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Sustainable Industry at Various Scales: Regulatory Approaches, Green Urbanism, and Low Impact Site Design

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Master of Regional Planning
Three-Course Option
Final Paper

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TABLE OF CONTENTS

I. INTRODUCTION

"In order to work towards ecological sustainability in the urban context, the built environment needs to be managed within the natural environment and not vice versa. Urban ecosystems are the foundation of many of the processes that help a city or town to operate, including those that have been suppressed or removed." – Marjorie van Roon, University of Auckland, 2004

Climate change and atmospheric warming are problems of global scale, significance, and impact and are arguably dealt with most effectively at the level of national and supra-national governance. The mixed success of the Kyoto Protocol demonstrated the importance of accommodating the needs and rights of nations with vastly different economic structures, development trends, and progress towards greenhouse gas reduction in order to reach a perception of fairness for and among all parties.[1] Despite some progress, the goal of an effective international agreement to reduce carbon emissions and other greenhouse gas-contributing pollutants remains unfulfilled.

In the absence of a workable international framework for addressing global climate change, smaller agencies, both governmental and private, have begun taking proactive steps to reduce their share of pollutants, greenhouse gas-contributing and otherwise. Regional intergovernmental alliances, such as the Regional Greenhouse Gas Initiative (RGGI), non-governmental agencies, such as ICLEI Global: Local Governments for Sustainability, and state and municipal governments, such as the Commonwealth of Massachusetts and the Town of Amherst, Massachusetts, have acted upon the recognition that global environmental problems can be addressed at all levels through local initiatives, such as those that reduce energy demand through increased building and vehicle efficiency and those that reduce waste output through increased recycling.

Within their own physical plant, states and municipalities can successfully implement efficiency improvements to reduce the energy use and pollution impacts of building infrastructure and vehicle fleets; purchasing and use policies can effectively improve the efficiency of office equipment and practices. Implementation and progress are relatively easy to monitor, and

[1] Richard Newell, Resources for the Future – Lecture, UMass Amherst, 13 November 2006

substantial opportunities for public education and influence are possible when a local government leads its citizens by example towards greater sustainability.

There are limits, however, to the reach and effectiveness of local governments and non-governmental agencies in influencing the pollution output and general sustainability of commercial industry within their jurisdictions. The standard regulatory approach within which national environmental control is framed is likely to have immediate economic consequences on the attractiveness of a city or town within its region; if companies perceive local regulations as a an undue burden on operations and profits, the option to 'vote with their feet' to a neighboring municipality with less restrictive controls is relatively easy.

The extent to which such relocations actually occur as a direct result of environmental regulation is difficult to measure, given the myriad factors that influence business decisions. The *perception* that such regulation influences decisions about business location, however, is pervasive among policy makers and industry representatives. It follows that this perception, regardless of actual evidence, influences policy decisions, so the argument can be made for addressing it along with the actual issue. The importance of maintaining an attractive local business climate makes it clear that a different tactic is required for cities and towns wishing to reduce their contribution to global climate change in the absence of broader governmental support.

Regulatory structures and economic incentives represent one avenue towards encouraging local sustainability. Another, more recent approach that is gaining traction is the direct influence on the physical layout and design of individual facilities, clustered developments, and entire neighborhoods and municipalities. Low Impact Design and Green Urbanism-Ecological Infrastructure are closely linked concepts which promote the use of energy-efficient technology, optimum spatial arrangement, higher densities, sensitive consideration of environmental constraints, and sustainable materials and techniques to reduce the environmental impact of human development.

Leadership in Energy and Environmental Design (LEED) Certification has gained cultural currency in the public's understanding of architectural excellence and sustainability; Low Impact

Design and Green Urbanism-Ecological Infrastructure can be viewed as LEED-style approaches to the landscape on both the site and regional levels of human development. Low Impact Design addresses sustainability at the level of site construction and function; it focuses on the spatial arrangement of buildings, on-site stormwater storage and infiltration, and the reduction of impervious surfaces by limiting road surfaces and encouraging permeable alternatives to traditional materials such as asphalt.

Green Urbanism-Ecological Infrastructure addresses sustainability at the municipal and regional level, and focuses on the role of the city within the larger environment. A major component of Green Urbanism is the establishment and protection of well-linked green (open space recreation and wildlife habitat) and blue (hydrologic) corridors, in balance with dense, well-defined areas of human development. The Ecological Infrastructure aspect of Green Urbanism focuses on maximizing the efficiency and sustainability of the building, energy and transportation systems that serve modern cities. Centralized heating plants for residential districts, dual water systems to recycle grey water for appropriate uses, and establishing mass transit networks to effectively discourage private car use are common techniques employed to influence the sustainability of urban infrastructure networks.

For my three course option in Regional Planning, I sought to address the issue of sustainable industry with the following sequence of courses:

- **Low Impact Industrial Park Design Independent Study Studio**
- **Green Urbanism and Ecological Infrastructure**
- **Political Economy of the Environment**

II. RESEARCH PURPOSE & QUESTIONS

My experience working with the Town of Amherst Energy Task Force to measure and plan for the reduction of local greenhouse gas emissions, along with my graduate coursework in Regional Planning and Landscape Architecture, spurred an interest in identifying incentives and techniques that inspire business and industry to *want* to cooperate with local efforts to improve environmental quality. While a minimum level of cooperation with desirable environmental

practices is achieved through legislation and legal enforcement, the layers of governance and enforcement that traditional approaches require shows room for improved efficiency.

Traditional approaches of environmental control were developed for and are better suited to state and national levels of governance. This limits the ability of individual municipalities to enact strong regulations for fear of creating an unprofitable, anti-competitive environment for local business and industry. In the absence of international, national, or even regional cooperation, this stifling effect is particularly troublesome for municipalities looking for innovative ways to reduce their local environmental impact and make a positive contribution towards the solution of global environmental problems.

Cities and towns looking to influence the physical form and infrastructure of new developments in their jurisdiction face road blocks of varying severity in terms of private property rights, outdated and regionally inappropriate zoning ordinances, and a lack of familiarity or expertise with making decisions influencing physical form. Another political sticking point, and perhaps the most pervasive, is the widely held perception that any regulation beyond the absolute minimum will deter development altogether and stall economic growth.

Specific questions that informed my research throughout the three courses were:

- What are the regulatory alternatives to traditional pollution control policies?
- How can local governments independently establish a framework in which businesses find it advantageous to voluntarily reduce pollutants and pursue technological innovation in pollution prevention?
- What are the lessons and objectives of Green Urbanism-Ecological Infrastructure and how can they be interpreted for use by local governments?
- What aspects of Low Impact Design can be incorporated into industrial parks, and what would a conceptual design for a property in western Massachusetts look like and cost?

The goal of this research is to explore the viability of techniques available at these three different scales – environmental regulation, Green Urbanism-Ecological Infrastructure, and Low Impact Design.

III. LITERATURE REVIEW

This review discusses the literature relevant to each course in the three-course sequence.

Low Impact Industrial Park Design Independent Study Studio Literature

As discussed earlier, Low Impact Design (LID) addresses sustainability at the level of site construction and function; it focuses on the spatial arrangement of buildings, progressive stormwater management, the reduction of impervious surfaces, and the use of innovative, permeable materials. New Zealand is among the front runners in experimenting with and implementing LID techniques. In *Emerging Approaches to Urban Ecosystem Management: the Potential of Low Impact Urban Design and Development Principles,* van Roon discusses New Zealand's 2003 sustainable development action program, which focused on sustainable cities and water management as two of its four objectives.

She notes that "Urban ecosystem management involves not just preserving or recovering habitat remnants, but also restoring processes and cycles such as the water cycle…In order to increase economic, ecological and social components of urban sustainability simultaneously, management of the total urban water cycle should be integrated into urban design and development (126)." She concludes that New Zealand's program is consistent with the concept of "strong" sustainability, which prioritizes environmental assets over economic ones, as opposed to "weak" sustainability, which flips these priorities. Given the importance of local economies and business in environmental decision-making by local governments, this example provides useful guidance in how to pursue strong sustainability without unduly burdening the local business climate.

Economic incentives have influenced recent industrial park development, where the most common approach to ecological sustainability has been to create a waste-reuse and reduction cycle by grouping industries that can consume certain waste products with the industries that produce them. This type of arrangement is typically structured through a set of performance standards, which can also dictate standards for aspects of production such utility usage, runoff generation, etc. Case studies of existing industrial parks in Orange, Massachusetts (Randall

Pond Industrial Park) and Kincardine, Ontario (Bruce ECO-Industrial Park) demonstrate the viability of this approach in the current market.

Randall Pond Industrial Park, which is located in western Massachusetts and provides an excellent precedent for area towns and cities, operates on an extensive set of performance standards; among those relevant to environmental quality and sustainability are air quality; odors and emissions; landscape lighting; pavement design specifications; noise and vibration; outdoor storage and waste disposal; wastewater generation; traffic; job creation; building design; site design and landscaping; town site plan review; water consumption; fire and explosive hazards; and toxic and hazardous materials[2].

Bruce ECO-Industrial Park in Kincardine, Ontario was founded on the premise that long-term economic policies must incorporate energy use in the most environmentally-friendly way possible. It has available infrastructure to supply clean energy to park businesses via a steam pipeline. Bruce ECO businesses aspire to enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. The main goal of the Bruce ECO is to improve the economic performance of the participating companies while minimizing their environmental impacts, by establishing a system where the by-product of one industry/process is the raw material of another neighboring industry or process, resulting in lower pollution and environmental impact[3].

