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Designing Waste Creating Space: A Critical Examination Into Waste Reduction Through Building Techniques, Architectural Design, and Systems

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DESIGNING WASTE CREATING SPACE

A CRITICAL EXAMINATION INTO WASTE REDUCTION THROUGH BUILDING TECHNIQUES, ARCHITECTURAL DESIGN, AND SYSTEMS

A Thesis Presented

by

Courtney M. Carrier

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Thank you to my family who has helped me succeed through the most challenging time in my life. To my Father, Mum, Christen, and Matt who without I would be nothing.

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ABSTRACT

DESIGNING WASTE CREATING SPACE: A CRITICAL EXAMINATION INTO WASTE REDUCTION THROUGH BUILDING TECHNIQUES, ARCHITECTURAL DESIGN, AND SYSTEMS

MAY 2016

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Can we design waste? This is a question I seek to answer through the research of design and systems. Waste is an ever evolving and growing issue in our world today. Buildings and the spaces we inhabit contribute to the vast destruction and increasing detriment to our natural world. There are many "remedies" in the construction industry that attempt to regulate building waste and inspire sustainability, but are merely ruses for a much deeper rooted problem than sustaining the way we live. Sustainability is not enough, it simply means we are doing less bad while still perpetuating the problem of waste. Design, architecture, and construction must go beyond this to eradicate the issue; producing "less" waste is not a solution, but a redefining of the essence in which we live is a mandate.

This thesis seeks to explore the conundrum of waste through the lens of design. This thesis will study systems as a tool for waste remediation and regeneration. It will explore and scrutinize both building systems such as HVAC and energy efficiency as well as space making systems, scenario based, environmental, sociological, and economical

systems, all which have an important and integral impact on design, our environment, and the human population.

To answer the question, can we design waste, we must redefine our lives and the systems that propel us habitually in the ways we make, produce, work, eat, and live. Moving away from systems of simplicity to those of diversity and complexity. To do this we must re-examine new and existing systems from socioeconomic to the natural cycles of rain water and evaporation. We must re-define the way we live, on all levels, from how we live and what we use to what we actually need to survive happily and harmoniously with ourselves and our planet. The key – Design.

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INTRODUCTION

Food for thought or an admonition, this Introduction can be read as both. *Heap House* by Edward Carey was recently published in 2014. By the title of the book alone one can guess the subject of the fictional work, waste. The story is about a privileged boy growing up in a mansion set in the center of "the Heaps" described by Carey as, "...a vast sea of lost and discarded items whose ever- shifting masses have been known to swallow people alive." These heaps are all consuming, so enormous that the lower class spends their days sorting the discards while living amongst it, like real life "pack rats". Each person of a high social status are deemed important enough to evade the heaps and have access to the sparse greenery that their city has to offer. Although, *Heap House* is simply a work of young adult fiction, when I picture our future I sometimes imagine that this is what it will become. The social elite govern the "trash pickers" and are enabled to live above ground, while the rest are left to toil in the grit. A world in which natural landscapes no longer exist. Carey's fiction could very well be an accurate depiction of the direction we as a society are heading and in many ways mirrors the accurate circumstances that occur in slums around the world.

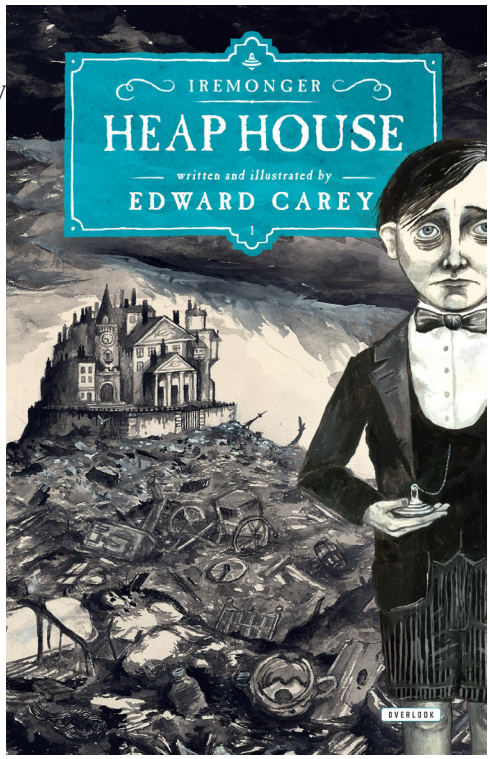

Figure 1: *Heap House* book cover. Edward Carey, 2014

Even more shocking, a rave review of the book stated:

"Astonishing! So peculiar, so magical that it bears comparison to *The Hobbit* or

The Wolves of Willoughby Chase, *The Golden Compass* or the Green Knowe books."

—Kelly Link, award-winning author of *Magic for Beginners*

In the reviews for *Heap House* it is compared to literary greats such as *The Hobbit* and Philip Pullman's *The Golden Compass*. It is a real shock to see the world of waste Carey has "dreamt up" compared to the sprightly and whimsical realms found in that of the *The Golden Compass* and the *Lord of the Rings* series. These worlds in which nature is a dominant force that inspires the likes of elves and hobbits are so contrasting to a world founded in trash. This is a worrying thought that one day nature might be a dream and a wasted world a reality. Even more alarming is that Carey's *Heap House* may just be the very foretelling of what waits ahead.

In 2015 our earth and the world we have forged is riddled with abundance. Our lives are bombarded with a constant whir and influx of clutter. We not only accumulate and populate at a proliferous rate, but are ruled by an acuminous need for instant gratification and satisfaction. As a result we have built a world that is plundered with mountainous heaps of waste that litter our cities and even worse our oceans, water, and air. Barges of society's excrement are sent off to drift astray and aimlessly out of sight. As long as we cannot see it or the harm it is causing our ecosystem we do not care.

The future of the planet is one of excess and depletion. A tenacious war between the man made toxic chemical cocktails that off gas into our air and seep into our water against a backdrop of the ever dwindling restorative and nourishing natural resources humbly provided by our planet. The earth asks nothing of us and in return we demand all

from it. All spheres of human waste fund this impending prospect including the coffee cups we buy and use daily to the buildings of brick and mortar we erect and destroy each day. Our world of waste is only growing and our aims of sustainability are merely stalling the inevitable. Sustainability is not the answer, but a redefining of the essence in which we live is a mandate.

This thesis seeks to explore the conundrum of waste through the lens of systems and design and will study systems as a tool for waste remediation and regeneration. It will explore and scrutinize both building systems such as HVAC and energy efficiency as well as space making systems, scenario based, environmental, sociological, and economical systems, all which have an important and integral impact on design, our environment, and the human population. Moving away from systems of simplicity to those of diversity and complexity. The answer is a redefinition of our lives and the systems that propel us habitually in the ways we make, produce, work, eat, and live. To do this we must re-examine new and existing systems from socioeconomic to natural cycles of rain water and evaporation. We must re-define the way we live, on all levels, how we live and what we use to what we actually need to survive happily and harmoniously with ourselves and our planet. The key – Design.

CHAPTER I

WASTE & AN ASSESSMENT OF THE WORLD TODAY

1.1 Waste 101 - A Waste Audit

At this very time, the future of our world, this planet, is teetering in uncertainty. This is proven with the increasing rise of temperatures, sea levels, carbon dioxide emissions, melting polar ice caps and the looming threat of global warming. With the rise of these environmental crises we have the paralleled rise of waste in the forms of 7 story landfills and the invisible yet poisonous toxins in the air, water, and soil leading us all to cancerous fates and eventual extinction. Not only is our detriment amassing around us, at the same wild and uncontrollable rate we are depleting our planet of every essence of goodness that it once thrived.

The bigger picture for not only how much and what we discard, but what we emit appears as so. Each year we generate over 250 million tons of trash in the United States alone and on a global scale an accumulated 750 million tons. The United States is one of the most progressive nations in the world, technologically, scientifically, and politically, but when it comes to waste we fall short. We are one of the most wasteful nations only second to that of China. Americans produce so much waste that by the time we die our bodies will only occupy one grave, but we will leave a trash legacy equivalent to that of 1,100 graves.[1] Every day we are barricading ourselves in our waste of coffee cups, plastic silverware, and paper towels. This pile is only growing.

Figure 2 is an information graphic published by the United States Environmental

1. Edward Humes, *Garbology: Our Dirty Love Affair with Trash* (New York: Penguin Group, 2012), 5.

Figure 2: Infographic about Municipal Solid Waste (MSW) in the United States in 2013. Courtesy of the US EPA

Protection Agency, also known as the EPA. This infographic provides the abysmal facts of what we waste on a yearly basis. The EPA attempts to remediate the catastrophic situation by providing the public with a reward, presenting bad news with the a glimmer of "progress".

This "progress" that the EPA claims, should be just as alarming as the facts of our wastefulness. The EPA states that while the amount of waste we produce each day per person has risen from 3.66 pounds in the 1980's to 4.40 pounds in 2013 our rate of recycling has also grown from less than 10 percent to 33 percent in the present day. This statistic should not by any means be applauded. It is a perfect example of our disillusioned culture. 75 percent of what we discard can be recycled, but still ends up in a landfill.[2] This is not a statistic of progress, but one of failure. What will it take for us to do better?

As stated above Americans discard 4.40 pounds of waste daily unfortunately, researchers outside of the EPA report that today this number has almost doubled. It is estimated that we discard more accurately nearly 7.1 pounds of waste per person per day. This amounts to 2,592 pounds of trash that is therefore generated each year per person, just in the United States alone. This amount

2 "Waste & Recycling," Office of Sustainability of Indiana University Bloomington accessed January 11, 2016, http://sustain.indiana.edu/living-sustainably/waste-and-recycling.php

of trash accrues to 254 million tons and over half of this, 167 million tons finds its way to landfills or the incinerator. The biannual study done by Columbia University in conjunction with the journal *BioCycle*, states that our annual waste is actually even greater then what the EPA publishes, amounting to an alarming total of 389.5 million tons for a population of 301 million.[3] Over 140 million tons of garbage goes unaccounted for by the EPA. This can be partly contributed to the EPA's over calculation of how much municipal solid waste is recycled. To put into an even greater perspective the, "...389.5 million annual load of trash is equivalent to the collective weight of the entire U.S. adult population eighteen times over".[4] What is even more astounding is that 75 percent of this

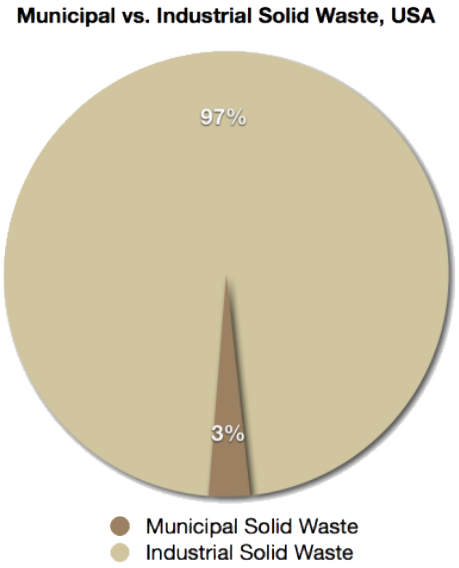

Figure 3: Chart based on figures from Royt 2007, Leonard 2010, EPA 1987.

waste can be recycled, but instead is neglected. 96 percent of our food waste ends up in landfills where it mutates into hazardous waste that does not decompose, but mummifies due to lack of oxygen and nutrients.

3 Humes, *Garbology, 8.*
4 Ibid., 8.

Solid waste in the U.S. is separated into two categories, Industrial Waste and Municipal Solid Waste. The EPA defines solid waste as any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities.[5] In figure 3, the 97 percent represents industrial waste and the 3 percent is municipal solid waste. Municipal solid waste is also known as what we personally throw away and discard on a daily basis. The EPA officially defines it as: "Municipal Solid Waste (MSW)—more commonly known as trash or garbage—consists of everyday items we use and then throw away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. This comes from our homes, schools, hospitals, and businesses".[6]

The 389.5 million tons of annual waste discussed previously represents this 3 percent. The 3 percent does not include all of the MSW that does not reach a trash bin. The additional waste that fetters our sidewalks, highways, and the hoards of plastic bags floating in the wind remain absent from count. This 389.5 million tons of waste could be closer to 400 or 500 millions tons with the unaccounted pieces that remain in our invisible wastelands.

Industrial waste is defined by the EPA as: "...a wide variety of non-hazardous materials that result from the production of goods and products".[7] We have created a

5 "Non - Hazardous Waste," last updated February 22, 2016, https://www3.epa.gov/epawaste/nonhaz/index.htm

6 "Municipal Solid Waste," last updated March 27, 2016, https://www3.epa.gov/epawaste/nonhaz/municipal/

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world in which all we do has an outcome of waste. The EPA breaks MSW into nine sub-categories including, paper, glass, metals, plastics, rubber, leather and textiles, wood, yard trimmings, food, and other. Of these categories organic materials tend to contribute to the largest percentage of what is wasted. Figure 4 published by the EPA clearly outlines the flaws of our wastefulness. 60 percent of our MSW will migrate to a landfill. 61.3 percent of the MSW that is going to the landfill is a combination of paper, wood, yard trimmings, and food. All of which are organic compounds that can decompose or be composted. We end the organic compounds natural cycle short by putting it in a landfill and banning the earth from receiving its abundant and fruitful nutrients. William McDonough co-author of *Cradle to Cradle: Remaking the Way We Make Things* writes on landfills, "The biodegradable materials such as food matter and paper actually have value too - they could decompose and return biological nutrients to the soil. Unfortunately, all of these

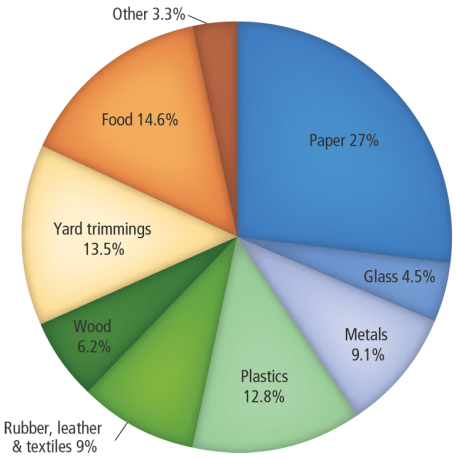

Figure 4: Chart of MSW Categories. Courtesy of the US EPA

things are heaped in a landfill, where their value is wasted."[8] We literally waste our waste. McDonough continues on waste, "They are the ultimate products of an industrial system that is designed on a linear, one-way cradle-to-grave model. Resources are

8 William McDonough and Michael Braungart, *Cradle to Cradle: Remaking the Way We Make Things* (New York: North Point Press, 2002), 27.

extracted, shaped into products, sold, and eventually disposed of in a "grave" of some kind, usually a landfill or incinerator"[9] Not only is it the consumer's fault for wasting products, but the design of the product meant to purposefully waste more than what is necessary in order for the consumer to consume more. This system is flawed and one might wonder what a more holistic system would look like. What if more than half of our MSW was avoidable and could be composed and reused as nutrients in our soil, plants, and water? This pie chart (Figure 4) proves just that. MSW should not exist and the remaining 39.7 percent can be recycled, but due to human flaws and mis-opportunity to recycle it rests destitute in our landfills. What should be sent to landfills is what is absolutely non-compostable and unrecyclable. If a product should have to go to a landfill than it should be redesigned so that it either does not exist or is designed more environmentally and economically efficient to avoid a pile up.

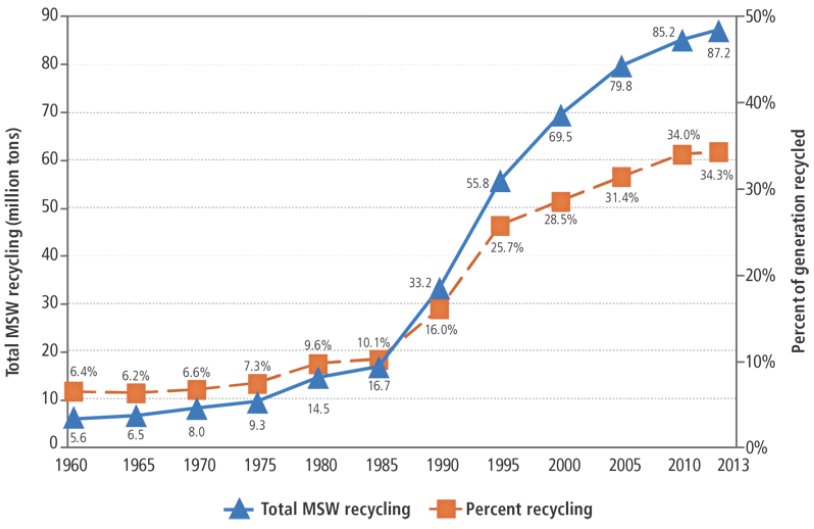

Figure 5: MSW and Percent Recycled. Courtesy of the US EPA

9 McDonough and Braungart, *Cradle to Cradle*, 27.

As discussed above, it is important to distinguish between MSW and industrial waste because the amount of MSW alone is appalling and yet is such an insignificant amount of our total solid waste stream. The three percent may seem very insignificant compared to the amount of industrial waste, but by reducing this three percent of MSW we could significantly reduce the amount of viable land being eaten up by landfills and reduce toxins released into our natural resources of water, soil, and air. The EPA published in its 2013 Review: "Recycling and composting prevented 87.2 million tons of material away from being disposed in 2013, up from 15 million tons in 1980. This prevented the release of approximately 186 million metric tons of carbon dioxide equivalent into the air in 2013—equivalent to taking over 39 million cars off the road for a year."[10] What would our world look like if the 35 percent of what we actually recycle rose to 100 percent? If we can save 87.2 million tons of waste with only recycling 35 percent this number would be even greater at 100 percent. Imagine how much we would save both from being emitted into our natural resources, but from taking up space in a landfill if this 35 percent were even raised to 80 percent. Perfection is not needed to make a significant difference. Lastly, the 3 percent of MSW is what every person has direct control over and it rests in our power to fix it and it is in our best interest to do so.

