: BUILDINGS • LANDSCAPE • UTILITIES

Yale University has one of the most unique collegiate campuses in the country. With over 16.7 million square feet of operational space in over 355 buildings utilized 365 days a year, Yale's building operations and maintenance consume a significant amount of energy, resources, and sta≠ hours. Given current operating impacts and in the context of the University's continued growth and ongoing commitment to environmental excellence, a sustainable approach to campus planning, building, and maintenance is essential. The following recommendations position Yale to meet its needs for growth with careful attention to environmental responsibility, resource e∞ciency, and human health in accordance with sustainable design best practices.

The recommendations are organized by the Campus Framework Systems (Buildings, Landscape and Utilities) by which Yale develops and manages its campus. They were created with an appreciation for the concept of ecosystems services, which guided their development (see Appendix A, Ecosystems Services Approach). Within each Campus Framework System, the recommendations are grouped by the Areas of Focus described in the previous section (see Appendix B, Recommendations Outline). As these planning and design principles are intended to enable ongoing sustainability, these recommendations also include operations and maintenance objectives, noted with the designation "O&M".

BUILDINGS: ENERGY

Targeting building energy use in design, construction, maintenance, and operation is crucial to reducing Yale's energy consumption and its associated greenhouse gas emissions.

Conservation & Efficiency

- Site buildings to optimize daylighting and natural ventilation to minimize energy consumption.
- Take advantage of shade from existing site trees to reduce building cooling needs.
- Optimize the building envelope thermal performance to minimize heat loss and improve occupant comfort, including the use of green roofs.
- Utilize natural ventilation systems to reduce need for air conditioning.
- Pursue energy-e∞cient HVAC, lighting, hot water, and other systems to provide optimal energy performance to meet usage requirements.
- Utilize computer-aided energy simulation to select the most e≠ective energy-e∞cient building envelope design.
- Utilize trees, green walls, and green roofs to lower ambient temperatures through shading and evaporative cooling. Design for future climate to ensure that the construction and operation of buildings are resilient to natural and manmade disasters.
- O&M: Maintain the thermal integrity of the building envelope and the proper functioning of operable components of the building envelope.
- O&M: Monitor and maintain high-albedo roof systems to ensure reflectivity as per design parameters.
- O&M: Maintain green roof systems to achieve insulating e≠ectiveness.

Management & Control

- Employ mechanical and electrical systems that can be modulated by active and passive means to minimize energy consumption while satisfying a majority of occupants' thermal comfort demands without the need for supplemental heaters or fans.
- Incorporate temperature and lighting controls that are automated to sense occupancy with a user-controlled override.
- Ensure comprehensive commissioning of mechanical and electrical systems.
- Implement retrofits for temperature setbacks for all noncritical areas.
- Implement lighting retrofits that install energy-e∞cient fixtures and replacement parts.
- O&M: Employ a preventive maintenance program to keep all building systems functioning as designed, including monitoring building for equipment leaks, and damage to ductwork, and piping insulation.
- O&M: Align cleaning schedule with daylight hours to minimize the need for night lighting in unoccupied buildings.

- O&M: Provide energy usage information to building users.
- O&M: Implement initiatives to motivate and reward users to actively engage in energy-saving behavior.

Metering

- Design new and upgrade existing building automation systems to direct digital control to monitor for enhancement of system performance.
- Design new lighting control systems to provide lighting performance information and programmability to central plant.
- O&M: Monitor and maintain existing occupancy sensors and upgrade space to include occupancy sensors where they do not currently exist.

Renewables

- Identify renewable energy sources on building site and integrate and adapt renewable energy infrastructure with overall building form.
- Use on-site renewable energy technologies as technically feasible and economically viable.
- Incorporate renewable energy systems into building envelope.

BUILDINGS: AIR

Yale is committed to supplying clean air in its buildings to provide for human health. Yale strives to improve indoor and outdoor air quality while reducing greenhouse gas emissions.

Emissions & Pollutants

- Eliminate or reduce refrigerants in building equipment.
- Specify only non-HCFC refrigerants.
- O&M: Monitor refrigerant systems for leaks.

Outdoor Air Quality

- Perform construction and maintenance activities to prevent air pollutants from a≠ecting users of neighboring buildings.
- Use construction processes that ensure clean and safe air quality during and post construction.
- Design and install e∞cient and clean air-handling systems to minimize toxic exhausts.

Indoor Air Quality

- Ensure construction activities maintain clean and safe indoor air quality during and post construction, and generate minimal dust and prevent particulate matter from entering building air circulation systems and building air intake areas.

- Design service nodes to access multiple buildings that circulate air away from building entrances and air intakes.
- Provide protection of HVAC systems during construction.
- Protect indoor finish materials from moisture or contamination during construction.
- Select materials, products, furniture, and building systems that do not o≠-gas or in any way negatively impact human health.
- Specify and use low/no-VOC paints, adhesives, caulks, solvents, cleaning agents, and finishes.
- Ensure through testing that radon and mold levels are nonexistent or at acceptable low levels.
- Employ interior vegetation to improve indoor air quality.
- O&M: Use nontoxic cleaning products in accordance with the Yale Green Cleaning Policy.
- O&M: Ensure regular maintenance of air filters for all heating, cooling, and ventilation equipment.

BUILDINGS: WATER

Yale is committed to reducing potable water consumption and to systematically mitigating stormwater runo≠ to lessen impacts on campus and city infrastructure. Buildings must integrate stormwater control systems that retain, reuse, and distribute water away from sewers as well as plumbing systems that reduce consumption of potable water and reuse gray water.

Stormwater Management & Reuse

- Minimize soil disturbance and preserve or restore natural vegetation.
- Incorporate rain gardens and bioswales to collect rainwater and aid in groundwater recharge.
- Use stormwater retention systems, green roofs, and roof gardens to reduce runo≠, capture water for reuse in the building for nonpotable uses, or to recharge groundwater.
- Limit impervious surfaces and use pervious pavement where appropriate.

Potable Water Management & Reuse

- Use toilets, urinals, lavatories, showers, and other fixtures that exceed EPA Watersense standards.
- Employ gray water systems that collect and reuse water for nonpotable uses.
- Install meters at all building potable water sources, condensate returns, and reuse water systems.
- Submeter all areas of high water use, such as dining facilities.
- Implement innovative wastewater or blackwater treatment technologies to recycle or reuse waste water.
- Monitor and analyze potable water use per building type to assess baseline water use, set benchmarks and reduction goals, and measure achievement.
- O&M: Reduce water use in cleaning operations.

- O&M: Meter water use and provide water usage information to users to promote conservation.
- O&M: Implement initiatives to motivate and reward users to actively engage in water-conserving behavior.

Process Water Management

- Employ gray water systems that collect and reuse water for nonpotable uses such as cooling tower makeup.
- O&M: Meter process water systems.

BUILDINGS: LAND

Yale advocates a comprehensive approach to site assessment and best practices in the design, construction, and renovation of buildings to minimize disruption to existing landscapes and natural areas. Yale protects, respects, and enhances the existing outdoor environment by ensuring proper drainage, surfacing, planting, and maintenance of campus landscape. Innovative green infrastructure solutions are encouraged.

Surfacing

- Design building-adjacent landscapes to handle the anticipated activities with minimal maintenance and provide for uses that will impact landscape such as tent anchors at campus locations where reunions and graduation ceremonies occur or non-planted areas (e.g., peastone) for yearly gatherings.
- Critically assess need for additional parking spaces with new building projects and consider the use of permeable paving materials for new parking and walkway surfaces.

Planting

- Preserve existing trees and planted areas in the design and construction of new buildings and renovations.
- Rehabilitate damaged ecosystems and/or contaminated soils if on site, restore plantings at tree pits and sidewalk planting beds, and remove invasive species.

Irrigation

- Integrate rainwater and/or gray water collection systems in the building design for use as irrigation water.

BUILDINGS: MOVEMENT

Yale expects building projects to consciously facilitate the efficient movement of people within and between facilities to help minimize energy consumption, to encourage healthful, physical activity, and create connection between building uses.

Accessibility

- Locate new buildings convenient to existing transit routes and pedestrian paths.
- Create new pedestrian and bicycle networks to connect precincts, buildings, and courtyards, and to make use of existing pathways.
- Design for accessible routes to and around buildings.
- Ensure that furniture and circulation supports all users and functions.

Mobility

- Design buildings to enable efficient and pleasant horizontal and vertical movement and connectivity.
- Connect buildings via tunnels to adjacent buildings.
- Integrate informational graphics and other way-finding techniques for facilitating movement in and around buildings.

Transportation

- Design for safe, attractive pedestrian and bicycle access to buildings.
- Design for safe, attractive transit access to buildings.
- Provide secure, covered, and sufficient bicycle storage and related amenities such as showers and lockers for cyclists in or near buildings.
- Provide alternative fuel vehicle and high-occupancy vehicle parking, charging stations, and other amenities.

BUILDINGS: MATERIALS

Yale is committed to the selection of safe and sustainable products, materials, and systems for construction and maintenance of buildings. Materials selection must favor those that are made of recycled materials and have a low ecological footprint, made of recycled materials, durability and extended life, and high potential for reuse. Proper disposal of waste materials (e.g., reuse and recycling) is required.