The influence of the physical plan of industrial parks through the application of Low Impact Design techniques is still too recent an idea to locate suitable precedents for case study, although some parks have been developed under local site plan review to ensure more efficient, clustered use of the land. In *The Potential for Planning an Industrial Cluster in Barre, Vermont*, Mullin and Kotval present the case study of a proposed industrial cluster, and include lessons and recommendations for the role of local government and the exploitation of regional industrial strengths. Clustering is a development option that is gaining momentum in the U.S.; in both residential and industrial construction, significant zoning and regulatory changes have occurred that allow higher densities to be built on smaller parcels. The associated open space and natural habitat preservation opportunities have been creatively utilized and appreciated. The cluster

[2] http://www.randallpondindustrialpark.com
[3] http://www.bruce-eco.com

framework is consistent with LID it its goal to minimize the developed footprint and maximize the efficiency of land that it disturbed for development.

Green Urbanism and Ecological Infrastructure Literature

Green Urbanism-Ecological Infrastructure focuses on sustainability and on the provision of multiple functions by the green "system," including stormwater management, water quality/quantity management, wildlife habitat, brownfield remediation, recreation, cultural heritage, tourism, environmental education, and social space[4]. In *Urban Ecological Systems: Linking Terrestrial Ecological, Physical, and Socioeconomic Components of Metropolitan Areas*, Pickett asserts that "If scientists, planners, and decision makers are to understand how the social, economic, and ecological aspects of cities interact, the feedbacks and dynamics of the ecological linkages must be assessed (139)." The authors review systems-oriented approaches to urban ecology and conclude with a "human ecosystem model" framework that "identifies key factors that should govern the structure and function of biotic, abiotic, and socioeconomic processes in and around cities (150)."

Exercising the principles of Green Urbanism-Ecological Infrastructure necessitates a discussion of the coordination between and appropriate roles for actors in the public and private sectors. Desirable, sustainable urban development cannot occur without the balanced involvement of both; the regulatory role of the public sector and the responsibilities of the private sector, and the negotiations between the two, determine the outcome of the development. Roelof Verhage examines this tension in *The Role of the Public Sector in Urban Development: Lessons from Leidsche Rijn Utrecht, The Netherlands*. The discussion of Leidsche Rijn concludes with the recommendation that a local land use plan clearly assess which aspects of public development belong to the public domain. In regulating certain aspects of a development, the plan sets the conditions for negotiations about other aspects. This approach creates well-defined space for negotiations to take place between the public and private actors, thus allowing for the design and technological innovation that are among the primary strengths of the private sector.

[4] RP 591F Course syllabus

In *Differentiation and Ecological Modernization in Water and Electricity Provision and Consumption*, Van Vliet explores the gap between green consumption and green production. Examining water and energy networks as "infrastructures of consumption," as the "social and technological link between consumption practices, on the one hand, and the depletion of energy and water resources and global warming, on the other (29)." He evaluates recent developments in sustainable water and electricity technologies from the perspective of Dutch implementation, and finds much greater differentiation in water and sanitation technologies (ranging from in-home rainwater and wastewater recycling to diverse house-on-site and community-on-site sanitation techniques) than in electricity provision, for which differentiation opportunities are more limited. Water management on all scales is a fundamental principle of Green Urbanism-Ecological Infrastructure and Low Impact Design; Van Vliet stresses the significant impact of new technologies and approaches on household practices and consumer roles. Extensive dialogue and consumer education is required to ensure the success of sustainable water management programs, and, as such, crucial to the successful implementation of any project looking to incorporate Green Urbanist or LID principles.

Political Economy of the Environment Literature

Environmental protection has traditionally been achieved under 'command-and-control' (CAC) regulations, under which the supervising agency establishes and enforces a series of technological requirements, such as smokestack scrubbers, for specific discharge points at plants (both new and existing) and mandatory permits that specify allowable emissions.[5] After the regulations are determined to have been violated, producers pay set fines for their infractions. Teitenberg's Handbook of Environmental and Resource Economics includes an in-depth discussion of CACs; The Clean Air Act amendments of 1970 and the Federal Water Pollution Control Act Amendments of 1972 typify this type of regulation.

In *Market-Based Approaches to Environmental Policy*, Paul Portney covers Market-Based Incentives, which are based on the premise of trying "to put the powerful advantages of markets to work in service to the environment" by confronting the producers of pollution with the same

[5] Teitenberg, p. 275

incentives present in markets that incentivize economization based on price.[6] The EPA began experimenting with what have judged fairly successful, market-infused reforms to CAC regulations as early as 1975 with an emissions trading program for SO_2, a pollutant associated with the deterioration of the earth's ozone layer.

IV. METHODS

The range of courses examines sustainable industry at three different scales: the design of specific industrial sites to reduce their impact on local resources, the integration of ecological infrastructure at the wider municipal level, and the economic implications of environmental policies intended to reduce pollutant emissions and encourage sustainable practices among industry at the state and municipal level. The three courses were chosen to include small-scale application of sustainable design concepts, theory and case studies in sustainable urbanism, and political and economic theory on environmental regulation.

The sequence of courses began in Spring 2006 with LA 696 – Low Impact Industrial Park Design Independent Study Studio, and RP 591F - Green Urbanism and Ecological Infrastructure. The sequence was completed in the Fall 2006 with EC 797E – The Political Economy of the Environment, and this research paper represents the fulfillment of the Regional Planning 3-Course Option. Other graduate coursework influencing this research include LA 597N - The Social Construction of Space, also taken in Spring 2006, and LA 547 - Landscape Pattern and Process, taken in Fall 2006.

V. COURSE DESCRIPTION & WORK PRODUCT

LA 696 - Low Impact Industrial Park Design Independent Study Studio

Under the supervision of Dean Cardasis and in collaboration with Research Assistant Frank Varro, I worked with Franklin Regional Council of Governments (FRCOG), the City of Greenfield, the Town of Montague, and a team of UMass Regional Planning graduate students to develop conceptual site plans for two proposed new industrial parks. At the request of the client (FRCOG), we incorporated Low Impact Design (LID) techniques, such as on-site retention and

[6] Portney, p. 15

treatment of surface runoff, minimization of impervious surfaces, and use of permeable materials as alternatives to traditional asphalt and concrete, into the development of conceptual site plans for industrial parks on two sites under consideration for development. The sites were simultaneously analyzed for industrial park suitability by the team of planning students.

In addition to the conceptual site plans, Frank and I conducted case studies of environmentally progressive industrial parks and prepared cost estimates for both the proposed sites under contrasting development scenarios using either low impact materials and drainage systems or traditional materials and drainage systems. We presented our designs and findings to FRCOG and the municipalities involved in client progress meetings and at a public forum upon completion of the project.

This course addresses the smallest scale of study for this research by examining the design of specific industrial sites to reduce their impact on local resources. In a small but growing trend, local and regional efforts are underway to build new or retrofit existing industrial facilities to meet a higher standard of environmental sustainability and stewardship. As a company's environmental record becomes an increasingly visible selling point (and potential brand/profit liability), private developers, non-profit organizations, and local governments have recognized an opportunity to attract ecologically-minded businesses by constructing sustainable facilities and operation frameworks. The implications of this approach are especially relevant to the towns and cities of western Massachusetts, many of whom are looking to expand their economies by attracting environmentally and socially progressive companies. The cost estimates accompanying each conceptual design demonstrate the cost effectiveness, and even potential savings, of developing a local industrial parks under a LID framework.

The product for this class consisted of the following elements for two sites in Greenfield and Montague:

- Site Analysis & Development Framework
- Conceptual Design Proposals – plan and section elevation views
- Site Statistics & Cost Estimates

Greenfield Development Framework

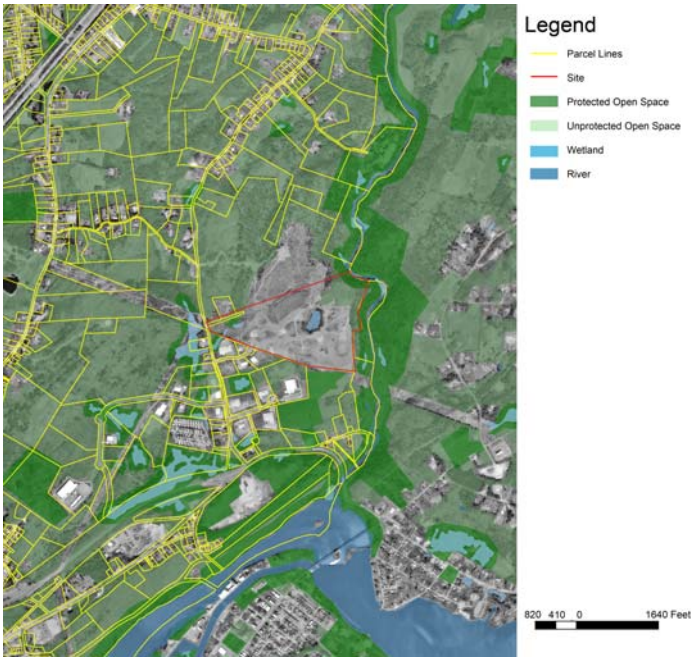
Existing Zoning

Setbacks: 50’ all sides
Frontage: 50’
Road Width: 30’
Road Right of Way: 50’
Cul-de-sac: 800’ maximum length
    12’ gated, gravel emergency access rd
Parking: ¾ space for each employee
    10,000sf = 17; 25,000sf = 44; 50,000sf = 85
Combined acreage: 80 acres

