

Sustainable Community Design

A Major Qualifying Project
Submitted to the faculty of
Worcester Polytechnic Institute
In partial fulfillment of the requirements for the
Degree of Bachelor of Science

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Abstract

This project was to address the issue of sustainable community planning for Stantec Consulting Ltd. Successful applications of sustainable community practices, specifically the LEED-ND rating system, were researched to determine the most successful methods to incorporate sustainability into various aspects of community planning and design. This included everything from public transit to local food production. This research was then compiled into a Best Practices Manual, to be used by Stantec engineers when discussing options for sustainable planning with clients.

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Executive Summary

Sustainability and sustainable development have been steadily gaining popularity for the past decade. This is due, in part, to an increased awareness of the environmental impacts human society has had in the last century with automobiles and sprawling urban development. More recently, there has been a surge in new green construction projects. Since people spend much of their time working and living in buildings, designing them to be more energy efficient and environmentally friendly has been the primary goal of groups such as the U.S. Green Building Council (USGBC) with their Leadership in Energy and Environmental Design (LEED) program.

In this constantly changing field, one of the most recent developments is LEED for Neighborhood Development (LEED ND), created by the USGBC. The program is designed to take green building a step beyond the structure and site of the building itself and encompass an entire neighborhood or small section of a community. This is a combined effort to change both living and transportation practices.

Stantec Consulting Ltd. is a global design and consulting firm that covers many disciplines of civil engineering and wants to maintain a position at the forefront of sustainable design and building. Sustainable community and neighborhood development is an area that combines urban planning and green building and is a developing field that could, potentially, involve many Stantec personnel.

The goal of this project was to use LEED ND as a starting point to develop a set of best practices to assist with standardizing the approach taken by all of Stantec's offices. After an initial review of the material covered by the program, the project focused on one of the sub sections, the Neighborhood Pattern and Design portion of LEED ND. These 15 credits were determined to embody what sets LEED ND apart from the standards designed for sustainable buildings.

The initial plan was to develop a guide to help Stantec assist their clients that were interested in a LEED ND certification by compiling information concerning the implementation of each credit. As research into the credits and the scoring system progressed, several flaws in the rating system became evident. Most of the credits themselves were important, but there was considerable inequity in the final scoring. For

example, having a community school and having several bike racks are both very legitimate portions of the program, but the problem is that the differences in size, impact, and cost are not reflected in their point values. Both building a school and providing bike racks earn one point each. After discovering this, it was decided that the focus of the manual would be on the benefits of the actual credits, not on their point value.

In order to accomplish this, all 15 Neighborhood Pattern and Design credits were researched in depth. The information was compiled into a table that highlighted LEED's intent for each credit, the associated best practices - based on case studies and government and private sector publications - and included a list of any outside agencies required to implement each credit. This table provided the basis of the Best Practices Manual (BPM). For each part of the best practices section, a separate appendix section was created to include further specific information, figures where applicable, and links to relevant electronic sources to provide further information to the user. In the electronic version, the separate appendices were replaced by links to new pages.

The difference between this format and the format presented in the LEED ND guide is that the LEED format only includes the intent, number of points available, and the methods used to measure and evaluate whether or not each credit was earned. The format of the manual developed for this project takes all the emphasis off the scoring system and places it on the credits themselves. It is designed to assist clients by displaying each of the credits, LEED's justification for including them, and then a section of information about how to implement them.

This design was chosen to help clients make a decision based on their goals and abilities rather than simply "chasing credits" in order to get a certification. This is not to say that it is discouraging developers from pursuing LEED certification. It is simply trying to guide them to focus on what they find to be most important. This may or may not result in certification, but is intended to result in a more sustainable development and a more satisfactory product for the client.

Capstone Design Statement

In order to satisfy the Capstone Design Requirement, a portion of this Major Qualifying Project applied the concepts of sustainable community design to the revitalization of a typical city alley. This is a practice that has already met with success, most notably, in Chicago, where 80 such restoration projects were completed by the end of the year 2008. The project addresses the following topics: sustainability, economic, environmental, health and safety, and social.

Sustainability:

The proper restoration of alleys assists communities in reducing their footprint in a practical way, while also incorporating several aspects of LEED ND certification. Sustainable practices used include pervious paving, replacing pavement with natural plants, encouraging walkability, and the reduction of light pollution.

Economic:

Revitalizing alleys presents a significant initial expense for the city, however it is a wise long-term infrastructure investment. Reducing stormwater in alleys reduces the overall volume of stormwater that the city needs to treat, which reduces operational costs. This water reduction can also reduce or prevent property damage caused by street or basement flooding. An estimate of overall city investment for the project was calculated for 6 cities around the United States.

Environmental:

To reduce the impact on the environment, these projects are completed using recycled aggregate material, rather than freshly excavated material, reducing what is sent to a landfill. Stormwater that could contain metals or other pollutants is filtered through the pavement and sub layers. High-albedo paving is used to reflect more of the sun's radiation to reduce the heat of the alley, and using properly shaded fixtures reduces light pollution. Stormwater runoff calculations were done to determine the effects of pervious paving in runoff reduction in the same cities.

Health and Safety:

Most city alleys are considered to be dirty and dangerous, but lighting and drainage can greatly increase their safety and appeal. Revitalized alleys are pleasant, low-traffic areas for outdoor activities and encourage walking and biking. These cleaner, well-lit open spaces support healthier lifestyles of the local residents.

Social:

In neighborhoods that lack parks and other open spaces, these restored alleys can provide a nearby substitute. This promotes interaction between the neighbors in residential areas and outdoor activity. In retail settings, local restaurants and cafes can utilize what was previously underutilized space for outdoor seating. In either setting, revitalized alleys add value and appeal to the community.

1.0 Introduction

The 20th century witnessed the rapid urbanization of the world population, and this trend continued into the 21st. According to the United Nations, nearly half the world population is living in urban areas. The percentage of urban dwellers grew from 29 percent in 1950 to 49 percent in 2005.¹ In North America, 81 percent of the population lived in urban areas in 2005.² By 2030, it is estimated that 60 percent of the global population, or 5 billion people, will live in urban areas.³ This population growth is anticipated to add even more strain to the world's limited resources unless urban density and sustainability are increased.

Urban sprawl is a term for scattered, low-density development. Improved transportation networks and widespread development of single-family houses in urban areas have contributed to urban sprawl. This kind of development increases the burden on existing municipal infrastructure and dependency on motor vehicles. In North America, this dependency meant 768 vehicles for every 1,000 people in 2005.⁴ This lifestyle caused North America to lead the world with carbon dioxide emissions: 20 metric tons per capita in 2004.⁵ This significant use of man made and natural resources and high level of emissions has led to increased levels of environmental degradation.

In order to keep pace with rising demand from environmentally conscious communities, consulting firms have had to familiarize themselves with sustainable development practices. Stantec decided to streamline and standardize their approach across all their branches in order to give them a better position in a competitive market. Stantec chose to develop a best practices manual (BPM) available to the entire company to assist with the standardization. This BPM is available electronically on the company's intranet and contains the methods that the company has chosen as the best to consistently achieve the results they and their clients need. By establishing this, the company saves time and money by using previously tested methods, rather than starting new each time.

¹ Department of Economic and Social Affairs, "Urban Population, Development, and the Environment 2007," United Nations, March 2008. Web. Nov. 5, 2009.

² Department of Economic and Social Affairs.

³ Department of Economic and Social Affairs.

⁴ Department of Economic and Social Affairs.

⁵ Department of Economic and Social Affairs.

The goal of this project was to develop a sustainable community development BPM for Stantec. The result was a subsection of the existing electronic BPM (eBPM) that was based on LEED 2009 for Neighborhood Development (LEED ND). The specific project focus was the Neighborhood Pattern and Design (NPD) section of LEED ND, and the 15 credits included in that section. The manual includes different implementation methods for each criterion in the NPD. The BPM is an evidenced based design manual that is presented in a comprehensive format that is intended as a quick reference for Stantec's employees.

2.0 Background

2.1 History of Stantec

Stantec began as D.R. Stanley Associates in Edmonton, AB in 1953. In the 1950s, the company primarily upgraded rural towns to municipal water and sewer systems. Throughout the 1960s and 1970s, the company expanded and altered its name to Stanley Associates Engineering. Stanley Associates Engineering diversified to include work on roads and traffic studies as well as mechanical and electrical services.

During the 1980s and 1990s, the company continued to diversify and expand to become an international group and a publicly traded company. The diversification was partially in response to the economic downturn in the 1980s. The expansion of the company included offices in Canada as well as the United States. When Dr. Stanley retired in 1989, the company became Stanley Technology Group and included a wide variety of government and commercial services. The Stanley Technology Group was later changed to Stantec in 1998.

In the early 2000s, Stantec expanded offices in the United States and Canada to include 10 states and 6 provinces. In 2008, Stantec boasted more than 10,000 employees and revenue of \$1.4 billion, establishing it as one of the top 10 global companies.⁶ Today, Stantec continues to diversify its expertise and is striving to become a regional leader in sustainability and alternative energy in order to provide its clients with a variety of services.

2.2 Development of Neighborhoods and Sprawl

Neighborhoods vary greatly in appearance from location to location; a century-old New York City Brownstone neighborhood looks much different than a midwestern suburb, but both are designed with similar goals in mind. According to Lewis Mumford, a highly respected urban scholar, “neighborhoods, in some primitive, inchoate fashion exist wherever human beings congregate, in permanent family dwellings; and many of the functions of the city tend to be distributed naturally—that is, without any theoretical

⁶ "The Evolution of Stantec." *StanNet*. Stantec. Web. 5 Nov. 2009.

preoccupation or political direction—into neighborhoods.”⁷ A social neighborhood should be designed to meet the immediate needs of its occupants, usually within a quarter mile walk, but this is not always the case.

North American cities began as close-knit, high-density settlements, for security purposes, with all the necessary services located in a mixed-use town center. Shops and homes were mingled and there was almost always a central community building such as a meetinghouse or church. By necessity, nearly all the services the people needed were located within walking distance, making the earliest neighborhoods far more sustainable than anything developed since.

As the expansion of the United States continued, the population became highly rural and agricultural. A vast majority of the people lived either on self-sufficient plantations or in sprawling farm towns. Until the year 1920, more than 50% of Americans lived in a rural setting, towns with fewer than 2,500 occupants.⁸

The 20th century witnessed a dramatic urbanization of the population. Employment opportunities present in city centers caused the population to move from rural areas into cities, and later into suburban neighborhoods. Suburban neighborhood development was expedited in part, by modern transportation of the 20th century. Trains and automobiles allowed people to increase the distances that they could travel to work.⁹ Thus, suburban developments primarily consisted of people who could afford modern transportation to commute daily. This trend of development was slow prior to WWII. In postwar North America, the rising standard of living and greater access to the automobile led to a mass exodus from the cities to newly expanding suburbs. “From 1918 to 1940, suburbanites grew modestly from seventeen to twenty percent of the nation’s population. By 1960, however, they had doubled to account for forty percent of the nation’s total and far more than doubled in absolute numbers.”¹⁰

⁷ U.S. Green Building Council. *LEED 2009 for Neighborhood Development Rating System*. Publication. U.S. Green Building Council, Fall 2009. Web. 10 Nov. 2009. Page xvi.

⁸ Ross, Kelley L. "Historical Statistics and Analysis on Unemployment, Poverty, Urbanization, etc., in the United States." *The Proceedings of the Friesian School*. 2003. Web. 16 Nov. 2009. <<http://www.friesian.com/stats.htm>>.

⁹ Birch, E., “The World of Urban and Regional Planning,” *The Urban and Regional Planning Reader*. (New York: Routledge, 2009), p. 4 and 5.

¹⁰ Ames, David L. “Interpreting Post-World War II Suburban Landscapes as Historical Resources.” *Preserving the Recent Past*. 1995. Web. 15 Dec. 2009. Page 3.

Suburban developments consist of a sprawling network of small roads with nearly homogeneous single-family housing developments. Unlike cities, suburbs were not always designed to provide necessary services or employment within walking distance. They were designed to be mostly dependent on automobiles and be separate from the noise and stress of the city.

Urban sprawl is characterized by low density and scattered development patterns. It is the practice of spreading an urban area farther from the city center and into undeveloped land. This increases the burden on municipal infrastructure and dependency on motor vehicles. Existing pipelines, road networks, and other public facilities must be extended to accommodate residents in the suburbs. Urban sprawl has destroyed natural habitat, forestland, and valuable farmland as well as increased air pollution and endangered water supplies.¹¹

As the population moved out of cities, the city density dropped dramatically. At the turn of the 20th century, the average city edge had a density of close to 60,000 people per square mile.¹² In the postwar years, this was reduced to only 10,000 per square mile.¹³ The resultant drop in population led businesses and manufactures to move out of the cities as well, further developing the land and continuing the sprawl. This in turn, opened the suburbs up to the working class and minorities; neither of which had previously had the ability or any reason to leave the city.

The sprawl and expansion of suburban communities continues to this day. This is partly because it is considered normal to live well outside the city in a single-family home with the privacy a yard and quiet street afford. Living in suburban areas is made easy by high rates of vehicle ownership, and few people notice the consequences of living in sprawling suburbs. Another primary factor is the combination of city real estate market and zoning regulations. In most cities, a majority of the space is now zoned for commercial use, and would otherwise be too expensive to be affordable housing. This perpetuates the expansion of suburban development.

¹¹ Nolon, J. "Shifting Ground to Address Climate Change: the Land Use Law Solution" *The Urban and Regional Planning Reader*, Ed. Birch Eugene (New York: Routledge, 2009), p. 375.

¹² Bruegmann, Robert. *Sprawl: A Compact History*. Chicago: University of Chicago, 2006. *Sprawl: A Compact History*. Google Books. Web. 11 Nov. 2009. Page 44.

¹³ Bruegmann, Page 44.

2.3 Sustainable Development

The Brundtland Report of 1987 defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”¹⁴

Sustainability is achieved through the reconciliation of economic, environmental, and social demands. The economic aspect of sustainable development is satisfied when the financial and economic needs of the current and future generation are met. The environmental component is intended to prevent the unnecessary destruction of natural resources and seeks to establish a system where resource consumption does not outpace new growth. The social aspect attempts to improve quality of life for all people at a reduced environmental cost. Three overlapping ellipses are often used to illustrate the interdependence of the three components of sustainable development. A community is sustainable when the quality of life and standards of living are satisfied or improved without causing further irreversible damage, or as little damage as possible to, the natural environment.

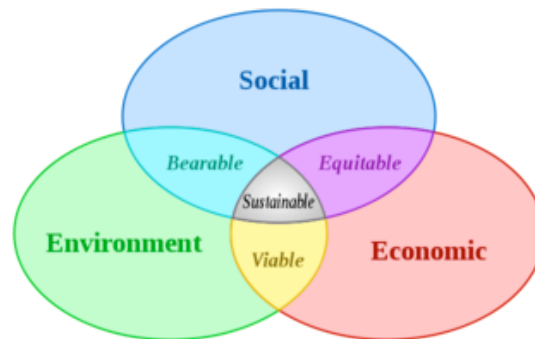


Figure 1: Venn Diagram of Sustainability¹⁵

The concept of sustainable development emerged in the early 1970s following a range of key publications. These publications drew attention to man’s over-exploitation of the environment, focus on economic development objectives, and environmental constraints. In addition, they examined the inextricable relationship between environment and development. A few notable examples include *The Limits to Growth*

¹⁴ Brundtland, G. H., Chairman. *Report of the World Commission on Environment and Development: “Our Common Future.”* Rep. no. A/42/427. United Nations, 1987. Web. 18 Nov. 2009. Page 24.

¹⁵ “Sustainability at ISU.” *Indiana State University.* Web. 18 Nov. 2009.
<<http://www1.indstate.edu/facilities/sustainability/>>.

(Meadows et al. 1972), *A Blueprint for Survival* (The Ecologist, 1972), and *Only One Earth* (Barbara Ward and Rene Dubos, 1972).

Early literature discussed a wide range of issues involving the concept of sustainable development, however, the World Conservation Strategy (WCS) made the first attempt to define this concept. The most frequently quoted definition is from the Brundtland Report, because WCS's definition was often criticized for focusing mainly on ecological sustainability, instead of sustainable development.

2.4 Leadership in Energy and Environmental Design

The U.S. Green Building Council (USGBC) was formed in 1993, as a nonprofit organization comprised of a non-government group of volunteers in various sectors of the building industry.¹⁶ These volunteers include contractors, architects, consultants, environmental groups, product manufacturers, and individual home and business owners. The USGBC set out to develop a program to encourage sustainable building. This program is known as Leadership in Energy and Environmental Design (LEED).

The first LEED pilot version began in August of 1998. By early 2000, 12 buildings had utilized and been certified by the program.¹⁷ Extensive revisions had been in progress and LEED 2.0 was released in March of 2000. LEED consists of several different programs, including LEED for New Construction, Homes, Commercial Interiors, LEED Core and Shell, Healthcare, Retail, Schools, LEED for Existing Buildings: Operations and Management, and LEED Neighborhood Development.

There are five different environmental categories that are evaluated by LEED programs concerning buildings: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Air Quality. Elements of these categories are also carried over to LEED ND, but they are presented differently. In addition, the Innovation and Design Process category awards additional points for going beyond LEED guidelines. Four different certification levels are awarded based on the number of points earned in each category; certified, silver, gold, and platinum levels. For example, a LEED New Construction building would need at least 40 points to be certified, at least 50 for Silver, 60 for Gold, and 80 points for Platinum certification.

¹⁶ U.S. Green Building Council. *LEED 2009 for Neighborhood Development*. Page xi.

¹⁷ Keoleian, Gregory A., and Chris W. Scheuer. *Evaluation of LEED Using Life Cycle Assessment Methods*. Rep. National Institute of Standards and Technology, Sept. 2002. Web. 10 Nov. 2009. Page 16.

2.5 LEED Neighborhood Development

LEED Neighborhood Development (LEED ND) began in 2007 as a pilot program, involving 238 projects in 39 states and 6 countries.¹⁸ The development of LEED ND was a joint effort between the USGBC, the Natural Resources Defense Council (NRDC), and the Congress for New Urbanism (CNU). The program is designed to encourage and measure smarter urban development, decreased automobile reliance, and increased efficiency of energy and water resources.