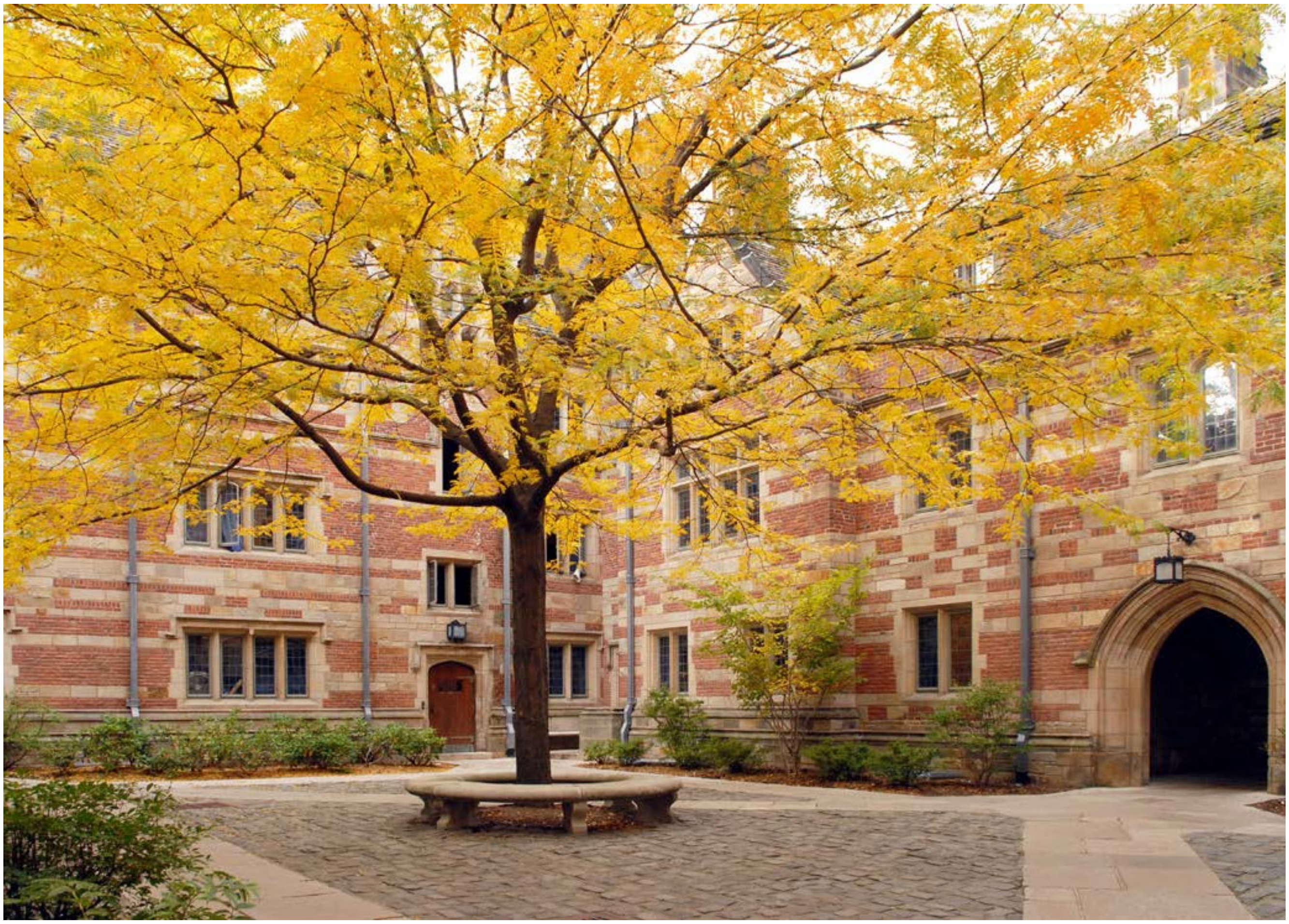
Source

- Optimize the adaptive reuse of existing buildings and structures.
- Reuse salvaged materials for reuse as available and applicable.

- Purchase local and sustainably produced structural and finish materials to reduce transportation requirements.

Composition

- Design buildings with adaptable spaces to extend flexibility of uses with minimal or no renovation.
- Consider the full life cycle of construction and finish materials with regard to environmental and health e≠ects of a product, reusability, recyclability, and disposal.
- Use wood products that meet the Forest Stewardship Council standard.
- Reduce air pollution by using low-VOC paints, sealants, adhesives, in the construction and finishing of buildings.
- Ensure new products follow suggestions and guidelines in the Yale Sustainable Products List.
- Procure furniture that is flexible and adaptable to multiple needs and configurations.
- Reuse furniture to the greatest extent possible.
- Purchase new furniture in accordance with furniture, fixtures, and equipment sustainable puchasing guidelines.



Mature growth of plantings in the Linonia Courtyard in Branford College allows for natural shading and sense of beauty.

SUSTAINABILITY RECOMMENDATIONS BY CAMPUS FRAMEWORK SYSTEM: LANDSCAPE

LANDSCAPE: ENERGY

Yale is committed to reducing its energy consumption and greenhouse gas emissions in landscape design, construction, and maintenance, including the integration of renewable energy technologies.

Conservation & Efficiency

- Use deciduous trees and/or shade structures to shade hard surfaces and buildings to reduce solar load in the cooling season yet allow for passive solar e≠ects in the heating season, reducing the reliance on mechanical systems.
- Use plantings that require minimal maintenance with gasoline- or electric-powered equipment.
- Provide energy-e∞cient, long-life outdoor lighting designed for excellent visual quality without glare or light pollution.

Management & Control

- O&M: Ensure lights and other outdoor equipment are maintained for maximum energy e∞ciency.

Metering

- Submeter pedestrian and site lighting by precinct.

Renewables

- Integrate photovoltaic or other viable renewable energy technologies to power outdoor lighting, security, or other equipment as applicable.

LANDSCAPE: AIR

Yale favors landscape design strategies and maintenance procedures that minimize or eliminate greenhouse gas emissions, particulates, and toxins to improve outdoor and indoor air quality on campus and for the New Haven region.

Emissions & Pollutants

- Specify plantings that are best suited for the particular site and are selected for the proper growth habitat, which minimizes the need for fertilization or intensive mowing.
- O&M: Change mowing protocols to reduce mowing frequency where applicable.
- O&M: Maintain or increase tree canopy cover and other vegetation to sequester carbon dioxide.

Outdoor Air Quality

- Ensure construction activities generate minimal dust and prevent particulates from entering the local atmosphere.

- Employ vegetation to improve air quality.
- O&M: Minimize the use of gasoline-fueled leaf blowers and mowers that generate excess fine particulates and noise.

Indoor Air Quality

- Ensure construction activities generate minimal dust and prevent particulates from entering building air intake areas.

LANDSCAPE: WATER

Yale is committed to the reduction of potable water consumption and stormwater runo≠ with increased water infiltration into soils through the use of low-impact development best practices and green infrastructure installations. Yale is actively reducing use of fertilizers, pesticides, and other chemicals to mitigate adverse impacts of runo≠ into waterways and Long Island Sound. Yale is committed to reducing potable water use for its campus landscapes and athletic fields that require water to maintain plant and ecosystem health. Yale supports landscape designs that minimize irrigation requirements and promotes the use of recycled rainwater or gray water from building projects for irrigation.

Stormwater Management & Reuse

- Prioritize restoration of watershed function with low impact stormwater management strategies including natural features, landscapes, and green infrastructure systems. Yale shall implement stormwater management strategies following a fundamental order of priority: first infiltration of stormwater where it falls, then storage for infiltration or reuse, and finally temporary detention and gradual release of stormwater to New Haven's combined and separate storm sewer systems.
- Use temporary stormwater storage systems (stormwater retention systems) to minimize site runoff, promote infiltration, facilitate groundwater recharge, and for reuse in other applications.
- Limit impervious surfaces and use pervious pavement only where appropriate.
- Design for snow removal or temporary storage to enable snowmelt to recharge groundwater.
- O&M: Monitor and reduce the usage of fertilizers, pesticides, herbicides, and other treatment chemicals.
- O&M: Utilize integrated pest management (IPM) techniques to reduce the need for long-term pesticide use.
- O&M: Maintain tree canopy coverage following the Yale Tree Management Plan to mitigate stormwater runo≠.

Potable Water Management & Reuse

- Use hardy, drought-tolerant, regionally adapted plant species.
- Reuse stormwater on-site retention systems for irrigation reuse in lieu of potable water.
- Employ passive irrigation and rainwater harvesting systems for nonpotable water irrigation,

including moisture sensors.

- O&M: Monitor irrigation systems for proper coverage, leaks, and correct watering times to meet actual soil moisture requirements.

Process Water Management

- O&M: Monitor and filter discharge/runo≠ from fertilizers.
- O&M: Use nontoxic/nonchemical snowmelt.

LANDSCAPE: LAND

Yale designs and maintains its landscapes to expand and preserve existing soil, trees, and plantings to encourage enjoyment of the outdoors, create spaces of campus identity, and support healthy ecosystems and biodiversity. Accordingly, Yale uses practices that balance environmental health with aesthetic expectations for the campus's outdoor spaces.

Surfacing

- Create conservation corridors and greenways by interconnecting open spaces uninterrupted by impervious surfaces.
- Assess, develop, and account for existing habitat and wildlife corridors.
- Design landscapes to handle the anticipated activities with minimal maintenance.
- Provide for uses that will impact landscape, such as tent anchors at campus locations where reunions and graduation ceremonies occur or non-planted (e.g., peastone) areas for yearly gatherings.
- Critically assess need for additional parking spaces with new building projects and consider the use of permeable paving materials for new parking and walkway surfaces.
- Anticipate the need to salt paths in winter months and design adjacent areas and plant material accordingly.
- O&M: Schedule all maintenance operations to best suit the horticultural needs of plants on campus, while maximizing campus use for the Yale community and pursuit of educational, recreational, and social events.

Planting

- Use a variety of plants selected adhering to "right plant, right place, right use" concept of landscape design and to encourage species diversity.
- Create clusters of trees and vegetation of su∞cient size to foster habitat.
- Develop planting plans to reduce heat island e≠ects from buildings and pavement, as well as to shade buildings.
- Select, locate, plant, and maintain trees in accordance with the Yale Tree Management Plan to maintain sustainable tree canopy coverage and species diversification.

- Design landscapes where plants with similar maintenance and survival requirements are located together (e.g., similar soil type and pH level, water requirements, etc.).
- Rehabilitate damaged ecosystems and/or contaminated soils if on site, restore plantings at tree pits and sidewalk planting beds.
- Determine limited areas where invasive plants will be accepted for desired campus aesthetic.
- O&M: Utilize IPM concepts in landscape design to reduce the need for long-term pesticide use.
- O&M: Ensure that all horticulture practices employed in maintenance on campus produce the most beneficial results to plants and the environment they compose.

Irrigation

- Ensure proper drainage of landscaping projects to avoid ponding and erosion.

LANDSCAPE: MOVEMENT

Yale ensures accessibility to and connectivity through campus at all times of year. Pathways and roadways should be accessible and safe for multiple modes of transportation, while prioritizing walking and bicycling.

Accessibility

- Design pathways to follow desire lines.
- Clearly demarcate areas that people should not occupy or move through.
- Design for accessible routes within the landscape/green areas of campus, accommodating campus community members' special needs for transportation (persons with limited mobility include the very young and the elderly).

Mobility

- Ensure landscape areas and outdoor paths remain safe and operational in all seasons.
- Include proper railings on sloped pathways to aid pedestrians and bicycle transfer.
- Install curb cuts, lighting, and other necessary features for uninterrupted bicycle access on campus.
- O&M: Ensure pathways are properly maintained with a level surface, free of cracks and protrusions.

Transportation

- Identify and plan for multimodal transportation hubs in campus expansion and development.
- Connect all important campus destinations via sustainable transportation modes.
- Design local streets to be shared to encourage pedestrian and bicycle use and discourage high-speed tra∞c.

- Design pathways to safely accommodate cyclists, pedestrians including baby strollers, scooters, etc.
- Design way-finding and information resources and appropriate signage for campus pedestrian and bicycle circulation.
- Provide su∞cient, covered bike racks near building entrances.
- Provide bus shelters and benches for the Yale Shuttle.

LANDSCAPE: MATERIALS

Yale is committed to the selection of safe and sustainable products, materials, and systems for construction and maintenance of outdoor spaces. Materials selection must favor those made of recycled materials and that have a low ecological footprint, durability and extended life, and high potential for reuse. Responsible disposal of landscape waste materials (e.g., reuse and recycling) is required.

Source

- Use existing materials salvaged or reused from former structures, hardscape, or landscape features as available and applicable.
- Purchase local and sustainably produced plants and materials to reduce packaging and transportation requirements.

Composition

- Prior to specifying, research the full life cycle of landscape materials with regard to environmental and health e≠ects of a product, reusability, recyclability, and disposal.
- Reduce air pollution by using low-VOC paints, sealants, and adhesives in the construction and finishing of outdoor structures.
- Reduce stormwater runo≠ through the use of porous paving materials.
- Reduce urban heat island e≠ect through the use of high-albedo paving materials.