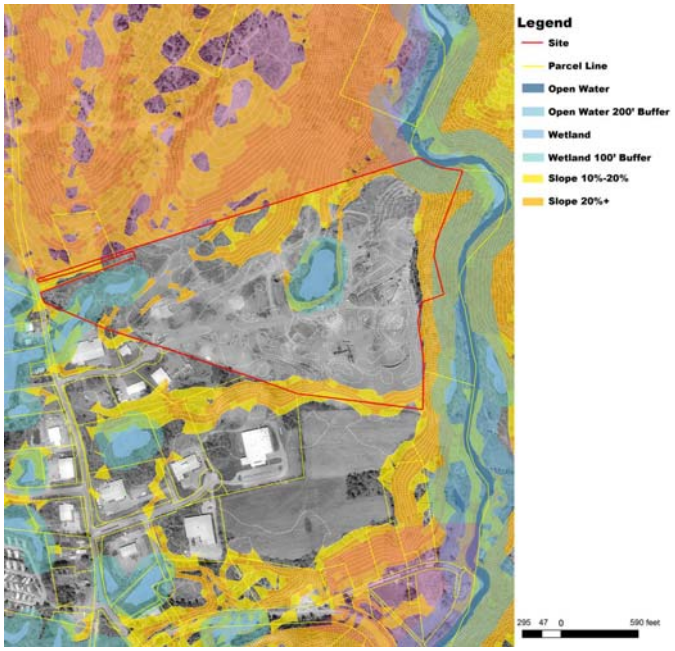
Adjacent Industrial Development

Montague – 226 acres, 31 lots,
    1 to 48-acre lots, average lot 3.8 acres
Greenfield – 266 acres, 37 lots,
    1 to 19-acre lots, average lot 3.7 acres

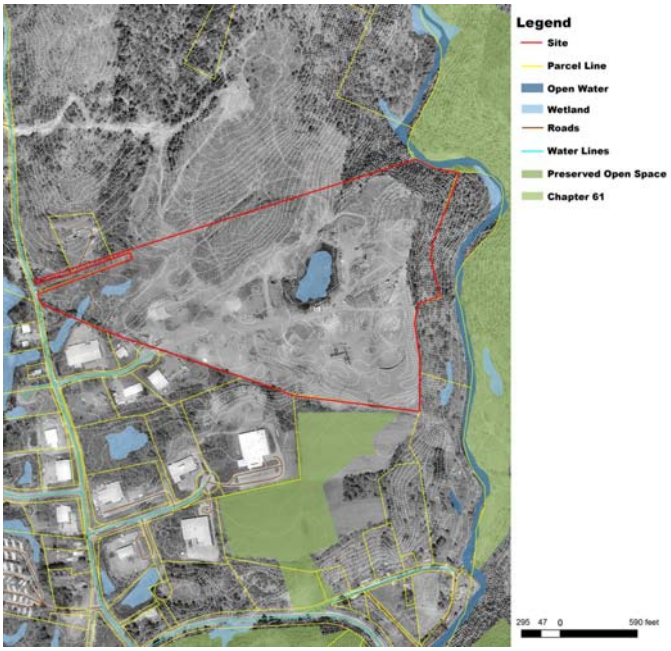
Context Map



Greenfield Constraints Map



Greenfield Opportunities Map



Design Principles for both sites

- Lot size: 5 - 10 acres
- Building size: 10,000 – 50,000 sf
- Incorporate Low Impact Design (LID)
- Connect development to the landscape

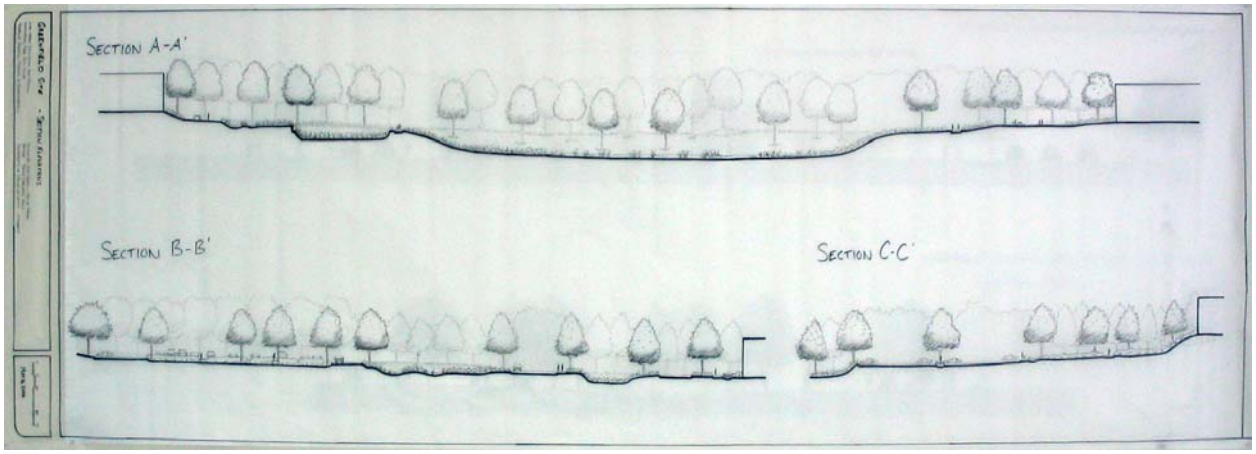
Greenfield Site Design Statistics

Lots: 13
Lot sizes: (1) 10 acre, (1) 7.5 acre,
(1) 6 acre, (2) 5 acre, (1) 4 acre,
(1) 3 acre, (2) 2.5 acre, & (3) 2 acre
Buildings: 335,000sf total –
(4) 50,000sf, (3) 25,000sf,
(6) 10,000sf
Linear Feet of Road: 3,080'
Linear Feet/Lot: 237'
Narrowed Road Width: 30'
Narrowed Right of Way: 40'
Square Feet of Road: 92,400sf
Square Feet Road/Lot: 7,107sf

Use Diagram

Greenfield Conceptual Master Plan

Greenfield Conceptual Section Elevations



Greenfield Cost Estimates

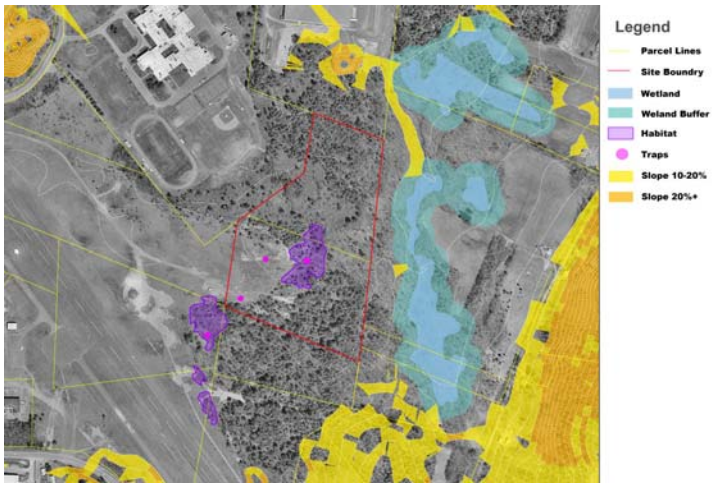
	LID	**CONVENTIONAL**
Roads	$1,594,000	$1,594,000
Parking Areas	$401,800	$2,755,832
Curbs	$0	$15,400
Drainage	$240,760	$508,870
Paved Areas	$1,011,795	$155,400
Lighting	$77,500	$77,500
Benches	$78,400	$78,400
Plantings	$44,637.50	$44,637.50
Total Site Cost	$6,460,345	$7,713,927
Cost Savings	**16%**	

Montague Development Framework

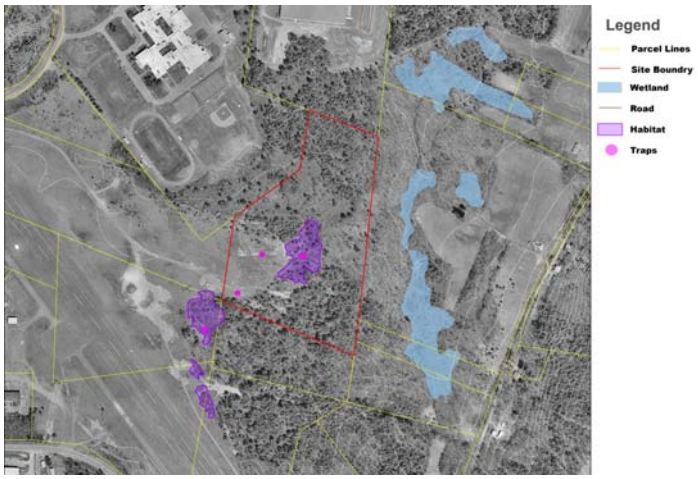
Existing Zoning
Setbacks: 25’ front, 30’ rear, 15’ side
Frontage: No set requirement
Road Width: 50’
Road Right of Way: 60’
Cul-de-sac: 500’ maximum length
12’ gated, gravel emergency access rd
Parking: One parking space per employee, plus one space per 175 sq ft of retail or office floor space
10,000sf = 27; 25,00sf = 67;
50,000sf = 130
Combined acreage: 22 acres