LEED ND is broken into three primary scoring categories: Smart Location and Linkage, Neighborhood Pattern and Design, and Green Infrastructure & Buildings. The other two categories are Innovation & Design Process and Regional Priority Credits.¹⁹ Of the three primary categories, Neighborhood Pattern and Design is the center of the program and contains the majority of the Neighborhood Development-specific credits. The other LEED ND categories are mostly carried over from LEED New Construction program; Smart Location and Linkage concerns sustainable sites, and Green Infrastructure and Buildings is essentially LEED for new construction, applied to all the neighborhood buildings, but only one LEED certified building will meet the certification requirements in this case.

For certification, a total of 110 points are available, provided that Innovation & Design and Regional Priorities apply where the development is located. A score of 40-49 points would earn a certification, 50-59 points for Silver, 60-79 for Gold, and 80 or more points would earn Platinum Certification.²⁰ (Refer to Appendix A for the complete LEED ND Project Scorecard.) Compared to other LEED programs, LEED ND focuses greater attention on site selection and layout. This is because neighborhoods poses greater potential damage to sites and greater strain applied to local infrastructure and resources.

Each of the three primary categories has several prerequisites before certification begins. These prerequisites are designed to ensure that the most important aspects of a more environmentally friendly community are met. For Smart Location and Linkage, the requirements are vital to choosing a smart building location and limiting impact. The

¹⁸ “238 New Developments from U.S. and Abroad Pioneering LEED for Neighborhood Development Pilot.” *Congress for the New Urbanism*. 14 Aug. 2007. Web. 10 Nov. 2009. <<http://www.cnu.org/node/1368>>.

¹⁹ U.S. Green Building Council. *LEED 2009 for Neighborhood Development*. Page xiv.

²⁰ U.S. Green Building Council. *LEED 2009 for Neighborhood Development*. Page xix.

Neighborhood Design and Pattern section emphasizes principals of smart growth and new urbanism practices. In the Green Infrastructure & Buildings category, the prerequisites require that standards of LEED certified buildings be met for at least one building.

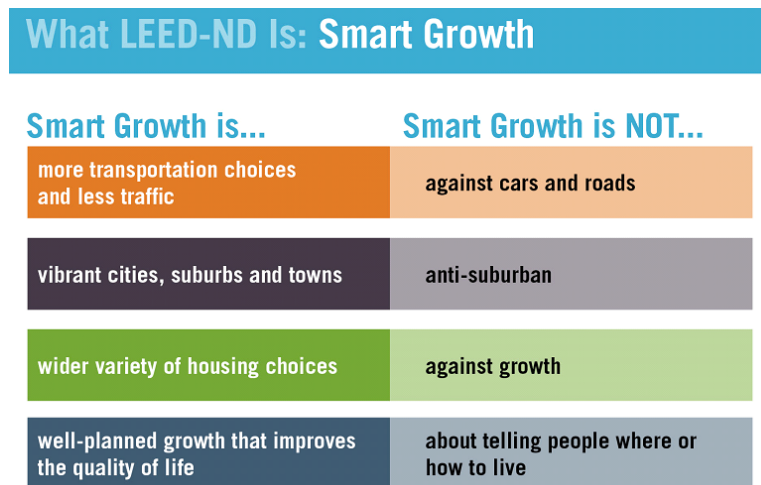


Figure 2: Smart Growth Diagram²¹

There are no specific requirements for size or type of development, however, the program recommends that the size be more than two buildings, but less than half a square mile in order to create the best, most connected community.²² A mixed-use setting is highly recommended to provide at least some services that are within walking distance. LEED ND is also focused on new neighborhood construction, not the restoration of existing construction, but the new construction can take place on a previously developed site, which is usually preferable.

LEED ND can be used in both urban and suburban settings. Existing suburban settings that are serviced by public transportation are best for establishing a new mixed-use neighborhood; however, new development could be a reason to expand the existing transit system. An urban site will most likely have existing utilities infrastructure and will also have transportation, services and jobs within a close distance.

Prior to applying for any stage of certification, a review is available to make sure that the building location meets all the prerequisites for Smart Location and Linkage. Since this category is dependent on the location, the review is designed to prevent

²¹ U.S. Green Building Council. *LEED for Neighborhood Power Point Presentation*. Slide 10.

²² U.S. Green Building Council. *LEED 2009 for Neighborhood Development*. Page xiv.

developers from investing more time and resources if their location is not viable for a LEED certified neighborhood.

There are three stages of certification for a neighborhood to account for the extended timeframe of neighborhood construction as opposed to the construction of a single building. The first two stages of certification are optional and are used to improve public image and attract financial backing.

Stage 1, Conditional Approval of a LEED ND Plan, is an option for any project that does not yet have ownership rights to more than 50% of the proposed development.²³ A letter is then issued by the USGBC to the developer to assist in acquiring the remaining ownership rights and financing. Once the developer has the rights, they must apply under Stage 2.

Stage 2, Pre-Certified LEED ND Plan, is available once a developer has the rights to the entire project site, but no more than 75% of the development is completed. At this point, any changes that could potentially impact the certification must be communicated. If more than 75% of construction is completed, then the entire project must be completed prior to applying for Stage 3, LEED ND Certified Neighborhood Development.²⁴ Stage 3 means that the developer can submit documentation for all the prerequisites and attempted credits. After all buildings are approved for occupancy and infrastructure is accepted by the local code enforcement, the neighborhood will receive a plaque to display the certification on site.

Certification Stage	Percentage Completed	Intent of Certification
Stage 1: Conditional Approval of a LEED ND Plan.	Optional before work begins, if developer owns less than 50% of project property.	To help the developer build the case for financing and land acquisition.
Stage 2: Pre-Certified LEED ND Plan.	100% of property owned, but no more than 75% of construction completed.	To complete some paperwork before the project is complete. Only credit documentation is needed at completion.
Stage 3: LEED ND Certified Neighborhood Development.	100% of project complete and documentation can be provided for all attempted credits.	Final certification. The development is listed on the USGBC website and a plaque for display is awarded.

Table 1: LEED ND Certification Levels

²³ U.S. Green Building Council. *LEED 2009 for Neighborhood Development*. Page xix.

²⁴ U.S. Green Building Council. *LEED 2009 for Neighborhood Development*. Page xix.

3.0 Methodology

In order to maintain a competitive edge in the sustainable design sector, Stantec began developing an electronic Best Practices Manual (eBPM) on StanNet, the company’s intranet. It was designed to be a reference for the company’s employees to use to familiarize themselves with the principles and current best practices associated with sustainable building practices and technologies. Stantec recommended that LEED ND be used as one of the tools for developing the manual, and as it was the most readily available and most comprehensive, the majority of the project was devoted to reviewing and assessing the credits and benefits associated with LEED.

3.1 Review of LEED

In order to determine a focus area in the diverse field, the team met bimonthly with the Stantec contact to establish their needs and supplemented this with a review of the LEED New Construction and Neighborhood Development manuals. This review demonstrated that covering all of the practices outlined in the LEED Neighborhood Development (LEED ND) program was not feasible. Priority was given to the “Neighborhood Pattern and Design” sub section. This is the section most specific to neighborhoods and contains 15 credits with a total value of 44 points or 40% of the total available credits.

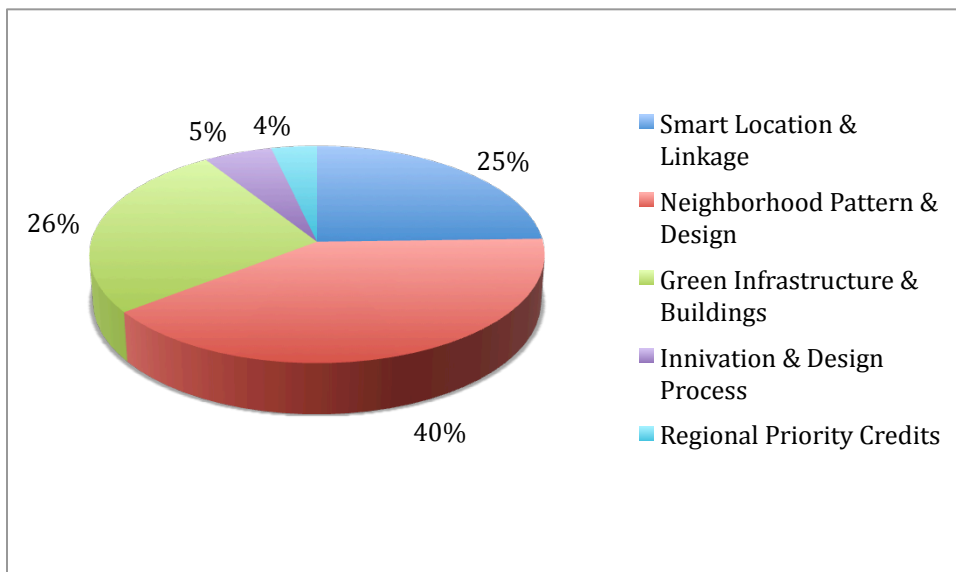


Figure 3: LEED ND Point Distribution By Credit Category

With the focus established, the team divided the 15 credits and researched implementation methods for each of them, outside agencies required to implement them, and the benefits and drawbacks associated with each. A table was created to display this information in a concise, easy to use format. The table utilizes a different format than LEED to present the information; it lists different goals, the associated best practices for each goal, and the agencies that the developer will need to cooperate with for each.

The different format is used to deemphasize the credits and number of points available for each, so that design decisions can be made based on the goals of clients, rather than trying to earn as many credits as possible. The intent is to help clients incorporate the elements that best suit them and their needs, rather than just laying out a means for achieving LEED ND certification, which may not be the best option.

3.2 Background Research

An extensive literature review was conducted to determine many different sustainable practices, including those not associated with LEED. This research included case studies of projects from all over North America. Some of these projects were based on the LEED system, while others were not. The practices utilized by both types of projects were deemed the most common and practical for sustainable neighborhood development. Institutional and government publications were also used to provide information regarding recent developments and regional goals, priorities, and regulations.

3.3 Meetings

Over the course of the project, numerous meetings were held to gather more information and to track progress. Meetings were held with Stantec employees, our Stantec advisor, WPI faculty advisors, and the Canada Lands Company - the branch of the Government of Canada responsible for developing surplus government property. These meetings were conducted in person and over the phone, both at the Stantec office and at the Canada Lands Company's Griesbach office.

A conference call was held weekly with WPI faculty advisors to review progress and solicit advice for different areas of the project. These meetings were conducted over the phone, occasionally with the Stantec advisor present. Meetings with the Stantec advisor were less regular, based on scheduling, but were conducted in person to monitor the project focus and progress. These meetings also served to establish contacts with

other knowledgeable Stantec personnel. Near the midpoint of the project a meeting was held with other Stantec personnel from offices outside Edmonton to present the progress made to that point and solicit outside feedback on the format of the manual. Early in the project, a visit was made to tour the Griesbach development and view the progress and compare it to the surrounding neighborhoods.

4.0 Results

4.1 LEED Neighborhood Development

The name recognition associated with the U.S. Green Building Council and LEED are important in order to continue spreading sustainable development into the mainstream. The program is a very good start to drawing national and international attention to the need to change building practices to those that are more capable of being sustained in the long-term. The credit score sheet associated with LEED ND provides an excellent starting point and design goal for developers planning housing developments and other neighborhood type developments by listing specific elements to include in their planning processes.

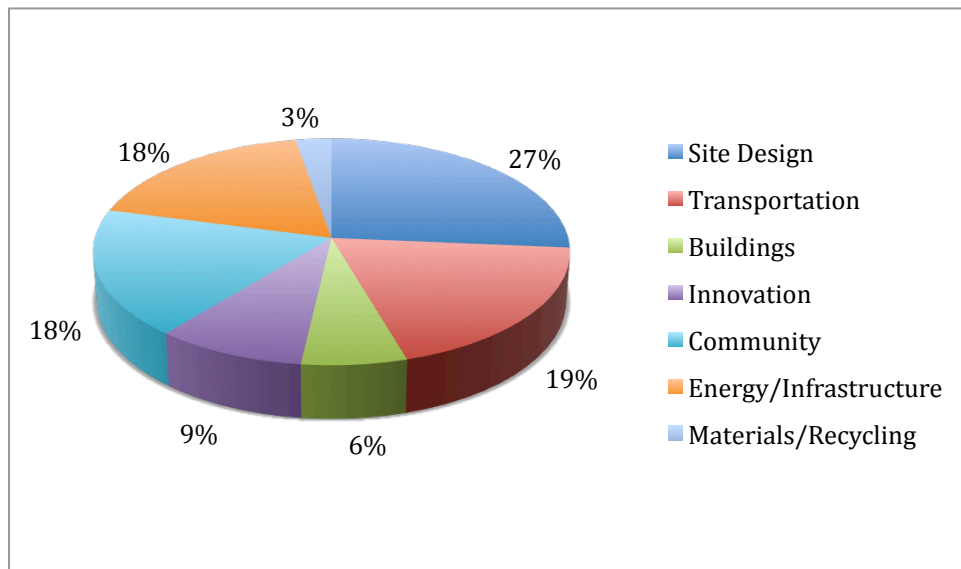


Figure 4: Distribution of LEED ND Credit Points

There are many very important elements that LEED ND incorporates that should be integral parts of any new neighborhood development. These include: ensuring a smart location for the development, redeveloping a brownfield site, creating walkable streets, providing transit facilities, water management and efficiency, and building reuse. As illustrated by the figure above, site design and transportation do account for 45% of the available points, which addresses the need to reduce personal automobile use.

While nearly half the points emphasize reducing vehicle travel, very little emphasis is put on recycling, landfill diversion, and the types of materials used for

construction. One example is the Village at Griesbach, where the homes in the LEED Gold Certified neighborhood were being constructed with the same materials and practices as any other homes in Canada. This is because the program only requires one building to be LEED certified.

LEED for Neighborhood Development has many very beneficial credits included in the rating system, however there are a few drawbacks to the program. As the score sheet in Appendix A shows, there is a great inequity with some of their credits. For example, having a bike storage facility such as a bike rack is worth a single point. Having transit facilities available is also worth one point, as is having a neighborhood school. There is a much different investment and planning process for providing several bike racks than there is for planning and providing for new transit facilities and routes. The requirements for having a local school built are also much different. The rating system does not account for these differences in the final score, which critics, including some Stantec personnel, say defeats the purpose of the point system and scoring.

4.2 Best Practices Manual

The research focused on the Neighborhood Pattern & Design section of the LEED-ND rating system, totaling 15 credits in all. Due to the number of individual credits, a large amount of information was collected, and some form of organization was needed to display the information in a user-friendly format. The easiest way to do this was in the form of a simple table.

The table is meant to serve as a cursory overview of implementing each credit in a project. It is not meant to serve as the only guide to a project, but rather a starting point to be used in the initial planning phase. For an explanation of the table itself, see the example below.

Credit: Title of LEED Credit		
Intent: This section provides the intent of the credit named above, as provided in LEED-ND handbook. Some credits have further Best Practices information in Appendices, as noted		
A. This section contains a further subdivision of the credit into smaller goals. This was done to more easily present information on a variety of topics that while related still span a broad base of knowledge.		
Goal	Associated Best Practices	Concerned Agencies
1. This column provides the goal of the subdivision	1. This column lists the best practices associated with	Since achieving many of these goals may require

<p>named above. While it may share a common theme with the intent of the entire LEED credit, it focuses more on one aspect of the credit, rather than the whole.</p>	<p>achieving the goal mentioned in the adjacent column. (Numbers) link to references at the end of the table for further information.</p>	<p>changes to zoning, streets design, bus routes etc, this column provides the name of any agencies or bodies that may need to be involved in the planning process in an effort to expedite completion of the project.</p>
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Credit 1: Walkability		
<p>Intent: To promote transportation efficiency, including reduced vehicle miles traveled. To promote walking by providing safe, appealing, and comfortable street environments which support public health by reducing pedestrian injuries and encouraging daily physical activity. See Appendix K for further information on the Best Practices.</p>		
A. Sidewalk Design and Layout		
Goal	Associated Best Practices	Concerned Agencies
<p>To provide adequate sidewalk connectivity throughout a neighborhood, and promote walking as a viable form of transportation.</p>	<ol style="list-style-type: none"> 1. Connect all residential areas with commercial centers via sidewalks (18, 27). 2. Vary sidewalk width depending on expected foot traffic volume; i.e., wider in downtown shopping areas, narrow in residential areas (5, 18). 3. Utilize pervious pavement when pouring sidewalks, reducing stormwater runoff (20). 4. Provide ramps at each 	<p>Department of Transportation</p> <p>Department of Public Works</p>

	<p>corner to maintain connectivity for disabled residents (18, 27).</p> <p>5. Plant trees along sidewalk to increase shading for pedestrians (5, 27).</p> <p>6. Follow planting system described in Credit 14 when planting trees.</p> <p>7. Provide adequate lighting to promote a feeling of safety (16, 27).</p>	
B. Traffic Easement Measures		
<p>Promote walking and reduce traffic risks to pedestrians by restricting or controlling traffic flow.</p>	<ol style="list-style-type: none"> 1. Limit traffic speeds through residential areas by reducing speed limits. (9, 14, 22, 23, 27). 2. Provide adequate pedestrian crosswalks at every major intersection and at mid-block points on larger streets (9). 3. Install raised pedestrian crosswalks, forcing cars to slow down (9, 27). 4. Utilize sidewalk bulbouts, or curb extensions, to reduce road width and slow traffic at necessary points (27). 5. Force car traffic to slow down by using narrow street design alternatives (14). 	<p>Department of Transportation</p>

	6. Utilize alternative paving surfaces, such as interlocking pavers, at some intersections or on smaller side streets (20).	
C. Alley Revitalization		
Reclaim alleys as walking paths for pedestrians, providing alternate routes throughout a city's center, and promoting connectivity.	<p>1. Increase lighting and signage, giving the alleys more of a "street" feeling (7, 24).</p> <p>2. Relocate or centralize garbage pickup at the end of alleys, limiting the need for trash trucks to use the whole alley.</p> <p>3. Replace asphalt with more pervious materials in an effort to reduce stormwater runoff (3, 24).</p> <p>4. Promote alleys as viable space to local businesses, especially for outdoor restaurant seating (3, 7).</p> <p>5. Where applicable, alleys could be turned into small public parks, provided it does not interfere with firefighter access to buildings (3).</p>	<p>Department of Public Works</p> <p>Local Business Owners</p>
D. Storefront/ Street front Beautification		
To create a more welcoming town center that would encourage foot traffic.	<p>1. Encourage businesses to utilize window displays, inviting pedestrians to walk and look (2, 4).</p> <p>2. Encourage street front restaurants to use outdoor</p>	Local Business Owners/ Organizations

	<p>seating, either on patios or sidewalks, provided the sidewalk is wide enough to still accommodate pedestrians (28).</p> <p>3. Maintain plantings and trees along sidewalk for shading (5, 27).</p> <p>4. Place benches at regular intervals along streets, creating small personal spaces that encourage pedestrians to use the sidewalk for more than just walking (15).</p>	
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Credit 2: Compact Development		
Intent: To encourage development in existing areas to conserve land and protect farmland and wildlife habitat. To promote livability, walkability, and transportation efficiency, including reduced vehicle miles traveled. To improve public health by encouraging daily physical activity associated with alternative modes of transportation and compact development. See Appendix L for further information on the Best Practices.		
A. Standards for New Construction		
Goal	Associated Best Practices	Concerned Agencies
To promote or enforce principles of compact development concerning new construction.	<p>1. Provide exemptions from development fees in high-density development areas (5).</p> <p>2. Reduce impact fees for high-density development projects (5).</p> <p>3. If possible, alter local zoning by setting a minimum unit density, effectively forcing compact development (5).</p> <p>4. Set a minimum floor to area ratio (FAR) for new construction.</p>	Local Zoning Body

B. Public Transit Access		
<p>Provide adequate access to various forms of public transit, reducing resident dependence on automobiles, as outlined in the credit intent.</p>	<ol style="list-style-type: none"> 1. Encourage high-density development near existing public transit (8, 11, 13, 25). 2. Encourage use of public transit through incentives, such as lower fares on monthly passes (10, 13). 3. If public transit is not currently available in development area, coordinate with local transit authority to provide bus service to new community. 	<p>Public Transit Authority</p>
C. Public Relations		
<p>Increase public opinion of high-density living, educating the public on both the environmental and economic benefits over traditional suburban living.</p>	<ol style="list-style-type: none"> 1. During project development, hold town hall meetings or information sessions for potential residents (28). 2. Promote the project throughout its duration, again showing the benefits of high-density living (28). 	
Credit 3: Mixed-use Neighborhood Centers		
<p>Intent: To cluster diverse land uses in accessible neighborhood and regional centers to encourage daily walking, biking, and transit use, reduce vehicle miles traveled and automobile dependence, and support car-free living. See Appendix M for further information on the Best Practices.</p>		
A. Standards for New Construction		
<p>To develop an area of the community specifically for mixed-use development</p>	<ol style="list-style-type: none"> 1. Designate an area for mixed-use in initial project development (22). 2. Design the area to have high walkability, as outlined in Credit 1 (5, 11). 	<p>Local Zoning Body</p>

	3. Limit amount of parking available in mixed-use areas, reducing dependency on cars, as well as reducing stormwater runoff (11, 13).	
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Credit 4: Mixed-income Diverse Communities

Intent: To promote socially equitable and engaging communities by enabling residents from a wide range of economic levels, household sizes, and age groups to live in a community. See Appendix N for further information on the Best Practices.