1.2 Waste, Where does it go?

In the United States landfills are the number one form of waste disposal and for most waste, landfills are the final destination. 69.3 percent of our waste is landfilled while the rest is either recycled / composted (24.1 percent) and only a mere 6.7 percent

10 "Municipal Solid Waste."

is used in a waste-to-energy system.[11] On a global scale the United States is one of the top offenders behind Bulgaria for the most waste sent to landfills. We have yet to follow in our cohorts footsteps that demonstrate that there are better ways to reduce our trash consumption and waste disposal, it is simply a matter of caring enough to take action

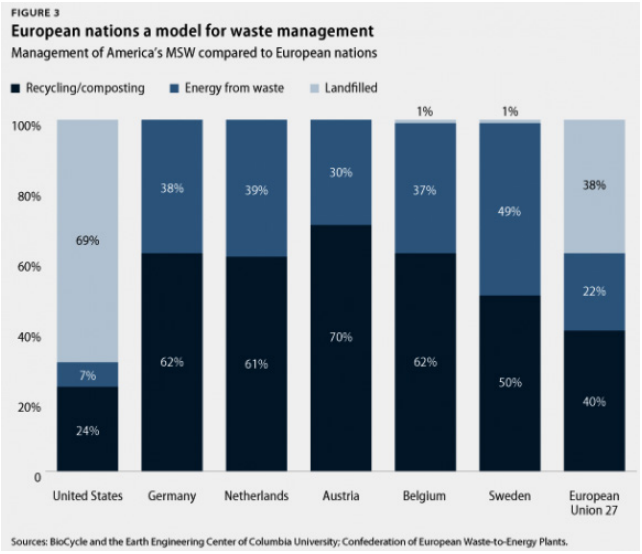

Figure 6: Management of America's MSW compared to European Nations. Courtesy of the Center for American Progress (CAP).

and change. Germany sends 0 percent of its waste to landfills and recycles 66 percent. Although Germany is much smaller in size then the United States, they do exemplify that recycling on a greater scale of merely 34 percent is possible. In an article from Green Tech Media titled *Look at How Much Waste America Puts into Landfills Compared to Europe* written by Stephen Lacey and published June 03, 2013 it states, "Indeed, some countries like Austria, the Netherlands and Germany have virtually eliminated landfilling because of strong recycling and energy from waste (EfW) policies. Those policies allowed the EU to cut the amount of waste it sent to landfills by nearly 20 percent between 2001 and 2011 -- contributing to a 34 percent reduction in greenhouse

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gas emissions from the waste sector since the 1990s." Many European countries rely on incineration for their waste composition, which is not exactly a "better" way of waste remediation, but their percentage of recycling to consumption is still greater or equal to what they incinerate. These countries are not relying on incineration as their main tract of disposal, but as a supplement to what they cannot recycle or decompose.

The facts of what we discard are very dismal, but where waste goes and how it is discarded is even more alarming. Unsurprisingly, landfills are the worst form of disposal. Landfills not only use viable land for our waste, but are still not a perfect container for our waste with toxins inadvertently and uncontrollably leeched into the air, ground, and water. Landfills only encourage us to continue our addiction to trash, because our waste is being taken "out of site and out of mind" and literally buried "away." Humes writes:

> …a landfill, by definition, will someday be full, and so all it does is enable the continued creation and flow of trash, rather than force a reconsideration of waste. A better question might be: Why do we have so much trash, and what we do to make less of it? Eventually that question will have to be addressed somehow, as the cycle of crisis cannot go on indefinitely. There simply are not enough affordable and convenient places for landfills left in many parts of the country to continue repeating the cycle indefinitely.[12]

Finally, to note we make our waste inherently worse, by shipping, trucking, and flying it to various landfill destinations not only in our country, but around the world. To provide perspective Humes writes:

> One out of every six big trucks in the U.S. is a garbage truck. Their yearly loads would fill a line of trucks stretching halfway to the moon. The creation of products and packaging that end up in those trucks contributes 44 percent of the greenhouse gas emissions that drive global warming, more than any other carbon-spewing category. Garbage costs are staggering: New York City alone spent $2.2 billion on sanitation in 2011. More than $300 million of that was just for transporting its citizens' trash by train and truck - 12,000 tons a day - to out of state landfills, some as far

12 Humes, *Garbology, 27-8.*

> as three hundred miles away. How much is 12,000 tons a day? That's like throwing away sixty-two Boeing 747 jumbo jets daily, or driving 8,730 new Honda Civics into a landfill each morning.[13]

Our waste not only takes up space, but harms natural resources and has an impregnable economic toll.

1.3 Case Study: SENSEable City Lab's Trash Track

Trash Track a project by MIT's SENSEable City Lab was designed to investigate how far our trash travels from its origin of disposal in hopes to raise awareness of habits of discarding or as the lab refers to it as the "removal-chain" of trash in cities, "Trash Track focuses on how pervasive technologies can expose the challenges of waste management and sustainability. Can these same pervasive technologies make 100 % recycling a reality."[14] The project was conducted in 2009 and the lab used "hundreds of small, smart, location aware tags."[15] The tags were dispersed on two ends of the United States hemispheres in the cities of Seattle, Washington and New York City, New York. In total 500 tags were deployed after being attached to a varied amount of objects being thrown away. The items included, old newspapers, soda bottles, paper cups to cell phones, dead or leaking batteries, abandoned washers, dryers and refrigerators, discarded computers, old furniture and car parts. The tags then tracked the time, days, and mileage it took for the object to reach its final destination. In some cases trash only traveled for as little as a day and a few miles up to an astounding two weeks across the United States.

The project was designed to bring awareness to how little we know about what

13 Ibid., 7-8.
14 "Trash Track," http://senseable.mit.edu/trashtrack/.
15 "Trash Track."

happens to our trash. Participants of the project were able to see where there discard landed, "A runner saw her old sneaker had meandered 337 miles from Seattle to the Columbia Ridge Landfill in Arlington, Oregon...A coffee cup took more than seven days to traverse the city...A lithium battery was trucked more than two thousand miles to Minnesota, while a printer ink cartridge was flown by Federal Express to Memphis, then driven 231 miles across the state to a recycling facility in La Vergne, Tennessee."[16] Trash Track brings bold awareness to the inefficiencies of the waste stream and management system as well as the consequences of discarding, "It raises serious questions about the efficacy of current recycling efforts, which all too often send certain kinds of waste great distances, expending fuel and energy that could be conserved if more waste and recycling was handled locally."[17] The idea that trash is being shipped and maneuvered from on side of the country to the other proves that our waste is even more wasteful than originally

Figure 7: Trash Track Tags (left) that use cellular Technology to report location of discarded Item. Courtesy of SENSEable City Lab.

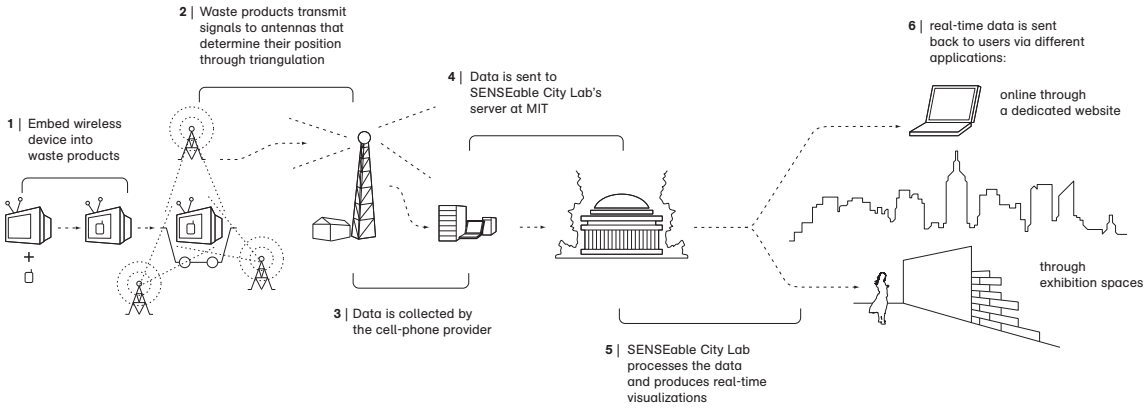


Figure 8: Trash Track Process. Courtesy of SENSEable City Lab

16 Humes, *Garbology, 152-3.*
17 Ibid., *153.*

thought. An analysis of the project points out some very important thoughts, "The idea that there is a waste-management "system," it seems, is more illusion than reality. At best there is a chaotic hodgepodge of potential trash destinations that eludes both control and detection in ways that would never be tolerated in other industries and supply chains. This revelation suggests that the second big question should be modified slightly: How

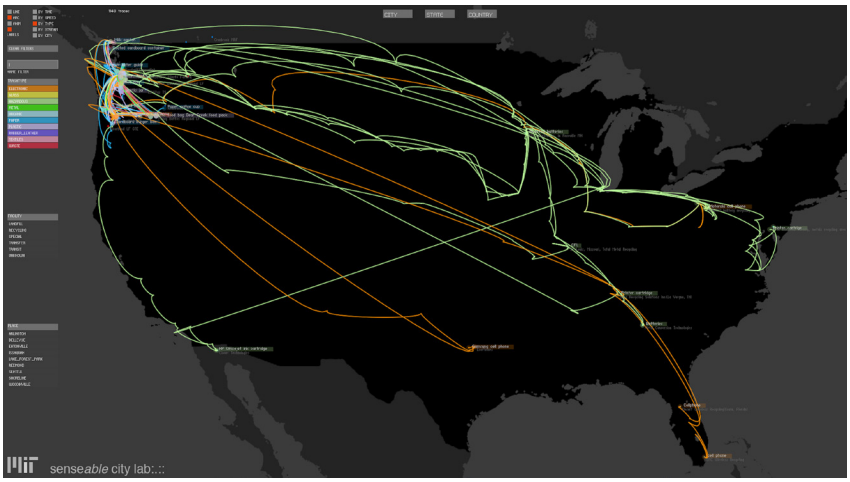


Figure 9: Trash Tracking Visual. Courtesy of SENSEable City Lab

can we ever put an end to waste if we can't even keep track of it?"[18] If the mountains of landfill and data produced by the EPA are not enough to convince us that there is need for change then Trash Track is only more proof in revealing the flaws in our waste system. How much more do we need before we see that change is necessary.

1.4 Waste, Where do we go from here?

With the creation and disposal of waste comes an intertwined web of issues that include water and air pollution, "Municipal planners should manage solid waste in as holistic a manner as possible. There is a strong correlation between urban solid waste

18 Ibid., 155-7.

generation rates and GHG emissions. This link is likely similar with other urban inputs/ outputs such as waste water and total energy use."[19] This thesis is not only about what we throw away, for waste is both about the visible and the invisible. We do not "throw away" water, but we do waste it every time we flush a toilet, shower, or ignore a leaky faucet. Each day we use a conservative amount of 100 gallons of water and 2.2 gallons of crude oil for menial tasks. This accrues up to one barrel every seventeen days or 22 barrels a year per person. Even items we do not consider as waste such as the food we buy have negative consequences. We waste inadvertently for our food now travels thousands of miles from where it was grown to reach our plates. Simply by buying and eating food we are contributing to a larger more corrupt system. Over the years we know that the level of environmental destruction has risen with the volume of stuff consumed and with the distance it is transported, "For every 100 pounds of product we create 3,200 pounds of waste. Currently our ecological footprint for each American embodies 5 hectares of land, but we only have 1.3 hectares of usable land to offer. If everyone lived like Americans we would need two more earths to sustain us."[20] We can attribute this habit of wastefulness to many other factors apart from ourselves, but to the lifestyle systems and the influence of systems of our economy:

> Waste composition is influenced by many factors, such as level of economic development, cultural norms, geographical location, energy sources, and climate. As a country urbanizes and populations become wealthier, consumption of inorganic materials (such as plastics, paper, and aluminum) increases, while the relative organic fraction decreases. Generally, low and middle income countries have a high percentage of organic matter in the urban waste stream, ranging from 40 to 85% of the total. Paper, plastic, glass, and metal fractions increase in the waste stream

19 "What A Waste: A Global Review of Solid Waste Management," The World Bank, http://www.worldbank.org/.

20 David Orr, "Architecture, Ecological Design, and Human Ecology," in *The Green Braid: Towards an Architecture of Ecology, Economy, and Equity*, ed. Kim Tanzer et al. (New York: Taylor & Francis Inc, 2007), 17.

of middle and high income countries."[21]

What is the root our wastefulness? The answer is simple our consumerist society. We can thank the Industrial Revolution for the beast we have created. As a society and culture we have an addiction to waste and are in denial about it. We choose to ignore the problem that is right in front of us, "…like any addict, America is living in an official state of garbage denial... What no one considered back then (and few acknowledge now) is waste's oddest, most powerful quality: We're addicted to it. It turns out our contemporary economy, not to mention the current incarnation of the American Dream, is inextricably linked to an endless, accelerating accumulation of trash."[22]

It is very important to note and bring reconnaissance to the fact that the world once took care of waste naturally and without human action. Waste was once not a problem nor an addiction. It had a self cleansing system, "A healthy environment automatically supplies not only clean air and water, rainfall, ocean productivity, fertile soil, and watershed resilience but also such less - appreciated functions as waste processing (both natural and industrial), buffering against the extremes of weather, and regeneration of the atmosphere."[23] This is the natural system of waste and life that we must return too and is further proof that we can because it did once exist. Ridding the world of all waste is not a possibility or a solution, for waste is a byproduct of millions of systems. For our future, this ideal should dictate the further steps we take in altering our systems and driving for behind design. The design portion of this thesis also bears this in mind in an attempt to show what can be done. Our solutions lie in the waste of

21 "What A Waste." Ch.5 Pg.2
22 Humes, *Garbology, 8.*
23 Paul Hawken, Amory Lovins, and L.Hunter Lovins, *Natural Capitalism: Creating the Next Industrial Revolution*, (Boston: Little, Brown and Company, 1999), 3.

humankind and the systems that we have set into motion that dictate our lives. We have created an apocalyptic problem with only an apocalyptic outcome possible. That is, only with the refusal of change. If we change the parameters of the systems we change the parameters of the outcome.

CHAPTER 2
SUSTAINABILITY AND ITS FLAWS

When discussing waste, design, environment, and our future it is hard to avoid the word sustainability / sustainable. Sustainability has become a catch all term to repress the guilt we feel about destroying our planet and in many cases now has become a headline for greenwashing products and consumers. Greenwashing is defined as the practice of promoting environmentally friendly programs to deflect attention from an organization's environmentally unfriendly or less savory activities. When the term sustainable / sustainability is discussed in this paper it will refer to the ideas outlined below.

2.1 Defining Sustainability

The term and idea of sustainability has continuously shifted and metamorphosed with the more knowledge that has been acquired through the current years of increasing hum about global warming and concern for the planet. Sustainability is not only linked to the idea of environment, but regards not only the world of design, but on a bigger scale from buildings, to products we produce, waste, energy, from our environment to cities and eventually the world. Although the definitions and tenets of sustainability often vary greatly what is most true is that everyone has a different understanding and definition of sustainability and what it encompasses.

There is a strong initial thought that sustainability implies that first and foremost it is meant towards buildings or that sustainability means reducing our carbon footprint, but no one mentions eliminating our footprint all together. It also provokes the ideas of designing buildings that are carbon neutral, along with the issues of the reuse of

materials, the locality of products used, and energy content.

It is no surprise that there is no one common idea behind sustainability for the way it is represented in texts books and the manner in which it is taught are all different. For architects this sometimes is a closed sphere. In textbook *Heating, Cooling, Lighting: Sustainable Design Methods for Architects* defines sustainability in that of sustainable design with a set of bullet points that include: saving energy, the recycling of buildings, creating community as a means to reduce dependence on automobiles, reduce material use, maximize longevity, and lastly make the buildings healthy. What is so frustrating with the final bullet point is the broadness of the subject, in what ways do you define a building as healthy? The book fails in truly addressing sustainability, it only delves into sustainable design and fails to define the difference between sustainability and sustainable design. Programs such as LEED are greenwashing for designers. LEED proves we have become complacent with our impending future environment because it makes designers feel as though they have done their part, even though they have just placed a band aid and stamp on a building to make ourselves feel better about the damage we have done and will continue to inhibit.

The Shape of Green: Aesthetics, Ecology, and Design a book written by Lance Hosey defines sustainability in regards to shape as "Sustainability should have style but not become a style. What designers need isn't an ecological aesthetic – it's an aesthetics of ecology, a set of principles and mechanics for making design more responsive and responsible, environmentally, socially, and economically."[24] Hosey supports his definition with examples of the Smart Car and the Prius and touches upon three very

24 Lance Hosey, *The Shape of Green: Aesthetics, Ecology, and Design* (Washington DC: Island Press, 2012), 28.

important factors that make up sustainability; environment, society, and economics. To design sustainably these three factors must be considered.

Sustainability is not just about the issue of how to dispose of waste in an environmental fashion, but it more importantly should be defined as how to prevent it. If we did not have waste would the word sustainability still exist? The Merriam-Webster dictionary defines sustainability in three basic ways: (1) able to be used without being completely used up or destroyed, (2) involving methods that do not completely use up or destroy natural resources, (3) able to last or continue for a long time. These definitions do not do the word justice. Sustainability cannot be defined in one simple sentence such as these and are examples of the challenge of defining such a dense word. The definition just like the word embodies a multitude of different spheres of our culture, society, and world. Sustainability shifts towards complex and diverse systems for survival and restricts the simple. William McDonough's *Cradle to Cradle* description of the "waste equals food" system is the closest most encompassing ideal of sustainability. Using the idea of "waste equals food" he completely avoids the misconceptions that are associated with sustainability. For the world to be sustainable we need to make the "waste equals food" system happen on a much larger scale and influence the extinction of the cradle to grave cycle.

Bill Reed who is a Principal at Regenesis a design firm in the field of regenerative development states that sustainability is not about making less waste, but is about producing no waste. Regenerative development is, "an approach to land use, community planning, and the built environment that has defined the leading edge of sustainability

practice."[25] For us to be sustainable our products and buildings must be able to have an infinite future either in that of a continuous use and reuse cycle or having the ability to truly last infinitely. This accounts for reliability and ownership as we become the stewards for our world.

Lastly, in a TED talk titled Hedonistic Sustainability by Danish architect Bjarke Ingels of the firm BIG, Ingels simply states:

> ...a general misconception is that sustainability is a question of how much of our existing quality of life are we prepared to sacrifice in order to afford becoming sustainable. Almost like this sort of protestant idea that it has to hurt to do good, but sustainability can't be like some sort of a moral sacrifice or a political dilemma or even like a philanthropic cause, it has to be a design challenge. We tried to ask ourselves if there was another sustainability than this sad depressing one? We tried to ask ourselves if we could find examples where sustainable cities and buildings increase life quality.[26]

This is the kind of world that we should be envisioning and questioning when we hear the word sustainability. Ingels goes on to discuss his intent with the exhibition of the Danish Pavilion for the Shanghai World Expo in 2010 that focused on sustainable cities. He wanted to demonstrate how design can be used as a tool to increase our lives while also being sustainable. Ingels stated the we can, "...show how essentially sustainable life can be more fun than normal life." In Copenhagen they have made this their mission. The Danish Pavilion's design offered some glimpses of what this sustainable life would be like for others by providing a swimming pool of harbor water for the harbor water in Copenhagen is so clean you can swim in it. Secondly, they provided bikes to travel around the pavilion for 37 percent of citizens in the city opt to bike for their daily commute over driving. These are only a few of the Dane's sustainable strategies, but give

25 "Who We Are," Regenesis, accessed January 02, 2016, http://www.regenesisgroup.com/team/.
26 Bjarke Ingels, "Hedonistic Sustainability" (talk presented at TEDxEAST, May 2011).

a glimpse at what can be accomplished if we use design and systems with sustainability for, "sustainability does not have to hurt in order to do good."[27] Ingels boasts a brilliant proposition of a revolution found on the ideal of "better city, better life" in that sustainable cities increase normal life an idea that should be supported without a qualm.