Context Map

Montague Constraints Map



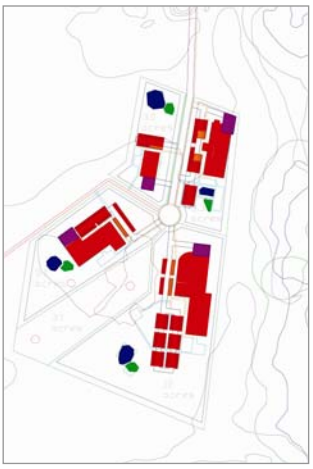
Montague Opportunities Map



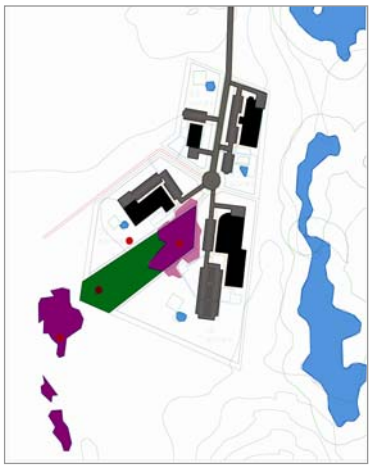
Montague Site Design Statistics

Developable Lots: 4
Lots sizes: (1) 3 acre, (1) 3.3 acre,
(1) 5.1 acre, (1) 10 acre
Undevelopable parcel: 3.1 acres
Buildings: (1) 10,000sf, (2) 25,000sf,
(1) 50,000
Linear Feet of Road: 2,665
Linear Feet/Lot: 667
Narrowed Road Width: 30’
Narrowed Road Right of Way: 40’
Square Feet of Road: 71,296
Sq. Feet Road/Lot: 17,824

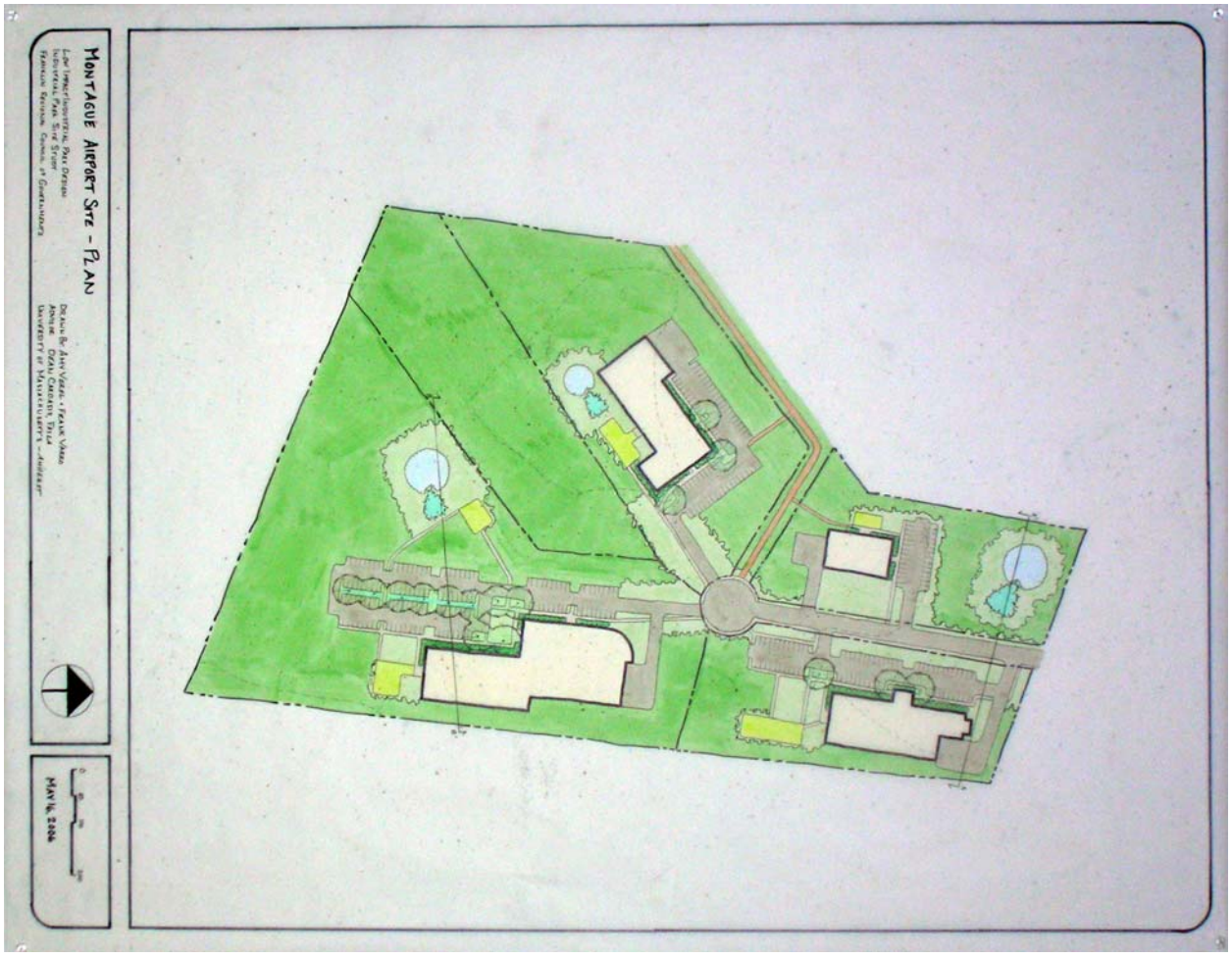
Use Diagram



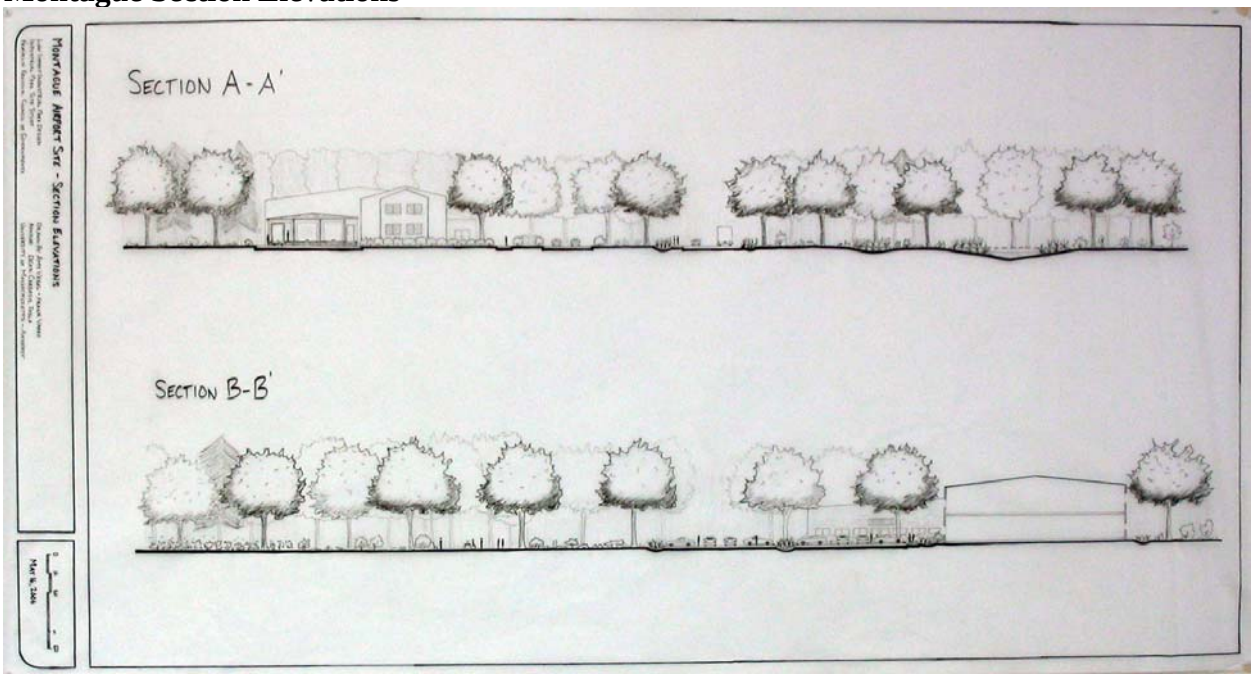
Preserved Habitat



Montague Conceptual Master Plan



Montague Section Elevations



Montague Cost Estimates

	LID	CONVENTIONAL
Site Prep	$78,512	$78,512
Roads	$1,391,600	$1,391,600
Parking Areas	$203,700	$1,045,400
Curbs	$0	$13,325
Drainage	$89,024	$154,724
Paved Areas	$389,514	$242,634
Lighting	$140,000	$140,000
Benches	$20,000	$20,000
Plantings	$24,432	$24,432
Total Site Cost	$4,483,753	$4,697,282
Cost Savings	5%	

RP 591F - Green Urbanism & Ecological Infrastructure

Green urbanism and ecological infrastructure are complementary concepts aimed at realizing sustainability in predominantly built environments worldwide, defined in the course syllabus as "Integrated systems of protected and managed lands (i.e. greenbelts, green fingers, green wedges) and designed infrastructure (i.e. stormwater infiltration systems, green roofs, wildlife habitat) to support sustainable neighborhoods, cities and metropolitan regions."[7] Green urbanism and ecological infrastructure relate with, and integrate a number of other complementary research and practice topics including: greenways, ecosystem services, urban ecology, urban design, sustainable design, and landscape ecological planning. The course focused on reading and seminar discussion of contemporary literature on ecological infrastructure including books, journal articles, and reports.