A. Implementation

Goal	Associated Best Practices	Concerned Agencies
To provide various housing types within a community, opening up residency to many different income brackets	1. Offer various forms of housing, including but not limited to apartments, condominiums, and stand-alone houses (5). 2. Ensure transit access for all housing types (11, 25).	

B. Public Relations

To encourage the adoption mixed-income housing in a community.	1. Develop an information campaign to dispel any reservations residents may have. Topics to address include: <ul style="list-style-type: none"> • Decreased real estate value due to lower income housing within the neighborhood (6, 11). • Increased crime due to low-income residents. (6, 11) • Negative impact on local school system, either due to overcrowding or the influx of lower income students (6, 11). 	
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Credit 5: Reduced Parking Footprint

Intent: To design parking to increase the pedestrian orientation of projects and minimize the adverse environmental effects of parking facilities. To reduce public health risks by encouraging daily physical activity associated with walking and bicycling. See Appendix O for further information on the Best Practices.

A. Parking Reduction

Goal	Associated Best Practices	Concerned Agencies
To physically reduce the amount of parking available, reducing stormwater runoff and promoting alternative transportation	<ol style="list-style-type: none"> 1. Where applicable, simply remove parking spots. 2. Promote alternative transportation by providing pedestrian and bicycle access to public areas (13). 3. Provide adequate bicycle storage where needed, such as in town centers or office parks (13). 4. To minimize the impact of reduced parking, businesses should provide incentives to employees for carpooling or using alternative transportation (11, 13). 	Local Businesses/ Employers

B. Parking Alteration

Where reduction in parking is not a viable solution, implement alternative design methods to reduce the environmental impact of the parking facility	<ol style="list-style-type: none"> 1. Replace traditional asphalt with pervious pavement to reduce stormwater runoff (1, 12, 20) 2. For lower impact parking, traditional asphalt may also be replaced with interlocking pavers (12, 20). 3. Centralize downtown parking into a single garage, offering the same amount of parking in a much smaller ecological footprint (11). 	
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Credit 6: Street Network		
Intent: To promote projects that have high levels of internal connectivity and are well connected to the community at large. To encourage development within existing communities, thereby conserving land and promoting multimodal transportation. To improve public health by encouraging daily physical activity and reducing the negative effects of motor vehicle emissions.		
A. Multimodal Access		
Goal	Associated Best Practices	Concerned Agencies
To reduce residents' dependence on automobiles for transportation, thereby reducing emissions and promoting alternative transportation	<ol style="list-style-type: none"> 1. Encourage high-density development, creating a more walkable community (5, 6, 11). 2. Follow principles of walkability, as outlined in Credit 1. 3. Encourage the use of bicycles for transportation, providing adequate storage facilities where necessary (10, 13, 25). 4. Provide a bicycle lane on all major roads, increasing the safety for those who choose to use alternative transportation (14). 5. Follow the principles of compact development, as outlined in Credit 2. 6. Minimize available parking in commercial centers, further encouraging walking or bike riding (11). 	Department of Transportation
B. Street Design		
To increase connectivity of streets, for both pedestrian and auto use, and in doing	1. The network of streets should allow for multiple routes to the same destination, providing	Department of Transportation

<p>so reduce traffic congestion and excess vehicle emissions.</p>	<p>options in the event of construction, accidents etc (14, 19, 21, 23).</p> <p>2. Street design should again incorporate the principles of walkability, as outlined in credit 1 (14, 27).</p> <p>3. Block size should be limited to a reasonable distance (urban setting approximately 400'), with crosswalks installed at adequately spaced distances (18, 22, 23).</p> <p>4. To still allow vehicle access but promote safety for pedestrians, street width should be limited, size depending in road type; i.e. residential road, main street, etc (14, 22).</p>	
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Credit 7: Transit Facilities

Intent: To encourage transit use and reduce driving by providing safe, convenient, and comfortable transit waiting areas and safe and secure bicycle storage for transit users.

A. Community Access

Goal	Associated Best Practices	Concerned Agencies
<p>To provide residents of the community with easy access to public transit.</p>	<p>1. Build near preexisting transit systems, so that all buildings are within walking distance of transit access (1/2 mile maximum distance) (8, 25, 27).</p> <p>2. Follow guidelines for public transit as set forth in Credit 2.</p> <p>3. Limit on site parking, rather opting for connectivity via walking paths and bicycle paths (5, 11).</p>	

B. Design		
Provide residents with adequate transit shelters, for both safety and comfort.	<ol style="list-style-type: none"> 1. Provide overhead cover for protection from the weather, be it stand-alone canopies, or overhangs off preexisting buildings (4, 15). 2. Depending on the climate, indoor facilities should be kept at a comfortable temperature. 3. Provide adequate onsite bicycle storage for commuters (25). 4. Maintain connectivity with the community via walking paths and bicycle paths (25). 	Public Transit Authority
Credit 8: Transportation Demand Management		
Intent: To reduce energy consumption, pollution from motor vehicles, and adverse public health effects by encouraging multimodal travel. See Appendix P for further information on the Best Practices.		
A. Public Implementation		
Goal	Associated Best Practices	Concerned Agencies
To promote alternative transportation among residents, thereby decreasing emissions and increasing physical activity.	<ol style="list-style-type: none"> 1. Provide adequate bicycle storage in town centers, as well as at public and civic spaces (11, 13). 2. Promote the use of public transit through discounted fares or other incentives (11, 13, 26). 3. Maintain bicycle lanes, as well as walkable sidewalks. 4. Limit parking in downtown areas, as noted in Credit 5. 5. Improve area of operations for public transit 	

	by creating new bus routes or expanding current routes, making it an inviting option to residents (25).	
B. Employer Actions		
To promote the use of alternative or fuel saving transportation among employees of local businesses.	<ol style="list-style-type: none"> 1. Provide adequate bicycle storage in business centers. 2. Provide lockers and shower facilities to employees who choose to utilize bicycle for transportation to work (10). 3. Promote carpooling among employees by offering incentives, such as a mileage matching service (10, 26). 4. Provide a car sharing service for errands while at work; i.e. Zipcar service. 5. If public transit is not within walking distance, implement a shuttle service for employees wishing to use public transit (10). 6. Provide employee incentives for alternative transportation i.e. awards for most miles biked to work, most miles carpooled, etc (26). 	

Credit 9: Access to Civic and Public Spaces
Intent: To improve physical and mental health and social capital by providing a variety of

open spaces close to work and home to facilitate social networking, civic engagement, physical activity, and time spent outdoors.

A. Connectivity

Goal	Associated Best Practices	Concerned Agencies
To provide access to public spaces to all residents of a community.	<ol style="list-style-type: none"> 1. Maintain walkable sidewalks and bicycle trails throughout the community, connecting to all public areas (14, 18, 27). 2. Provide spaces accessible by all residents, regardless of age or physical ability. See credit 11 for information on universal design (18, 27). 3. Limit parking in an effort to promote alternative transportation (11). 4. Provide adequate bicycle storage facilities. 	Department of Public Works

B. Distribution of Public Space

To allow all residents an equal opportunity to use public spaces.	<ol style="list-style-type: none"> 1. Rather than centralizing public space in one location, create smaller public areas throughout a community (15). 2. Create a variety of spaces, such as parks, plazas, town squares, etc. to meet the different needs of residents. 3. Promote the use of these spaces through public events, such as concerts and markets (5). 	
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Credit 10: Access to Recreation Facilities

Intent: To improve physical and mental health and social capital by providing a variety of

recreational facilities close to work and home to facilitate physical activity and social networking.

A. Connectivity

Goal	Associated Best Practices	Concerned Agencies
To provide access to recreation facilities for all residents.	<ol style="list-style-type: none"> 1. Maintain walkable sidewalks and bicycle trails throughout the community, connecting to all public areas (14, 18, 27). 2. Provide spaces accessible by all residents, regardless of age or physical ability. This can be accomplished by incorporating principles of universal design, as well as having a variety of spaces available to the community, e.g. playgrounds, walking paths, public pools, etc (18, 27). 3. Limit parking in an effort to promote alternative transportation (11). 4. Provide adequate bicycle storage facilities. 5. Locate recreation facilities near other services, such as downtown shopping centers, to promote walkability and reduce the number of vehicle trips necessary for residents. 	Department of Recreation

B. Facility Usage

To provide a variety of usages for recreational facilities.	<ol style="list-style-type: none"> 1. Form afterschool programs that utilize recreational facilities. 2. Encourage recreational sports leagues to use the facilities, creating a greater sense of community among residents. 	
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Credit 11: Visitability and Universal Design

Intent: To enable the widest spectrum of people, regardless of age or ability, to more easily participate in community life by increasing the proportion of areas usable by people of diverse abilities. See Appendix Q for further information on the Best Practices.

A. Building Accessibility

Goal	Associated Best Practices	Concerned Agencies
To provide access to all potential residents of the community.	<p>1. Incorporate access for people with physical disabilities into all buildings, public or private, by having at least one zero rise entrance to every building.</p> <p>2. If a zero step entrance is not possible due to grade, a ramp of appropriate length and angle should be provided.</p> <p>3. Incorporate ramps at all sidewalk intersections, as outlined in Credit 1 (18, 27).</p> <p>4. Regardless of implemented parking reductions for normal use vehicles, incorporate parking for people with disabilities into public space design.</p>	<p>Local Zoning Body</p> <p>Code Enforcement Authority</p> <p>Local Disability Services Coordinator</p>

Credit 12: Community Outreach and Involvement

Intent: To encourage responsiveness to community needs by involving the people who live or work in the community in project design and planning and in decisions about how it should be improved or how it should change over time.

A. Community Involvement and Participation

Goal	Associated Best Practices	Concerned Agencies
To involve residents in decisions affecting their community.	<p>1. Create and implement a public awareness campaign to alert residents to any meetings or votes that may be needed in order to implement the project (18).</p> <p>2. Regular public meetings</p>	<p>Local Governing Body</p> <p>Town Council</p>

	<p>should be held, with residents encouraged to voice their opinions about changes to the community master plan they deem necessary.</p> <p>3. Utilize surveys, either paper or electronic, to gather residents’ opinions about the community as a whole.</p> <p>4. Create committees concerned with various aspects of the community, such as beautification projects or community events planning, and encourage resident to join (18).</p>	
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Credit 13: Local Food Production

Intent: To promote community-based food production, improve nutrition through increased access to fresh produce, support preservation of small farms producing a wide variety of crops, reduce the negative environmental effects of large-scale industrialized agriculture, and support local economic development that increases the economic value and production of farmlands and community gardens. See Appendix R for further information on the Best Practices.

A. Resident Participation

Goal	Associated Best Practices	Concerned Agencies
<p>To involve residents in both the growing and purchase of local food.</p>	<p>1. Create a community garden with available public space, encouraging residents to use it for personal food production (28).</p> <p>2. If present, vacant lots can be used as temporary public gardens, with the added benefit of neighborhood beautification.</p> <p>3. Ensure that the community garden only grows low maintenance fruits and vegetables, keeping water</p>	

	<p>consumption to a minimum.</p> <p>4. Provide educational programs for all interested residents to learn proper gardening methods.</p> <p>5. Create farmer’s markets in public spaces, for small local farms to sell their produce directly to the residents (28).</p>	
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B Local Business Participation

To involve local businesses in supporting small local farms.	1. Encourage local markets to buy locally, highlighting the benefits of doing so.	
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Credit 14: Tree-Lined and Shaded Streets

Intent: To encourage walking, bicycling, and transit use and discourage excessive motoring speeds. To reduce urban heat island effects, improve air quality, increase evapotranspiration, and reduce cooling loads in buildings. See Appendix S for further information on the Best Practices.

A. Implementation

Goal	Associated Best Practices	Concerned Agencies
To provide shading along pedestrian pathways and streets, encouraging further foot traffic	<p>1. Plant trees at regular intervals along street (5).</p> <p>2. Ensure trees are native, low-maintenance species (15).</p> <p>3. Utilize gravel-planting trenches, running parallel to the street, to allow plant roots to grow laterally without disturbing either the sidewalk or street pavement (20).</p> <p>4. Plant trees along bicycle</p>	<p align="center">Department of Transportation</p> <p align="center">Department of Public Works</p>

	paths, providing necessary shade.	
To use alternate paving methods, in conjunction with planting trees, in an effort to further reduce the heat island effect felt in all major communities.	<ol style="list-style-type: none"> 1. In warm weather climates, concrete can be used rather than asphalt for roadways; lighter color absorbs less heat (17, 20). 2. Implement principles of cool paving, either using concrete pavement, or adding pigments to asphalt to change its color (17). 3. Pavements should also all be permeable, to aid in stormwater runoff as well as keep the pavement cool by way of evaporation (17). 	

Credit 15: Neighborhood Schools		
Intent: To promote community interaction and engagement by integrating schools into the neighborhood. To support students' health by encouraging walking and bicycling to school.		
A. School Location		
Goal	Associated Best Practices	Concerned Agencies
To provide local schooling in a convenient location, thus encouraging alternative transportation	<ol style="list-style-type: none"> 1. If building a new facility, try to locate it within ½ mile of the majority of housing (27). 	
B. School Connectivity and Design		
To provide safe and easy access to schools, making it feasible for children to not rely on buses for transportation.	<ol style="list-style-type: none"> 1. Incorporate bicycle paths that tie into school grounds (28). 2. Provide adequate bicycle storage for both students and employees who choose alternative transportation. 3. Provide sidewalk access to school grounds, with 	

	adequate crosswalks in place, as outlined in Credit 6 (18).	
	4. Increase the use of traffic easement measures in the immediate area of schools; these measures are outlined in Credit 1 (18).	

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The practicality and applicability of each credit to sustainable development as based on the BPM research is listed below. Some of these credits were determined to be very useful, but others only contribute to the social aspects of the neighborhood. This is important for a well-rounded development, but does not directly make it more sustainable.

1. **Walkable Streets:** Streets that encourage walking are essential to reducing the amount of driving done by residents. Streets must be direct, comfortable, and safe (shaded and set back from the street or have reduced speed limits in areas where walking is common). If they are not, it will be hard to promote walking.
2. **Compact Development:** Increasing density is one way to reduce vehicle dependence and also reduces sprawling development. Even if retail areas are higher density and residential areas maintain lesser density for the comfort of the residents, driving could be reduced to just driving to the shopping center, rather than to each individual store.
3. **Mixed-Use Neighborhood Centers:** Having a neighborhood center like this creates a sense of a small, main street community where residents are more likely to walk and can accomplish all or most of their shopping needs in one area. This is another good method for reducing traffic and vehicle use. The best location for this would be somewhere with high walking and transit accessibility to reduce the need for personal vehicle use.
4. **Mixed Income Diverse Neighborhoods:** This is a nice way to integrate many social groups into one area, and reduce the segregation of income levels, however it is not something that directly encourages sustainability or green development.
5. **Reduced Parking Footprint:** Reducing the acreage devoted to parking reduces the impermeable surface in the development which has a large impact on stormwater reduction. If parking is moved underground or into a multi-level garage, more area in the development can be left undeveloped, or at least be landscaped.
6. **Street Network:** This is designed to create many ways to get from one location to another and prevent high traffic corridors. It essentially creates city blocks for the

- development and provides for easier mobility from one place to another, but it isn't a major factor in reducing emissions or promoting other forms of transportation.
7. **Transit Facilities:** It is very important to have easy access to transit facilities near a neighborhood in order to encourage the use of public transportation. Ensuring that multiple bus routes are located near the neighborhood allows people to drive fewer miles and, if the transit network is good enough, it could eliminate the need for some people to cars.
 8. **Transportation Demand Management:** It is important for public transit to implement a plan for the operation and promotion of local transit, as well as providing other options such as encouraging carpooling. If public transit exists, but few people know about it or how it works, then it is not reaching its full potential. Having a group devoted to promoting transit as well as assessing and improving its performance is crucial to having functional community transit.
 9. **Access to Civic and Public Spaces:** This is important for a town or municipality, however it is not going to make a difference for the environment and isn't a way to encourage sustainable living.
 10. **Access to Recreation Facilities:** This is similar to the previous credit; not something that helps to increase the sustainability of the development.
 11. **Visitability and Design:** Also not directly related to sustainability, but it is important to allowing people of all abilities to live in the neighborhood and allows the elderly to remain in their homes longer.
 12. **Community Outreach and Involvement:** This is something that should be done for most new developments in a community. It is very important to inform the local residents of what the plan is and gather feedback. This helps to improve the design and alleviate the concerns of neighbors.
 13. **Local Food Production:** Producing food near housing developments is a practice that is going to become increasingly important. The square footage reserved for gardens or the mandate to cooperate with a local farm shows effort, but is not likely to be the way of the future. See Appendix J for the Scientific American Article on Vertical Farming.