Disposal

- Coordinate landscaping projects with other projects either on campus or within the New Haven region to find potential use for excess or waste material such as excavated soil, ledge, stones, wood, or plantings.
- Implement techniques to generate zero net waste with landscaping projects through reuse and recycling strategies.
- O&M: Compost or mulch waste plant material for use elsewhere on campus.
- O&M: Waste from landscaping activities will follow the hierarchy of: reuse on site, reuse on campus, reuse o≠ campus, recycle, and discard to municipal waste facility.


The cogeneration facility at Sterling Power Plant is highly efficient saving up to 18,000 metric tons of carbon equivalent per year.

SUSTAINABILITY RECOMMENDATIONS BY CAMPUS FRAMEWORK SYSTEM: UTILITIES

UTILITIES: ENERGY

Yale's central utility systems are designed to be flexible and to address economic and environmental factors in purchasing, generating, and delivering energy on campus in order to maximize reliability and e∞ciency. Utilities department sta≠ work with planners and designers to evaluate the energy needs for new and renovated facilities to assess the system requirements and demand management opportunities to ensure capacity for serving those needs.

Conservation & Efficiency

- Design plant systems to highest e∞ciency standards with most appropriate technology, such as inlet air cooling for generators and water-side free cooling, and consider advanced technology development when planning plant expansions or upgrades.
- Work with building design engineers to right-size mechanical equipment in order to match energy delivery to loads.
- Utilize heat exchange technologies to harvest usable energy for preheat of building-specific systems or general energy production.
- Utilize variable primary pumping to avoid unnecessary pump energy consumption.
- Design for resiliency that ensures the construction and operation of infrastructures are resilient to natural and manmade disasters.
- O&M: Minimize heat loss throughout supply and return piping through ongoing inspection and maintenance procedures.

Management & Control

- O&M: Establish a demand-side management program that will encourage the use of downstream elements to reduce energy usage during events such as high ozone alert days or extended heat waves.
- O&M: Ensure proper training of operators in preventive and predictive maintenance of plant equipment and building energy control systems, especially when implementing new technologies.

Metering

- Encourage building-level metering and submetering of major systems for connection and management from central plants.
- Implement lighting control systems that provide digital addressable control monitoring and metering integration with central plants.

Renewables

- Investigate the applicability of on-site and o≠-site renewable energy production strategies to provide innovative alternative energy sources.

UTILITIES: AIR

Yale utility systems operate with the highest e∞ciency standards and consistently meet and exceed air pollution regulatory compliance. This is essential for minimizing Yale's impact on regional air quality and for supporting its greenhouse gas emissions reduction goals.

Emissions & Pollutants

- O&M: Commit to continuous emissions monitoring for tracking and compliance reporting. Plant operators ensure that continuous emissions monitors are operating and collecting data. The O∞ce of Environmental Health & Safety ensures that proper reporting is done.
- O&M: Maintain refrigerant systems and report refrigerant use at highest appropriate levels and in compliance with regulatory statutes, with an objective to eliminate CFC refrigerants such as R22.

Outdoor Air Quality

- O&M: Commit to natural gas as primary fuel, with diesel and fuel oil as secondary fuels to be dispatched fewer than 45 days per year.
- O&M: Commit to flexibility in dispatch and operations in response to high ozone and low air quality days.

UTILITIES: WATER

Yale promotes integrated water management strategies campus-wide to reduce demand for and use of potable water and to mitigate stormwater runo≠. Yale recognizes that water use is closely linked with energy use, considering that demand for water at Yale's cooling towers is nearly 40% of Yale's potable water consumption.

Stormwater Management & Reuse

- O&M: Manage and monitor stormwater discharge to reduce quantity and increase water quality in alignment with the goals of the Stormwater Management Plan.

Potable Water Management & Reuse

- Collect rainwater and/or gray water for reuse as cooling tower makeup water at central plants or individual buildings as appropriate.
- Collect and treat wastewater for reuse at cooling tower makeup at central plants.
- Install water- and moisture-sensing irrigation controls.
- Meter water at the building level to track and report direct water use and allocated costs.
- Submeter irrigation and dining water usage flows separately.
- O&M: Use appropriate chemical treatment to minimize scale and biologic contamination and to increase cycles of concentration in mechanical equipment.

- O&M: Continually inspect piping and plumbing to detect and repair leaks.
- O&M: Manage and monitor potable water use to reduce consumption in alignment with the Water Management Plan.

Process Water Management

- Use equipment of the highest e∞ciency possible to conserve process water.
- Reuse clear condensate and other nonpotable sources of water to provide alternative source makeup water for cooling systems.
- Use nonpotable sources of water to supplement irrigation supply as appropriate.
- Submeter process water to track and report usage.

UTILITIES: LAND

Yale is committed to assessing the environmental impact on landscape and surface structures when utilities are transported beneath and above campus land. Sustainable practices will guide the construction of new facilities as well as the maintenance and repair of existing systems.

Hardscape

- Plan and implement sustainable site management practices to minimize surface disturbance, erosion, and runo≠ during construction or implementation of new systems.

Planting

- Minimize surface disturbance, erosion, and runo≠ during repair maintenance of sub-surface systems.
- Use vegetation and related green infrastructure options to reduce energy or water use, improve air and water quality, as well as improve enjoyment of the campus.

UTILITIES: MOVEMENT

Yale ensures accessibility to and connectivity through campus in the context of the ongoing upkeep of Yale utilities systems. Utilities upkeep requires that vehicles have access to all corners of campus as well as the occasional need to impede tra∞c flow to gain access to subsurface systems.

Accessibility

- Address tra∞c flow patterns in the planning of major repair projects to help minimize unnecessary vehicular idling.

Mobility

- O&M: Promote ride sharing or nonvehicular transportation whenever applicable.

Transportation

- Implement alternative-fuel or electric vehicles, including recharge stations throughout campus.
- Maintain passenger vehicles and construction equipment to optimize fuel performance.
- Minimize or eliminate passenger vehicle and construction equipment idling at construction sites.

UTILITIES: MATERIALS

Yale selects environmentally preferable products, materials, and systems when procuring and using major materials for infrastructure construction and maintenance, including piping, wiring and equipment. Responsible disposal of waste materials (e.g., reuse and recycling) is required.

Source

- Minimize the shipping distance from source to Yale in order to reduce transportation energy and emissions by creating awareness of the source and proximity of products commonly used by utilities.

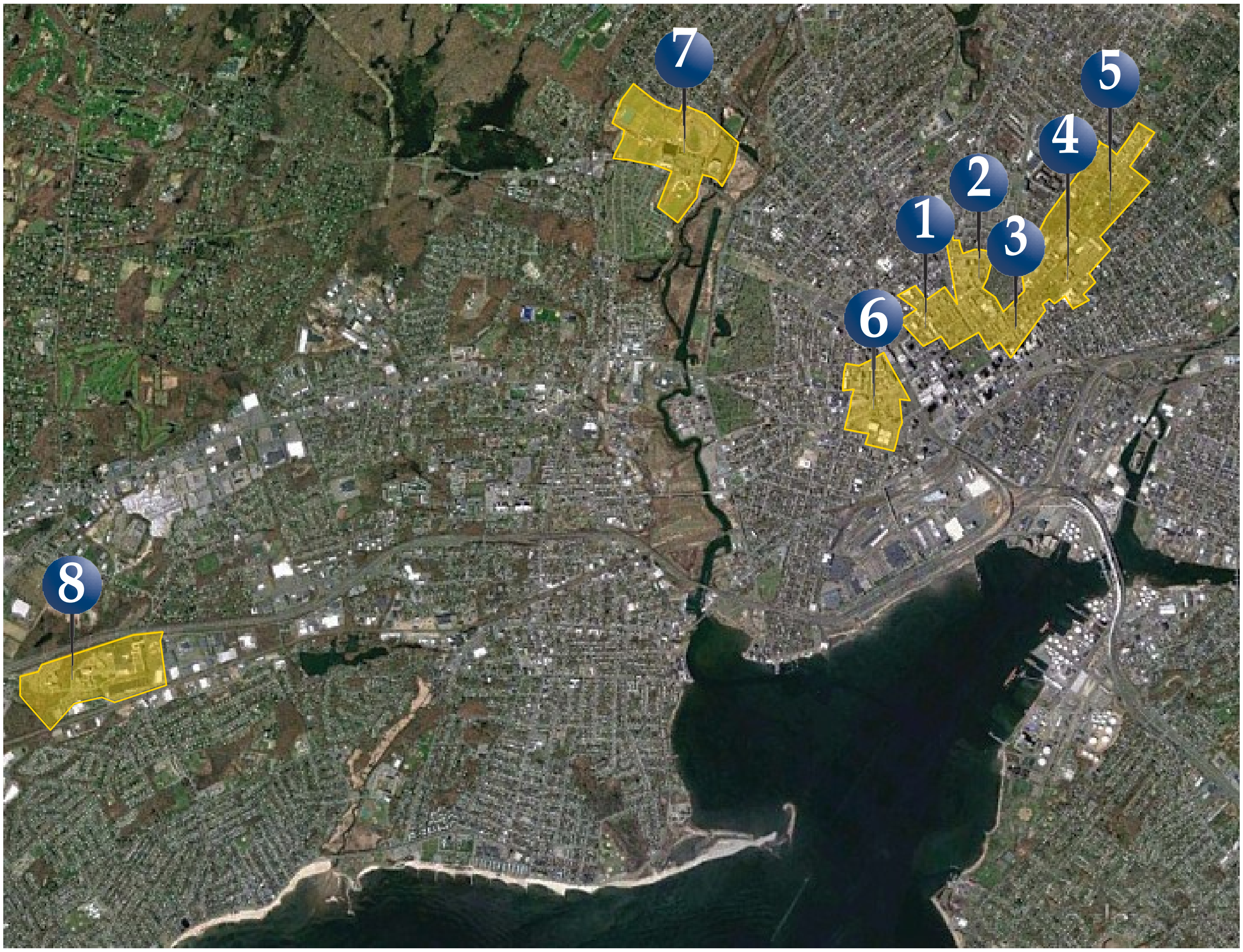
Composition

- Research the material content of major products, materials, components, and technologies used frequently to understand the environmental impacts of various metals, ceramics, plastics, etc.
- Purchase from vendors that sell environmentally responsible material and product alternatives for testing and consideration by Yale.
- Require manufacturers to provide transparency of material contents by listing components in the product or material.
- O&M: Develop standard specifications that encourage the usage of environmentally preferable products.

Disposal

- Direct infrastructure projects to follow Yale guidelines for maximizing construction and demolition waste recycling.
- Salvage or reuse durable materials and components.