The main research requirement of this course was a case study of a green urbanism/ecological infrastructure plan or project to be presented to the class and in a page on the course website. My case study examined the emerging Dutch city center of Leidsche Rijn, which is currently under construction as an extension to the city center of Utrecht, Netherlands. The web page is located at http://www.people.umass.edu/jfa/greenurbanism/averel/index.html. As part of a 1990 Dutch urban expansion policy which mandated the construction of 1.1 million new dwellings by 2005, Leidsche Rijn is a wholly sustainable development that will add 30,000 new dwelling units, 180 commercial and public buildings, major new transportation infrastructure, and 90,000 new residents by 2015.

[7] RP 591F Course syllabus

As one of the largest new residential projects currently underway in Europe, Leidsche Rijn offers an excellent opportunity to explore the middle scale of study for this research: the integration of ecological infrastructure at the wider municipal level. The use of a Dutch example is particularly appropriate when seeking a strong model for ecological sustainability because the Dutch, owing to unique circumstances of geographic size, elevation and water quality, decades ago elevated sustainability to a level of priority that the rest of the world will eventually be forced to emulate. Their experience forms an informative model for all levels of organization to work towards sustainable infrastructure, however it is important to note that the Dutch have operated under a system of strong national policy, which is one aspect distinctly absent in the American municipal framework. Nevertheless, it is useful to study models occurring under more ideal circumstances because in conceiving workable policies for American cities, good ideas can always be scaled down to meet political realities, whereas progressing in the opposite direction is more difficult.

Major infrastructural changes for Leidsche Rijn entail the partial relocation and covering of Highway A2 with a linear park, three bridges connecting to Utrecht Centre over the Amsterdam-Rijn Canal, rail connections to future the Randstadspoor rail line, express bus connections to Utrecht Centre, and a 1.2 square mile central park. Also significant in the landscape are two large projects by Dirk Sijmons, principal of H+N+S Landschaparchitecten and Dutch National Advisor on Landscape: De Rijnkennemerlaan Bikeway and Groot Archeologiepark, an archeological park highlighting the unique resources in this location, once an edge of the Roman Empire.

The Leidsche Rijn Master Plan

The master planning of Leidsche Rijn began with the assemblage of a broad coalition of the professions, public officials, and community representatives with a stake in the development. The urban design firm Maxwan and the architectural historians Crimson developed a master planning concept for Leidsche Rijn that they have termed "Orgware," which derives from economic theory combining ideas & knowledge (software) with physical elements (hardware).

The master planning concept states that "The orgware of a plan has to be understood before its software can be intelligible and its hardware made real." Changes in Dutch policy have led large-scale development to be enacted less by top-down decision-making and more by

employing pluralist techniques and public involvement, leading the designers to embrace an "urbanism of negotiation," in which "bureaucratic obstacles & dynamic systems are accepted as part of the orgware & lead to the urban design itself, so the form it takes is unpredictable." The project planners and designers recognize that "Whereas urbanism once provided guarantees (of coherence, collectivity and form), it is now being called upon for its capacity to create opportunities" and assert that "the shift of attention from collective to individual now requires an urbanism based on such generative concepts as contrast, temporal uncertainty, market conformity, image (in the general, cultural sense) and ambiguity."

By September 2002, 5,246 housing units were ready for occupancy. Residency is restricted to those with economic or social bonds to Utrecht region. Neighborhoods are being individually designed and constructed with varying architecture and layout to allow for flexibility to adapt to local situations and to attract different "target groups," such as live/work for former homeless, artists & art lovers, communal elderly housing, and various themed communities formed around such concepts as education, solidarity, and reduced consumption.

Leidsche Rijn Sustainability Innovations

Leidsche Rijn was conceived from the beginning as a sustainable development. The management of water resources is of paramount importance for the Netherlands, so stormwater management and energy efficiency are the staples for sustainability for Leidsche Rijn. Features of the water system include the collection of rainwater in broad infiltration channels called wadi, eliminating the need to draw water from the Amsterdam-Rhine canal so as to maintain the level of the water table. Large and small parks are linked by inter-connecting zones, maximizing the recreational, wildlife, and water infiltration benefits of the open space and habitat.

A centralized heating system serves the development, reducing fuel demand and greenhouse gas emissions. All residences are constructed to be low energy demand houses, with customizable interiors designed to easily accommodate changes in household composition. The latter feature fosters social as well as environmental sustainability, as it allows for the most efficient use of interior space as families change in size.

Dual Water Supply System

A large-scale pilot program involved supplying non-potable water from the Rhine River for household functions such as toilet flushing, washing machines, and garden taps. A water quality incident occurred in 2002 that has led to the suspension of this program, which is discussed in the evaluation section.

De Rijnkennemerlaan

In 2002, as part of the ongoing construction of Leidsche Rijn, work began a to realign one of Utrecht 's largest water pipelines (5 feet in diameter) for approximately 3.1 miles. Future plans include widening the A2 Freeway between Utrecht and Amsterdam and partially covering the roadway between Utrecht and Leidsche Rijn, necessitating a shift of the pipeline in several locations. Construction is underway in Utrecht to move the pipeline from the east side of the A2 to the west, where the ground above it will be incorporated into the "Rijnkennemerlaan", a 3.1 mile long, 60 foot wide green belt. Providing paths for walking and biking, it will be one of the longest lanes in the Netherlands and provide a unique park feature to Leidsche Rijn.

The WRK Pipeline Project will create a closure dike which will allow for much more efficient water sluicing, a technique employed for water retention that can only occur when the water is at certain levels. The Pipeline Project will be jointly constructed with an area of brackish water several thousands hectares in area that will serve as fish habitat and maintain the integrity of fresh water sources.

Leidsche Rijn Evaluation: Urbanism & Master Planning

Early reviews of the success of Leidsche Rijn as an extension of urban Utrecht and the antithesis of Dutch suburbanization have been mixed but cautiously optimistic. Income levels of new residents are considerably higher than the Utrecht province average, suggesting that Leidsche Rijn hasn't yet achieved the economic diversity that it aspired to in the master plan. There is also concern that the new development has been growing much like a traditional suburb, in which families and individuals with the means and desire to leave Utrecht pack up and settle in perceived countryside of Leidsche Rijn. Financial concerns in the early development of

individual neighborhoods have led to decisions to increase the construction of higher-end homes, which could exacerbate this trend.

Langerak, one of the first neighborhoods to be completed, has been received by some critics as "nothing more than an attractively designed suburb for young families with a child, a dog and a car." The flexibility and fluidity envisioned in the master plan was intended to allow residents to have an active role in making their communities their own. Local design of the community courtyards is intended to be a mainstay of this concept, however many of the courtyards were quickly used and declared as parking lots, and the construction of private fences beyond the height and placement permitted by the master plan has become a significant problem.

The flexibility of the master plan to allow for local decision-making appears to have left the distinction between the public and private realm ill-defined for the new inhabitants, and the response has been a typically suburban one of carving out space for private enjoyment and automobiles. These small-scale land use decisions being made by the early residents have the potential to greatly impede increased densities - a main intent of the master plan.

Critics of the early colonization of Leidsche Rijn are quick to admit that the small amount of initial development can't be taken as a basis for judging the project as a whole. The greater presence of automobiles and parking lots than planned, for example, is a response to be expected because of delays in the construction of major transportation links. The resemblance of young neighborhoods to a more suburban than urban likeness can be viewed as an early stage in the evolution of a dense neighborhood.

Historical models of city neighborhoods that have experience rapid growth have typically been entirely unplanned, resulting from bursts of employment opportunities and immigration, and resulting in undesirable, unsustainable, and unhealthy densities and living conditions. The planned, sustainable nature of Leidsche Rijn place in more in the realm of the neighborhood which gradually densifies as the prospect of living there becomes attractive to higher numbers and different types of people.

The challenge for Leidsche Rijn in this respect is to defeat the suburban problem of dispersed resources. The initial web of infrastructure is what must remain elastic and accommodating to

different levels of density; residents should be able to inhabit neighborhoods at all stages of growth. Early review of the success of Leidsche Rijn is, in this respect, that development is on the right track. The master plan is ensuring that growth is being directed where desired and prevented where it is not. Neighborhoods will no doubt experience some growing pains as the amenities of the early suburban pattern, such as excessive numbers of cars per residence, give way to the demands of scarcity as density increases. The basic layout, however, will be able to accommodate growth rather than freeze after certain densities are reached, as occurs in sprawling suburban development.