14. Tree-Lined and Shaded Streets: This credit is designed to make a difference with both the heat island effect, and the amount of walking in the neighborhood. Shaded streets are more comfortable to walk on, and the trees also reduce the heat radiation absorbed by the pavement. Trees also add beautification to the streets.
15. Neighborhood Schools: Having a local school can reduce the cost and emissions of transportation, while creating a sense of community. If a new development already has an existing school in close proximity, then this is a reasonable credit. Otherwise, it is unlikely that a new development will be enough to warrant its own school, unless the expected population is very large. Schools are a very large investment and are probably not a developer's priority.

5.0 Conclusions

The LEED program is one of the most widely recognized green building programs in the world. There are LEED projects in 91 countries and all 50 states. Worldwide, there are nearly 20,000 registered projects, as shown in the table below.

LEED	Registered Projects	Certified Projects
New Construction	11,597	1,600
Commercial Interiors	2,047	479
Existing Buildings	2,490	200
Core & Shell	2,488	157
Neighborhood Development	225	13
Schools	713	4
Retail	189	36
Total	19,524	2,476

Table 2: Number of LEED Projects - April 2009²⁵

With numbers like this, it is evident that LEED is a very popular tool for developers and building owners to use to help reduce their impact on the environment. Based on the research done for this project, there are many elements of LEED in general, and LEED ND in particular, that are very effective at reducing the human footprint on the earth. At the same time, the program is far from perfect, as can be seen with the several revised and updated versions released since the start of the program.

As with any new program, there is a need to research how the program works in order to find the best way to implement it. The methods outlined in this manual are intended to assist Stantec in presenting the available options to clients and saves Stantec personnel from spending valuable time on research. The list is by no means exhaustive, however it is only intended to be an initial tool to be used in determining whether or not a LEED neighborhood is right for the client.

The primary shortcoming of the LEED ND guidebook is that it only provides the intent for each credit; there is no information about how to implement them. This manual makes up for this for one portion of the program. It also successfully removes the emphasis from the point values and the certification itself and emphasizes choosing the best options for a real sustainable neighborhood. When used in partnership with the LEED ND guidebook, this manual is a very helpful tool, particularly for those who are new to sustainability and community design.

²⁵ U.S. Green Building Council. *Green Building Facts*. Page 2.

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Appendix A: LEED ND Project Scorecard



LEED for Neighborhood Development 2009 Ballot Draft - Project Scorecard

Project Name:

Yes ? No	Smart Location & Linkage	27 Points Possible
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Y	Prereq 1 Smart Location		Required
Y	Prereq 2 Imperiled Species and Ecological Communities		Required
Y	Prereq 3 Wetland and Water Body Conservation		Required
Y	Prereq 4 Agricultural Land Conservation		Required
Y	Prereq 5 Floodplain Avoidance		Required
	Credit 1 Preferred Locations		10
	Credit 2 Brownfield Redevelopment		2
	Credit 3 Locations with Reduced Automobile Dependence		7
	Credit 4 Bicycle Network and Storage		1
	Credit 5 Housing and Jobs Proximity		3
	Credit 6 Steep Slope Protection		1
	Credit 7 Site Design for Habitat or Wetland/Water Body Conservation		1
	Credit 8 Restoration of Habitat or Wetlands/Water Bodies		1
	Credit 9 Long-Term Conservation Management of Habitat or Wetlands/Water Bodies		1

Yes ? No	Neighborhood Pattern & Design	44 Points Possible
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Y	Prereq 1 Walkable Streets		Required
Y	Prereq 2 Compact Development		Required
Y	Prereq 3 Connected and Open Community		Required
	Credit 1 Walkable Streets		12
	Credit 2 Compact Development		6
	Credit 3 Mixed-Use Neighborhood Centers		4
	Credit 4 Mixed-Income Diverse Communities		7
	Credit 5 Reduced Parking Footprint		1
	Credit 6 Street Network		2
	Credit 7 Transit Facilities		1
	Credit 8 Transportation Demand Management		2
	Credit 9 Access to Civic & Public Spaces		1
	Credit 10 Access to Recreation Facilities		1
	Credit 11 Visitability and Universal Design		1
	Credit 12 Community Outreach and Involvement		2
	Credit 13 Local Food Production		1
	Credit 14 Tree-Lined and Shaded Streets		2
	Credit 15 Neighborhood Schools		1

Yes ? No

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Green Infrastructure & Buildings

29 Points Possible

Y
Y
Y
Y

Prereq 1	Certified Green Building	Required
Prereq 2	Minimum Building Energy Efficiency	Required
Prereq 3	Minimum Building Water Efficiency	Required
Prereq 4	Construction Activity Pollution Prevention	Required
Credit 1	Certified Green Buildings	5
Credit 2	Building Energy Efficiency	2
Credit 3	Building Water Efficiency	1
Credit 4	Water Efficient Landscaping	1
Credit 5	Existing Building Use	1
Credit 6	Historic Resource Preservation and Adaptive Reuse	1
Credit 7	Minimize Site Disturbance in Design and Construction	1
Credit 8	Stormwater Management	4
Credit 9	Heat Island Reduction	1
Credit 10	Solar Orientation	1
Credit 11	On-Site Renewable Energy Sources	3
Credit 12	District Heating and Cooling	2
Credit 13	Infrastructure Energy Efficiency	1
Credit 14	Wastewater Management	2
Credit 15	Recycled Content in Infrastructure	1
Credit 16	Solid Waste Management Infrastructure	1
Credit 17	Light Pollution Reduction	1

Yes ? No

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Innovation & Design Process

6 Points

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Credit 1.1	Innovation in Design: Provide Specific Title	1
Credit 1.2	Innovation in Design: Provide Specific Title	1
Credit 1.3	Innovation in Design: Provide Specific Title	1
Credit 1.4	Innovation in Design: Provide Specific Title	1
Credit 1.5	Innovation in Design: Provide Specific Title	1
Credit 2	LEED® Accredited Professional	1

Yes ? No

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Regional Priority Credits

4 Points

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Credit 1.1	Regional Priority Credit: Region Defined	1
Credit 1.2	Regional Priority Credit: Region Defined	1
Credit 1.3	Regional Priority Credit: Region Defined	1
Credit 1.4	Regional Priority Credit: Region Defined	1

Yes ? No

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Project Totals (Certification estimates)

110 Points

Certified: 40-49 points, Silver: 50-59 points, Gold: 60-79 points, Platinum: 80+ points

Appendix B: Capstone Design

This capstone design analyzed the feasibility of renovating an alley, and in doing so create a more sustainable site. Rainfall data was collected for six major U.S. cities in an effort to encompass several different climate regions in our calculations. Stormwater calculations were performed to determine the reduction in runoff when porous pavement was present instead of traditional pavement. Cost estimation was also performed for each of the cities to address issues of constructability.

Alley Dimensions

For the purpose of our calculations, we set the alley dimensions at 20' by 400', giving a total area of 8000 square feet. These dimensions are fairly standard for most major cities such as Sacramento and Chicago, which are included in our calculations below. The size of alleys certainly varies from city to city and even in different areas of the same city, but this variation isn't important to our design since the same runoff equation, as seen in Appendix D, can be applied to any surface area. Standardizing the alley, however, makes the effects of revitalization easier to see quantitatively.

Rainfall Data

In order to design for stormwater runoff, data for rainfall was needed. To show the benefits of alley revitalization in various geographic areas, this information was collected for Boston, Chicago, Seattle, Los Angeles, Houston, and Atlanta. Average values for both 2-year and 100-year, 60-minute storms were collected from the National Oceanic and Atmospheric Administration (NOAA).

City	2 year	100 year	
Boston	1.1	2.5	In/hr
Chicago	1.45	3.11	In/hr
Seattle	1.4	1.6	In/hr
Los Angeles	2.16	2.58	In/hr
Houston	2.3	4.6	In/hr
Atlanta	1.8	3.75	In/hr

Table 3: Metropolitan Rainfall Data: 2 and 100-Year Storms

Stormwater Calculations

A major component of alley revitalization, and sustainable community design as whole, is stormwater runoff mitigation; runoff can lead to flooding in highly developed areas and can also contaminate local water sources due to the debris and chemicals it absorbs when falling on impervious surfaces. This runoff can be addressed in one of two ways. The traditional approach is to incorporate an adequate drainage system and retention ponds into a community. These systems allow stormwater to collect in a centralized location, thereby reducing the risk of flooding and allowing natural percolation back into the groundwater table. Alternatively, by reducing the area covered by impervious surfaces, specifically asphalt parking lots and roads, water will be able to be absorbed and naturally filtered by the ground. While this absorption does not take away the need for traditional drainage and retention pond systems, it can greatly reduce the demand place upon them and in doing so reduce the required maintenance, saving money over the lifetime of the system.

This reduction in impervious surfaces can be achieved through removal of asphalt entirely, or by replacing it with interlocking pavers or porous pavement. For the purpose of this capstone design, both porous pavement and grass were chosen as alternative surfaces. Porous pavement was chosen because it maintains functionality in the alley while still providing environmental benefits, whereas grass was chosen because many urban areas are lacking green space, and unused alleys are seen as a place to put small parks or public spaces. An analysis using the rational method was performed in which the total runoff (in cubic feet per second) was calculated for an alley with both traditional and porous pavements, as well as grass. Calculations were done using Excel, but also verified by hand, as seen in Appendix D. From the tables below it is clear that both porous pavement and grass provide reductions in runoff, with porous pavement being the most significant.

City	Pavement	Grass	Porous	Units
Boston:	0.192	0.051	0.010	cfs
Chicago:	0.253	0.067	0.013	cfs
Seattle:	0.245	0.064	0.013	cfs
Los Angeles:	0.378	0.099	0.020	cfs
Houston:	0.402	0.106	0.021	cfs
Atlanta:	0.332	0.083	0.017	cfs

Table 4: Runoff Values for a 2-Year, 60 Minute Storm

City	Pavement	Grass	Porous	Units
Boston:	0.437	0.115	0.023	cfs
Chicago:	0.544	0.143	0.029	cfs
Seattle:	0.280	0.074	0.015	cfs
Los Angeles:	0.451	0.119	0.024	cfs
Houston:	0.804	0.220	0.042	cfs
Atlanta:	0.656	0.173	0.035	cfs

Table 5: Runoff Values for a 100-Year 60 Minute Storm

Cost Estimation

In order to perform cost estimation for the alley revitalization projects in each of the selected cities, construction cost data was required. This was acquired using RSMeans construction data for major U.S. cities, as of April 2009. Chicago was used as a baseline, simply because the cost of alley revitalization, specifically using porous pavement and native plantings, was found during initial research.

RS Means Data (as of April 2009)

City	Costs
Boston	1.80%
Chicago	0%
Los Angeles	-6.70%
Seattle	-10%
Atlanta	-25.20%
Houston	-26.90%

Table 6: Construction Cost Data for Model Cities

Alley Design

To demonstrate the various options for alley revitalization, three different designs for our model alley were planned, and cost estimation was completed for each. Design 1 is meant for an alley that sees regular traffic flow, either in a residential setting with back

lot access or in a more urban setting traditionally used for trash pick-up. Designs 2 and 3 are intended to serve as examples of what an unused alley can be converted into, particularly in urban settings where traffic is not common in the alleyways.

Design # 1- Full Automobile Access Alley

This design is the most basic of those presented; it calls for full replacement of the existing asphalt with porous pavement, thereby reducing runoff. Dark sky compliant lighting is also placed in the alley, maintaining a safe environment while not contributing to the existing issue of light pollution in all major cities. This design allows continued use of the alley, be it for trash pickup or movement by cars. As seen in Tables 5 and 6, replacing traditional pavement with a porous alternative reduces runoff by almost 95%, certainly a welcome scenario in any city. The cost was determined from an average cost of porous pavement installation, as well as installation of 3 dark sky compliant lights, factored according to the RS Means data presented above. The results are as follows:

City	Pavement	Lights	Total
Boston	\$48,864.00	\$7,940.40	\$56,804.40
Chicago	\$48,000.00	\$7,800.00	\$55,800.00
Los Angeles	\$44,784.00	\$7,277.40	\$52,061.40
Seattle	\$43,200.00	\$7,020.00	\$50,220.00
Atlanta	\$35,904.00	\$5,834.40	\$41,738.40
Houston	\$35,088.00	\$5,701.80	\$40,789.80

Table 7: Cost Estimate for Alley Design #1

Design #2- “Green Space” Alley - No Multimodal Path

Alleys exist in many cities, but in some they serve little more purpose than a rarely used eyesore. Many cities are also lacking in publically accessible parks and outdoor gathering spaces, a major point that advocates of new urbanism and sustainable development are attempting to address. By converting underutilized alleys into small public parks, issues of stormwater runoff and public accessibility are addressed, making this a viable option for many communities.

This design completely replaces the existing asphalt with natural grasses and plantings, reducing stormwater runoff by around 75%, as seen in Tables 5 and 6. Again, lighting is incorporated into the design to increase safety for nearby residents and users of the park. Trees are also incorporated into the design, in an effort to provide shade to

residents, as well as further reduce stormwater runoff by another 5%.²⁶ This design incorporates no pavement, so it is not surprising that it is the cheapest of the three options presented here. Cost was determined by the average cost of native plantings for the surface area given, planting of trees, and installation of three dark sky compliant lights, with the total being factored by the RS means data.

City	Grass/Plants	Lights	Trees	Total
Boston	\$32,576.00	\$7,940.40	\$4,886.40	\$45,402.80
Chicago	\$32,000.00	\$7,800.00	\$4,800.00	\$44,600.00
Los Angeles	\$29,856.00	\$7,277.40	\$4,478.40	\$41,611.80
Seattle	\$28,800.00	\$7,020.00	\$4,320.00	\$40,140.00
Atlanta	\$23,936.00	\$5,834.40	\$3,590.40	\$33,360.80
Houston	\$23,392.00	\$5,701.80	\$3,508.80	\$32,602.60

Table 8: Cost Estimate for Alley Design #2

Design #3- “Green space” Alley- Multimodal Path

This design is very similar to the one described above, incorporating lighting for safety and trees for positive environmental effects. It does, however, differ in that it includes a pathway composed of porous pavement, in an effort to maintain connectivity for both walking and bicycling residents. While this does limit the available space for native plants and grasses, by having the path closer to the edge of the alley the available space is still maximized for public use. Due to the incorporation of the porous pathway, the price is slightly higher than Design #2. Cost was determined similar to the above examples, with average cost of installation for all elements being determined, and the total being factored by the RS Means data.

City	Pavement	Grass/Plants	Lights	Trees	Total
Boston	\$14,659.20	\$22,803.20	\$7,940.40	\$4,886.40	\$50,289.20
Chicago	\$14,400.00	\$22,400.00	\$7,800.00	\$4,800.00	\$49,400.00
Los Angeles	\$13,435.20	\$20,899.20	\$7,277.40	\$4,478.40	\$46,090.20
Seattle	\$12,960.00	\$20,160.00	\$7,020.00	\$4,320.00	\$44,460.00
Atlanta	\$10,771.20	\$16,755.20	\$5,834.40	\$3,590.40	\$36,951.20
Houston	\$10,526.40	\$16,374.40	\$5,701.80	\$3,508.80	\$36,111.40

Table 9: Cost Estimate for Alley Design #3

²⁶ U.S. Department of Agriculture. *Using Trees to Reduce Stormwater Runoff*. Publication. Forest Service, Northeast Area, State and Private Forestry. Slide 7.

Summary

Alley revitalization is a cost-effective strategy in reducing stormwater runoff, and if done properly, it can also improve the aesthetics of a community. The extent to which the alley is changed depends on the needs of the community, either leaving it as an access point for delivery trucks or providing much needed park space to congested urban areas. Porous pavements, or other pervious surfaces, can greatly reduce stormwater runoff. When planted properly, trees not only add to a community aesthetically, but also provide shade to public areas and can aid in the reduction of stormwater management. Lastly, proper lighting allows public spaces to be usable throughout the day and night without negatively affecting the surrounding community through light pollution. With the push towards sustainability occurring across the United States, there should be a concerted effort to revitalize the vast networks of alleys present in many cities, providing both environmental and social benefits to residents.

Appendix C: Method of Calculation

METHODS OF CALCULATION

The total system runoff Q for 10-year storm shall be calculated using the Rational Method:

$$Q = C I A$$

Q = Rate of runoff (ft³/sec)

C = Coefficient of run-off (unitless)

I = Rainfall intensity (in/hr) relative to the storm-frequency and time of concentration T_c

A = Drainage area (acres)

Coefficient of Run-off

Pervious Surfaces		C	Impervious Surfaces		C
Lawn/Soil/Undeveloped Areas	See C _{soil} equation		Rooftops	0.75-0.95	
Ponds	0		Swimming Pools/Spas ⁴	0	
Streams/Creeks	0		Patios	0.75-0.95	
Unpaved Gravel Driveways	0.4		Concrete	0.85-0.95	
Pervious Concrete ¹	0.05		Asphalt	0.80-0.95	
Pervious Asphalt ¹	0.05		Cobbles	0.6	
Permeable Pavers (Unit Pavers) ²	See note		Brick (grouted)	0.7-0.85	
Gravel Bed	0.05				
Natural Stone (without grout)	0.35				
Green Roofs ³	0.1-0.5				

Table 10: Various Runoff Coefficients Used in Calculations²⁷

¹Pervious concrete and pervious asphalt slabs less than 6" thick should use run-off coefficient of the sub-grade. Subject to change pending further research.

²Permeable pavers shall use the run-off coefficient of the underlying soil. If pavers are laid over a greater than 15% void content aggregate base, use a C of 0.10. Subject to change pending further research.

³C varies greatly between green roof designs and depends greatly on the rainfall volume. Use best judgment or ask city engineer for suggestion.