With all of these influences the definition for sustainability should be a conglomerate of many ideas from many sources, that sustainability is an infinite process one that cannot be broken and one that produces no waste. It encompasses not just the

Figure 10: Danish Pavilion at the Shanghai World Expo, 2010. Courtesy of Bjarke Ingels Group

Figure 11: Interior Danish Pavilion at the Shanghai World Expo, 2010. Courtesy of Bjarke Ingels Group

world of design and the idea behind protecting our environment, but to better ourselves and the quality of our life we will need to transition to a smarter being. We must extensively probe our cities, cultures, homes, processes and design not a building, but a sustaining system that will blend together, society, economy, environment, happiness, and design into one cohesive cradle to cradle system.

27 Ingels, "Hedonistic Sustainability."

2.2 Case Study - Scandinavia and the Slums

When thinking of design and systems it is important to think about the problem in a larger context. In this case how the design of a building fits into a universal whole of a city and the world. It is important to look at the way cities function and how this influences the design of individual structures and their added texture to a city and its values. Case studies of sustainable cities are important to see how the building function against the backdrop of a larger whole, both design, socially, and economically. What can forward thinking design and a building provide to the city and its inhabitants.

With a size of 1/16th to that of Texas, Denmark is a hidden gem of Scandinavia. It is a mere 16,000 square miles with a population of 5.6 million people. The government is a social democracy in which they rest their standards on free health care and welfare for all. It is this thoughtful and caring attitude towards not only every Dane, but their environment that has allowed them to become a leader in world sustainability. Although Denmark is quite small compared to most countries around the world, it is making monstrous strides towards sustainability on every level from transportation to energy and even up to policy. With this in mind it should be to no surprise that Denmark has proposed to make Copenhagen the first carbon neutral capital in the world by the year 2050 and to reduce carbon emissions by 20 percent by 2015.

Denmark, especially its capital city of Copenhagen is most greatly known for its bikes. This is no lie, biking is a form of everyday transportation and is not just for sport. It is a serious resource for travel and has become a culture in itself as well part of the culture of the Danish lifestyle. What is truly admirable is the way in which the cities

have been adjusted to support the use of the bicycle. In the United States most cities are not meant for bikes, because the cities were planned from their conception not to support them, but the automobile. Copenhagen is embedded with historic buildings and narrow streets has been able to overcome this feat, why can't we? Not only is there sufficient room in the streets for bikers to bike safely to their destinations, but in some cases the bike path is offset from the street and nestled safely next to the pedestrian side walk with distance from the automobiles. Not only does Copenhagen support bikers, but so do the surrounding towns, with paths that run through the forests and Danish countryside to each humble abode. Not only are the bike routes convenient, but also provide a beautiful view of the country.

Figure 12: Danes Commuting by Bicycle

Copenhagen is not only biker friendly, but pedestrian friendly as well. Through the years it has made it a mission to reduce the use of cars in the city and open it up to the pedestrian and allow room for green space:

> Cities like Copenhagen have set the stage, beginning in the early 1960s, gradually taking back their urban centers from cars…the city has adopted the policy of converting 2-3 percent of its downtown parking to pedestrian space each year, to dramatic effect over several decades…Today the amount of pedestrian space is tremendous. Eighteen pedestrian squares have been created in Copenhagen where there was once auto parking – some 100,000 square meters in all.[28]

28 Timothy Beatley, "Planning for Sustainability in European Cities: A Review of Practices in Leading

If Copenhagen can achieve this, why can't we?

One clever component to their pedestrian friendliness is the expense of a car. The taxes on cars in Denmark is absurdly high so that it is rare to own one or at least for a family to have more than one car. The public transportation is so efficient that it becomes convenient. For American's we are a society of convenience. The issues with our systems can be turned to this. What makes the public transportation so successful is its ease of use and enjoyable atmosphere. The Danes take care of their trains and metro so that they are very clean and without graffiti. What also makes public transportation so feasible is their extension to practically every town outside of Copenhagen. The planning is truly genius for if the train does not run directly to your destination you merely have to take a short bus ride to your destination after arriving at the train station or the metro.

Apart from being sustainable in means of transportation and the walkability of the city, Copenhagen is sustainable in its energy use. It utilizes power from wind turbines and its trash for heat and electricity. Denmark uses the power produced by incineration and then further uses the leftover ash for fertilizer. It also has a successful bottle return system. The incentive to return bottles at the local grocery stores is extremely convenient and the payback is significant enough to make it worthwhile. Plastic bottles are rarely thrown away and if they are they are collected by the homeless so that they can reap the reward for returning them. We have a similar process here, but why is it not utilized? Where are its flaws?

Finally, not only are they sustainable in these practices but as well as housing. One form of popular housing is cohousing communities. Not only does this lifestyle

Cities," in *The Sustainable Urban Development Reader Second Edition*, ed. Stephen M. Wheeler et al. (New York: Routledge, 2009), 335.

foster brothership between the families, but promotes a lifestyle of minimalism. The houses are not big or exorbitant, but contain only the amount of space needed to live comfortably with all the essentials. Having studied them greatly and speaking with people who lived in these communities firsthand the consensus was always one of success. The communal housing reservations were always located near a local train line so that the use of the car was reduced.

Figure 13: Wind Turbines in Denmark

For future precedent the United States should look towards Denmark not for its flaws, but for its impressive successes. The United States is not classified as a third world country, but we are far more unsustainable and need more adjustments than a third world country. We must reverse the routines and habits we have become accustomed while a third world country can begin anew.

It is important to look at an array of how different countries of varying wealth function with waste. If we look towards countries that have vast areas of slums such as

India's Mumbai and Nigeria's Lagos we can see their citizen's response to waste. The system of slums is reminiscent to that of the zero waste culture of the 1800 and 1900's pre-industrial revolution time that Susan Strasser discusses in her book *Waste and Want*. The communities of the slums act as harvesters of trash and create cities made completely of waste. One may view this as a flaw in one's country or as strong ingenuity. The communities of the slums although have little means, live much more sustainably than Americans. Of course, the people of the slums would not choose this lifestyle, but designers and architects can study the structure of these slums to create a better living situation and economically viable and sustainable solution in terms of design to replace the slums. This could either be achieved by studying the specific culture of waste and manipulating the most abundant product of waste of an area to become shelter. If we can begin to break down the barrier between the extreme rich and the extreme poor common ground can be broken. This common ground can serve as a leeway to an intermingled community in which the rich and poor support each other for a more balanced environment.

A slum in Lagos called Makoko exists completely on water. Its inhabitants have built their homes with remaining wood from the once existing sawmills. The houses appear to be in shambles and one may wonder how they ever stand, but what is most surprising about these structures is that many have existed for over 40 years. If these shoddy structures can last this long, one might imagine how long they could last with adequate bracing and support. What also makes this slum sustainable is their transportation. Resting completely on water, the inhabitants use canoes to shuttle from place to place. The economic activity as a result is mainly fishing and smoking fish. The

flaws in Makoko are due to a lack of waste removal such as plumbing causing the water on which they live to be extremely polluted. This although can be fixed if they had the means for modern technology or specific landscaping to correctly dispose of their waste.

For America, even though we are educated on sustainability we are not much closer to being an example than that of the slums. We may practice recycling but we are still the biggest consumers and producers of waste in the world resting in the top three places for largest ecological footprint. Many third world countries do not even have a footprint because they use such little of the world's resources, in this case they are making greater strides than us. Ultimately, we should look towards a country such as Denmark that is triumphant in making these strides. They may have yet to reach their goals of carbon neutrality or a zero waste society, but are much closer to solving our current crisis. They ultimately prove that sustainability is possible and that we can still enjoy the luxuries of modern technology all at the same time.

Figure 14: Image of Makoko Slum. Courtesy of The Guardian

In conclusion, there once was a time a time we never had to think about waste, because there was no waste. All waste was used and reused until it ceased to exist or was re-purposed into something else. Commodities were too expensive and rare, that wasting was not economically possible. The aim of this thesis is to explore the use of systems with design to redefine waste. Can design be used as a tool to reduce our footprint instead of enlarging it? What can we do about this monumental problem? We can use design and systems together to reconstruct the outcome of our actions. In the following

chapter I will discuss the different types of systems to which I'm referring. Waste is not a problem and in nature nothing is wasted. Today waste has a bad connotation because we have made it "bad" and undesirable. This thesis investigates how we can reintroduce waste back into our systems so that it becomes a benefit and not a hindrance. Bill McDonough could not have been more precise when he wrote in *Cradle to Cradle*, "Once you understand the destruction taking place, unless you do something to change it, even if you never intended to cause such destruction, you become involved in a strategy of tragedy. You can continue to be engaged in that strategy of tragedy, or you can design and implement a *strategy of change.*"[29] We must do exactly this.

29 McDonough and Braungart, *Cradle to Cradle*, 44.

CHAPTER 3
SYSTEMS THINKING

Design is our solution to waste, specifically design within systems. To remediate the problem we need to rethink how we make, why we make, what we make, and how much of we make against the realities of what is actually needed and necessary. Systems are abundant and exist in all that we do, we are part of a millennium of systems everyday, simply by existing. Our own bodies are their own system acting within systems of societal, environmental, and even economical contexts. Systems can be invisible and visible just as our waste, and they are a driving force behind many of our actions, behaviors and mindsets. Systems will help us re-identify our place in this world and bring light to our actions. Design alone is not the answer, but design in conjunction with systems is the solution. One might wonder how design works with systems, Danish architect Bjarke Ingels states it perfectly:

> Architects have to become more than just designers of two dimensional facades or three dimensional architectural objects. We have to become designers of ecosystems, systems of both ecology and economy, that not only channel the flow of people through our cities and buildings, but also the flow of resources, like heat energy, waste, and water, into these sort of perpetual motion engines and stop seeing our presence like the human presence on planet earth as a sort of a detriment to our ecosystem, but actually tries to sort of integrate and incorporate our consumption patterns, our leftovers into our natural environment.[30]

Systems allow us to see flows of incomes and outcomes. They allow us to assess areas that are being overworked and areas that are idle. Our output today is waste, not only in what we throw away, but everything we do and the things we make. We can use systems and design to remediate our waste and behaviors of wastefulness. This calls for an assessment of material cycles as small as a tin can, to candy bar rappers and

30 Ingels, "Hedonistic Sustainability."

magnifying into perspective where architecture and design fits into the overall picture. Eliminating waste is not the answer, because it has always been a part and an outcome of systems and fuel for others, but we need to return waste to its natural state. A return to waste that is decomposable and if it cannot break down then we need to question whether it should be made. Below is a brief overview of systems thinking and a definition of the types systems and thinking that went into this thesis.

3.1 SYSTEMS OVERVIEW

What is a system? A system is defined as, "A set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviors, often classified as its "function" or "purpose."[31] A system can be more than the concrete web of plumbing pipes running through a building, but extend to much larger and smaller adjacencies as the building and its role in a city, or a function. What is most important to remember is that systems are intuitive, sensitive, and intimately linked with human behavior. If we can identify which systems need editing we can begin to make a difference in ourselves and our world. Meadows writes, "Systems thinkers call these common structures that produce characteristic behaviors "archetypes." When I first planned this book, I called them "system traps." Then I added the words "and opportunities," because these archetypes, which are responsible for some of the most intransigent and potentially dangerous problems, also can be transformed, with a little systems understanding, to produce much more desirable behaviors."[32]

Systems can have a domino effect and if we adjust one part successfully we can have a

31 Donella H. Meadows, *Thinking in Systems: A Primer*, ed. Diana Wright (White River Junction, VT: Chelsea Green Publishing, 2008), 188.
32 Meadows, *Systems,* 6.

myriad of positive outcomes. Systems can be complex and contain a whole and its parts and many systems combined can create a bigger overall system.

Main system characteristics defined by Meadows include:

1. A system is more than the sum of its parts
2. Many of the interconnections in systems operate through the flow of information
3. The least obvious part of the system, its function or purpose, is often the most crucial determinant of the system's behavior.
4. System structure is the source of system behavior. System behavior reveals itself as a series of events over time.
5. Many relationships in systems are non linear
6. There are no separate systems. The world is a continuum.
7. Systems need to be managed no only for productivity or stability, they also need to be managed for resilience.
8. Systems often have the property of self-organization – the ability to structure themselves, to create new structure, to learn, diversify, and complexity.
9. Hierarchical systems evolve from the bottom up. The purpose of the upper layers of the hierarchy is to serve the purposes of the lower layers.

Where changing one input effects the output, changes the system in its entirety so that the function is altered from one outcome to another.[33] This thinking must be applied to our current waste management, stream, and mentality. When thinking of systems, one can think of where our waste is situated on its own as well as the overarching system that our society has constructed. Meadows author defines it perfectly as, "…a set of things – people, cells, molecules, or whatever – interconnected in such a way that they produce their own pattern of behavior over time. The system is buffeted, constricted, triggered, or driven by outside forces. By the system's response to these forces is characteristic of itself, and that response is seldom simple in the real world."[34]

33 Ibid., 188-9.
34 Ibid., 2.

A characteristic of a strong system is one that is non-linear, where the outcome produced is not easy to follow, but complex and dense. Our waste stream at the moment is a linear one. It has an simple end; the landfill. If we hope to improve the waste stream we need to create one the has resilience, self – organization, and a hierarchy. As humans we are drawn to linearity because it is easier to understand and follow the flows from one end to another, but linearity provides for a weak system. If one part fails in a linear

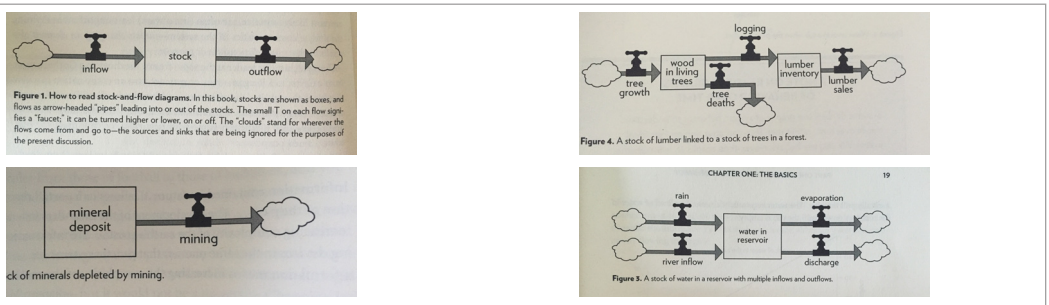


Figure 15: Examples of systems from simple to complex. Courtesy of Donella H. Meadows

system than the entire system fails for there is no feedback loop to protect it,

> In ecosystems change does not happen in a linear fashion. Unlike laboratory experiments, where one factor can be evaluated in isolation, in an ecosystem a change in one factor, seemingly innocuous, can have disproportionate impacts on other elements of an ecosystem, or on the health of the ecosystem itself. Nonlinear change, the value of diversity, non-hierarchical organization recognizing the equal importance of many elements of a system and the very concept of considering species in the context of complex systems – all these are concepts brought forward by practitioners of ecology.[35]

Our culture of waste is much like a bad habit or an addiction. Through a systems lens it can be explained as, "Drug addiction is not the failing of an individual and no one person, no matter how tough, no matter how loving, can cure a drug addict – not even an addict. It is only through understanding addiction as part of a larger set of influences

35 Kim Tanzer and Rafael Longoria, Introduction: Networked ways of knowing to *The Green Braid: Towards an Architecture of Ecology, Economy, and Equity,* ed. Kim Tanzer et al. (New York: Taylor & Francis Inc, 2007). 7-8.

and societal issues that one can begin to address it."[36] This route of addiction is not knew and can be traced back to the Industrial Revolution. One can see when reexamining the systems that put the Industrial Revolution in motion how sub-systems and larger systems sprung out of each other to create the system of waste we have today. Right now, our system of waste and waste disposal is not successful. Referencing the past can provide incite on what steps should be taken next and what mistakes to avoid repeating.

3.2 A Re-Examination of the Past through Systems, Waste, and the Industrial Revolution

The root of our current wasteful trends can be attributed the turn of the century Industrial Revolution. Meadows, writes of systems:

> …there is an integrity or wholeness about a system and an active set of mechanisms to maintain that integrity. Systems can change, adapt, respond to events, seek goals, mend injuries, and attend to their won survival in lifelike ways, although they may contain or consist of nonliving things. Systems can be self-organizing, and are often self-repairing over at least some range of disruptions. They are resilient, and many of them evolutionary. Out of one system other completely new, never- before imagined systems can arise.[37]

The Industrial Revolution did exactly what meadows describes of system behavior above, while creating the outcome of waste we have today. At the time, a new system of mechanization evolved the system of cradle to cradle into cradle to grave. The Industrial Revolution did not have any intention of causing such environmental disruptions, but truly stemmed out of a need for solving current societal and economic problems and a want to support the masses instead of the exclusive upper elite. William McDonough writes, "In fact, the Industrial Revolution as a whole was not really designed. It took

36 Meadows, *Systems,* 2.
37 Ibid., 12.

shape gradually, as industrialists, engineers, and designers tried to solve problems and to take immediate advantage of what they considered to be opportunities in an unprecedented period of massive and rapid change."[38] And just as Meadows previously stated, one system can lead to the birth of other interior systems and the Industrial Revolution did just this:

> As industrialization boomed, other institutions emerged that assisted its rise: commercial banks, stock exchanges, and the commercial press all opened further employment opportunities for the new middle class and tightened the social network around economic growth. Cheaper products, public transportation, water distribution and sanitation, waste collection, laundries, safe housing, and other conveniences gave people, both rich and poor, what appeared to be a more equitable standard of living.[39]

The Industrial Revolution at its roots was a shift in systems from one of manual labor to one of efficient mechanization and production and as a result the system shifted the entire world and rocketed it into capitalism. The Industrial Revolution proves exactly how much the design of independent products created an entirely set of new systems, McDonough states, "For obvious reasons, the design goals of early industrialists were quite specific, limited to the practical, profitable, efficient, and linear. Many industrialists, designers, and engineers did not see their designs as part of a larger system, outside of an economic one."[40] Our waste stream for products today appears as such, in which 90 percent of materials that go into making a product become waste almost immediately with a great possibility that the product will have an even shorter life span. Goods are made to omit durability. The Industrial revolution paved the way for what Susan Strasser describes as the "throw away culture." Today it is easier and often less of a financial burden to buy anew than to replace a part of a broken object. With the production of

38 McDonough and Braungart, *Cradle to Cradle*, 18.
39 Ibid., 21.
40 Ibid., 24.

goods and services a large and dramatic shift in the world occurred. If we can do this once we too can do this with waste.