Leidsche Rijn Evaluation: Environmental Quality & Sustainability

It is difficult to assess the success of the environmental quality and sustainability measures applied in Leidsche Rijn while the project is still under construction. Some measures, such as the centralized heating system, low impact homes, and the open space system taking shape, can be reliably assumed effective in contributing to the goals of reducing the environmental impact of the development.

Others measures, namely the water quality and preservation measures, have experienced growing pains as the development progresses and cannot be fully assessed until the development is complete. For example, in the neighborhoods that have been built, the wadi and other infiltration devices are fully installed and form prominent design features within the landscape. This high visibility presents both tremendous opportunity and imperative to educate residents on the purpose and proper stewardship of the infiltration system. Rules surrounding car washing, pet control, and the use of treated wood products in the landscape have been established to preserve the integrity of the wadi, however there is evidence that of a lack of awareness has led to some residents not following the rules and presenting a threat to water quality.

A water quality incident in 2002 had the unfortunate impact of reducing confidence in the experimental water systems intended to make Leidsche Rijn a sustainable development. In December 2002, an accidental cross-connection occurred between the mains for potable and non-potable water, impacting approximately 4,000 homes and resulting in 200 documented cases of gastroenteritis. In order to restore public confidence in the water system, health officials decided in 2003 to terminate the pilot and future dual water supply schemes for the Netherlands. This

incident has received world-wide attention by those interested in urban water conservation schemes, and represents both an unfortunate setback for dual water supply schemes and a large-scale, real world scenario to be used as a teaching tool for future systems of this type.

Leidsche Rijn Evaluation: Transferability

The master planning process for Leidsche Rijn represents a significant shift for Dutch urbanism, which has traditionally been dominated by the state both in terms of planning and finances. Political and economic changes have contributed to a more pluralistic process, and the master planner's "Orgware" concept was a natural evolution. Similar changes in the political and planning processes are occurring in other parts of the developing and developed world, and the processes employed and lessons learned could provide a rich resource for other communities planning growth.

The approach to water management and sustainability in Leidsche Rijn is distinctly Dutch in that the Netherlands has reached an environmental precipice much sooner than many other places in the world. This imperative has placed sustainability and water management as a high priority in Dutch policy, removing a major hurtle faced in many communities in the large-scale implementation of cutting-edge sustainability techniques. The 2002 water quality incident is a telling example of the risks involved with trying experimental systems. In this respect, it is reasonable to expect that the road to a successful implementation of the Leidsche Rijn master plan will experience some bumps and roadblocks. Ultimately, communities less inclined to occupy the frontier of sustainable design benefit from tremendous learning opportunities offered by the Dutch drive and willingness to experiment with new ways to build the city.

Economics 797E: The Political Economy of the Environment

The primary goal of this course was to "analyze how scarce environmental and natural resources are allocated not just among competing ends, but also among competing individuals, groups, and classes."[8] Effective environmental regulation is a complex process, and making recommendations to cities and towns on how to incentivize local sustainability requires a rich understanding of the political and economic framework of global environmental policy through which efforts towards sustainability are accomplished. This course served the broadest scale of this research in the examination of the economic implications of environmental policies intended to reduce pollutant emissions and encourage sustainable practices among industry at the state and municipal level.

Specific tools and approaches for improving environmental equity and quality were studied for their applicability at the scale of municipal government; the two common approaches and a potential third, hybrid approach to inducing business and industry to control pollution emissions were the topic of the final research paper for this class. Command-and-control (CAC), the traditional, top-down, policy and enforcement-based approach, was contrasted with market-based incentives (MBI), which adapt the market incentives of economization to environmental practices. CAC and MBI approaches are typically viewed, in the literature and by strong proponents of one or the other, as two distinct techniques for achieving pollution reduction results. To be sure, there are strengths and vulnerabilities inherent with both approaches. There are, however, elements common to both that can be seen as weaknesses. The research paper for this class examined these and proposed a third regime into which the two are hybridized in order to employ the strengths and address the vulnerabilities and uncertainties that result from the use of each technique on its own.

The "Polluter Pays" Principle

The Polluter Pays Principle (PPP) first emerged in the early 1970s in its 'strict sense,' which was limited to costs and pollution prevention and control. According to the OECD Joint Working Party on Trade and Environment's "The Polluter-Pays Principle as It Relates to International Trade," it was intended to "prevent new environmental protection measures from having to be

[8] ECRU 797E Course syllabus

financed by governments in the form of subsidies and to prevent differences in subsidies between countries from causing significant distortions in international trade and investment."[9] The emergence of the PPP can be attributed to the concurrent rise of environmental protection legislation (particularly in the U.S.), strong forces for trade liberalization, and concern that governments would subsidize increased production costs resulting from environmental legislation.

The PPP has since broadened to include compensation payments, taxes, charges, and all pollution-related expenditures. Accords such as the Rio Declaration of 1992 have moved the PPP towards a more complex understanding of its interactions with property rights and the valuation of the social costs of pollution, a sentiment well-articulated as "It's better to be approximately right than precisely wrong – that any amount of pollution control is likely to be more accurate than zero control."[10]

From the PPP, it can be argued that the absence of adequate incentives for producers to reduce pollution is equivalent to a pollution subsidy. Without enforcement of the PPP, producers are logically incentivized to externalize pollution costs for the benefit of their own efficiency, which creates the impact of a pollution subsidy and allows for a substantial distortion in the market. Enforcing the PPP bars producers from "evading the discipline of the free market" by forcing them to pay the true cost of products they bring to the market; this removes the distortion from and improves the efficiency of the market.[11]

The PPP plays an important role in discussing the difference between CAC and MBI approaches to pollution regulation. In their simplest forms, both techniques essentially allow a defined range of pollutants to be emitted for free, thus violating the PPP. Both can be modified to come closer to meeting the premises of the PPP; however the ideal scenario would involve a third regime that combines the best of both approaches and comes the closest to achieving the premises of the PPP.

[9] OECD Joint Working Party on Trade and Environment 'The Polluter-Pays Principle as It Relates to International Trade,' p. 6
[10] Interpreted from ED 797E personal class lecture notes, 24 November 2006
[11] Robert F. Kennedy, Speech at the Sierra Summit, 10 September, 2005

Pollution Control Approaches: Command-and-Control Regulations

The command-and-control (CAC) approach, defined as the establishment of maximum ambient standards for each pollutant and mandatory technological requirements for specific point sources, is generally favored by environmentalists and lawyers. The CAC approach is appealing because it is often relatively easy and inexpensive to enforce. The explicit, strict, and penal aspects of the approach resonate with the implication that the environment is 'not for sale,' and that a fairly visible premise of the PPP is being enforced. The CAC approach also helps to guard against 'hot spots' of pollution in areas where many polluters are located, because the EPA requires local areas to devise plans for attaining EPA-determined levels of pollution.

The approach is, in fact, consistent with the PPP, but only in the narrower, strict sense. It fails to comply with the broader sense of the PPP, because polluters pay nothing for all pollution within the legal envelope established by the regulatory authority. Polluters are essentially supplied with a "target" amount of pollutants that they are allowed (and thereby encouraged to produce because it is "free" via the subsidy of pollution within the regulatory envelope) to emit. Because polluters must fall within the allowed level of emissions with specified, compulsory equipment, any incentive to decrease emissions through altered production practices or investment in newer, more efficient technologies, is effectively neutralized. Additionally, the occurrence and rate of fines to punish infractions is, under realistic enforcement, infrequent and low enough to potentially be regarded as a 'cost of doing business' by a polluter large enough to absorb the penalty costs.

Pollution Control Approaches: Market-Based Incentives

Market-Based Incentives (MBI), which tend to be favored by economists, function by presenting the polluter with the same incentives present in markets that incentivize economization based on price. The most common form of MBI is the "cap and trade" system established to control sulfur dioxide (SO_2), a powerful pollutant that contributes to ozone layer deterioration. Under this plan, transferable emissions permits are issued to firms, which are then given a range of choices, not available under a CAC approach, in how they satisfy the set "target" amount of allowed emissions.[12]

[12] Teitenberg, p. 276

The primary advantage of the MBI approach is its short-run efficiency; assuming that the marginal cost of a unit of pollution reduction varies across firms (depending on their size, location, and the age of the their equipment), firms are presented with an incentive to reduce pollution at a lower cost than the permit price, which they can then sell at a profit. The result is that the marginal cost of reducing pollution is pushed down while the incentive for firms to pursue new technologies that best suit their individual needs pushes forward the development of ever more efficient pollution-treating technologies. The SO_2 emissions trading program has been tremendously successful in the U.S., and serious consideration is being given to the concept of a similar program for reducing carbon dioxide (CO_2), the primary greenhouse gas indicated in global temperature change and atmospheric warming.

The primary complaint about MBI approaches among environmentalists and lawyers is that, unlike CACs, they make the environment 'for sale' for the price of a permit. The perception, though unsubstantiated, is that any type of MBI will usher in a regulatory environment in which "unfettered competition between unregulated private firms will determine how clean our air or water will be, how much open space we will have, or how many fish stocks will be driven to collapse."[13] This potential failure of the market to protect the environment would not occur under any reasonably constructed MBI because, similar to the CAC approach, the MBI approach establishes clear emissions targets which cannot be exceeded.