5. PRECINCT CONSIDERATIONS



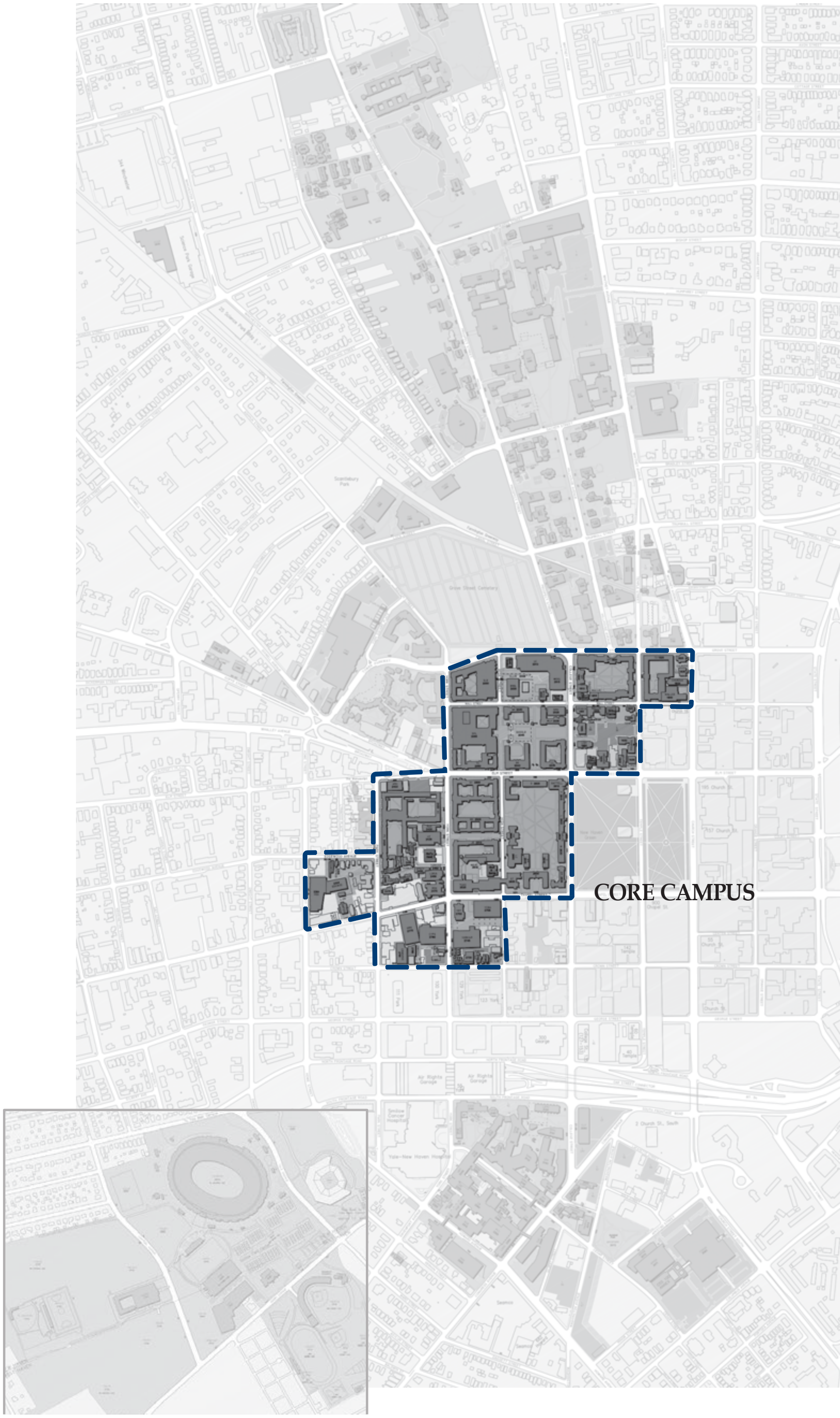
Yale University regional precinct locations

PRECINCT CONSIDERATIONS

Yale's campus is divided into eight distinct and interrelated planning precincts:

1. Core Campus
2. Broadway/Tower Parkway
3. Hillhouse
4. Science Hill
5. Upper Prospect
6. Medical Center
7. Athletic Fields
8. West Campus

The precinct boundaries are established on common uses, topography, and the physical characteristics of building types. These attributes inform precinct-specific sustainable design issues and opportunities requiring attention to all Areas of Focus and Campus Framework Systems. The following descriptions characterize these eight precincts and highlight selected Areas of Focus for particular emphasis and objectives. The Areas of Focus for each precinct are listed in order or priority.


CORE CAMPUS

PRECINCT: CORE CAMPUS

Core Campus includes Old Campus, Cross Campus, the Residential Colleges, and the Yale Arts Area. The uses are academic, administrative, residential, and cultural. The building typology embodies the Neo-Gothic iconography of Yale with several significant modern facilities, including several new and renovated LEED-certified buildings, such as the Art and Architecture complex, the Sculpture Building, Stoeckel Hall, and 493 College. It is a high-density urban area, adjacent to the New Haven Green and its downtown area. The precinct is fully walkable, but bounded and intersected by busy public streets. The mature and mostly flat landscaping in and around the residential colleges provides a collegiate atmosphere. Core Campus buildings are predominantly served by central plant utilities. Most buildings were renovated in the previous decade, including the addition of cooling for many previously naturally ventilated facilities. The key Areas of Focus for Core Campus are Air, Water, and Energy.

AIR

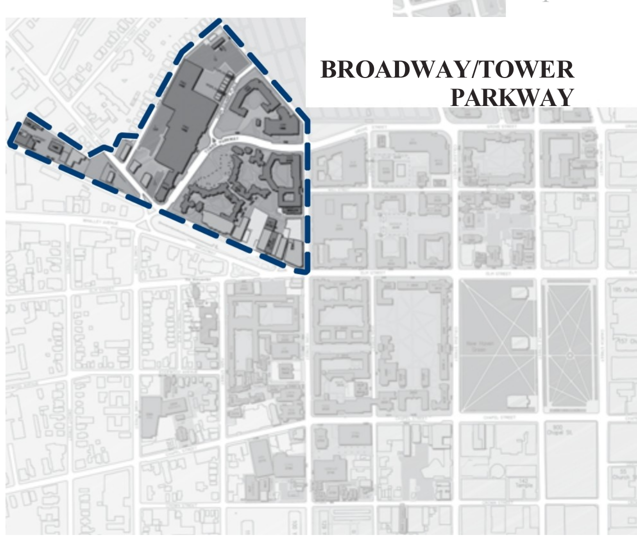
High vehicular tra∞c combined with minimal building setback from the curb increases the exposure to automotive exhaust and particulates to building occupants and pedestrians. Planning and design objectives are to reduce tra∞c and to enhance landscape planting to improve outdoor and indoor air quality.

WATER

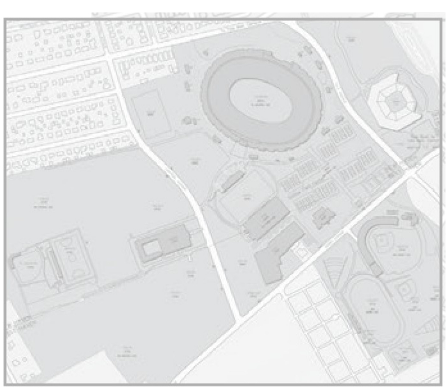
The frequency and potency of storm events is increasing and will continue to result in flooding problems in this high-density precinct. Project objectives include stormwater mitigation, infiltration, capture, storage, and reuse methods as well as water-retaining and aquifer-recharging landscape features.

ENERGY

The wide diversity of academic and residential usage makes comprehensive control of energy consumption di∞cult. The density of buildings provides beneficial shade during the cooling season and reduction of heat island e≠ects, but increases the need for wintertime heating. Objectives include existing building envelope improvements and control system upgrades that provide centralized operation and monitoring. Programs to engage building users to encourage energy-conserving behavior are needed.



BROADWAY/TOWER PARKWAY



PRECINCT: BROADWAY/TOWER PARKWAY

Broadway/Tower Parkway includes Payne Whitney Gym, Morse and Stiles Colleges, the Swing Dorm, Central Power Plant, and the Broadway retail area. The uses are athletics, utility services, residential, retail, and some academic. The majority of building typology is Neo-Gothic, interspersed with significant modern developments. The buildings are generally large complexes, some of which have been recently renovated with upgraded mechanical and electrical systems, most significantly Morse and Stiles. Large lawn areas provide green space but have fewer mature trees than Core Campus. Large plazas at Payne Whitney Gym and Morse and Stiles provide outdoor gathering spaces. This precinct is bounded and crossed by very busy public streets. The key Areas of Focus for Broadway/Tower Parkway are Energy, Water, and Air.

ENERGY

The variety and complexity of buildings in this precinct makes comprehensive energy management and control challenging. Planning and design objectives include existing building envelope and mechanical system improvements as well as control system upgrades that provide centralized operation and monitoring. Programs to engage building users to encourage energy-conserving behavior are needed.

WATER

Similar to Core Campus, the amount of roadway and hardscape combined with the frequency and potency of storm events makes this a flood-prone precinct. Objectives include stormwater infiltration, capture, storage, and reuse methods as well as water-retaining landscaping. Gray and/or wastewater from nearby buildings should be considered for collection and reuse by the Central Power Plant cooling tower for makeup water.

AIR

Similar to Core Campus, high vehicular tra∞c increases the exposure to automotive exhaust and particulates to building occupants and pedestrians. Additionally, lawn areas require frequent mowing, and the hardscape plazas create heat island e≠ects. Objectives are to reduce tra∞c and to enhance landscaping to minimize mowing requirements and mitigate heat island impacts to improve outdoor and indoor air quality.


HILLHOUSE

PRECINCT: HILLHOUSE

Hillhouse, located between Core Campus and Science Hill, encompasses a wide range of building types and usages. These include several energy-intensive laboratory and engineering facilities, as well as academic buildings, departmental o∞ce buildings of various sizes and vintages, the President's House, the new Health Center, and the planned Residential Colleges. Several buildings have been recently constructed or renovated to LEED standards and feature energy-e∞cient HVAC, lighting, and control systems, as well as environmentally sensitive landscaping. It is a walkable, medium-density, and relatively quiet precinct characterized by tree-lined streets on Hillhouse Avenue and moderately busy Prospect Street, as well as a section of the Farmington Canal trail. The key Areas of Focus for Hillhouse are Energy, Water, and Land.