It has been proven time and time again in our past that we have used systems to mediate pending problems. Not did the Industrial Revolution set into motion a string of systems but this can also be said about the birth of monoculture crops and its aim to aide hunger and starvation in third world countries. The system of monoculture originated from a current problem and need, but hurtled out of control when it was discovered it could be used for much more than starvation in countries other than our own. There was an economic factor tied to mass producing food in this country. Monoculture stripped the agricultural industry of its complex diversity and simplified growing to one crop.

If there are any lessons to be learned from the past it is that we must be careful in identifying which parts of a system need to be changed or refined or whether the entire whole must be replaced. Many attempts in history have proved that changing a single part of an overarching system can have adverse effects. We must look at all systems as part of an overarching system, pieces to a whole. We have experienced change in the past that remediates one problem, but in its wake causes twenty others. This can no longer be done, Meadows states:

> Serious problems have been solved by focusing on external agents – preventing small pox, increasing food production, moving large weights and many people rapidly over long distances. Because they are embedded in larger systems, however, some of our "solutions" have created further problems. And some problems, those most rotted in the internal structure of complex systems, the real messes, have refused to go away.[41]

A perfect example of this can be seen as discussed previously in the creation of monoculture crops. This system brought about unseen negative consequences such as

41 Meadows, *Systems,* 4.

soil depletion and crop epidemics that wipe out entire acres of growth due to lack of diversity. During the Industrial Revolution no one could comprehend or even predict the immense change that would occur and that a completely new way of life would be born, nor could they foresee the lasting effects that would be caused by it. If there is anything to be gained from the past is that there is still hope for us and the redesign of our waste. It merely takes the alteration to one part of a system to begin to change the many.

The lasting effects of the Industrial Revolution can be seen in even the most obscure places even architecture. Architecture was simplified so that the process could save time and money ultimately reflecting an outcome of box stores stripped of character, stylization, and craftsmanship. For example, the International Style of architecture and works by such greats as Ludwig Mies van der Rohe, Walter Gropius, and Le Corbusier can be seen in their designs with the devoid and rejection of ornament. McDonough writes:

> Today the International Style has evolved into something less ambitious: a bland, uniform structure isolated from the particulars of place – from local culture, nature, energy, and material flows. Such buildings reflect little if any of a region's distinctness or style. They often stand out like sore thumbs from the surrounding landscape, if they leave any of it intact around their "office parks" of asphalt and concrete.[42]

With a systems view design does not have to be this way, but it will take a shift in all realms of society, from economics, to manufacturing, design, to behaviors, mindsets and actions, "At some point a manufacturer or designer decides "We can't keep doing this. We can't keep supporting and maintaining this system." At some point they will decide that they would prefer to leave behind a positive design legacy. But when is that point?"[43] From this one can sense the importance that rests in systems thinking. The

42 McDonough and Braungart, *Cradle to Cradle*, 29.
43 Ibid., 43.

following case studies are different theoretical systems that tackle the intangible, but very extant factors that are necessary to designing a world void of waste. These systems deal with such factors as community, economics, exchanges, and specific mindsets. Although these are all inputs we cannot physical see they are existential to the success of our future planet. Many of the following studies are systems thinking ideals and reflective in the design decisions made in the design component of this thesis.

3.3 Literature Review

3.3.1 Stewart Brand - How Buildings Learn

Stewart Brand approaches architecture with a systems mind. In his book *How Buildings Learn: What Happens After They're Built* he explores different systems to use as tools for design to prolong and enhance the lives of buildings for the present and the future. This section will explore his ideas regarding space planning and scenario buffered design.

The craft of architecture is meant for that of a renaissance man. An architect is not only responsible for the design of a building, but must grapple with the already innumerable tasks of mastering light, space, form, sound, view, texture, materiality, comfort, and safety while also taking into consideration environmental factors as well as the life and death of the structure. For author Stewart Brand though, the architect must probe more. For him, the architect now must conquer the unthinkable, unimaginable, intangible capability with that of time. For Brand this is the tool that architects have been missing, the one utensil that has prevented the creation of a lasting architecture, one that

is not only well designed, but reusable and even editable.

Reading excerpts from his book, H*ow building's Learn: What happens After They're Built*; Brand saturates our minds with the idea of permanence and time. He critiques and questions our past and present, our art form and construction processes in relation to that of time. He questions how it inhibits and hinders our abilities as well as when, where, and how it cripples and inversely rejuvenates the craft of building. His main argument for the introduction of a buildings inability to withstand time is its singular purpose and rigidity to be reshaped when the world around us is ever changing, on a micro-scale from technology to a macro-scale of politics and culture. Brand writes: "Where "architecture" may strive to be permanent, a "building" is always building and rebuilding. The idea is crystalline, the fact fluid. Could the idea be revised to match the fact."[44] Architecture is not a separate entity, but one embedded in our life which is why buildings have an existence. Brand's argument is that we dream about the permanence of buildings, one that will stand the test of time, but we do not design them in a way that will allow them too. The permanence we imagine is the wrong form of permanence; it is one of over-permanency.

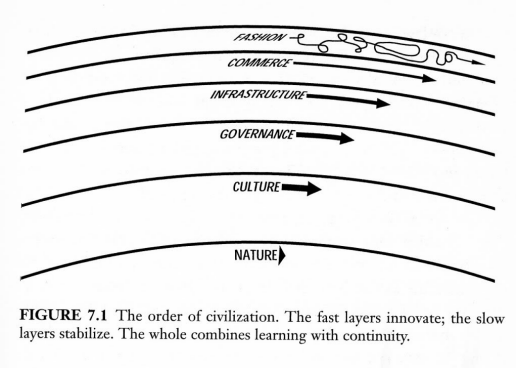


FIGURE 7.1 The order of civilization. The fast layers innovate; the slow layers stabilize. The whole combines learning with continuity.

Figure 16: Layers of Society by Stewart Brand

Brand identifies what catalysts cause buildings to despair. It is due to the precariousness of our society's transfixion with technology, money, fashion; three

44 Stewart Brand, *How Buildings Learn: What Happens After They're Built* (New York: Penguin Group, 1994), 2.

distinct drivers of our world that evolve at a much more expeditious rate than that of our buildings. This in part, due to the way that they are built. Our architects are not designing buildings to nurture future trends, but only those of the present moment at which they are constructed. Must architects now become clairvoyants too, so that our buildings will be ahead of the future? Will this reaction therefore make buildings infinite? Brand, questions this dilemma as well and proffers up a "tool box" of intricate systems to aide in this persisting conundrum.

Brand questions and then ameliorates the dilemma of time with a 6 step solution: Site, Structure, Skin, Services, Space Plan, and Stuff. By examining these six layers of a building we can predicate its existence with the use of Scenario Planning in lieu

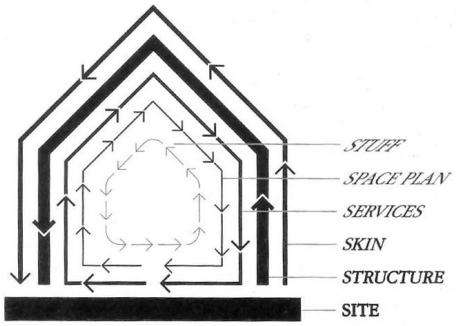


Figure 17: Design System by Stewart Brand

of Program Planning. Programming a building is one of many culprits that leads to a buildings inability to adapt and adds to its unrelenting purpose. Programming is meant for a single minded use group, it literally places a building into a "box". Brand suggests we rewire the way we approach designing a new building by reversing the order and planning for what is to come. Scenario Planning involves summating as many different and possible outcomes of a buildings use, by interviewing the users, incorporating

thoughts of future users and stem from there. Brand hopes that this approach will allow for a building to become more versatile in its use and form and remediate future changes by predicting them before they happen. Simple, right?

One cannot proceed with scenario planning without first including Time. Time is the biggest constraint to the scenario based design method. Time becomes a constriction in the process as well as the future. If we master Brand's sequence Time can become the prominent proponent and propeller that allows the building to see its future and shed its label as a constraint. To master time as a characteristic of a building we must first understand it as a hierarchical element: "…the same goes with buildings: the lethargic slow parts are in charge, not the dazzling rapid ones. Site dominates the Structure, which dominates the Skin, which dominates the Services, which dominates the Space Plan, which dominates the stuff…you could add a seventh "s" – human souls at the very end of the hierarchy, servants to our Stuff."[45] Here, Brand emphasizes a shift to systems thinking. We think of Cradle to Cradle in a revolving cycle of birth and rebirth with the outcome of no waste, while Brand's system is not too different. It is an infinite loop of rebirth and birth as well, but in the sense of repurposing a building instead of decomposing and then rebuilding. Although we cannot completely obliterate the program, for the present inhabitants still have specific needs, is there a way to blend both program and scenario?

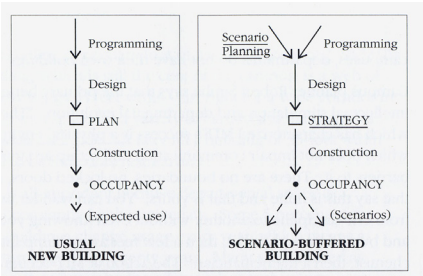


Figure 18: Scenerio Planning by Stewart Brand

45 Brand, *How Buildings Learn*, 17.

I appreciate Brand's gesture towards the stewardship of buildings as the seventh S, "human souls". The touch of human care is often forgotten as buildings age. We begin to lose interest in what was once new and the care taking that once took place diminishes. Once a building begins to dissipate it is extremely difficult to reincarnate. Not only do problems seem to persist and multiply, but so does the cost for remediation. Just as Brand wrote, we must invest our souls into our buildings. If we are to invest our souls then these structures should be worthwhile, but to keep them worthwhile, they must be up-kept. A simple concept we struggle with to this day. Do we stop caring because when we believe buildings are no longer worth caring for or because they have outlived their design purpose? Brand suggests as he does so throughout his book to evolve our thinking, "A shift that minor could transform the way civilization manages its built environment – toward long term responsibility and constant adaptivity."[46] Brand does not mention the word sustainability in his book, but I believe this to be an extremely sustainable solution. When discussing sustainability we always imagine how we can make buildings sustainable when we neglect how we can make ourselves and mindsets sustainable.

Not only do we have to make a mental transformation, but a societal one too. Brand states: "A building is a huge investment, a black tarry pit of sunk costs, a trap and a prison. The job of scenario planning is to question whether a building is really needed at all and, if it is, to convert it from a potential prison into a flexible tool."[47] The key word here is "need". It is an ideal we need to return to if Brand's sequence is to be successful. This is a reflection of our consumerist society, the urge to want, before the urge to

46 Ibid., 210.
47 Ibid., 183

question what is really needed. This factor becomes dependent on the shift in thinking of building consumers.

We cannot discuss time without the component of age. Brand discusses the beauty age brings upon the built environment as well as the dejection. Unfortunately, it is not only a handful the charm of age encapsulates, but as well as the rest of the world according to Brand. So much so that we grasp it ever so tightly so that museums glass it up. For us buildings that age have become a commodity. Like perfectly ripened fruit, the buildings cannot be completely soiled so that they can barely stand on their own, but not so completely new that they lack character. This component of time is another tenet an architect must muster along with its many other caveats. Brand writes:

> Apparently the older a building gets, the more we have respect and affection for its evident maturity, for the accumulated human investment it shows, for the attractive patina it wears - muted bricks, worn stairs, colorfully stained roof, lush vines. Age is so valued that in America it is far more often fake than real…It seems there is an ideal degree of aging which is admired….Genuinely old buildings are constantly refreshed, but not too far, and new buildings are forced to ripen quickly.[48]

It is this "time" that provides a value to our buildings, but only in certain regards. The building must have aged gracefully and cannot be too disheveled, in that large amounts of "time" also linked with monetary value would have to be placed in restoration. It must be the right amount of old so that it is still functional. Brand questions "How does design honestly honor time?"[49] Brand proposes another transformation in thought and the architectural methods of time, "With that perspective in mind, it is possible to rethink perspective forward and to imagine designing buildings that invite adaptation. Doing it right requires an intellectual discipline that doesn't yet exist.

48 Ibid., 10.
49 Ibid., 11.

The study is worth undertaking because, more than any other human artifact, buildings excel at improving with time, if they are given the chance."[50]

With this in mind, we should imagine that buildings grow better as they age, reversing the system so that old age becomes unrelated from decrepitness to that of exuberance. Buildings become better with age like wine. If this were the case, would this not make them worthwhile? Adopting this attitude could redeem the exorbitant cost for building a building especially if we knew that eventually we would obtain a better building for our money. I believe with this strategy we could create buildings like caterpillars. Caterpillars although young still contain beauty, but they cocoon themselves and grow, and ultimately become more graceful butterflies. Could this system work for buildings? Brand reminds us that to succeed in aging and with time there must be adaptability: "Age plus adaptivity is what makes a building come to be loved. The building learns from its occupants, and they learn from it."[51] A symbiotic relationship is paramount.

The 7 sequences and scenario planning process has yet to reach its greatest potential. I support Brand's ideals of scenario based design and believe that this unexplored territory is an adventure that needs exploring in both professional practice and design school. His 7 layers study although in text appears sound, arises in many more questions and qualms. How can we follow this method and come up with simply more than an open ended box? This is always the true challenge of design. Adapting this methodology to our current building system is a huge feat that would need an army of architects to support such a shift in an "age" old system. It would need to shift the minds

50 Ibid., 11.
51 Ibid., 23.

of not only designers, but clients and contractors. What is the real feasibility of a method such as this?

Brand wrote How Buildings Learn in 1994, but it could not be more prevalent now. These are the days of extreme population growth, city expansions, and dwindling natural resources. Would this system allow us to build less? Could we potential remove ourselves from the business of building if we design infinite standing structures that fulfilled ones every need? Would this system eventually make architects obsolete? Will Brand's seven steps lets us bypass this idea of age, so that buildings do not age through time, but simply imprint themselves for our ever-changing uses?

What is most perplexing in this reading is the recollection of the future. Does the future become a driving force behind the birth of a building and if so is it because we are trying to avoid making cheap ugly buildings? Why is the future of pre-existing buildings such as cathedrals sanctified and without question? Is it because they are already beautiful? Besides their longevity and appearance what makes them more important than others such as a gas station?

Lastly, although Brand makes many broad gestures, he provides a plethora of substance to support himself. The substance is not only that of an architectural standpoint, but from an assortment of topics such as historic preservation to ecology, economics, environmental science, and systems.

3.3.2 David Orr - Architecture, Ecological Design, and Human Ecology

David Orr writes in Architecture, Ecological Design, and Human Ecology about

the founding principals of ecological design. Ecological design is more than a theoretical system, but a design practice, and mindset for living lightly and in unison with nature and our planet. Ecological design is as much about design as it is about intentions. It questions how the design of a building will fit and function in the overall fabric of a city and its community.

First and foremost we must think of a building as not just a building but a smaller cog in a bigger machine. Architecture and design is more than a tool to build, but a tool for change in shaping the world around us and our experiences in it. Orr writes, "….buildings that contribute greatly to traffic congestion, poverty, climatic change, pollution, biotic impoverishment, and land degradation."[52] Ecological design should be used to counteract these current flaws in the design system. Ethics and pedagogy become important factors that need revamping. It is important to note that ecological design is not architecture, but architecture is an input of ecological design. Orr also recognizes that our intentions of the Industrial Revolution highly effected our ecological systems. This was not the intent of the Industrial, but now we have let it run rampant, Orr writes, "We intend one thing and sooner or later get something very different. We intended merely to be prosperous and healthy but have inadvertently triggered a mass extinction of other species, spread pollution throughout the world, and triggered climatic change – all of which undermines our prosperity and health."[53] Orr suggests that these problematic outcomes are proof of design failure:

> The possibility that ecological problems are design failures is perhaps bad news because it may signal inherent flaws in our perceptual and mental abilities. On the other hand, it may be good news. If our problems are, to a great extent, the result of design failures the obvious solution is

52 Orr, "Architecture, Ecological Design, and Human Ecology," 15.
53 Ibid., 16.

> better design, by which I mean a closer fit between human intentions and the ecological systems where the results of our intentions are ultimately played out.[54]

By better design Orr does not mean designing more beautifully, but designing more wisely with specific intentions at hand. Orr also stresses the importance of imminent change. With the expeditious population growth and depletion of resources we are running out of time and need to choose a new more discerning course.

With this in mind ecological design is not only an option, but a necessary need. Throughout this thesis I have called for a reassessment of design systems, Orr calls it ecological design. Ecological Design is defined as, "any form of design that minimize(s) environmentally destructive impacts by integrating itself with living processes…the effective adaptation to and integration with nature's processes."[55] It is important to note here, that ecological design is not just about mimicking natural processes, but about integrating with them. Ecological design also encompasses, "…a fundamental revision of thinking and operation. Good design does not begin with what we can do, but rather with questions about what we really want to do. Ecological design, in other words, is the careful meshing of human purposes with the larger patterns and flows of the natural world and the study of those patterns and flows to inform human actions."[56] Today we are out of touch with nature, because we have tried to control it and blockade ourselves from it for far too long, if we take time to listen and observe our interactions with it, we can begin to mend the error of our ways.

Other factors that are included in ecological design are politics, culture, and

54 Ibid., 16.
55 Ibid., 21
56 Ibid., 21.

economy. We cannot have change without also changing these factors for so much of our living is rooted in these pediments, "A real design revolution will have to transform human intentions and that larger political, economic, and institutional structure that permitted ecological degradation in the first place."[57] Intentions must be made clear from the beginning, Orr puts it best, "…without intending to do so, we are creating a world in which we do not fit."[58] The intention of the Industrial Revolution was not mass degradation of the planet it was to be able to provide goods and services to a wide-span group of people. The environmental and human harm of the Industrial Revolution were results of intentions that had not been considered.

There are 6 guiding principles that make up ecological design:

1. Designing with Ecology in mind. Ecology therefore is an intention and a questioning of, "…how to make things that fit gracefully over long periods of time in a particular ecological, social, and cultural context."[59]

Ecological intentions include:

a. Preserving diversity both cultural and biological
b. Utilizing current solar income
c. Creating little or no waste
d. Accounting for all costs
e. Respecting larger cultural and social patterns
f. Keeping complexity, diversity, and non-linearity

2. Design with community in mind and this includes a move away from consumerist behavior and toward, "how to make decent communities in which people grow to be responsible citizens and whole people who do not confuse what they have for who they are."[60] In this case design with a new society standard in mind, one that moves away from the assignment of importance based on goods and commodities, but where nature and environment have a greater value and priority.