⁴Pools and Spas are classified as impervious because the water does not infiltrate into the soil; hence not allowing recharge of ground water.

²⁷ *Requirements for the Preparation of Hydrology Reports*. Publication. City of Menlo Park Public Works Department, Engineering Division, 20 Aug. 2006. Web. 25 Nov. 2009.

Appendix D: Typical Storm Water Calculation

Typical Stormwater Runoff Calculations

Alley dimensions: 20' wide by 400' long
Surface area = $20 \times 400 = 8000 \text{ ft}^2$

$$1 \text{ sq ft} = 2.296 \times 10^{-5} \text{ acre}$$
$$8000 \times 2.296 \times 10^{-5} = 0.184 \text{ acres}$$

Using the Rational Method:

$$Q = CIA \quad \text{where} \quad \begin{aligned} Q &= \text{Rate of runoff (cfs)} \\ C &= \text{Coefficient of runoff (unitless)} \\ I &= \text{Rain intensity (in/hr)} \\ A &= \text{Area of drainage (acres)} \end{aligned}$$

$$C \text{ value for standard pavement} = 0.95$$

$$C \text{ value for pervious pavement} = 0.05$$

For Boston: 2 yr storm: 1.10 in/hr
100 yr storm: 2.50 in/hr

Standard pavement:

Pervious pavement:

$$2 \text{ yr: } Q = 0.95(1.10)(0.184)$$

$$Q = 0.05(1.10)(0.184)$$

Appendix E: Storm Water Calculation Spreadsheet

NOAA Rainfall Data:							
City:	2 Year	100 Year		Acreage=	0.184		
Boston:	1.10	2.50	in/hr	C Grass=	0.25		
Chicago:	1.45	3.11	in/hr				
Seattle:	1.40	1.60	in/hr				
Los Angeles:	2.16	2.58	in/hr				
Houston:	2.30	4.60	in/hr				
Atlanta:	1.80	3.75	in/hr				
Las Vegas:	0.50	1.60	in/hr				
Rational Method: $Q=CIA$							
Q= Rate of runoff (cfs)							
C= Coefficient of runoff (unitless)							
I= Rain intensity (in/hr) (relative to storm frequency)							
A= Area of drainage (acres)							
C value for standard concrete/asphalt = 0.95							
C value for pervious concrete/asphalt = 0.05							
Standard Pavement:				Pervious Pavement:			
City:	2 Year	100 Year		City:	2 Year	100 Year	
Boston:	0.192	0.437	cfs	Boston:	0.010	0.023	cfs
Chicago:	0.253	0.544	cfs	Chicago:	0.013	0.029	cfs
Seattle:	0.245	0.280	cfs	Seattle:	0.013	0.015	cfs
Los Angeles:	0.378	0.451	cfs	Los Angeles:	0.020	0.024	cfs
Houston:	0.402	0.804	cfs	Houston:	0.021	0.042	cfs
Atlanta:	0.332	0.656	cfs	Atlanta:	0.017	0.035	cfs
Las Vegas:	0.087	0.280	cfs	Las Vegas:	0.005	0.015	cfs
Grass							
City:	2 Year	100 Year					
Boston:	0.051	0.115	cfs				
Chicago:	0.067	0.143	cfs				
Seattle:	0.064	0.074	cfs				
Los Angeles:	0.099	0.119	cfs				
Houston:	0.106	0.212	cfs				
Atlanta:	0.083	0.173	cfs				
Las Vegas:	0.023	0.074	cfs				
Grass/ Porous							
City:	2 Year	100 Year					
Boston:	0.0385	0.0875	cfs				
Chicago:	0.05075	0.10885	cfs				
Seattle:	0.049	0.056	cfs				
Los Angeles:	0.0756	0.0903	cfs				
Houston:	0.0805	0.161	cfs				
Atlanta:	0.063	0.13125	cfs				
Las Vegas:	0.0175	0.056	cfs				

Appendix F: Construction Cost Spreadsheet

RS Means Data			
City	Costs		Factor
Boston	1.80%		1.018
Chicago	0%	Baseline	1
Los Angeles	-6.70%		0.933
Seattle	-10%		0.9
Atlanta	-25.20%		0.748
Houston	-26.90%		0.731

Pavement			
City	per sq. ft.	8000 sq.ft.	2400 sq.ft.
Boston	\$6.11	\$48,864.00	\$14,659.20
Chicago	\$6	\$48,000.00	\$14,400.00
Los Angeles	\$5.60	\$44,784.00	\$13,435.20
Seattle	\$5.40	\$43,200.00	\$12,960.00
Atlanta	\$4.49	\$35,904.00	\$10,771.20
Houston	\$4.39	\$35,088.00	\$10,526.40

Grass/Plants			
City	per sq.ft.	8000 sq.ft.	5600 sq.ft.
Boston	\$4.07	\$32,576.00	\$22,803.20
Chicago	\$4	\$32,000.00	\$22,400.00
Los Angeles	\$3.73	\$29,856.00	\$20,899.20
Seattle	\$3.60	\$28,800.00	\$20,160.00
Atlanta	\$2.99	\$23,936.00	\$16,755.20
Houston	\$2.92	\$23,392.00	\$16,374.40

Trees		
City	per tree	16 trees
Boston	\$305.40	\$4,886.40
Chicago	\$300	\$4,800.00
Los Angeles	\$279.90	\$4,478.40
Seattle	\$270.00	\$4,320.00
Atlanta	\$224.40	\$3,590.40
Houston	\$219.30	\$3,508.80

Lights		
City	per light	3 lights
Boston	\$2,646.80	\$7,940.40
Chicago	\$2,600	\$7,800.00
Los Angeles	\$2,425.80	\$7,277.40
Seattle	\$2,340	\$7,020.00
Atlanta	\$1,944.80	\$5,834.40
Houston	\$1,900.60	\$5,701.80

Design #1			
City	Pavement	Lights	Total
Boston	\$48,864.00	\$7,940.40	\$56,804.40
Chicago	\$48,000.00	\$7,800.00	\$55,800.00
Los Angeles	\$44,784.00	\$7,277.40	\$52,061.40
Seattle	\$43,200.00	\$7,020.00	\$50,220.00
Atlanta	\$35,904.00	\$5,834.40	\$41,738.40
Houston	\$35,088.00	\$5,701.80	\$40,789.80

Design #2				
City	Grass/Plants	Lights	Trees	Total
Boston	\$32,576.00	\$7,940.40	\$4,886.40	\$45,402.80
Chicago	\$32,000.00	\$7,800.00	\$4,800.00	\$44,600.00
Los Angeles	\$29,856.00	\$7,277.40	\$4,478.40	\$41,611.80
Seattle	\$28,800.00	\$7,020.00	\$4,320.00	\$40,140.00
Atlanta	\$23,936.00	\$5,834.40	\$3,590.40	\$33,360.80
Houston	\$23,392.00	\$5,701.80	\$3,508.80	\$32,602.60

Design #3					
City	Pavement	Grass/Plants	Lights	Trees	Total
Boston	\$14,659.20	\$22,803.20	\$7,940.40	\$4,886.40	\$50,289.20
Chicago	\$14,400.00	\$22,400.00	\$7,800.00	\$4,800.00	\$49,400.00
Los Angeles	\$13,435.20	\$20,899.20	\$7,277.40	\$4,478.40	\$46,090.20
Seattle	\$12,960.00	\$20,160.00	\$7,020.00	\$4,320.00	\$44,460.00
Atlanta	\$10,771.20	\$16,755.20	\$5,834.40	\$3,590.40	\$36,951.20
Houston	\$10,526.40	\$16,374.40	\$5,701.80	\$3,508.80	\$36,111.40

Appendix G: Capstone Revit Renderings



Figure 5: Revit Rendering of Capstone Alley Before Restoration

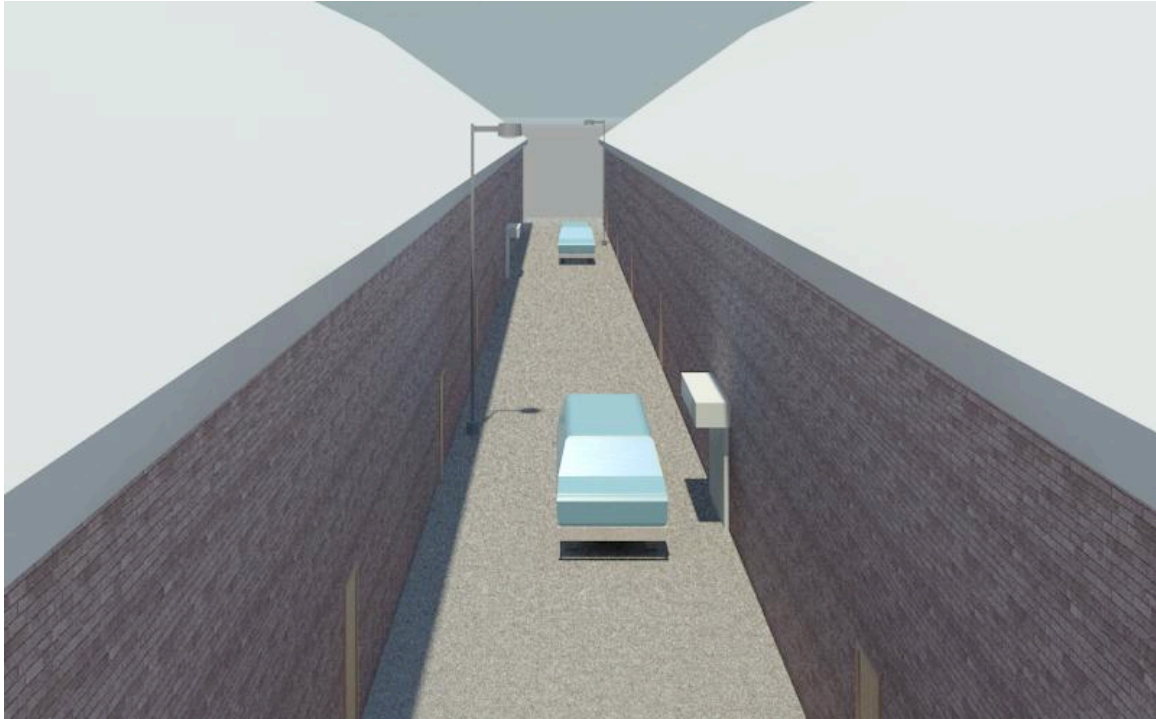


Figure 6: Revit Rendering of Capstone Alley With Pervious Pavement and Lighting

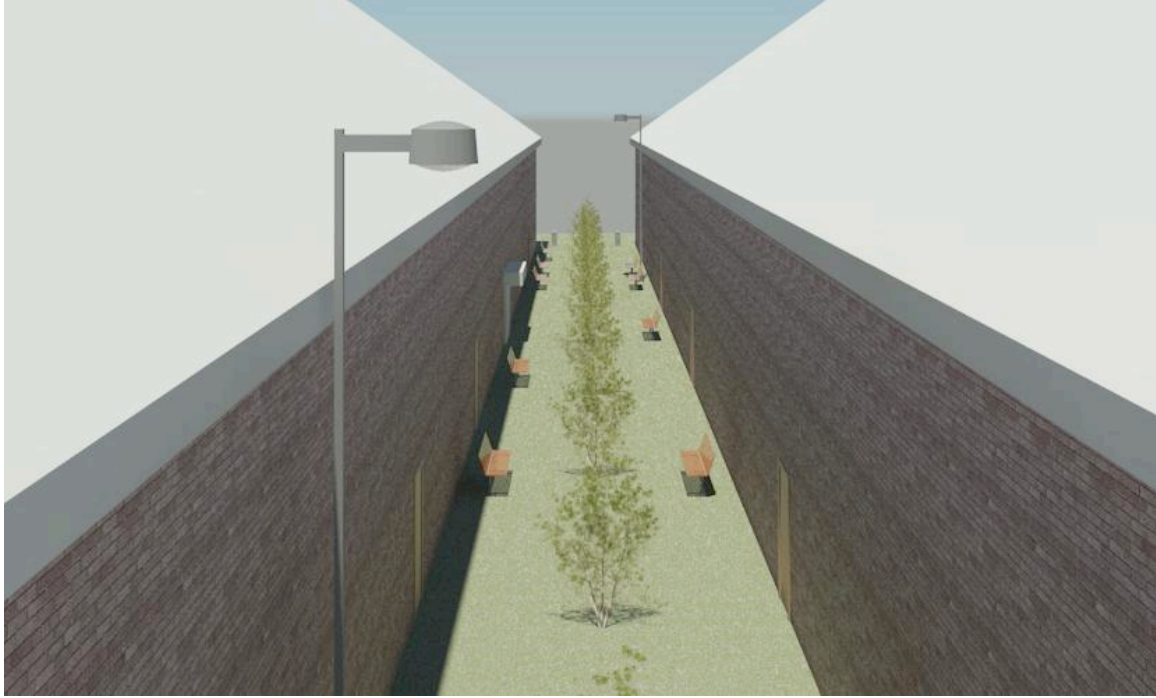


Figure 7: Revit Rendering of Capstone Alley With Grass and Trees



Figure 8: Revit Rendering of Capstone Alley With Grass and Pervious Walkway

Appendix H: Chicago Green Alley Pictures



Figure 9: Chicago Alley Before Restoration²⁸

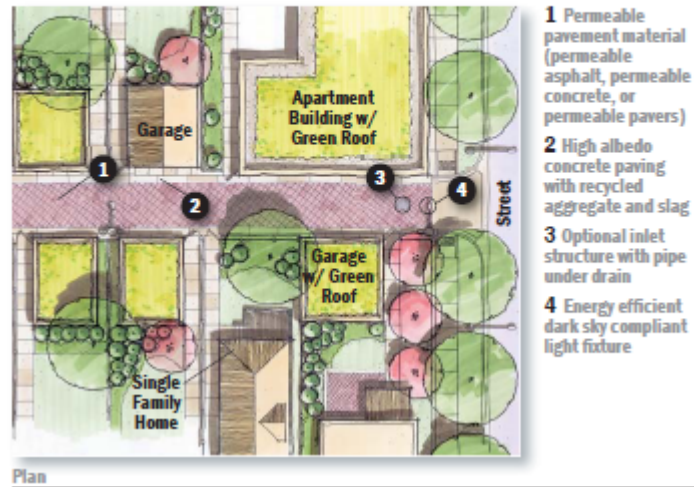


Figure 10: Chicago Alley After Restoration²⁹

²⁸ *The Chicago Green Alley Handbook*. Chicago Department of Transportation. Page 4.

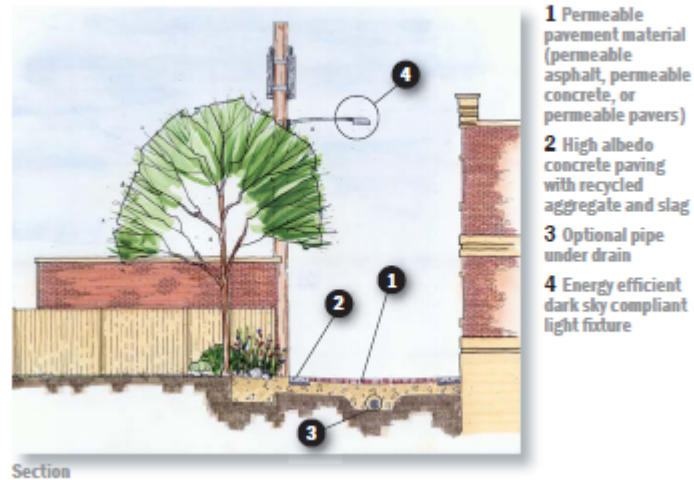
²⁹ *The Chicago Green Alley Handbook*. Page 4.

Full Alley Infiltration Using Permeable Pavement



- 1 Permeable pavement material (permeable asphalt, permeable concrete, or permeable pavers)
- 2 High albedo concrete paving with recycled aggregate and slag
- 3 Optional inlet structure with pipe under drain
- 4 Energy efficient dark sky compliant light fixture

Plan



- 1 Permeable pavement material (permeable asphalt, permeable concrete, or permeable pavers)
- 2 High albedo concrete paving with recycled aggregate and slag
- 3 Optional pipe under drain
- 4 Energy efficient dark sky compliant light fixture

Section

Figure 11: Sketches from the Chicago Green Alley Handbook³⁰

³⁰ *The Chicago Green Alley Handbook*. Page 7.

Appendix I: Pervious Pavement Pictures

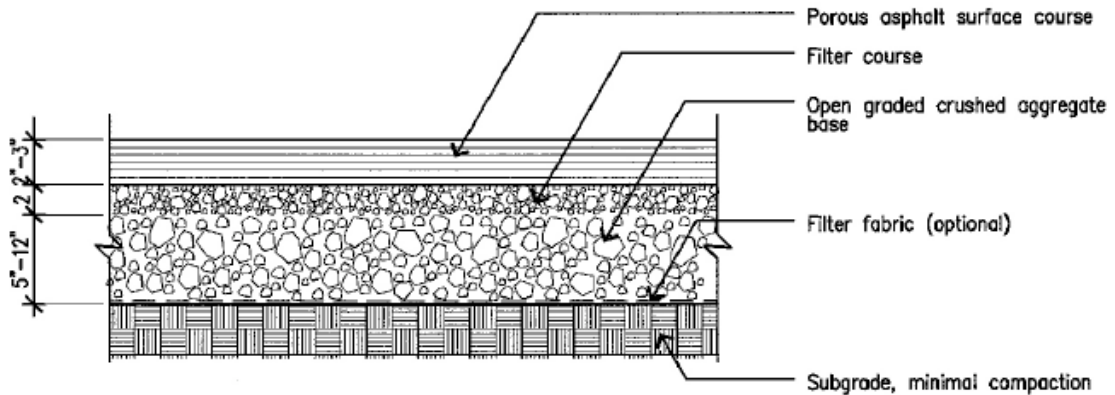


Figure 12: Section View of Typical Pervious Pavement Application³¹



Figure 13: Parking Lot With Both Typical and Pervious Pavements After Rain³²

³¹ Chapter 4." *San Mateo Countywide Water Pollution Prevention Guide*. San Mateo, CA. Page 42.

³² "Section 6- Comprehensive Stormwater Management: Structural BMPs." *Pennsylvania Stormwater Best Management Practices Manual*. Page 6-205.