The real problems associated with the MBI approach are several: enforcement is more difficult and expensive than under a CAC structure; there is no protection against pollution 'hot spots;' permit prices can stifle entry into and competition within a particular industry; and long-range incentives can generate the unintended consequence of 'hitting the target,' where more pollution is emitted, i.e. cars become more efficient but the number of them on the road doubles. The vulnerabilities of MBI are real but rather easily ameliorated with appropriate solutions. For example, the 'hitting the target' problem can be solved with a stringent cap-and-trade system; 'hot spots' can be averted by enforcing emissions caps on regional areas as well as individual polluters.

[13] Portney, p. 15

The congruency of MBI with the PPP varies depending on their implementation and whether or not the 'fixes' for specific problems are attached. This is especially important concerning the social objectives explicit in the broader, more modern premise of the PPP, i.e. elimination of hot spots is highly significant to discussions of environmental justice. Additionally, the way in which permits are distributed is crucial to congruence with the PPP; if the permits are given to polluters for free, as was the case in the U.S. SO_2 program, the permits represent a subsidy to polluters that is completely at odds with even the narrow interpretation of the PPP. If, however, the permits are initially auctioned at prices that reflect the total social cost of the pollution rights being purchased by the polluter, and are made available to parties other than polluters, such as non-profit organizations buying them for conservation purposes (as with the current renewable energy certificates available through Massachusetts electricity providers) then the broader premises of the PPP are met.

Green taxes are another form of MBI that can be applied with varying congruence with the PPP. This type of tax is designed to accomplish two simultaneous ends, thereby producing a so-called 'double dividend;' by taxing pollutants such as CO_2, the behavior that results in its production, i.e. driving a car, is discouraged, while at the same time money is raised that may be spent on further pollution reduction measures.[14] One drawback of the 'green tax' is that it can be easily undone by its own success - if pollution levels drop to the desired level, revenue from the tax will also decrease. As such, phasing and careful consideration of the tax's relation to other taxes and contingent spending programs are essential to successful implementation.

Whether or not the money collected is redistributed equally to the community is where the implementation of a 'green tax' hinges on congruence with the PPP. In the case of a sky trust or a free-bate scheme, in which polluters pay according to their use/emissions and receive a dividend in reverse proportion to their use, the broad interpretation of the PPP is met. In the case of the City of Boulder, CO, which recently voted to accept a carbon tax, the money collected (which will be in the millions of dollars) will go into city coffers but is designated to fund for the City's "Climate Action Plan, efforts to 'increase energy efficiency in homes and buildings,

[14] Ecological Tax Reform, p. 193

switch to renewable energy and reduce vehicle miles traveled," putting it in line with a broad, but not the broadest, view of the PPP.[15]

Pollution Control Approaches: Hybrid "Third" Regime - A New Model

The "hybridized" third regime would maintain the basic positive and negative rules of both MBI and CAC approaches. All current constraints and 'envelopes' of permissible pollution levels would be retained. This would guard against any perception that polluters would be free to buy and sell unfettered access to the environment. The key difference between the third regime and CAC/MBI approaches would be that polluters pay for their emissions *even within* the envelope of allowable emissions; however they are legally barred from exceeding the allowable amounts. This would ensure that the long-run efficiencies and incentives of the MBI approach are maintained.

In the case where emissions permits are issued, they would be auctioned at prices that reflect the total social cost of the pollution rights being purchased by the polluter, and made available to parties other than polluters, such as non-profit organizations buying them for conservation purposes. In the case where 'green' taxes are instituted, equitable distribution or use of the monies collected would ensure the progressive implementation of a tax that is inherently regressive in its basic form, since poorer people spend a larger percentage of their income on energy sources. 'Free-bate' schemes, in which polluters pay according to their use/emissions and receive a dividend in reverse proportion to their use, are particularly progressive and encouraged. The third regime would be designed to comply with the broadest interpretation of the PPP, which includes compensation payments, taxes, charges, all pollution-related expenditures, a complex interpretation of property rights, and the meaningful valuation of the true social costs of pollution.

Conclusion: Municipal Viability

The ability of local firms to remain commercially competitive is one of the primary concerns associated with implementing environmental protection measures at the local level. If this concern isn't measured carefully, existing businesses can become vulnerable to increased production costs if the cost-cutting techniques of competitors located elsewhere aren't available

[15] Kelley, Katie

to them. Attaining political support and cooperation is also exceeding difficult if not impossible if the real costs and benefits to every type and size of business impacted aren't properly weighed. New businesses looking to locate facilities will 'vote with their feet' if the punitive impact of local regulations and taxes outweigh other locational benefits. As such, environmental regulation should be carefully meshed with local economic development efforts and stakeholders.

Three important considerations in balancing the relationship between local environmental regulation and economic development are:

- Whether and how environmental regulations affect business decisions;
- Whether the long-run economic impact of regulations is positive or negative; and
- What measures can be adopted to compensate businesses for any competitive disadvantages resulting from regulations.

Regarding the first two concerns, Jaffe maintains that "Overall, there is relatively little evidence to support the hypothesis that environmental regulations have had a large adverse on competitiveness, however that elusive term is defined."[16] His findings are detailed with caveats about the difficulty of obtaining reliable environmental compliance costs, accurately accounting for the pollution actually generated by individual firms, and the difficulty of measuring enforcement measures.

Jaffe recommends that policy makers "should seek to reduce the magnitude of these costs by identifying and implementing flexible and cost-effective environmental policy instruments, whether they be of the conventional type or of the newer breed of market-based approaches."[17] It is not surprising to hear the conclusion that measuring 'industry competitiveness,' environmental impacts and regulations are inexact sciences that must be given careful local consideration and stakeholder input. The suggestion that officials should look to both CAC and MBI approaches and tailor them to their specific situations seems to support the concept of the hybridized 'third regime' outlined here.

[16] Jaffe et. al. p. 157
[17] Jaffe et. al. p. 159

Municipalities looking to expand their environmental protections can employ several measures to protect and even promote the short and long-term interests of local businesses with respect to profitability and competitiveness. Taken alone, both the CAC and MBI approaches have significant strengths and vulnerabilities in achieving the goal of environmental protection. The compromises entailed in the 'third regime' that bring parts of both CAC and MBI approaches in line with the broadest view of the PPP will also serve the needs of municipalities to maintain competitive and attractive to new business and industry:

- All current constraints and 'envelopes' of permissible pollution levels are retained
- Polluters pay for their emissions *even within* the envelope of allowable emissions
- Emissions permits are auctioned at prices that reflect the total social cost of the pollution rights being purchased by the polluter,
- Emissions permits are made available to parties other than polluters, such as non-profit organizations buying them for conservation purposes; and most important,
- Where 'green' taxes are instituted for firms, either
  - funds are expressly earmarked for expenditures on further economic development promotion or infrastructure, or
  - a 'free-bate' type scheme is set up to ensure that the tax is levied according to use/emissions and funds are redistributed in a dividend in reverse proportion to use.

VI. CONCLUSION AND COURSE SYNTHESIS

The sequence of three courses examined sustainable industry at three different scales: the design of specific industrial sites to reduce their impact on local resources, the integration of ecological infrastructure at the wider municipal level, and the economic implications of environmental policies intended to reduce pollutant emissions and encourage sustainable practices among industry at the state and municipal level. Specific questions that informed my research throughout the three courses, and the possible solutions discussed herein are:

- *What are the regulatory alternatives to traditional pollution control policies?*

In my research for the Political Economy of the Environment course, I explored the market-based alternatives to CAC approaches. CAC-based approaches are not without merit and

effectiveness, and MBI approaches have their own risks when applied in their simpler forms. For these reasons, an optimum environmental protection scheme should seek to employ the strengths of both approaches while tempering their potential weaknesses. MBI approaches should be leveraged, especially at lower levels of government, to effectively encourage technological innovation in production methods and pollution control, however strict enforcement of rules that ensure the application of the wider interpretation of the PPP is necessary. Similarly, advantageous aspects of CAC approaches, such as the effective prevention of pollution 'hotspots,' must be preserved. Removing the pollution subsidy implicit in CAC approaches via controlled MBIs could help create an economic environment that encourages both technological innovation and increased activity within a framework that is palatable and profitable to businesses.

- *How can local governments independently establish a framework in which businesses find it advantageous to voluntarily reduce pollutants and pursue technological innovation in pollution prevention?*

CAC approaches, which are the form of most federal and state environmental regulations, can be supplemented locally with MBIs such as green taxes (i.e. Boulder, Colorado's carbon tax) and free-bate schemes. As discussed, care must be taken to ensure the application of the PPP to avoid socially regressive and self-defeating outcomes with green taxes, and that free-bate schemes function to discourage and encourage the intended behaviors. Cap-and-trade agreements are better suited to larger government and organizational bodies, however it is conceivable that a relatively isolated city with a lot of industry, given the right conditions, could enact its own, scaled-down version of a cap-and-trade system.

- *What are the lessons and objectives of Green Urbanism-Ecological Infrastructure and how can they be interpreted for use by local governments?*

The city center expansion of Leidsche Rijn is a uniquely Dutch example that had the advantage of being entirely new construction. There are, however, many aspects of the project that can be applied on the local level in the U.S. Ecological infrastructure projects such as centralized heating plants and dual water systems are most effectively applied to new developments, and require careful user education and monitoring efforts to ensure their effectiveness. If executed

and managed with care, such large-scale infrastructural efforts can significantly improve energy efficiency, lower costs, reduce emissions, and reuse materials.