57 Ibid., 23.
58 Ibid., 25
59 Ibid., 26.
60 Ibid., 27

Orr suggests asking ourselves these questions:

a. How can we do the same old things more efficiently
b. Do we need it?
c. Is it ethical?
d. What impact does it have on the community?
e. Is it safe to make and use?
f. Is it fair?
g. Can it be repaired or reused? Is it worth repairing?
h. What is the full cost over its expected lifetime?
i. Is there a better way to do it?

This series of questions beckon the integrity of design for, "…good design solves for pattern" thereby preserving the larger patterns of place and culture and sometimes this means doing nothing at all."[61] We must emphasize the need based on degrees of desire, want, and necessity.

3. Intentions of politics / policy / power are just as important as intentions of ecology from principle 1. These are all included in matters of design, "At the heart of design, then, are procedural questions that have to do with politics, representation, and fairness."[62] It is important that everyone partakes in the design and that all have a voice and opinion.

4. Intention of Inclusions and a replacement of the individual for the greater good of the whole. Orr describes this principle as an "ongoing negotiation".

Open discourse not only between humans, but ecology and the environment is imperative. What is most important about this principal is the addition of accountability, "Good design results in communities in which feedback between action and subsequent correction is rapid, people are held accountable for their actions, functional redundancy is high, and control is decentralized. In a well-designed community, people would know quickly what's happening and if they don't like it, they know who can be

61 Ibid., 27.
62 Ibid., 27.

held accountable and can change it."[63] With accountability comes the idea that to be accountable the range of the community must be limited to that of locality. Building accountability also deems responsibility. One can only feel responsible when they have direct access to their means. It only makes sense that ecological design is one that is comprised of accountability, locality, and responsibly are linked. The idea that one is connected to what is happening in their community also provides and attitude of care and connection. When someone endears something they generally value it, by moving back to the locality of place one begins to re-root themselves into a place that they care, value, and love. One also has the opportunity to learn their locale and understand its strengths and limits of what it can heed, reap, and sow, as Orr describes it, "…an ongoing negotiation between community and the ecology of particular places."[64]

5. Intention of health through both human and environment, "…the standard for ecological design is neither efficiency nor productivity, but health, beginning with that of the soil and extending upward through plants animals and people."[65]

Health is just another system in the overall makeup of ecological design, "Ecological design is an art by which we aim to restore and maintain the wholeness of the entire fabric of life increasingly fragmented by specialization, scientific reductionism, and bureaucratic division…this means that ecological design must be done cautiously, humbly, and reverently."[66] It is also about an attempt at taking a holistic approach to all angles of life.

6. It is not a set of skills that can be marked on a checklist, but it truly is a style of life and agreement we make with ourselves, to each other, and our planet.

It may seem that these principals at first glance are more like an unattainable Eden than a

63 Ibid., 27.
64 Ibid., 27.
65 Ibid., 28.
66 Ibid., 28.

reality, but Orr truly states it best,

> …the goal of ecological design is not a journey to some Utopian destiny, but is rather a homecoming... For all of the technological accomplishments, the twentieth century was the most brutal and destructive era in our short history. In the century ahead we must chart a different course that leads to restoration, healing, and wholeness. Ecological design is a kind of navigation aid to help us find our bearings again. And getting home means remaking the human presence in the world in a way that honors ecology, evolution, human dignity, spirit, and the human need for roots and connection.[67]

We must return to a system that once worked, and this is what Orr refers to as home

Many tenets of ecological design can be seen in alternate theoretical systems thinkings such as William McDonough's closed loop system and cradle to cradle theories as well as Paul Hawkins, Amory Lovins, and L. Hunter Lovins Natural Capitalism as well as the ideals of Permaculture and Biomimicry. Each of these systems has its own voice about what should be done, bending and skewing in different ways. The next theory discussed is Natural Capitalism, which one can guess from the title leans more towards a standpoint of nature and economy than that of ecological design, but nonetheless echoes many of the same principals.

3.3.3 Paul Hawken - Natural Capitalism

This thesis attempts to incorporate a selection of tenets from the ideas of Natural Capitalism, a theory conceived by founder of the Natural Capital Institute Paul Hawken and founders of the Rocky Mountain Institute Amory B. Lovins and L. Hunter Lovins. Natural capital is defined as, "…all the familiar resources used by mankind: water, minerals, oil, trees, fish, soil, air, et cetera. But it also encompasses living systems, which

67 Ibid., 29.

include grasslands, savannas, wetlands, estuaries, oceans, coral reefs, riparian corridors, tundras, and rainforests."[68] The theory of Natural Capitalism is the thinking or belief that it, "...recognizes the critical interdependency between the production and use of human-made capital and the maintenance and supply of natural capital."[69] Natural capitalism has the best interest of our planet at its heart, in hopes to maintain all that makes our world beautiful. In this beauty, the plants, our soil, air, trees, and ecosystems are the answers to living our greener world.

To have a working economic system we need these four types of capital to function:

Human capital
Financial capital
Manufactured capital
Natural capital

The flaw in our economic system currently is that we use all of our natural capital to produce the other three without a feedback loop in the system to replenish it. For years we have been consuming natural capital at a much faster rate that it can restock itself. The industrial system omits natural capital and treats it as a singular system, one that moves in only one direction, that of depletion. It is missing the most vital step in that it must also cultivate our natural capital from which we gain everything we make and need, "The Industrial system uses the first three forms of capital to transform natural capital into the stuff of our daily lives: cars, highways, cities, bridges, houses, food, medicine, hospitals and schools."[70] We are not only exhausting our resources, but exhausting the natural systems that produce them. Depleting at a faster rate than they

68 Hawken, Lovins, and Lovins, *Natural Capitalism,* 2.
69 Ibid., 3-4.
70 Ibid., 4.

can be regenerated. Our production system is treated as a single stream system, but needs to become a symbiotic one, that works with our natural systems to reproduce our natural capital at a natural rate instead of an acrid one.

If there were ever a time for a sense of urgency it should be now. Natural Capitalism was published in 1999 and at this time Lovins' and Hawkins write,

> In the past three decades, one-third of the planet's resources, its "natural wealth," has been consumed. We are losing freshwater ecosystems at the rate of 6 percent a year, marine ecosystems by 4 percent a year. There is no longer any serious scientific dispute that the decline in every living system in the world is reaching such levels that an increasing number of them are starting to lose, often at a pace accelerated by the interactions of their decline, their assured ability to sustain the continuity of the life process. We have reached an extraordinary threshold.[71]

What is even more discerning is that it is now 15 years later and we are still waiting for a major change to occur.

Capitalism in itself is unsustainable, but how do you place a value on resources that are indispensable for life? The conundrum that we face with Natural Capitalism is how do we place a value on natural resources and without a value we are headed toward disaster, "It is clear, however, that behaving as though they are valueless has brought us to the verge of disaster."[72] For natural capitalism to be applicable it needs to approached with a simultaneous change in economic and ecological systems.

According to Hawken and Lovins' we have now taken the Industrial Revolution a step further. Instead of only spewing toxic chemicals into our atmosphere, water, and soil, we are now depleting the natural landscape with the ever evolving technology used to strip our earth down to its bedrock. This depletion is not accounted for when materials

71 Ibid., 4.
72 Ibid., 6.

are sold in our economy. Today our industrial process appears as so, "After richer ores are exhausted, skilled mining companies can now level and grind up whole mountains of poorer-quality ores to extract the metals desired. But while technology keeps ahead of depletion, providing what appear to be ever - cheaper metals, they only appear cheap, because the rivers, the impoverished villages and eroded indigenous cultures – all the consequences they leave in their wake – are not factored into the cost of production."[73] We have created a society of depletion and we are limiting ourselves by the systems we have created.

What is clear is that we need to take better care of the place that takes care of us. We are depleting more than trees from the rainforest for wood, but an entire system that provides water and air. It is much easier to take than it is to give. Selfishness is an innate human quality and one that we must overcome.

The ideals of natural capitalism are rooted in four main principles:

1. Radical resource productivity – radically increased resource productivity is the cornerstone of natural capitalism because using resources more effectively has three significant benefits. It slows resource depletion at one end of the value chain, lowers pollution at the other end, and provides a base to increase worldwide employment with meaningful jobs.
2. Biomimicry – eliminating the very idea of waste – can be accomplished by redesigning industrial systems on biological lines that change the nature of industrial processes and materials, enabling the constant reuse of materials in continuous closed cycles, and often the elimination of toxicity.
3. Service and flow economy
4. Investing in natural capital

What can be taken from Natural Capitalism is that it does not call for a complete

73 Ibid., 3.

return to the dark ages, but a return to conscientiousness. One of the four founding principles of natural capitalism is a focus on efficiency as a result a move away from waste production, "using resources more effectively."[74] Using all parts of a system instead of the most important ones. Becoming more efficient inadvertently automatically reduces waste and requires a more holistic thought for the end product.

3.3.4 Cradle to Cradle

Discussed in both Natural Capitalism and Ecological Design is the idea of the closed loop system. This idea was originated by William McDonough and Michael Braungart already mentioned earlier in this thesis. They strongly champion a redesign of the way in which we make things and call for system design which improves our lives rather than destructs them. McDonough and Braungart envision a future in which, "buildings that, like trees, produce more energy than they consume and purify their own waste water…(to)…transportation that improves the quality of life while delivering goods and services."

Cradle to cradle is not a new concept it is an origin, the origin of our world and its natural system. David Orr calls for a return home in his theory of Ecological Design and McDonough does too with cradle to cradle, "If humans are truly going to prosper, we will have to learn to imitate nature's highly effective cradle to cradle system of nutrient flow and metabolism in which the very concept of waste does not exist. To eliminate the concept of waste means to design things – products, packaging, and systems – from the very beginning on the understanding that waste does not exist."[75] They suggest

74 Ibid., 10.
75 Ibid., 54.

a founding of a new understanding or design guideline that if it cannot be reused or decomposed than it should not be made.

> Similar to Ecological Design McDonough calls for a return to place. As well as a call to the local and connection to place, because being sustainable can only succeed when it is local, "…It means that in the course of our individual activities, we work toward a rich connection with place, and not simply with surrounding ecosystems; biodiversity is only one aspect of diversity. Industries that respect diversity engage with local material and energy flows, and with local social, cultural, and economic forces, instead of viewing themselves as autonomous entities, unconnected to the culture or landscape around them...We begin to make human systems and industries fitting when we recognize that all sustainability (just like all politics) is local. We connect them to local material and energy flows, and to local customs, needs, and tastes, from the level of the molecule to the level of the region itself.[76]

Just as in Ecological Design, a connection with place is imperative. One must foster a relationship not only with the environment, but the place they dwell for any of these systems to be successful. One cannot be sustainable if they do not live locally.

The most important ideal of Cradle to Cradle is the closed loop system, in which nothing is wasted not even waste. McDonough calls this phenomenon, waste = Food in which, "nature operates according to a system of nutrients and metabolisms in which there is no such thing as waste."[77] He even sheds light on humans giant capacity to waste and need to quit this habit, "humans are the only species that takes form the soil vast quantities of nutrients needed for biological processes but rarely puts them back in usable form. Our systems are no longer designed to return nutrients in this way, except on small, local levels."[78] If there is any tenet that should imprint in ones mind after reading this is the necessary need for change and that waste is not the enemy the human race is.

76 Ibid., 122-3.
77 Ibid., 93.
78 Ibid., 96.

CHAPTER 4
SITE AND CONTEXT

4.1 Palmer, MA

Palmer is small town in Western Massachusetts in the county of Hampden. It is bordered by Ware and Belchertown to the North, Ludlow and Wilbraham on the West, Monson on the South, and Brimfield and Warren on the East. Palmer's origins are that of an agricultural one between the times of 1716 and 1775. It began as a farming community, but due to its ideal location at the crossings of four major rivers including, the Chicopee, the Quabog, the Ware, and Swift River it was tapped for its hydroelectric power during the boom of the Industrial Revolution of the 19th century. The mills in the area manufactured mostly cotton goods and straw hats between the 1870s and 1915, "The mills caused Palmer's population to grow to a peak of 11,044 in 1925, but fell off after 1925 when the mills began to decline, close, and consolidate."[79] Soon after, the town picked up again during the first half of the twentieth century with the novel production of carpet and wire. Three textile mills were erected and Palmer transitioned into a manufacturing hub. The mills were not the only new technological institution

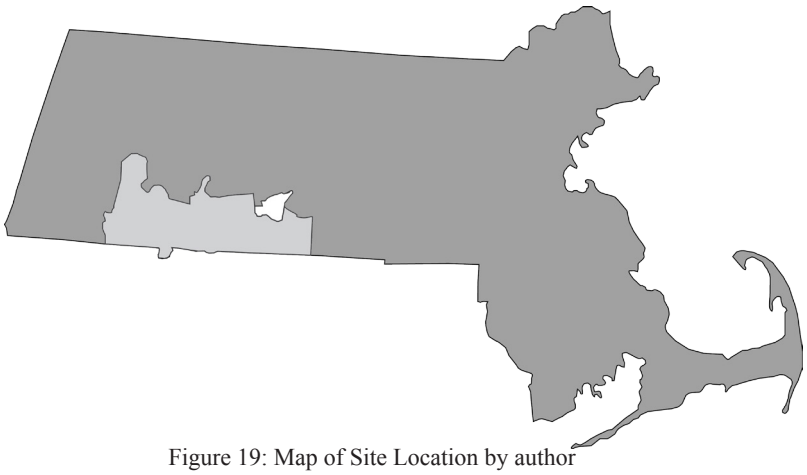


Figure 19: Map of Site Location by author

79 Palmer Reconnaissance Report, June 2009.

that allowed for the towns growth, but the addition of the railroad line introduced ease of transportation through and to and from the town. Palmer grew so much that it was divided into four separate villages known as and still existing today as Depot Village, Bondsville, Three Rivers, and Thorndike.

Palmer once a bustling hub of production and innovation, today rests desolate and in shambles. With the gradual closing of the mills through the 1950's until 1980 the town lost its economic zest and in its aftermath left a majority of its residents jobless. Apart from the textile mills there was no other industry associated with Palmer after having lost its agricultural roots. Today Palmer has a population of 13,300 with about 66 percent of its constituents commuting out of Palmer to work. Due to its ideal location adjacent to the highway and rail lines there have been proposals to convert the town into Casinos or racetrack centers. This would be a shame for, "Palmer, with its four villages Thorndike, Bondsville, Three Rivers and Depot Village, accrues up to 20,946 acres of land. Of those acres, 14,261 are undeveloped, and 3,110 are in residential use. Agriculture continues to be practiced on 1,296 acres. This means that Palmer has concentrated areas of dense population, but the town has large expanses of woodland, and open space, and river landscape within its borders."[80] Palmer is a place of untapped potential and can become so much more than a facility for betting and gambling.

Today, Palmer rests 1.5 miles from the Massachusetts turnpike I-90 and is a town that many "pass through" to reach the highway. It also sits amidst an intersection of routes that include 32, 181, 67, and 20 that run in every direction. Due to lack of infrastructure it is not a destination that many tend to stop on their travels, but could be

80 Palmer Reconnaissance Report, June 2009.

with the introduction of a new program. Palmer has plenty of potential it just needs the right program for revitalization.

Figure 20: Thorndike Granite Mill 2. Palmer Reconnaissance Report

4.2 Thorndike Mills, 4145 Church Street

The site chosen is situated in the village of Thorndike in Palmer, located at 4145 Church Street. This site is also known as the Thorndike Mills. The village of Thorndike is the smallest and most residential in nature of the four villages that make up Palmer. The village of Thorndike originally had two granite mills located along the banks of the Ware river, but unfortunately granite Mill 1 was destroyed by a fire in the early 80's and no longer exists. This thesis will focus on the adaptive re-use of granite Mill 2 and its surrounding location.

This site was specifically chosen for the lure of granite Mill 2 and its important historical significance. During the 1900s, granite Mills 1 and 2 were responsible for providing over 600 jobs as textile manufacturers. Later on in the twentieth century the

mills became the Diamond International Company, in charge of producing paper based egg cartons and employing over 200 people. With the din of the mills, Thorndike as well as Palmer brimmed with ado. Mills 1 and 2 rest on two major roadways of Thorndike and are adjacent to the once bustling "downtown". The downtown of Thorndike once consisted of a variety of markets, a café/tavern, ice cream shop, post office, church, and grade school, but with the closing of the mills came the end of the downtown. Today it remains mostly vacant and grim with little economic stimulus apart from a lone bakery, liquor store, post office, and pub.

An asset to the site is its prime location due to the transportation that borders it on every side, "The Ware River centrally loops through the village and is the alignment along which the rail follows as it enters and exits Thorndike. The main access roads through the village center are Church and Main streets. High and Commercial streets traverse the opposing side of the river. There are two state highways passing through Thorndike. Route 181 traverses over the Ware River at the western edge of the village and route 32 pass though the eastern side of the village within a quarter mile of the subject site."[81] Due to the sites central locality amid a plethora of integral transportation routes, introducing a new program into the site could draw in visitors simply by its convenient location. With a new program Palmer could become a destination rather than a shuttle route to the highway.

Mill 2 sits on 5 acres of land and has a series of 9 buildings each in different states of disrepair. Mill 2 is the oldest building on site and was constructed in 1845-46 and structurally is in great condition. The nine buildings account for over 100,00 SF of

81 http://www.wmaia.org/Live%20Files/Competitions/Smart%20Growth%20Competition%20Publication%20Final.pdf

Figure 21: Site Plan for 4145 Church Street, Palmer MA by author

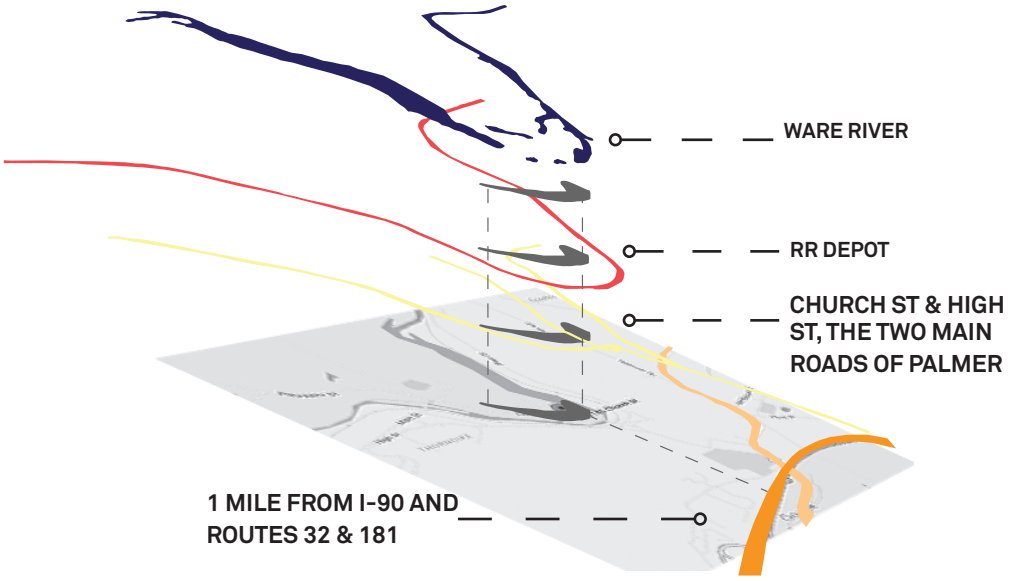


Figure 22: Diagram of Transportation around Site, by author

viable space. Today, the site is owned by Thorndike Energy LLC who use the site for its hydropower. The site contains 4 generators that still produce all the power for the site as well as extra power that is sold back to the national grid. Presently 80 percent of the 9 buildings remain vacant and idle deteriorating and wasting away. With the right program the site and the structures have the capability to become active and vibrant characters in the fabric of the town.