The RISE of VERTICAL FARMS

Growing crops in city skyscrapers would use less water and fossil fuel than outdoor farming, eliminate agricultural runoff and provide fresh food

By Dickson Despommier

KEY CONCEPTS

- Farming is ruining the environment, and not enough arable land remains to feed a projected 9.5 billion people by 2050.
- Growing food in glass high-rises could drastically reduce fossil-fuel emissions and recycle city wastewater that now pollutes waterways.
- A one-square-block farm 30 stories high could yield as much food as 2,400 outdoor acres, with less subsequent spoilage.
- Existing hydroponic greenhouses provide a basis for prototype vertical farms now being considered by urban planners in cities worldwide.

—The Editors

Together the world's 6.8 billion people use land equal in size to South America to grow food and raise livestock—an astounding agricultural footprint. And demographers predict the planet will host 9.5 billion people by 2050. Because each of us requires a minimum of 1,500 calories a day, civilization will have to cultivate another Brazil's worth of land—2.1 billion acres—if farming continues to be practiced as it is today. That much new, arable earth simply does not exist. To quote the great American humorist Mark Twain: "Buy land. They're not making it any more."

Agriculture also uses 70 percent of the world's available freshwater for irrigation, rendering it unusable for drinking as a result of contamination with fertilizers, pesticides, herbicides and silt. If current trends continue, safe drinking water will be impossible to come by in certain densely populated regions. Farming involves huge quantities of fossil fuels, too—20 percent of all the gasoline and diesel fuel consumed in the U.S. The resulting greenhouse gas emissions are of course a major concern, but so is the price of food as it becomes linked to the price of fuel, a mechanism that roughly doubled the cost of

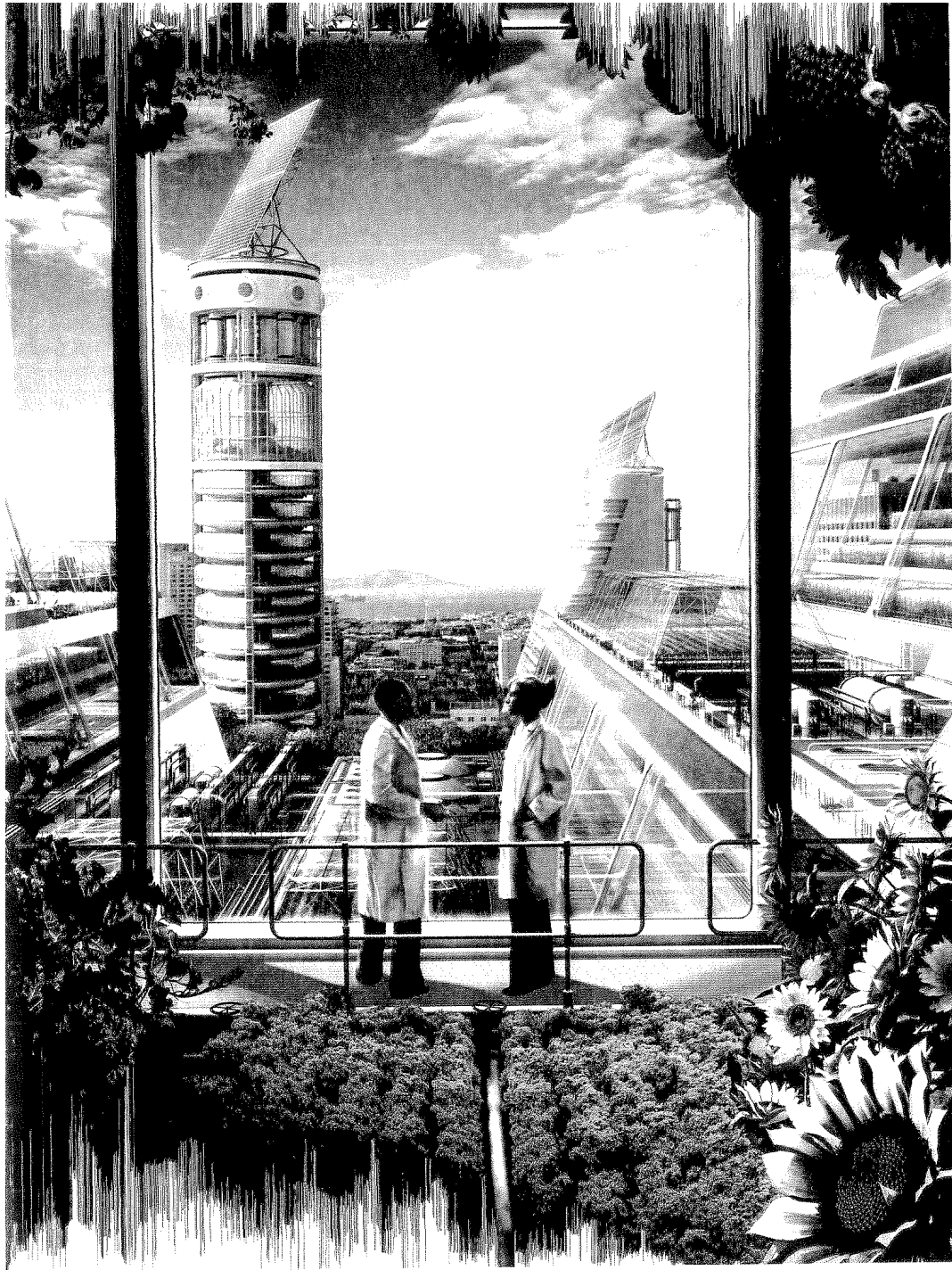
eating in most places worldwide between 2005 and 2008.

Some agronomists believe that the solution lies in even more intensive industrial farming, carried out by an ever decreasing number of highly mechanized farming consortia that grow crops having higher yields—a result of genetic modification and more powerful agrochemicals. Even if this solution were to be implemented, it is a short-term remedy at best, because the rapid shift in climate continues to rearrange the agricultural landscape, foiling even the most sophisticated strategies. Shortly after the Obama administration took office, Secretary of Energy Steven Chu warned the public that climate change could wipe out farming in California by the end of the century.

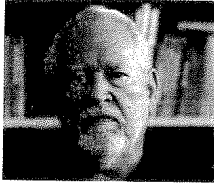
What is more, if we continue wholesale deforestation just to generate new farmland, global warming will accelerate at an even more catastrophic rate. And far greater volumes of agricultural runoff could well create enough aquatic "dead zones" to turn most estuaries and even parts of the oceans into barren wastelands.

As if all that were not enough to worry about, foodborne illnesses account for a significant

PHOTO: GETTY IMAGES/ALAMY



[THE AUTHOR]



Dickson Despommier is professor of public health and microbiology at Columbia University and president of the Vertical Farm Project, which functions as a clearinghouse for development work (see www.verticalfarm.com). As a postdoctoral fellow at the Rockefeller University years ago, he became friends with René Dubos, a renowned agricultural sciences researcher who introduced him to the concept of human ecology.

number of deaths worldwide—salmonella, cholera, *Escherichia coli* and shigella, to name just a few. Even more of a problem are life-threatening parasitic infections, such as malaria and schistosomiasis. Furthermore, the common practice of using human feces as a fertilizer in most of Southeast Asia, many parts of Africa, and Central and South America (commercial fertilizers are too expensive) facilitates the spread of parasitic worm infections that afflict 2.5 billion people.

Clearly, radical change is needed. One strategic shift would do away with almost every ill just noted: grow crops indoors, under rigorously controlled conditions, in vertical farms. Plants grown in high-rise buildings erected on now vacant city lots and in large, multistory rooftop greenhouses could produce food year-round using significantly less water, producing little waste, with less risk of infectious diseases, and no need for fossil-fueled machinery or transport from distant rural farms. Vertical farming could revolutionize how we feed ourselves and the rising population to come. Our meals would taste better, too; “locally grown” would become the norm.

The working description I am about to explain might sound outrageous at first. But engineers, urban planners and agronomists who have scrutinized the necessary technologies are convinced that vertical farming is not only feasible but should be tried.

Do No Harm

Growing our food on land that used to be intact forests and prairies is killing the planet, setting up the processes of our own extinction. The minimum requirement should be a variation of the physician's credo: “Do no harm.” In this case, do no further harm to the earth. Humans have risen to conquer impossible odds before. From Charles Darwin's time in the mid-1800s and forward, with each Malthusian prediction of the end of the world because of a growing population came a series of technological breakthroughs that bailed us out. Farming machines of all kinds, improved fertilizers and pesticides, plants artificially bred for greater productivity and disease resistance, plus vaccines and drugs for common animal diseases all resulted in more food than the rising population needed to stay alive.

That is until the 1980s, when it became obvious that in many places farming was stressing the land well beyond its capacity to support viable crops. Agrochemicals had destroyed the natural cycles of nutrient renewal that intact ecosystems use to maintain themselves. We must switch to agricultural technologies that are more ecologically sustainable.

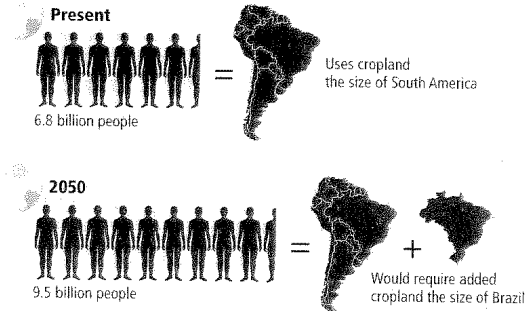
As the noted ecologist Howard Odum reportedly observed: “Nature has all the answers, so what is your question?” Mine is: How can we all live well and at the same time allow for ecological repair of the world's ecosystems? Many climate experts—from officials at the United Nations Food and Agriculture Organization to sustainable environmentalist and 2004 Nobel Peace Prize winner Wangari Maathai—agree that allowing farmland to revert to its natural grassy or wooded states is the easiest and most direct way to slow climate change. These landscapes naturally absorb carbon dioxide, the most abundant greenhouse gas, from the ambient air. Leave the land alone and allow it to heal our planet.

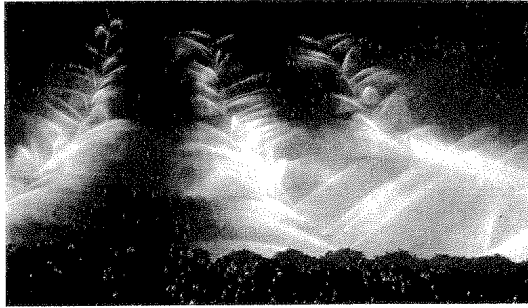
Examples abound. The demilitarized zone between South and North Korea, created in 1953 after the Korean War, began as a 2.5-mile-wide strip of severely scarred land but today is lush and vibrant, fully recovered. The once bare corridor separating former East and West Germany is now verdant. The American dust bowl of the 1930s, left barren by overfarming and drought, is once again a highly productive part of the nation's breadbasket. And all of New England, which was clear-cut at least three times since the 1700s, is home to large tracts of healthy hardwood and boreal forests.

[PROBLEM]

Feeding the Future: Not Enough Land

Growing food and raising livestock for 6.8 billion people require land equal in size to South America. By 2050 another Brazil's worth of area will be needed, using traditional farming; that much arable land does not exist.





The Vision

For many reasons, then, an increasingly crowded civilization needs an alternative farming method. But are enclosed city skyscrapers a practical option?

Yes, in part because growing food indoors is already becoming commonplace. Three techniques—drip irrigation, aeroponics and hydroponics—have been used successfully around the world. In drip irrigation, plants root in troughs of lightweight, inert material, such as vermiculite, that can be used for years, and small tubes running from plant to plant drip nutrient-laden water precisely at each stem's base, eliminating the vast amount of water wasted in traditional irrigation. In aeroponics, developed in 1982 by K. T. Hubick, then later improved by NASA scientists, plants dangle in air that is infused with water vapor and nutrients, eliminating the need for soil, too.

Agronomist William F. Gericke is credited with developing modern hydroponics in 1929. Plants are held in place so their roots lie in soil-less troughs, and water with dissolved nutrients is circulated over them. During World War II, more than eight million pounds of vegetables

FARMING EXACTS a heavy toll on the environment: fertilizer runoff feeds large algae blooms that create ocean dead zones (left; blue and green swirls); irrigation and vehicles waste massive quantities of water and fossil fuels (top right); and pesticides contaminate food, land and groundwater (bottom right).

were produced hydroponically on South Pacific islands for Allied forces there. Today hydroponic greenhouses provide proof of principles for indoor farming: crops can be produced year-round, droughts and floods that often ruin entire harvests are avoided, yields are maximized because of ideal growing and ripening conditions, and human pathogens are minimized.

Most important, hydroponics allows the grower to select where to locate the business, without concern for outdoor environmental conditions such as soil, precipitation or temperature profiles. Indoor farming can take place anywhere that adequate water and energy can be supplied. Sizable hydroponic facilities can be found in the U.K., the Netherlands, Denmark, Germany, New Zealand and other countries. One leading example is the 318-acre Eurofresh Farms in the Arizona desert, which produces large quantities of high-quality tomatoes, cucumbers and peppers 12 months a year.

Most of these operations sit in semirural areas, however, where reasonably priced land can be found. Transporting the food for many miles adds cost, consumes fossil fuels, emits carbon dioxide and causes significant spoilage. Moving

ALGAL BLOOM: JEFFREY M. BRONKHORST/ISTOCKPHOTO.COM; OCEAN DEAD ZONE: JEFFREY M. BRONKHORST/ISTOCKPHOTO.COM; HYDROPONIC FARMING: JEFFREY M. BRONKHORST/ISTOCKPHOTO.COM; FARMER: JEFFREY M. BRONKHORST/ISTOCKPHOTO.COM

greenhouse farming into taller structures within city limits can solve these remaining problems. I envision buildings perhaps 30 stories high covering an entire city block. At this scale, vertical farms offer the promise of a truly sustainable urban life: municipal wastewater would be recycled to provide irrigation water, and the remaining solid waste, along with inedible plant matter, would be incinerated to create steam that turns turbines that generate electricity for the farm. With current technology, a wide variety of edible plants can be grown indoors [see illustration on opposite page]. An adjacent aquaculture center could also raise fish, shrimp and mollusks.

Start-up grants and government-sponsored research centers would be one way to jump-start vertical farming. University partnerships with companies such as Cargill, Monsanto, Archer Daniels Midland and IBM could also fill the bill. Either approach would exploit the enormous talent pool within many agriculture, engineering and architecture schools and lead to prototype farms perhaps five stories tall and one acre in footprint. These facilities could be the "playground" for graduate students, research scientists and engineers to carry out the necessary trial-and-error tests before a fully functional farm emerged. More modest, rooftop operations on apartment complexes, hospitals and schools could be test beds, too. Research installations already exist at many schools, including the University of California, Davis, Pennsylva-

GROWING TECHNIQUES

Three technologies would be exploited in vertical farms.

AEROPONICS

Plants are held in place so their roots dangle in air that is infused with water vapor and nutrients. Good for root crops (potatoes, carrots).

HYDROPONICS

Plants are held in place so their roots lie in open troughs; water with dissolved nutrients is continually circulated over them. Good for many vegetables (tomatoes, spinach) and berries.

DRIP IRRIGATION

Plants grow in troughs of lightweight, inert material, such as vermiculite, reused for years. Small tubing on the surface drips nutrient-laden water precisely at each stem's base. Good for grains (wheat, corn).

nia State University, Rutgers University, Michigan State University, and schools in Europe and Asia. One of the best known is the University of Arizona's Controlled Environment Agriculture Center, run by Gene Giacomelli.

Integrating food production into city living is a giant step toward making urban life sustainable. New industries will grow, as will urban jobs never before imagined—nursery attendants, growers and harvesters. And nature will be able to rebound from our insults; traditional farmers would be encouraged to grow grasses and trees, getting paid to sequester carbon. Eventually selective logging would be the norm for an enormous lumber industry, at least throughout the eastern half of the U.S.

Practical Concerns

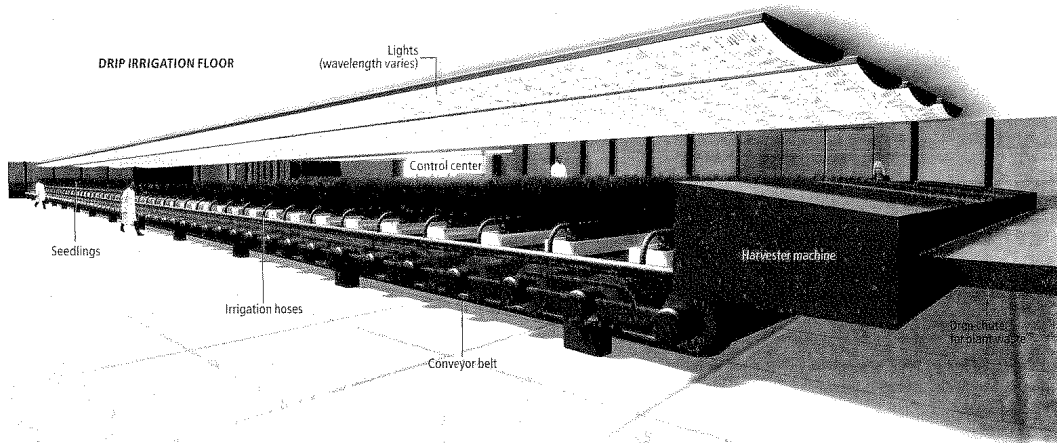
In recent years I have been speaking regularly about vertical farms, and in most cases, people raise two main practical questions. First, skeptics wonder how the concept can be economically viable, given the often inflated value of properties in cities such as Chicago, London and Paris. Downtown commercial zones might not be affordable, yet every large city has plenty of less desirable sites that often go begging for projects that would bring in much needed revenue.