ENERGY

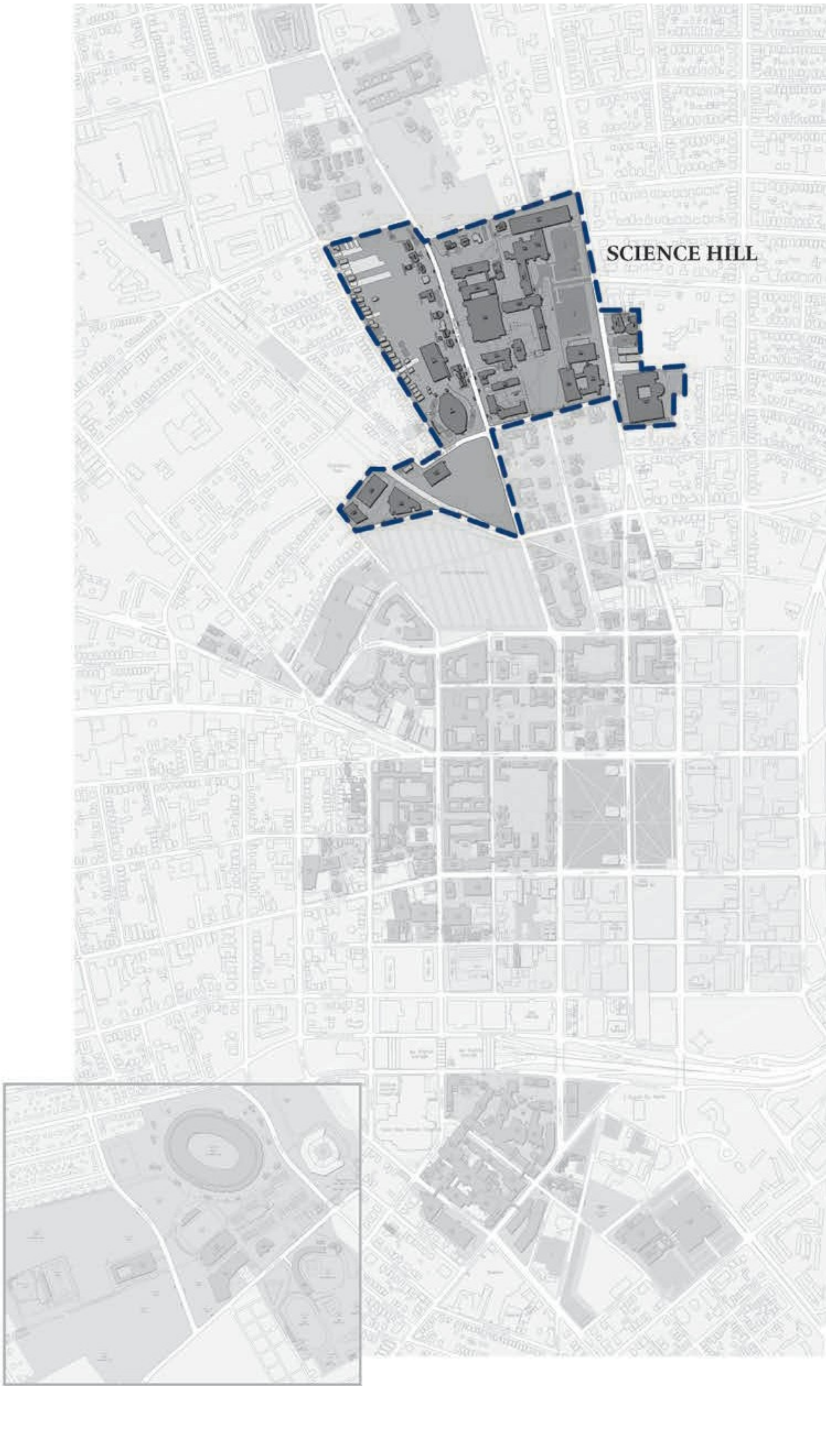
Most of the 19th- and 20th-century buildings in this precinct have not yet been renovated to current Yale design and performance standards. Not all buildings are connected to central plant utilities. The engineering and laboratory buildings have particularly high energy use intensities. With the exception of some of the new buildings, energy management controls are inconsistent and outdated. Planning and design aims for this diverse precinct range from building envelope improvements and energy management controls to integration of natural ventilation strate- gies, mechanical and electrical system upgrades, and geothermal or renewable energy strategies. Programs to engage building users to encourage energy-conserving behavior are needed.

WATER

Flooding is common in this precinct during significant rainstorms or snowmelt. Goals include storm-water mitigation, infiltration, capture, storage, and reuse methods, as well as water-retaining land-scaping.

LAND

With its semi-urban blend of streets, sidewalks, and vegetation in planting strips, lawn areas, and tree-lined streets, this precinct has many opportunities to improve surfacing and to further encourage walking and bicycling and to enhance biodiversity. Objectives include landscape planning to minimize mowing, irrigation, and fertilization, reduction of hardscape to allow water infiltration, and enhance-ment of pedestrian paths and greenway corridors.


SCIENCE HILL

PRECINCT: SCIENCE HILL

Science Hill, bounded by Edwards Street to the north and Sachem Street to the south, has the greatest elevation variation of any precinct on Yale's campus. Dominated by massive masonry buildings around the open landscape of Sachem Woods, it encompasses the largest collection of high-energy and water-intensive buildings on campus. Science Hill also contains several LEED-certified and comparatively e∞cient buildings, including Kroon Hall and the Class of 1954 Chemistry Research Building. Ingalls Rink and the new School of Management are also considered part of this precinct, as well as several large surface parking lots and parking structures. Most facilities are served by central plant utilities and new developments are being considered for stand-alone systems. The precinct is relatively low density with widely spaced buildings but provides pedestrians access to most buildings and courtyards without having to cross major thoroughfares. However, it is expected that Science Hill will continue to be developed with new facilities that will considerably increase its density. The key Areas of Focus for Science Hill are Energy, Water, and Movement.

ENERGY

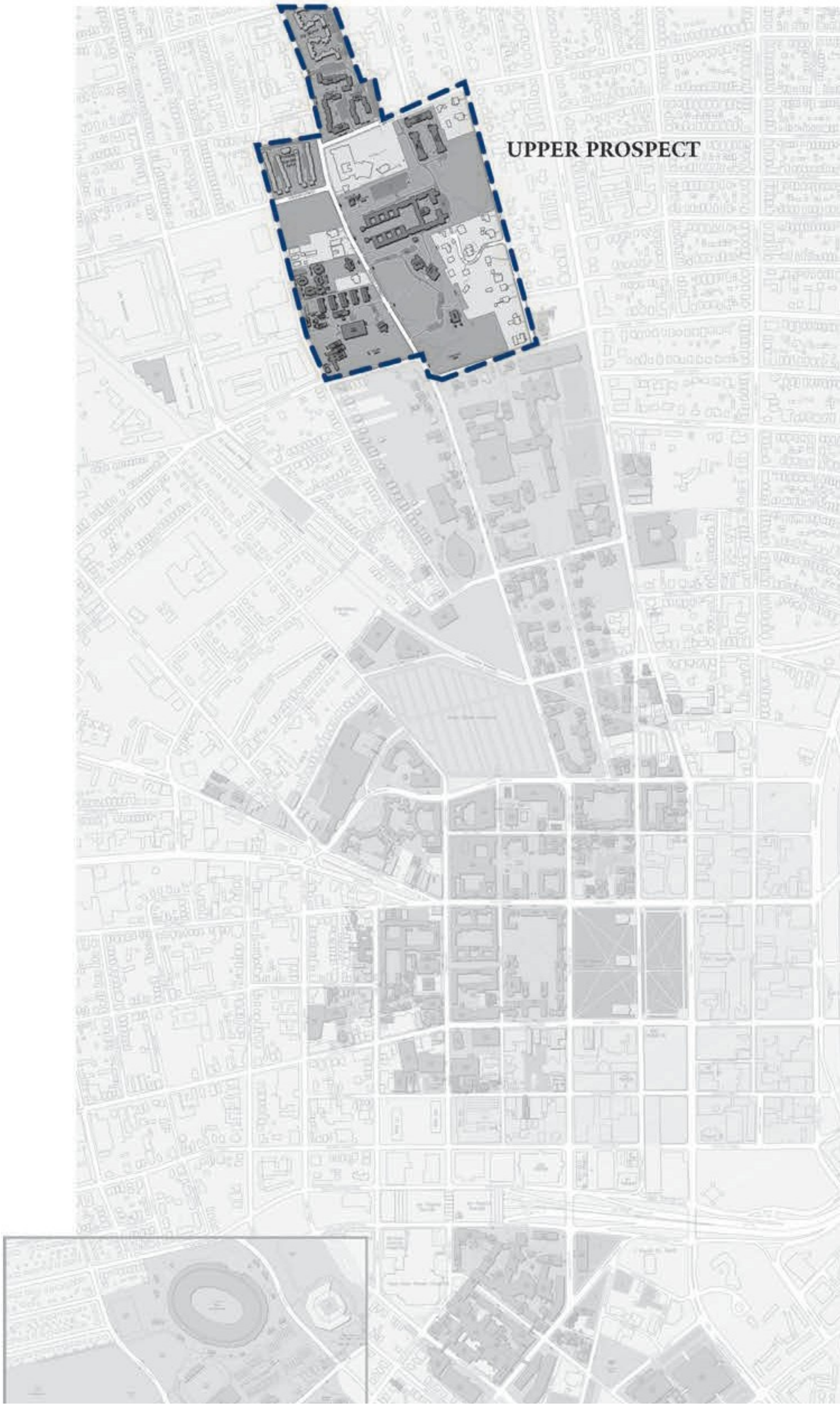
Laboratory facilities demand large amounts of energy to meet ventilation and cooling requirements and to power energy-intensive research. Goals include innovative, integrated mechanical ventilation and cooling strategies, lighting upgrades, and centralized control strategies that reduce energy use intensity. This also includes considerations of space planning, equipment sharing, and ventilation flow requirements, as well as operational adjustments and user-awareness programs to further save energy.

WATER

Science buildings also require significant amounts of process water for research. The topography results in stormwater runo≠ problems and basement flooding of some buildings during significant rain events. Identifying innovative strategies to reduce or reuse process water prior to disposal are necessary. Cooling tower makeup water is also intensively used for Science Hill buildings. This provides opportunities to explore water retention and recycling strategies to reduce or eliminate potable water consumption for stand-alone cooling systems. Green infrastructure strategies should be used to enhance stormwater mitigation.

MOVEMENT

Science Hill is well served by public transportation and by University shuttle buses, but it is distant from Core Campus and New Haven retail and dining areas. This presents planning and design challenges to improve pedestrian, bicycle, and other multimodal access to and around the precinct. These planning improvements should include considerations of transportation hubs, accessibility at and below grade, and planning for clustered amenity and support services.


UPPER PROSPECT

PRECINCT: UPPER PROSPECT

Upper Prospect, located on Prospect Street on the hilltop north of the Science Hill precinct, is distant from Core Campus and has a relatively low density of buildings. This precinct includes the Divinity School, Greeley Memorial Laboratory, and Leitner Observatory, as well as the LEED-certified Greenberg Conference Center. It also includes significant park-like spaces such as Farnam Gardens, Marsh Gardens, and the Yale Farm. It adjoins a wetlands greenway and conservation corridor connecting back to the Science Hill and Hillhouse precincts. The typology is a mix of 19th- and 20th-century Georgian and Victorian structures serving as departmental o∞ces and academic facilities with a mix of contemporary low-rise residential buildings. Many are not served by central plant utilities. The key Areas of Focus for Upper Prospect are Water, Land, and Movement.

WATER

The hilltop location and topography of this precinct, combined with large areas of surface parking, contribute to rapid runo≠ of stormwater. The large green spaces need ample water to thrive. The buildings have relatively low water consumption demands but are located where water retention and reuse is viable. These interrelated challenges provide opportunities for stormwater management strategies to minimize runo≠, retain and reuse rainwater for gardening and landscape irrigation or building consumption, and recharge to nearby greenways and conservation corridors. Green infrastructure strategies should be used to enhance stormwater mitigation.

LAND

With its uniquely large and distinctive mix of park-like landscape areas, large lawns, mature trees, and gardens, this precinct has many opportunities to improve surfacing, reduce parking hardscape, and to further encourage walking and bicycling. The considerations should include landscape planning to minimize mowing, irrigation, and fertilization, reduction of hardscape to allow water infiltration, and enhancement of pedestrian paths and greenway corridors to enhance biodiversity.

MOVEMENT

Upper Prospect is typically accessed by University shuttle buses, some public buses, and automobiles from Prospect Avenue only. It is distant from Core Campus and New Haven retail and dining areas. This presents planning and design opportunities to improve pedestrian, bicycle, and other multimodal access to and around the precinct. It is especially important to consider enhancements to sidewalks, street crossings, and landscape paths, as well as greenway corridors to encourage pedestrian access.