As discussed in Chapter 1, 97 percent of our waste is industrial waste. This site was chosen for its opportunity to be reused and therefore, omitting contribution to the 97 percent. With reuse we are also eliminating the use of new materials that simply in their creation and transportation to site use enormous amounts of natural resources and emit tons of carbon dioxide. A key to restoring our environment is to use what we have and

this site provides the perfect vessel for just that. Directly across Church Street is another pocket of land that contains 6 acres and a small brick building. This is also part of the site as it was once home to the upper granite Mill 1. In sum, the site has 11 acres of land and 100,000 SF of designable space.

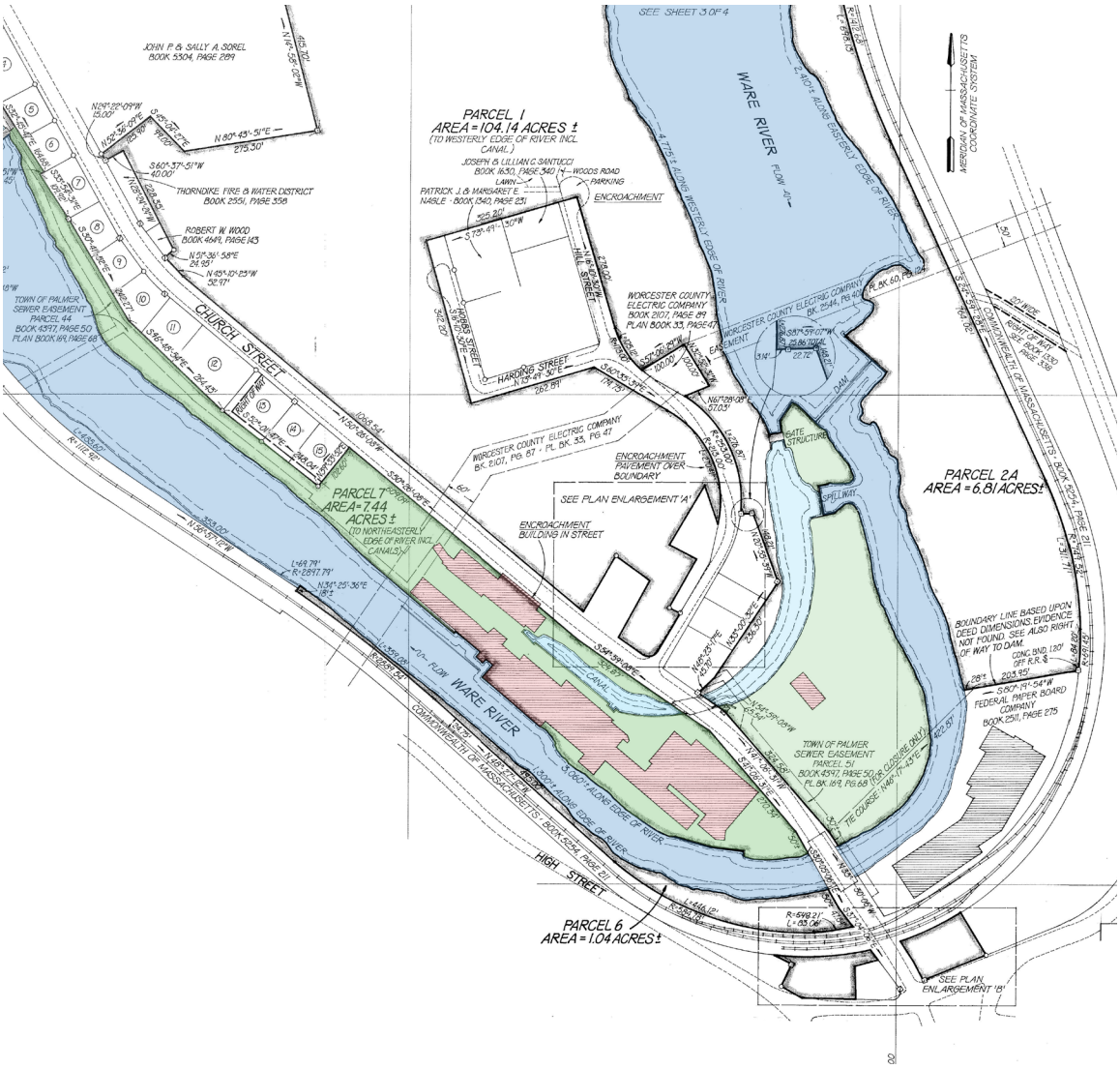


Figure 23: Highlighted Site within greater context of town, by author

CHAPTER 5
PROGRAM

5.1 Design Intentions

The design portion of this project is meant to serve as an example or sample community that can be designed in a small sub context of a city, to demonstrate that with the ideals of systems thinking discussed in Chapter 3 and the implementation of both thinking and physical systems a cradle to cradle and closed loop system can be achieved. Although the project is hypothetical it serves as proof that a change is possible even when at times the problem of our waste can seem insurmountable. The intention of the project is to identify waste streams and put systems in play, to use waste to better the site, the programs, and the people who are main actors in the systems.

There are four essential programmatic components that drive both the design and the sub-programmatic elements. As stated before the design component of this thesis is to set an example of the way systems, systems thinking, and design when brought together can create a holistic system that improves the environment and quality of life of its inhabitants. With this in mind the four driving programmatic components are, waste, systems, education, and living. In Figure 24, the programmatic diagram demonstrates how these four components bring together all nine buildings as well as the 11 acres of land. Each building has an individual program, but are all connected by one component, waste.

Waste is the first of the four major components and is the one in which all other components of the site function. Waste is defined in this project as anything that is a result of systems and activities on site. Based on sub-programmatic elements' outputs

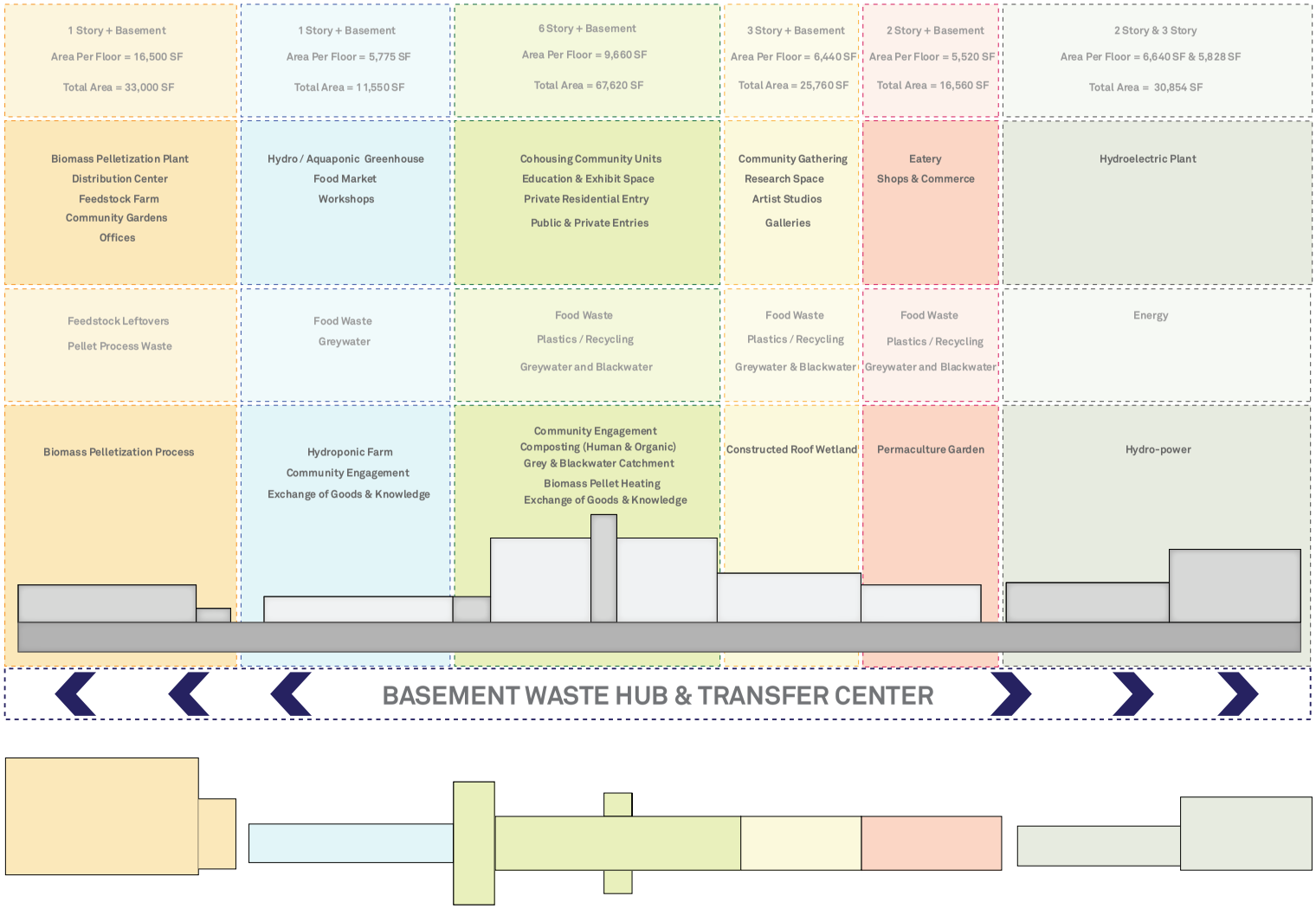


Figure 24: Program Diagram, by author

of waste streams were discovered and therefore drove the systems that were designed on site. To determine more specifically the exact waste streams and systems particular sub-programmatic elements were put into place, the first being that the site would function as a micro-community within the village of Thorndike and the town of Palmer. The micro-community is designated as self - sustaining. In keeping in mind tenets from the literature review, Ecological Design suggests returning to local governance. By becoming self sustainable,the inhabitants and town take control of their own waste output. To accompany the self-sustaining community is a cohousing component that will live on site and monitor the growing of food and gardens and keep the self-sustaining system in order. Having residents live on site will further nurture and strengthen the relationship between humans, place, and earth.

A hope for this project is that with the addition of a new program and the enlivening of space would inadvertently draw the community in. The site would then foster a relationship with the town and enrich its citizens. The site would also grab the attention of people driving through to stop and stay awhile, therefore further invigorating Palmer out of its dormant state.

5.2 Bioenergy

Electricity is already being generated on site in the building coded in gray, but heat is not. To be self sustaining means moving away from using conventional resources of fossil fuel for heating and electricity. Since the site is already generating its own electricity it should do the same for heat. The system that is put into action here is bioenergy. Bioenergy is defined as, “The renewable energy derived from recently

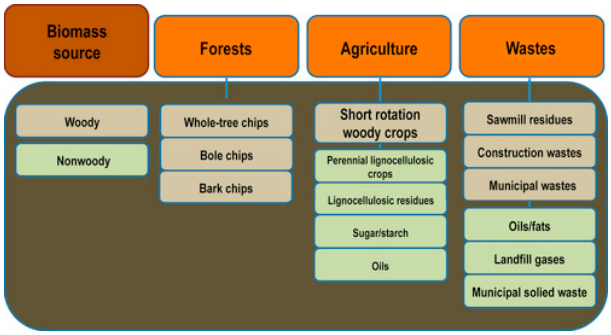


Figure 25:Biomass Options. Image from *Bioenergy: Biomass to Biofuels*

living biological material called biomass."[82] The 6 acres of land across from the site is designated for the growing of plants and vegetation specifically biomass to turn into pellets that would then be burned in a furnace to generate heat on site. Biomass is defined as, "an energy resource derived from organic matter."[83] There are many different sources that can be used for biomass to generate bioenergy in this case wheat grass and sorghum were chosen for the production of on site energy. In reality, a diversity of feedstocks can be harvested for bioenergy and in many cases leftover organic food waste can even be used as a biomass for bioenergy. Bioenergy as a system although not perfect yet, emits significantly less carbon dioxide than typical fossil fuels, "Bioenergy is a form of renewable energy because the energy contained in biomass is energy from the sun captured through natural processes of photosynthesis. As long as the quantity of biomass used is equal to or less than the amount that can be regrown, it is potentially renewable indefinitely."[84] This is only one of many systems that are active on site.

The economic upside of creating pellets is that it harbors new employment opportunities for the citizens of the town of Palmer. Pellet production would also

82 Anju Dahiya, *Bioenergy: Biomass to Biofuels* (Waltham, MA: Academic Press, 2015). http://proquestcombo.safaribooksonline.com.silk.library.umass.edu/, Chap 1.
83 Ibid., Chap 1.
84 Ibid., Chap 2.

establish a new relationship with the town and foster an exchange between micro-community, town, and environment. If enough pellets could be produced not only the site but the town of Palmer could become fossil fuel independent. This would simply entail gradually replacing all buildings with a pellet furnace. This system of bioenergy also begins to build a new relationship with the land and influences a return to Palmer's agricultural roots. One begins to see the system at hand as they grow their own energy. The site has always been a center for manufacturing and with this program it reintroduces the component, but in a much more eco-friendly fashion. It is an innate characteristic of the site to produce and has proven in the past to be successful, in this case the parameters of the original system are being altered so that the inputs and outputs are much more ecologically aligned, but the function of production remains the same.

Figure 26: Pellet Production Plant. Image by author

Figure 27: 6 Acre lot that would be used for growing the biomass. Image by author

The pellet production would take place in the building coded in orange in Figure 24 and seen above in Figure 26. Right now, it exists with two floors, but the new design would remove the first floor and leave the building to be completely open for

the production and transferring of pellets from place to place on site and from place to town. By bringing fossil fuel independence to a site and demonstrating the way it works allows the town and visitors to see that there are other options for alternative energy. The leftover ash from burning the pellets can later be used in compost on site and ultimately close the system loop of heat and energy production.

5.2.1 Case Study - Gateway Center - SUNY ESF College of Environmental Science & Forestry

Fossil fuel independence is not as unachievable as one might imagine. On a similar scale to this thesis, the Gateway Center at SUNY ESF College of Environmental Science & Forestry in Syracuse, NY has already achieved what is being proposed above with bioenergy. Although it is not an adaptive reuse project it does have many similar constraints seen in this thesis.

Figure 28: The Gateway Center at SUNY ESF. Image courtesy of AIA.org

Completed in 2014 by firm Architerra, the Gateway Center replaced a latent parking lot to become, "...a symbol for environmental stewardship."[85] The Gateway Center totals 54,000 SF and serves as a mixed use space with a conference facility, cafe, bookstore, and space for students and public gatherings. The building was built as a response for the want to achieve campus climate neutrality and to prune a culture of sustainability and environmental awareness within the faculty, students, and community. Where it most parallels the design portion of this theses is the addition of a district energy plant that resides in the basement of the building. The plant is a 7,000 SF combined heat and power plant that is interconnected with four other adjacent buildings.

The Gateway Center resides on a 15 acre campus that is now completely run on biomass. The plant is fueled by waste in the this case a biomass of wood pellets from a nearby forest in Syracuse. This thesis proposes exactly this, but with a different feedstock component. The plant provides 60 percent of the annual campus heating needs and 20 percent of its annual power needs. The power plant also functions on a myriad of other systems, including the harnessing of natural gas, biodiesal, solar photovoltaics, and

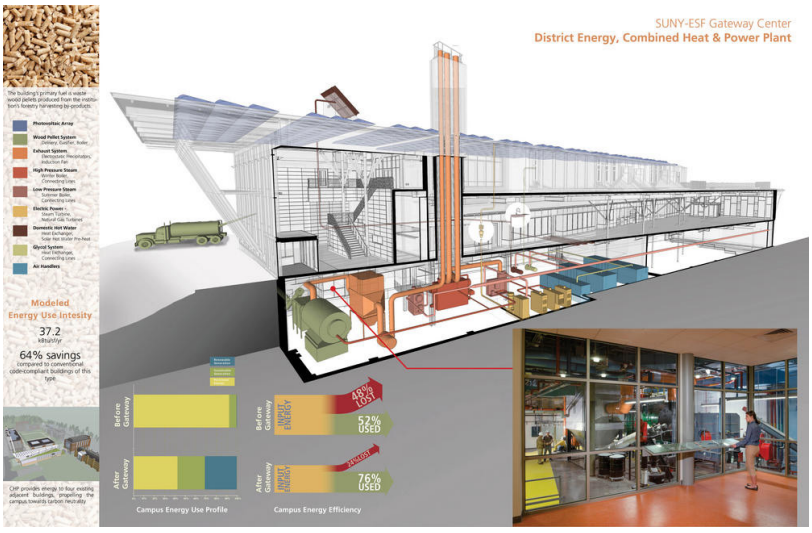


Figure 29: Diagram of Power Plant inside the Gateway Center. Courtesy of AIA.org

85 "Gateway Center, SUNY ESF," http://www.aiatopten.org/node/336.

solar thermal energy all in the aims of energy efficiency. The Gateway Center is a perfect example of a diversity of systems working together and separate, but also in unison towards one common goal.

The aim of the power plant's location in the basement of the welcome center is to educate students and the public and to put energy and waste on display, "All system components are visible identifiable, explained and celebrated."[86] The building is a destination and one that is not only a power plant but a multi-use facility that is

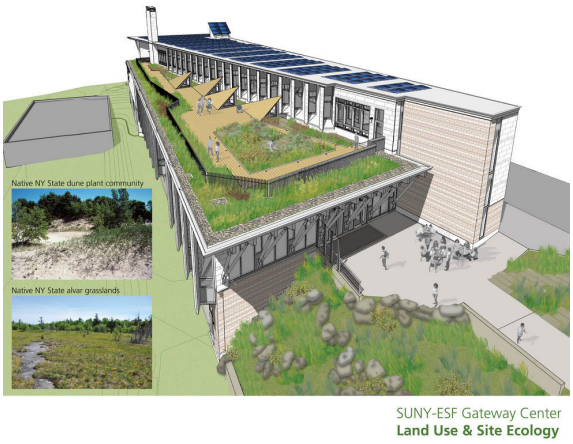


Figure 30: Green Roof of the Gateway Center. Courtesy of AIA.org

Figure 31: Green Roof of the Gateway Center. Courtesy of AIA.org

aesthetically appeasing. When one imagines a power plant one normally does not envision a place that we want to spend copious amounts of time, and the Gateway Center has done the exact opposite. Since the center is part of a university it utilizes the visibility and accessibility of the power plant to teach classes as well as various outreach programs for education about bioenergy and the environment.