In New York City, for example, the former Floyd Bennett Field naval base lies fallow. Abandoned in 1972, the 2.1 square miles scream out for use. Another large tract is Governors Island,

Maximum Yield

On most floors of a vertical farm [see opposite page], an automated conveyor would move seedlings from one end to the other, so that the plants would mature along the way and be at the height of producing grain

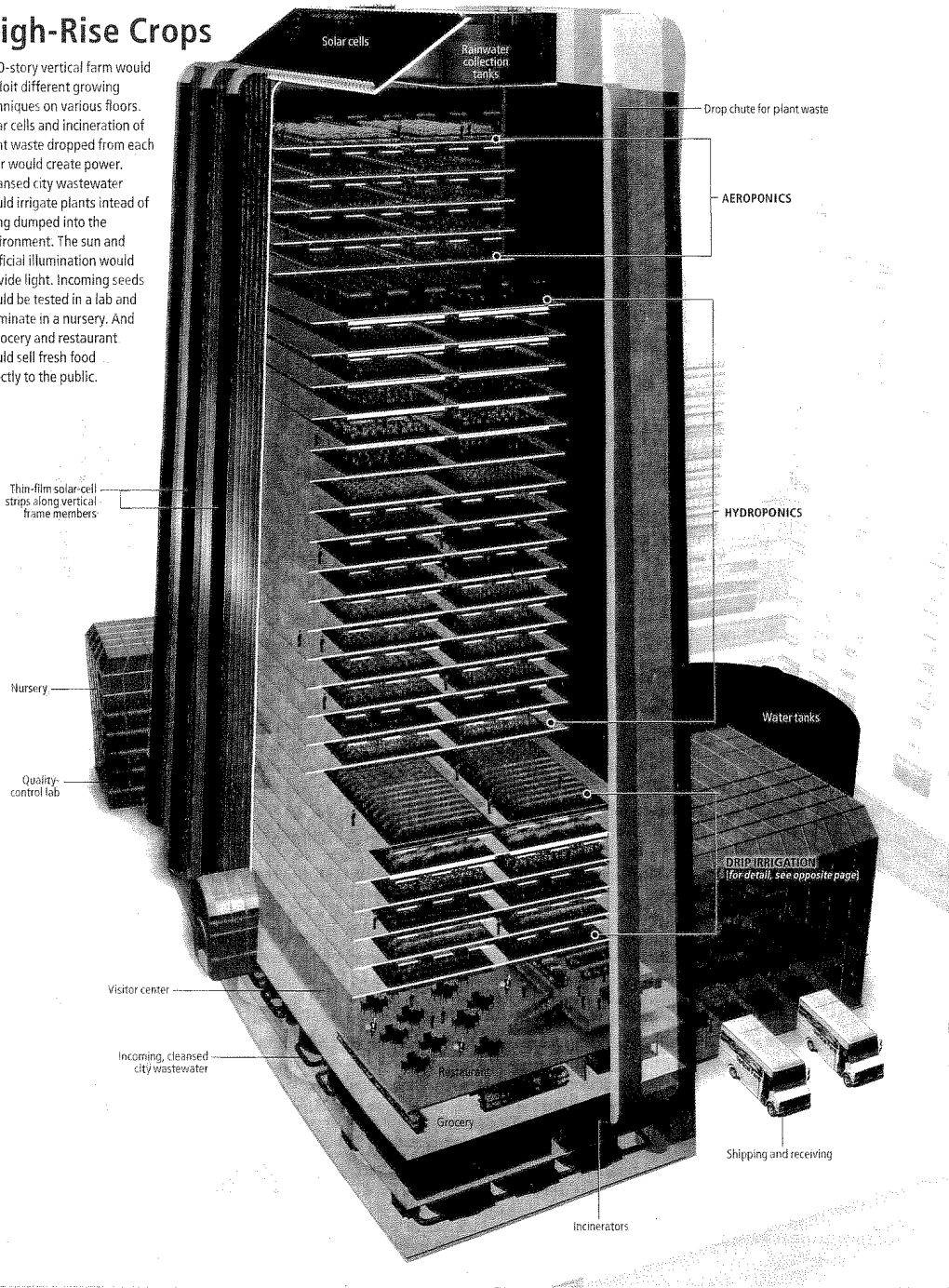
or vegetables when they reached a harvester. Water and lighting would be tailored to optimize growth at each stage. Inedible plant material would drop down a chute to electricity-generating incinerators in the basement.

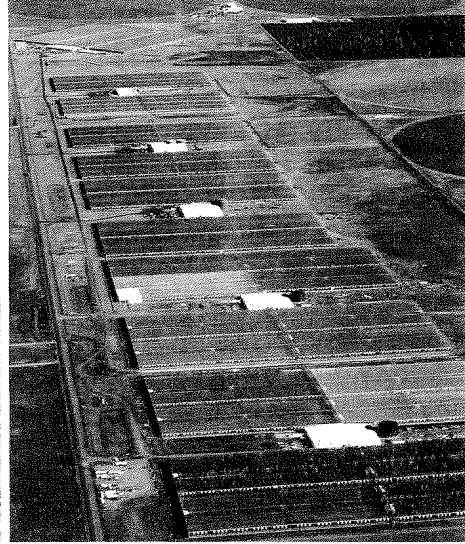
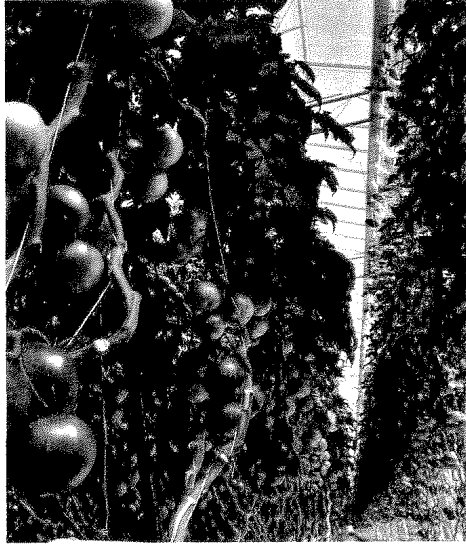


KEVIN HANCOCK

High-Rise Crops

A 30-story vertical farm would exploit different growing techniques on various floors. Solar cells and incineration of plant waste dropped from each floor would create power. Cleansed city wastewater would irrigate plants instead of being dumped into the environment. The sun and artificial illumination would provide light. Incoming seeds would be tested in a lab and germinate in a nursery. And a grocery and restaurant would sell fresh food directly to the public.





EUROFRESH FARMS, enclosing 318 acres in Willcox, Ariz., has grown tomatoes, cucumbers and peppers hydroponically for more than a decade, proving that the technology—and indoor farming—can be efficient on a massive scale.

a 172-acre parcel in New York Harbor that the U.S. government recently returned to the city. An underutilized location smack in the heart of Manhattan is the 33rd Street rail yard. In addition, there are the usual empty lots and condemned buildings scattered throughout the city. Several years ago my graduate students surveyed New York City's five boroughs; they found no fewer than 120 abandoned sites waiting for change, and many would bring a vertical farm to the people who need it most, namely, the underserved inhabitants of the inner city. Countless similar sites exist in cities around the world. And again, rooftops are everywhere.

Simple math sometimes used against the vertical farm concept actually helps to prove its viability. A typical Manhattan block covers about five acres. Critics say a 30-story building would therefore provide only 150 acres, not much compared with large outdoor farms. Yet growing occurs year-round. Lettuce, for example, can be harvested every six weeks, and even a crop as slow to grow as corn or wheat (three to four months from planting to picking) could be harvested three to four times annually. In addition, dwarf corn plants, developed for NASA, take up far less room than ordinary corn and grow to a height of just two or three feet. Dwarf wheat is also small in stature but high in nutritional value. So plants could be packed tighter, doubling yield

per acre, and multiple layers of dwarf crops could be grown per floor. "Stacker" plant holders are already used for certain hydroponic crops.

Combining these factors in a rough calculation, let us say that each floor of a vertical farm offers four growing seasons, double the plant density, and two layers per floor—a multiplying factor of 16 ($4 \times 2 \times 2$). A 30-story building covering one city block could therefore produce 2,400 acres of food ($30 \text{ stories} \times 5 \text{ acres} \times 16$) a year. Similarly, a one-acre roof atop a hospital or school, planted at only one story, could yield 16 acres of victuals for the commissary inside. Of course, growing could be further accelerated with 24-hour lighting, but do not count on that for now.

Other factors amplify this number. Every year droughts and floods ruin entire counties of crops, particularly in the American Midwest. Furthermore, studies show that 30 percent of what is harvested is lost to spoilage and infestation during storage and transport, most of which would be eliminated in city farms because food would be sold virtually in real time and on location as a consequence of plentiful demand. And do not forget that we will have largely eliminated the mega insults of outdoor farming: fertilizer runoff, fossil-fuel emissions, and loss of trees and grasslands.

The second question I often receive involves

COURTESY OF HOLLER GRAPHICS (LEFT); NASA/AG; COURTESY OF EUROFRESH FARMS (RIGHT)

the economics of supplying energy and water to a large vertical farm. In this regard, location is everything (surprise, surprise). Vertical farms in Iceland, Italy, New Zealand, southern California and some parts of East Africa would take advantage of abundant geothermal energy. Sun-filled desert environments (the American Southwest, the Middle East, many parts of Central Asia) would actually use two- or three-story structures perhaps 50 to 100 yards wide but miles long, to maximize natural sunlight for growing and photovoltaics for power. Regions gifted with steady winds (most coastal zones, the Midwest) would capture that energy. In all places, the plant waste from harvested crops would be incinerated to create electricity or be converted to biofuel.

One resource that routinely gets overlooked is very valuable as well; in fact, communities spend enormous amounts of energy and money just trying to get rid of it safely. I am referring to liquid municipal waste, commonly known as blackwater. New York City occupants produce one billion gallons of wastewater every day. The city spends enormous sums to cleanse it and then dumps the resulting "gray water" into the Hudson River. Instead that water could irrigate vertical farms. Meanwhile the solid by-products, rich in energy, could be incinerated as well. One typical half-pound bowel movement contains 300 kilocalories of energy when incinerated in a bomb calorimeter. Extrapolating to New York's eight million people, it is theoretically possible to derive as much as 100 million kilowatt-hours of electricity a year from bodily wastes alone, enough to run four, 30-story farms. If this material can be converted into useful water and energy, city living can become much more efficient.

Upfront investment costs will be high, as experimenters learn how to best integrate the various systems needed. That expense is why smaller prototypes must be built first, as they are for any new application of technologies. Onsite renewable energy production should not prove more costly than the use of expensive fossil fuel for big rigs that plow, plant and harvest crops (and emit volumes of pollutants and greenhouse gases). Until we gain operational experience, it will be difficult to predict how profitable a vertical farm could be. The other goal, of course, is for the produce to be less expensive than current supermarket prices, which should be attainable largely because locally grown food does not need to be shipped very far.

www.ScientificAmerican.com

HURDLES

Several roadblocks could stifle the spread of urban farms, but all can be solved.

Reclaim enough abandoned city lots and open rooftops as sites for indoor agriculture.

Convert municipal wastewater into usable irrigation water.

Supply inexpensive energy to circulate water and air.

Convince city planners, investors, developers, scientists and engineers to build prototype farms where practical issues could be resolved.

MORE TO EXPLORE

Our Ecological Footprint: Reducing Human Impact on the Earth. Mathis Wackernagel and William Rees. New Society Publishers, 1996.

Cradle to Cradle: Remaking the Way We Make Things. William McDonough and Michael Braungart. North Point Press, 2002.

Growing Vertical. Mark Fischetti in *Scientific American Earth* 3.0, Vol. 18, No. 4, pages 74–79; 2008.

University of Arizona Controlled Environment Agricultural Center: <http://ag.arizona.edu/ceac>

Vertical Farm: The Big Idea That Could Solve the World's Food, Water and Energy Crises. Dickson Despommier. Thomas Dunne Books/St. Martin's Press (in press).

Desire

It has been five years since I first posted some rough thoughts and sketches about vertical farms on a Web site I cobbled together (www.verticalfarm.com). Since then, architects, engineers, designers and mainstream organizations have increasingly taken note. Today many developers, investors, mayors and city planners have become advocates and have indicated a strong desire to actually build a prototype high-rise farm. I have been approached by planners in New York City, Portland, Ore., Los Angeles, Las Vegas, Seattle, Surrey, B.C., Toronto, Paris, Bangalore, Dubai, Abu Dhabi, Incheon, Shanghai and Beijing. The Illinois Institute of Technology is now crafting a detailed plan for Chicago.

All these people realize that something must be done soon if we are to establish a reliable food supply for the next generation. They ask tough questions regarding cost, return on investment, energy and water use, and potential crop yields. They worry about structural girders corroding over time from humidity, power to pump water and air everywhere, and economies of scale. Detailed answers will require a huge input from engineers, architects, indoor agronomists and businesspeople. Perhaps budding engineers and economists would like to get these estimations started.

Because of the Web site, the vertical farm initiative is now in the hands of the public. Its success or failure is a function only of those who build the prototype farms and how much time and effort they apply. The infamous Biosphere 2 closed-ecosystem project outside Tucson, Ariz., first inhabited by eight people in 1991, is the best example of an approach not to take. It was too large of a building, with no validated pilot projects and a total unawareness about how much oxygen the curing cement of the massive foundation would absorb. (The University of Arizona now has the rights to reexamine the structure's potential.)

If vertical farming is to succeed, planners must avoid the mistakes of this and other non-scientific misadventures. The news is promising. According to leading experts in ecoengineering such as Peter Head, who is director of global planning at Arup, an international design and engineering firm based in London, no new technologies are needed to build a large, efficient urban vertical farm. Many enthusiasts have asked: "What are we waiting for?" I have no good answer for them. ■

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Appendix K: Credit 1 Walkable Streets

Traffic Easement

Traffic easement, when done properly, can increase the safety of pedestrians and bicyclists while still allowing drivers utilize automobiles for efficient transportation. The simplest form of traffic easement is reducing speed limits in high traffic areas, such as downtown shopping areas or in roads adjacent to schools. This strategy is only effective if speed limits are thoroughly enforced, which in many areas isn't always possible due to understaffed police forces. To effectively control traffic, then, physical measures must be installed or incorporated into road design.

- Reduction in Street Width
 - Many residential roads offer parking on both sides, making roads almost 40 feet wide
 - Wide roads offer more margin for error, and thus more opportunities to speed
 - By narrowing street width, traffic is forced to slow down
 - Associated benefits
 - Narrower roads cover less surface area with impervious material, resulting in less stormwater runoff
 - Reduction in asphalt will reduce the heat island effect present in many communities
- Crosswalks
 - Offer a safe way for pedestrians to move about in both residential and commercial areas
 - Installing speed bumps before crosswalks slows traffic
 - By raising crosswalks (to be level with the curb), visibility is increased
 - Also acts as a larger speed bump, requiring traffic to slow down
- Bulb-outs (curb extensions)
 - Curb extensions can be used to drastically narrow roadways
 - Ideal for crosswalks and high foot traffic areas
 - Shorten the crossing distance for pedestrians
 - Increase visibility of pedestrians to oncoming motorists
 - Also useful at transit centers
 - Allows riders to step directly onto grade with the sidewalk
 - Handicapped accessibility to public transit is made easier



Figure 14: Diagram of a Street That Includes Bulb-outs

References:

Road Width Control

http://www.deq.state.id.us/water/data_reports/storm_water/catalog/sec_3/bmps/19.pdf

Traffic Calming

<http://www.vtpi.org/tdm/tdm4.htm>

Effects of Traffic Calming

http://www.ci.berkeley.ca.us/uploadedFiles/Public_Works/Level_3_-_General/ch5.pdf

Street Lighting

Adequate street lighting can be defined as:

- Staggered lights spaced 150' within 1300' of transit facilities
 - This spacing is also ideal for alleys to provide maximum illumination in an attempt to deter crime
- Staggered lights spaced 300' outside of 1300' from transit facilities

All installed lights should be dark-sky compliant fixtures. Examples include:

- LED light arrays
- High Pressure Sodium (HPS)
- Pulse Start Metal Halides (PSMH)

Increased street Lighting is not proven effective in reducing crime; it does, however, give the community a sense of well-being and as such should be considered in community design.

References

Dark Sky, and organization dedicated to reducing light pollution

<http://www.darksky.org/mc/page.do?sitePageId=59690>

San Diego guide to street light design

<http://www.sandiego.gov/undergrounding/pdf/streetdgnman.pdf>

British Study on Crime Reduction by Street Lights

www.celfosc.org/biblio/seguridad/atkins.pdf

Chicago Alley Lighting Project

<http://www.icjia.org/public/pdf/ResearchReports/Chicago%20Alley%20Lighting%20Project.pdf>

Alley Revitalization

Alley revitalization can be as simple as replacing the paving surface, or as complex as changing the alley into a public park, square, etc. The end goal, however, remains the same; to turn an often neglected space into a more welcoming environment for a variety of uses.

References

Chicago Green Alley Handbook

http://brandavenue.typepad.com/brand_avenue/files/greenalleyhandbook.pdf

Sacramento Alley Activation Report

http://www.cityofsacramento.org/dsd/customer-service/AlleyActivation_FINAL.pdf.pdf

Los Angeles Alley Treatment Options

http://csc.usc.edu/documents/mwd_brochure_june_30_09.pdf

Appendix L: Credit 2 Compact Development Standards for New Construction

Commercial developers will build what they see to be the most economically viable option. In many areas, the most viable option will be large houses on large lots, giving residents the personal space they desire. However, there are some communities that are calling for a reduction in lot size and increase in density, thereby reducing the environmental impact caused by the community. This can be achieved in several ways, each listed in the table.

References

Guide to compact Development

http://www.metrocouncil.org/planning/TOD/Compact_dev.pdf

Developer Incentives for Compact Development

http://www.ecy.wa.gov/climatechange/2008GMAdocs/Concept_DeveloperIncentives.pdf

Public Transit Access

Increased access to public transit is one of the easiest and most effective ways to reduce vehicle miles traveled (VMTs), thereby reducing excess carbon emissions in the community. For this to be an effective strategy, however, there must be access for the majority of residents, with a maximum walking distance of ½ mile to the access point. Compact development aims to meet this goal of public access by building near preexisting public transit and providing safe walking and bicycle access to these facilities.

Public transit use can be increased through public policies, such as providing fare free zones, offering reduced fares to daily riders, or working with local businesses to reduce the amount of free parking available to both workers and customers. Some countries, Canada included, have also offered a tax credit for public transit use, covering up to 15% of the yearly cost of using public transit.

References

Ottawa Master Plan for Increased Public Transit Use

http://www.ottawa.ca/city_services/planningzoning/2020/transpo/7_en.shtml

Canada Transit Use Tax Credit

http://www.transitpass.ca/about_e.asp

Public Relations

Gathering public support for any project is a vital step, and in some cases can be one of the most difficult. Both the U.S. and Canada have seen the growth of suburbs over the last 60 years. This trend towards suburban life led to residents becoming accustomed to more land per capita, much more than would be present in a newly constructed compact development. As such, it may be difficult to find buyers for these new homes, seeing as it goes against what many people see as the traditional family dwelling. By showing the positive benefits of compact development, residents for a new development should be easier to find.