MEDICAL CENTER

PRECINCT: MEDICAL CENTER

The Medical Center, located south of Core Campus, encompasses the School of Public Health, the School of Medicine, 100 Church Street South, and Sterling Power Plant, as well as several large parking structures. The precinct is a very dense, urban section of New Haven separated from the downtown area by the Route 34 Connector. The Medical Center campus is characterized by large, intensively used research facilities that enable movement between buildings due to adjacency and connecting corridors and bridges. Tra∞c congestion is common in this precinct due to proximity to Yale-New Haven Hospital and very limited on-street parking. Landscaping is limited to street trees and some relatively small and noncontiguous lawn areas. The key Areas of Focus for the Medical School are Energy, Water, and Air.

ENERGY

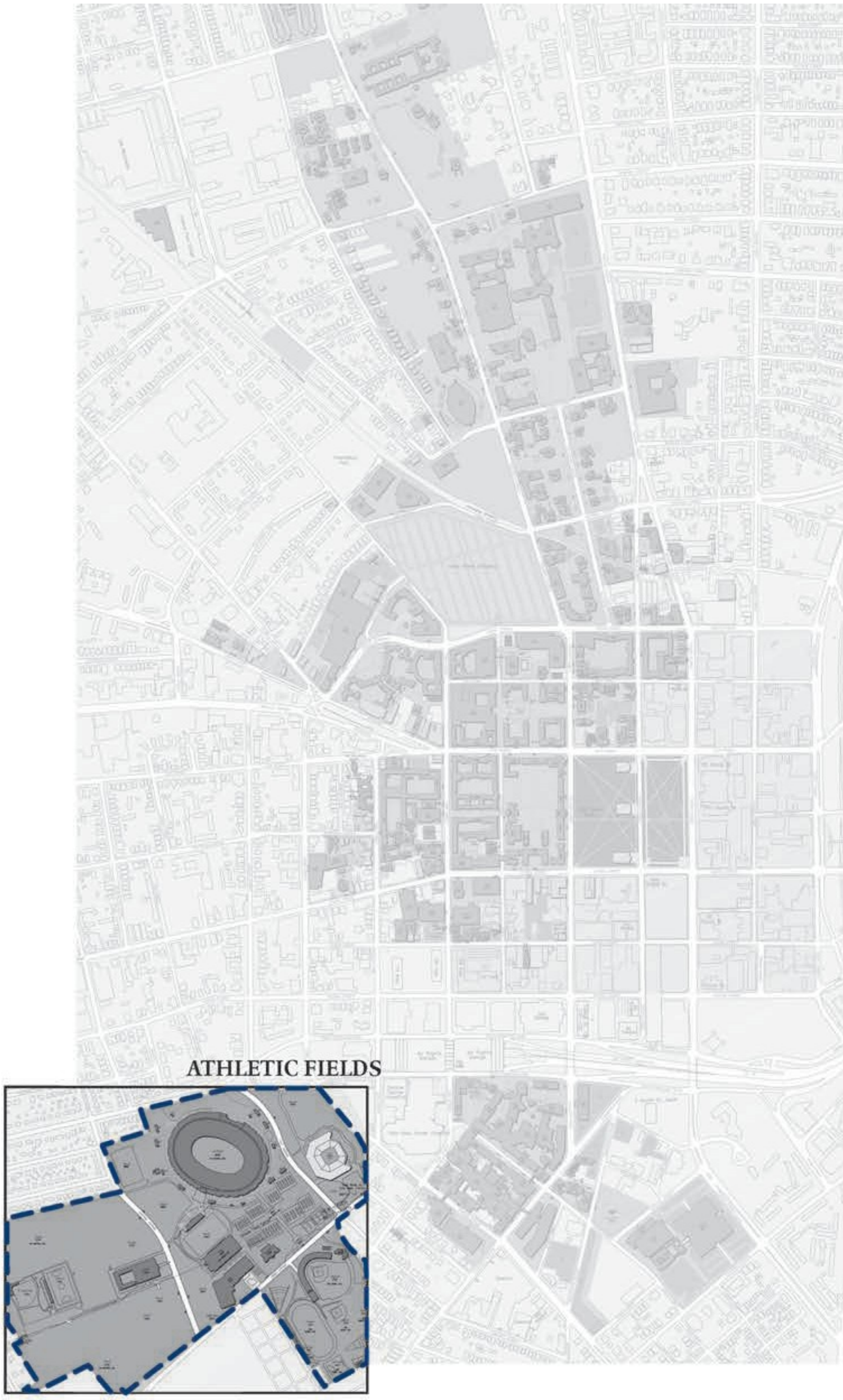
Medical Center laboratory facilities demand enormous amounts of energy to meet ventilation and cooling requirements and to power energy-intensive research. Many of the laboratories have been renovated to LEED standards and demonstrate new approaches to ventilation, lighting, daylighting, and energy management. This experience is the basis for objectives to continually develop innovative, integrated mechanical ventilation and cooling strategies, lighting upgrades, and centralized control strategies that reduce energy use intensity. These objectives also include considerations of envelope improvements, space planning, equipment sharing, and ventilation flow requirements, as well as operational adjustments and user-awareness programs to further save energy.

WATER

The Medical Center laboratories also require significant amounts of process water for research. As a high-density urban area with very little landscaped area, it is prone to flooding and rapid runo≠ during storms. Therefore, rooftop and grade-level landscaping and stormwater detention strategies should be explored. Green infrastructure strategies should be used to enhance stormwater mitigation. Newly renovated laboratories demonstrate techniques and technologies for reducing and reusing process water that should be targeted in developing new and innovative water-saving strategies. Cooling tower makeup water is also intensively used for Medical Center buildings. Other goals include water retention and recycling strategies to reduce or eliminate potable water consumption for cooling systems upstream and downstream of the Sterling Power Plant.

AIR

High vehicular tra∞c combined with minimal building setback from the curb increases the exposure to automotive exhaust and particulates for building occupants and pedestrians. Objectives are to reduce tra∞c and enhance landscape and planting to improve air quality. Laboratory air intakes need to provide satisfactory indoor air quality, while exhaust systems must protect against harmful emissions and pollutants. The waste heat from exhaust systems can also provide supplemental energy. Service access to buildings should be organized and clustered to minimize vehicular exhaust.


ATHLETIC FIELDS

PRECINCT: ATHLETIC FIELDS

The Athletic fields precinct, located two miles northwest of Core Campus, is typically accessed by private vehicle and school buses. It is intensively used and served by Yale's biodiesel shuttle buses only during major sports events. It is a suburban area characterized by open land with widely spaced, large athletics facilities interspersed among sports fields. These facilities are used for a wide variety of University-sanctioned sports and by the local community. There is some hardscape surface parking, but most parking for large events is on designated turf areas. The key Areas of Focus for the Athletics fields are Energy, Land, and Movement.

ENERGY

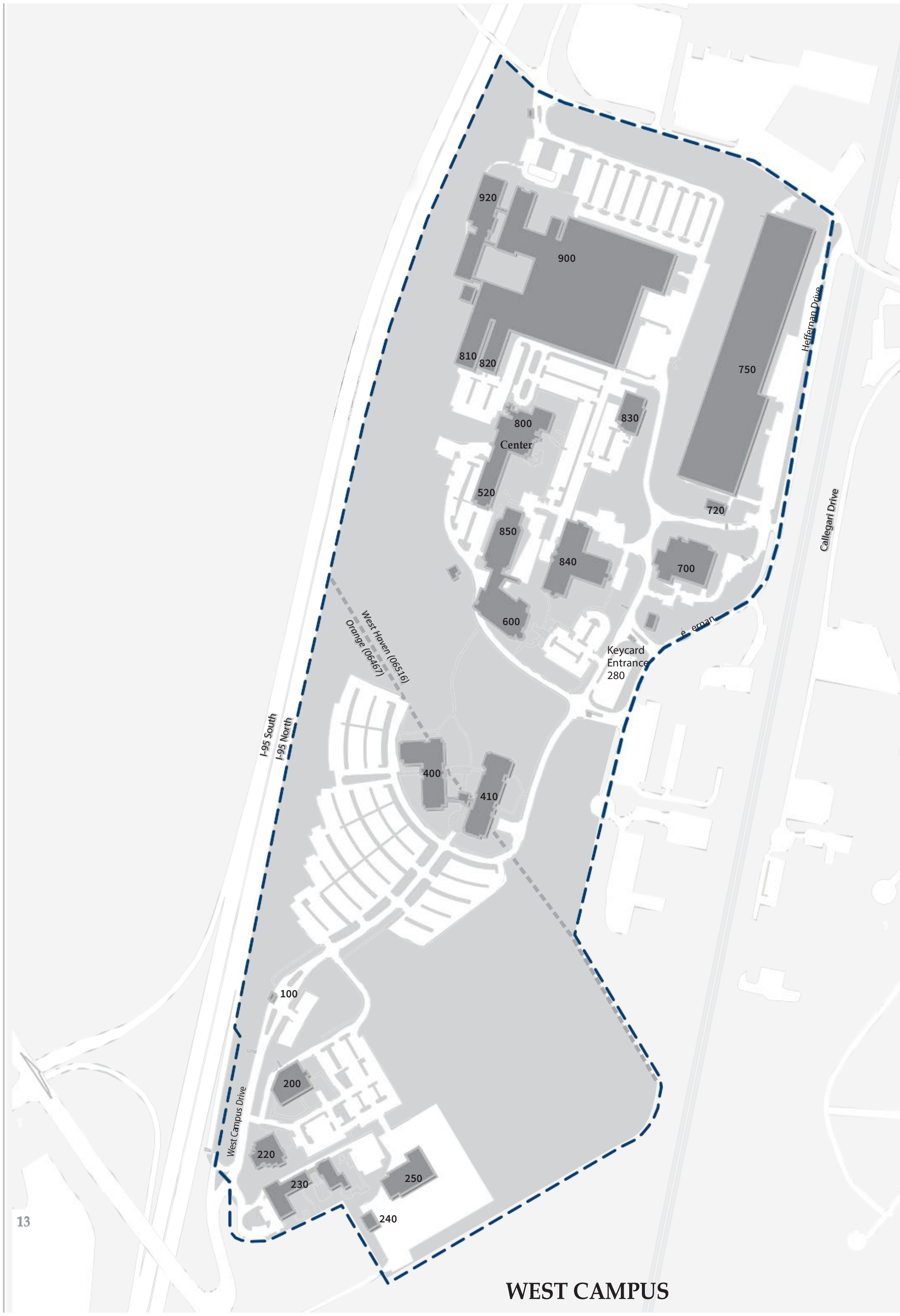
The large Athletic fields buildings have basic lighting, heating, and ventilation requirements that drive objectives for improving building envelope performance and upgrading lighting and HVAC technology and control capability. Occupancy and setback controls are particularly important for ensuring HVAC and lighting system deactivation during long periods of building vacancy. The openness of the area enables optimal siting and orientation of new buildings to take full advantage of natural lighting and ventilation potential. Similarly, this precinct provides opportunities for large-scale renewable energy installations. Programs to engage building users to encourage energy-conserving behavior are needed.

LAND

The large expanses of sports fields and lawn require mowing, fertilization, and irrigation. It is near greenways and conservation areas. Goals for this precinct include surfacing improvements to encourage walking and bicycling to the site. The considerations should include landscape planning to minimize mowing, irrigation, and fertilization; elimination of invasive species; reduction of hardscape to allow water infiltration; and enhancement of pedestrian paths, greenway corridors, and biodiversity. Water-retention systems should be considered to provide supplementary irrigation water.