86 "Gateway Center, SUNY ESF."

Figure 32: Exterior View of the Gateway Center. Courtesy of AIA.org

The Gateway Center is also a great example of how to reintroduce greenery to a once predominately paved site. The building reduces the previous impervious area by over 50 percent, turning a parking lot into a stunning natural habitat. The Center has a 10,000 SF green roof that reinstitutes native plant species back into the site. Rain gardens border both the north and south ends of the site, a continuous tree trench lies to the east and all of these systems direct and clean the flow of water in, through, and around the site. Most importantly are all meant for study and education as seen with the power plant. If one studies this building they will find an amalgamate of systems at play, with each other, individually, and ultimately under a common whole for bettering the environment.

The scope of the Gateway Center is much like this thesis's intentions, especially in making the architecture cohesive with the system it houses and in making the building, nature, and education a priority. Although the project is not 100 percent fossil fuel free yet, it is making great strides in the right direction. With this one power plant the campus has already reduced its carbon emissions by 25 percent. This project most importantly

reminds us that architecture and systems can be aesthetically beautiful, function successfully, and demonstrates that we do have options for our future.

5.3 Other Systems on Site

New systems of production are also being enacted on site with the addition of a hydroponic farm in building marked in blue as well as permaculture gardens over on the northwest corner of the site. Hydroponic farming is defined as the process of growing plants in sand, gravel, or liquid, with added nutrients, but without soil. Hydroponic gardening has a high yield rate when growing vegetables and fruit, but one caveat is the sensitivity of the system. The growing environment is very temperamental and needs to be highly regulated, monitored, and controlled. Although for many this can be viewed as a setback, being able to grow indoors allows for food production year round even during the brutal winter climate of New England. Hydroponics is a closed loop system and becomes another sub system working on site as part of the greater whole.

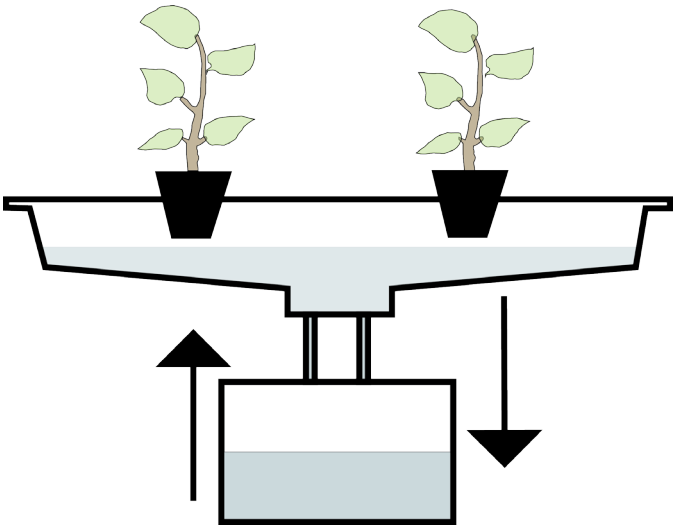


Figure 33: Diagram of Hydroponic System, by author

A second programmatic element in this building is the addition of a food market to bring the outside community onto site. The market would be held in the same building as the hydroponic garden so that upon visiting, the hydroponic system is on display and the possibilities of growing are demonstrated. Growing food on site eliminates the use for shipping and trucking ones vegetables across the world therefore reducing carbon dioxide polluting the atmosphere. This system is "green" because it is local, but one also has the luxury of knowing where their food has originated and in what way it was grown. This also reduces the risk of ingesting extra poisonous pesticides and hormones that riddle much of our produce today.

The vision for the entire site is to put into full range an exhibit of different ways to grow and reconnect with site, land, and nature, as well as demonstrate that growing can occur in many environments. It is also to show that growing can be achieved in just about any way, from a small plot of land in your yard to your kitchen window. By allowing the systems to be viewed while they are in action contributes to the education component of the program, in this case seeing is believing. The constraint to produce food on site was chosen as a tool for reconnecting us with place. The idea that the community living on site would tend to their own food would bring an awareness to all that occurs at this location. It is also a tool to inform eduction to future generations. The living component will be discussed further on in the paper, but it is important to note that the families and persons that choose to live in the cohousing community will have a common investment in the site, their land, and the importance of raising future generations to do the same:

> When we design ecologically, we are instructed continually by the fabric of everyday life - pedagogy informs infrastructure which in turn informs us. The growing of food on local farms and gardens, for example, becomes a source of nourishment for the body and instruction in soils,

> plants, animals, and cycles of growth and decay. Renewable energy technologies become a source of energy as well as insight about the flows of energy in ecosystems. Ecologically designed communities become a way to teach about land use, landscapes, and human connections. Restoration of wildlife corridors and habitats instructs us in the ways of animals. In other words, ecological design becomes a way to expand our awareness of nature and ecological competence.[87]

This site would be a place where children grow up knowing the land. A mutual respect is formed, because they have a grounded relationship to the earth. Overtime this knowledge becomes as natural as learning how to work a computer, innate. In a world such as this it would be an expectation that everyone has some degree of familiarity with the land and the inner workings of earths natural systems.

Other systems that are put into play in the series of buildings are related to dealing with waste that is produced by humans and leftovers from natural processes. These systems include gray and black water collection as well as composting of both human wastes and organic food wastes. The building denoted in green also referred to in Chapter 4 as the granite Mill 2 is the biggest on site as well as the one that has the greatest presence. It is centrally located and rises above the rest of the structures guarding and watching over the site. It will serve as the main collection unit of waste. It is also the building that has been designed in most detail, but will be discussed in the following chapter. This building along with the others all have basements that align as you can see in the program diagram (Figure 24). The basement will serve as the waste hub and transfer station for the entire site. Since the buildings are all connected by this space waste can be redistributed through opposite ends of the site. The basement of Mill 2 will house machinery for rain water and gray water collection as well as composters

87 Orr, "Architecture, Ecological Design, and Human Ecology," 30.

Figure 34:Figure 32: Image of Mill 2, by author

for composting toilets and pellet furnaces for heating. Sizing of these elements for the project were based on building occupation and a comparison to other buildings of relative size. In reality, the sizing and amount of machinery, pipe placement etc., would need additional engineering.

The composting of human excrement takes a longer time to process, up to a year, but once completed is another valuable resource to provide sustenance to the soil. Although at this time human waste is not used due to many government regulations and is yet another example of what we have deemed “bad” and “undesirable”, but is proven as a great fertilizer in enriching gardens especially fruit orchards. Just like organic food compost the human waste compost would be redistributed on site.

The building colored in yellow is adjacent to Mill 2 and contains a rooftop constructed wetland that would filter and clean the gray water from the basement of Mill 2. As it is filtered through the constructed wetland the water is cleaned and returned to its

natural environment, further draining to a permaculture garden growing below. Although at this point it is not recommended to use gray water on gardens that are growing food hopefully in the future as our water becomes pure again there will be less contaminates that linger to worry about it and gray water can be more often used in this manner. Other programmatic components include, community gathering space, research space, artists studios, and galleries.

Lastly, the building noted in red takes advantage of many of the systems that are active in the previous buildings. Programmatic elements include eatery and shops and commerce. The vision of the eatery is that of a farm to table system that uses the goods grown from the hydroponic greenhouse, that eventually get returned to the land. The shops and commerce element represents a specific type of business that would be housed. Entities that offer an exchange of knowledge and goods such as a bike shop that holds events to demonstrate to the public how to build your own bike with scraps. Other options include swap shops in which you trade goods for goods, and limit the amount of consumption and production of the new while forming bonds not only over knowledge but over friendship.

The programmatic components of both the yellow and red buildings work in tangent with each other. They do not house as many physical systems that one can see and touch, but are more about fostering community and the exchange of goods, services, and knowledge. These are all the invisible systems that work amongst the relationships of people and community. All of these different systems create a network of sub systems that are integrated into a larger more complex and diverse whole, for a full cradle to cradle system.

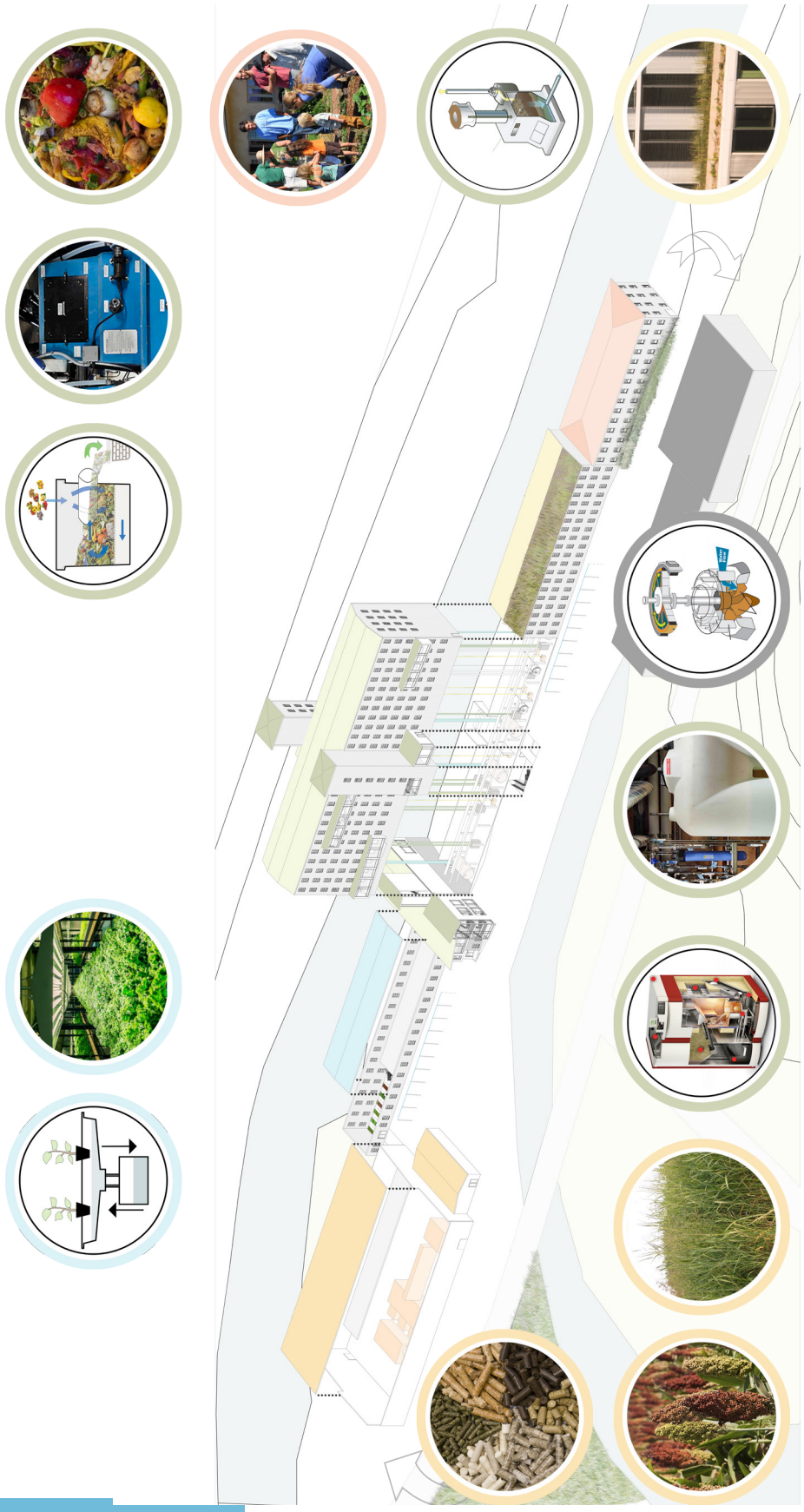


Figure 35: Diagram showing systems on site, by author

CHAPTER 6

DESIGN

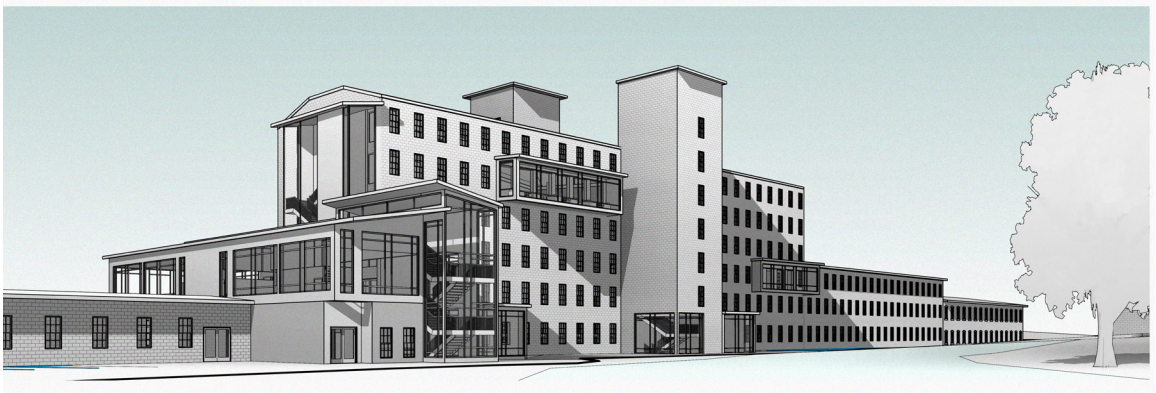


Figure 36: North Elevation of new building facade and entry. Graphic by author

The design segment of this thesis focused in most detail on Mill 2 with light design edits to the surrounding buildings. The idea was to use the space that the site had while limiting the addition of even more space to the building's footprint. The design intent for the Mill 2 building is to be the emblem of the site, with minimal facade alteration, but just enough to know that there was something new at hand. In conclusion, the design was implemented only after the waste and systems were discovered, decided, and designed. The final result of the design is reflected in the movement of systems both seen and unseen as well as a desire to form a strong connection with site, building, and land.

6.1 Cohousing Community and Design Integration

Living is one of the four programmatic components emphasized in Chapter 5, but was briefly discussed. The living component of the program is intimately intertwined with the design of Mill 2 and is important not only within the entirety of the site, but even

more so within the buildings function.

Mill 2 is 67,620 SF with 9,660 SF per floor with six floors and an additional basement. The top three floors, 6,5, and 4, function as living space for the cohousing community and floors 3,2,1,and Basement are exhibit space for waste education. Cohousing communities are ideal for a waste and environmentally conscious program such as this because the site is rooted in the idea of a coming together both of people and nature. Cohousing communities strive to instill a network of support between its members which range from families to individuals of all ages. They are also centered around the ideal that the members take ownership and aim to enrich their environment. This aligns with many of the systems thinkings discussed in Chapter 3. The proposed cohousing community can accommodate up to 45 persons within this site. The type of lifestyle chosen for the site and design was important, because it needed to be in balance within these systems and ideals. A cohousing community was chosen because it will not wrinkle the natural movement of the systems put in motion, but blend harmoniously with them.

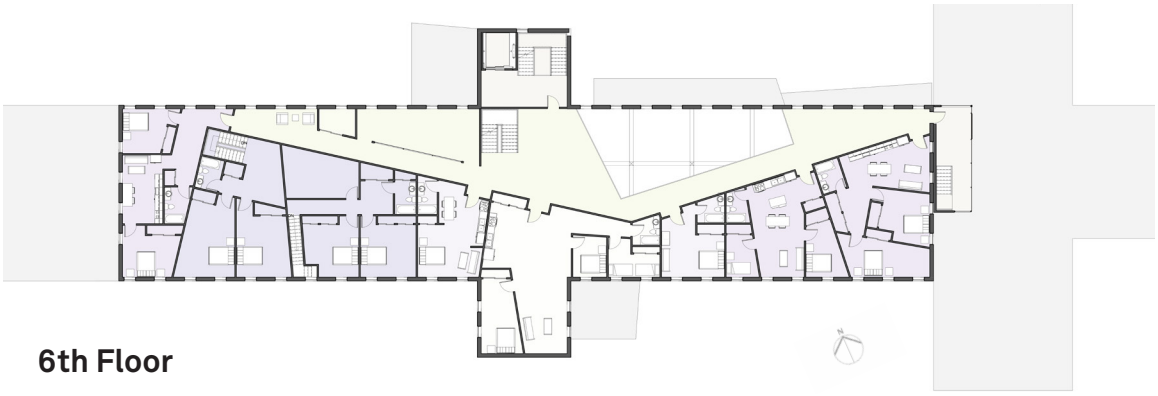
Unlike normal apartment style living many amenities are shared such as kitchens, dining room, dens, and laundry rooms. This allows for smaller living spaces, simultaneously reducing carbon footprint and less "stuff" because cohousing prospers within the borrow and lend culture. It is common for families to trade off cooking weekly meals for the community and share responsibility for watching children. These communities are also accustomed to the idea of limiting vehicular movement on site in favor of the pedestrian. This sets a mutual consideration to locate cars on the outskirts of site to allow for a safe haven for children to play and exploit the use of walking and biking.

Family - 4 Units

2 Bedroom - 9 Units

Studio - 6 Units

Communal Space



6th Floor

5th Floor

4th Floor

With this in mind, the cohousing community is designed so that the apartments are all aligned along the south facing wall. When one enters on all floors (6,5,4) they enter into a common space so that interactions happens on a more frequent basis, one can always see what is happening within the community. By doing this it eliminates long hallways with limited light and opens up the north side of the building to everyone.

The apartments are designed so that there is a range of family style apartments both single floor or double floor as well as two bedroom apartments and studio apartments to support a variety of different lifestyles. They are scattered on each floor to mix the families with the individuals so no one person feels "alone". The common spaces noted in light yellow on every floor get direct light from the north side of the building and are open enough to invite one to come outside of their private apartment and spend time with others. The common spaces that are typically found in cohousing are located on the fifth floor, this includes a large living room, children's play room, and communal kitchen, with dining space. The communal kitchen is strategically placed on the fifth floor so that no matter which apartment one may live everyone comes together in the middle to commune. The sixth floor in the center directly above the common kitchen has a guest sweet for the community members. The placement of the apartments on these three floors was very specific so that the dwellers could overlook their site and the earth that they till. Placing the apartments on the south side of the building also provides a beautiful view of downtown Thorndike and the Ware River, cultivating their connection to place.