References

Compact Development Fact Sheet

<http://www.greatcommunities.org/intranet/library/sites-tools/great-communities-toolkit/CompactDevl.pdf>

High Density Development Myths and Facts

<http://www.nmhc.org/Content/ServeFile.cfm?FileID=4647>

Appendix M: Credit 3 Mixed-Use Neighborhood Centers

Mixed-use construction is very common in most U.S. cities, with apartments located above first floor stores. It helped increase the density in cities, having the positive effect of reducing the strain on utilities such as electrical and water infrastructure. This high density was developed in the past partly out of necessity, since many people who lived in cities didn't have access to automobiles and as such had to have all services located within the city. With the rise of automobile ownership and the increase in urban sprawl, residential and commercial spaces were gradually isolated from one another.

In an effort to reduce vehicle use and increase pedestrian activity, many urban centers and some new developments are going back to mixed-use development. While not necessarily having housing located above shops, the same goal is achieved by having stores and services in very close proximity to housing units. This can be an issue in some areas, however, due to zoning regulations regarding multiple uses for the same location. By working with the local zoning body, this issue should be addressed in the initial development of the project by showing the benefits, both economic and social, of mixed-use construction.

References

Mixed-Use Master Plan

https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/7633/Lebanon_Russell_Drive_Plan_Final.pdf?sequence=1

Minneapolis Housing Initiative Mixed-Use Plans

http://www.housinginitiative.org/pdfs/Mixed%20Use%20Developments/mixed_use_MD_C.pdf

Mixed-Use Code Handbook (Oregon)

<http://egov.oregon.gov/LCD/docs/publications/commmixedusecode.pdf>

Appendix N: Credit 4 Mixed Income Diverse Communities

Implementation

In reality, creating a mixed-income community has little to do with sustainability. The intent behind it, however, is clear; to promote a sense of community among people of different income brackets, ending the traditional practice of separating communities based on housing type. By having a mix of apartments, condominiums, and standalone houses, the community will be affordable to a variety of residents.

One community that achieved this mix of housing types successfully is Griesbach Village. Located in north Edmonton, this new development offers a variety of housing styles in close proximity to one another, ranging from single family homes, to small rental homes for low-income residents. The land was not zoned for any particular housing type, so houses and apartments could both be built with ease. In some communities this may not be the case, and there made to be changes made to the building code to allow for denser housing.

References

Griesbach Village

<http://www.villageatgriesbach.com/>

Sustaining Urban Mixed-Income Communities

<http://www.uli.org/ResearchAndPublications/Reports/~//media/Documents/ResearchAndPublications/Reports/Affordable%20Housing/SustainingMixedIncome.ashx>

Public Relations

Overcoming initial resistance to mixed-income housing could prove to be a difficult step for many communities. Many people have an idea that low income is associated with crime, which is not necessarily the case. Through a campaign of public information, these concerns could be readily addressed, allowing the community to move forward without concerns or reservations being held by some of its members.

References

Housing and Urban Development- Study on Mixed-Income Housing

<http://www.hud.gov/offices/cpd/affordablehousing/library/modelguides/2004/200315.pdf>

Urban Land Institute Strategies for Mixed-Income Communities

<http://www.uli.org/~//media/Documents/ResearchAndPublications/Reports/Community%20Catalyst/Report%208.ashx>

Appendix O: Credit 5 Reduced Parking Footprint

Parking Reduction

By reducing available parking, a community is essentially pushed into the mindset of walkability. While this may not be an option for all areas, it is fairly easy to implement in those that can afford the limited parking. New opportunities for public spaces also arise. Much as alley revitalization was described in Credit 1, the same could be done to a no longer necessary parking lot, turning into urban green space. Restaurants could also utilize these new spaces for outdoor seating.

In some business districts removing parking may cause problems for many employees. If this may be the case, employers or the local government could offer incentives for public transportation, as outlined in Credit 2.

Parking Alteration

In some communities, reducing the available parking may not be an option. The community may be too spread out, and therefore not walkable, or there just may be too many businesses that rely on automobile transportation. If this is the case, several steps can be taken to reduce the negative environmental effects often associated with asphalt paving.

Porous pavement and interlocking pavers allow stormwater to penetrate into the soil, reducing stormwater by as much as 90%. This drastic reduction in runoff can be achieved at relatively low initial cost, and will have effects on the built environment as a whole. Flooding will be reduced for most major storm events, and any preexisting drainage systems will see much less water flow, and thus need less maintenance. Even a mix of porous and traditional pavements will make a difference, and will also last longer.

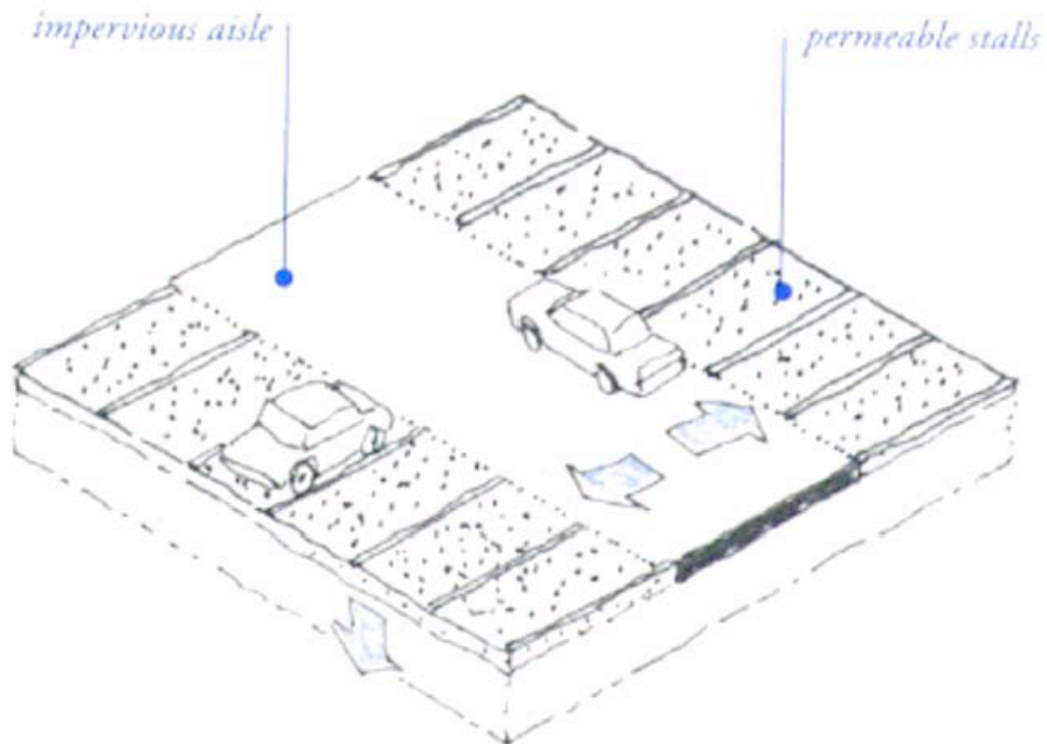


Figure 15: Parking Lot With Porous Parking Spaces³³

References

Pennsylvania Stormwater Management Guide (covers benefits and installation of porous pavement)

http://www.dep.state.pa.us/dep/subject/adv coun/stormwater/manual_draftjan05/section06-structuralbmps-part1.pdf

The San Mateo Countywide Water Pollution Prevention Guide (includes more porous pavement information)

http://www.flowstobay.org/documents/business/new-development/4.7_Pervious_Paving_Technical_Guidance.pdf

Sample Alley Redesign (shows stormwater runoff reduction as well as cost estimation for porous pavement installation)

(See Appendix B)

³³ San Mateo Countywide Water Pollution Prevention Guide. Page 42.

Appendix P: Credit 8 Transportation Demand Management Transportation Management Implementation

In many downtown areas, heavy traffic congestion is an everyday sight. This congestion is caused by an overdependence on cars, brought on in part by urban sprawl and the resulting decentralization of services. In an effort to combat this inefficient form of transportation, many cities around the world utilize some form of transportation demand management. These management practices are usually implemented on a governmental level, but individual business owners and employers could also help in the effort to reduce traffic flow.

- Governmental
 - Limiting available parking makes driving a less feasible option
 - Also opens up new opportunities for open space
 - Discounted or tax deductible public transit use are great options
 - Canada has implemented a plan to refund 15% of public transit cost to the individual
 - Many suburban areas are not served by public transit
 - Adding train line isn't feasible due to development
 - Extending/expanding bus routes is possible, may result in higher taxes
 - Public should be educated on the benefits of public transit
- Business
 - Encouraging the use of multimodal transportation can be quite beneficial
 - Awards based on number of miles walked/biked can be implemented
 - Many offices have wellness programs, biking could easily be incorporated; e.g. Stantec's program with Kersh Wellness
 - Implement monthly parking rate if not already in place
 - If already existent, increase rate
 - Carpooling
 - See "vanpooling" in Washington State

References

Basic Transportation Management Policies

<http://www.walkinginfo.org/develop/policies-transportation.cfm>

Arlington VA TDM Plan

http://www.commuterpage.com/TDM/pdf/TDM_Policy1990_2008.pdf

Washington State TDM

<http://www.wsdot.wa.gov/tdm/>

Appendix Q: Credit 11 Visitability and Universal Design

Universal Design

Several laws, such as the Americans with Disabilities Act, have addressed the issue of handicapped accessibility but these laws only apply to public buildings or businesses. To fully participate in the community, handicapped access should be incorporated into all aspect of the neighborhood.

Most houses are not handicap accessible; they only become so when a resident requires it. By making all houses accessible, visitabilty is achieved. Visitabilty calls for three basic requirements of any house:

- 1) One zero-step entrance.
- 2) Doors with 32 inches of clear passage space.
- 3) One bathroom on the main floor accessible by wheelchair.

By incorporating these three requirements into new construction, it allows persons of any mobility to have access to the houses of friends and family where they usually might not, further increasing their feeling of being part of the community.

Universal design could be an issue in older communities or many urban areas, where front doors are raised with a raised basement below it. If this is the case for a community undergoing redevelopment, then this credit simply isn't achievable without major dedication of funding and time for the remodeling of all residential units.

References

Visitability

<http://www.visitability.org/>

Visitabilty Initiative

<http://www.ap.buffalo.edu/idea/Visitability/index.asp>

Center for Universal Design

<http://www.design.ncsu.edu/cud/>

Iowa Program for Assistive Technology. *A Practical Guide to Universal Home Design: Convenience, Ease, and Livability.*

<http://www.uiowa.edu/infotech/universalthomedesign.pdf>

Appendix R: Credit 13 Local Food Production

Food Production

Community gardens provide a number of benefits, first and foremost being fresh fruits and vegetables. They also provide a space for social interaction, further increasing the sense of community felt by residents. If those who used the garden chose to, the produce could be sold at local markets, providing extra income for residents and stimulating the local economy. Community gardens can also serve as green space for urban communities that may be lacking in outdoors areas.

Community gardens can be made to suit the needs of the community, i.e. crops, size, and location are all variable. Vacant lots are present in many communities and can serve as a prime location for a garden. Soil conditions, however, can be variable and as such the previous use of the land should be known before planting to ensure that the site is not contaminated.

Another option is Community Supported Agriculture. Information is available from the sites listed below.

References

American community Gardening Association

<http://www.communitygarden.org/learn/>

City Farms and Community Gardens

<http://www.farmgarden.org.uk/>

Vertical Farm (an interesting idea to provide adequate crops in limited space)

<http://www.verticalfarm.com/>

Ontario CSA Directory

<http://csafarms.ca/index.html>

CSA in the US

<http://www.attra-pub/PDF/csa.pdf>

University of Massachusetts information for US/Canada

http://www.umassvegetable.org/food_farming_systems/csa/

Appendix S: Credit 14 Tree-Lined and Shaded Streets

Benefits of Trees

While many people think of trees as just a decorative feature used to increase residential property value, they do offer many environmental, economic, and safety benefits:

- Environmental
 - Reduction in stormwater runoff
 - 10% increase in canopy cover reduces runoff by 5%
 - Reduced “heat-island” effect
 - Temperatures of shaded pavement is considerably lower, thus a lower ambient air temperature is achieved
- Economic
 - Lower ambient air temperatures result in lower cooling costs for residents
 - Shade streets last longer without the need for resealing
 - The cooler temperatures allow the slurry seal to last longer
 - 20% shading will result in 60% cost reduction over 30 years
- Safety
 - Shaded streets result in lower light levels, so drivers tend to slow down
 - Trees along the side of the road can show a curve in the road long before they reach it, especially helpful at night
 - Trees act a natural barrier between drivers and pedestrians in the event of an accident

References

U.S. Forest Service

<http://www.forestsforwatersheds.org/reduce-stormwater/>

Safety Benefits of Trees

<http://www.coloradotrees.org/benefits.htm#16>

EPA- Heat Island Reduction Strategies

<http://www.epa.gov/hiri/resources/pdf/TreesandVegCompendium.pdf>

Cool Pavements

Traditional asphalt has a very low albedo, or reflectivity, causing it to hold large amounts of heat. This heat more rapidly deteriorates the asphalt and also increases the ambient air temperature, which causes the heat-island effect. By adding lighter pigments to asphalt mixtures the albedo can be greatly improved, resulting in pavement that retains much less heat. Lighter pavements also increase visibility on roads at night, further increasing driver safety.

References

Heat Island Research

<http://heatisland.lbl.gov/Pavements/LowerTemps/>

Economic Benefits of Cool Pavements

<http://www.ci.gilbert.az.us/planning/urbanheatisland.cfm?style=print>

Appendix T: Case Study Summaries

A variety of case studies were used for background information. These included [The Chicago Green Alley Handbook](#), alley restoration in Sacramento, CA, and a tour of the Village at Griesbach, Stage 8 in Edmonton, AB. In Chicago, both residential and commercial alleys have been restored to reduce stormwater runoff and the heat island effect. Sacramento has begun restoring mixed-use alleys for outdoor seating and recreation. Griesbach applied for LEED ND certification for one stage of their redevelopment of a former military facility.

The Chicago alley case study was published by the Chicago Department of Transportation to better inform the public of the initiative, begun by Mayor Richard Daley, to make the city more environmentally considerate. The city has had many issues with the flooding associated with their combined sewer-stormwater system, so resurfacing the city's alleys with pervious pavement was one option used to reduce stormwater. In addition to this, other sustainable elements were incorporated, such as lights that reduce light pollution.

Alley projects that the city completed were restored using recycled aggregates and pervious pavement to reduce the impact on landfills and reduce the cost of treating stormwater. The heat island effect (heat trapped by non-reflective city surfaces such as streets and roofs that raises the city's temperature) was also reduced in areas with these green alleys. This helped turn the alleys into spaces that the community could use and take pride in.

In an effort to become a more sustainable city, Sacramento recently initiated several pilot programs for alley revitalization. While not specifically citing the LEED-ND rating system for any aspect of the project, their intent clearly follows the desire for sustainability and community improvement, key features of this new LEED program. These pilots cover a variety of topics, including traffic restriction, overall alley redesign and beautification, utilizing alleys as entrances to new residential developments, and possibly using alleys as outdoor gathering spaces for both public and business use.

Overall alley revitalization is the major portion of the work for the pilot programs, and covers a variety of issues. One key element is the plan to repave these alleys with

porous pavement, a strategy proven effective in reducing stormwater runoff and the negative effects associated with it. Porous pavement will still support the load of a vehicle if necessary, such as in the event that emergency vehicles require access. The plan also calls for trash consolidation near the ends of alleys rather than in multiple dumpsters along its length, reducing the disturbance caused by trash trucks. While this disturbance doesn't necessarily go against the tenets of sustainability, it could dissuade residential development or multimodal transportation in the alley.

Beautification also includes the addition of lighting and naming the alleys for ease of navigation. With simple steps like this, the goal is to increase the public's sense of safety and in doing so promote the use of alleys for transportation. This would also be an important step if residential units were actually added to an alley, as the safety of residents should be a paramount goal of any community.

The plan to use alleys as gathering spaces is not a new idea, as seen in projects in both Los Angeles and San Francisco where alleys have been used as both parks and seating for restaurants. These uses would require the complete removal of traffic, but by zoning for such an event the project should be effective. These applications also show a holistic approach to the program, showing that there are several options for how to better utilize an alley.


The Village at Griesbach was still in progress at the time of the tour, however several streets worth of housing were complete. There was a focus on keeping the density relatively high, while maintaining the feel of a typical Edmonton suburban neighborhood. There was also a mix of housing options, including single family, duplex, and townhouse style apartments, all in close proximity to earn LEED credit for mixed income housing.

The streets were also much different from those in surrounding areas. They included trees and sidewalks both set back from the street, and right at the curb and were narrower, to reduce vehicle speeds. The onsite stormwater retention ponds incorporated walking paths and footbridges to create community parks. The development was LEED certified, but it was clear that the developers were more concerned with the certification than the actual sustainability of the community. This was evident in both the presentation and the lack of energy efficiency, green buildings, and mixed-use development.

Appendix U: The Village at Griesbach Development Map



Edmonton's LEEDing Green Community

 Village at Griesbach's unique character is enriched through environmentally responsible neighbourhood design based on the world's foremost principles of sustainable development.

This environmentally sensitive community features carefully planned and preserved natural amenities. These beautiful areas are supplemented through professional landscape design to

improve environmental integrity. Dozens of heritage trees, many more than half a century old, have been protected or transplanted to sustain the land's natural form and enrich the living space residents enjoy. Innovative road design, and the creation of tree lined sidewalks and trails, promote pedestrian activity and create quiet, safe streets.

Village homes are also healthier. 'Green' homes are more energy




efficient, use less water and natural resources, create less waste and offer less exposure to mold and mildew. Not only are they healthier and more comfortable, reduced utility bills are healthier for your budget also.



service access within walking distance of home or accessible via public transit. It also requires 'green' construction practices that deliver enhanced natural resource efficiencies.


Village at Griesbach will be one of Alberta's only LEED®-ND certified communities. To learn more about the LEED®-ND rating system, please visit www.usgbc.org.

 In Stage 8, The Village takes environmental stewardship to the highest standard by implementing the world renowned LEED®-ND (Leadership in Energy and Environmental Design) standards - Gold Level.

LEED®-ND integrates smart growth, new urbanism and 'green' building technologies to reduce vehicular traffic and promote job creation and



A PARTNER IN SUSTAINABLE DEVELOPMENT

 The vision of Canada Lands Company is to stimulate economic growth, generate financial benefits and enhance the quality of life in communities where the company conducts business.

Canada Lands Company is committed to meeting, and indeed exceeding, the highest standards of environmental stewardship, and always respects the legacy of its development properties.

In Village at Griesbach, 95% of heritage trees have been preserved and the need to drive your car has been reduced thanks to smart growth principles. Both of these simple steps have improved the quality of life residents enjoy and reduced harmful greenhouse gas emissions.



www.villageatgriesbach.com

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