MOVEMENT

The Athletic fields are distant from Core Campus and New Haven retail and dining areas. Important aims are to improve pedestrian, bicycle, and other multimodal access to and around the precinct.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Callegari Drive
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West Haven (06516)
Orange (06477)
Keycard
Entrance
280
I-95 South
I-95 North
400
410
100
200
West Campus Drive
220
230
250
240
13

WEST CAMPUS

PRECINCT: WEST CAMPUS

West Campus, located seven miles west of Core Campus in the towns of West Haven and Orange, Connecticut, is the most remote of the precincts. Adjacent to the I-95 corridor, West Campus is a complex of o∞ce buildings, laboratory facilities, and a central plant constructed in the 1980s for a commercial pharmaceutical firm and acquired by Yale in 2007. The precinct is characterized by large, stand-alone buildings amid impermeable asphalt surface parking lots. It also contains five acres of developed wetlands with nature paths and a greenbelt along the Oyster River that flows through the site. These natural areas are used by local schools for eco-system and biodiversity study. The precinct is accessed by personal vehicle and shuttle bus. The key Areas of Focus for West Campus are Energy, Water, and Air.

ENERGY

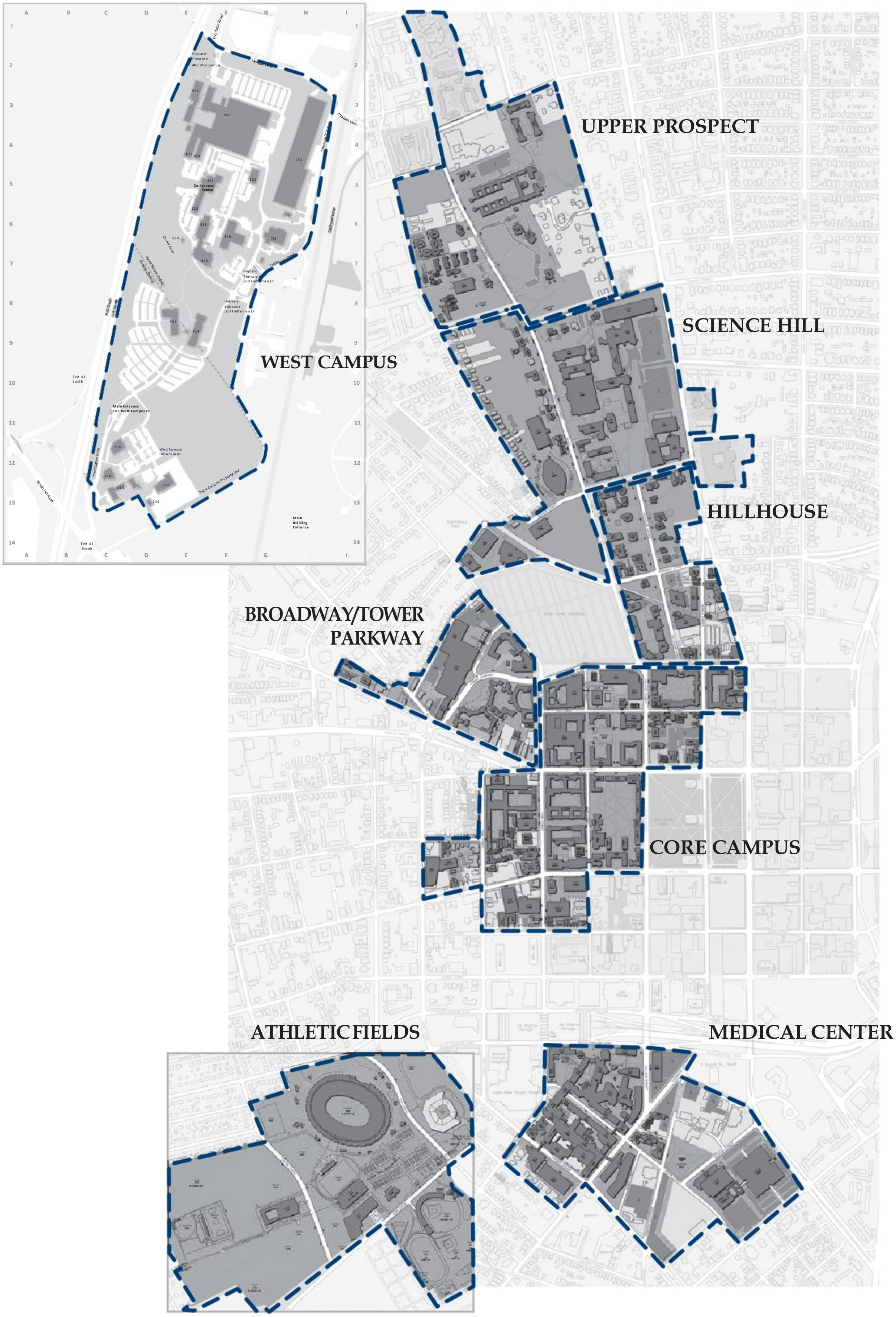
This precinct contains numerous laboratory facilities that demand large amounts of energy through increased ventilation rates for cooling and intensive equipment use. The natural gas-driven central plant delivers chilled water for cooling. Objectives include innovative, integrated mechanical ventilation and cooling strategies, lighting upgrades, and centralized control strategies that reduce energy use intensity. This also includes considerations of space planning, equipment sharing, and ventilation flow requirements, as well as operational adjustments and user awareness programs to further save energy. The large, open site has potential for photovoltaic and other renewable energy systems.

WATER

The large areas of hard surface paving makes this precinct prone to flooding and rapid runo≠ during storms. Laboratory facilities have intensive process water requirements. Therefore, rooftop and grade-level landscaping and stormwater detention and retention strategies should be explored. Techniques and technologies for reducing and reusing process water should be considered in developing new and innovative water-saving strategies. Green infrastructure features and low-maintenance landscaping can enhance infiltration and biodiversity.

AIR

Proximity to Interstate 95, surrounding parking areas, and truck loading docks increases the exposure to automotive exhaust and particulates for building occupants and pedestrians. Planning and design objectives are to reduce tra∞c, protect pedestrians, and enhance landscape and planting to improve air quality. Laboratory air intakes need to provide satisfactory indoor air quality, while exhaust systems must protect against harmful emissions and pollutants. The waste heat from exhaust systems can also provide supplemental energy. Service access to buildings should be organized and clustered to minimize vehicular exhaust. Among many benefits, tree planting can provide carbon sequestration, beneficial shade, and air filtration. Service access to buildings should be organized and clustered to minimize vehicular exhaust near intakes.


WEST CAMPUS
UPPER PROSPECT
SCIENCE HILL
HILLHOUSE
BROADWAY/TOWER PARKWAY
CORE CAMPUS
ATHLETIC FIELDS
MEDICAL CENTER

6. GLOSSARY

GLOSSARY

The area of sustainability is heavy with jargon and “buzz-words” with potentially several meanings or ways of being interpreted. Throughout this document, a number of such terms have been used. The following glossary clarifies the the most important terms.

- **Adaptive Management**: A structured, iterative process of robust decision making in the face of uncertainty, with an aim to reduce uncertainty over time via system monitoring.
- **Alternative Fuel Vehicle**: A vehicle (passenger or commercial) that is not powered by gasoline. Examples include hybrid-fuel, biodiesel, and electric vehicles.
- **American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE):** A group of 54,000 members worldwide focused on building systems, energy e∞ciency, indoor air quality, refrigeration and sustainability within the industry.
- **Best Management Practices (BMP)**: Resource management techniques representing the most e∞cient, economical, and environmentally responsible practices.
- **Biome**: An ecological region comprised of a distinctive community of flora and fauna living inter-dependently within a specific geographic region and climate.
- **Bioswale**: A manmade landscape element designed to remove pollutants and silt from surface runo≠ water.
- **Built Environment**: Manmade elements of the environment, including buildings and infrastructure.
- **Carbon Sequestration**: The process of removing carbon from the atmosphere (through natural or artificial means) and depositing it in a reservoir. Trees and other biomass naturally sequester carbon.
- **Circulation System**: Physical infrastructure for moving people and materiel throughout an area or region, including buses, cars, trains, pedestrian walkways, etc.
- **Cost-Benefit Analysis**: A process for calculating and comparing benefits and costs of a project, decision, or government policy.
- **Demand Side Management**: A plan to modify consumer energy demand through education and financial incentives, with the goal of encouraging consumers to reduce energy consumption through equipment retrofits and control improvements and to shift energy use from

peak to o≠-peak times, in order to stabilize the grid, lower utility costs, and reduce the need for power plant and network investments.

- **Ecosystem**: An ecological community together with its abiotic environment, interacting as a system.
- **Ecosystem Services**: Benefits to humans that are derived from multiple resources and processes supplied by natural ecosystems.
- **Energy Simulation**: Evaluating the energy demand and use of a building, based on external and internal loads, envelope constructions, HVAC systems, lighting, and occupancy schedules. Typically conducted to compare the energy performance of a proposed building against a code or ASHRAE baseline building, to determine potential savings in energy cost.
- **Environmental Footprint**: Measure of the resource demand a project places on the Earth's ecosystems.
- **Environmental Impact**: Possible adverse e≠ects caused by a development, industrial, or infra-structural project or by the release of a substance in the environment.
- **Enthalpy Wheel**: A type of energy-recovery heat exchanger.
- **Green Cleaning**: A cleaning program designed to preserve human health, improve indoor air quality, and prevent water and soil pollution by eliminating cleaning chemicals that may cause respiratory, dermatological, or environmental harm.
- **Greenhouse Gases (GHGs)**: Atmospheric gases, such as carbon dioxide (CO2) and methane (CH4), that absorb and emit radiation within the infrared range.
- **Green Waste**: Biodegradable waste, such as grass or hedge trimmings, as well as food waste. Generally high in nitrogen, as opposed to brown waste, which is primarily carbonaceous.
- **Green Infrastructure**: Systems planned and constructed to reduce stress on traditional water drainage and sewer infrastructure to improve stormwater management, reduce overflows and flooding, and enhance groundwater recharge.
- **Green Roof**: A roof partially or completely covered with vegetation to absorb rainwater and regulate stormwater runo≠, as well as mitigate urban heat island and create a habitat for wildlife. Intensive green roofs refer to those that can support a wide variety of plants, while extensive roofs typically only have a light layer of vegetation.
- **Greenhouse E≠ect**: Trapping of solar radiation in Earth's atmosphere, caused by the presence of greenhouse gases such as carbon dioxide, methane, and water vapor, increasing the mean temperature of the planet. Greenhouse gases are defined as those that allow sunlight to pass through, but absorb the infrared radiation emitted back by the planet's surface.
- **Gray Water**: Wastewater generated from domestic activities such as laundry, dishwashing, and bathing, which can be recycled on-site for landscape irrigation.
- **Heat Island E≠ect**: The thermodynamic phenomenon that leads areas of heat-trapping materials, such as concrete and asphalt, to be warmer than surrounding areas.