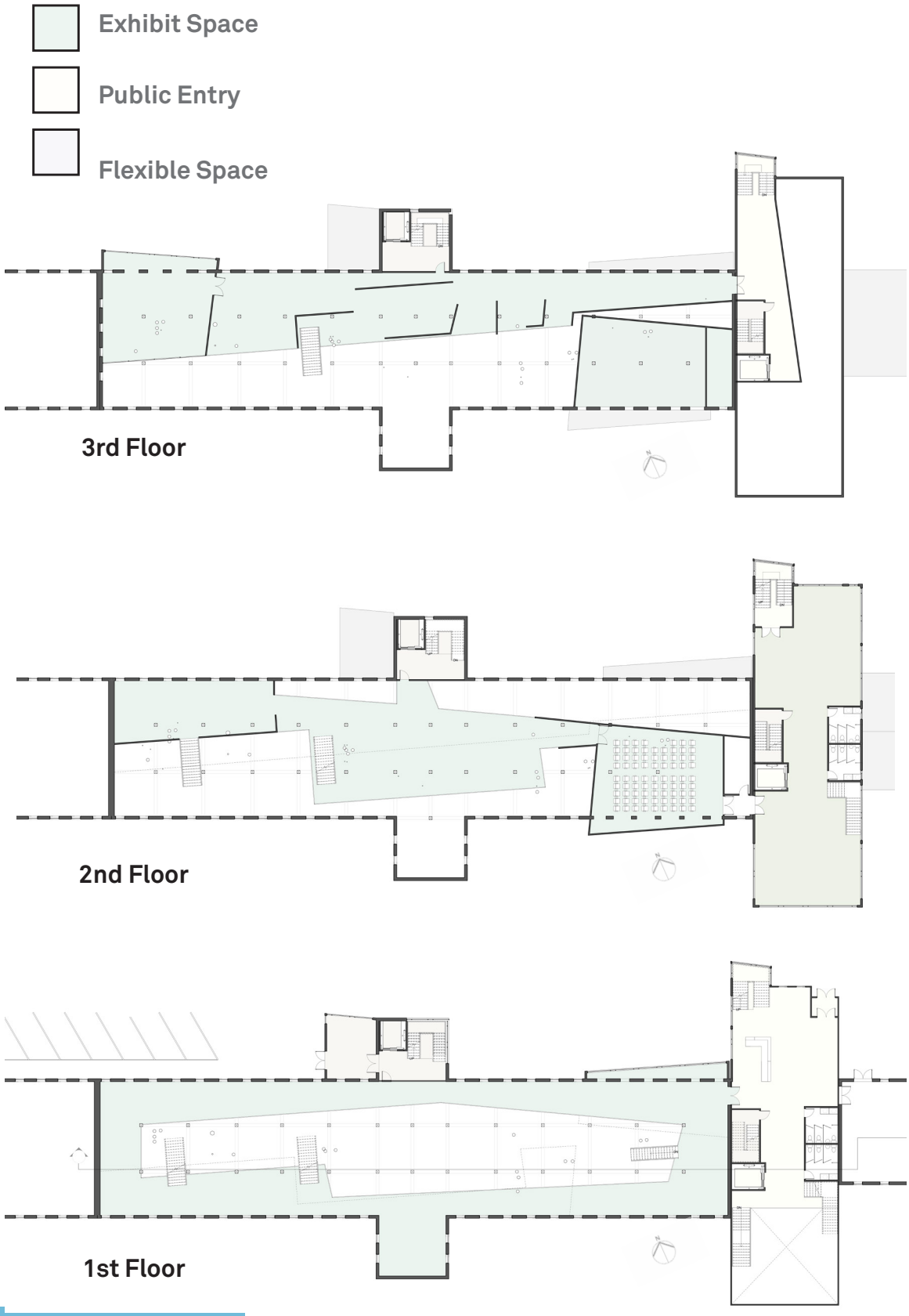
The placement of the cohousing on the top three floors of Mill 2 was not an accident. By doing this, the waste of the inhabitants becomes centralized and localized.

The organic food waste, human excrement, and gray and black water waste streams move horizontally from one end of the site to the other. By placing the cohousing on the top floors of the building it introduces a new vertical language within the waste system. The waste from the cohousing community runs from the apex of the site, flows down through the buildings first vertically then horizontally and leaves them only when it is ready to be returned to the earth and used again.

6.2 Education and Exhibition

The second programmatic component of Mill 2 is the design of the exhibition and education center. What better way to involve the community and the world than to educated and demonstrate waste. The design of floors 3,2, and 1, were heavily influenced by two factors. The first is a specific pedagogy that outlines the movement of the visitor and the second is the driving idea that the waste streams, the guts of the building should be exposed. Just as the vertical movement of waste works its way from the top of the building down, the visitors too would work their way down to the basement with the waste flows. As the waste is being processed and decomposed the visitors are joining in on the journey.

The experience of the exhibit begins on the third floor. A new public entry was added to the small building to the left of Mill 2 (also noted in green). This building originally served no purpose, but the new programmatic function introduced it as a transition space between Mill 2 and the hydroponic greenhouse / food market. A new and inviting staircase carries the visitors up to the third floor where they begin their adventure.



In the design it was important that this vertical movement happened separately, before entering the exhibit space. The connecting stairwell bids the visitor time to disorient themselves and while traveling upwards they are permitted scenic views of the site that they will soon learn about. Upon reaching the entry to the exhibit they are reoriented and ready to begin a journey, fresh, and malleable.

The design of the exhibit was one of subtraction and a carving out of space rather than addition. As one moves down from level 3 to level 2 the floor plates begin to disintegrate beneath ones feet. The floor begins as a whole plate on level 3 but dissipates into smaller pieces with the downward movement. The floor plates are mimetic of the process and system of decomposition and meant to remind the visitor of this through their path of travel.

The educational program also begins on the 3rd level informing participants about waste. It sheds light on current issues regarding waste, and the rate at which we are producing it. The aim of this floor is to bring awareness to why waste is an important issue today and why there is an imperative need for change.

While moving through the floors large pipes extend through the space interrupting flow and asking for attention. Moving down to the second level the floor plate stretches an begins to open up, allowing for subtle glimpses below. The exhibit presents the waste that is being designed on site as well contains a large lecture space. With the opening up of the floor plate one can begin to question the pipes amidst them. Where at they going? What do they do? Where are they coming from? Soon it will all be made clear and revealed.

Once the first floor is reached the middle is completely open to below and one is free to move around the periphery. Certain and specific information is proffered about the machines and the systems and waste they partake. The visitor than has the opportunity to venture into the basement and travel in and out of the forest of machinery. They have now completed their cycle of knowledge on waste.

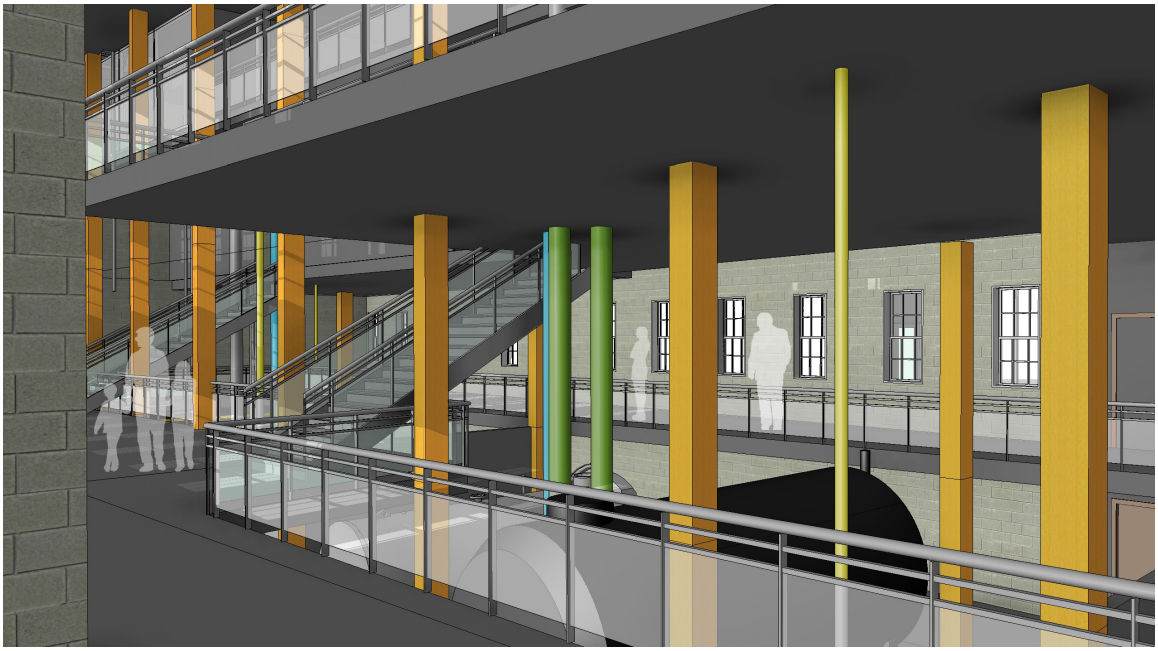


Figure 37: Image of first floor opening below to basement with waste pipes. Graphic by author

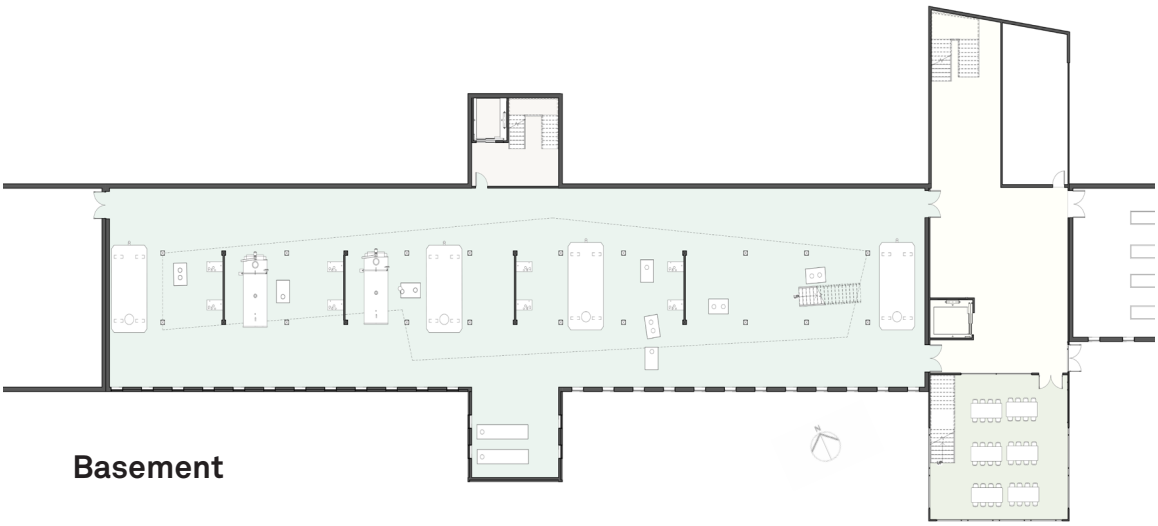
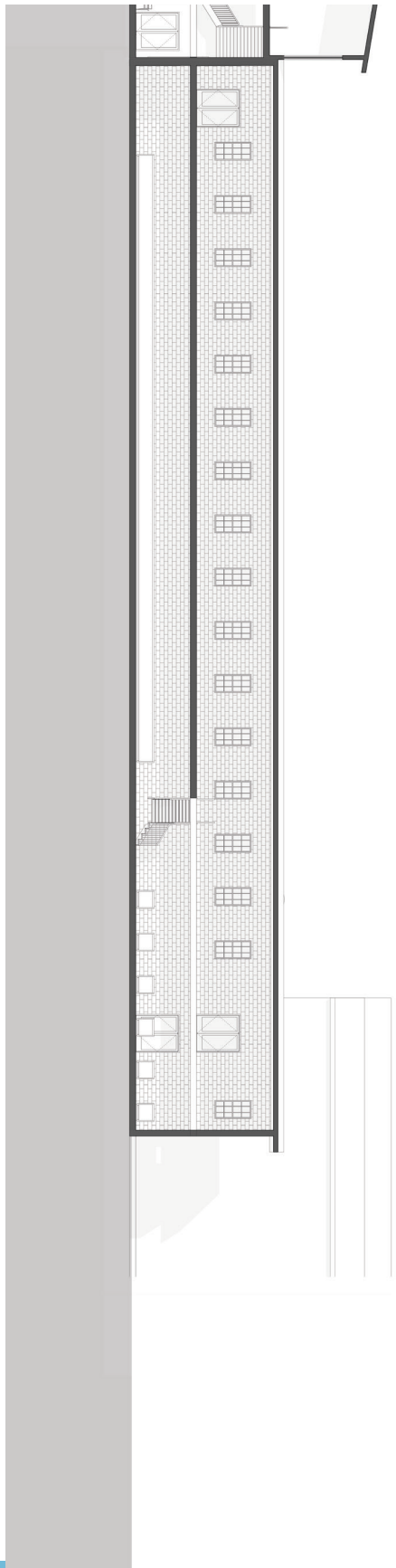


Figure 38: Section through Mill 2 and Hydroponic / Food Marking (Blue Colored Building from Figure 24. Graphic by author



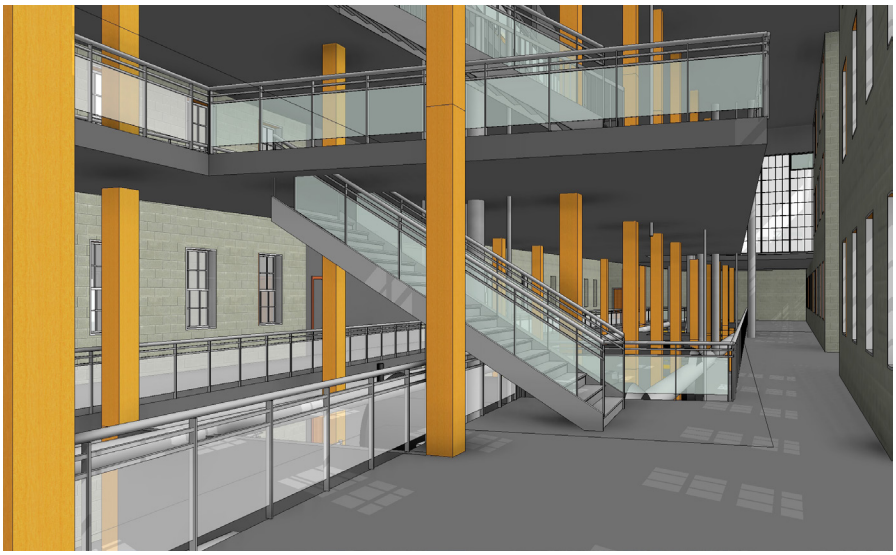


Figure 39: Image shows connection of second floor to first floor, looking down towards lecture space as well as the mixed double and single heights. Graphic by author

6.3 Design and Details

The final design intention was about keeping the integrity of the building while introducing a new language, one that brought notice to the old while also recognizing the new. To accomplish this the design was guided by the column and beam structural grid. The design of the new program was introduced against a backdrop of the conventional grid system. The structure of timber columns and beams have withstood over 100 years of time and the design embraces their presence instead of concealing it. The gaps in the floor plates especially on floors 3, 2, and 1 reveal the beams spanning the spaces below and one can see their connections within the integral bounds of the building. Beams and columns such as these are beautiful and rare and provide a color of warmth against the stark gray and bitterness of the granite stone. It is simply another system working within the larger context of the site.

A main goal with the design was to keep and endear the integrity of the old.

The granite stone has a bold presence both from the exterior and on the interior of the building. To introduce a contemporary language in the building a new program was initiated to break through the confinement of the orthogonality of the original footprint. This disturbance of the regularity is seen in the protruding facade extensions. On the interior the granite is kept intact, but incisions are made within the granite walls to create porticoes. These incisions in the walls allow one to walk full circle around the stone and truly gain a sense of its essence. These cut outs are also where the facade protrusions occur and allow for uninhibited panoramas of the environment and systems that are learned about.

Figure 40: Up close image of granite. Image by author

Figure 41: Granite facade. Image by author

With the design it was important to highlight the buildings for what they were and are now. Large granite mills like Thorndike are rare and many are the last of their kind. Normally antiques are valued, but unfortunately with the tied costs that comes with old

buildings, they are not. It is important to think that a building such as this could be one of the last of its kind, and to find moments of pause and gratitude in its form. The granite stone is beautiful and alluring and has existed for over 100 years. It is not on display within the design, but meant to serve as a presence that can be felt. When one touches the granite one forms a connection, just as one does when they toil in the dirt that grows our food. It forms yet another connection with place. Most importantly, one can feel the energy of what came before and appreciate the presence of it today. With the new systems in place the buildings continue their purpose, but within different constraints.

CONCLUSION

Alain de Botton wrote in his book *The Architecture of Happiness*, "We owe it to the fields that our houses will not be the inferiors of the virgin land they have replaced. We owe it to the worms and the trees that the buildings we cover them with will stand as promises of the highest and most intelligent in kinds of happiness."[88] These words echo the values of this thesis. De Botton implies that, intentions before the landscape must be cultured and respected when building upon the environment. We owe it to ourselves to do this, because to find this ideal happiness with the worms, trees, and buildings, we must also find this happiness within ourselves. In the combination of these words Botton reverberates the sentiments of the heart of ecological design, and what can be achieved with careful thought and consideration.

Systems as a tool with design are integral to our future and should not be overlooked. One must be cognizant of the world around them and the role that they play in the overarching system. We must approach all design in such a manner from buildings to clothing with a mapping out of webs of influences and consequences in the great system of things. This thesis was meant to help exemplify the powerful ways design can literally change our lives and environment. If we begin to bolster a new careful consideration for our environment we might just be able to return to our planetary goodness. What is so astounding is that design can do this. If this paper exudes any one conviction it is that design is not just design, but a cross disciplinary profession. As architects we are not only problem solvers, but thinkers, designers, creators, biologists, and philanthropist. We cannot just design, but must explore overall outcomes and inputs

88 Alain de Botton, *The Architecture of Happiness* (New York: Pantheon Books, 2006), 267.

of the greater whole, within our selves, building, and the world.

Most importantly though, this thesis is an exploration in possibility. It questioned whether it is possible to do more with design and architecture then create beautiful buildings, and the answer is most resoundingly yes! Architecture is a powerful tool for it allows us to see the world through a different scope and understand that, "Design is not just about how we make things, but rather how we make things that fit harmoniously in an ecological, cultural, and moral context. It is therefore about systems, patterns and connections. It is also part of a long-term conversation between ecologists and designers of the built environment and technosphere, the essence of which is whether design becomes yet one more clever way to make end-runs around natural systems or is disciplined and informed by an understanding of nature."[89] This is what we must practice and is the very essence of this thesis. With design, systems, and problem solving, we can return our waste to the goodness it once was and in return reclaim our home. The time is now, lets not wait.

89 Orr, "Architecture, Ecological Design, and Human Ecology," 31.

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