Other more spatial aspects of Green Urbanism can be incorporated at different stages of development; although it is always easier and less expensive to incorporate new ideas and technologies at the beginning (i.e. new construction), cities should not be swayed from adopting green urbanist methods during eventual remodeling, if not earlier for the sake of the environmental and cost savings. The planning of transportation infrastructure to maximize the efficiency and use of mass transit, for example, can be most comprehensively accomplished at the conceptual level, but all expansions and repairs to an existing system can also be approached with green urbanist objectives as a high priority. Similarly, extensive, connected open space systems and recreational/wildlife corridors can be achieved within a built community through careful planning and strategic land acquisition if green expansion is properly prioritized. Municipal partnerships with private and non-profit organizations can be leveraged to achieve community-wide goals while spreading the financial burden of acquisition and management among local stakeholders.

Leidsche Rijn's extensive planning process serves as a model for integrating the involvement of both the public and visionary master planners and urban designers with the expertise to guide the process towards the desired sustainable outcome. The roles and responsibilities of municipal, private, and public actors, as well as the platform for negotiations, must be carefully delineated and managed in order to allow each party to do what it does best in the process. When municipal officials can effectively set the performance standards for development, and private actors are able and effectively encouraged to present innovative solutions to meet those standards, the possibilities for success at sustainability are improved.

- *What aspects of Low Impact Design can be incorporated into industrial parks, and what would a conceptual design for a property in western Massachusetts look like and cost?*

Spatial organization, such as clustering, is an effective and increasingly common way to lower the impact of industrial park design. The zoning precedent for this has already been established and successfully employed in Massachusetts, as in the case of Randall Pond Park in Orange.

Randall Pond Park also demonstrates the viability of strict performance standards governing a wide range of environmental and business behaviors beyond the realm of local, state, and federal regulation. Companies (even Wal-Mart) are becoming increasingly aware of and concerned for their environmental image as a potential selling point and brand liability; municipalities can capitalize on this concern by establishing a sustainable development framework that appeals to environmental concerns.

At the site level, stormwater management and habitat preservation are the main areas of concern. In the conceptual designs for Greenfield and Montague, all stormwater generated on site was captured, retained, treated, and infiltrated back into the ground using constructed wetlands. In order for a system like this to be effective, the amount of new impermeable surface and runoff generation must be carefully calculated in order to ensure the construction of adequate wetland areas. As with any conventional infrastructural system, proper maintenance must be factored into the function of working wetlands. From a design perspective, on site drainage and water retention can be treated as an amenity to be revealed, understood, and appreciated. Vegetated swales and shallow retention canals, such as the wadi installed in Leidsche Rijn, can highlight be attractive and educational elements in the landscape. The conceptual designs for Greenfield and Montague demonstrate how the wetland areas can be responsibly enjoyed as recreational assets as well as important infrastructural components.

The minimization of impervious surfaces, and the maximization of water infiltration, is paramount to Low Impact Design, and is easily accomplished at the site level. Roads should be as short as possible and designed to the minimum level of engineering necessary; traditional curbs should be avoided if possible because they channel and accelerate the speed of stormwater runoff. Permeable alternatives to traditional asphalt and concrete are increasingly available and financially viable in areas of lower circulation volume, such as parking lots.

Habitat preservation is an important principle in lowering the environmental impact of an industrial design. The conceptual designs for Greenfield and Montague highlight the importance of preserving existing wetlands and rare species habitats (if they must be disturbed at all) by

leaving significant connections to larger habitats; creating biological 'islands' and 'patches' without connectivity diminishes the habitat potential and sustainability of natural areas.

In the absence of adequate international, national, and even state-level frameworks for addressing pollution and global climate change, municipal governments like the Town of Amherst have sought ways to effect the behavior of local business and industry to improve sustainability. The goal of this research was to explore the viability of techniques available at three scales of environmental regulation: Low Impact Design, Green Urbanism-Ecological Infrastructure, and environmental regulation approaches. The classes chosen to study these concepts and the associated approaches to industrial sustainability allowed me to focus my coursework on applicable case studies, research and design; the techniques studied and presented in this paper reflect the variety of approaches available at each scale.

Every municipality is unique in its sustainability needs and implementation strategies, and the techniques discussed here all require careful crafting to local and site-specific characteristics. Sustainability is difficult to achieve in part because there is no 'one-size-fits-all' solution, even for seemingly similar towns. The examples discussed here, from Montague, Massachusetts to Leidsche Rijn, Netherlands, prove that with commitment and diligence, the right balance between sustainability and local economic health can be achieved.

VII. BIBLIOGRAPHY

Atelier Rijksbouwmeester website - http://www.rijksbouwmeester.nl, accessed March 2006.

Bovenberg, A. Lans (1999) 'Green Tax Reforms and the Double Dividend: An Updated Reader's Guide,' *International Tax and Public Finance* 6: 421-443.

Boyce, James K. (2002) The Political Economy of the Environment. Cheltenham: Edward Elgar.

Brenner, Mark, Matthew Riddle and James K. Boyce (2006) 'A Chinese Sky Trust? Distributional Impacts of Carbon Charges and Revenue Recycling in China,' *Energy Policy*, forthcoming.

Bruce ECO-Industrial Park website - http://www.bruce-eco.com, accessed March 2006.

De Canio, Stephen (2003) Economic Models of Climate Change: A Critique. New York: Palgrave Macmillan.

Dorman, Peter (2005) 'Evolving Knowledge and the Precautionary Principle,' *Ecological Economics*, 53: 169-176.

Doubilet, Susan (1999) 'The Dutch invade America , bringing with them their own take on commercial development and the American suburb, *Architectural Record*, pp. 73, May.

Groetelaers, Daniëlle 'To be or not to be in control: Changes in Urban Land Development in The Netherlands,' *OTB Research Institute for Housing, Urban and Mobility Studies* - d.groetelaers@otb.tudelft.nl.

H+S+ N Landschaftarchitecten website - http://www.hnsland.nl, accessed March 2006.

Helfand, Gloria E. (1999) 'Standards versus Taxes in Pollution Control,' in J.C.J.M. van den Bergh, ed., Handbook of Environmental and Resource Economics, Cheltenham: Edward Elgar, ch. 15.

Jaffe, A; Peterson, S; Portney, P.; Stavins, R. (1995) 'Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?' *Journal of Economic Literature*, Vol. XXXIII, 19 March: 132-163.

Kelley, Katie (2006) 'City Approves 'Carbon Tax' in Effort to Reduce Gas Emissions,' *The New York Times*, November 18.

Kennedy, Robert F (2005) Speech at the Sierra Summit, September 10 - http://www.sierraclub.org/pressroom/speeches/2005-09-10rfkjr.asp, accessed December 2006.

Leidsche Rijn Municipality website - http://www.utrecht.nl, accessed March 2006.

Maimberg-Snodgrass, Catharina (2005) 'Urban Action - How to Initiate and Manage Successful Projects,' *Green Places*, Issue 20, pp. 38.

Monolab Urban Design website - http://www.monolab.nl, accessed March 2006.

Mullin, John and Zenia Kotval (1998) 'The Potential for Planning an Industrial Cluster in Barre, Vermont: A Case of *Hard Rock* Resistance in the Granite Industry,' *Planning Practice & Research*, 13 (3), pp. 311.

OECD Joint Working Party on Trade and Environment (2002) 'The Polluter-Pays Principle as It Relates to International Trade,' *Paris: OECD Environment Directorate and Trade Directorate*, December.

S.T.A. Pickett, et. al. (2001) 'Urban Ecological Systems: Linking Terrestrial Ecological, Physical, and Socioeconomic Components of Metropolitan Areas,' Annual Review of Ecological Systems, 32:127–57.

Portney, Paul R. (2003) 'Market-Based Approaches to Environmental Policy,' *Resources*, Spring.

Randall Pond Industrial Park website - http://www.randallpondindustrialpark.com/, accessed March 2006.

Rushton, Betty (2002) 'Enhanced Parking Lot Design for Stormwater Treatment,' *Proceedings of 9th International Conference on Urban Drainage*, September 8-13.

'Taxes for a Cleaner Planet,' (1997) *The Economist*, June 28, p. 84.

Tietenberg, Tom (1999) 'Lessons from Using Transferable Permits to Control Air Pollution in the United States,' in J.C.J.M. van den Bergh, ed., *Handbook of Environmental and Resource Economics*, Cheltenham: Edward Elgar, ch. 19.

Utrecht Province website - http://www.provincie-utrecht.nl, accessed March 2006.

van Roon, M. R. (2005) 'Emerging Approaches to Urban Ecosystem Management: the Potential of Low Impact Urban Design and Development Principles.' *Journal of Environmental Assessment, Policy and Management, 7*(1), 1-24.

Van Vliet, Bas (2003) 'Differentiation and Ecological Modernization in Water and Electricity Provision and Consumption,' *Innovation*, Vol. 16, No. 1.

Verhage, Roelof (2003) 'The Role of the Public Sector in Urban Development: Lessons from Leidsche Rijn Utrecht, The Netherlands,' *Planning Theory & Practice*, Vol. 4, No. 1, pp. 29-44.

WRK Waterworks website - http://www.wrk.nl, accessed March 2006.