- **High-Albedo Pavement:** Light-colored pavement that reflects the majority of solar radiation, which helps mitigate the heat island e≠ect and keep outdoor areas cooler.
- **Integrated Pest Management:** An approach to pest management focused on long-term prevention using environmentally preferable, nonchemical, and mechanical practices to mitigate pest damage and improve sanitation while protecting human and environmental health.
- **Invasive Species**: Non-indigenous flora and fauna that adversely a≠ect the habitats they invade by threatening biodiversity. These are commonly characterized by fast growth, rapid reproduction, high tolerance to climatic ranges, and association with humans.
- **LEED**: Leadership in Energy & Environmental Design, primary green-building rating system published and administered by the U.S. Green Building Council.
- **Life Cycle Assessment**: A technique to assess environmental impacts associated with all the stages of a product's life from cradle to grave.
- **Low Emission Vehicle**: A motor vehicle that emits a relatively low level of motor vehicle emissions.
- **Natural Resources**: Resources that occur naturally within environments that exist relatively undisturbed by mankind, in a natural form.
- **O≠-Gassing (also Out-Gassing)**: The release of a gas that was dissolved, trapped, frozen, or absorbed in a material; can have a negative impact on indoor air quality.
- **Passive and Active Adaptive Management**: In active adaptive management, managers implement more than one alternative to determine which action best meets their objectives, while in passive adaptive management, only a single option is implemented, with corrections being made as necessary.
- **Post-Consumer Waste**: A waste type produced by the end consumer of a material stream.
- **Precinct Methodology**: A planning methodology that divides an area into smaller precincts and addresses needs specific to each precinct rather than to the entire area.
- **Pre-Consumer Content**: A material that is diverted from a waste stream during the manufacturing process that is then used in an alternative application, product, or material.
- **Rain Garden**: A vegetated depression sited to allow for the absorption of rainwater runo≠ from impervious surfaces (roofs, parking lots, sidewalks, etc.) to reduce stormwater runo≠ and filter water through layers of soil, thereby improving local water quality.
- **Resiliency**: The ability of an ecosystem or building to respond to a disruption (e.g., wildfires, deforestation, floods, etc.) by withstanding damage and recovering quickly.
- **Stormwater Runo≠**: Water that is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and is not absorbed back into the ground.
- **Sustainable Development (Brundtland Report Definition)**: A pattern of economic growth in which resource use aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for generations to come.

- **Wildlife Corridor**: An area of habitat connecting wildlife populations and/or facilitating migration.
- **Zero-Emission**: An object or energy source that emits no net waste products that pollute the environment or disrupt climate.

7. REFERENCES

REFERENCES

The following lists documents for reference by design teams, consultants, and internal sta≠. The current version of each document provides essential information and describes Yale University's preferred approach when considering campus planning, design, construction, and management.

1. Framework for Campus Planning
   - Supplement to Framework for Campus Planning
   - Sustainability Supplement to the Framework for Campus Planning

2. Sustainability Strategic Plan

3. Utilities Master Plan

4. Stormwater Management Plan

5. Water Management Plan

6. Integrated Waste Management Plan (in development)

7. Sustainable Transportation Plan

8. Design Standards
   - Sustainable Design Requirements 01352
   - Sustainable Products List
   - Landscape Design & Construction Standards (in development)
   - Signage Standards
   - Indoor Air Quality Guidelines (in development)
   - Lighting Standards (indoor and outdoor) (in development)

9. Green Purchasing Standards

10. Green Cleaning Standards

8. APPENDIXES

APPENDIX A: ECOSYSTEM SERVICES APPROACH

Ecosystem services are defined as the life-support services that nature provides to humans, and as such are considered essential to human well-being. Although Yale will manage and measure progress based on specific recommendations within each Campus Framework System by the Areas of Focus described herein, it is important to understand that an "ecosystem services approach" provided the basis for the development of the recommendations. Further, this approach was integral to the definition of the Sustainability Planning Principles. Ecosystem services are fundamental to Yale's understanding of campus development, and specific ecosystem services are here identified that Yale can preserve and restore on its campus and within the greater New Haven region. This approach necessitates a shift in thinking about the stewardship of University open space, but not an upheaval. The concepts of an ecosystem services approach are incorporated into the Sustainability Areas of Focus of Air, Water, and Land.

For over three centuries, the open space of Yale's campus has been integral to the identity of the institution. It has played an essential role in the aesthetics and the functionality of the University, working to support the architectural and academic heritage for which Yale is renowned. In recognition of the environmental challenges of the 21st century and as a leader in education and research, Yale has the opportunity to expand the role of campus open space beyond its traditional scope to tackle problems such as climate change, stormwater management, and habitat fragmentation.

Defining Ecosystem Services at Yale

The Millennium Ecosystem Assessment (MA), launched by the United Nations in 2000, is considered the global authority on ecosystem services and is used as a foundation for Yale's approach. The MA divides ecosystem services into four categories: provisioning, regulating, supporting, and cultural. Within these categories, the range of services is very broad, including everything from drinking water to timber to medicinal resources. In an urban environment like Yale's, examples of relevant ecosystem services include stormwater management, microclimate mediation, nutrient cycling, and pollination. Although urban development has the tendency to deplete the capacity of an ecosystem to provide services, there is tremendous potential to rehabilitate some of those services in the planning, design, and management of campus natural resources. The ecosystem services approach provides a way to understand the benefits we derive from natural capital and to plan for carefully considered management.

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Glossary

An ecosystem services approach to campus planning, design, and management at Yale builds upon existing practices to create new opportunities for environmental stewardship in a wide range of spaces from courtyards, quadrangles, walkways, and roofs to parking areas and large open green spaces. It strengthens current practices by enhancing the two existing criteria of aesthetics and function. Each project that Yale undertakes currently requires consideration of how it will fit with existing Campus Framework Systems, including built form, landscape and open space, circulation, utilities, and signage (cited in the 2000 Framework Plan). Using the lens of ecosystem services, each project will also be evaluated for its ecological performance, including its impact on human and nonhuman dimensions at a local, regional, and global scale. An ecosystems services approach encourages the University to think of itself as integrated within a larger ecosystem upon which it can choose to have positive and/or negative impacts.

Application

Natural resources may not be visually dominant throughout the entire urban environment of Yale's campus, yet the University benefits from significant existing natural capital and has great potential to expand that capital. Some natural resources, such as trees and lawns, already exist in one state or another on the campus; others, such as green roofs and bioswales, either exist in low numbers or have yet to be explored. It is important to recognize that the majority of Yale's natural resources have been constructed through human intervention and are not remnants of an original regional ecosystem. As such, the ecosystem services approach addresses the creation of new natural resources in addition to the restoration and maintenance of existing ones.

As an example, a common application of an ecosystem services approach is with respect to stormwater runo≠ and tree canopy coverage:

Stormwater and Green Infrastructure: Every city needs traditional gray infrastructure, but green infrastructure can be a highly e≠ective complement to mechanical systems. Not only is green infrastructure less expensive than gray, it also provides a wide range of benefits that go beyond the quantitative services of stormwater mitigation to include, for example, water cleansing, temperature regulation and erosion control. In contrast, sewer systems are tremendously e∞cient but they perform only one function- the conveyance and treatment of waste water and stormwater.

Tree Canopy Coverage: Trees perform an impressive array of functions. By absorbing rainwater, trees keep water out of the sewer system and reduce the water quantity going into sewage treatment plants. This in turn reduces the amount of untreated wastewater discharged into water bodies when the amount of water entering the system exceeds infrastructural capacity. Trees provide habitat and food for pollinators, local bird species, and migratory bird species and have a positive impact on air quality by capturing particulate matter on leaves. A phenomenon known as urban heat island can be mitigated when trees shade the hard surfaces that absorb sunlight and retain heat.

These are a handful of the benefits provided by urban natural resources. Integrating an ecosystem services approach, the University can infuse its current practices with the interconnectivity of all natural systems. The health of each component-plants, soil, water, air, animals, and microbes-is integral not only to the ecological health of the campus but also to the social fabric and economic health of the Yale community. The approach supports the resiliency, integrity, and longevity of the campus ecosystem and the people who inhabit it.

Ecosystem Services Applicable to the Yale Campus
The following list outlines the ecosystem services that Yale's campus can provide. This is a selective list and does not include all the ecosystem services any ecosystem can provide; instead, it is tailored to Yale's urban campus. It draws from both the Millennium Ecosystem Assessment (MA) and the Sustainable Sites Initiative (SSI). ("The Case for Sustainable Landscapes." Sustainable Sites Initiative, 2009. Web. http://www.sustainablesites.org/report.)

Provisioning Services:
Habitat: The provisioning of habitat is essential to the provisioning of all other services. Land management provides refuge and reproduction habitat to plants and animals, thereby contributing to conservation of biological and genetic diversity and evolutionary processes.

Regulating Services:
Local Climate Regulation: Regulating local temperature and humidity through shading, evapotranspiration, and windbreaks.

Global Climate Regulation: Maintaining balance of atmospheric gases at historic levels, creating breathable air, and sequestering greenhouse gases through photosynthesis and respiration.

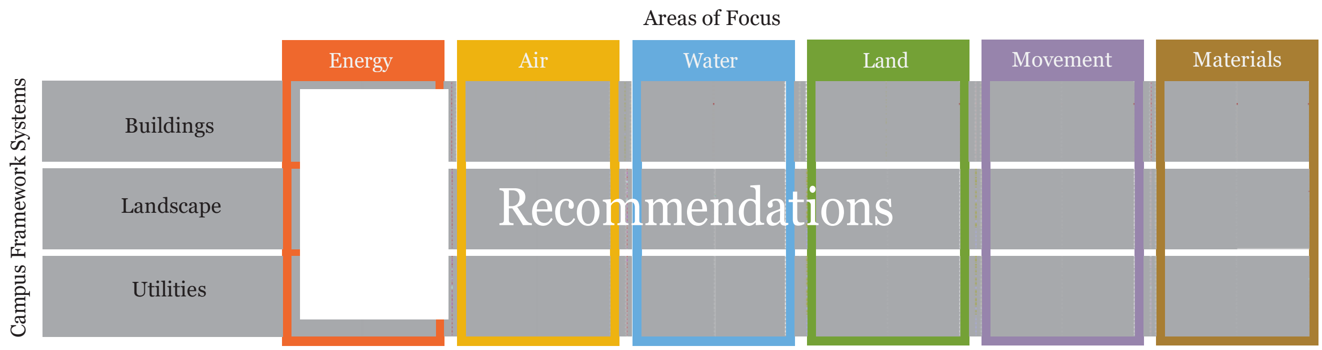
Air and Water Cleansing: Removing and reducing particulates and pollutants in air and water through filtering provided by plants and soils.
Pollination: Vegetation provides habitat for pollinator species for the reproduction of plants

Erosion Control: Retaining soil within an ecosystem, preventing damage from erosion and siltation; vegetative cover and maintenance practices play an important role in soil retention.

Supporting Services:
Nutrient Cycling: Maintaining soil fertility through the ecological process of nutrient cycling.

Cultural Services:
Human Health: Enhancing physical, mental, and social well-being as a result of interaction with nature.

Cultural Benefits: Enhancing cultural, educational, aesthetic, and spiritual experiences as a result of interaction with nature.


Areas of Focus
Energy
Air
Water
Land
Movement
Materials
Campus Framework Systems
Buildings
Landscape
Utilities
Recommendations

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